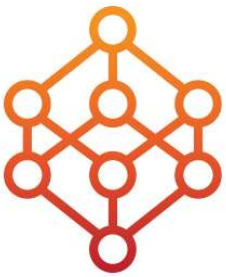

# PHYSICS

oPTIMIZED HYBRID SPACE-TIME SERVICE CONTINUUM IN FAAS

# D7.5 – BUSINESS INNOVATION DEVELOPMENT, EXPLOITATION AND HANDBOOK

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| 1.1 | 2021-12-10 | GFT | Version for Peer Reviews |
| 2.0 | 2021-12-17 | GFT | Version for QA |
| 3.0 | 2022-12-28 | GFT | Version ready for submission |

# LIST OF ABBREVIATIONS

| **AI** | **Deliverable** |
|---|---|
| **API** | Artificial Intelligence |
| **CAGR** | Application programming interface |
| **CPU** | Compound Annual Growth Rate |
| **CSP** | Central processing unit |
| **D.** | Cloud Service Provider |
| **EPO** | Deliverable |
| **FaaS** | European Patent Office |
| **GDPR** | Function as a Service |
| **IaaS** | General Data Protection Regulation |
| **IoT** | Infrastructure as a service |
| **IPR** | Internet of things |
| **KPI** | Intellectual property rights |
| **PaaS** | Key Performance Indicator |
| **PHYSICS** | Platform as a service |
| **RAMP** | oPtimized HYbrid Space-time servIce Continuum in FaaS |
| **SWOT** | Reusable Artefacts Marketplace Platform |
| **GFT** | GFT Technologies |

# EXECUTIVE SUMMARY

The present D7.5 report describes the initial version of the Exploitation & Business Innovation Development Plans of PHYSICS project with the contributions of all partners and stakeholders integrated in a coherent vision able to transform a set of proof of concepts and artefacts at different maturity levels in an effective business value proposition tuned to the needs of the FaaS cloud computing sector and ecosystem.

This deliverable sets up the general approach and the methodology to be followed during the rest of 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 will be provided, the business models and monetization strategies of the services of the market platform.

The purpose of the deliverable is to identify and 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. Specific recommendations are given to address the mentioned issues, allowing the PHYSICS innovation solution to freely operate.

As part of the exploitation strategy of the project, both joint exploitation and individual plans were developed regarding the PHYSICS market platform and the individual partners' exploitation. For the joint exploitation activities, an initial version of business models and exploitation plans were developed and will be further iterated and complemented in later stages 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. In this sense, the Cloud Design Environment is designed for CSPs that lack advanced workflow definition, the Optimized Platform Level FaaS Services Toolkit targets CSPs who wish to extend their services from IaaS to FaaS, and the Backend Optimization Toolkit focuses on the CSPs that wish to enrich their currently sophisticated offering. On the other hand, the RAMP aims at bringing contributors and buyers from the cloud computing environment around one central artefacts marketplace.

Lastly, the deliverables' findings will 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. It will thus formalize the findings of Deliverable D7.5 in a manner suitable to be applied by external entities in their specific cases of PHYSICS adoption.

# TABLE OF CONTENTS

# TABLE OF FIGURES

# 1. INTRODUCTION

The present D7.5 report describes the initial version of the Exploitation & Business Innovation Development Plans of the project. The main focus of this first version of the report is the initial approach to market transfer and exploitation of the project results. This deliverable sets up the general approach and the methodology to be followed during the rest of 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 will be provided, the business models and monetization strategies of the services of the market platform.

The Market analysis and gaps identification (D2.1) analyzed the Function as a Service (FaaS) segment within the cloud computing industry with the aim to assess its potential and the gaps in the offering. The main objectives of the D2.1's findings were to set the basis for a comprehensive understanding of the FaaS and to set forth the PHYSICS project's potential benefits. Indeed, these results serve as major inputs and useful background for T2.2 activities, dealing with reference scenarios, and this D7.5, focusing on business modeling and the exploitation strategy of the project. For this purpose, the described indications will contribute to create a solution capable of innovating and enhancing the market's technology landscape.

Building upon the insights derived from the analysis conducted in D2.1, deliverable D7.5 explores and outlines the business modeling and exploitation strategy of PHYSICS.

The purpose of the deliverable is to identify and 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.

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.

# 2. MAIN INSIGHTS FROM THE MARKET ANALYSIS AND GAPS IDENTIFICATION

In the next sections, the SWOT analysis of FaaS has been 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.

## 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 on the one hand 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).

The insights from the analysis conducted across this deliverable are synthesized in the SWOT analysis performed below:

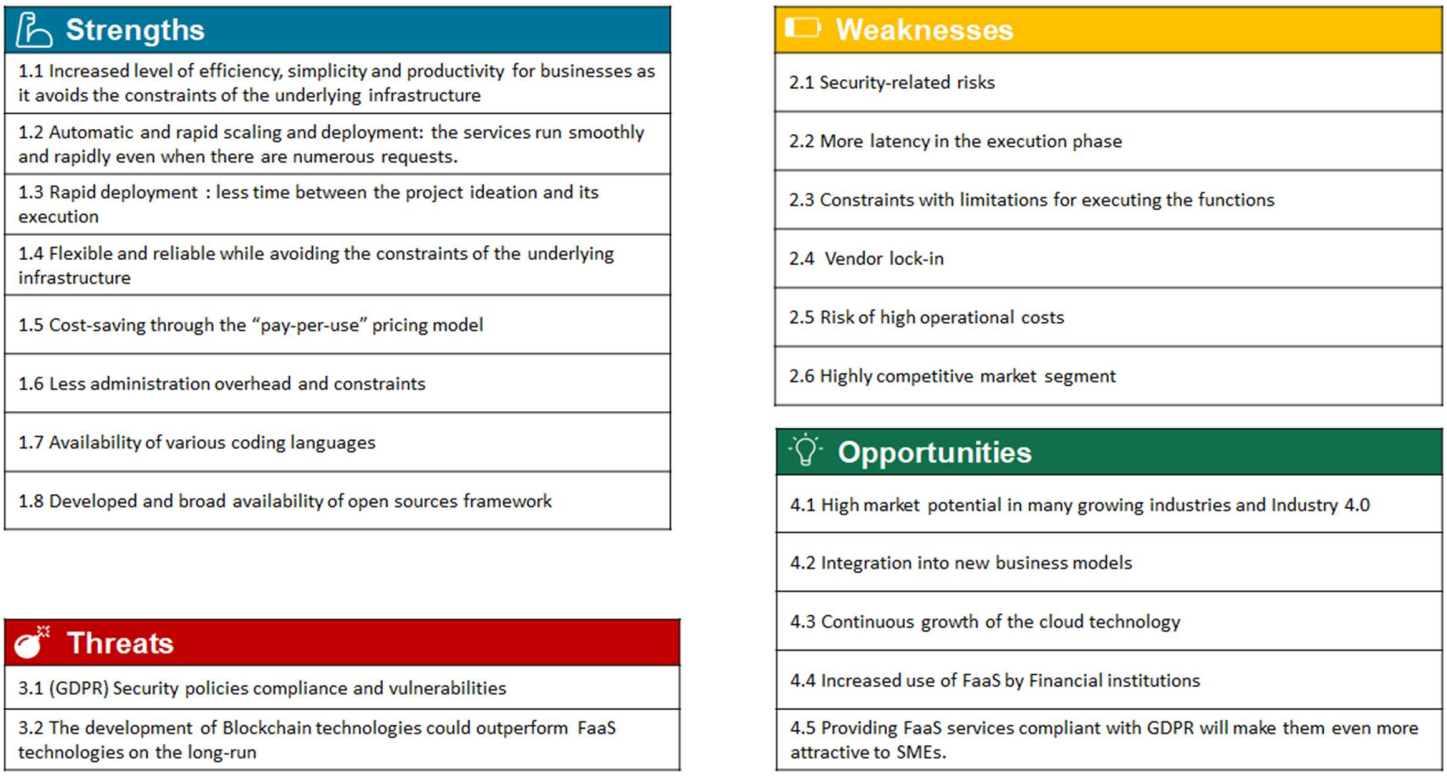


*Figure 1 - SWOT analysis*

**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 which 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 is able to 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, etcetera. Hence, it corresponds better to the output levels of the service's actual consumption.

