PHYSICS

oPTIMIZED HYBRID SPACE-TIME SERVICE CONTINUUM IN FAAS

D7.6 – BUSINESS INNOVATION, EXPLOITATION PLAN & HANDBOOK II

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CONTRIBUTING PARTNERS

Partner Acronym	Role	Name Surname
GFT	Lead Beneficiary	Maurizio Megliola
BYTE	Contributor	Elina Papadopoulou
ATOS	Contributor	Lara Lopez Muñiz
HPE	Deliverable Review	Alessandro Mamelli
CYBE	Deliverable Review	Théophile Lohier
FTDS	Quality Assurance	Niklas Franke

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
APAC	Asia Pacific
API	Application programming interface
CAGR	Compound Annual Growth Rate
CPU	Central processing unit
CSP	Cloud Service Provider
D.	Deliverable
DMS	Distributed Memory Service
EPO	European Patent Office
EUIPO	European Union Intellectual Property Office
FaaS	Function as a Service
GDPR	General Data Protection Regulation
IaaS	Infrastructure as a service
IoT	Internet of things
IP	Intellectual property
IPR	Intellectual property rights
KPI	Key Performance Indicator
ML	Machine learning
NPM	Node Package Manager
PaaS	Platform as a service
PHYSICS	oPtimized HYbrid Space-time servIce Continuum in FaaS
RAMP	Reusable Artefacts Marketplace Platform
RF	Reasoning Framework
TRL	Technology readiness levels
XaaS	Anything as a service

EXECUTIVE SUMMARY

The present D7.6 report describes the second version of the Exploitation, Business Innovation Development Plans and Handbook activities of PHYSICS project with the contributions of all partners integrated in a coherent vision. In addition, a deeper insight on the Innovation Management is integrated in this document as well as an overview of the activities toward the Handbook.

This deliverable sets up the updated approach and methodology that is being used during the project lifespan and the project's commercialization strategy, with special focus on the project's market platform, the identification of the exploitable items, the solutions/services that are provided, the business models and monetization strategies of the services of the market platform.

The purpose of the deliverable is to present potential business models for the PHYSICS exploitable results. One of the key challenges faced by the PHYSICS project is to ensure sustainability beyond the existing funding of the project. Dealing with this challenge requires an actionable exploitation plan underpinned by a set of robust business models.

In the IP Rights analysis section of this report, the possible risks arising from the fact that legislation is often lagging behind the current state of the technology when it comes to cloud computing are highlighted and discussed in terms of their impact and probability to occur.

As part of the exploitation strategy of the project, both joint exploitation and individual plans were revised regarding the PHYSICS market platform and the individual partners' exploitation. For the joint exploitation activities, an updated version of business models and exploitation plans were developed and will be further iterated and complemented in the final year of the project. Exploitation will proceed in a manner that maximizes the project's wider impact and benefits beyond the consortium, disseminating and facilitating further use of their results by industry and society.

Looking at the opportunities and solutions, potential viable options regarding exploitation plans include leveraging exploitable results both as a whole thanks to the 3 bundles approach working in synergy with the RAMP, or individually through 3 bundle-specific exploitation paths with the RAMP also working independently.

Lastly, the deliverables' findings set the basis for T7.4 - Adoption Impact and PHYSICS Handbook, which will contribute to increased adoption of project outcomes through a handbook that will address the context, requirements and advancements of evolving PHYSICS technologies and supporting environments through a set of recommendations and best practices.

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1. INTRODUCTION

The present D7.6 report contains the second version of the **Exploitation & Business Innovation Development Plans** of the project, the progress made in the innovation management activities and the action undertaken in the development of the PHYSICS handbook. The main focus of second version of the report is the development of the approach to market transfer and exploitation of the project results, and the initial validation of the business models. Given the developments of the RAMP on-line and the initial activities undertaken to make it public and usable, a strong focus was put on that.

This deliverable develops the approach and the methodology to be followed during the last year of the project lifespan and the project's commercialization strategy, with special focus on the project's market platform, the concretization of the exploitable items, the solutions that will be provided, the business models and future strategies of the services of the market platform.

Dealing with this challenge requires an actionable exploitation plan underpinned by a set of robust and validated business models.

The aforementioned tasks have been performed through comprehensive desk research based on market reports and scientific papers on top-tier databases and primary research, while also leveraging insights from the partners, in particular regarding exploitable results and exploitation plans thanks to the organization of a second exploitation workshop.

In addition to that, to be sure that the exploitation has a relevant audience, the project consortium has finalized in September 2022 the first impact intensification period, in which efforts were further pursued to increase the external involvement in the project activities. Partners collectively reach out to stakeholders to build an online connected community, leveraging expertise in social media strategy and existing partner networks. In order to boost this first round, three hackathons have been scheduled, with a pool of selected participants to test the Physics platform and give feedbacks.

The first hackathon took place from the 22nd until the 24th of November 2022, while the following ones are to be held in early 2023. In addition, the consortium has organized a clustering webinar with CHARITY project, which took place on the 29th of November, to introduce and demonstrate the design environment.

A workshop about the three-project pilots is scheduled for early 2023, to present and share more hands-on results. A stronger work about innovation potential has also been performed and integrated in this document.

2. UPDATE INSIGHTS FROM THE MARKET ANALYSIS

In the first year of the project, an initial SWOT analysis of FaaS was performed, followed by the review of the critical success factors to overcome the challenges, and build on the strengths and concluding with definition on PHYSICS value proposition. D2.1 was then updated in the second year of the project after the comments of the PO with new insights. In PHYSICS project, in order to define the Business Model for the future exploitation of the proposed solutions, we analyze the market with some of the methodological tools described below. The main objective was to define the more appropriate business model or models considering the players, their relationships and possible business models.

2.1 SWOT Analysis

The SWOT analysis performed below was aimed to assess and analyze the strengths, weaknesses, opportunities, and threats of FaaS both for the developers and for serverless providers on the other hand. The aim of conducting this analysis is to define the pros and cons of this cloud computing model in the FaaS providers' shoes such as AWS Lambda and Microsoft Azure and in the customer side (developers for businesses), while foreseeing the main drivers through an outlook of the threats and weaknesses that could potentially impact players on both sides (developers and providers).

Figure 1- SWOT analysis

2.1.1 Strengths

Overall, making cloud computing serverless through FaaS enables increased efficiency, simplicity, and productivity for businesses. Indeed, one of the main benefits of FaaS lies in the fact that it avoids the constraints of the underlying infrastructure. The increased demand for asset-light and serverless infrastructural approach has consequently led to a growing demand for FaaS providers in a more and more digitalized era for traditional businesses and industries. On the other hand, however, this requires FaaS providers strong internal capabilities and to come up with technology almost foolproof in order to ensure the quality of the service and that operations run smoothly.

Moreover, serverless cloud computing providers succeeded in making their product run smoothly and rapidly even when there are numerous requests, enabling automatic and rapid scaling. These vendors (FaaS providers) are also in charge of managing the scaling part, which takes a thorn out of businesses' side.

Another aspect that makes FaaS a rapidly growing segment in the cloud computing market increasingly popular, is the **rapid deployment it enables**. For businesses, there is less time between the project ideation and its execution; it also allows to ease multiple deployment of a given service in different context (for example, deploy the same data processing pipeline in different greenhouses). Serverless cloud computing is also flexible and reliable: the serverless provider takes care of the setting and executing the application and can do it in a qualitative way as code runs smoother.

Furthermore, given the pay-per-use pricing model, businesses only need to pay to execute the functions and the resources used (memory, storage, CPU…), and not anymore for idle time. Therefore, this pricing model results in cost savings in most cases for businesses as it does not imply extra costs such as acquiring and installing the servers, maintenance costs, operating system management costs, etc. Hence, it corresponds better to the output levels of the service's actual consumption. It also facilitates the selling and billing process for the commercial department and results in better cost management for end-users.

Moreover, with the increased traffic, deploying and executing functions efficiently and automatically is a real challenge for serverless cloud computing providers. In serverless cloud computing, automatic scaling is a critical success factor, and players like AWS Lambda and Azure can satisfy the demand in this area as the functions' execution runs smoothly. The systems automatically adjust the capacity to maintain steady and predictable performance at the lowest cost.

The core purpose of FaaS implies less administration overhead and constraints. Going serverless means that businesses do not need to manage the servers anymore and to hire specialized staff in charge of managing infrastructure, thus saving costs, and reducing complexity.

Current most prominent players in the FaaS segment have deployed their product while enabling high availability of various coding languages. Hence, despite going serverless, the main players' products still allow coding in any language required (HTML, Java, Node.js, Python, etc.).

Open source serverless frameworks are highly available and developed. Its main advantage lies in the fact that it can be deployed on any infrastructure. Also all the customers can benefit from updates and improvement without having to perform any technical action.

2.1.2 Weaknesses

One of the main weak spots in FaaS cloud computing is related to **security risks**. Security-related vulnerabilities need to be addressed as a few issues remain in this domain and can therefore harm businesses and their willingness to go serverless (function event data injection, broken identification, insecure serverless deployment configuration, insecure application secrets storage, etc.).

Latency is another major drawback with regards to serverless cloud computing. Latency in the execution phase might occur. Improving efficiency and execution of the functions, addressing the latency issue, could be a pivotal area of improvement for market players.

Some other issues may be mentioned regarding the execution of the functions in FaaS. There are some constraints aside from the latency with limitations when executing the functions. For instance, the lack of memory is the main one when it comes to coding size.

Vendor lock-in can potentially become a drawback as being stuck with one cloud provider may become harmful and tend to decrease the agility in businesses' operations. In other words, once one begins working with a vendor (Cloud Service Provider) and that it starts executing functions and moving workloads into the cloud, it might be hard afterwards to drive them away and take control back. Businesses' data is critical, and with this data being managed by external vendors, cloud customers become highly dependent on these external providers.

Despite the pricing model being on paper appealing and beneficial, it is yet key to monitor and mitigate the potential risks of high operational costs related to overhead and retrials due to data not being optimal for FaaS.

On the vendor side, the main issue in this market is that with the cloud adoption among businesses becoming more and more mainstream, it becomes increasingly difficult and challenging for new players to penetrate the market. With huge existing market players already operating in this ever-growing market in terms of size (volume and value) and the competition intensifying with the China giants such as Alibaba also breaking into the market with extensive internal capabilities and strong financing capabilities, the cloud computing industry can already be referred to as a red ocean.

2.1.3 Opportunities

It is crucial to consider the high market potential in many growing industries and overall Industry 4.0. Indeed, advancements in new technologies have sped up the transition towards a more digitalized world. The development of data-driven technologies and connected objects such as Machine Learning, AI, Big Data, IoT and 5G in many sectors represent a significant growth opportunity for FaaS.

Secondly, the potential integration into new business models. The COVID-19 pandemic has sped up a transition towards smart technologies. In the healthcare sector, benefits such as enhanced data usage, medical research and lowering costs, drive the market. The e-Health sector relies on cloud technology and is forecasted to grow at an exponential pace. Smart agriculture and manufacturing are primarily driven by IoT and require large amounts of data to be processed. Lower resource allocation and the need for real-time management technology will create immense opportunities for FaaS integration.

Next, the continuous growth of the cloud technology, (20,5% CAGR over 8 years [1]), whether used in mobile apps, streaming platforms, storage services or web applications, is correlated directly with the growth of FaaS technology, as the pricing model of FaaS can translate into drastic cost savings for service providers and consequently for consumers.

Another pivotal opportunity lies in the increased use of FaaS by Financial institutions. FaaS technology is already widely adopted by the financial sector for multiple reasons. Indeed, financial institutions are increasingly using FaaS for automation of routine operations and facilitating cost reduction. As investments in the financial sector towards digitalization keep increasing, so does the industry's demand for FaaS services.

Conclusively, providing FaaS services compliant with GDPR will make them even more attractive to SMEs. SMEs often struggle to comply with GDPR due to its complexity. Some studies even argued that GDPR harms competition within the EU as start-ups tend to be more challenged by regulation than Big-Tech companies. For this reason, providing FaaS services compliant with GDPR will make them even more attractive to SMEs.

2.1.4 Threats

FaaS frameworks will need to satisfy GDPR in Europe. Developers still need to provide end-users with accessible and transparent ways to comply with foundational pillars of GDPR. The increased regulatory requirements are inferring an increased risk concerning breaches of data. Additionally, in some sectors where data is highly subjected to GDPR such as patient information, development of services will have to ensure full security.

The blockchain growing trend has the potential to maintain its current development and importance and develop functionalities that can substitute the FaaS platform. While this scenario is yet to be clearly defined, it is an eventuality that must be kept into account as it may disrupt FaaS long-term survival.

2.2 Porter's 5 Forces

Porter's Five Forces is a model that identifies and analyzes five competitive forces that shape every industry and helps determine an industry's weaknesses and strengths. Porter's 5 forces are:

- Competition in the industry
- Potential of new entrants into the industry
- Power of suppliers
- Power of customers
- Threat of substitute products

In PHYSICS specific case, given the nature of the project, this analysis is particularly relevant, because it allows the consortium to be strongly aware that, although the competition in the industry is very strong (having many leading players already in place), the model of the business is highly mutable, allowing even new comers to access the market, if the solution they are proposing is relevant enough.

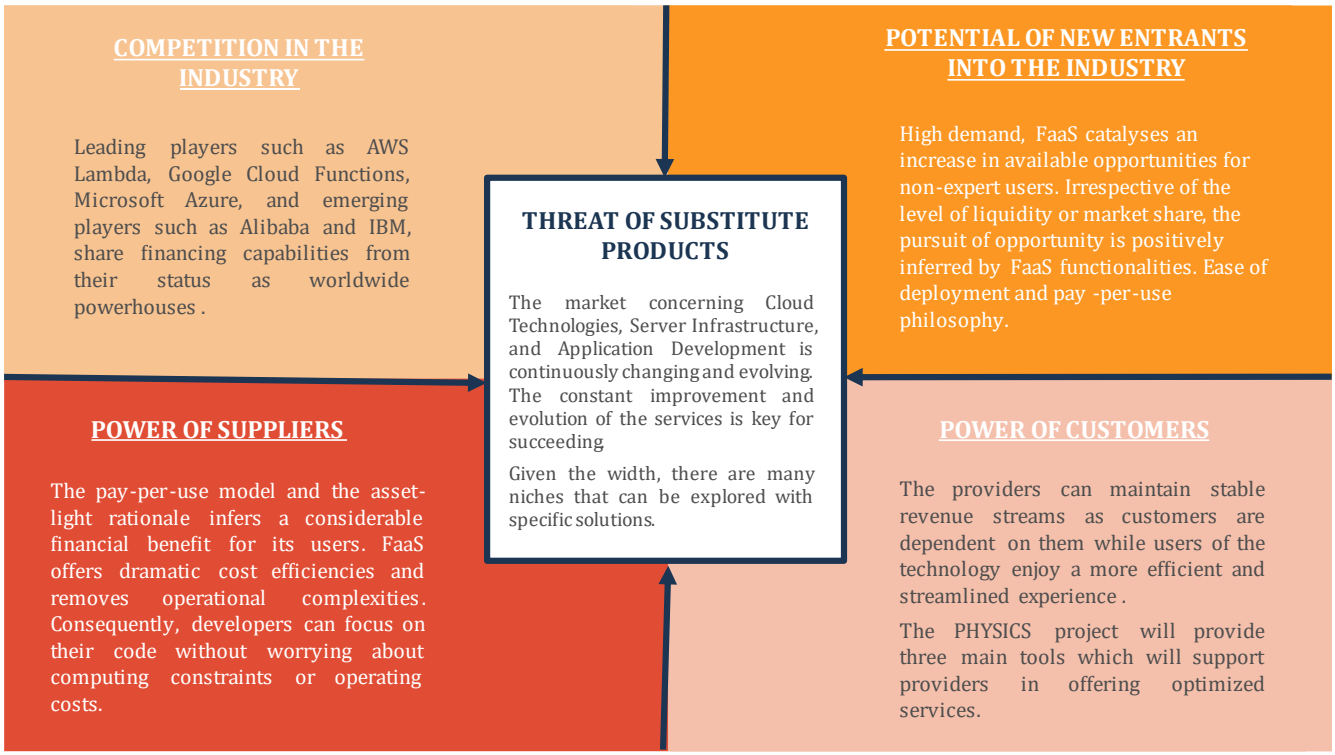

Figure 2 – Porter's 5 forces analysis

2.3 PESTLE

A PESTLE analysis studies the key external factors (Political, Economic, Sociological, Technological, Legal and Environmental); it is a technique that considers the variables of the external environment that have the greatest impact on the future impact. It is crucial in this phase to understand how the main variables of the environment can act on the future of the business, how they change and how they interact with one another. Variables should not be considered as separate but interdependent entities.

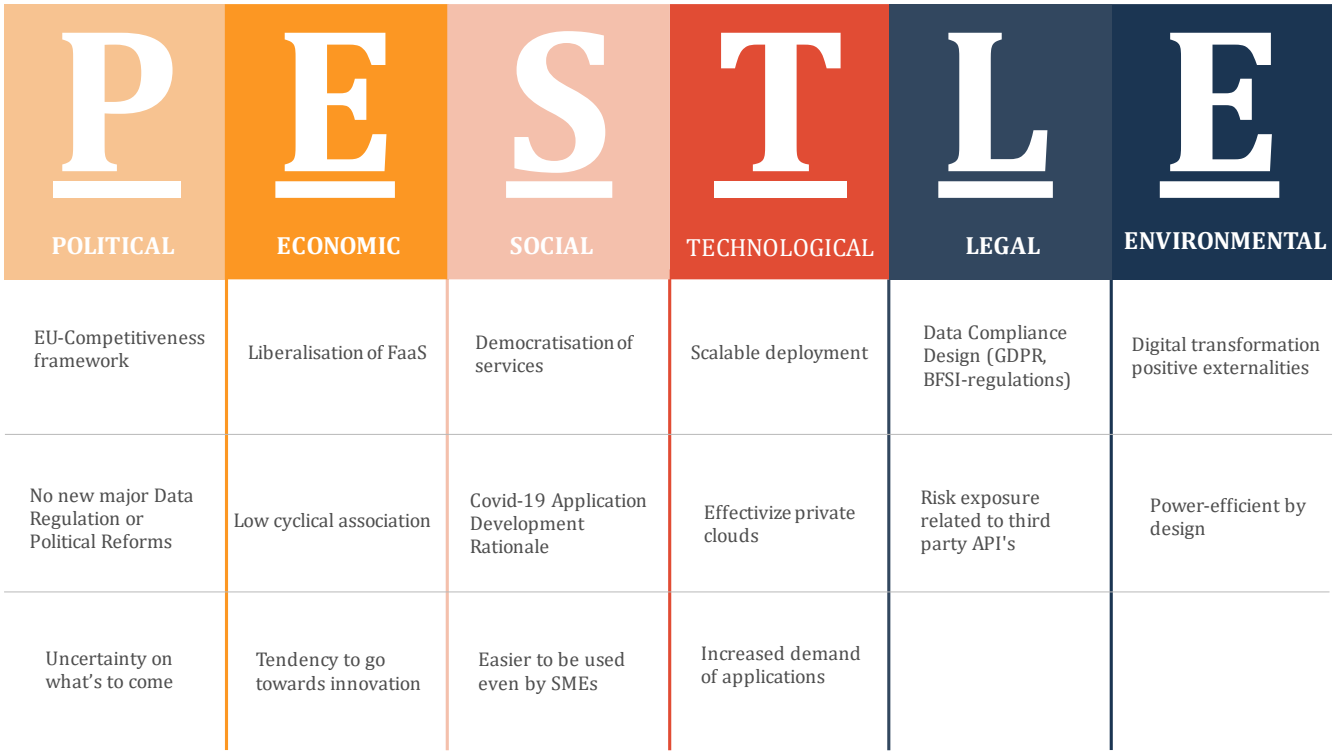

Figure 3 – PESTLE analysis

2.3.1 Political

European firms are too small to sustain competitive operations on a singular basis and need cooperation and support from the European Union, which shortens the relative distance between governments and businesses. APAC has a comparative advantage in the cost of production and human capital resources from a cost-based perspective. At the same time, US-counterparts cover the largest market share, most robust business intelligence with respect to implementation on the market and have the most extensive balance sheets of assets and attractive value offerings to customers as per aforementioned data. For European firms to compete, diversification and innovation have to be the leading comparative advantages globally as the APAC and US comparative advantages are less realistic on the European market structure. Niche initiatives such as the PHYSICS project and integrations of digital economies via the Digital Single Market are pivotal political forces to foster a competitive environment and innovation.

