PHYSICS

oPTIMIZED HYBRID SPACE-TIME SERVICE CONTINUUM IN FAAS

D7.7 – BUSINESS INNOVATION, EXPLOITATION PLAN AND HANDBOOK ACTIVITIES V3

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CONTRIBUTING PARTNERS

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

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LIST OF ABBREVIATIONS

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

EXECUTIVE SUMMARY

The present D7.7 report describes the final version of the Exploitation, Business Innovation Development Plans and Handbook activities of PHYSICS project, with the updated contributions of all partners integrated in a coherent vision. The Innovation Management is integrated in this document as well as an overview of the activities that were brought to the Handbook.

This deliverable presents up the updated approach and methodology that has been used during the project lifespan and the project's exploitation strategy, with special focus on the project's market platform, the identification of the exploitable items, the solutions/services that are provided, the business models and the initial version of the exploitation agreement among the partners.

The purpose of the deliverable is to present 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 risks arising from the fact that legislation is still lagging behind the current state of the technology when it comes to cloud computing are highlighted and discussed in terms of their impact and probability to occur.

As part of the exploitation strategy of the project, both joint exploitation and individual plans were revised. For the joint exploitation activities, an updated version of business models and exploitation plans were developed regarding the PHYSICS platform and marketplace.

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

Lastly, the D7.7 findings set the basis for T7.4 - Adoption Impact and PHYSICS Handbook, which has been developed in the last year of the project and delivered in M36. The Handbook contributes to increased adoption of project outcomes that address the context, requirements and advancements of evolving PHYSICS technologies and supporting environments through a set of recommendations and best practices.

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1. INTRODUCTION

The present D7.7 report contains the final version of the **Exploitation & Business Innovation Development Plans** of the project, the progress made in the innovation management activities and the action undertaken in the development of the PHYSICS handbook. The main focus of this final version of the report is the development of exploitation agreement and finalization of the activities toward individual exploitation.

This deliverable covers the approach and the methodology followed during the last year of the project lifespan and the project's exploitation strategy, with special focus on the project's market platform, the concretization of the exploitable items the business models and future strategies of the services of the market platform.

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

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

In addition to that, to be sure that the exploitation has reached a relevant audience, the project consortium has finalized in December 2023 the second impact intensification period, in which efforts were further pursued to increase the external involvement in the project activities, finalizing the product availability following pre-market analysis, recommendations, exploitation plans and PHYSICS handbook. In order to reach this result, three hackathons have been organized, with a pool of selected participants to test the PHYSICS platform and give feedback.

The final internal exploitation workshop was organized in June 2023 to finalize the alignment among the partners towards the finalization of the exploitation strategy.

Two external workshops about the three-project pilots have been held in 2023, to present and share more hands-on results and collect feedback from experts. A stronger work about innovation potential has also been performed and integrated in this document.

2. FINAL MARKET ANALYSIS

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

2.1 SWOT Analysis

The SWOT analysis performed below was aimed to assess and analyze the strengths, weaknesses, opportunities, and threats of FaaS both for the developers and for serverless providers on the other hand. The aim of conducting this analysis is to define the pros and cons of this cloud computing model in the FaaS providers' shoes such as AWS Lambda and Microsoft Azure and in the customer side (developers for businesses), while foreseeing the main drivers through an outlook of the threats and weaknesses that could potentially impact players on both sides (developers and providers) (More on this in D2.1).

Figure 1 - SWOT analysis

2.1.1 Strengths

Embracing serverless cloud computing, facilitated by Function as a Service (FaaS), brings forth heightened efficiency, simplicity, and productivity for businesses. A key advantage of FaaS lies in its liberation from the constraints of underlying infrastructure. The surging demand for asset-light and serverless infrastructural approaches has fueled an increasing need for FaaS providers in today's progressively digitalized landscape, reshaping traditional businesses and industries. However, this necessitates FaaS providers to possess robust internal capabilities and deploy virtually foolproof technology to ensure the seamless operation and quality of their services.

Moreover, serverless cloud computing providers have successfully optimized their products to operate seamlessly and rapidly, even under a substantial influx of requests, facilitating automatic and swift scaling. These FaaS providers bear the responsibility of managing scaling aspects, alleviating a significant burden for businesses. Another factor propelling the rapid growth of FaaS in the cloud computing market is its capability for swift deployment. Businesses benefit from reduced time between project ideation and execution, enabling easy deployment of a given service across various contexts. Serverless cloud computing is also characterized by its flexibility and reliability; the provider handles the configuration and execution of applications, ensuring efficient code execution.

Furthermore, the adoption of a pay-per-use pricing model translates to cost savings for businesses. This model eliminates expenses associated with server acquisition, installation, maintenance, and operating system management, aligning more closely with the actual consumption levels of the service. It streamlines the selling and billing processes for commercial departments, fostering better cost management for end-users. With increased traffic, effectively deploying and executing functions becomes a significant challenge for serverless cloud computing providers. Automatic scaling is a critical success factor in this domain, and industry leaders such as AWS Lambda and Azure excel in meeting the demand, automatically adjusting capacity to maintain steady and predictable performance at the lowest cost. Fundamentally, FaaS minimizes administration overhead and constraints. Going serverless relieves businesses of server management responsibilities and the need to hire specialized infrastructure management staff, resulting in cost savings and reduced complexity. The leading players in the FaaS segment have deployed products that ensure high availability across various coding languages. Despite the serverless approach, these products support coding in any language required, including HTML, Java, Node.js, Python, and more. Additionally, open-source serverless frameworks are widely available and developed, offering the advantage of deployment on any infrastructure. Customers benefit from updates and improvements without the need for technical interventions.

2.1.2 Weaknesses

FaaS cloud computing, while advantageous, grapples with security vulnerabilities like function event data injection and insecure configurations, posing risks to businesses considering a serverless approach. Addressing these issues is crucial to foster trust in serverless adoption.

Latency emerges as a significant challenge in serverless computing, impacting the execution phase. Market players should focus on enhancing function efficiency to mitigate latency issues, representing a key area for improvement. Function execution in FaaS encounters constraints beyond latency, with limitations in coding size due to memory constraints. This aspect hinders the seamless execution of functions, necessitating attention for smoother operations. Vendor lock-in poses a potential drawback, restricting businesses to a single cloud provider and diminishing operational agility. Overreliance on external vendors for critical data management intensifies the challenge of reclaiming control, emphasizing the need for careful consideration during vendor selection.

Despite an appealing pricing model, businesses must diligently monitor and mitigate potential operational costs, including overhead and retries, to ensure optimal performance in FaaS. On the vendor side, the cloud computing market faces challenges for new entrants due to mainstream adoption and the dominance of existing players. Intensifying competition, including the entry of giants like Alibaba, characterizes the cloud computing industry as a red ocean, making it challenging for newcomers to establish a foothold.

2.1.3 Opportunities

Consider the vast market potential across growing industries and the overarching trend of Industry 4.0. Rapid advancements in technologies like Machine Learning, AI, Big Data, IoT, and 5G are opening substantial growth avenues for Function as a Service (FaaS).

A key driver is the integration of FaaS into emerging business models, accelerated by the COVID-19 pandemic. Sectors such as healthcare, leveraging enhanced data usage, medical research, and cost reduction, are witnessing significant FaaS-driven growth. The forecasted exponential expansion of the e-Health sector, driven by cloud technology, highlights the potential for FaaS in smart agriculture and manufacturing, fueled by IoT and large-scale data processing needs.

The FaaS pricing model translates into substantial cost savings for service providers, directly benefiting consumers in various domains like mobile apps, streaming platforms, storage services, and web applications. Financial institutions stand as another crucial avenue for FaaS adoption. Widely embraced for automating routine operations and cost reduction, FaaS technology aligns seamlessly with the increasing digitalization investments in the financial sector. The expanding demand for FaaS services is a natural consequence of this digital transformation. In conclusion, aligning FaaS services with GDPR compliance enhances their appeal to Small and Medium Enterprises (SMEs). SMEs, often grappling with GDPR complexity, find GDPR compliance challenging. Offering GDPR-compliant FaaS services addresses this concern, making FaaS an even more attractive solution for SMEs, contributing to a broader market adoption.