For FaaS providers, on the other hand, it implies that forecasting their revenues from such service is harder due to the lack of fixed-bundles because of the pay-per-use pricing model they offer to businesses.

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.

**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.

**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.

As observed in chapter 2.1, under the focus on *Financials*, the blockchain growing trend has the potential to maintain its current development and importance and, ultimately, develop functionalities that can substitute the FaaS platform. While this scenario is yet to be clearly defined, it is an eventuality that has to be kept into account as it may disrupt FaaS long-term survival.

**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 mainly 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

[1]Baron, C. (2021). *Cloud computing*. Statista. https://www.statista.com/study/15293/cloud-computing-statista-dossier/

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.

## 2.2 Reminder of the Critical Success Factors

After performing the SWOT analysis, we identified the following critical success factors in order to overcome the challenges and build on the strengths.

**IT capabilities**

FaaS is one of the most promising cloud computing services and is increasingly popular among businesses in various industries. Developing the aforementioned service for enterprises requires robust internal capabilities on the provider side due to the complex infrastructure behind operating the product. Developing this technology is not an easy task. Indeed, the competition is intense, and the cloud computing industry keeps growing with FaaS adoption becoming more and more widespread. Consequently, it becomes increasingly challenging for new providers to break into the market to develop and provide the appropriate technology offering that fits users' demands. Therefore, it requires consistent IT capabilities to build a robust FaaS solution for businesses on the provider side.

**Financial capabilities to support heavy investments and development costs**

Building a robust FaaS solution comes with strong financial capabilities required to support the heavy development costs needed to build, run and operate the serverless cloud computing infrastructure. Currently, leading players such as AWS Lambda, Google Cloud Functions, Microsoft Azure, and emerging players such as Alibaba and IBM, share financing capabilities from their status as worldwide powerhouses.

**Technical features as a competitive edge**

To provide a comprehensive service as well as value for money, FaaS cloud providers need to offer a cloud platform with reliable technical characteristics as these features may represent a vital differentiating factor against the increasingly fierce competition. When choosing their preferred serverless cloud computing provider, users demand several technical features, such as scalability and deployment to execute functions under the cloud platform, the flexibility of the offer (execution on-demand), storage capacity and the ability to program in any language. The ability to deploy and execute functions efficiently, and at scale, is challenging due to increasing traffic and can indeed be a competitive advantage for providers who will succeed to deliver it. Automatic scaling is also pivotal; services such as those offered by AWS Lambda and Azure can satisfy the demand in this area as the functions' execution runs smoothly. Therefore, all these features represent a critical success factor as successfully developing the cloud offering will be a crucial component in order to become a successful player in the FaaS market.

**IT Management & Implementation of serverless infrastructure**

Developing FaaS requires IT management of the underlying infrastructure to make the cloud service run and operate efficiently. Infrastructure management should be integrated into the continuous delivery pipeline so that infrastructure stacks are updated together with any code changes. Moreover, dependencies between separate stacks must be understood and handled to make infrastructure management more effective. In the meantime, when offering their service to businesses, transparency becomes increasingly essential and needs to be tackled by FaaS vendors. This feature mainly relates to the storage, maintenance and usage of client sensitive information reinforcing client trust and ensuring regulatory compliance. Vendors should take into account customer expectations of their platforms, as businesses exploiting this service rely more and more on their hosting capabilities.

**Cost and pricing model management**

One of the most significant advantages of Serverless lies in its pricing model. Indeed, the pay-per-use model and the asset-light rationale infers a considerable financial benefit for its users because they pay exclusively when executing the service and do not need to invest directly into assets using their own cash assets or debt. Different providers offer different pricing models, but they generally have similar market-clearing prices, and they all allow customers to access various services, and layers within those services, paying only for actual computing usage. FaaS offers dramatic cost efficiencies and removes operational complexities. Consequently, developers can focus on their code without worrying about computing constraints or operating costs.

**External regulation**

On one side, with increasing data regulation in the EU, FaaS vendors need to be aware of and comply with continuous amendments in the respective field to avoid significant penalties due to possible data breaches. Any breach or data leak would result in a lack of trust for both the customers, especially in industries with sensitive information (e.g. Healthcare, Financial Services) and external regulators. On the other side, governing decision-makers need to provide tailored frameworks in which the aforementioned vendors can operate. The EU should attempt to incorporate the promising future and implications of FaaS technology to lay out a legal and fair playing field. Policymakers should seek to find solutions which provide vendors and developers with enough freedom, where possible, to be able to generate an internationally competitive platform.

## 2.3 Summary of the Value Proposition Definition of PHYSICS

As an outcome of the analysis conducted in D2.1, the findings enabled the conceptualization of a value proposition that can guarantee pain relievers and gain creators to overcome the core challenges detected. On the one hand, the figure below shows the most significant pains perceived in the document, especially in the users' exploration section and in the interviews conducted (T2.1). On the other hand, it indicates the aspirations (gains) of end-users exposed in the document (D2.1). The FaaS cloud offering, which takes into consideration all the insights explored throughout the deliverable would: "guarantee access to a scalable, capacious, secure, cost-effective, European Cloud Framework, compliant with GDPR".

Value proposition are the ones that can create gains and relief pains to the end-users based on their aspirations and needs, and for FaaS cloud computing gains would be that customers want to outsource infrastructure maintenance costs for effective and better margins and also flexibility along with product efficiency with preferably cheaper and well-built computing power based on the situation demands. Pains would include the actuality that customers and end-users focus their attention on allotment of legal,

financial and operational resources while all these expenses can be considered to be under strategic or innovative aspects that could progress a customer's position in its relative industry.

The major gain creators and pain relievers for FaaS cloud computing gains concerning the project would be the cost efficiency, where billing is constructed on functions executed and memory used i.e. the pay-per-use model. Flexibility in scaling, the convenient accessibility and the speed in terms of time is also very efficient and effective. The pain relievers would be its services that are built in compliance with European data protection legislation. Implementation of services focus on operational ease with efficient and customer-centric platforms with high storage capacities.

More details regarding pains, gains, pain relievers, and gain creators can be observed in the figure.