Compliance and Regulations are both aspects of the Political and Legal parts of the PESTLE. With respect to Political, the focus is on the political processes in the European Union and the intended political effects of such proposals. With more restrictive data regulations comes a political environment that strengthens the individual's consumer rights while imposing a more regulatory burden on the business. It can thus far be inferred that the EU, compared to other political bodies, is more interventionist in their approach to data given the extensiveness in the latest set regulations in relation to equivalent governing legislatures.

As of right now, GDPR-compliance as a single regulation aspect is no major factor affecting FaaS due to early adaptation and a design environment that allows enhanced logging and privacy-preserving functions. As of now, there are no substantial present political risks related to FaaS that would disrupt operations. There are no anticipated major data regulations in the pipeline that would lead to drastic FaaS compliance changes. Furthermore, no regulatory aspects on a national and EU-level have supported any significant political element. Therefore, the risk associated with political effects and intentions from the EU or other political institutions cannot be credited as extensive based on currently available information. The legal effects based on passed legislation are, however, more substantial and are discussed in the Legal section.

2.3.2 Economic

The Covid-19 crisis has, without reasonable doubt, affected all economies on a global scale. When looking at the monetary, fiscal, and financial indicators concerning FaaS, no significant risk or impacting factor is present due to FaaS lack of association with capital market trends, interest rate policies, and fiscal policies. It should still be recalled that FaaS clients end users may face economic distress which would directly impact FaaS delivery and revenue opportunities. Looking at the current growth despite Covid -19, the trend suggests that such a liquidity risk is unlikely to occur.

Nevertheless, the indirect effects of resource allocation regarding human capital have led to an increase in demand for FaaS services. As the general workforce is scattered, serverless development provides an efficient solution to the increased demand for digital services from companies and end-users. When looking at the aforementioned trends for FaaS, the cyclical nature of the crisis can, to some extent, explain a current upside on demand. Nevertheless, growth in the FaaS field is still to remain post-Covid.

2.3.3 Social

As a high concentration of SMEs characterizes the European market, and as the general market regardless of industry is moving towards increasing technology use in their operations, FaaS catalyzes an increase in available opportunities for non-expert users. Irrespective of the level of liquidity or market share, the pursuit of opportunity is positively inferred by FaaS functionalities. Two major factors are the ease of deployment and pay-per-use philosophy.

In general, market demand suggests a shift toward serverless computing. Henceforth, increased demand for FaaS services by FaaS providers is inferred, and growing market capture opportunities are present. Because of this, the distinction between development and operations may not be as clear. Due to FaaS services' nature, automation, and abstraction lead to decreased demand for operations management over the development side in the processes. The rationale has changed in terms of application development and use; people get used to use connected services running in the cloud rather than local software. A further boost and stronger need for this type of application has been given in the last three years by the happening of the COVID-19 Pandemic, that made even clearer the need for such agile solutions.

2.3.4 Technological

The Technology that FaaS offers on the market can effectively process for users and successfully scale deployment processes.

FaaS technology is still relatively novel in the Cloud Computing market and is still emerging. Nevertheless, the critical feature of scalable deployment and flexible models is a significant pull factor that converts a wide range of stakeholders to adopt FaaS technology. Regardless, technological constraints need to be addressed in order for FaaS technology to scale as a technology. While the PHYSICS project aims to reduce vendor lock-in due to open-source technologies, the clouds and environments among FaaS-providers infer a high vendor lock-in risk. To mitigate this, investments into automation of application translations processes, deployment and abstraction using FaaS middleware are pivotal.

Touching based on security and the preference to utilize private cloud elements (usually in a hybrid manner), cost and efficiency effects have to be considered in developing the FaaS technologies as such constraints may lead to less scale of returns among desired target users and developers. By creating more sophisticated security features in the public cloud domain and reducing operational costs related to private clouds, the economic and social effects derived from this technological aspect may improve profitability indicators and increase production scale.

2.3.5 Legal

If looking at the legal effects and implications of imposed data regulations on EU-based FaaS-providers, compliance per se is not an element that extensively affects the daily operations. Providers of FaaS are showing adequate levels of adaptation to GDPR, but the increased regulatory requirements are inferring an increased risk concerning breaches of data, as well as an increased risk among third party APIs. For providers, the legal sanction of not complying with regulations is sometimes a larger risk itself than any obstacles related to GDPR implementation due to the drastic liquid and reputable effect of such data breach incidents. Consequently, risk mitigation is usually done through private cloud solutions dependent on traditional data center staffing and maintenance. For some sectors where data is highly subjected to GDPR, such as patient information, the development of services has to ensure full security.

There are also sector-specific regulations such as the Payment Services Directive 2 (PSD2) or Markets in Financial Instruments Directive II (MiFID II) which, if looking at relevant aspects for FaaS, refers to increased consumer data protection measures in payments and more extensive reporting standards of trades respectively. These regulations are more commonly imposed and updated according to legal demand. Based on historical regulations, these regulations infer a higher risk for sectors such as the BFSI, which have been subject to both major non-sector specific regulations such as GDPR, as well as sector-specific regulations. Therefore, the need to design by compliance is pivotal, which is over-all successful among FaaS-providers due to the agility in the development of the FaaS environment.

2.3.6 Environmental

The current ongoing digital transformation supported by FaaS services leads to positive externalities as manufacturing, agriculture, and healthcare sectors operate more efficiently, automated, and digitally. As FaaS enables digital opportunities that may not have been previously feasible, it supports a tech-and-environmental integration.

Typical servers may have an unconscious state of 30% while their annual usage rates are dramatically low, sometimes as low as 5 to 15% per annum. The environmental footprint of software and servers can be improved thanks to the intrinsic advantages of the FaaS models pay-per-use rationale. Furthermore, increased server consolidation combined with an optimized provider level scheduling may reduce power consumptions for data centers - currently making up 3% of worldwide total current power consumption which constitutes around 416 terawatts in generated electricity.

2.4 Summary of the Value Proposition Definition of PHYSICS

The applications developed within the PHYSICS platform stand to benefit significantly from the PHYSICS approach in terms of agility and adaptation to more advanced computing models and distributed edge/cloud modes of deployment, enhancing aspects such as development, adaptation, integration, redundancy, safety and operational cost, scalability, and functionality (in terms of exploiting the Cloud/Edge interplay). The project tools include primarily platform and infrastructure services such as:

- Cloud application design environment based on the FaaS model, which embeds a rich palette of available annotations (to be exploited by the platform services as developer directives) and ready-made reusable design and functionality patterns that can be easily dragged and dropped in the application, be combined with custom application logic, and enrich its functionality. The environment also undertakes the management, building and testing of the created application flow.

- Platform services that aim to undertake the final deployment to one or more operational clusters, while exploiting the cloud/edge interplay and the concept of space-time continuum (combining location and duration of execution). Platform services undertake the role of orchestrating the application execution based on the developer directives and needs.
- Infrastructure level services that aim to optimize the local operation of each cluster, collaborating with the platform services in order to abide by the directives of the developer (expressed interest in terms of importance of a specific application component, optimization etc.) The project pilot use cases cover a wide and diverse range of available edge resources, spanning from small IoT sensors and mobile related devices in eHealth, to medium size servers in the Smart Agriculture and more powerful Edge nodes in the case of Smart Manufacturing.

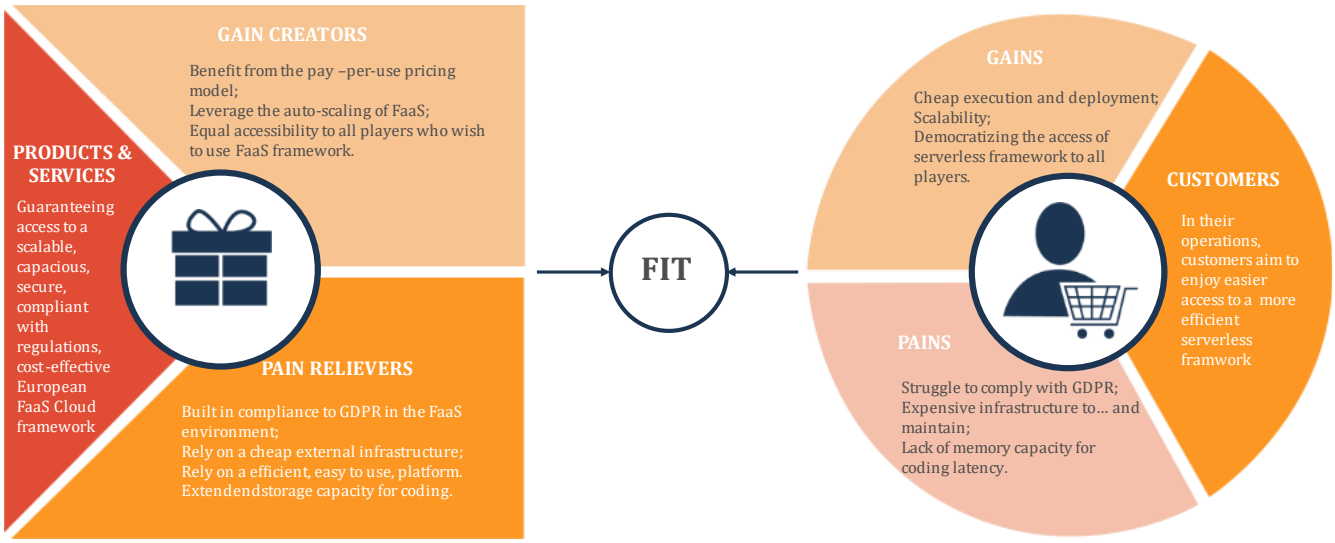

Figure 4 – PHYSICS value proposition

3. INTELLECTUAL PROPERTY RIGHTS ANALYSIS

This section aims at diving deeper into legal questions in the FaaS cloud services market, specifically related to Intellectual Property rights. Not many updates have been drawn in the last year, so mainly the remarks and indications remain the same. It should draw a clear picture of the legal requirements to operate freely in that business environment and of the strategies to overcome the biggest legal threats in the sector. Compromised out of the protection for literary works, namely copyright, and the industrial IP rights, namely patents, trademarks, and trade secrets, the protection of intellectual property forms the core of many business strategies around the world.

In the EU alone it accounts for as much as 45% of the GDP of the member states, translating into a money value of € 6.6 trillion.[2] However, the nature of IP rights of being territorial, national, and exclusive poses difficulties with the multi-jurisdictional, amorphous nature of cloud computing. To make the cloud computing sector accessible to that big part of the EU economy relying on strong IP protection, those legal concerns must be addressed.

3.1 EU Framework for IP Rights

At this time, the IP rights in the EU are still being managed on a national level, although the harmonization of that matter is of great interest for the European single market. Member states have their own legislation and institutions, while the European Patent Office (EPO) manages patents on an EU level, counting for all member states. In a recently published action plan by the EU Commission in Nov. 2020, the harmonization of IP protection is being pushed further through the implementation of a unitary patent system.[3] Furthermore, the action plan also addresses IP issues regarding the digital service act, including the cloud computing sector.

3.2 Key Points about IP Rights in a cloud computing environment

In varying degrees, depending on the type of service used in the cloud, there are some key issues of intellectual property in a cloud computing environment, posing threats to the businesses operating therein. To begin with, cloud systems stretching over international borders clash with the jurisdictional nature of IP rights. Infringements of IP rights on content stored in the cloud can touch multiple jurisdictions, making the protection of such legally a complex issue to be addressed by businesses. Additionally, the operation of the cloud by different parties, intricately structured, may divide possible IP infringements over different providers. Finally, the detection of an infringement alone already poses a challenge, as cloud software systems are closed off and generally cannot be traced backward, making a posterior assessment of an infringement impossible.

The multi-jurisdictional nature of the cloud makes GDPR compliance more difficult and restrains the business environment one can operate in. Key points as data retention periods and data deletion in accordance with the GDPR guidelines must be considered on that multi-jurisdictional level with different requirements. Also, the processing of data outside the European Economic Area (EEA) must be faced with appropriate safeguards.

Liability remains a cornerstone for business operating in a cloud computing environment. Diversifying the risks through cloud insurance can shift the balance between risks associated and benefits to be gained into the right direction, however at the moment there still exists a lot of uncertainty on how courts will decide in critical cases. New approaches to intellectual property must be introduced into a digital context in the future to make it possible for all businesses to tap into the emerging cloud computing sector.

3.3 Why are IP Rights fundamental for Business success?

For any company, especially those working in the cloud computing sector, guarding the business against creative theft is a primary concern. Moreover, it is important that those companies know how to leverage their IP rights to foster growth of their business. By effectively protecting their intellectual property, innovative companies can secure financing, grow, collaborate, and create value. Companies have started to see them as a key lever to gain a competitive advantage in the market. IP rights provide companies with new opportunities to reap the benefits of their original works and adequately monetize their intellectual property, becoming flexible instruments that provide firms with an array of strategic options. Patent portfolios, technology licensing programs, brand equity and goodwill determine much of the value of many modern companies and have become central to their financial performance. Indeed, the corporate value of many large firms in advanced economies is now mostly accounted for by intangible rather than tangible assets[4]. Ideas and creativity are often the most valuable source of input, replacing the more traditional factors of production such as labor and capital. Within this changing environment, businesses are adapting their models accordingly, and seek appropriate returns on their investments by exploiting their intangible assets. A range of options from formal to informal tools of protection of their intellectual assets is at their disposal. The choice of specific tools depends on a number of factors, including the size of the firm and the sector in which it operates. For example, firms that are interested in generating funds can use Patents to commercialize their inventions and eventually sell them for a profit to some investors. On the other hand, companies which operate in highly competitive markets, establishing a trademark can be of valuable importance to establish their market presence and then expand to other industries. Additionally, instead of focusing on one IPR at a time, companies increasingly look at their intellectual assets collectively and take the combination and interaction of various IPRs into account in their decisions. In fact, the use of IPRs as a bundle displays significant potential for firms to strengthen their competitive position in the market, and research has shown that IPRs can be used in a complementary way in order to generate additional streams of revenue and to improve a firm's financial performance.

A study by the European Patent Office (EPO)[5] and the European Union Intellectual Property Office (EUIPO) shows that companies which own at least one patent, registered design or trademark generate on average 20% higher revenues per employee than companies which do not own any of those intellectual property rights (IPRs). Moreover, these IPR-owning companies were found to be paying 19% higher wages on average than other companies.

The study also isolated the effect of IPR ownership from other factors such as the size of a firm or the countries and sectors in which it operates. The results confirm the positive link between IPR ownership and economic performance, with revenue per employee 55% higher for IPR owners than for non-owners.

Overall, the report further demonstrates that IPR-owning firms are more strongly represented in the sectors of information and communication (with 18% of companies in that sector owning IPRs), manufacturing (14%) and other service activities (14%), as well as scientific and technical activities (13%).

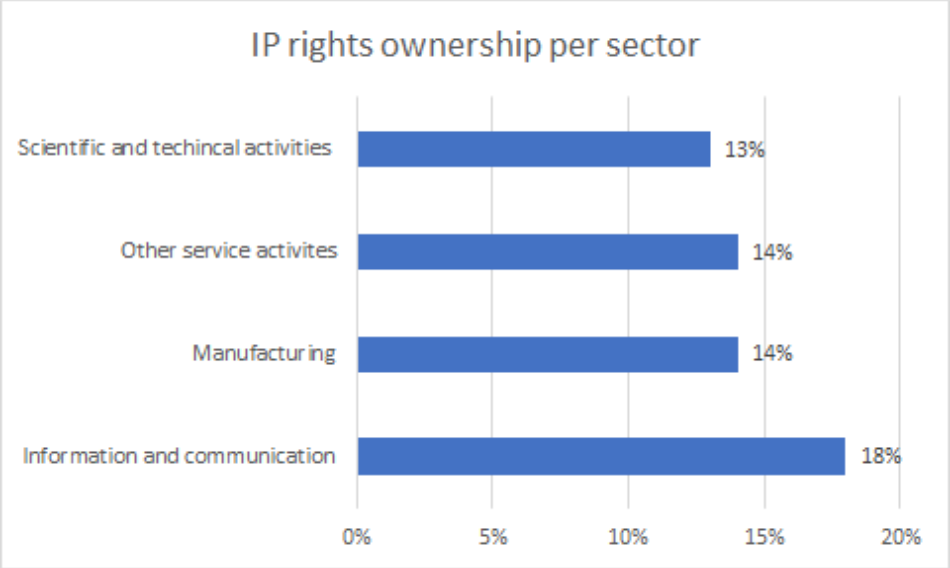

Figure 5 - IP Rights ownership by sector

3.4 IP Rights interaction with GDPR and the effects on the Cloud computing business model

The implementation of GDPR regulations in the EU on May 25, 2018, have had serious implications for businesses using FaaS applications in their processes[6].

First of all, EU businesses will be required to ask documented affirmative consent to users to transfer their information to other businesses. Under the GDPR a person can even exercise the "right to be forgotten" and demand that their personal data is erased. Since one of the most common FaaS applications is to stream data processing that implicates the transfer of personal data, businesses will need to operate with extreme diligence to avoid transferring unauthorized data. Moreover, there exists a fundamental trade-off between the disclosure of private information and the enforcement of IP Rights, since IP Litigation will create a potential conflict between the protection of IP rights and the protection of personal data, which requires that data will only be processed when there are appropriate safeguards and transparency. A company operating in the cloud sector can leverage this trade-off by guaranteeing customer data protection and disclosing their storage location.

3.5 Risks and recommendations

Cloud computing is flexible, cost-effective and a proven method of delivering and using services over the Internet. As business services and data are outsourced through cloud computing, security and privacy are exposed to a higher level of risk as the cloud exploits different technologies but also all its vulnerabilities.

Knowing the threats not only helps the cloud to grow but also the people who use it to protect themselves. Possible dangers can be limited with corporate procedures and warnings that must be followed by every user, because security must always start from the inside. Very often, procedures are the product of common sense and prudence on the part of consumers and the company.

In addition, cloud computing services are used for their convenience and low cost of services. However, every day there are security problems associated with the cloud that make companies and individuals vulnerable to cybercrime and hacker attacks. These attacks use a very wide variety of techniques to gain access to cloud services without obtaining authorization or access from companies, managing to disrupt and tamper with cloud services to achieve specific goals. For example, hackers could trick the cloud into storing confidential information and using it for their purposes.

Since many attacks are launched on servers and web resources, the cloud provider must have the ability to armor its structure and protect it from any attack, using the most up-to-date techniques. However, it would be difficult to impose rigid and binding usage procedures, as this would take away the flexibility that characterizes cloud computing. Those who use cloud resources must impose policies and rules that reflect the company's dispositions, and among these, usage and security procedures must be at the forefront.

The importance of using intelligence solutions to detect signs of compromise and quickly remedy them, are techniques that are the result of a correct approach to security, which must be implemented at multiple levels, using for example encryption, advanced authentication and not settling for standard systems and protections that are not entirely immune to different types of attacks.

Companies need to train and update their staff, showing with practical cases what dangers and all possible risks organizations using cloud resources are exposed to. Increasing employee awareness and responsibility creates unity of purpose and contributes to the correct use of security tools.

For this reason, an awareness of cloud security threats is necessary and appropriate to provide more secure services to cloud users.

Cloud computing is continuously developing to make different levels of services available to customers. People indeed enjoy the benefits that the cloud produces but it is also true that cloud security is and remains a key challenge for the future.