2.1.4 Threats

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

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

2.2 Porter's 5 Forces[i]

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

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

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

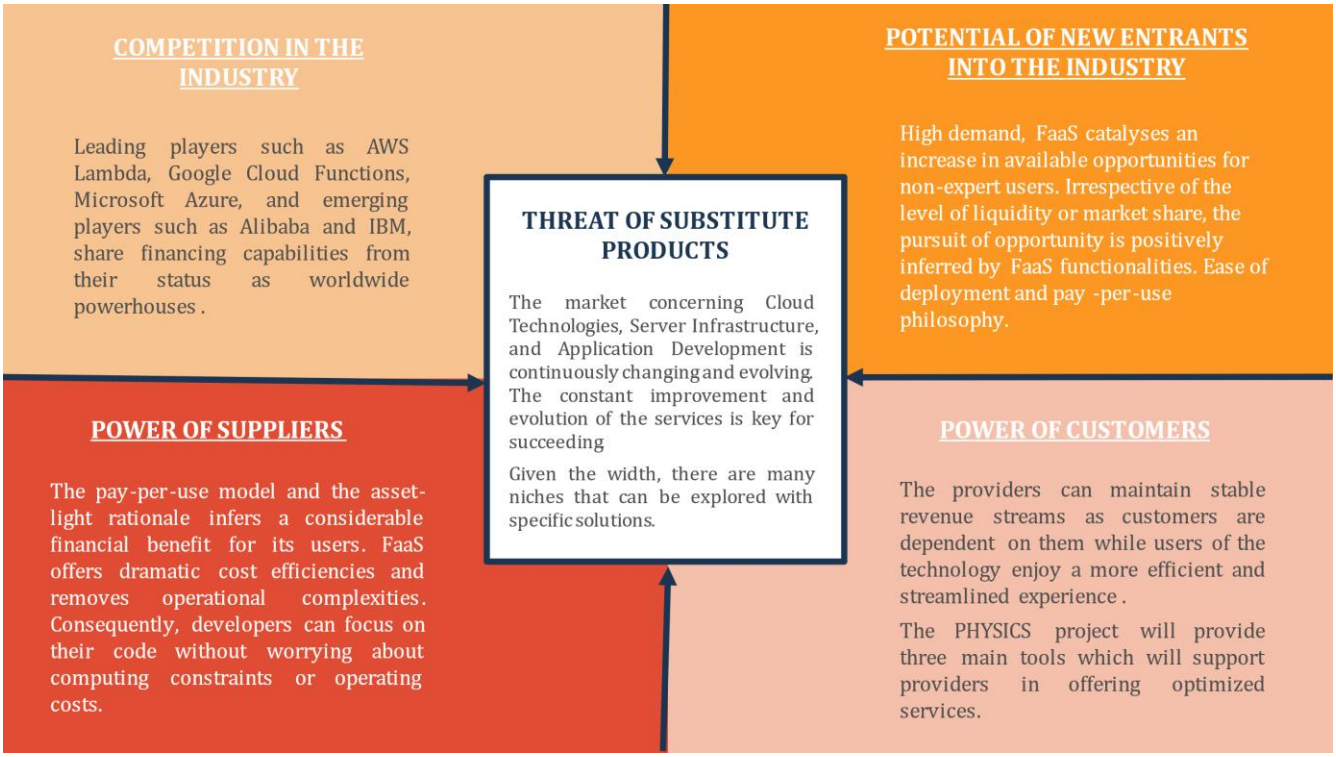


Figure 2 - Porter's 5 forces analysis

2.3 PESTLE

A PESTLE analysis studies the key external factors (Political, Economic, Sociological, Technological, Legal and Environmental); it is a technique that considers the variables of the external environment that have the greatest impact on the future impact. It is crucial in this phase to understand how the main variables of the environment can act on the future of the business, how they change and how they interact with one another. Variables should not be considered as separate but interdependent entities. After reviewing the previous work, it was noted that it is still updated. You can read more in D7.6.

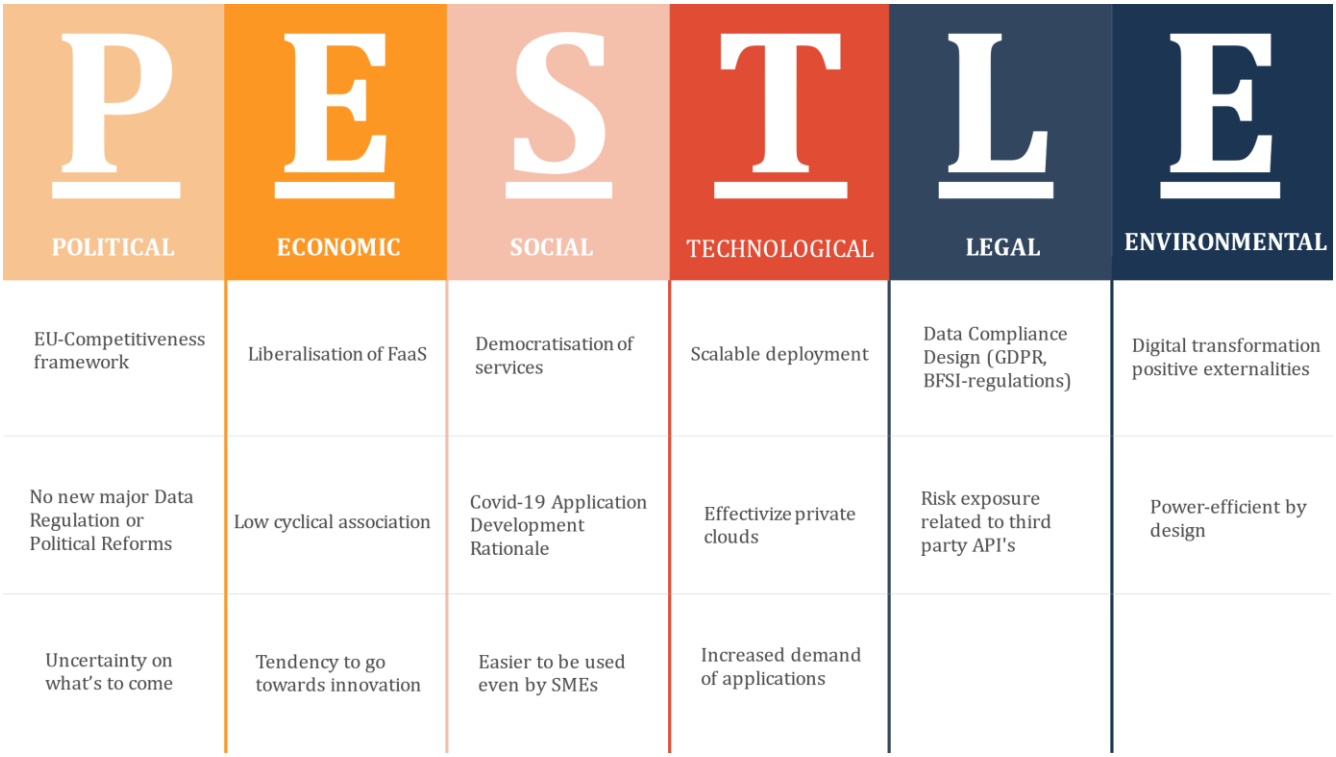


Figure 3 - PESTLE analysis

2.4 Summary of the Value Proposition of PHYSICS

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

- Cloud application design environment based on the FaaS model, which embeds a rich palette of available annotations (to be exploited by the platform services as developer directives) and ready-made reusable design and functionality patterns that can be easily dragged and dropped in the application, be combined with custom application logic, and enrich its functionality. The environment also undertakes the management, building and testing of the created application flow.
- Platform services that aim to undertake the final deployment to one or more operational clusters, while exploiting the cloud/edge interplay and the concept of space-time continuum (combining location and duration of execution). Platform services undertake the role of orchestrating the application execution based on the developer directives and needs.
- Infrastructure level services that aim to optimize the local operation of each cluster, collaborating with the platform services in order to abide by the directives of the developer (expressed interest in terms of importance of a specific application component, optimization etc.) The project pilot use cases cover a wide and diverse range of available edge resources, spanning from small IoT sensors and mobile related devices in eHealth, to medium size servers in the Smart Agriculture and more powerful Edge nodes in the case of Smart Manufacturing.

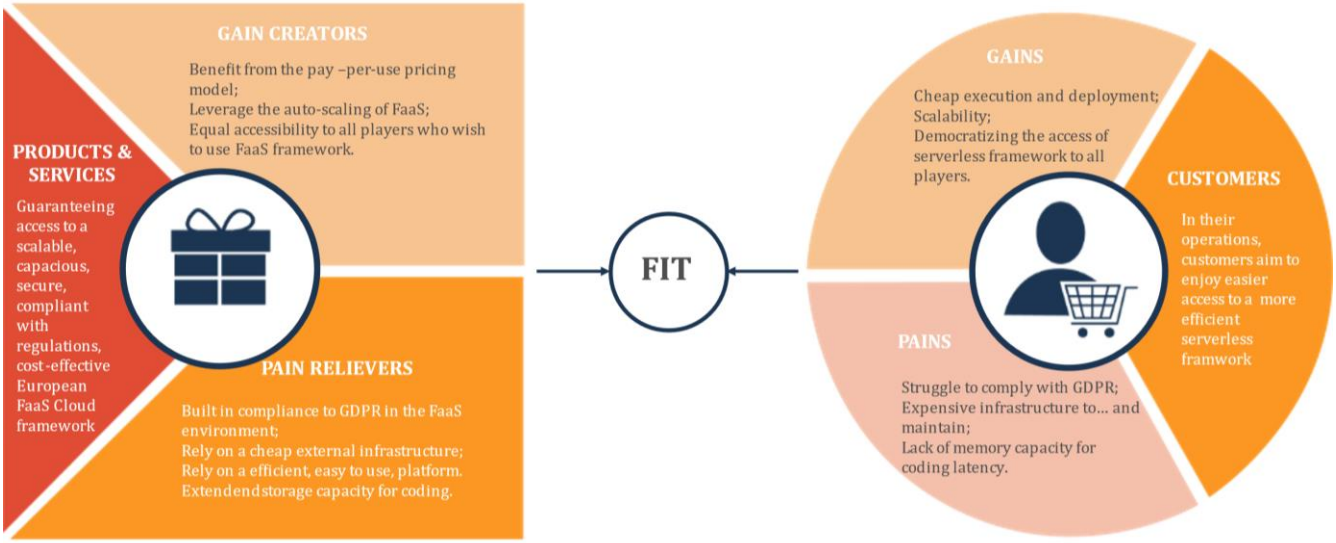


Figure 4 - PHYSICS value proposition

3. INTELLECTUAL PROPERTY RIGHTS ANALYSIS

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

In the EU alone it accounts for as much as 45% of the GDP of the member states, translating into a money value of € 6.6 trillion.[ii] 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.[iii] Furthermore, the action plan also addresses IP issues regarding the digital service act, including the cloud computing sector.