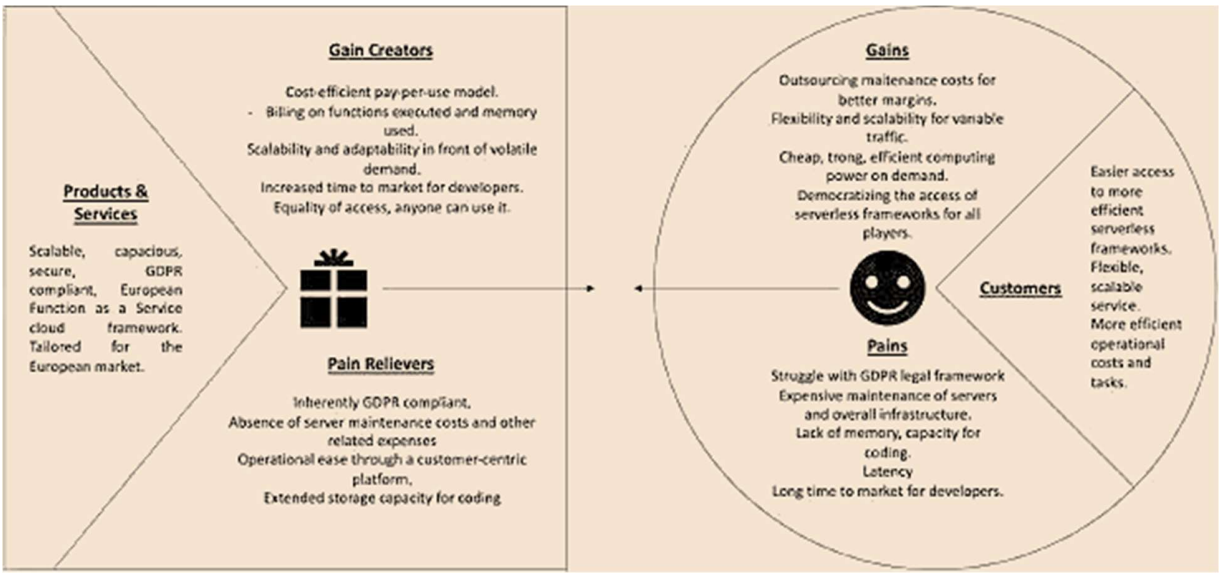


*Figure 2 - Value proposition*

# 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. 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 systems 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.

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[2] European Patent Office. (2019, September 25). EPO - *Intellectual property rights strongly benefit the European economy*. Retrieved December 9, 2021, from https://www.epo.org/news-events/press/releases/archive/2019/20190925.html

[3] European Commission*, Intellectual property action plan implementation*. (2021, September 6), Retrieved December 9, 2021, from https://ec.europa.eu/growth/industry/strategy/intellectual-property/intellectual-property-action-plan-implementation_en

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 inputs, 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 it 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.

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[4] GIFTTM, *Global Intangible Finance Tracker- an annual review of the world's intangible value*. (2019), https://brandfinance.com/wp-content/uploads/1/gift_2.pdf

[5] EUIPO, *Intellectual property rights and firm performance in the European Union*. (2021, February), https://documents.epo.org/projects/babylon/eponet.nsf/0/7120D0280636B3E6C1258673004A8698/$File/ipr_performance_study_en.pdf

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%).

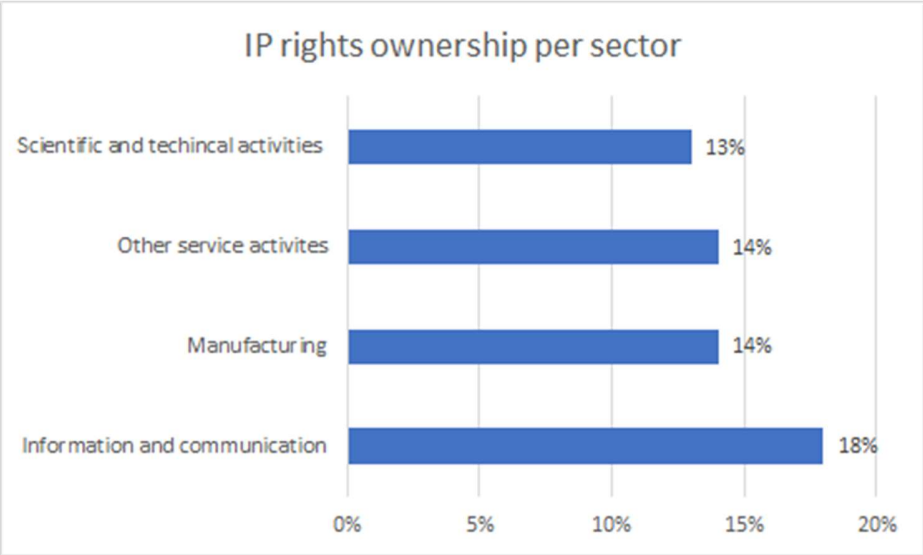


*Figure 3 - IP Rights ownership by sector*

## 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.

[6] EUR-Lex, *The general data protection regulation applies in all Member States from 25 May 2018* - EUR-Lex. (n.d.), Retrieved December 9, 2021, from https://eur-lex.europa.eu/content/news/general-data-protection-regulation-GDPR-applies-from-25-May-2018.html

## 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

**Issue 1:** 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 landscape of the cloud with respect to copyright.[7]

**Risk 1:** 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.

Probability: Low
Impact: Medium

**Issue 2:** "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.

**Risk 2:** Eventual disputes over IPR within the consortium for mainly copyrighted protected literary works.

Probability: Low

Impact: Low

**Issue 3:** The next question is regarding 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.

**Risk 3:** 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.[8]

Probability: Low
Impact: Medium

**Issue 4:** The scope of copyright itself is called into question in the cloud arena. There is an underlying 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

[7] Kurakar, L.T., *IP Issues in Cloud Computing*. (2021, September 15). Intellectual Property, IPR & Corporate Law Firm Chennai, Bengaluru. Retrieved December 9, 2021, from https://www.altacit.com/ip-management/ip-issues-in-cloud-computing/

[8] Ehle, K., *Copyright Infringement on User Generated Platforms*. (n.d.). Morrison Foerster. Retrieved December 9, 2021, from https://www.mofo.com/resources/insights/190122-copyright-infringement.html

works owned by others.[9]

**Risk 4:** Indirectly breaching the copyrights rules by displaying in an invasive or irresponsible way copyrighted material from clients. This issue is not commonly applicable for FaaS providers as much as for IaaS of PaaS providers.

Probability: Very Low
Impact: Low

**Issue 5:** 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 programme 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.[10]

**Risk 5:** 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.

Probability: Low
Impact: High

**Issue 6:** 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.[11]

**Risk 6:** Hackers could trick the cloud into storing confidential information and using it for their purposes.

Probability: High
Impact: Medium

**Recommendations**

[9] Kurakar, L.T., *IP Issues in Cloud Computing*. (n.d.). Intellectual Property, IPR & Corporate Law Firm Chennai, Bengaluru. Retrieved December 9, 2021, from https://www.altacit.com/ip-management/ip-issues-in-cloud-computing/

[10] Wejnert J., *Cloud Services Indemnification Promises and Pitfalls*. (2017, September 30). IPWatchdog.Com | Patents & Patent Law. Retrieved December 9, 2021, from https://www.ipwatchdog.com/2017/10/01/cloud-services-indemnification-promises-pitfalls/id=88602/

[11] Katrenko A., *Cloud Computing Attacks: A New Vector for Cyber Attacks*. (n.d.). Apriorit. Retrieved December 9, 2021, from https://www.apriorit.com/dev-blog/523-cloud-computing-cyber-attacks

1. 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.

2. 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.

3. 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.

4. Another option might be the contracting of cloud insurance for IPR violations both in the case of the software provider or the cloud provider. Defense coverage covers the associated costs of a defense 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.

5. 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.

6. 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 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 its services and should normally include a right in its standard terms to remove any data from its servers.

# 4. METHODOLOGICAL FRAMEWORK

The main focus of this first version of the report is the initial approach to the exploitation of the project outcomes, hence this deliverable sets up the general framework for approaching the exploitation of the identified assets as well as a preliminary methodology to be followed during the rest of the project lifespan and the project's commercialization strategy, with a focus on the business models of the exploitable results and exploitation plans.