3.6 Risks and recommendations within the FaaS market - Risk assessment matrix

Issues	Risk	Probability	Impact	Recommendations
Copyright issues are more problematic in the cloud. When the various laws of copyright meet in the cloud, this results in increased ambiguity. What an infringement represents in one country may not have the same impact in another. For example, if a copyrighted work is copied and disseminated by a user in India, after the period of protection has expired (i.e., 60 years), it would still infringe the US Copyright Act which guarantees protection for 70 years. Hence, the courts must tread with caution when trying to define the dynamic	By providing a FaaS service for a software company in a country where the company follows a different regulation for the use of personal data of users or IPR of a copyrighted content from the FaaS provider regulations but acts globally; in case a violation of IPR is constituted by the client's activities, the FaaS provider might be considered liable for the violation.	Low	Medium	Instead of the entire cloud computing system or its server-side elements, a service provider may assess if any possible elements of the clients' operations are eligible for patent protection. Activities at the client-side normally are more localized, distinctive, and easily distinguishable. Therefore, it is always better to investigate any creation or innovations eligible both in our operations and more importantly in the client's operations.

landscape of the cloud with respect to copyright.				
"There will be specific procedures included in the project Consortium Agreement to protect the confidentiality and security of the individual and collective IPR shared for and/or arising from the collaborative work of the partners. Furthermore, multiple exploitation paths and models will be investigated during the course of the project, resulting in various participation schemes available to the project partners." - Physics report, Risks and Contingency Plan Section.	Eventual disputes over IPR within the consortium for mainly copyrighted protected literary works.	Low	Low	To some extent, potential issues that can arrive from legal patent conflicts can be avoided by carefully crafting protective intellectual property rights before signing the contract. This ensures clarity and predictability in any potential IPR claims for FaaS or IaaS providers.
The liability for IPR violation. Whether the cloud service providers can be made liable for any infringement of IPR using their services is debatable. One argument is that they act as merely conduit pipes for communication. As intermediaries, they cannot be imposed with any liability for copyright infringement by users. The other side might argue that they induce infringement by users and are hence liable for that inducement.	To promote scalability, flexibility and usability, cloud computing providers must serve an easy to implement with as few blocks and burdens as possible for the clients. But by facilitating the implementation of the services and respecting the client's privacy, they might be indirectly acting as intermediaries in a possible copyright violation, risking being liable for such infringement.7	Low	Medium	When obtaining IP protection for client-side elements of cloud computing systems, the cloud provider should identify the potential. It may not be in a company's best interest to assert patent rights against the users of a cloud computing service, since that may alienate those users from ever signing up.
The scope of copyright itself is called into question in the cloud arena. There is an underlying	Indirectly breaching the copyrights rules by displaying in an invasive or irresponsible way	Very low	Low	An option might be the contracting of cloud insurance for IPR violations both in the case of the software

presumption that the owner of the copyright can only control the display uses of the copyrighted material. When searching sites like Google, copy whole books for the purpose of indexing them (for refining the search technology), it is a non-display use. The cloud providers are clearly making a commercial use of the works owned by others.[8]	copyrighted material from clients. This issue is not commonly applicable for FaaS providers as much as for IaaS of PaaS providers.			provider or the cloud provider. Defence coverage covers the associated costs of a defence of an IP suit, which are usually a substantial amount. It should be kept in mind that although cloud insurance companies are getting creative to sell more accessible insurance policies, the market price can still be a bit too pricey for smaller companies.
Another issue is the making of copies of copyright protected material within cloud computing, and which rules apply in this instance. For example, the owner of a software program or music file does not have a general ownership per se, but rather a license to an individual copy. Some countries allow individuals to make copies of music and film files for private use, as well as to a close circle of friends and family. But when files are saved on cloud servers, it is difficult to interpret what this means, and uncertainty exists regarding what distribution is permissible.[9]	Through one of Physics open-sourced Functions, occurs automatically the inappropriate sharing of a copyrighted material or even a trade secret that does not comply with local regulations of the country of the user or the client.	Low	High	1. It is often the case that the cloud service provider will not always own the intellectual property rights (IPRs) in the software that is the subject of the cloud computing service. In such circumstances, it is necessary for the cloud service provider to procure the right to sub-license the third-party software to its customers. All of the contractual arrangements will then be between the cloud service provider and the customer directly.
Every day there are security problems associated with the cloud that make companies and individuals vulnerable to cybercrime and hacker attacks. These attacks use a very wide	Hackers could trick the cloud into storing confidential information and using it for their purposes.	High	Medium	The terms and conditions offered by many cloud service providers include a broad license allowing the service provider to use any content stored on its servers and often perpetually and

variety of techniques to gain access to cloud services without obtaining authorization or access from companies, managing to disrupt and tamper with cloud services to achieve specific goals.[10]				irrevocably. Uses may be limited but rights to pass the content to third parties or use it for the purpose of promoting the cloud computing service are often reserved. Cloud service providers should seek to exclude all liability for content stored or posted on their services and should normally include a right in its standard terms to remove any data from its servers.

Table 1 - Risk assessment matrix

4. INNOVATION MANAGEMENT

PHYSICS has formulated a structured process for assessing the project's emerging innovations from an early stage. As depicted in Figure 6, the process consists of 5 steps and is followed by the Innovation Manager during the whole duration of the project.

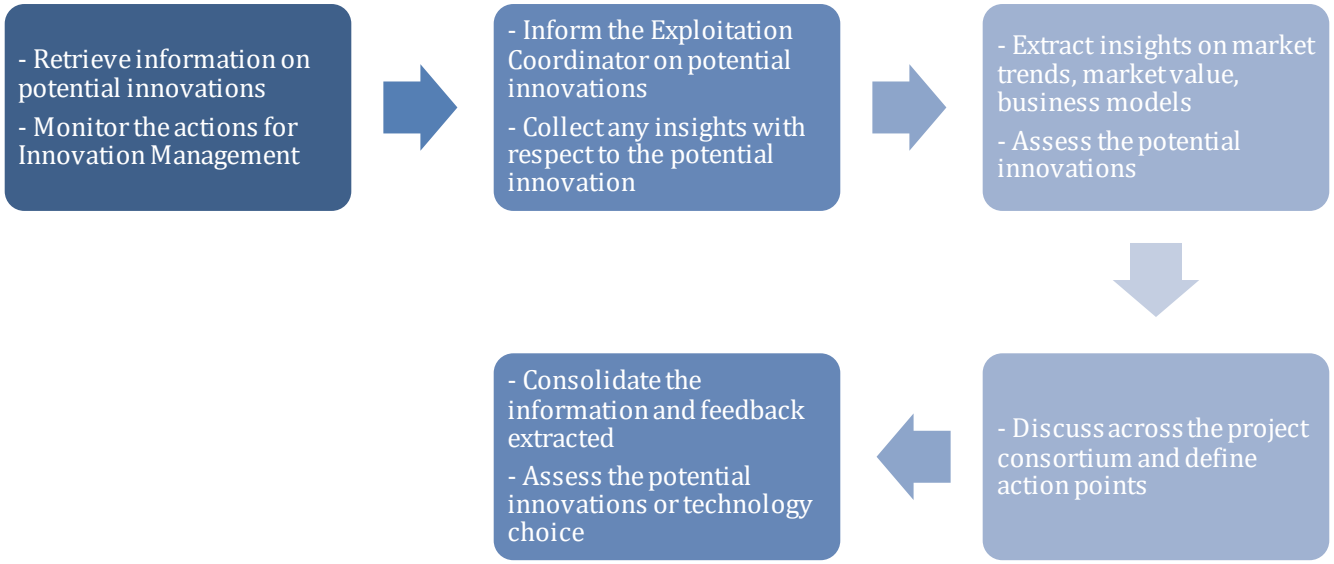

Figure 6 – 5 steps process for the innovation

The Innovation Manager closely collaborates with the technical team of the project to investigate the potential of project's innovations and provide advice on project's technology choices based on existing and emerging market trends. In parallel, the Innovation Manager is also collaborating with the exploitation team through the Exploitation Manager. More specifically, the Innovation Manager in collaboration with the Exploitation Manager, derives information related to the innovations or technology choices. Throughout this process, the Innovation Manager assesses the market potential of the project's innovations and technology choices from an early stage such that the changes imposed by the forthcoming market trends can be included in the development lifecycle of the project. Additionally, the outcomes of this process will boost the exploitation potential of the project's innovations as their production will be directly related to the trends of the markets. Figure 7 illustrates how the information exchange between the Exploitation and the Innovation Manager.

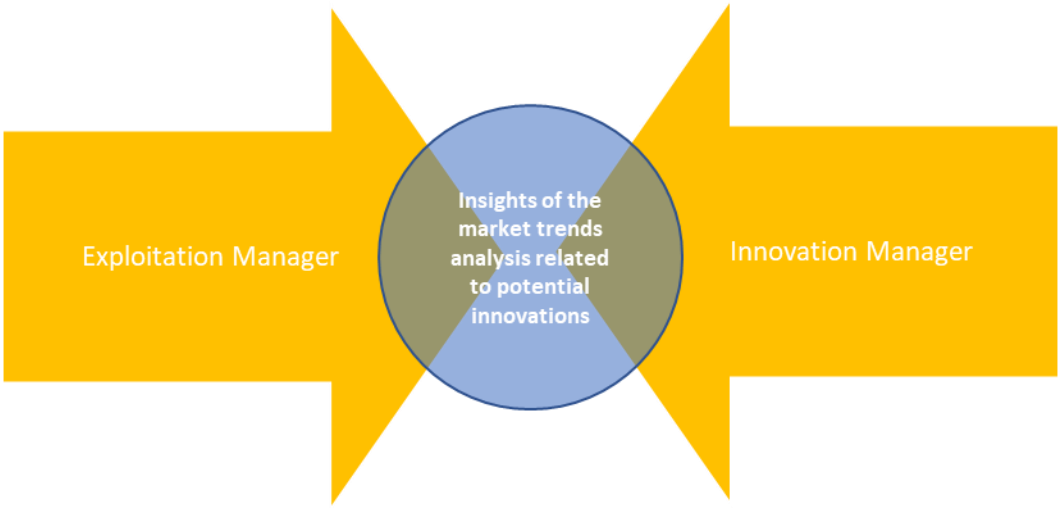

Figure 7 - Process of the exchange information

4.1 Partners' Innovations

The tables below (See Table 2, Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13) provide an analysis of the innovations identified during the reference period of the project. A mature innovation is an Innovation with a TRL over 7. Technology readiness levels (TRLs) are a method for estimating the maturity of technologies during the acquisition phase of a program. TRLs enable consistent and uniform discussions of technical maturity across different types of technology. TRLs are based on a scale from 1 to 9, with 9 being the most mature technology. Additionally, the following table responds in three more key points: a) who will be the customer/ users/ beneficiary of each component b) which benefit will provide each component c) which are the key innovations that create impact.

4.1.1 Cybeletech

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 7: A prototype of the service is tested under real conditions	-The developer of Cybeletech through the coding approach with Node-Red and the deployment methodologies based on Jenkins. -The growers through the improvement achieved in terms of reliability and performance of the decision support system enabled by cloud computing assets such as OpenWhisk.	The decision support system (DSS) for greenhouse management commercialized by Cybeletech will benefit from the components developed in PHYSICS. The expected benefits are the reduction in deployment and maintenance effort and improved scalability. This will in turn benefit to the growers by improving the cost management and	The use of Cybeletech DSS at a large scale, facilitated by the PHYSICS components, will allow to reduce the energy costs of greenhouse production and then lower the environmental impact of this kind of production.

		the performance of the DSS.	

Table 2 - Cybeletech Innovation components

4.1.2 Byte

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 4-5: A prototype of the Service Semantics is operational and integrated within the PHYSICS platform. The component's functionalities have been validated by the project's use cases and other indicative applications/workflows used for testing purposes.	Can be any entity that expects to compare services in a structured format that acts as a common basis among cluster different solutions. This can be either a software or a cloud developer that leverages this component for infrastructure management or application deployment.	Service management platforms, or domain experts will be able to utilise outcomes of this component to ease the infrastructure management process. By providing a common basis for comparison and a structured unified information representation format, application migration and selection of more than one vendor to combine services for the realization of one application will be enabled.	1. An ontology to describe cluster settings in a common holistic basis and therefore efficiently compare them. 2. A service that automatically gathers information collection from Kubernetes based clusters to semantically transform it.

Table 3 - Byte Innovation components

4.1.3 DFKI

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 4: Technology is validated in lab. The lab is a sophisticated experimental platform for industrial manufacturing lines.	Manufacturing businesses building up new manufacturing lines or improving manufacturing lines. The evaluation by the DFKI helps to improve the quality and leads to a user centric development of the PYHSICS components. In the long term these PHYSICS components will be more suited for the	The DFKI is a research institute. Therefore, there will be no direct commercial profit. The DFKI will use the gathered knowledge in the long term to create future knowledge and consulting improvements.	Smart manufacturing related functions and needs are identified and provided as examples and a starting point to drive manufacturing in the future FaaS market space

	manufacturing businesses (e.g., how to utilize manufacturing machine data and processes using FaaS instead of classic approaches)		

Table 4 - DFKI Innovation components

4.1.4 Fujitsu Services GmbH

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
N/A	The customers of our developed methodology are non-industry specific. Mainly Business process owners will benefit from guided advisory to align technical perspectives with business process owner perspectives in order to implement new technologies in the enterprise and to measure performance.	Fujitsu will complement its technology expertise with additional consulting services to position technology in a second step. A business model for the methodology consulting has been designed and first offers to customers have been made.	Service which can be provided to customers to help them in defining their use cases in a high technology environment and give guidance in defining and measuring performance.
TRL of 6-7: The Software Pattern to be released will achieve a TRL of 6-7	The Customer of our software development is the production planning of enterprises in the manufacturing and automotive sector that will benefit from a job shop scheduling as a service to optimize machine utilization. The customers of our developed methodology are non-industry specific.	Easier access to simulated annealing optimization in all areas where large scale combinatorial optimization can bring a benefit (e.g., Optimizing warehouse picking or traffic in cities). Fujitsu will use the PHYSICS marketplace for demonstrations in transferable business cases at customers.	The simulated annealing pattern enriched the Faas-Market with Job Shop Scheduling pattern that focuses on the business logic of the customer.

Table 5 - Fujitsu Services GmbH Innovation components

4.1.5 GFT

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL: 5	The beneficiary of the workflow designer are mainly the developers, with which will	The benefit of the innovation is the efficiency in the workflow design, improved	Workflow designer should enable not technical staff to design workflows. Business organizations will be able to develop

	improve the efficiency in workflow design as they will have many reusable patterns that can be used through drag and drop on the workflow and joining them with the available connectors. Only few annotations will be needed to customize the nodes and complete the workflow. Also, companies adopting the workflow designer will take a big advantage in relation to the improved time to market. It also facilitates the migration to a serverless execution model	time to market due to reusable patterns and no need to code development, together with abstracted workflow creation, build and deployment, faster testing	workflows in a very short time meeting increasingly demanding market requirements

Table 6 - GFT Innovation components

4.1.6 Innov-Acts

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
N/A	(Component: Reusable Artefacts Marketplace (RAMP) 1) Large IT enterprises, consulting firms and SMEs integrating artefacts. 2) Universities and research initiatives using or enhancing artefacts. 3) Developers, researchers, and students contributing artefacts at the RAMP.	1) Enterprises delivering consulting services could provide clear, tangible solutions for the processes of their clients in the form of specific artefacts and integrate these artefacts in existing use cases. SMEs can benefit through the commercialization of proprietary features on the RAMP, and additional consulting and training services. 2) Universities and research initiatives can use the RAMP to improve existing products, or to integrate the outcomes in different programs. 3) Other stakeholders could see in this platform the opportunity to increase their knowledge, know-how, and integration capacities.	-
TRL 4-5: A prototype of the Reasoning framework is	(Component: Reasoning Framework)	IaaS/FaaS providers could exploit RF to enhance their services with semantic	RF incorporates the following key innovations:

operational and integrated within the PHYSICS platform. The component's functionalities have been validated by the project's use cases and other indicative applications/workflows used for testing purposes.	The FaaS platform leverages RF to (i) optimise and automate the deployment of a given application in multi/hybrid cloud resources; (ii) store application and resource metadata; (iii) retrieve structured information (i.e., image location, user-defined annotation, performance evaluation scores, etc.) of the registered applications and resources in a service-oriented manner. The user of the FaaS platform leverages RF indirectly when annotating the application's functions at design time. These annotations are processed by the RF that guides the final placement of each function.	reasoning functionalities. In addition, enterprises that deploy their applications in multiple resources (e.g., cloud, private servers, edge devices) can reduce their computational cost without compromising performance and easily manage them by integrating RF. INNOV plans to provide RF as open-source software (OSS) that allows robust community-driven support for further development and enhancement. However, technologies developed in the scope of RF may be used or integrated into other commercial services offered by INNOV, including training and consulting services.	1) Multi-cloud and edge semantic modelling allowing for interoperability between different resources. 2) New service that enables reasoning both on serverless and legacy applications in order to assist proper and fast deployment on the available federated resources. These innovations create substantial impact in the cloud domain by addressing the challenge known as "vendor-lock-in".

Table 7 - Innov-Acts Innovation components

4.1.7 InQBit

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 7: system prototype demonstration in operational environment	InQBit aims to exploit the technology and the knowhow, which will be acquired and developed within this project, to the international market and specifically to the US market, through the company's strong business and distribution channels with US companies. Moreover, FaaS professionals can potentially benefit from cybersecurity training provided by InQBit on this field.	The innovation will assist InQBit to broaden its scope and extend the range of services offered, significantly contributing to the maturity of the company and assisting in its financial growth.	Innovative way to design cloud environments and pass cybersecurity knowledge to professionals.

Table 8 - InQBit Innovation components

4.1.8 Innovation Sprint

TRL	Who is the Customer/User/Beneficiary ?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 7: A prototype of the services is tested under real conditions	The user of the deployed services is the healthcare professional, who receives the results of the inference and the phenotyping of their patients in a dashboard provided by Healthentia, the eClinical platform of Innovation Sprint.	The ML services Healthentia are deployed today in the traditional way, where Innovation Sprint needs to manage the resources, making them available all the time, even when used sporadically, and making sure they can scale in times the requests scale. The PHYSICS way of deploying the services facilitates hosting costs reductions and scalability boosts. Hence PHYSICS will improve the way we offer Healthentia to healthcare organizations.	The eHealth pilot enriches the FaaS market/user base with patient-centric ML services.

Table 9 - Innovation Sprint Innovation components

4.1.9 Red Hat

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 7 and greater: After code is merge upstream it is ready to be consumed by anyone and be tested in operational environments.	The extensions to the infrastructure are done for the upper layer PHYSICS components. However, as this is done following the Kubernetes best practices,its API and functionality should be available for any other component running on top of Kubernetes.	The extensions made to the infrastructure will be available in Red Hat portfolio offering after being merged upstream. The work done in PHYSICS helps to extend the infrastructure capabilities to support new use cases, as well as further testing those infrastructure components in different scenarios	Better support for FaaS on top of Kubernetes multicluster environments, with extra scaling capabilities and abstraction capabilities.

Table 10 - Red Hat Innovation components

4.1.10 Ryax

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
Global Continuum Placement component target **TRL at the end of the project 6.** Local Cluster Scheduler component target TRL **at the end of the project 7.**	PHYSICS platform along with the particular scheduling components are designed to be transparent in the different applications to be executed and agnostic to the different domains that they can apply. However, the main customer/user of the scheduling components that we develop are the Data Engineers, the DevOps Engineers or the Cloud Infra administrators because they will mainly observe the improvements in performance, energy, and cost of the applications' execution upon the Edge-Cloud continuum. In particular: Global Continuum Placement and Local Cluster Scheduler help the Cloud Infra Administrator improve the performance of its applications execution while minimising the costs of the infrastructure and the energy consumption needed for the execution	The value of the particular software is related to the fact they can reduce the costs of Cloud infrastructure along with the energy consumption while improving the efficiency and performance of applications' execution. Optimal selection of resources and efficient scheduling based on multi-objective optimizations are complex software components which can provide important benefits to end-users. Hence, the initial simple scheduling algorithms may be free, but the more advanced versions can have particular fees based on their usage. This will be the case when they will be used in the context of RYAX low-code automation platform.	Global Continuum Placement component target **TRL at the end of project 6.** Local Cluster Scheduler component target TRL **at the end of project 7.**

Table 11 - Ryax Innovation components

4.1.11 ATOS

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
A TRL between 6 and 7 is expected at the end of the project	Components are useful for FaaS providers who own their own infrastructure so they can operate the proper deployment and execution of functions. Additionally, OS projects such as OCM can benefit of	Main innovation is the extension of functionalities from existing tools, such as OCM, Submariner or OpenWhisk, that allows them function orchestration and	ATOS' work translates results from non-Kubernetes projects into a Kubernetes-native standard. This represents a high market impact taking into consideration that Kubernetes is the most commonly used de-facto standard nowadays.

	the extensions developed within PHYSICS for extending their functionalities.	adaptation based on QoS metrics. All these components will be released as open source and can be offered as a service as part of the overall PHYSICS platform business model.	