3.2 Key Points about IP Rights in a cloud computing environment

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

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

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

3.3 Why are IP Rights fundamental for Business success?

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

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

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

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

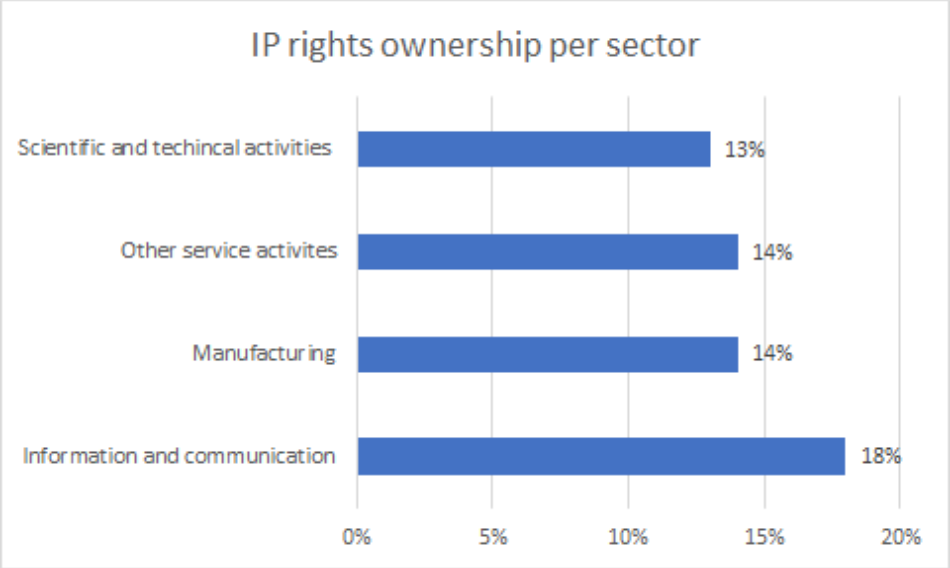


Figure 5 - IP Rights ownership by sector

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

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

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

3.5 Risks and recommendations

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

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

In addition, cloud computing services are used for their convenience and low cost of services. However, every day there are security problems associated with the cloud that make companies and individuals vulnerable to cybercrime and hacker attacks. These attacks use a very wide variety of techniques to gain access to cloud services without obtaining authorization or access from companies, managing to disrupt

and tamper with cloud services to achieve specific goals. For example, hackers could trick the cloud into storing confidential information and using it for their purposes.

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

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

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

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

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

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

Table 1 - Risk assessment matrix

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

for 70 years. Hence, the courts must tread with caution when trying to define the dynamic landscape of the cloud with respect to copyright.				
"There will be specific procedures included in the project Consortium Agreement to protect the confidentiality and security of the individual and collective IPR shared for and/or arising from the collaborative work of the partners. Furthermore, multiple exploitation paths and models will be investigated during the course of the project, resulting in various participation schemes available to the project partners." - Physics report, Risks and Contingency Plan Section.	Eventual disputes over IPR within the consortium for mainly copyrighted protected literary works.	Low	Low	To some extent, potential issues that can arrive from legal patent conflicts can be avoided by carefully crafting protective intellectual property rights before signing the contract. This ensures clarity and predictability in any potential IPR claims for FaaS or IaaS providers.
The liability for IPR violation. Whether the cloud service providers can be made liable for any infringement of IPR using their services is debatable. One argument is that they act as merely conduit pipes for communication. As intermediaries, they cannot be imposed with any liability for copyright infringement by users. The other side might argue that they induce infringement by users and are hence liable for that inducement.	To promote scalability, flexibility and usability, cloud computing providers must serve an easy to implement with as few blocks and burdens as possible for the clients. But by facilitating the implementation of the services and respecting the client's privacy, they might be indirectly acting as intermediaries in a possible copyright violation, risking being liable for such infringement.[vii]	Low	Medium	When obtaining IP protection for client-side elements of cloud computing systems, the cloud provider should identify the potential. It may not be in a company's best interest to assert patent rights against the users of a cloud computing service, since that may alienate those users from ever signing up.

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

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.[x]	it for their purposes.			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 their services and should normally include a right in its standard terms to remove any data from its servers.

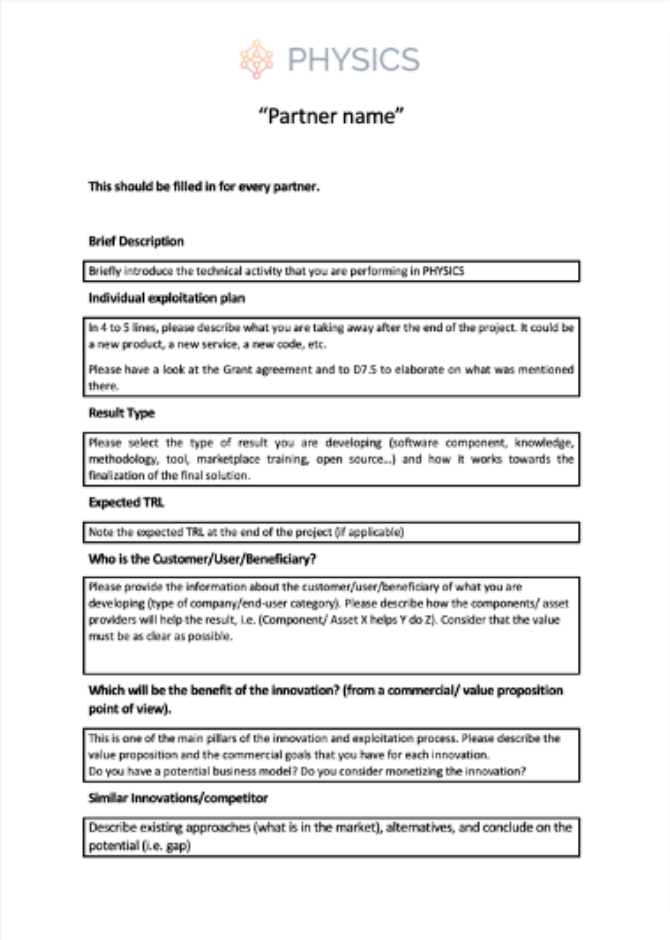
4. INNOVATION MANAGEMENT

The Innovation Strategy Report delved into the crucial area of innovation management within the PHYSICS H2020 project. As per the adopted definition, innovation management encompasses a range of processes and structures that enable the monitoring and control of innovation activities within the project. By implementing an effective innovation management strategy, PHYSICS H2020 ensured that innovative ideas are nurtured and harnessed for maximum impact.

The innovation management strategy within PHYSICS H2020 encompassed several essential steps, including:

- Retrieving information on potential innovations
- Informing the Exploitation Coordinator of potential innovations
- Extracting insights on market trends, market value, and business models
- Engaging in thorough discussions to define actionable points
- Consolidating the extracted information and feedback

During the three-year duration of the project, three different files were created to collect all the valuable information about the innovation components. The first file that has been created included the following categories that partners completed (see Figure 6):



PHYSICS

"Partner name"

This should be filled in for every partner.

Brief Description

Briefly introduce the technical activity that you are performing in PHYSICS

Individual exploitation plan

In 4 to 5 lines, please describe what you are taking away after the end of the project. It could be a new product, a new service, a new code, etc.

Please have a look at the Grant agreement and to D7.5 to elaborate on what was mentioned there.

Result Type

Please select the type of result you are developing (software component, knowledge, methodology, tool, marketplace training, open source...) and how it works towards the finalization of the final solution.

Expected TRL

Note the expected TRL at the end of the project (if applicable)

Who is the Customer/User/Beneficiary?