The recommended methodology for selecting and adapting the PHYSICS business model will imply digging deeper into the granularity of the potential business models and monetization strategy based on the value proposition identified (i.e., PHYSICS Value Proposition Canvas). Thus, when refining and finalizing the Business Model Canvas, it will be necessary to further assess the potential revenue models that can be taken into account for PHYSICS solution based on the revenue streams and monetization strategy previously identified. In a later stage, it will then be critical to assess these potential revenue models in order to opt for the most fitting and viable ones by tracking KPIs (Key Performance Indicators). To achieve so, it is recommended to set at least one quantifiable measurement. Generating assumptions on the desired outcomes of that business model in a quantifiable manner (such as profit of X thousands or X users) and keeping track of the results obtained could give the opportunity to evaluate whether that business model is in line with the expectations and eventually of how much it differs either positively or negatively from what has been set as standard. After comparing expected/realized there is space for judgment over validation of that business model.

A more robust business validation of the solution will be finalized during the later stages of the PHYSICS project, based on its deployment and use by the partners. As part of the business validation of the solution, potential models will be explored and evaluated regarding the offering of the solution.

# 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 are going to be organized for PHYSICS project, the first one took place on the 29/09/21, with the purpose of being a collaborative session to draft the first version of an exploitable asset list and its consequent potential exploitation paths. Even before that an artefact analysis table was created to collect the first details about the artefacts and validated with the consortium. In addition to this activity, partners have also revised the individual exploitation plan (that was part of the proposal) considering the first year of PHYSICS project activities.

## 5.1 Outline of the exploitable results

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

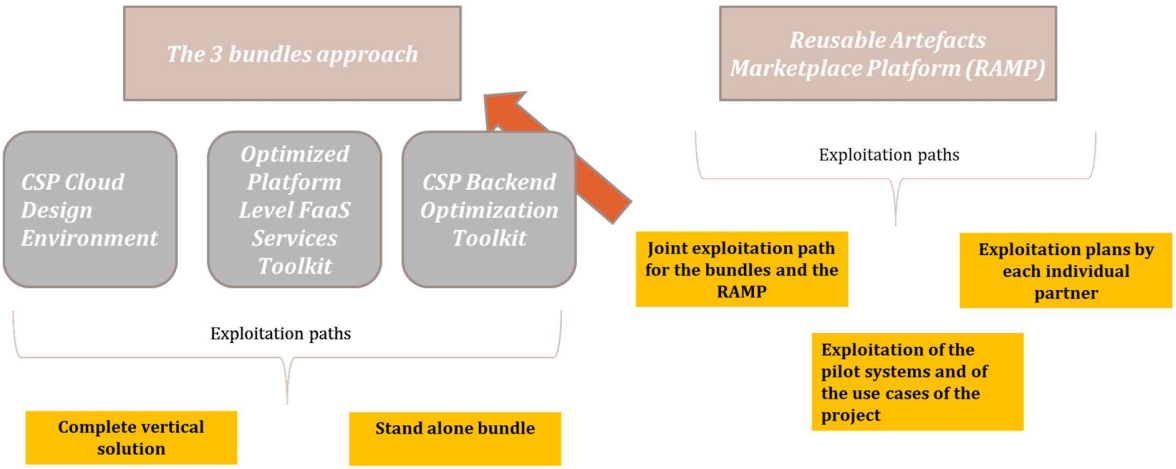


*Figure 4 - PHYSICS exploitable results*

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

"*CSPs to offer advanced cloud application design environments to their main end customers (Application Developers) to abstractedly create workflows of their applications, exploiting generalized Cloud design patterns for functionality enhancement with existing application components, easily designed and reused through intuitive visual flow programming tools*" - PHYSICS Proposal Technical Annex, sections 1-3, p3.

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

"*Platform-level functionalities to be easily incorporated by providers in order to translate the created application workflows to deployable functional sequences, based on the Function as a Service model, optimizing their placement across the Cloud computing domain and exploiting the computational space-time continuum as well as advanced semantics for the definition of a global service graph*" - PHYSICS Proposal Technical Annex, sections 1-3, p3.

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 European 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 final asset is the CSP Backend Optimization Toolkit, "*Provider-local resource management mechanisms that will enable providers to offer competitive and optimized services with extended interfaces offering local fine-grained control of elasticity rules and policies, while applying a holistic set of provider-local strategies based on a wide set of controlling techniques and tackling key aspects of multi tenancy*"- PHYSICS Proposal Technical Annex, sections 1-3, p3.

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[12] and Openshift[13] 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 either 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 in the focus of including the specific cross-layer individual artefacts of the project. It will incorporate reusable solutions across the various fields of PHYSICS, such as cloud patterns implementations, controller/optimizer algorithms, management schedulers, and more. This way it will

[12] Kubernetes, also known as K8S, is an open-source system for automating deployment, scaling, and management of containerized applications. It groups containers that make up an application into logical units for easy management and discovery. https://kubernetes.io/

[13] OpenShift is a family of containerization software products developed by Red Hat. Its flagship product is the OpenShift Container Platform — an on-premises platform as a service built around Linux containers orchestrated and managed by Kubernetes on a foundation of Red Hat Enterprise Linux. https://docs.openshift.com/

create additional exploitation opportunities for various stakeholders in the European ecosystem (application owners, cloud providers, external developers...) to access the reusable resources but also to become active contributors of such artefacts.

Furthermore, the RAMP will provide services and products such as PHYSICS Bundles Customization and Instantiation Services, Training and Consulting Services, Support services for the clients of the bundles and an Artefact marketplace.

Each artefact is defined as follows:

- **A code**: identifier (progressive number)
- **A typology**: service, hardware, software,... By the end of the first year of the project the categories below have been identified.

| | |
|---|---|
| SRV-00X | SERVICE |
| APP-00X | Web application / Development tool |
| SRV-00X | SERVICE |
| MTM-00X | Metamodel |
| NRD-00X | Node-red flow |
| CMP-00X | Component |
| DTA-00X | Data |
| ALG-00X | Algorithms and Models |

- **Keywords**: relevant keywords to best identify the artefact
- **Name** of the artefact (short and intuitive)
- **Description**: short summary of the artefact's performance as well as the innovation brought by it
- **Background**: information about what are the technologies/services/patent/copyright/IP behind the artefact's development
- **Lead partner**: main partner developing the artefact and specific contacts
- **Contributing partner**: who will support the development of the artefact
- **Planned components**: connection with prior technologies/ other PHYSICS artefacts this artefact depends from
- **Exploitation path**: how is this artefact going to be exploited? Sold as a stand-alone? Used to improve another product?
- **Barriers**: what is/will be preventing the exploitation of the artefact? Competitors? Patent?
- **Licensing potential**: standalone service, patent, tool, rent, etc..
- **Packaging/Dockering**[14]: how the artefact is packaged and made available to the users
- **Potential impact:** grade in a scale from 1 to 10

[14] Dockerizing is the process of packing, deploying, and running applications using Docker containers. Docker is an open-source tool that ships applications with all the necessary functionalities as one package. https://developerexperience.io/practices/dockerizing

- **Presentation**: how the artefact is going to be showcased
- **Links**: any useful link to help/support/show the artefact

RAMP Artefacts Description

- Artefact **SRV-001**: Named "In-Memory service", which is from the Service type, and is used for sharing large (large) state among functions. It is based on Pocket which uses Apache Crail[15]. The lead partner developing the artefact is UPM and there are no contributing partners. Also, this In-Memory service artefact will be integrated with the FaaS platform and will be exploited as an open source. One potential barrier for this artefact is that the pocket is not maintained anymore, changes in the code may take longer due to lack of support. Finally, the artefact will be made available to its users through a docker image, and presented with a video.

- Artefact **SRV-002**: Named "Co-allocation service", which is from the Service type, and will be used for providing a strategy for co-allocation of pods in a cluster. The lead partner developing the artefact is UPM and RHT is the contributing partner. Also, the Co-allocation service is connected to prior technologies: the co-allocation component. The output will be exploited as an open source. Finally, the artefact will be made available to its user through a docker image.