Table 12 - Atos Innovation components

4.1.12 HPE

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
To be defined in the final stage of the project, after a careful evaluation of the final maturity of the developed artefacts.	As stated before, where the knowledge gained in PHYSICS will be appropriately fed into the best-suited services to gain a strategic advantage over the competitors in the Edge to Cloud market, and consequently the customers of such business unit which span in different market sectors (Telecoms – Public Sector – Finance – Manufacturing - Energy – etc.)	The main beneficiary of HPE outcomes will be the Pointnext Advisory & Professional Services business unit portfolio, and the revenue generating services delivered to the b.u. customers.	

Table 13 - HPE Innovation components

4.1.13 Harokopio University of Athens (HUA)

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 5	FaaS platform providers can utilize the artefacts in order to generate load and monitor/evaluate the condition of the cluster, its configuration etc. FaaS platform provider/services can use the monitor in order to dynamically configure the cluster parameters during runtime (e.g., scale up/down) Function developers for evaluating the	In the serverless domain, given that cost estimations are more difficult in the case of FaaS, accurate performance predictions of function runtime can be critical for a user to understand how they will be billed following a migration to the FaaS paradigm.	• Multiple performance metrics including system, network, and function related ones • Easy application of the load generation through a pluggable function load generator • Investigation and understanding of the complex manner FaaS systems operate, schedule, and adapt to varying demand patterns

	runtime performance of the function, the associated costs and potential performance changes between different versions/implementations of a function	From a provider point of view, the evaluation of different strategies with relation to resource management, scheduling etc. may need constant and easy evaluation of the applied techniques.	
TRL 5	Faster application development, incorporation of ready-made patterns, adaptation to the deployment specification of FaaS, easier application composition through visual workflows for application/function developers	Faster development times, lower testing times, more complex application workflows with less development time, lower learning curve for FaaS migration	• Implemented parametric patterns that can be used in arbitrary workflows to extend their functionality

Table 14 – HUA - Innovation components

4.1.14 Universidad Politecnica de Madrid

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL will be 3-4 The two components developed by UPM are research prototypes	Potential users are any company providing services with a FaaS platform and the applications that use the platform (any type of application/user). The DMS avoids one of the limitations of FaaS platforms that can only communicate through parameters (limited in size) or accessing slow storage (making functions execution time longer). The DMS overcomes this limitation by providing shared in memory state. The co-allocation component maybe useful for customers operating a FaaS platform and their users in order to improve the performance of the applications run in a Kubernetes cluster.	The DMS will facilitate efficient data sharing across functions in the FaaS model. Nowadays all similar solutions are research prototypes. The main goal of UPM as a research institution is to do research that can be transferred to the industry in the form of patents, prototypes, and know-how.	The DMS has the potential of increasing the number of applications executed on FaaS platforms. This has the benefit of easing the development of applications that are fully managed by the FaaS platform simplifying the application developers work.

Table 15 - UMP - Innovation components

During the reporting period, information on innovations was retrieved and accessed in close cooperation with all the involved project partners. These activities resulted in the formulation of the project Innovation Profile. The 16 identified innovations have good potential. As for the time being, 4 of them can be characterized as mature innovations as the TRL level is 7.

Innovations of Fujitsu Services GmbH, RYAX and ATOS by the end of the project will achieve the maturity level of 7.

All of the aforementioned innovation components are in good synchronization with the exploitation stage of the project.

5. EXPLOITATION PATHS

From the beginning of the project, an analysis on the FaaS market in terms of size, growth, profitability, cost structures, trends and critical success factors identifying gaps and potential for impact was performed. This serves as a basis for the development of the exploitation phase. To keep the exploitation activities on track, annual Exploitable result workshops have been organized for PHYSICS project, the first one took place on the 29/09/21, and the second, which also covered aspects concerning standardization and open access, as well as a cooperative session about the Handbook development, was held on the 30/09/2022. The main objective of these session was to discuss as a group what results we are envisaging to reach by the end of the project and how they interact with each other's.

5.1 Outline of the exploitable results

During the Exploitation workshops mentioned above, it was confirmed that PHYSICS aims to exploit its outcomes through different strategies. These strategies are built around the following exploitable results:

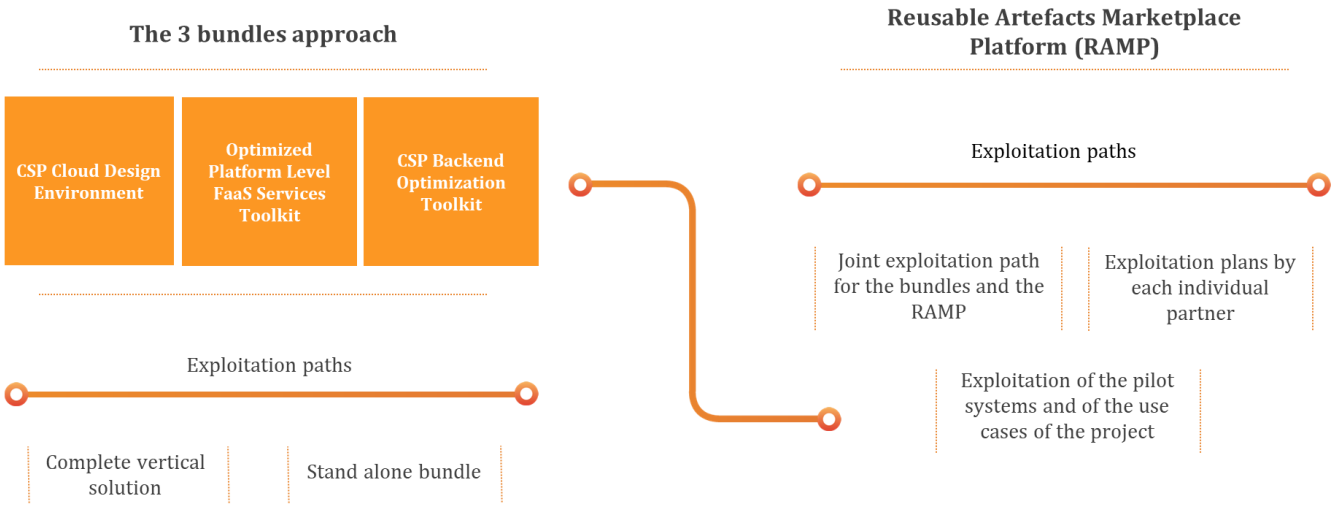

Figure 8 - PHYSICS exploitable results

A) the Cloud Solution Provider - CSP - Cloud Design Environment,

B) the Optimized Platform Level FaaS Services Toolkit and

C) the Cloud Solution Provider - CSP - Backend Optimization Toolkit.

Those three standalone bundles are part of the so called "**3 bundles approach**" which is composed of the aforementioned components as possible vertical solutions completely independent from one another. In addition to this, we have the Reusable Artefacts Marketplace Platform (**RAMP**), which can be used as a reference to create joint exploitation paths in conjunction with the 3 bundles approach.

The 3 bundles approach

As stated earlier, the 3 bundles approach consists of the following assets: CSP Cloud Design Environment, CSP Optimized Platform Level FaaS Services Toolkit and CSP Backend Optimization Toolkit. These tools' main objective is to support providers in offering optimized services.

A - CSP Cloud Design Environment

The Cloud Design Environment encompasses primarily outcomes of WP3 and targets:

- Application developers that need to develop and deploy a FaaS based application in their internal premises
- CSPs that already have a public cloud environment, even at the platform layer, but do not have sophisticated workflow definition and management services
- The migration process from a typical current application to the Function as a Service approach, including optimization patterns that may enhance a number of aspects for a FaaS based execution

This tool details the front-end facing FaaS design to be displayed by the CSPs (Cloud Services Providers) to the CSDs (Cloud Services Developers) their customers - mainly developers and owners - through which the latter can directly adapt to the FaaS model. It mainly defines the incorporation process and application graph of the implementation of permitting cloud design patterns to be exploited by the application components. This cloud design environment will facilitate the direct implementation in the FaaS paradigm by enabling the reuse of function flows templates and visual programming tools. Thus, enforcing an "assembly line" type of service creation incorporated using the CSP Optimized Platform Level FaaS Services Toolkit.

B - Optimized Platform Level FaaS Services Toolkit

The Optimized Platform Level FaaS Services Toolkit includes outcomes of WP4 and targets mainly:

- CSPs that need to extend their offerings from simple IaaS to more advanced platform services and specifically FaaS
- The deployment and runtime management phase of the platform level offering, enabling the creation of multiple separate but collaborating virtual clusters, the dynamic adaptation of the platform as well as meeting the application constraints and requirements

This tool will enable the CSPs to undertake new platform roles as well as revealing the means to implement these roles. Such as the spawning and orchestration of services through an automated process, and the implementation of interconnected and federated infrastructures.

C - CSP Backend Optimization Toolkit

The Backend Optimization Toolkit that includes developments in WP5 targets primarily

- CSPs that have an IaaS service that they need to extend with Kubernetes as well as enrich it with specific functionalities and management approaches for FaaS support (e.g., specialized scheduling strategies)
- The overall K8S[11] and OpenShift[12] community, to which the contributions from PHYSICS will be used to enrich the aforementioned projects
- The existence of operators that may be used either together or independently from the overall framework.

This tool improves the backend management - management of infrastructure resources to be used by CSP - by enabling new performance monitoring and adaptation techniques, providing a superior adaptation to user demands.

The PHYSICS solution may be offered as one complete vertical solution for a CSP to upscale their functionalities in the FaaS offerings domain. However, usage of an individual bundle is also foreseen and will be aided through complete specifications as to how one entity can utilize for example only the Design environment and adapt it to their existing platform offering, through replacing designated mechanisms (e.g., platform specification adapters etc.). Specific considerations have been applied in the architecture of the technical WPs, so that adaptations can be performed in a pluggable manner (e.g., the meta-specification of Node-RED used in WP3 can be extended to be translated through relevant adaptations into different target platforms). This is also a very interesting area for post-project exploitation, in terms of undertaking such extension support towards potential interested entities.

Further services can be developed for each bundle, for example coaching and training/support activities for the migration of a given application to the FaaS model, aided through the Cloud Design environment, custom patterns and flows needed for a given application, as well as custom scheduling strategies or performance model creation adaptations and optimizations.

Reusable Artefacts Marketplace Platform (RAMP)

The RAMP is created with the purpose of including the specific cross-layer individual artefacts of the project. It incorporates reusable solutions across the various fields of PHYSICS, such as cloud patterns implementations, controller/optimizer algorithms, management schedulers, and more. This way it will create additional exploitation opportunities for various stakeholders in the European ecosystem (application owners, cloud providers, external developers, etc.) to access the reusable resources but also to become active contributors of such artefacts.

The main aim of the RAMP is bringing contributors and buyers from the cloud computing environment around one central artefacts marketplace, in order to include standalone cross-platform artefacts and assets. Considering this project, various stakeholders among large enterprises, small and medium enterprises, and research partners, show great interest and show promise of a maturation path for the RAMP. Because of the large number of artefacts that we expect to make available, and the knowledge of the platform acquired during its development, companies delivering consulting services could provide clear, tangible solutions for the processes of their clients in the form of specific artefacts and integrate these artefacts in larger macro strategies.

The main characteristics of the Reusable Artefacts Marketplace Platform are the following:

- Providing one central place to bring together all actors of the cloud computing environment
- Commonly defined interfaces between similar types of elements, so that different controlling flavors can be included in a plug-and-play manner and with no functional difference in an operational flow
- Easy incorporation through packaging them in the target code/application design framework.
- Easy reference of external sources that needs to be included in the code/description segment.
- Means of evaluation and feedback, as well as rating of the respective element, in order to enable community feedback, indicate element usability and reliability, features that are needed also from the business aspect of the ecosystem such as developer compensation for marketplace participation.

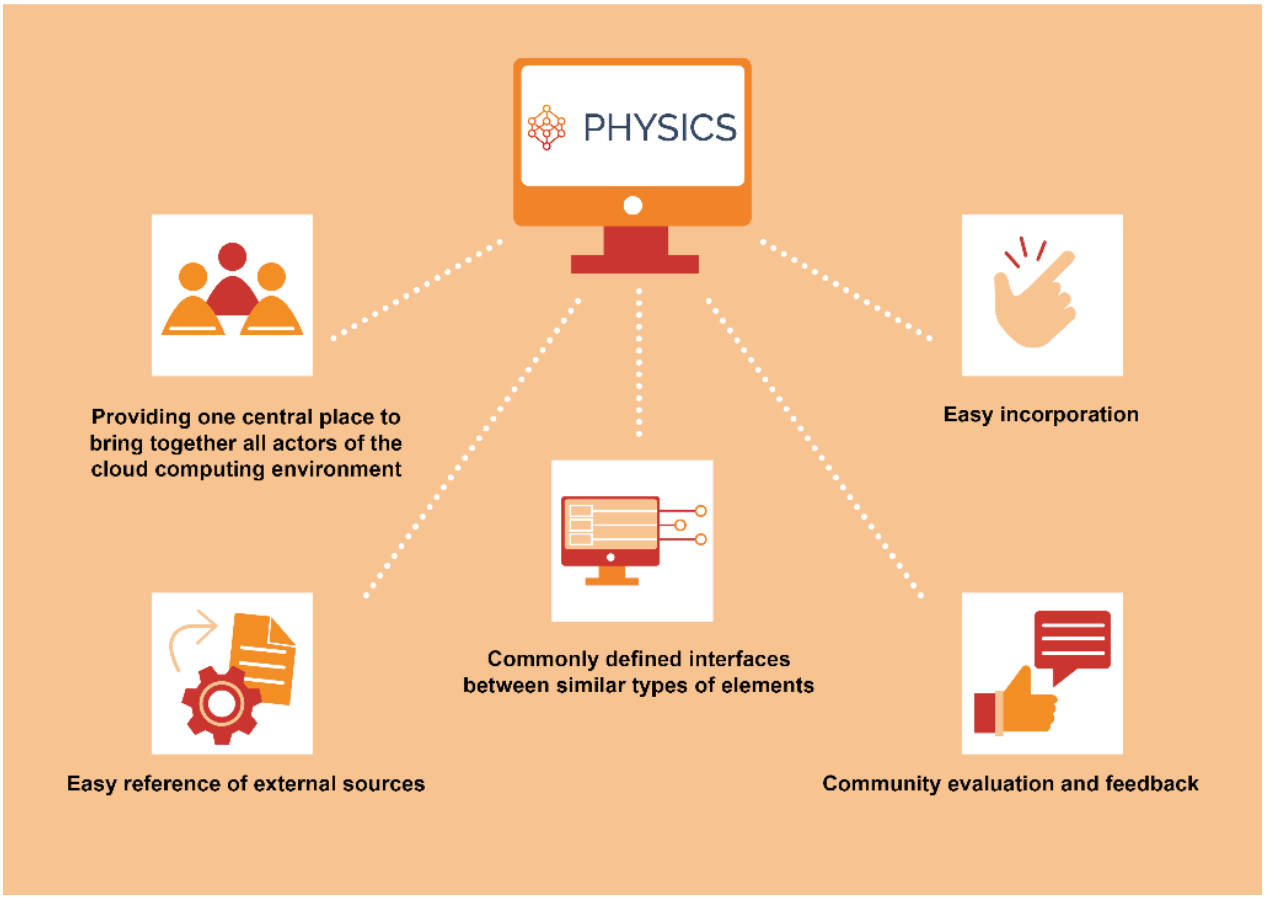

Figure 9 - RAMP aims

From April 2022, the public website for contributing to the marketplace is up and running and can be found here. Each added artefact is defined by Name, Category, Release Date, field of use, type of License, keywords, Owner, and any useful link to help/support/show the artefact.

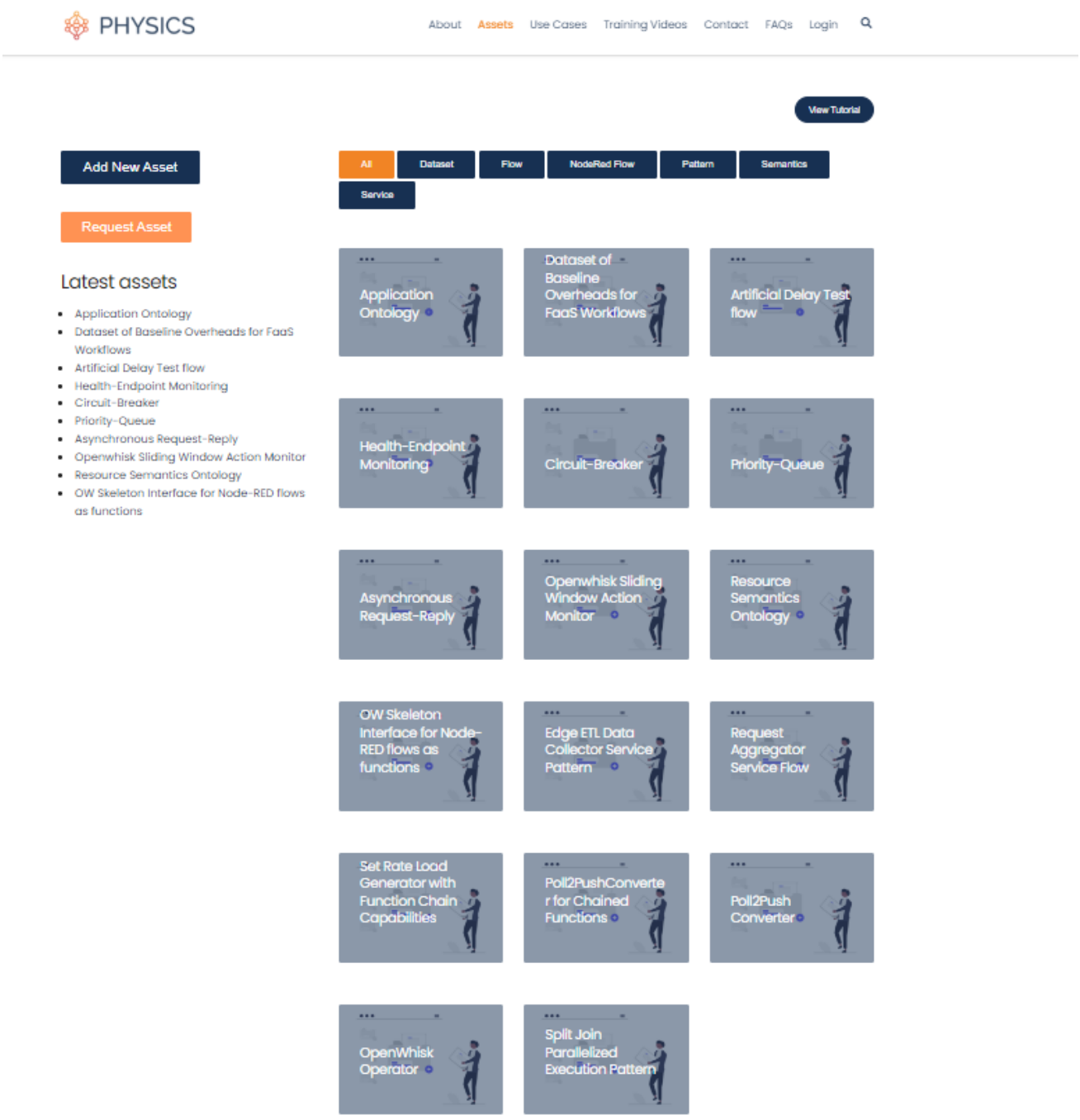

Figure 10 - RAMP asset catalogue

As of December 2022, there are currently 19 assets published on the Marketplace, 6 of which from external contributors, 30 users, 8 of which are external and 3 use cases. RAMP does not require registering for viewing or downloading the assets. To ease the use of the platform, 6 training videos (https://marketplace.physics-faas.eu/training) have also been created and uploaded.