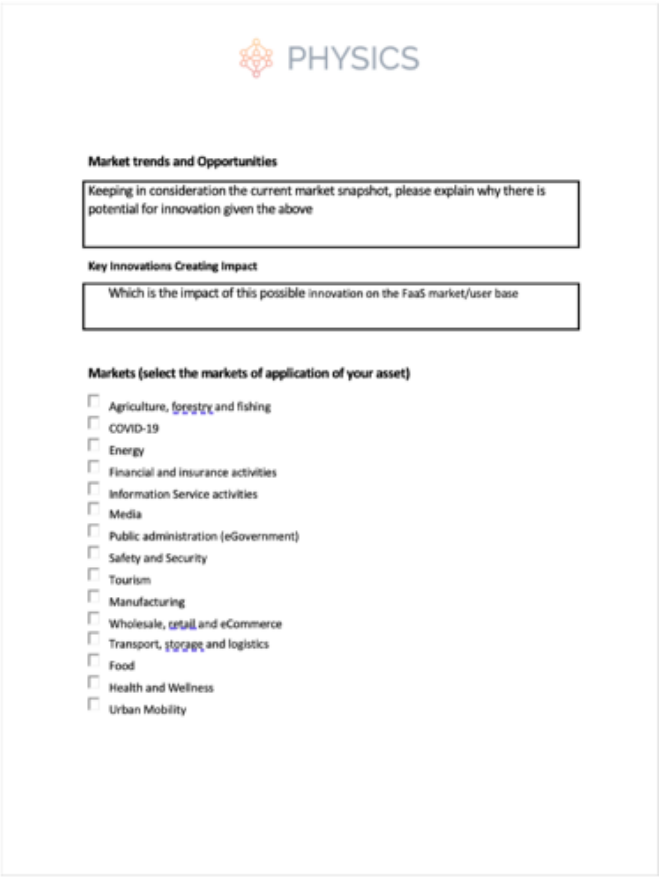
Please provide the information about the customer/user/beneficiary of what you are developing (type of company/end-user category). Please describe how the components/ asset providers will help the result, i.e. (Component/ Asset X helps Y do Z). Consider that the value must be as clear as possible.

Which will be the benefit of the innovation? (from a commercial/ value proposition point of view).

This is one of the main pillars of the innovation and exploitation process. Please describe the value proposition and the commercial goals that you have for each innovation.
Do you have a potential business model? Do you consider monetizing the innovation?

Similar Innovations/competitor

Describe existing approaches (what is in the market), alternatives, and conclude on the potential (i.e. gap)



PHYSICS

Market trends and Opportunities

Keeping in consideration the current market snapshot, please explain why there is potential for innovation given the above

Key Innovations Creating Impact

Which is the impact of this possible innovation on the FaaS market/user base

Markets (select the markets of application of your asset)

- Agriculture, forestry and fishing
- COVID-19
- Energy
- Financial and insurance activities
- Information Service activities
- Media
- Public administration (eGovernment)
- Safety and Security
- Tourism
- Manufacturing
- Wholesale, retail and eCommerce
- Transport, storage and logistics
- Food
- Health and Wellness
- Urban Mobility

Figure 6-The first file regarding the selection of innovation components

The necessary answers that each partner should give are the following:

- Brief Description: Briefly introduce the technical activity that the innovation component performing in PHYSICS H2020
- Individual exploitation plan: A description of what the innovation is taking away after the end of the project. It could be a new product, a new service, a new code, etc.
- Result Type: The type of result that is developing (software component, knowledge, methodology, tool, marketplace training, open source) and how it works towards the finalization of the final solution
- Expected TRL: The expected TRL at the end of the project (if applicable)
- Who is the Customer/User/Beneficiary? The information about the customer/user/beneficiary of what is developing (type of company/end-user category) should be mentioned
- Which will be the benefit of the innovation? (from a commercial/ value proposition point of view): This is one of the main pillars of the innovation and exploitation process. The partner

should provide a description of the value proposition and the commercial goals that you have for each innovation

- Similar Innovations/competitor: A description of the existing approaches (what is in the market) and alternatives, and conclude on the potential (i.e., gap)
- Market trends and Opportunities: Keeping in consideration the current market snapshot, it should be an explanation of why there is potential for innovation given the above
- Key Innovations Creating Impact: A description of the impact of this possible innovation on the FaaS market/user base
- Markets: Which are the markets in which the component is applicable

Additionally, a new online Google Drive file was presented to the partners to collect more valuable information regarding the innovation components (see Figure 7).

Partners	Which component have you developed that can be considered innovative? (It is innovative because it does...)	What does the component do? e.g Component X helps Y to do Z	What is the added value of the component that you have created? Does expand an existing service? Does it offer an entirely new product?	Which is the target audience that the component is going to serve?
BYTE	**Service Semantics component.** While the concept of ontologies in the cloud paradigm is not new, this component introduces innovation through extra functionalities. In essence, the points of innovation include the expansion of a cloud-resource ontology to include performance, energy and FaaS specifics. Additionally, the component also incorporates the necessary methods for extracting raw information and translating it to semantically annotated information.	The component enables the application to resource matching depending on predefined user criteria, e.g. availability of gpu, locality etc. More specifically, the semantically transformed information of the platforms available resources is passed to the reasoning framework where the resources that meet the requirements for application deployment are filtered and are deemed as potential deployment candidates.	It introduces a new holistic ontology that captures many aspects (System information, performance, energy) of the cloud and FaaS ecosystem and the operations to extract that information in an automated manner.	The component is intended to be used as part of a resource management suite, providing information on multi – cluster systems that include multiple cloud vendors, edge devices, local hosting of cloud systems and so on. As such, potential users are other services that utilize this kind of information (as is the reasoning framework in the PHYSICS platform) or cloud administrators.
CYBE				
DFKI	N/A	N/A	N/A	N/A
FUJITSU	**Digital Annealer Quantum-Inspired Optimization Pattern:** The Digital Annealer (DA) is designed to solve combinatorial optimization problems at high-speed and to find very good solutions near the global optimum. For this, the combinatorial optimization problem has to be formulated as a Quadratic Unconstrained Binary Optimization (QUBO) problem. The pattern provide an example how such a QUBO problem should be formulated and then how it can be solved using DA.	The pattern shows some of the functionalities of Digital Annealer at the example of a typical assignment problem: In collaborative work environments or shared workspaces, there often arises the need to distribute tasks or responsibilities among two individuals or teams efficiently. This scenario can be likened to the classic "Two Persons Assignment" problem, where a set of items, representing tasks or projects, must be allocated to two persons in a manner that minimises the difference in the workload or items assigned to each person. The pattern flow solves the two-person-assignment as an example and provides the basics for other QUBO optimization patterns. The goal of the studied example is to divide a set of items (given as a list of values) between two persons in such a way that the difference in the sums of the assigned items is minimised.	The component enabels solving Quadratic Unconstrained Binary Optimization (QUBO) pattern by using Fujitsu's Digital Annealing Unit. Using the Digital Annealing Unit can be complex. This component flow should ease the process to call the Digital Annealing Unit API in the correct steps. It also provides the basics for further DA patterns.	Developers of the Node-RED platform as well as users interested in Digital Annealer Quantum-Inspired Optimization
GFT	N/A	N/A	N/A	N/A
	Application Semantic Models. These consist of a novel Ontology to describe concepts of FaaS as well as a mechanism for expressing application developer requirements through a set			

Figure 7-The Google Drive form with additional information about the innovation components.

The online Google Drive file selected information regarding:

- the innovative aspects of the component that has been developed (this section aims to highlight the unique and groundbreaking features of innovative' components).
- description of the usage of the component (to provide clarity and foster understanding, this segment offers a detailed account of how the component is intended to be utilized).
- mention of the added value of the component that has been developed (an explicit mention of the added value: Recognizing the importance of delivering value to the stakeholders, this section emphasizes the additional benefits that the designed component brings to the table).

- the target audience that the component is going to serve (by identifying and understanding needs and aspirations of the target audience, innovation team can ensure that the innovation components resonate with the target audience on a profound level).

In the last months of the project, one more file was created to collect all the valuable data for the innovation components from each partner (see Figure 8).

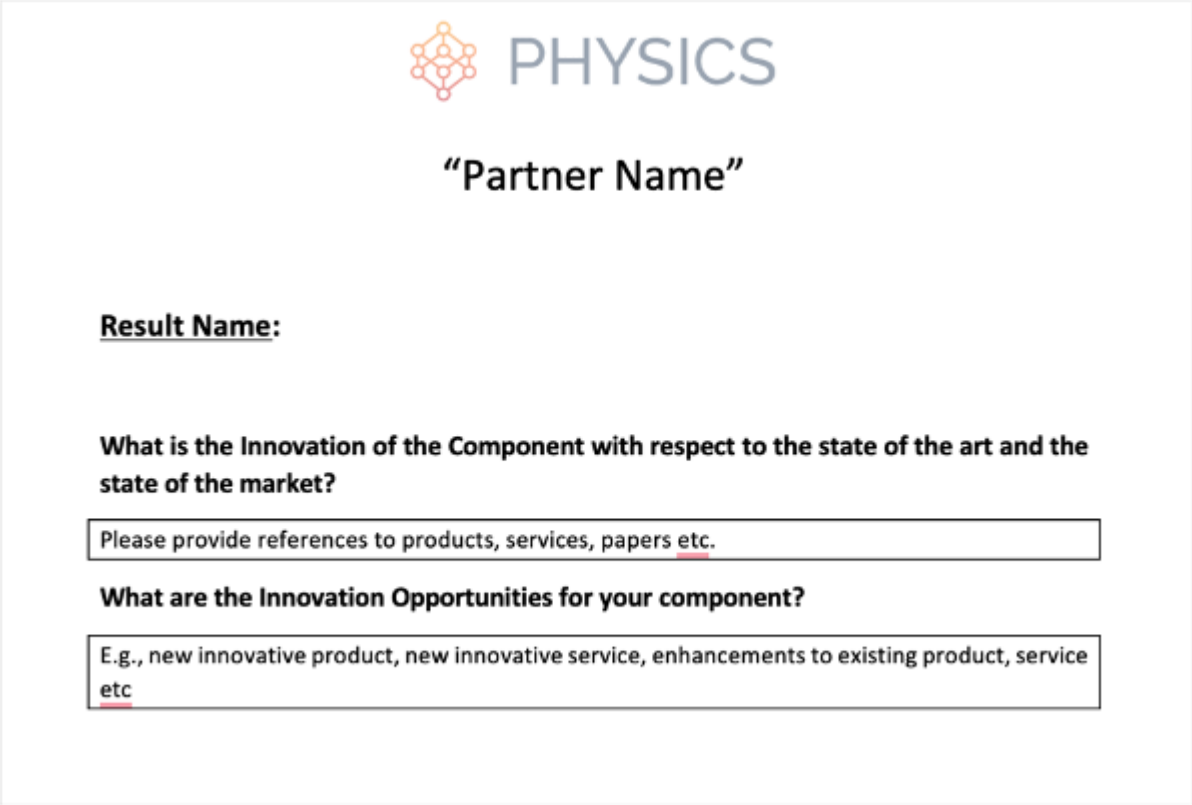


Figure 8-The two-extra questions that were created in the last months of the project.