- Artefact **APP-001**: Named "Node Red Administration Panel", which is from the web application/development tool type, and will be used to manage nodes, flows and deployments of Node-RED[16] instances. Some background information (technologies, services, patent, copyrights, IP) about the artefact: angular, Node-RED, Docker. The partner developing it is GFT, and the contributing partner could potentially be HUA (to be confirmed). The artefact is connected to prior technologies: Node-RED, Serverless Function Generator (and probably everything else since its main entry to the system). It will be exploited as part of the Visual Workflow, Standalone, but integrated with Node-RED instance HTTP API. One potential barrier for this artefact is that the Node-RED extensions can be unreliable and there can be a need to replace them by GFT's own implementation. Finally, the artefact will be made available to its users through a compose file with docker images of angular app and node-red.

- Artefact **SRV-003**: Named "FaaS Converter", which is from the service type, is an Application programming interface Application programming interface (API) used to convert Node-RED flows to OpenWhisk FaaS. Some background information (technologies, services, patent, copyrights, IP) about the artefact: NodeJS, Express JS, Node-REd, OpenWhisk, Docker. The lead partner developing the artefact is GFT, and the contributing partner is HUA. The output is connected to prior technologies which are Node-RED and OpenWhisk. It will be exploited as part of the Visual Workflow, standalone, but integrated with Node-RED instance HTTP API. Finally, the artefact will be made available to its users through a docker image.

- Artefact **MTM-001**: This output is named "Resource Semantics", and its typology is unsure between specification and metamodel. This ontology will capture the different semantics of cloud resources and edge services and their connections in a structured format. Technologies/patent/copyright behind the

[15] https://crail.apache.org/
[16] https://nodered.org/

artefact's development are OWL, Tosca and Protege. The lead partner developing it is Byte and there is no contributing partner. Resource semantics has a connection with a prior technology or depends on another artefact which is T4.1 Inference Engine. Its exploitation path will be through open source as well as its licensing potential. Finally, the artefact will be made available through docker image.

- Artefact **SRV-004**: This output is named "Physics-orchestrator-interface" and is a service-type artefact. Its role will be to input parser and API for the Physics components. A technology/patent/copyright behind the artefact's development is Orchestrator. The lead partner developing it is ATOS and the project T4.4 will be contributing. Its exploitation path will be through open source as well as its licensing potential. Finally, the artefact will be licensed via open source (Apache 2.0).

- Artefact **SRV-005**: This output is named "Orchestrator" and is a service-type artefact. It will play the role of core components for meta-orchestrating functions and/or services. Technologies/patents/copyrights behind the artefact's development are Prometheus, Kubernetes, and OpenWhisk. The lead partner developing the artefact is ATOS and the project T4.4 will be contributing. Orchestrator will be exploited as a Standalone, as being part of the core platform and will be licensed through open source (Apache 2.0).

- Artefact **SRV-006**: This output is named "DevOps process for Node-RED flow as OW function", and is a service-type artefact. It will play the role of specializing the DevOps process for Node-RED flow as OW function. Technologies/patents/copyrights behind the artefact's development are DevOps, Node-RED and OpenWhisk. The lead partner developing the artefact is HPE and the HUA (T3.1) will be the contributing partner.

- Artefact **MTM-002**: This output is named "PHYSICS Application Ontology", and its typology is unsure between specification or metamodel. This artefact is a set of concepts definitions in the form of an ontology/specification for handling application related aspects such as app graph specification, app attributes, pattern attributes, etc. Technologies/patents/copyrights behind the artefact's development are Protege, OWL and JSON-ld. The lead partner developing the artefact is HUA, and INNOV and BYTE in the context of the overall PHYSICS semantic toolbox will be contributing. The artefact has connections with T4.1 Semantic Framework + Inference Engine, and also, it needs to be exploited by relevant processing flows of Node-RED created flows. Speaking of exploitation, its exploitation path will be done by sharing the ontology, by using it in the context of Linked Data, or reused in other ontologies/publications. Finally, this output will be licensed through open source and made available to the users via an OWL file.

- Artefact **SRV-007**: This output is named "Semantic Extractor", and is a service-type artefact. It is best described as a set of annotation mechanisms and relevant processing logic in order to extract the annotations from Node-RED flows and map them to the ontological concepts for triple creation. Technologies/patents/copyrights behind the artefact's development are Node-RED, OWL and JSON-ld. The lead partner developing the artefact is HUA and the project T3.2 will be contributing. The output has connections with Semantic Extractor, a prior technology it depends on or to be used in combination with. The output will be exploited through open source, and with the offering of flows in Node-RED repository. Finally, the artefact will be licensed via open source as well, and made available to the users via Node-RED flow and nodes created.

- Artefact **NRD-001**: This output is named “Patterns”, and is a Node-RED extension. This artefact is a set of created pattern implementations in order to enhance code reuse and application development. The lead partner developing it is HUA and WP3 partners will be contributing. Patterns will be exploited through open source, via the offering of flows in Node-RED repository and by the creation of images on dockerhub. The artefact will be licensed via open source, and will be made available to its users depending on the pattern implementation: they can be Node-RED flows, nodes or external container images in which the implementation will be based. Finally, there is an example of pattern implementation available from a conference presentation.

- Artefact **CMP-001**: This output is named “uShift”, and is a component-type artefact. It is best described as a low footprint single node OpenShift flavor optimized for the device edge. Technologies/patents/copyrights behind the artefact’s development are K8s and OpenShift. The lead partner developing the artefact is RHT and WP5 partners will be contributing. uShift has connections or must be used together with WP5, edge devices and is to be managed through Open Cluster Management. The output will be exploited through an open-source project, and integrated into Red Hat ACM. Some potential barriers to it would be the adaptation to different system architectures (ARM), or the even lower footprint requirements. It will be licensed in open source and made available to the users in Binary form. Finally, according to the partner, the potential impacts of uShift are low footprint, network constraints tolerance, edge devices targeting, consistent development and management experience with standard OpenShift. Here are links that present the artefact: *https://www.youtube.com/watch?v=QOiB8NExtA4* , *https://next.redhat.com/project/microshift/*

- Artefact **SRV-008**: This output is named “Inter cluster connectivity: submariner” and is a service (TBC)-type artefact. Its role is to connect different K8s resources (services) residing in different K8s clusters, in a secure way. Technologies/patents/copyrights behind the artefact’s development are K8s, OpenShift and VPN. The lead partner developing the artefact is RHT and WP 4 & 5 partners will be contributing. The artefact has connections or must be used together with WP5, edge devices and is to be integrated into OCM. The output will be exploited through an open-source project and integrated into Red Hat ACM. A potential barrier is competition, other technologies capable of doing similar things in a different way (ex: Cilium). This artefact will be licensed in open source and made available to the users as K8s operators. Finally, according to the partner, its potential impact is the ease of connecting applications living in different K8s clusters. Here is a link presenting the artefact: *https://submariner.io/*

- Artefact **SRV-009**: This output is named “Open Cluster Management” and is a service-type artefact. Its role is to orchestrate multi K8s clusters, including life cycle management for applications. Technologies/patents/copyrights behind the artefact’s development are K8s and OpenShift. The lead partner developing the artefact is RHT and WP 4 & 5 partners will be contributing. The artefact has connections or must be used together with WP5, edge devices, and integrates other components like submariner and uShift. It is also connected to the management of the applications deployment/policies across K8s clusters. The output will be exploited through an open-source project, extension of OCM and by integrating their enhancements into the downstream Red Hat version (RH, ACM). Potential barriers are the scalability limits regarding the number of edges. This artefact will be licensed in open source and made available to the users as K8s operators. Finally, according to the partner, its potential impact is the ease of managing distributed K8s clusters, and the deployment of applications on top of them. Here is a link that presents the artefact: *https://open-cluster-management.io/*

- Artefact **CMP-002**: This output is named “Local scheduling”, and is a component-type artefact. Its role is to schedule algorithms for efficient resource sharing between multiple tenants and optically manage resources for FaaS execution. Technologies/patents/copyrights behind the artefact’s development are Kubernetes, OpenWhisk, and Batkub/Batsim/Simgrid. The lead partner developing the artefact is RYAX and WP 5 partners will be contributing. The artefact has connections or must be used together with T5.2 scheduling algorithms components. The output will be exploited through open source, and there is a possibility for it to be integrated to RYAX products. Finally, this artefact will be licensed in open source.