5.2 Commercialization Strategy

Figure 11 - PHYSICS business targets

Below the exploitation paths for the exploitable results previously identified have been drafted.

5.2.1 Reusable Artefacts Marketplace Platform (RAMP)

Alongside the three bundles approach usable as a vertical solution or as standalone bundles, the PHYSICS project aims at developing the Reusable Artefacts Marketplace Platform in order to include standalone cross-platform artefacts. Considering this project, various stakeholders among large enterprises, small and medium enterprises, and research partners, show great interest and show promise of an exploitation path for the RAMP. Furthermore, similar or converging strategic interests appear between the commercial stakeholders of the PHYSICS project. One of these strategic interests regards consulting services. Indeed, large companies such as Atos, GFT, HPE or Fujitsu for instance, show interest in the consulting and training services associated with the marketplace. In fact, synergies can exist between the RAMP and the services provided by some of the commercial partners. Because of the large number of artefacts available on the RAMP and the knowledge of the platform acquired during its development, companies delivering consulting services can provide clear, tangible solutions for the processes of their clients in the form of specific artefacts and integrate these artefacts in larger macro strategies. Even smaller companies such as RYAX see an exploitation approach through the commercialization of proprietary features potentially on the RAMP, and additional consulting and training services. Other stakeholders of the PHYSICS project, and more specifically of the RAMP, see in this platform the opportunity to increase their knowledge, know-how, and integration capacities. Companies and/or research partners such as BYTE, Innov or HUA intend on using the outcomes of the PHYSICS project and the RAMP to improve existing products, or to integrate the outcomes in different programs.

The main characteristics of the Reusable Artefacts Marketplace Platform are the following:

- Smallest granularity
- Exchange of used artefacts, customizable solutions possible (=combining variations of open source and/or fee-based artefacts)
- RAMP can be used to connect suppliers and buyers by centralizing all available artefacts.
    - Providing one central place to bring together all actors of the cloud computing environment
- RAMP can follow 2 paths:
    - Non-profit
    - For profit

- Monetizing opportunities include:
  - Platform-related transaction fees
  - Creation of customizable bundles of artefacts

Exploitation path:

a) Creation of an exploitation agreement and a legal entity for the RAMP platform project.
   i) All parties (contributors/providers and the operator of the marketplace) enter into an agreement on the supply of used artefacts, the distribution of artefacts, and all the parameters pertaining to a potential commercial agreement.
   ii) Agreement over non-profit or commercial nature of the platform among other decisions to be taken.
   iii) Responsibilities of each party are clearly defined (governance, rules, obligations, rights)
   iv) Open-source actors are included in the process, their contribution and role are adapted to their particular nature.

b) Definition of the platform' content.
   i) Stakeholders of the project agree on the nature of the services the platform will offer.

c) Definition of a clear business model and business plan for the platform.
   i) Identification of all potential stakeholders, and decision on the acquisition model of platform users, both supply and demand side.

d) Definition of the monetization strategy to be adopted for the platform.
   i) Depending on the agreement previously established.

e) Development of the platform and its content
   i) The platform is created, each used artefact is categorized and described according to its nature, function, usage, price, interoperability and so on.
   ii) A significant number of various artefacts are added to the platform to ensure an adoption of the platform by various players in the cloud computing ecosystem.
   iii) Developers and actors can be incentivized to fill the platform to ensure commitment along the development of the platform.

f) Development of a customer service application within the platform to accompany clients through their acquisition processes, and developers through their contribution processes.
   i) Customer service and more generally, a platform help desk, can guarantee the good functioning of the platform and the positive experience of contributors, whether they are on the supply or demand side of the RAMP.

g) Launch of a heavy marketing and business development campaign to explain the benefits of the platform.
   i) The marketing campaign can enhance the platform's visibility in the cloud computing ecosystem. It can also bring many users to the platform.
   ii) Business development is necessary to convince and stimulate external contributions to the platform, and to create a holistic RAMP experience.
   iii) The proactivity of the stakeholders in these matters is crucial to spread the platform's professional credibility across all actors of the cloud computing ecosystem.

h) Monitoring of the performances of the platform after its launch and test launch.
   i) Collection of feedback from demand and supply side to understand the different pain points of RAMP

ii) This monitoring can result in turn in strategic discussions among the platform operator and other invested stakeholders on the next strategic turn that the platform should take, or on new iterations to be brought to the RAMP project

5.2.2 CSP Cloud Design Environment

The Cloud Design Environment is the most macro level bundle in terms of its application and its intent. Its aim is to create an environment which facilitates the direct implementation in the FaaS paradigm by enabling the reuse of function flows, templates, and visual programming tools. This environment is programmed to offer intuitive visual flow programming tools, and generalized cloud design patterns. In addition, it will allow for abstractions to facilitate the work of application developers who will adopt this environment from partner cloud service providers. With this in mind, a couple of PHYSICS stakeholders will strongly benefit from this standalone bundle because of the almost ready-made solution provided and its future similarity with other stakeholders of the PHYSICS project who will make fewer modifications. This project and more specifically this bundle, offers an opportunity to standardize cloud design environments at least at the European level, and to provide a different way for application designers. Companies such as Byte for instance, can use the outcomes of the PHYSICS project on this bundle to develop a minimum viable product for their clients with new FaaS functionalities. Similarly, a company like InQBit, whose portfolio directly includes software design, can use these outcomes of the project to sustain competitiveness and evolve. The exploitation of this standalone bundle offers an opportunity for the stakeholders of the project to develop their cloud design environments in order to standardize them up to a certain level (in terms of FaaS inclusions) and to strongly increase interoperability among different cloud service providers, open-source developers, and more broadly, other actors of the cloud computing environment.

The main characteristics of the CSP Cloud Design Environment are listed below:

- Adaptable to individual CSPs
- Top-level application environment
- Front-end facing FaaS design and Cloud Pattern environment
- Definition of application graph,
- Incorporation of implementations and abstractions
- Enabling cloud design patterns

Exploitation path:

a) Agreement drawn between the different stakeholders of the PHYSICS project
   i) Stakeholders determine before starting the design of the first bundle, what they want to make out of this top-level application environment. This includes the attribution of responsibilities for different characteristics of the end product.
b) Definition of the content of the new cloud design environment.
   i) Typically, this new environment should be designed to include the strengths and weaknesses of all CSPs participating in the project.
c) Elaboration of an individual business model for this bundle in case it should be used separately from bundles 2 (CSP Optimized Platform Level FaaS Services Toolkit) and 3 (CSP Back-end Optimization Toolkit) as well as separately from the RAMP.
d) Design of the common environment under the PHYSICS project.
   i) PHYSICS' stakeholders create a common environment for CSPs including reused abstracted programming flows.
   ii) This environment comprises various designs, ready-made functions, and common patterns among other things.

iii) Function as a Service approach is integrated in this new environment.
iv) Ready-made functions and patterns are integrated in a specific repository which will be available with the new front-end environment.
v) This new environment will be designed and created with a user-centric approach, in order to make it easy to adopt for developers with different skills.
vi) The repositories and libraries of this new environment are the abstractions that hide complex processes, and which contribute to the fast and easy adoption of the new environment.
vii) The new cloud design and its reusable flows also abstracts GDPR-compliant processes such as data portability and security. This characteristic of the first bundle can encourage the adoption across the European cloud computing environment

e) Definition of additional services and customer services that can be added to the bundle
f) Development of marketing and business development activities around the cloud design environment

5.2.3 CSP Optimized Platform Level FaaS Services Toolkit

This standalone bundle is made of platform-level functionalities that can be integrated by providers based on the Function as a Service model to optimize their placement across the cloud computing domain. As mentioned in this report, these functionalities can enable cloud service providers to undertake new platform roles such as the spawning and orchestration of services through an automated process. Following this brief summary of this standalone bundle's application, we identify various commercial and non-commercial stakeholders whose exploitation plan consists of a (partial) exploitation plan for this optimized platform level FaaS services toolkit. Among these stakeholders, large companies such as Atos, Redhat, HPE as well as smaller companies like Ryax show potential exploitation plans for this single bundle. Indeed, these companies' exploitation plans are among the topics of orchestration, and more specifically along the topics of cloud, edge and hybrid cloud orchestration. The similar exploitation path for these companies is to leverage the tools developed with the PHYSICS project for their different commercial activities performed. Smaller companies such as Ryax Technologies for instance, intend to enhance its capacities in contrast to larger players. With the development of this standalone bundle, the company intends to validate its middleware by using the outcomes of the project, mainly with orchestration enhancements or large-scale datasets in various high-performance computing testbeds.

The main characteristics of the CSP Optimized Platform Level FaaS Services Toolkit are listed below:

- Adaptable to individual CSPs
- Mid-level platform support, deployment, and federated execution layer
- Platform-level, Global continuum FaaS operational framework
- Enable new platform roles for European CSPs with appropriate tools
- Includes spawning and orchestration of services across providers offerings

Exploitation path:

a) Agreement between stakeholders involved is in the continuation of the agreement orchestrated around the first bundle
    i) Responsibilities are attributed to different parties, risks are identified and spread among the parties involved and so on.
b) Definition of the optimized platform-level FaaS Services toolkit, and its content and function

i) This process must take into account the work previously executed for the first bundle (CSP Cloud Design Environment)

c) As for the first bundle, parties involved can prepare an alternative business plan, should this business plan be commercialized or at least used independently from the other bundles

d) Design of the CSP Optimized Platform-Level FaaS Services Toolkit
   i) This platform-level toolkit can allow cloud service providers of the PHYSICS project to bring new roles to their platforms.
   ii) Tools of the toolkit will help with the implementation of the new platform roles.
   iii) New roles and tools can include for instance spawning and orchestration of services across provider offerings.
   iv) This platform-level toolkit can transform application workflows to functional sequences in the FaaS model.
   v) This platform support also includes services and functionalities to enable component semantics, services benchmarking and evaluation, adaptation of application specifications to the necessary deployment language as well as deployment optimization and definition, spanning across different and diverse providers and services.

e) Definition of additional services and customer services that can be added to the bundle

f) Development of marketing and business development activities around the FaaS service platform-level toolkit

5.2.4 CSP Back-end Optimization Toolkit

Finally, this standalone bundle, as previously mentioned in this report, is a toolkit for providers to offer competitive and optimized services, and to improve the backend management of resources. This improved management of resources is performed by enabling new performance monitoring and adaptation techniques, which in turn, helps provide a superior adaptation to user demands. On this specific standalone bundle, larger companies will tend to show more interest as they are more likely to be involved in the strict infrastructure level. Nonetheless, it does not preclude smaller stakeholders of the consortium formed around the PHYSICS project to leverage the outcomes of the development of this back-end optimization toolkit bundle. In the larger companies contributing to the project, Atos and HPE among others stand to develop an exploitation plan tailored to this individual bundle. In fact, Atos already has activities in infrastructure resource management, which is why Atos Canopy, Atos' orchestrated hybrid cloud, is targeted as a recipient for the research conducted under the PHYSICS project. Hewlett Packard Enterprise is also poised to leverage, in the techno-economic environment, the benefits of the research conducted under the PHYSICS project.

The main characteristics of the CSP Back-end Optimization Toolkit are listed below:

- Adaptable to individual CSPs
- Bottom level execution layer
- Back-end virtualized resource optimization management techniques
- Enables new performance monitoring and adaptation techniques and interfaces
- → Enable baseline Cloud offerings to better adapt to user demands.

Exploitation path:

a) Agreement between stakeholders involved is in the continuation of the agreement orchestrated around the first bundle and second bundle, as well as with the Reusable Artefact Marketplace Platform
b) Definition of content for this bundle and the functions this back-end toolkit will have
c) Definition of an individual business model and business plan, as well as a monetization plan in case the bundle should be used independently from the other bundles or assets of the project.
d) Design of the CSP Back-end Optimization Toolkit
    i) This bundle can be created with the intent to improve performance monitoring and can include adaptation techniques and interfaces that will enable baseline Cloud offerings.
    ii) These baseline offerings allow for a better adaptation to user demand.
    iii) In fact, the mechanisms developed at this level can be designed to answer specific needs of cloud service providers' clients, and to optimize specifically the provider-local strategies and resource management.
    iv) The baselines designed have the ambition of abstracting differences between resources and to provide a somewhat transposable mechanism.
e) Definition of additional and/or complementary services that could be provided along this bundle for a better customer experience.
f) Definition of marketing and business development strategies for the individual exploitation of this bundle.
g) Set up a monitoring mechanism to record the commercial (or not) performance of the bundle, as well as the satisfaction of the stakeholders, the different pain points encountered and so on. The following paragraph highlights the different individual exploitation paths of each partner in their business and research strategy. The project supports the SMEs in their already existing business strategy and will boost the innovation of the companies, resulting in more competitiveness. All the partners are active in the development of UC and cloud-related services, as CSP and service integrators or as research organization partners, where the RAMP will also play a significant role in the individual exploitation. Further, the application of the results of the project will show the project functionalities and market readiness, thus also serving as a point of reference for the development of the project as a whole. In addition to that, the individual exploitation plans set out the activities that the different actors involved in the project should carry out to successfully exploit the project results, firstly in terms of industrial development of the products or processes and secondly in terms of its placing on the market. The individual exploitation plans have been updated in this second year of the project, after the review meeting and the multipurpose workshop

5.3 Individual Exploitation Plans

Below are highlighted the different ways in which each partner will exploit the PHYSICS results in the afterlife of the project.

5.3.1 GFT

GFT's strategy for service integration combines AI, Cloud, IoT and BigData solutions in various applications. GFT will exploit the project's results in order to expand the scope of the services that it offers. The company will promote PHYSICS solutions and services to its existing accounts, using established sales and marketing channels. Furthermore, it will consider the creation of private cloud instantiations based on the PHYSICS

vertical solution towards promoting it and selling it to private sector customers. Another exploitation direction involves integrating the project's tools within the digital innovation labs of the company. This will allow the expansion of PHYSICS solutions to other market segments in the private and public sectors, including segments beyond the existing clientele of the GFT Group.

The main technical development for GFT is the Visual Cloud Application Workflow Design Environment and Transformation. The beneficiary of the workflow designer are mainly the developers, with which will improve the efficiency in workflow design as they will have many reusable patterns that can be used through drag and drop on the workflow and joining them with the available connectors. Only few annotations will be needed to customize the nodes and complete the workflow. Also, companies adopting the workflow designer will take a big advantage in relation to the improved time to market. It also facilitates the migration to a serverless execution model

5.3.2 ATOS

ATOS is a Cloud and Edge computing provider, with Canopy and infrastructure management services in the Cloud and a defined strategy in Edge computing development. PHYSICS advances and planned outcomes are closely integrated with Atos' entire business strategy, commercial products, and research initiatives. Infrastructure and data management now account for 56 percent of Atos' income. Edge computing is certainly a significant strategic pillar for the corporation, with Atos identifying it as a vital potential in its ADVANCE 2021 strategy plan. Atos is making progress through its hardware business, BDS, with the "Atos Edge Computing Box," which is now available as a prototype. Atos Codex is the Atos brand for providing clients with data analytics solutions. It is a fully integrated, cross-market end-to-end analytics solution that enables enterprises to maximize the value of their data swiftly and cost-effectively by including infrastructure services at both the Cloud and the Edge. Atos Codex delivers end-to-end data analytics throughout the whole IT value chain. Digital transformation strategy and consultancy, use case business modeling, agile analytics implementation, and continuing evolution management are among the services offered. ATOS is developing a set of components for orchestrating the deployment and execution of functions in a FaaS environment. Although the current state of the art of the developments is fully dependent of the whole PHYSICS platform, the baseline technologies and the know-how gained will be further reused to be included as part of the ATOS research assets. These assets are planned to be integrated in a new commercial solution to be integrated within the ATOS portfolio. Components are useful for XaaS providers who own their own infrastructure so they can operate the proper deployment and execution of functions. Additionally, OS projects such as OCM can benefit of the extensions developed within PHYSICS for extending their functionalities.

5.3.3 HPE

In PHYSICS, HPE is one of the technology partners, mainly providing its technical expertise.

As main role, HPE leads the task dealing with the integration of all the PHYSICS services and functional components in a common solution framework, also delivering all the DevOps and Continuous Integration/Continuous Delivery processes put in place to support all the development, testing and integration activities

Moreover, HPE is also a key contributor of the Visual Workflow / Design Environment component design and development, and contribute (so not leading) to the requirements analysis, to the reference architectural design and specification, and provides support to the use cases adaptation & experimentation.

HPE Italy's primary use of PHYSICS achievements and results will not mainly target the production of specific products. Instead, it will look to the Pointnext Advisory & Professional Services business unit portfolio, where the knowledge gained in PHYSICS will be appropriately fed into the best-suited services to

gain a strategic advantage over the competitors in the Edge to Cloud market. HPE will also incorporate novel findings into techno-economic models for scarce resource/infrastructure pools in order to improve its services and strengthen its competitive edge.

5.3.4 REDHAT

Redhat is working from upstream initiatives to productize them to enterprise-level solutions which is the foundation of the REDHAT development approach. The project's exploitable results and contributions to relevant upstream initiatives will be included in RHT's sellable products. Redhat has identified the next upstream projects to which the company wants to contribute to the Physics project: Kubernetes/OpenShift, Submariner, and OpenClusterManagement (Red Hat Advance Cluster Manager). In addition, Redhat has established a new project called uShift (https://github.com/redhat-et/microshift) for low-footprint OpenShift for edge/IoT, which we hope to grow a community around.

Red Hat model is "upstream first", everything they do, they try to do in a way that is submitted upstream to its relevant community repository. Then, after being part of the upstream project, this is later part of the Red Hat portfolio. In PHYSICS project, Red Hat is in charge of enhancing the lower layers of the architecture (infrastructure side), as well as performing integration activities. Red Hat is developing software components and API extensions for the infrastructure layers (kubernetes, submariner, OCM, …), and contributing them to their respective open-source repositories. In addition, Red Hat is leading the efforts on the open-source activities, trying to help other partners to also contribute their components to the relevant communities

5.3.5 FUJITSU

FUJITSU is developing to main technical results, which is planning to further exploit after PHYSICS:

- Fujitsu provides an optimization pattern in Node-Red to the RAMP which uses a simulated Annealing technology. FUJITSU will use the released reusable artefact marketplace platform to promote its simulated annealing service. Moreover, Fujitsu will use a provided job shop scheduling use case to transfer the optimization pattern to different businesses.
- Fujitsu develops a Use Case and KPI Design Frameworks during the Work Package Lead in the "Use Case Adaption, Experimentation and Evaluation" Work Package. FUJITSU will apply the knowledge and methodologies obtained in the project to provide use case modelling and performance measurement consulting services, moderated workshops and build business-relevant solutions in the manufacturing and automotive industries. Moreover, FUJITSU will exploit parts of the smart manufacturing use case as a showcase of its edge device and its ability to be deployed in conjunction with a serverless architecture.