Workshop

On June 9th, 2023, the innovation team participated in the online workshop (see Figure 9) organized by GFT. During the workshop, showcased a detailed presentation that delved into PHYSICS H2020 innovation strategy. During the workshop, significant information was presented and meticulously analyzed based on the data provided by the partners in the Google file (see Figure 10).

Figure 9-Workshop's presentation.

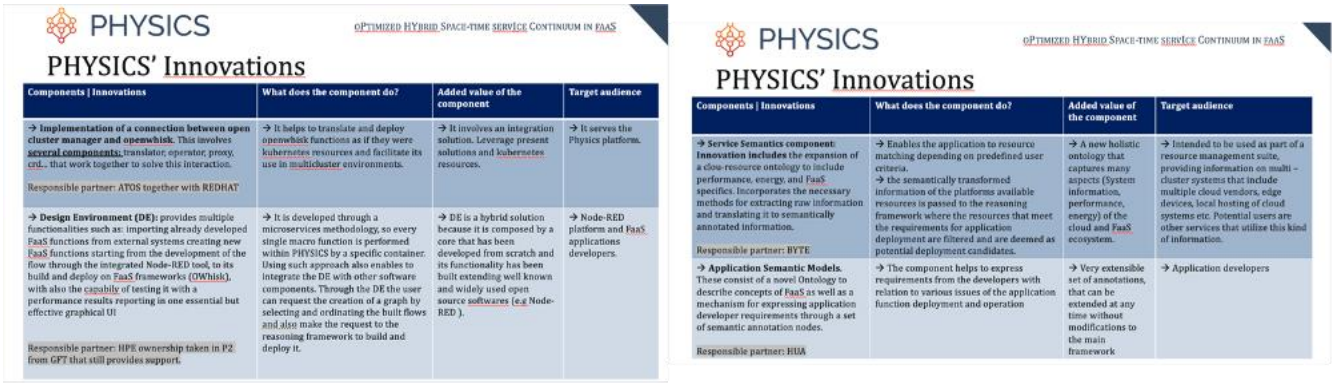


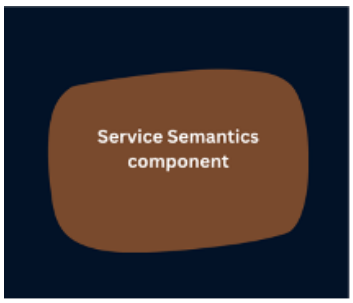
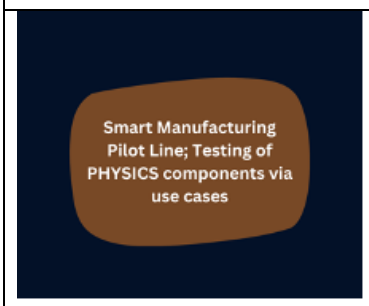
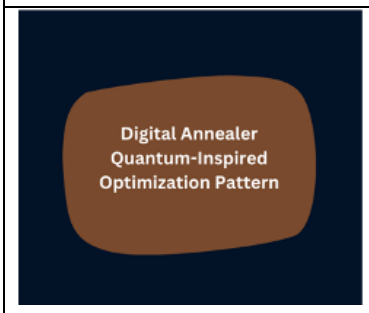
Figure 10-Sample of the presentation with partners' inputs

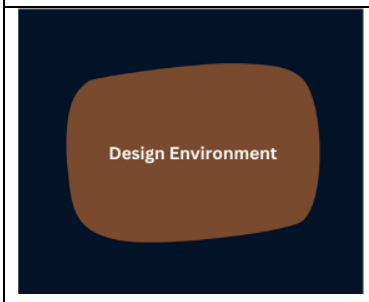
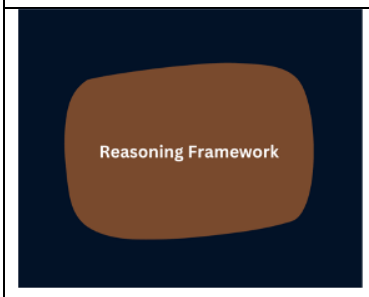
4.1 Partners' Innovations

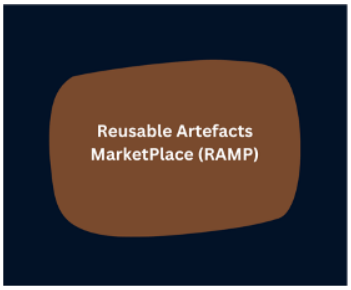
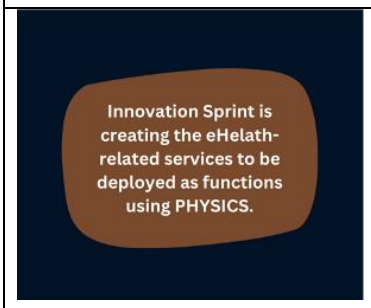
Table 2 below provides the name of each innovation component and the market in which each component is applicable.

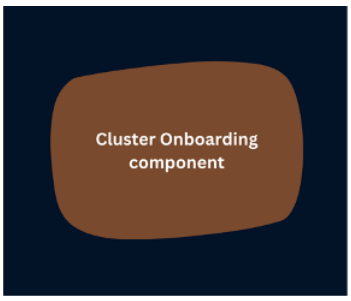
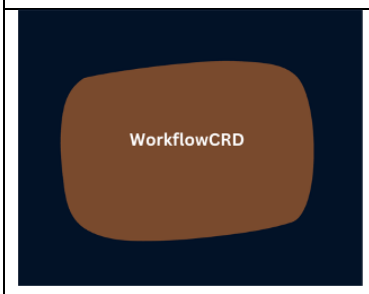
Table 2-Markets of application of each asset.

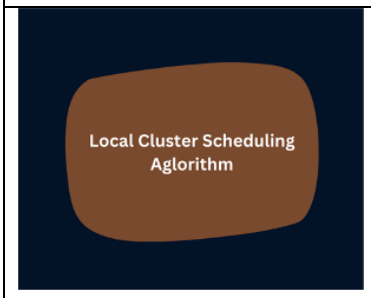
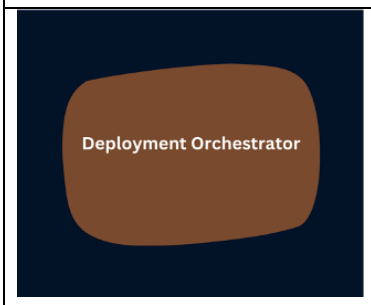
Visual	Innovation	Owner	License	Market
	Decision support system for greenhouse management	Cybeletech		Agriculture, forestry and fishing

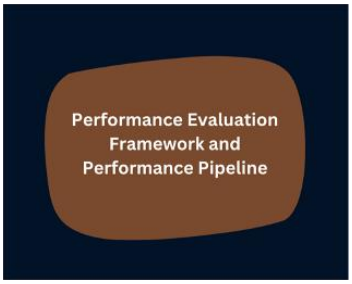
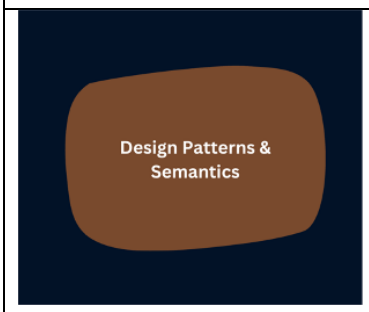
	Service Semantics component	Byte		The component's value can be observed when combined with others such as a reasoning tool to enable tasks such as cluster comparison, matching of resources to applications et
	Smart Manufacturing Pilot Line; Testing of PHYSICS components via use cases	DFKI		Manufacturing
	Digital Annealer Quantum-Inspired Optimization Pattern	Fujitsu Services GmbH		Energy Manufacturing Transport, storage and logistics Urban Mobility
	Use-Case and KPI Design Framework	Fujitsu Services GmbH		Manufacturing Transport, storage and logistics Health and Wellness