- Artefact **CMP-003**: This output is named “Global Continuum Placement” and is a component-type artefact. Its role is to assist the decision making of efficiently selecting the right compute resources for the placement of the different tasks of the applications to be executed on a hybrid edge-cloud infrastructure. Technologies/patents/copyrights behind the artefact’s development are Python, Rest-API, and Batsim/Simgrid. The lead partner developing the artefact is RYAX and WP4 partners will be contributing. The artefact has connections or must be used together with T4.3 global continuum placement. The output will be exploited through open source, with a possibility to be integrated to RYAX products. A potential barrier would be the real-scale evaluation, thus the need to pass from simulation. Finally, this artefact will be licensed in open source.

- Artefact **SRV-010**: This output is named “Reasoning Framework” and is a service-type artefact. Its role is to match and reason between applications and available resources. The lead partner developing the artefact is BYTE and INNOV will be contributing. Finally, the output will be exploited as part of the Semantic Block (reasoning framework, applications graph, resources graph).

- Artefact **SRV-011**: This output is named “Performance Evaluation Framework'', and is a service-type artefact. Its role is to experiment management and implementations in order to evaluate serverless platforms, model creators for applications and performance issues. Technologies/patents/copyrights behind the artefact’s development are Node-RED and Docker Swarn. The lead partner developing the artefact is HUA and the project T4.2 will be contributing. The artefact is extended from H2020 BigDataStack Flexibench tool. The output will be exploited through open source, consulting services on benchmarking and through performance modeling. Finally, it will be licensed via open source (Apache 2.0).

- Artefact **MTM-003**: This output is named “Typical designed workloads for serverless performance issues”, and its typology is unsure between specification or metamodel. Its role is to provide workload descriptions that can be used as inputs for request generation, following specific patterns needed to test aspects of a serverless platform (e.g. hot/cold/warm). These workload descriptions will be used as inputs to the Performance Evaluation Framework (PEF) but can also be used as standalone. The lead partner developing the artefact is HUA and WP 4-5 partners will be contributing. It has connections or must be used together with Apache Jmeter Workload Generator and PEF is also included (but can be used as standalone). The output will be exploited through open source, and consulting services. A potential barrier would be the black box nature of FaaS platforms. Finally, this artefact will be licensed via an Apache license, and made available to the users as a Jmeter jmx file format.

- Artefact **MTM-004**: This output has no name, and its topology is unsure whether it is specification or not. Its role is to adapt benchmarks from FunctionBench in order to be compatible with Openwhisk as well as scripts to automate setup of OW. A technology/patent/copyright behind this artefact’s

development is FunctionBench Benchmark suite. The lead partner developing it is RYAX and no other partner is contributing. It can be used as benchmark functions in the context of T4.2 and PEF. The output will be exploited through open source. Finally, this artefact will be licensed via open source and made available to the users via compose file, setup scripts and adapted code.

- Artefact **DTA-001**: This output is named "Datasets produced from the PEF experiments", and it is a data-type artefact (unsure whether data is too general). Its role is to produce raw data by the experiments, and the data will be shared/reused by the community. All the partners will be leading this artefact. Finally, this output will be exploited by uploading it into Zenodo, and by increasing citations in project related publications.

- Artefact **ALG-00**:1 This output is named "Performance Models derived from datasets of PEF", and it is an algorithms/models-type artefact. Its role is to use the raw Data produced by the PEF to train performance prediction models that can be later queried during the runtime management of a platform. These models will be packaged in a docker container so that they can be queried independently of the remaining PHYSICS platform. Technologies/patents/copyrights behind this artefact's development are Docker and GNU Octave. The partner leading the development of this artefact is HUA, with the contribution of WP4 and WP5 (still unsure). It can be used as standalone as docker image but can be integrated into PEF as well. Finally, this output will be exploited by scientific publications, increasing the reuse of data, and the ability to offer on-demand model creation services.

- Artefact **NRD-003**: This output is named "PHYSICS created nodes and flows", and it is a Node-RED extension. Its role is to support tasks such as semantic annotation, pattern implementation, security, etc. A technology/patent/copyright behind this artefact's development is Node-RED. The partner leading the development of this artefact is unsure between HUA or GFT, and WP3 partners will contribute. Also, it has connections with prior technologies as it is included in the Design Environment. This output will be exploited by an inclusion in Node-RED flows and nodes repository. Finally, the artefact will be licensed via open source and made available to the users through Node-RED based packaging.

## 5.2 Commercialization Strategy

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 the Harokopio University 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 is 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 accordingly 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.

# 6. EXPLOITATION PLANS

## 6.1 Individual Exploitation Plans

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.

**Individual Exploitation Plans**

- **GFT**: GFT is PHYSICS vertical solution that has the aim of integrating the project's tools within the digital innovation labs of the company incorporating AI, Cloud, IoT, and Big Data solutions in a variety of applications. The outcomes of this project will be exploited by GFT to broaden the scope of its services. Without changing its sales and marketing channels GFT will be able to broaden the scope of its services and to offer those products and services to its existing accounts and at the same time, it can launch private cloud instances based on the PHYSICS vertical solution in order to promote and sell it to private sector clients.

- **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. At this time, the Atos Edge Computing Box Software Stack, Atos Canopy Orchestrated Hybrid Cloud, and Atos Codex have been selected as particular targets to benefit from the PHYSICS study.

- **HPE**: HPE, part of HPE Pointnext A&PS (Advisory & Professional Services), offers a portfolio heavily focused on Hybrid Cloud-enabled and Edge-connected solutions, with a particular focus on cybersecurity. The projected solution architecture emerging from PHYSICS will be presented as a foundation for numerous of the above-mentioned customized solutions and will fit well into the HPE

portfolio. PHYSICS, in particular, will provide essential know-how to HPE's skills and methodology in the development of innovative Edge-to-Cloud Design tools and procedures aimed at Edge-to-Cloud scenarios. HPE thinks that its involvement in PHYSICS, in combination with HPE's engagement in other H2020 innovation initiatives like ACCORDION and CHARITY, would considerably increase its revenue potential in the Edge/Cloud/IoT domains. Overall, because the Pointnext unit's goal and focus are mostly on technology advising and consultancy, rather than product creation, HPE Italy's primary use of PHYSICS findings will not be dependent on the production of specific goods. Instead, it will look at the Pointnext advisory service 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.

- **REDHAT**: Redhat is working from upstream initiatives to productizing 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.

- **FUJITSU**: FUJITSU will apply the technology produced in this project and the knowledge obtained to solve use cases and build business-relevant solutions in the manufacturing and automotive industries, with a focus on offering extended services from Germany or Europe. Furthermore, Fujitsu will use its newly acquired knowledge to create marketable FaaS services and/or products.