5.3.6 RYAX Technologies

RYAX is mainly responsible to design and implement the 2 levels of scheduling that takes place within PHYSICS platform. The 1st scheduling layer named Global Continuum Placement allows the selection of most adapted cluster to schedule a certain task considering aspects such as performance, energy, etc. The 2nd scheduling layer named Local Scheduler enables the selection of most adapted node in a cluster considering FaaS related optimizations, etc. RYAX will make use of the scheduling components developed in PHYSICS along with possibly other parts as well such as the resource management controllers, the performance evaluation framework, etc. in order to enhance its open-source low-code workflow-based automation platform which is commercialized and enables the customers of RYAX to leverage on Cloud technologies and FaaS runtimes in production. Furthermore, it will enable RYAX to open up its services

towards the edge-cloud continuum and allow users to design and deploy their application seamlessly on the edge-cloud continuum.
Both components that RYAX is developing are open-source software components which are both important components of the software stack of PHYSICS. RYAX has currently implemented its first versions which enable an efficient scheduling already, but further optimizations are currently being developed and will be available for the final solution of PHYSICS. In parallel, since they are independent components, they can be used in similar contexts and in particular they will be used as schedulers in particular contexts of the open-source RYAX low-code workflow-based automation platform.

5.3.7 InQBit

InQBit primarily contributes to the areas of security and privacy, enabling cloud design pattern implementations and abstracted function nodes that implement relevant encryption and privacy preservation mechanisms, as well as modelling of security and privacy concepts. InQBIT will acquire know-how pertaining to cloud design environment and FaaS functionalities, making it possible to exploit this knowledge and methodology in future endeavors aiming at the company's growth.
The participation of InQBit in PHYSICS will facilitate the company to sustain its competitiveness and considerably evolve in the area of secure cloud service design and provision. Moreover, InQ Bit is in the process to develop a new business activity, providing cyber security training services, therefore enhancing cybersecurity in the field of FaaS is a new and promising opportunity for the company.

5.3.8 iSPRINT

Innovation Sprint is creating the eHelath-related services to be deployed as functions using PHYSICS. Innovation Sprint, via its work in PHYSICS, is testing and using the PHYSICS way of deploying services. During this process, it's evaluating the FaaS benefits. As a result, at the end of the project, Innovation Sprint will be able to deploy key ML services in the FaaS way to leverage on the benefits.

5.3.9 INNOV

INNOV-ACTS is responsible for the development of the Reasoning Framework of the PHYSICS platform. Reasoning Framework (RF) is a service responsible to perform semantic matching between FaaS-based applications and resource services. Notably, leveraging custom ontologies, semantic rules, and knowledge graphs, RF filters the available computational clusters (e.g., cloud, edge) to them that m eet the specific requirements of each function/workflow of the given application. This process facilitates the hybrid and multi-cloud deployment of FaaS applications in a timely manner. This component also offers querying endpoints to other platform components to ease and automate an input application's deployment. Through PHYSICS and the acquired know-how on semantics, interoperability, and knowledge mining, INNOV will improve its offerings, making it more attractive, and will reuse the project's outcomes to investigate further models, solutions, services, and methodologies in the cloud domain. In addition, INNOV will exploit the application of the developed Reasoning Framework in existing AI-based solutions to enhance machine and deep learning models with semantics.
Moreover, INNOV-ACTS has developed the architecture behind the RAMP platform, to provide access to the PHYSICS solutions emphasising in patterns that can be reused in FaaS applications. Besides that, RAMP exploits the project results by offering relevant training materials (e.g., videos, webinars) and demonstrating the utilisation of its offerings in real-life use cases. RAMP is available at URL: https://marketplace.physics-faas.eu/
INNOV, as co-owner of the RAMP platform, will extend its network engaging with organisations and SMEs

that either rely or contribute on the development of FaaS-based applications. Moreover, INNOV will benefit through the commercialisation of the artefacts available at the RAMP.

5.3.10 CYBELE

Cybeletech is developing decision support system for greenhouse management. Three use cases are implemented with PHYSICS components: 1) a data collection pipeline deployed on the edge; 2) a simulation pipeline deployed in FaaS; and 3) an optimization pipeline which takes advantage of parallelization capabilities of cloud computing.

The data collection pipeline implementation and associated deployment procedure developed in PHYSICS will be used in the greenhouses of Cybeletech new customers. Moreover, the simulation and optimization pipelines will be deployed and run in the cloud as a service using the PHYSICS components.

5.3.11 HUA

Inside PHYSICS framework, HUA is developing the PHYSICS Design Patterns and Semantics, as an extension palette for the Node-RED environment offering parametric implementation subflows that help addressing recurring problems and functionality needed in the FaaS paradigm and beyond. It is embedded in the PHYSICS Design Environment, but it can also be used as typical Node-RED contributions and flows.

The Semantic nodes category can be used to include annotations around a created graph that can be exploited down the stack at the platform side, in order to apply the function creator directives for function management. HUA is looking to exploit the created patterns in a variety of ways. Initially they have been uploaded to the open-source flows repository of Node-RED. Furthermore, they have been uploaded in the project marketplace. Future exploitation plans include the ability to perform on demand modifications/adaptations to published patterns as well as creation of custom patterns for a fee. Training around the usage of patterns is also a foreseeable exploitation artefact. The design patterns can also be exploited in the context of the Design Environment, as a part of the joint exploitation item, in which HUA can also support user training for flow creation.

Moreover, HUA is also working on The Performance Evaluation Framework, which enables the on demand launching, monitoring and orchestration of performance tests against target platforms of interest, in particular Functions deployed on FaaS. Therefore, it can be used for performance testing of a created function. It includes a number of metrics that are related to performance, such as latency, wait time, initialization time and function duration. Especially the latter is directly associated with billed costs for the function execution, therefore the tool can also be used as a cost estimator. HUA is looking to exploit the created artefact through its use in performance stress testing and consulting services. Furthermore, the created software artefacts (load generator, OW monitor) have been uploaded on open-source repositories (npm for the OW monitor, docker registry for the load generator image), through which they can be easily reused by the community, helping in attracting visibility for the university and its researchers.

5.3.12 DFKI

SmartFactoryKL lab at DFKI employs cutting-edge technologies and incorporates them in its Industry 4.0. The PHYSICS project's solutions will bring new unique functions to the demonstrator, which will subsequently be offered to the lab's 50 partnership partners from academia and industry. The project outcomes will be utilized in future initiatives and potential follow-up projects. The scientific methodologies employed to achieve the objectives can also be used in lectures for bachelor and master students at Kaiserslautern Technical University.

The main technical results for DFKI are the Smart Manufacturing Pilot Line and the Testing of PHYSICS

components via use cases.

5.3.13 BYTE

The component that BYTE is involved in PHYSICS targets information management through semantics. Specifically, the Service Semantics component provides two main functionalities for the platform; Firstly, it combines several methods to compose a service responsible of gathering information from each managed cluster and secondly, it includes the necessary services to transform this raw information into semantics that can be later leveraged by other components to enable optimized application deployment. These semantics are depicted in an ontology for service semantics, designed within the scope of the task to capture domain knowledge into a machine-readable format capable of inference.

The outcomes from the research and development process of the semantic components in PHYSICS will substantially improve current offerings around the cloud-domain and enable the enhancement of a variety of others with semantics. Both gained expertise and software components developed will be aligned with current technologies to improve offered solutions where applicable.

5.3.14 UPM

UPM is developing two software components: a distributed memory service (DMS) for sharing data across functions in the FaaS platform and the co-allocation component, in charge of finding suitable deployments of functions in a Kubernetes cluster. UPM also is developing knowledge in the internals of FaaS platforms and its integration with Kubernetes

UPM will take advantage of the project's results towards enhancing and validating its BigData/AI research outcomes in terms of persisting, processing, and managing very large datasets in the cloud and in-memory. It will exploit PHYSICS to improve the maturity and robustness of its data management services while validating it in the scope of pragmatic applications including distributed data management across cloud/edge environments. UPM will also exploit the project's outputs in order to strengthen its technology transfer activities towards the Spanish industry. UPM will also exploit the outcomes of the project in its educational activities it will integrate outcomes within existing courses, using them to ensure those course curricula are developed in line with the evolution of the state of the art in FaaS and distributed in-memory management. Finally, it will exploit PHYSICS results in the development of professional training courses in support of technology transfer and lifelong learning activities. Till now some of the preliminary results of PHYSICS have been presented in master's degree lectures (FaaS platforms, benefits, drawbacks, data sharing services and their implementation). The performance evaluation of the Distributed memory service and its integration with some of the pilots will be used as a demonstrator for companies UPM collaborates with.

5.4 Joint Exploitation plan

This path ensures the sustainability and uptake of the project's jointly created artefacts and exploitable results. It includes the development of a credible business plan for the sustainability of the bundles and the RAMP, along with the building of a vibrant community of interested and committed stakeholders. All PHYSICS partners worked collaboratively and intensively in community development around this joint exploitation path, building on established partner networks and customer accounts in the cloud, edge, service, and application related markets. For this purpose, hackathons, webinars, and multi-projects events have been organized, reaching out to the relevant communities. The exploitation and long-term viability of PHYSICS will be initially pursued through a non-profit entity established by the project, yet a commercial (for-profit) route will be also planned.

Overview

The 3 Bundles Approach

1) CSP Cloud Design Environment
2) Optimized Platform Level FaaS Services Toolkit
3) CSP Backend Optimization Toolkit

- Exploitation Paths:
  - Complete vertical solution
  - Stand-alone bundle

Therefore, the 3 Bundles Approach will be offered as one complete vertical solution for a CSP to upscale their functionalities in the FaaS offerings domain. Usage of an individual bundle will also be foreseen (hence the separation into bundles) and **aided through complete specifications** as to how one entity can utilize for example only the Design environment and adapt it to their existing platform offering, through replacing designated mechanisms (e.g., platform specification adapters, etc.).

4) The Reusable Marketplace Artefacts Platform (RAMP)

- Exploitation Paths:

a) Joint exploitation path for the bundles and the RAMP
b) The exploitation of the pilot systems and of the use cases of the project
c) Exploitation plans by each individual partner

This way, the impact of the platform is amplified, since in many cases, external audiences may be interested in single artifacts generated.
The RAMP may follow multiple business models, for example combining open-source artefacts with compensation-based ones, offering support for integration and usage, etc.

Services and Products of the Reusable Marketplace Artefacts Platform

1) PHYSICS Bundles Customization and Instantiation Services: Customization of the 3 bundles in -line with the needs of clients.

2) Support services for clients of the bundles: Aiming to enable further uptake of the project bundles.

3) Training and Consulting services: Services offered to solution integrators, service providers, and application developers. They also strive to facilitate stakeholders in accessing, using, and fully leveraging the capabilities of the project

4) Artifact marketplace: Allow the fine-grained exploitation of individual items such as controllers, algorithms, flows, etc.

Joint exploitation path for the bundles and the RAMP

This path will ensure the sustainability and uptake of the project's jointly created artifacts. It includes:

a) Developing a credible business plan for the sustainability of the bundles and the RAMP;

b) Building a vibrant community of interested and committed stakeholders.

i) **CSPs** at various levels (PaaS, IaaS) as the main users and customers of the previously mentioned bundles approach;
ii) **Application Providers** of technologies and tools for the *"FaaSification"* of their applications, which will be able to enhance their current offerings and transform them to the FaaS model;
iii) **External developers and researchers**, who will be incentivized to exploit the individual offerings from the RAMP as well as enable their participation and contribution with further implementations, while also offering a direct monetization path for their contributions through the marketplace.

All PHYSICS partners will work collaboratively and intensively in community development around this joint exploitation path, building on established partner networks and customer accounts in the cloud, edge, service, and application-related markets.

The **exploitation** and **long-term viability** of PHYSICS will be **initially pursued** through a **non-profit entity** established by the project, yet a commercial route (for-profit) route will be also planned.

Prerequisite steps for joint exploitation

In order to promote and raise awareness, there will be an Implementation of a group of extensive pre-marketing activities as part of the project's dissemination plan, which will go on through the whole duration of the project and in its afterlife.

1) Integration of the RAMP with the individual and bundled outputs of the project:

It targets to comprise all the tools, algorithms, containerized solutions, programming flows, and other instruments of the project. The integration into bundles will enable them to offer turnkey solutions to various entities. The packaging and identification of individual artifacts will enable a more fine-grained exploitation of specific outputs of the project.

2) Specification and implementation of governance schemes for **RAMP** users including:

a) The **rules** governing the operation of the RAMP (i.e., rules for **registering** and **participating** in the RAMP);

b) **Rights and obligations** of the various participants (PHYSICS partners or external entities) according to their activities and goals for joining the RAMP;

c) **Pricing schemes** and **business models** for the use of artifacts

3) Enhancing the maturity of the platform

Includes both the technical/technological maturity, but also the maturity of the artifacts to be offered through the platform, including specifications for artifact packaging, documentation, description, etc. per category.

4) Development of an Exploitation Agreement

Partners' contributions (including IPR shares) in the development of the platform, while also regulating partners' rights and obligations related to the joint exploitation process.

5) Ensuring the sustainable enterprise class hosting of the RAMP

The stability and sustainability of the platform is one of the key aspects for bringing the outcome to the cloud-computing market.

6) Creation of a legal entity

The entity will take over the joint exploitation activities following the project's end. Instead of establishing a new legal entity, the partners may also opt to **jointly exploit the RAMP** and its

instantiations based on their **existing legal entities**, following the establishment of the EA and the signature of a **Memorandum of Understanding** (MoU) between the partners.

Business Targets

The joint exploitation plan for the PHYSICS outcomes will aim at the following business targets:

1) Provide FaaS design and platform management services with business relevance and clear ROI (Return on Investment) for potential customers (i.e., CSPs and/or application developers). PHYSICS will take into account market requirements and market analysis findings to offer services that address tangible needs of CSPs, including platform providers and service integrators, as well as their clients such as application owners and developers. This primarily refers to the bundles' exploitation scope.

2) Liaise with key initiatives such as Gaia-X[13], SmartFactory-EU[14] etc., to which PHYSICS partners already have links in order to accelerate the community building efforts of the project. These communities are established ones and include members with expertise and interest in using services like the bundles offered by PHYSICS.

3) Establish a strong relationship with providers of functional programming tools and approaches (including SMEs), notably tools that can be used to expand the platform with additional features and functionalities and artefacts. The project will seek to integrate novel functionalities complementary to the ones it provides, facilitating the uptake and wider use of the RAMP (especially the individual artefact collection).

4) Partner with solution integrators in various EU countries, as a means of creating a network of PHYSICS ambassadors. This network will greatly facilitate the expansion of the PHYSICS use base in terms of geography and potential client attraction.

5) Establish a strong relationship with entities from the UC applications domain (manufacturing, eHealth, agriculture) through the UC partners business networks, since these domains will be able to demonstrate primarily the gain and advanced functionalities achieved through the PHYSICS outcomes at the application domain, further incentivizing and attracting participants from these business networks.

6) Establish a strong relationship with key open source (e.g., node.js, Openshift, Node-RED, OpenWhisk) and topic specific (e.g., AI/ML experts) communities, towards attracting more external developers in order to populate the individual artefacts marketplace. The aforementioned communities are highly active and dynamic and can be a considerable source of external expertise brought in the RAMP.

5.5 Exploitation of the use cases of the Project

The use cases will be used to validate the project's developments (DFKI/FTDS, iSPRINT, CYBEL) and will provide early highlights of the project's functionalities, gradually advancements in terms of maturity and market readiness towards a viable route to market, supported by effective marketing campaigns and practical workshops in live streaming.

Partners involved will take advantage of the main exploitable items of PHYSICS as specified above (3 bundles and RAMP) as the main environment that will support the operation of their use cases.

1) **Industry 4.0 Use case (DFKI)**: At the end of the project, DFKI will have deployed and demonstrated a set of FaaS use cases in its SmartFactoryKL lab[15]. DFKI will exploit the developed demonstrator in two complementary directions: (i) Development of a FaaS lab for industrial use cases and

deployment of PHYSICS technologies in more demonstrators. This direction involves the development of more FaaS demonstrators and their use for dissemination and training of the members of the SmartFactoryKL lab; (ii) Technology Transfer of the demonstrator to the industry, based on its deployment in real production lines. In this direction, DFKI will replicate the demonstrator in production lines of the industrial members/partners of SmartFactoryKL. As a first step, presentations of the Use Case to the industrial partners of DFKI & SmartFactoryKL will be planned. Specifically, presentations to a minimum of five (>=5) partners will be pursued. Accordingly, a deployment plan of the Use Case to the selected production lines (e.g., through support for their devices and automation platforms) will be prepared and executed. Moreover, the FUJITSU will exploit parts of the use case as a showcase of its Industrial IoT platform and its ability to be deployed in conjunction with a serverless architecture. To this end, FUJITSU will develop a relevant business plan concerning the showcasing and pilot deployment of serverless solutions to its customers.

2) **Remote Healthcare Management Use Case (iSprint):** The exploitation of the healthcare use case will be carried out by Innovation Sprint (iSPRINT) and will aim at ensuring the sustainability and wider use of the PHYSICS project outcomes as part of iSPRINT's products and services. Specifically, based on the use case demonstrator, iSPRINT will introduce serverless/FaaS capabilities in certain core smart services of its product (i.e., AI-based prediction models in Healthentia[16]). Accordingly, it will plan for offering FaaS functionalities to existing accounts and future accounts of the company, notably healthcare organizations using the Healthentia e-clinical platform. iSPRINT will plan four presentations to selected accounts during the final stages of the project, i.e., before the completion of the FaaS integration in its e-clinical products. iSPRINT will market the benefits of serverless architectures in delivering key features and functionalities such as the real-time management of real-world data towards disease management.

3) **Precision Agriculture Use Case (CYBELE)**: CYBELE plans to bundle functionalities and features of the use case (e.g., FaaS enabled Digital Twins) to its precision agriculture solutions portfolio. Specifically, the use case will evolve to a Precision Agriculture as a Service solution, which will be high performance levering on the speed / low latency and quality of service of serverless architectures. The new Precision Agriculture as a Service solution will be marketed towards existing and prospective customers of CYBELE in the agrofood sector. It will provide low-latency functionalities such as real-time plant health diagnostics as a service.

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6. BUSINESS MODELS FOR SOLUTIONS

6.1 Business Models for Solutions Insight to the FaaS Business Model

A FaaS-provider business model is constructed to reduce the DevOps-demand of developers and cater a full-service experience to the developer in a serverless environment with high scalability and low costs. The business model is asset-light, and a rented service as users do not take ownership of the technologies but utilize it as consumers. Therefore, the providers can maintain stable revenue streams as customers are dependent on the providers, while users of the technology enjoy a more efficient and streamlined experience. In the FaaS business model, the main risk is placed on the FaaS provider as the following elements:

- Data storage,
- Middleware,
- Containers,
- Operating System (OS),
- Virtualization and
- Hardware

are abstracted by the vendor whilst functions are the customer-managed unit of scale, and the application code is the customer-managed element. The latter leads to a broader range of customers given the comparative ease concerning technical knowledge and the non-existent infrastructural demand to develop applications.

The PHYSICS project will provide three main tools known as CSP Cloud Design Environment, CSP Optimized Platform Level FaaS Services Toolkit and CSP Backend Optimization Toolkit. These tools will support providers in offering optimized services. The FaaS provider in PHYSICS will, in turn, have to provide tools such as Hardware or Containers.

6.2 The Main Common Industry Elements of the Business Models

Given the scope of the PHYSICS project and lack of public access to the business intelligence of individual FaaS providers, this part will address main characteristics observed among the previously defined and relevant market players rather than presenting the exact business model for each provider.

Element 1: All-inclusive Value Offer
The leading providers on the market seek to make life for the developers more focused on developing application code for the functions and are therefore taking steps to make the process more seamless. Thus, elements that used to be integrated into DevOps are implemented in the FaaS environment to create an all-inclusive value offer.

Element 2: Pay-Per-Use Pricing Method
The pay-per-use rationale is one of the most vital elements of the general FaaS value offering. It is described more in detail in the "pricing and profitability" paragraph of this chapter. In short, it facilitates low-cost deployment, efficient production, and lack of ownership of assets.

Element 3: No application language barriers nor frameworks
The FaaS model allows a wide diversity of programming languages and does not require coding to be written according to specific frameworks due to the third-party services' ability to handle the code. The deployment process differs from traditional options as the front-end code is uploaded on the FaaS service which then manages the backend processes. For instance, the provisioning and instantiating virtual machines. Developers enjoy flexibility and ease in their process of developing applications.