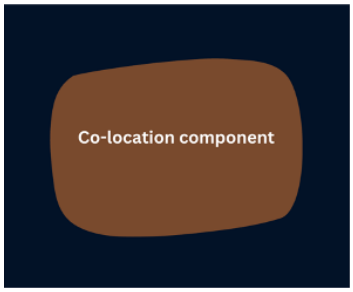
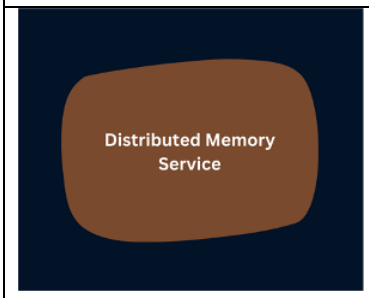
	Visual Cloud Application Workflow Design Environment and Transformation. Workflow Designer Software	GFT		Agriculture, forestry and fishing COVID-19 Energy Financial and insurance activities Information Service activities Media Public administration (eGovernment) Safety and Security Tourism Manufacturing Wholesale, retail and eCommerce Transport, storage and logistics Food Health and Wellness Urban Mobility
	Design Environment (DE)	HPE		Energy Financial and insurance activities Information Service activities Media Public administration (eGovernment) Manufacturing Transport, storage and logistics Food Health and Wellness
	Reasoning Framework	Innov-Acts		Information Service activities

	Reusable Artefacts Marketplace (RAMP)	Innov-Acts		Agriculture, forestry and fishing Information Service activities Manufacturing Transport, storage and logistics Health and Wellness
	Gamification Server	InQbite		Financial and insurance activities Information Service activities Public administration (eGovernment) Safety and Security
	Innovation Sprint is creating the eHelath-related services to be deployed as functions using PHYSICS	Innovation Sprint		Health and Wellness

	Cluster Onboarding	Red Hat		Red Hat is working on the lower levels, so any of the markets (Agriculture, forestry and fishing, COVID-19, Energy, Financial and insurance activities, Information Service activities, Media, Public administration (eGovernment), Safety and Security, Tourism, Manufacturing, Wholesale, retail and eCommerce, Transport, storage and logistics, Food, Health and Wellness, Urban Mobility) can benefit of the enhancements being done at the infrastructure level (Kubernetes, multicluster)
	Workflow CRD (Custom Resource definition)	Red Hat		Red Hat is working on the lower levels, so any of the markets (Agriculture, forestry and fishing, COVID-19, Energy, Financial and insurance activities, Information Service activities, Media, Public administration (eGovernment), Safety and Security, Tourism, Manufacturing, Wholesale, retail and eCommerce, Transport, storage and logistics, Food, Health and Wellness, Urban Mobility) can benefit of the enhancements being done at the infrastructure level (Kubernetes, multicluster)

	Global Continuum Placement	RYAX		Agriculture, forestry and fishing COVID-19 Energy Financial and insurance activities Information Service activities Manufacturing Wholesale, retail and eCommerce Transport, storage and logistics Urban Mobility
	Local Cluster Scheduling Algorithm	RYAX		Agriculture, forestry and fishing COVID-19 Energy Financial and insurance activities Information Service activities Manufacturing Wholesale, retail and eCommerce Transport, storage and logistics Urban Mobility
	Deployment Orchestrator	ATOS		Financial and insurance activities Information Service activities Media Public administration (eGovernment) Health and Wellness

	Performance Evaluation Framework and Performance Pipeline	Harokopio University of Athens		Given that functions may be created for every one of the fields mentioned, we consider that the asset relates to all of them: Agriculture, forestry and fishing, COVID-19, Energy, Financial and insurance activities, Information Service activities, Media, Public administration (eGovernment), Safety and Security, Tourism, Manufacturing, Wholesale, retail and eCommerce, Transport, storage and logistics, Food, Health and Wellness, Urban Mobility
	Design Patterns & Semantics	Harokopio University of Athens		Given that functions may be created for every one of the fields mentioned, we consider that the asset relates to all of them: Agriculture, forestry and fishing, COVID-19, Energy, Financial and insurance activities, Information Service activities, Media, Public administration (eGovernment), Safety and Security, Tourism, Manufacturing, Wholesale, retail and eCommerce, Transport, storage and logistics, Food, Health and Wellness, Urban Mobility

	Co-location component	Universidad Politecnica de Madrid		Agriculture, forestry and fishing, COVID-19, Energy, Financial and insurance activities, Information Service activities, Media, Public administration (eGovernment), Safety and Security, Tourism, Manufacturing, Wholesale, retail and eCommerce, Transport, storage and logistics, Food, Health and Wellness, Urban Mobility
	Distributed Memory Service	Universidad Politecnica de Madrid		Agriculture, forestry and fishing, COVID-19, Energy, Financial and insurance activities, Information Service activities, Media, Public administration (eGovernment), Safety and Security, Tourism, Manufacturing, Wholesale, retail and eCommerce, Transport, storage and logistics, Food, Health and Wellness, Urban Mobility

Each PHYSICS partner had a significant role in innovations during the three-year period of the project. Specific details of each partner's component are analyzed below. Particularly, below is a presentation regarding each component that has been developed and can be considered innovative. Also, there is an analysis of what each component does and what is the added value of each component that has been created; if it expands an existing service or offers an entirely new product. Finally, it is mentioned which is the target audience that the component is going to serve. Additionally, the Tables below (See Table 2, Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14, Table 15, Table 16) provide information about: a) who will be the customer/ users/ beneficiary of each component b) which benefit will provide each component c) which are the key innovations that create impact.

4.1.1 Cybeletech

Cybeletech is developing decision support system for greenhouse management. Three use cases are implemented with PHYSICS components: 1) a data collection pipeline deployed on the edge; 2) a simulation pipeline deployed in FaaS; and 3) an optimization pipeline which takes advantage of parallelization capabilities of cloud computing. In PHYSICS Cybeletech developed a new coding methodology for implementing our pipelines in a more functional way using Node-Red as well as a new methodology for

pipelines deployment both on the edge and in the cloud based on PHYSICS components. This led to a refactoring of the software components used in Cybeletech greenhouse decision support system.

Table 3-Cybeletech Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 7: A prototype of the service is tested under real conditions	The work done in PHYSICS will benefit to: 1) the developer of Cybeletech through the coding approach with Node-Red and the deployment methodologies based on Jenkins; 2) to the growers through the improvement achieved in term of reliability and performance of the decision support system enabled by cloud computing assets such as OpenWhisk	The decision support system (DSS) for greenhouse management commercialized by Cybeletech will benefits from the components developed in PHYSICS. The expected benefits are the reduction in deployment and maintenance effort and improved scalability. This will in turn benefit to the growers by improving the cost management and the performance of the DSS	The use of Cybeletech DSS at large scale, facilitated by the PHYSICS components, will allow to reduce the energy costs of greenhouse production and then to lower environmental impact of this kind of production.

As a use case, Cybeletech did not develop components that could be integrated into a PHYSICS offer and used by future users. Cybeletech instead uses the components to adapt their offer (which is a private offer).

4.1.2 Byte

Service Semantics component.

While the concept of ontologies in the cloud paradigm is not new, this component introduces innovation through extra functionalities. In essence, the points of innovation include the expansion of a cloud-resource ontology to include performance, energy, and FaaS specifics. Additionally, the component also incorporates the necessary methods for extracting raw information and translating it to semantically annotated information.
The component enables the application to resource matching depending on predefined user criteria, e.g., availability of gpu, locality etc. More specifically, the semantically transformed information of the platforms available resources are passed to the reasoning framework where the resources that meet the requirements for application deployment are filtered and are deemed as potential deployment candidates.

It introduces a new holistic ontology that captures many aspects (System information, performance, energy) of the cloud and FaaS ecosystem and the operations to extract that information in an automated manner.

The component is intended to be used as part of a resource management suite, providing information on multi – cluster systems that include multiple cloud vendors, edge devices, local hosting of cloud systems and so on. As such, potential users are other services that utilize this kind of information (as is the reasoning framework in the PHYSICS platform) or cloud administrators.

Table 4-Byte Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 6	The component targets cluster information extraction and as such it is intended to be used by any entity (company or individual) with interested in such offering. Specifically, entities that manage multiple clusters can leverage this offering to efficiently compare them in a standardized way. Additionally, the ontology can be used as a point of reference between cloud developers and researchers alike, so as to have a common point of reference for cluster descriptions which in turn can lead to better evaluation of future developed cluster related approaches.	The component's value can be observed when combined with others such as a reasoning tool to enable tasks such as cluster comparison, matching of resources to applications etc. This holds especially true in the PHYSICS platform as it plays a key part in application deployment. As such, the component as a standalone makes less sense to be productized. However, the developed code and expertise are expected to be reused in similar scenarios and as such will benefit the development and potentially productization of future services and products.	1. An ontology that semantically presents cluster related information. Based on several semantic topics such as energy, basic concepts, efficiency, cost and others this ontology is a complete offering to describe a single cluster. 2. A service that handles automatic communication and information extraction and transformation from Kubernetes clusters with Prometheus deployed.

What is the Innovation of the Component with respect to the state of the art and the state of the market?

The Service Semantics component presents innovation through the approaches developed to solve 2 different sub-tasks, relevant to the cloud-edge cluster management paradigm.