- **RYAX Technologies:** RYAX Technologies intends to capitalize on the project's findings by developing orchestration upgrades for real-large size datasets delivered on heterogeneous HPC testbeds. This objective is part of Ryax's mission of providing orchestration engines for contemporary hybrid infrastructures. The company anticipates that deploying our suggested additions on a broad scale utilizing actual datasets and testbeds would verify the middleware while also promoting and advertising the firm and its mission to potential future clients. The focus areas include Data Science Industrialization, Data Analytics Workflow Orchestration, and Hybrid Infrastructure Management from Edge to HPC. Also, the approach to exploitation is built on open-source software with proprietary features for better functionality. It includes selling licenses as well as providing support (training, maintenance, and consulting services).

- **InQBit:** InQBit’s portfolio includes a diverse range of innovative products and services in the following areas:
    - a) software design and software deployment
    - b) networking solutions
    - c) advanced security services (such as security evaluation, penetration testing, risk analysis, and risk management)

  - d) security solutions (such as identity management, confidential computing, and further)
  - e) forensics and code analysis/review
  - f) application shielding, runtime application self-protection (RASP), code hardening
  - InQbit's involvement in PHYSICS will help the firm maintain its competitiveness and significant advance in the field of secure cloud service design and deployment. InQbit also promises to bring the technology and know-how gained and created as part of this initiative to the international market, notably the US market, through the company's strong business and distribution connections with US enterprises.

- **iSPRINT:** The project's outputs will be used in two ways by Innovation Sprint (iSPRINT). To begin, iSPRINT intends to improve its key business product, Healthentia, by including cloud and edge computing technologies based on the FaaS/Serverless Computing paradigm. Specifically, the company intends to be future proof in terms of scalability and performance when it comes to allowing sophisticated online AI prediction models for end-users of the digital medicine's solutions using the PHYSICS platform. Second, iSPRINT intends to verify its product in a FaaS use case by experimenting with the performance and flexibility benefits of serverless computing. Speeding up the certification of their RWD platform as an AI-based and cloud-based medical device based on project activities (CE mark) is considered another goal.

- **INNOV**:
  - A) PHYSICS Tool Development & Consulting: INNOV is involved in the design, definition, and creation of the semantics for internal data transfers in the PHYSICS system, as well as the development of the inference engine. As a result, INNOV will have a thorough grasp of the PHYSICS FaaS middleware and tool. INNOV is planning to use the latter for the development of its own FaaS solutions in other research, commercial, and consulting projects.
  - B) Technology transfer and FaaS training: INNOV will use PHYSICS results to expand its technology transfer and training portfolio with advanced FaaS cloud concepts and serverless computing case studies.
  - C) Joint Exploitation of PHYSICS Open Source: INNOV will actively participate in PHYSICS joint exploitation initiatives, including the provision and monetization of value-added services (e.g., training, solution integration, technical support) based on the project's open-source outcomes.

- **CYBELE:** will leverage the PHYSICS proven technology to power its current and future commercial solutions for greenhouse growers based on edge computing and will demonstrate it in yearly presentations to 50-100 farmers. Furthermore, the PHYSICS solution might be extended to our forestry/breeding goods.

- **HUA:** will use its involvement in PHYSICS activities and outputs to expand its research portfolio of tools derived from R&D in order to give advice to the Greek public and commercial sectors. T4.2's Performance Evaluation Framework and WP3's pattern development are also potential tools for this purpose. Reusability, adaptation, or expansion of the offered patterns, particularly for the latter, maybe a direct purpose of exploitation. Furthermore, HUA will use the project's data to better its academic operations (including pre and post-graduate courses enrichment). It has expanded its

Web Engineering M.Sc. program (which also receives a significant share of the institution's externally obtained financing) with a new course on Cloud services development, which includes specific FaaS-based ideas, patterns, and resource management methodologies. Other exploitation goals include the creation of high-quality articles (three conferences have already been held in the project's first year) and contributions to existing open-source repositories (e.g. node-red flows repository). Furthermore, HUA has used its experience and research in PHYSICS to participate in the SPEC Cloud WG, which has resulted in a number of high-profile possibilities (such as the participation in the 20201 Dagstuhl Seminar on Serverless Computing). Further efforts, such as the staging of hackathons, will be undertaken in order to involve people outside of the project and solicit contributions for project development.

- **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.

- **BYTE:** BYTE's exploitation goal is twofold: (i) it aims at exploiting the project's results in order to improve its existing products and services based on PHYSICS outcomes; (ii) it aims at using R&D projects in order to validate potential new products and services. The outcomes of the project will be utilized in the enterprise applications and services offered to customers in manufacturing, retail, healthcare, hospitality, etc. Through PHYSICS BYTE aims to develop an MVP (Minimum Viable Product) of new FaaS functionalities and validate it against business requirements.

- **UPM:** 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: First, 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.

## 6.2 Joint Exploitation plan

This path will ensure 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 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 (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 may be amplified, since in many cases, external audiences may be interested in single artifacts generated.

- Multiple business models may be followed by the RAMP, for example combining open-source artifacts 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**, that 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[17], SmartFactory-EU[18] 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.

## 6.3 Exploitation of the use cases of the Project

These use cases will be used to validate the project's developments (DFKI/FTDS, iSPRINT, CYBEL) and will provide early showcases 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[19]. 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

[17] https://www.gaia-x.eu/
[18] https://smartfactory.eu/
[19] https://www.dfki.de/en/web/technologies-applications/living-labs/smartfactory-kl

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[20]). 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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[20] https://healthentia.com/

# 7. BUSINESS MODELS FOR SOLUTIONS AND USE CASES

## 7.1 Business Models for Solutions

### 7.1.1 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[21] at a CAGR of 32,3% with the industry breakdown as follows[22]:

- 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**

[21] *PHYSICS Technical Annex, Sections 1–3*. (2020)

[22] Journal of Cyber Policy, *Function-as-a-Service (FaaS) Market Size Worth USD 31.53 Billion at CAGR of 32.3%, By 2026 – Report and Data*. https://journalofcyberpolicy.com/2021/10/01/function-as-a-service-faas-market-size-worth-usd-31-53-billion-at-cagr-of-32-3-by-2026-report-and-data/

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%.[23] 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

[23] Weissberger A., *Reports and data: Telecom cloud market*. (2021, September 12). Technology Blog. https://techblog.comsoc.org/2021/09/11/reports-and-data-telecom-cloud-market-to-grow-at-cagr-of-19-7-through-2026/

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.

### 7.1.2 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[24], Google Cloud Functions[25] and Microsoft Azure Functions[26]. 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[27], Fission[28] 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

[24] https://aws.amazon.com/lambda/
[25] https://cloud.google.com/functions
[26] https://docs.microsoft.com/en-us/azure/azure-functions/
[27] https://www.openfaas.com/
[28] https://fission.io/

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%)[29], 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

[29] Synergy Research Group, *Synergy Research Group market research*, October 28th 2020. https://www.srgresearch.com/articles/amazon-microsoft-google-grab-the-big-numbers-but-rest-of-cloud-market-still-grows-by-27

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).

### 7.1.3 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 somewhat 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 monetisation 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).

## 7.2 Business Models for specific use cases

### 7.2.1 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[30], DoctoLib[31] and the National Health Service[32]. 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[33]. 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

[30] https://www.liviconnect.com/
[31] https://www.doctolib.com/
[32] https://www.nhs.uk
[33] Statista, *Global digital health market size 2019–2025 forecast*. https://www.statista.com/statistics/1092869/global-digital-health-market-size-forecast/

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.

**Value proposition of PHYSICS**

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.

**Competitors:**

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.

### 7.2.2 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.

**Value proposition of PHYSICS**

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.

**Competitors**

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)

### 7.2.3 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 labour 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[34].

**Value proposition of PHYSICS**

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.