Element 4: No need for maintenance nor development of infrastructure
Developers may spend more time on design, development, and execution of functions related to the end-product rather than developing and maintaining an in-house set-up that does not generate value. The latter reduces time and increases efficiency, something fundamentally crucial for smaller developer teams without the means to maintain the infrastructure themselves.

6.3 Business model validation

6.3.1 Increased Productivity

When looking at the properties of FaaS, the cost-of-service production is dynamic, and therefore better corresponding to the output levels of the service's consumption. While cost predictability is less clear due to the lack of fixed-expenses elements on the income statement, the dynamic pricing model ensures general efficiency in terms of financial expenditures. Furthermore, dynamic scaling reduces idle time and enables effects linked to economies of scale.

6.3.2 Operational Risk Assessment

While FaaS is poised for substantial growth, there are associated risks and uncertainty related to third-party APIs. Another non-liquid operational risk is interlinked with security concerns, which is especially pivotal among companies operating under EU-jurisdiction due to the high level of European data regulation. As risk is placed on the FaaS provider, all cloud components are under the provider's responsibility. Given that serverless functions utilize plenteous event sources such as HTTP Application Programming Interfaces and cloud storage assets, standardized web application firewalls may not effectively inspect the range of protocols and message structures. In terms of the General Data Protection Regulation (GDPR), providers have constructed fully compliant data models. Nevertheless, developers still need to provide end-users with accessible and transparent ways to comply with the four foundational pillars of GDPR:

- The Right to Data Portability: users have the right to have a copy of their stored personal data.
- The Right to Be Forgotten: users have the right to have their personal data deleted.
- Privacy by Design: the security policies should be considered since the earliest stages of development.
- Notifications about Breaches: all breaches must be reported within 72 hours.

As serverless functions are yet the status quo of application development, visualization and general monitoring opportunities are less user-friendly. Therefore, comprehensive logging is an essential component of troubleshooting.

6.3.3 Pricing and Profitability

The pricing models for FaaS services are harmonized, meaning that pricing is not a competitive-advantage differentiation strategy among FaaS providers. Production pricing consists of two main parts, the first coefficient is requested, and the second coefficient is GB-seconds. GB-seconds are the seconds a function runs multiplied by the amount of Random-Access Memory (RAM) consumed.
The price function is the following: Price = (Request Price Coefficient * Y) + (#GBs * Duration Price) where Y is every 1M request post any free tier offering as providers usually provide a free-tier option for certain amounts of requests and then charge for execution beyond the tier.
Providers such as AWS Lambda use a geographical open price discrimination strategy. The segmentation is not limited to APAC and EMEA regions, but segmented and priced on a country-to-country basis. For instance, in London (EMEA), the request is priced at $0.2 per 1M requests and $0.0000166667 for every GB-second. The same pricing model in Milan (EMEA) is $0.23 per 1M requests and $0.0000195172 for every GB-second. Providers such as AWS Lambda, Azure, IBM, and Google functions are typically more expensive than bare-metal FaaS providers like Heroku as the latter do not work with the same amount of abstraction

such as including load-balancing, debugging and local development tools in their value offer. They seek to eliminate the demand for DevOps, hence making the value offer more all-inclusive.

As aforementioned and will be explained in the next part of this analysis, FaaS users face several positive financial effects by utilizing FaaS technology. A direct consequence is the efficient pricing model, low cost of assets, and therefore lower need for investment and/or financial liability to finance assets as such. In a more forward-looking manner, indirect effects related to ease of deployment and general development facilities revenue opportunities with impact in which the additional revenue surpasses additional cost, thus making the P&L's of firms incurring opportunities for profit, not accounting for other revenues or expenses. In other terms, the pricing model leads to increased value for money and requires no or little initial cash contribution. Businesses such as those in agriculture may improve profitability by making more accurate assessments using data-driven and auto-scalable solutions, mitigating inventory impairment and non-realized revenue transactions.

Looking at non-asset, human capital resources, the serverless computing paradigm allows developers to focus on producing code without considering the provisioning, configuration, management, and manual scaling of any back-end infrastructure. Henceforth, the realization of deployment and execution is faster, and the time spent on the processes decreases as the complexity threshold decreases when creating scalable applications. When assessing profitability, effects are expected throughout the entire spectrum, meaning that the application's data size and complexity are not deviating modalities. Nevertheless, momentum using FaaS can be especially important for the profitability indicators for Minimum Viable Products (MVPs) and smaller applications as the development costs are in relation to the value they might create.

With respect to the predictability of expenditures which leads to a more accurate profitability assessment, the FaaS model both leads to cost reductions and an improved opportunity to oversee fees due to the variable cost based on usage. As operations expenditures are proportional to use, the general business model of a product built on application code is more comfortable assessing profitability. According to Tim Wagner, former GM of AWS Lambda, FaaS may yield a 4:1 to 10:1 cost compression ratio for a typical workload.

6.3.4 Cost Structure Analysis

One can look at the cost structure in FaaS from two different perspectives, those being from the developer and provider perspectives. FaaS technology infers a more tailored and efficient spending opportunity while providers face some risk in facilitating the serverless infrastructure model's operations.

For FaaS developers (a consumer in business terms), the main factor for implementation is the pay-per-use rationale. Simply put, there is no need to pay for infrastructural assets that may not be optimized fully, but instead, maximize the use of FaaS providers and their services. But how do FaaS users minimize their expenses in their income statement by this asset-light production model? The main explanation lies in the fact that FaaS providers facilitate more efficient data transportation. To understand how cost is incurred in

FaaS, the main cost is found in charges outside of the price per function invocation which benchmarks at approximately $0.0000002.
Frankly, operational costs related to the execution of functions make up the largest incurred cost ratio due to computational resources usage. When looking at the two major providers AWS Lambda and Azure, they both charge around $0.00001667 per Gigabyte-second (seconds a function run multiplied by the amount of Random-Access Memory consumed). Depending on the function execution demand level, the total cost will vary with respect to the allocated memory configuration, which is usually subject to the composition in the range of 128 MB to 1.5 GB. Regardless, FaaS provides a low-cost solution in relation to an asset-based function execution model as costs are usually lower than for IaaS-models.

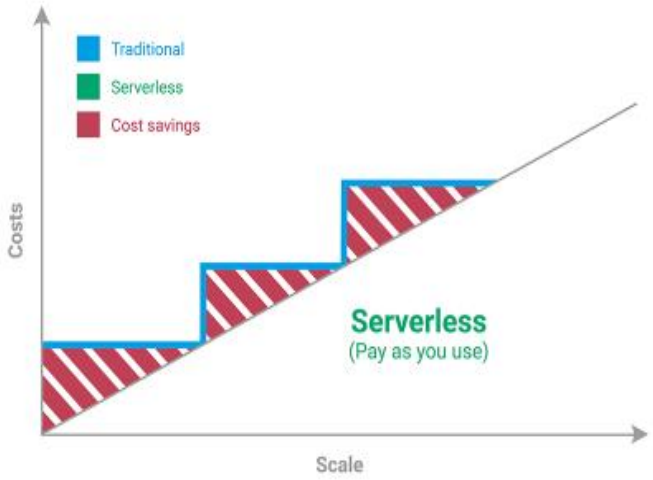

Figure 12 - Cost analysis

Nevertheless, a key consideration for any consumer is the feasibility of each technology based on their demand. Serverless computing services may not be the most efficient technology for all types of computing. The following characteristics of computing operations are considered as cost-efficient:

- Ease of division to smaller independent units;
- Non-linear data traffic patterns;
- Short start-up time frames;
- Demand of either higher developer velocity or short time to each market.

While workloads carrying the following elements may not have FaaS as the most efficient technology:

- Tasks in demand for incense computation power that are long-run;
- Workloads in demand of direct execution with no risk for delays.

From this, it can be concluded that FaaS is more cost-effective for execution that is not dependent on any traffic delays. As pricing is solely based on execution time instead of process idle time, higher scalability can be achieved at a low cost at the expense of increased latency. Finally, the operational risk of running non-suitable invocations may lead to overhead and retries in the FaaS environment. As the invocation of functions fails, retries will occur until the event is retained. Automated monitoring efforts to quickly spot scaling costs are therefore recommended to leave room for cost mitigation.

6.3.5 Market Analysis

Overview of the main market sectors

FaaS services are used in various industries as a cloud computing solution. The FaaS market is estimated to be worth $31.5 billion by 2026[17] at a CAGR of 32,3% with the industry breakdown as follows[18]:

- Banking / financial services (25%)
- Telecommunication and ITES (21%)
- Consumer Goods and Retail (16%)
- Healthcare and Life Sciences (13%)

- Government and Public Sector (10%)
- Others (15%)

Banking / Financial Services

The Financials sector encompasses banking, financial services and insurance industries. FaaS technology is widely adopted across the financial sector. This segment is continually evolving and characterized by an intense competitive landscape, worldwide expansion, consolidation, varied regulatory norms, and ever-changing consumer demands. Financial institutions are increasingly using FaaS for automation of routine operations and facilitating cost reduction. Moreover, FaaS services enable a more comprehensive view of customers and financial products and further drive customer retention and acquisition. FaaS services allow the efficient integration of multiple delivery channels for banks, which has further helped drive these services' growth in this industry.

Based on the serverless nature of cloud and FaaS technology, an alternative universe of decentralized web is powered by blockchain technology. Blockchain is also used extensively in the financial industry and expected to grow rapidly. Potentially it could lead to enhanced services and protocols that may develop similar characteristics to FaaS technology and even substitute it (Yuan, 2020.).

Telecommunication and ITES

ITES refers to Information Technology Enabled Services. This sector has experienced a sharp increase in cloud computing usage. By 2025, the cloud telecom industry is forecasted to be valued at $50.77 billion with a compounded annual growth rate (CAGR) of 19.7%.[19] Telecommunication and ITES companies store and process huge volumes of customers' data, and FaaS services enable operators to derive valuable insights from this data with the help of data science and data analytics. As a result, companies use the insights from data to improve their operation. For example, during the COVID-19 pandemic, telecommunication operators provide data to monitor how people and crowds are moving and potentially spreading the virus.

Partnership between telecommunication and ITES companies and cloud providers will support further market growth. These companies can offer their infrastructures to cloud providers to help them get closer to customers by launching platform solutions dedicated to telecoms infrastructure and integrate directly with 5G networks. In 2021, Google Cloud and AT&T have announced a collaboration to deliver a portfolio of 5G edge computing solutions to enterprises to help them address business challenges.

Consumer Goods and Retail

Cloud computing and FaaS are transforming the consumer goods and retail sector in various ways including inventory management, customer experience and disaster management. Cloud architecture and FaaS offer access to real-time data on a retail company's inventory, and analytics platforms to build both predictive and prescriptive inventory forecasting. Therefore, when managing multiple stores, managers do not need to manually synchronize the inventories of each store, but just can access a holistic picture of real-time stock availability.

Healthcare and Life Sciences

The Healthcare sector includes two primary industries: the healthcare equipment and services sector and the pharmaceuticals, biotechnology, and life sciences sector. The COVID-19 crisis amplified the demand for improved healthcare around the globe. For this purpose, benefits such as enhanced data usage, medical research, and lowering costs drive the market.

In the current market, more digital health applications enter the market such as Livi3, DoctoLib4 and the National Health Service5. They serve the purpose of connecting medical staff with patients, which is a huge inconvenience during the pandemic. Telemedicine is expected to reach a global $180 billion valuation by 2026 and the total digital health market a valuation of $500 billion by 2025. However, one pivotal factor to consider in e-Health applications is the risk of providing sensitive data to third parties. For this reason, an extra precaution in the design and choice of the cloud is highly relevant. Therefore, the sector could benefit from efficient and secure data management techniques, which are critical for patient management, hospital resources management, doctor-patient relationship management, medical supplies management, and maintaining patients' health record. The industry has shifted into a model that collectively supports and coordinates the workflows and medical information on cloud with the support of FaaS.

For example, one key technology currently developed with FaaS in the Healthcare sector is WBAN - Wireless Body Area Network (also referred to as BSN - Body Sensor Networks). It aims at providing real-time healthcare monitoring services. As WBANs have limited memory, energy and computing power, a scalable high-performance computing and storage infrastructure, such as FaaS, is required to provide real-time data processing and storage.

Government and Public Sector

This sector must deal with various issues such as tax collection, public interest, safety, and education. As consumer experience is enhanced by digitalization in private sector businesses, users' expectations of government agencies' services demand superior service in terms of quality and efficiency. Hence, there has been a surge in government agencies moving to the cloud in order to deliver better services to citizens. The cloud facilitates these agencies to make fast and cost-effective capacity decisions, scaling up and down depending upon data traffic, seasonality, and business requisites. FaaS services enable government and public agencies to extend tailored services to handle mixed consumer demands. Government departments are increasingly using FaaS services to provide government alerts, manage air services, manage accommodations at national parks and many other such applications.

6.3.6 Competitor Analysis - Overview of the main cloud service providers

This section will perform a market analysis of the main providers focusing primarily on the structural sources and execution capabilities at the core of the services provided by AWS Lambda [20], Google Cloud Functions[21] and Microsoft Azure Functions[22]. In other words, it will be investigated the effort of the companies to improve their frameworks in one or more characteristics.

Afterwards, it will be considered that a FaaS platform does not necessarily run on a serverless environment, such as AWS Lambda. Still, many FaaS implementations such as OpenFaaS[23], Fission[24] and OpenWhisk, allow us to deploy and run FaaS on users' hardware. In this reality of open-source frameworks, most of them use licenses such as MIT and Apache 2.0, which allow users to use the software for any use with minimal limitations. OpenFaaS, for example, uses an MIT license, which allows users to use code for any

purposes, even if the code is part of proprietary software, with the only limitation of including the original copy of the MIT License.

Amazon AWS Lambda

Amazon introduced Lambda in 2014 as part of AWS. Lambda is a serverless, event-driven compute service that allows users to run code for any type of application or backend service without provisioning or managing servers. Even though Lambda was not the first mover on the FaaS market nor the very first serverless compute service, it still was a successful entrant that soon became a model to replicate for other prominent players in the cloud computing market.

With Lambda, customers upload their code as a ZIP file or container image, and Lambda automatically and precisely allocates execution power and runs the code based on the incoming request or event, for any scale of traffic. Customers can set up their code to automatically trigger from 140 AWS services or call it directly from any web or mobile app. Furthermore, customers can write Lambda functions in all types of languages (Node.js, Python, Go, Java, and more) and use both serverless and container tools, such as AWS SAM or Docker CLI, to build, test and deploy their functions. Lambda thus makes it possible to run the code without having to take care of deploying the servers anymore.

Soon after Amazon Web Services introduced Lambda, its main competitors also started developing and commercializing their own serverless FaaS frameworks. But its competitors did not reach the same level of success as Lambda did. Their offering was simply catching up to what AWS had previously delivered through Lambda without bringing additional added value or features. Given the difference in their timeline, AWS Lambda holds an advantage over the other platforms as it provides scalability and fully automated administration with concurrent controls and event source mapping.

Microsoft Azure

When a company is looking for the best cloud infrastructure provider, it should look at the leading player in such a market (namely AWS) or try to take inspiration from its competitors in the choice they made for such a service. Thus, even though Amazon Web Services is the leading cloud provider worldwide with 1/3 of the cloud infrastructure market share (33%)[25], way ahead of its competitors, a company should look for the provider that best fits its needs. Part of the main criteria that constitute the specifications when making a call for bids include requirements for performance, availability, security, storage, and workload, to name a few.

Microsoft launched Azure in January 2010. A decade later, Azure is AWS's strongest competitor with an 18%[16] market share as it is closing the gap against Amazon's cloud infrastructure solution. Azure thus presents a lot of critical strengths which make it a fierce challenger to AWS in this market. Therefore, it is increasingly difficult for companies to choose the better service between the two GAFAM Giants and other providers such as Alibaba and IBM. However, there are still some differences in the quality of the offerings and in the technical characteristics that can be spotted. Microsoft Azure leverages Microsoft's existing customer base using Office 365 to fuel its rapid and constant growth over the last few years in the cloud infrastructure market. While rapidly growing and gaining market share in the cloud market, the outlook also looks promising for Azure. It has made several exciting moves in recent years that might give it a competitive edge. For instance, Microsoft's cloud solution prevailed to win a 10-billion-dollar deal from the Pentagon for its cloud computing services.

Azure also agreed on a substantial contract with the NBA and Blackrock, the world's most prominent asset management firm for its well-known Aladdin platform. The long-term agreement sealed with AT&T is

another significant move from Azure which can be mentioned as Microsoft is moving fast in the cloud universe.

These milestones emphasize how Microsoft can benefit from its existing products such as Windows and other Microsoft tools and software to build on these existing partnerships that it can leverage for its Azure service. Microsoft Azure, therefore, stands as the more straightforward go-to solution for businesses' executives to have an all-in-one place package through one provider, through a combination of Microsoft services (Azure, Office 365, Teams, and many others) to run all their applications in one single cloud, not to mention other players it is associated with (Salesforce, Adobe, SAP, Oracle). Furthermore, despite its late mover advantage in this market, Microsoft also leverages the multiple on-premises software it has developed throughout its existence and repurposed it for Azure, making it a severe cloud computing provider.

Azure benefited from Microsoft Software-as-a-Service (SaaS) footprint it has earned throughout the years

on an external site. Also, it helped Azure internally as, from an execution and technology perspective, the learning curve from Windows has been a critical success factor according to Microsoft Azure EVP Jason Zander.

In terms of scalability, performance, reliability and security, Microsoft Azure is known as one of the best solution providers even though it is not a differentiating factor against Amazon Web Services or Google's GCP for instance. As mentioned by Jason Zander, Microsoft Executive Vice President, it is also a central focus. Additionally, Microsoft Azure possesses more robust hybrid options than AWS, while also offering more specialized storage options (e.g., Data Lake) (Varonis, 2020). However, on the other hand, Azure is weaker than AWS in terms of the depth of its offerings, as AWS offers a broader range of services to its customers. Moreover, even though Microsoft has an extensive experience in serving corporate clients with its various offerings, Azure still reportedly underperforms in technical support, training and breadth of the ISV partner ecosystem, and documentation. Finally, it can improve its cloud offering as the learning curve can be qualified as steep, making Azure more complicated than its direct competitors and harder to use and manage.

With its recent acquisitions of 5G specialists Metaswitch Networks and Affirmed Networks, Microsoft makes a critical move to improve its 5G cloud offering, thus strengthening its Azure solution's capabilities. This latter will grow at scale through enhanced capabilities via a more secure, broad, and efficient ecosystem (Khalidi, 2020).

Microsoft will be looking in the future to leverage AI capabilities for Azure by integrating the Brainwave Project (Deep Learning system). This area is still catching up with Google, which already made critical investments in AI and machine learning. Out of the main tech giants, Google has indeed invested the most in AI, as it has invested around $3.9 billion since 2016, thus far ahead of Amazon and Microsoft, respectively second and fifth most prominent investors in Artificial Intelligence to date (according to research conducted by RS Components, 2018).

6.3.7 Google Cloud Services

In September 2017, Google strategically acquired Apigee Corp for $625 million (Clement, 2018). Apigee is a provider of application programming interface (API) management. Various companies already use their services, such as Burberry, Walgreens, Live Nation, etc.

The acquisition of the API oriented tech business was a crucial development strategy for Google, as it gave it a competitive advantage. According to the research, 84% of the tech industry experts state that API implementation is critical or critical for their business strategy and further growth (Marklein, 2019). Research shows that US companies alone have spent nearly $3 billion on API management (Greene, 2016).

The current industry leaders are implementing APIs in various ways to develop their business, with 55%

of them using API as a revenue stream. The examples of companies with API-based business models, including Google with Google Maps, Analytics, Calendar, Contacts, or Facebook, Spotify or PayPal, are mainly API-based, connecting their services to millions of third-party websites and apps. Also, Japanese Sony has an API for developing applications integrated into their devices (Vector ITC, 2019). The main benefits of introducing API to Google's offer was to improve its cloud offering focused mostly on corporate clients (Trefis Team, 2016) by providing the following advantages to their service. The main benefit of adding API Apigee to Google Cloud is accelerating moving the customers into high-quality digital interactions. The service will allow faster and easier APIs implementation and publishing with excellence (Greene, 2016). That means that the customers will be able to, for example, enable their developers to work on the code of their application while maintaining the stable interface in the apps and services.