Firstly, for the needs of the component an ontology has been designed to encapsulate domain knowledge on cloud clusters. More specifically, it provides the necessary schema to represent functional and non-functional aspects of a cluster such as it's hardware specifications, location, benchmark results from applications ran on the cluster, etc. Additionally, it includes ontology entities that describe the cluster's energy consumption, SLA's and expenses. To the best of our knowledge no it-related ontology in the literature has been designed to include all the aforementioned information, while having also practical application to a real-world scenario.

Moreover, the component includes the necessary and developed for the project's need code to automatically extract cluster information and transform it according to the ontology. Based upon a variety of python libraries that enable communication with Kubernetes and Prometheus API, it wraps the necessary functionalities collectively to easy-to-use methods. All of the developed code can be reused as a new library or as service. When used as a service, additional endpoints have been created that allow easier debugging, ontology manipulation etc.

What are the Innovation Opportunities for your component?

While it is possible for the component to be used as a service in a managed cluster, parts of it can also be utilised independently.

Firstly, if the component is indeed utilised as a service, it can be used for application to cluster matching similar to how it is used for the PHYSICS multi-cluster platform. However, one can select and use parts of the component; The ontology designed can be used standalone in any scenario that a schema for cluster description is required and the methods for cluster information retrieval and transformation can be used as a standalone python library. Each of the application scenarios described, we have identified as potential improvements upon the existing solutions.

4.1.3 DFKI

Table 5-DFKI Innovation components.

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

What is the Innovation of the Component with respect to the state of the art and the state of the market?

N/A – DFKI runs Smart Manufacturing Use Cases (utilize components other partners provide).

What are the Innovation Opportunities for your component?

N/A – DFKI runs Smart Manufacturing Use Cases (utilize components other partners provide).

4.1.4 Fujitsu Services GmbH

The Fujitsu Services GmbH has developed two innovation components, the Use-Case and KPI Design Framework and Digital Annealer Quantum-Inspired Optimization Patter.

Digital Annealer Quantum-Inspired Optimization Pattern: The Digital Annealer (DA) is designed to solve combinatorial optimization problems at high speed and to find very good solutions near the global optimum. For this, the combinatorial optimization problem has to be formulated as a Quadratic Unconstrained Binary Optimization (QUBO) problem. The pattern provides an example of how such a QUBO problem should be formulated and then how it can be solved using DA. The pattern shows some of the functionalities of Digital Annealer at the example of a typical assignment problem: In collaborative work environments or shared workspaces, there often arises the need to distribute tasks or responsibilities among two individuals or teams efficiently. This scenario can be linked to the classic "Two Persons Assignment" problem, where a set of items, representing tasks or projects, must be allocated to two persons in a manner that minimises the difference in the workload or items assigned to each person. The pattern flow solves the two-person-assignment as an example and provides the basics for other QUBO optimization patterns.

The goal of the studied example is to divide a set of items (given as a list of values) between two persons so that the difference in the sums of the assigned items is minimised. The component enables solving Quadratic Unconstrained Binary Optimization (QUBO) pattern by using Fujitsu's Digital Annealing Unit. Using the Digital Annealing Unit can be complex. This component flow should ease the process to call the Digital Annealing Unit API in the correct steps. It also provides the basics for further DA patterns.

The target audience that the component is going to serve are developers of the Node-RED platform as well as users interested in Digital Annealer Quantum-Inspired Optimization.

Table 6-Fujitsu Services GmbH Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
Use-Case and KPI Design Framework: TRL N/A	● Applied methodology ● Understand the customer's use case ● Define objectives and measures or anti-measures	-	Service that can be provided to customers to help them in defining their use cases in a technology like PHYSICS and how to define and measure success.
The Software Pattern to be	In collaborative work environments or shared workspaces, there often arises the need to distribute tasks or responsibilities among two	The customers of our developed methodology are non-industry specific. Users could learn the digital annealer functionalities by solving the Two-persons	Using the Digital Annealing Unit can be complex. This flow should ease the process to call the Digital Annealing Unit API in the correct

released will achieve a TRL of 6-7.	individuals or teams efficiently. This scenario can be likened to the classic "Two Persons Assignment" problem, where a set of items, representing tasks or projects, must be allocated to two persons in a manner that minimizes the difference in the workload or items assigned to each person. Consider a co-working space with two freelancers, who share various projects and responsibilities. To ensure fairness and productivity, it is crucial to optimize the allocation of tasks between them. This is where the "Two Persons Assignment" pattern proves invaluable. Other problems which need a load balancing can also be formulated as a two-person assignment pattern. Aside from the two-persons assignment, the component eases the use of annealing optimization in all areas where large scale combinatorial optimization can bring a benefit.	assignment and solving more complex QUBO problems. The optimization could be performed using Digital Annealer Unit API or using a CPU solver. Fujitsu will use the PHYSICS marketplace for demonstrations in transferable business cases for customers.	steps. It also provides the basics for further patterns.

Use-Case and KPI Design Framework

What is the Innovation of the Component with respect to the state of the art and the state of the market?

Other consultancy companies could have similar methods or adaptations (e.g., Requirement Workshops, KPI Design…). The added value of the developed use case and KPI Design Framework is that it can be used in different domains and situations which deal with complex usage of new technologies or concepts.

What are the Innovation Opportunities for your component?

The innovation potential of the use case and KPI design framework is that the understanding of use case scenarios and the definition of objectives and measures is key to the adoption of new technologies or, in general, to digital transformation.

Digital Annealer Quantum-Inspired Optimization Pattern

What is the Innovation of the Component with respect to the state of the art and the state of the market?

Easier access to simulated annealing optimization in all areas where large-scale combinatorial optimization can provide an advantage (e.g., city traffic optimization, traveling salesman problem, etc.). The QUBO formulation is problem-specific and, depending on your constraints or the weighting of prior factors, not necessarily unique. This component can be used to get a first idea of the underlying approach. More information presented in a detailed tutorial with many different examples, from academia to industry, in the Digital Annealer tutorial (https://www.fujitsu.com/de/themes/digitalannealer/get-started/get-started-en.html).

What are the Innovation Opportunities for your component?

Many companies lack direction in the landscape of quantum-inspired optimization solutions. The Digital Annealer Quantum-Inspired Optimization component can be used in any area where a scaled combinatorial optimization solver is required. This pattern has the potential to enrich the FaaS-Market with numerous large-scale combinatorial optimization examples that focus on the business logic of the customer using the annealing service.

4.1.5 GFT

GFT developed of the Visual Cloud Application Workflow Design Environment and Transformation. Workflow Designer Software component based on Node-Red to allow developers to design pipeline of functions in a graphical way with no code or low code, using reusable patterns through drag and drop functionalities. GFT collaborated with HPE as HPE has taken the responsibility of the component improvements about Design Environment (DE) in P2, with the support of GFT personnel.

Table 7-GFT Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL: 5	The beneficiary of the workflow designer are mainly the developers, which will improve the efficiency in workflow design as they will have many reusable patterns that can be used through drag and drop on the workflow and joining them with the available connectors. Only a few annotations will be needed to customize the nodes and complete the workflow. Also, companies adopting the workflow designer will take a big advantage in relation to the improved time to market. It also facilitates the migration to a serverless execution model.	The benefit of the innovation is the efficiency in the workflow design, improved time to market due to reusable patterns and no need to code development, together with abstracted workflow creation, build and deployment, faster testing.	Workflow designer should enable not technical staff to design workflows. Business organizations will be able to develop workflows in a very short time meeting increasingly demanding market requirements.

4.1.6 Innov-Acts

Innov-Acts has developed the **"Reasoning Framework."** This system is innovative because it enables automated and optimized Function as a Service (FaaS) deployment of applications in a hybrid-cloud setting by performing semantic matching between application characteristics and individual descriptions of available compute clusters. It leverages Knowledge Graphs, ontology technologies, and semantic reasoning to facilitate information sharing among the FaaS platform components.

The Reasoning Framework helps FaaS platforms to deploy applications efficiently in a hybrid-cloud setting. It does so by comparing the application's requirements to the capabilities of the available resources from different compute clusters, both from public or private cloud or edge facilities. The Reasoning Framework interprets application function workflow and developer-inserted annotations as graphs, matches them with the dynamic information retrieved from available clusters, and applies semantic rules to filter resources and facilitate efficient information retrieval.

The added value of the Reasoning Framework lies in its ability to automate and optimize the process of FaaS deployment in hybrid cloud environments. It expands on existing FaaS platforms by providing a more efficient method of matching application requirements to available resources. This system enhances decision-making in the deployment process, thus increasing the overall efficiency of cloud computing services. Moreover, by leveraging Knowledge Graphs, ontology technologies, and semantic reasoning, the Reasoning Framework pushes the frontier of semantic matching in FaaS platforms, offering an innovative solution that augments current capabilities.

The target audience for the Reasoning Framework includes cloud service providers, application developers using FaaS platforms, and organizations implementing hybrid cloud infrastructures. It will be especially beneficial to those seeking efficient and automated solutions for application deployment, those dealing with complex applications with specific requirements, and those wishing to maximize their use of available resources across different cloud and edge facilities.

Additionally, Innov-Acts has developed the **"Performance Forecaster".** This system is innovative because it predicts the performance of Function as a Service (FaaS) applications in a hybrid-cloud setting using metrics from the OpenWhisk API of each available compute clusters. It leverages an Exponential Smoothing algorithm to produce relative and absolute scores in terms of execution latency and scores. The output of this component allows the load balancing between the available clusters and optimizations in terms of performance or cost.