**Competitors**

[34] GVR, *Smart Manufacturing Market Size, Share & Trends Analysis Report, 2021-2028* (May, 2021), Grand view Research. https://www.grandviewresearch.com/industry-analysis/smart-manufacturing-market

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).

**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

This task 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. It will receive feedback from WP6 experimentation, T7.1 and T7.2 and formalize it in a manner suitable to be applied by external entities in their specific cases of PHYSICS adoption. It will provide key guiding material and experiences achieved for usage in the context of the reuse and sustainability of the bundles following the project end, the context of the RAMP, as well as their usage in wider or individual context beyond the project use case domains and cases. It will receive and integrate the feedback from the external audiences regarding the process and potential enhancements with regard to the process automation, necessary level of abstraction or knowledge barrier etc. from the two Impact Intensification periods. It will also include lessons learned, potential final modifications needed, future scope and adaptations needed for the post project exploitation phases. The activities of T7.4 Adoption Impact and PHYSICS Handbook will begin in M16.

## 8.1 Handbook elaboration methodology

To develop a usable handbook, the project will follow a clear methodology linking innovation, dissemination, exploitation and technical activities. The results will be included in D7.8 PHYSICS Handbook (M36) with instructions not only about how to use project results, but to replicate them in several domains different from the project use cases. Furthermore, it will contain information about how such a solution may impact on businesses and the benefits of its adoption.

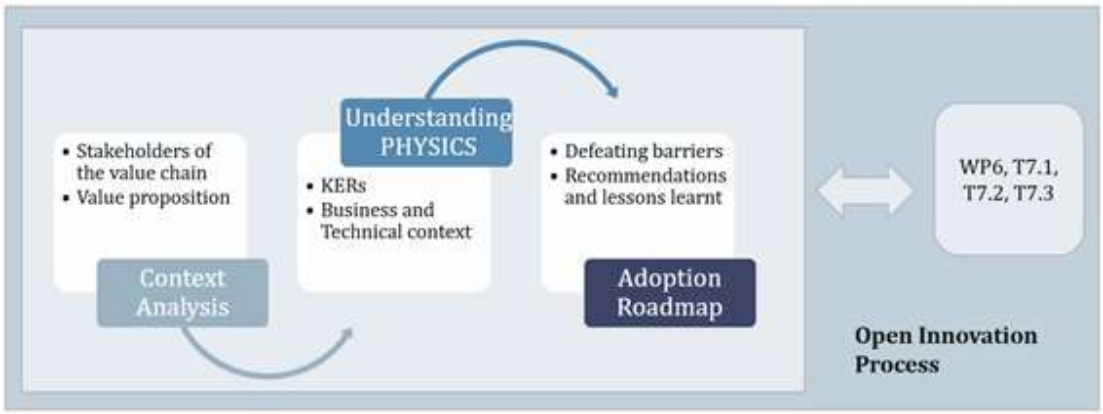


*Figure 5 - PHYSICS handbook roadmap*

According to this, the activities for developing the PHYSICS handbook will be structured into three main pillars:

1. Highlight PHYSICS benefits: it is important to identify all relevant actors in the value chain, developing the correct messages for the involved stakeholders, mapping them with the proper offering. This will be done in conjunction with the dissemination and exploitation activities. Furthermore, PHYSICS aims to follow an open innovation process involving stakeholders since early stages of the project through different open consultations, questionnaires or conducted interviews. In this way, PHYSICS approach from a business and technical perspective can be validated and relevant inputs will be gathered to define the adoption roadmap according to real market needs.

2. Adoption roadmap: not all project results will be marketable at the same time or will have the same market value. For this reason, this activity will be performed in close collaboration with the exploitation and innovation ones to identify the most promising exploitable results and their time-to-market. In this way, the handbook will present adoptable results and the appropriate timings according to the go-to-market strategy for the project.

3. Maximise impact through PHYSICS adoption: not only about the replicability of results under the same domains of the project use cases, but also in other domains where such a solution can provide benefits for its users. Outputs of WP6 will be used to develop the appropriate set of guidelines, including recommendations and best practices.

Although this task will not officially start until M16, the consortium has already identified some actions than can be performed in advance:

Before M12:

- Identify and categorize stakeholders' groups, as part of T7.1 activities.
- Identify PHYSICS proposition for these groups within T7.2.

After M12:

- Once the results of these activities are available, different conducted interviews will be performed using the consortium networks. For that, different questionnaires, according to the different categories of stakeholders, will be elaborated. Results will be analysed to provide feedback to technical work packages and to update the project exploitation plan.

# 9. CONCLUSION

Based on the output from D2.1 which reviewed the FaaS market to evaluate the potential of the Cloud Computing Service, and identified the most pivotal areas to address, as well as the critical characteristics of FaaS to develop, to exploit market trends and growing demands predicted over the foreseeable future, Deliverable D7.5 serves to assess the business innovation and develop viable exploitable plans for the PHYSICS solution to operate successfully and sustainably.

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 WP2. Several different exploitation paths were identified and analyzed which over the long run in the continuation of the project will serve to draw further insights on the most suitable ones that can ensure the sustainability of the project. The combination of these efforts and the strategy defined in Section 2.2.1 were leveraged in the generation of a set of business models as possible ways towards sustainability and outreach beyond the project phase, both for the project UC applications and the technical exploitable items. A first draft of a methodology to validate these business models was performed in this report in order to determine their viability and those with a higher score will be used as a guide to refine individual and joint exploitation plans. All these inputs will be further revised and iterated in the later phases of the project but D7.5 serves as a basis in the process of deriving key insights for all the partners within the project.

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. De facto, Cloud computing is in many terms still a relatively new technology, leading to the fact that legislation is often lagging behind the current state of the technology. Thus, specific recommendations are given to address the mentioned issues, allowing the PHYSICS innovation solution to freely operate. Further, this part of the report discusses the importance of IP rights for modern day businesses and their business models. This constellation makes a thorough analysis of the IP rights situation, critical for the successful implementation of the PHYSICS solutions. As highlighted, the legal situation is constantly subject to changes, as institutions like the EU Commission design new legal frameworks for the most recent technology.

Looking at the opportunities and solutions, research partners aim at developing exploitable outcomes through PHYSICS. 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. In this sense, the Cloud Design Environment is designed for CSPs that lack advanced workflow definition, the Optimized Platform Level FaaS Services Toolkit targets CSPs who wish to extend their services from IaaS to FaaS, and the Backend Optimization Toolkit focuses on the CSPs that wish to enrich their currently sophisticated offering. On the other hand, the RAMP aims at bringing contributors and buyers from the cloud computing environment around one central artefacts marketplace. All these individual outcomes will come with additional services such as coaching and consulting for implementation and use.

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 current use cases will evolve, however, at this point they already serve as a point of reference in the development of innovative solutions. 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.

Regarding the market situation, the overall Cloud computing and FaaS market segment are rapidly growing and have tremendous potential to be applied across various industries. More specifically, the PHYSICS project focuses on eHealth, Smart Agriculture and Smart Manufacturing. Integrating cloud computing

capabilities and FaaS more specifically in these areas allows current developments to function with larger amounts and more accurate data and an opportunity to migrate existing technologies to cloud. The market for FaaS is highly competitive, with both leading cloud providers such as AWS and Microsoft who offer solutions in a wide range of industries, as well as smaller cloud providers whose focus is rather on a few sectors particularly. The European landscape is rapidly evolving as it hosts many startups working on cloud-based solutions in the three sectors of the PHYSICS project.

Closing, this deliverable will be directly connected to 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. It will thus formalize the findings of Deliverable D7.5 in a manner suitable to be applied by external entities in their specific cases of PHYSICS adoption.

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