Google has chosen this particular company because this API fulfills most of the requirements: supporting security and allowing the developers to select the development environment they want to work in. It includes testing support and usage analytics. A few years ago, such an investment into the API management systems was indeed a bold move as API is now at the core of everything digital. This market is currently valued at $1.97 billion by revenue.

The main benefits of implementing API in Google are that it drives efficiency and accelerates time to

market and, as visible above, it has substantial growth potential. The efficiency comes from how the apps are built, without API's they were made monolithically, but smaller teams can work on different parts of the app at their speed. Therefore, the customers of Google Cloud are launching their projects quicker and more efficiently. Also, API allows Google's partners to unlock new business models and revenue opportunities. For example, AccuWeather and Pitney Bowes have pursued API monetization strategy with Google by selling the data and functionalities captured by API and selling them to third parties.

Another aspect is that Google's API allows its customers to activate data and inject intelligence into

business processes. It lets the enterprises connect their digital assets to the APIs that provide machine learning services running in the cloud to develop their business utilities. Also, the API allows combining the code to be reused and incorporated for different cases, making it modular and composable in the IT systems, creating resiliency (Hood & Kasiviswanathan, 2020).

7. BUSINESS MODELS FOR SPECIFIC USE CASES

7.1 eHealth

The healthcare sector includes two primary industries: the healthcare equipment and services sector and the pharmaceuticals, biotechnology, and life sciences sector. The COVID-19 crisis amplified the demand for improved healthcare around the globe. For this purpose, benefits such as enhanced data usage, medical research, and lowering costs drive the market.

In the current market, more digital health applications enter the market such as Livi [26], DoctoLib [27] and the National Health Service [28]. They serve the purpose of connecting medical staff with patients, which is a huge inconvenience during the pandemic. Digital health is expected to reach a global $657 billion market size by 2025 [29]. However, one pivotal factor to consider in e-Health applications is the risk of providing sensitive data to third parties. For this reason, an extra precaution in the design and choice of the cloud is highly relevant. Therefore, the sector could benefit from efficient and secure data management techniques, which are critical for patient management, hospital resources management, doctor-patient relationship management, medical supplies management, and maintaining patients' health record. The industry has shifted into a model that collectively supports and coordinates the workflows and medical information on cloud with the support of FaaS.

For example, one key technology currently developed with FaaS in the Healthcare sector is WBAN - Wireless Body Area Network (also referred to as BSN - Body Sensor Networks). It aims at providing real-time healthcare monitoring services. As WBANs have limited memory, energy and computing power, a scalable high-performance computing and storage infrastructure, such as FaaS, is required to provide real-time data processing and storage.

7.1.1 Value proposition of PHYSICS in eHealth

The agility, scalability (in times like the pandemic to meet the demands), distributed and personalized monitoring nature, along with extension of its analytics and machine learning algorithms portfolio are enhanced with the help of the PHYSICS solution. These improvements are predominant for very large-scale intervention trials business cases. In the clinical research industry, the main flow of intervention development involves recruiting patients using a CRO (Contract Research Organization) and collecting data from patients. The process is associated with heavy burden, high patients' dropout, and poor data quality which in turn leads to high costs and limited clinical outcomes to prove the effectiveness of a drug. There is indeed a lot of room for optimization by reducing cost and time of intervention development and by getting insights of the clinical trial, leading to richer clinical outcomes to prove efficacy.

Some of the prominent companies leading the global eHealth market are Boston Scientific Corp, IBM, Motion Computing Inc., Medisafe, SetPoint Medical, Lift Labs, CompuMed, GE Healthcare, etc. IBM is taken as an example to illustrate how cloud computing can add value to the healthcare industry.

IBM Cloud helps healthcare industry clients to manage their workload, to accelerate research, inspire patient confidence with innovative customer experiences, and improve system uptime while meeting security and compliance requirements. IBM developed a system called Clarify Health which delivers insights to optimize the clinical workflow by seamlessly integrating advanced analytics and smart workflows. This empowers healthcare professionals to guide patients through the healthcare journey.

7.2 Smart Agriculture

According to Eurostat, the EU agricultural sector contributed a total of 181 billion euros in net added value to the European economy. Agriculture is becoming more complex with the increasing population and climate change. Over the years, resource usage performance and efficiency have not improved much. The

agricultural domain is responsible for 44% of total EU water usage, 2.8% of energy consumption and 10% of greenhouse gas emissions. Given the challenges, precision agriculture is the next solution.

Using greenhouses to grow crops is nowadays a common and complicated way to increase productivity and crop quality. Greenhouses are able to reduce the impact of climate uncertainty, protect crops from diseases and physical damages; therefore, they reduce the need for chemicals and pesticides.

A common technology used in agriculture is greenhouses, which provide the benefits of controlling resource consumption and protecting crops from environmental change and natural disasters. Statistically speaking, greenhouses enable 0% pesticides thanks to the physical protection they bring to crops. However, the difficulty in using greenhouses is the complicated parameters that need to be controlled and monitored, including temperature, humidity, CO2 level, etc. Most greenhouses set these parameters to default values without adapting to the location of the farm, the need of the species, the potential yield and quality. Thus, we need a more dynamic approach to gather data in the greenhouses, model and optimize the parameter settings. This is the idea of smart precision agriculture.

An example of smart precision agriculture is CYBELETECH, a high-tech SME addressing issues in food production, sustainable farming, and forest exploitation. CYBELETECH provides tools, software, and services to optimize conditions in greenhouses, which significantly improves crop management. The technology is able to save 50-100 €/ha/day of CO2 and reduce emission of liquid CO2 by 90% on tomato crops.

Smart precision agriculture requires constant monitoring of various data points and performing rigorous modeling to simulate the environment. On average, farmers have to process around 30 climate variables coming every 10 to 60 minutes from the greenhouse sensors. The data assimilation needs to process 500,000 to 1,000,000 simulations every day on each greenhouse. This is an estimation as the method has never been tested on such a complex, continuous model given the lack of interplay with cloud services. Therefore, a cloud-based solution is needed to ensure robust computation and data assimilation.

7.2.1 Value proposition of PHYSICS in Smart Agriculture

PHYSICS is able to offer a continuous monitoring and operation system to smart precision agriculture. The objective is to migrate existing modeling and simulation components that are based on legacy technologies to cloud, in order to integrate the overall lifecycle of smart precision agriculture, from data collection to forwarding and launching the simulation to obtaining results and applying them to the greenhouses. Furthermore, a cloud-based solution will help to achieve cost and performance optimization. The FaaS model consists of multiple, short-duration simulations of 1-5 seconds, which increases the amount of data collected and the accuracy of the environment simulations. Farmers could also benefit from the pay-as-you-go model of FaaS services, which helps to reduce costs.

IBM, as one of the largest cloud providers in the world, has an Environmental Intelligence Suite that offers digital solutions to agriculture. The suite combines the power of cutting-edge technologies including AI, cloud computing, data analytics and IoT, as well as the expertise in the food and agribusiness industry. The IBM Watson Decision Platform for Agriculture helps to optimize field output by analyzing relevant data and comparing actual yield against benchmarks from similar fields. Users can thus identify ways to improve the yield in their fields.

iFarming is a startup business that makes use of IBM technologies to provide AI-driven and cloud-based insights for the water ecosystem. The business was established in 2017 as part of the Sofia Holding Group, which is headquartered in Tunisia and operates in France. The platform is supported by IBM Watson and IBM Cloud technology and uses IoT sensor data to forecast water needs and control irrigation in real time, adjusting water levels based on crop growth and local weather. The average users of iFarming are able to save their water use by 40%. Fujitsu is a Japanese multinational information technology company which launched a food and agriculture cloud “Akisai” in 2012. The “Akisai” cloud is designed to provide

comprehensive support for all aspects of agricultural management, such as administration, production and sales in open field cultivation. "Akisai" collects, stores and analyses data, such as the results of daily on-site operations and planting information in cloud so that customers can visualize the quality and cost figures of their planted fields. Fujitsu's food and agricultural cloud utilizes Fujitsu's FGCP/S5 global cloud platform service, which offers servers, storage spaces and other ICT infrastructure via a network from Fujitsu's data centers. Using the "Akisai" platform, Fujitsu has been producing low-potassium lettuce since 2014, which grows more quickly than normal lettuce and stays fresh for weeks. (Fujitsu, 2012)

7.3 Smart Manufacturing

The manufacturing field is highly accepting of effective innovative approaches such as data-driven models of Machine learning or improved optimization algorithms, high-speed computing resources and cloud technologies. Implementation of these technologies into the manufacturing sector is however a challenge for the companies even though there are a lot of benefits in doing so. The usual manufacturing processes are mostly based on common and tested rigid approaches that have high limitations in terms of flexibility, changeability and maintainability which use software that relates to few dedicated aspects to point connections or integration databases whilst the communication part is established on proprietary protocols and data models.

A productivity gap has been created in Europe's manufacturing lines since the major production lines have in the past decades moved to other regions (such as Asia), noticeable also during the covid-19 pandemic time, in which supply chain disruptions were a typical phenomenon. The labor costs in Europe when compared to other competitive regions are highly matchless. This requires Europe to invest in technology and smart optimization to reduce production costs to be competitive enough in this field and strengthen relevant employment levels.

Innovative cloud manufacturing platforms have been developed for a broad range of applications such as planning, monitoring, control, and management and design, and it has been used in various industries as shown in the following graph. The global smart manufacturing market size was valued at USD 236.12 billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 12.4% from 2021 to 2028[30].

7.3.1 Value proposition of PHYSICS in Smart Manufacturing

The main advantage of PHYSICS is that it will demonstrate the FaaS concepts in a pre-industrial testbed of a wide industrial association network (SmartFactory). This process has never been done in a manufacturing environment by transforming Classical System Architecture into Serverless Architecture. Doing this will help in other potential scenarios, for example, enhancing the usability of new AI or Optimization Services by dividing these applications into manageable workflows including (expert) functions from 3rd parties and using extended computing resources (e.g., Cloud) where applicable. Implementing and testing serverless architecture in a manufacturing testbed ensures that the PHYSIC Continuum system has a business impact, particularly by giving early and business-relevant feedback within the SmartFactory partner network to which the UC partners are involved.

This additionally causes the exploitation of the results within the network and demonstration on industrial fairs (e.g., Hannover Fair), reaching an extra 100 SMEs and acting as a blueprint for advanced smart factories. Through the activities in the GAIA-X initiative, the Smart manufacturing UC will contribute the results, concepts and findings of the PHYSICS project and vice versa.

Some of the prominent companies in the world that are operating in the smart manufacturing market are Bosch, Hitachi, Schneider Electric, ABB, SAP SE, Siemens AG etc.

In 2021, Siemens announced a new cooperation with Google Cloud to optimize factory processes and improve productivity on the shop floor. Siemens intended to integrate Google's specialty in data cloud and

machine learning technologies with its factory automation solutions. With this new partnership, manufacturers will be able to harmonize their factory data and run cloud-based AI models with that data. This enables more automated inspection of products or prediction of the wear-and-tear of machines on the assembly line (Siemens Press, 2021).

7.4 Monetization Strategy

PHYSICS' service offering will provide revenue streams that will support the business plan of the project. The project will initially pursue a business strategy based on high volume and low margin so as to attract a large number of stakeholders (especially customers in the initial phases) around the platform. This is needed to tackle the common "two-sided network problem" in such marketplace environments, i.e., how to attract enough customers when supply is not adequate and at the same time how to attract suppliers given that demand is not adequate in the platform environment. Given that the project will initially produce a certain number of artefacts (through the RAMP), the initial supply is guaranteed, as well as the extended network of collaborators of the project partners. This will enable the initial RAMP uptake, creating the necessary critical mass in order to attract external developers for generating more artefacts after the project comes to an end. The business plan of the project will also consider revenues from registration fees, collected in exchange for tangible services provided to registered participants (e.g., free training materials and content).

8. HANDBOOK ACTIVITIES

As already presented in the first iteration of WP7 series of deliverables, several activities were performed in order to progress with the Handbook task-related activities.

First of all, the project has identified four main groups of stakeholders and how they can benefit from PHYSICS. The list is summarized below:

- **Providers:** Mainly XaaS providers who own their own infrastructure and are providing the means for application providers to deploy their applications. For them, PHYSICS offers a set of tools, which can be integrated with their own systems, so they can improve their offering or benefit from, e.g., better used systems.
- **Early adopters:** In this case, they are the PHYSICS use cases who will benefit from tailored solutions, adapted to their needs within the project context, to improve their own applications.
- **Users**: Application providers who will benefit of using PHYSICS in the same way early adopters are doing.
- **End users:** Or users of early adopters/users' applications that are expected to benefit from an improved QoS/QoE.

Following the open innovation process designed for this task, an initial workshop with project representatives was performed in order to gather feedback about stakeholders' needs and expectations and how they should be covered by the project. This information will be also used to develop the project adoption roadmap and the PHYSICS Handbook.

The workshop was held on September 30th and, at least, one representative per partner, including use cases, participated to provide his/her point of view. The workshop was organized in the form of a World Café using Klaxoon[31], an online collaboration tool for organizing project activities where participation is required.

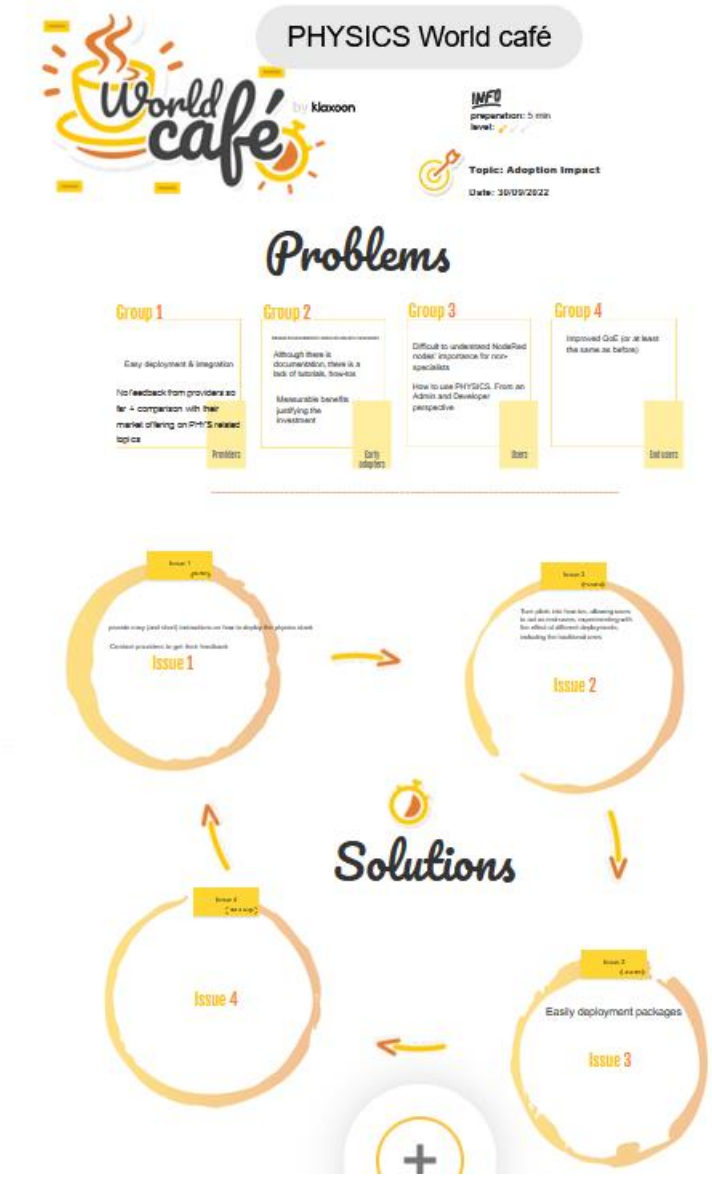

Figure 13 - Screenshot of the World Café board

During the session the work focused on identifying problems, from the consortium perspective, and how they can be addressed.

The list of problems and solutions is summarized as follows:

- Providers will need a platform easy to deploy and integrate with their current solutions. PHYSICS must provide easy, and short, instructions on how to deploy the project stack. Furthermore, PHYSICS should contact providers to gather their feedback.
- Early adopters, represented by use cases, will need more tutorials and how-to guides so they can easily use PHYSICS for their applications. Apart from that, they need measurable benefits to justify the investment. PHYSICS must easily provide deployment packages to easy its installation and use.
- Some of the technologies used within PHYSICS are difficult to understand for non-specialists. So, the underlying idea is to turn pilots into how-to guides, allowing them to experiment, e.g., the effect of different deployments.

- End users will need to see improved QoE, or at least the same one as before. So, during the project lifespan, work on the use cases will also focus on measuring the QoE before and after using PHYSICS. Additional interviews with end users' representatives are also taken into consideration.

All this information is being considered from technical work packages in order to provide detailed and easy to follow documentation for each of the component, but also for the whole PHYSICS platform.

Regarding the other problems identified, they have been considered for developing the PHYSICS Handbook. Thus, this task will produce two different results:

1. The adoption impact deliverable, as initially planned in the DoA, that will document all the open innovation activities performed by the project, such as workshops or interviews, and the main conclusions extracted from them
2. The PHYSICS Handbook, an additional document that will contain instructions and how-to guides for using project tools, and also the main benefits obtained by the project use cases, as well as some recommendations for replicate them. This document is intended to be used by external stakeholders in order to understand how costly is using PHYSICS opposite to the benefits they can get.

So, in order to gather all the needed feedback, additional interviews will be held with the consortium technical members to identify best practices and lessons learnt of the different tools. But also, with the use cases to perform a cost-benefit analysis for their specific cases.

Additionally, interviews are planned with external stakeholders using the consortium networks, as well as short surveys within the project planned workshops.

9. CONCLUSIONS

The Report refines and deep dives into the exploitable results of the project and goes deeper in the IP Rights analysis, thus performing a continuation of the analysis of the current market situation in D7.5. Several different exploitation paths were identified and analyzed, with a particular focus on individual plans, thanks to the contribution to each partner.

The SWOT analysis was refined with new findings, in parallel with a Porter's 5 forces studies of the various players in the targeted sector and a revision of the PESTLE, followed by a first glance to the value proposition.

In the IP Rights analysis section of this report, the possible risks are highlighted and discussed in terms of their impact and probability to occur. A study of the current legislation and how it could change in the future is considered as well.

In this new version, a special attention was given to the innovation potential of the project results, with a close analyses partner by partner of the expectation by the end of the project, and cutting deep on customer, impact and benefit.

The section which refers to the individual exploitation plans sheds light on the latest version of the strategies of the PHYSICS partners to implement the exploitable results as a potential solution in their own business models. It demonstrates the market readiness of the proposed solutions, as many of the outcomes of the project will already be of significant use for the partners. As the project moves forward, the use cases evolve. The following outline of the joint exploitation plan highlights the general direction for a sustainable uptake of the project's jointly created artefacts and exploitable results. It includes the development of a business plan for the different bundles and of the RAMP, but most importantly the engagement of stakeholders through different networks to make the collaborative work as effective as possible.

Moreover, the exploitation paths and the key results overview went deeper. As the RAMP has been made public and the artefacts have started being integrated on it, as of December 2022, there are currently 19 assets published on the Marketplace, 6 of which from external contributors, 30 users, 8 of which are external and 3 use cases. RAMP does not require registering for viewing or downloading the assets. In the last year of the project the plan is to integrate more and more assets in the RAMP, while in parallel, keep spreading the knowledge of PHYSICS framework in the FaaS sector.

In the second part of the document, business models for use cases, individual results and joint solution are explored and validated. In the final part, the PHYSICS Handbook initial steps and aims are presented, as well as what is going to contain and the proper target receivers.

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