The Performance Forecaster is a REST API that retrieves recent performance data from the OpenWhisk metrics API of various clusters. After preprocessing this data to a usable format and retaining only the relevant fields, it employs an exponential smoothing model to predict function execution times and wait times, and subsequently calculates performance and cost scores for each cluster. These scores are then transformed into relative scores, collated into a JSON object to facilitate data-informed, dynamic routing decisions based on real-time performance and cost metrics.

The Performance Forecaster adds value by providing a mechanism to make dynamic routing decisions based on real-time performance and cost metrics of various clusters. It augments the existing FaaS applications by enhancing the decision-making process through an in-depth analysis of function execution times, wait times, and associated costs. Rather than simply expanding on an existing service, it offers a specialized layer that aids in optimizing routing decisions by continually adapting to the real-time dynamics of the deployment, ensuring efficient resource utilization and cost-effectiveness.

The Performance Forecaster is designed to serve developers, system administrators, and organizations that utilize Function-as-a-Service (FaaS) platforms, particularly those leveraging the OpenWhisk ecosystem. Its primary target audience includes those responsible for optimizing routing decisions, ensuring efficient resource allocation, and managing cost-effectiveness within cloud-based systems and serverless architectures.

Table 8-Innov-Acts Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
N/A	(Component: Reusable Artefacts Marketplace (RAMP) 1) Large IT enterprises, consulting firms and SMEs integrating artefacts. 2) Universities and research initiatives using or enhancing artefacts. 3) Developers, researchers, and students contributing artefacts at the RAMP.	1) Enterprises delivering consulting services could provide clear, tangible solutions for the processes of their clients in the form of specific artefacts and integrate these artefacts in existing use cases. SMEs can benefit through the commercialisation of proprietary features on the RAMP, and additional consulting and training services. 2) Universities and research initiatives can use the RAMP to improve existing products, or to integrate the outcomes in different programs. 3) Other stakeholders could see in this platform the opportunity to increase their knowledge, know-how, and integration capacities.	Several artefacts available at the RAMP have already been validated at the project's use cases (i.e., e-health, Smart Agriculture, and Manufacturing), streamlining their performance, costs, and overall efficiency. Indicatively: - OW Skeleton pattern allows the timely migration of existing code into a function format that can be deployed in the OpenWhisk FaaS platform. - Split Join Pattern allows for parallelized execution of increased input loads by splitting the input into chunks that can be executed in parallel and merging their outputs. - FaaS Monitoring pattern retrieves performance metrics from the FaaS platform for a given time window. Through this, a relevant routing logic can be applied, sending by default the requests to the central location and only using the local execution if the performance metrics of the former are not satisfactory or if the location is unavailable. - Edge ETL pattern offers reliable data collection at the edge data providing resilience during connection loss between the edge and the cloud. The pattern stores the input data (coming from IoT devices) locally, and a general retry is performed in a cron job fashion.
TRL 4-5: A prototype of the Reasoning framework is	The FaaS platform leverages RF to (i) optimise and automate the deployment of a given application in multi/hybrid cloud resources; (ii) store application and resource metadata; (iii) retrieve structured information (i.e., image location, user-defined	IaaS/FaaS providers could exploit RF to enhance their services with semantic reasoning functionalities. In addition, enterprises that deploy their applications in multiple resources (e.g., cloud, private servers, edge devices) can reduce their	RF incorporates the following key innovations: 1) Multi-cloud and edge semantic modelling allowing for interoperability between different resources. 2) New service that enables reasoning both on serverless and legacy applications in order to assist proper

operational and integrated within the PHYSICS platform. The component's functionalities have been validated by the project's use cases and other indicative applications /workflows used for testing purposes.	annotation, performance evaluation scores, etc.) of the registered applications and resources in a service-oriented manner. The user of the FaaS platform leverages RF indirectly when annotating the application's functions at design time. These annotations are processed by the RF that guides the final placement of each function.	computational cost without compromising performance and easily manage them by integrating RF. INNOV plans to provide RF as open-source software (OSS) that allows robust community-driven support for further development and enhancement. However, technologies developed in the scope of RF may be used or integrated into other commercial services offered by INNOV, including training and consulting services.	and fast deployment on the available federated recourses. These innovations create substantial impact in the cloud domain by addressing the challenge known as "vendor-lock-in".

Reasoning Framework

What is the Innovation of the Component with respect to the state of the art and the state of the market?

1) Hybrid-Cloud Focus: Unlike mainstream CSPs, the Reasoning Framework emphasizes FaaS deployment in hybrid-cloud environments, blending public, private, and edge resources.

2) Advanced Semantic Matching: Utilizing Knowledge Graphs and ontologies, the framework offers matching between application requirements and resource capabilities.

3) Developer Annotations: Incorporates developers' annotations, ensuring richer context and proper resource allocation.

4) RESTful Interface: Streamlines data access and integration with a RESTful interface, facilitating efficient information sharing.

5) Overcoming Existing Limitations: Unlike systems like Fogbow, the framework offers standardized multi-cloud interoperability. It also surpasses TOSCA-based approaches by capturing extensive application details.

6) Semantics in Deployment: The framework pioneers the use of semantics in knowledge graphs for hybrid cloud deployment, addressing a notable gap in the field.

What are the Innovation Opportunities for your component?

One primary opportunity for the Reasoning Framework (RF) is its expansion to integrate with other FaaS platforms (besides OpenWhisk), ensuring a broader range of compatibility and functionality. This can be complemented by the incorporation of machine learning algorithms to predict and optimize resource allocation based on historical data and patterns. The RF could also be enhanced to adapt in real-time to changing application requirements or resource availabilities, guaranteeing optimal performance. Furthermore, adapting the framework for cross-domain applications, such as IoT, healthcare, or finance, would make it versatile in addressing industry-specific challenges.

Reusable Artefacts MarketPlace (RAMP)

What is the Innovation of the Component with respect to the state of the art and the state of the market?

The state of the art in the marketplaces for cloud patterns is still in its early stages of development, but there has been significant progress in recent years. A number of marketplaces have emerged, offering a variety of cloud patterns and templates to help users deploy and manage cloud-based applications and services more efficiently and effectively.

One of the key trends in the market is the increasing focus on multi-cloud and hybrid cloud patterns. Another trend is the growing adoption of cloud-native patterns. These patterns are designed specifically for cloud computing environments and can help users to improve the performance, scalability, and manageability of their applications.

RAMP's concept and offerings are in line with the key market trends while it is open-source oriented offering solution.

What are the Innovation Opportunities for your component?

Low-code Development Expansion: As the low-code development market continues to grow, RAMP can position itself as the go-to platform for low-code FaaS solutions. This would not only attract enterprises looking to develop new applications but also those aiming to integrate or enhance existing applications.

FaaS Market Penetration: The FaaS market is witnessing a surge, and RAMP can capitalize on this trend by offering unique and efficient patterns tailored for the FaaS cloud paradigm.

Open-Source Orientation: RAMP's foundation on open-source principles promotes community-driven enhancements, ensures transparency, and allows for widespread adoption and customization by developers and organizations alike.

4.1.7 InQBit

InQbit implemented a gamification platform for training and instructing flow-programming users and developers in a gamified manner. It presents an intriguing novel approach to facilitating learning sessions by engaging the user in storylines that encompass multiple objectives to complete. The platform also integrates smart contracts blockchain technology to provide users with a place to monetize their storyline and flow creations as non-fungible tokens. It offers a completely new product and strategy for applying gamified training techniques in Node-RED flow development. This can be further expanded with more gamified resources in the form of storylines with objectives.

Its target audience is flow-programming users and Node-RED developers. The gamification server will help aid beginners and intermediate flow-programming users to learn by playing storylines and completing objectives to advance their skills and knowledge of Node-RED.

Table 9-InQBit Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
Gamification Server Technology Development TRL 4	- Research Organisations and Universities can use the platform to provide hands-on flow-programming experience. - Businesses can train employees in flow-programming using the platform. Users: - Individuals can learn flow-programming using the user-friendly and engaging platform. Experienced flow-programmers can create and share their creations. Gamification server will help aid beginners and intermediate flow-programming users to learn by playing storylines and completing objectives to advance their skills and knowledge of Node-RED. Beneficiaries: - The cloud service developing community can grow and strengthen through learning, collaborating and sharing using the platform.	Gamified Platform for Flow-Programming: The gamified flow-programming education platform meets the increasing need for flow-programming skills by providing a distinctive and captivating learning experience. It is a great tool for enterprises and educational institutions, encouraging the use of flow-programming and fortifying the flow-programming community. Smart Contracts as a Service: Offering a safe and user-friendly platform for developing and implementing smart contracts, the Smart Contracts as a Service solution gives companies an affordable substitute for customary development techniques. By automating operations and procedures, cutting costs, and improving security and transparency, it satisfies the rising need for blockchain-based solutions. Decentralized Applications for Flow-Programming: The flow-programming platform's capabilities are increased by the Decentralized Applications for Flow-Programming solution,	A novel approach to facilitating learning sessions by engaging users in storylines with multiple objectives to complete. Users are also able to create their own tutorials and storylines for Node-RED, expanding the content and knowledge base of gamified resources. The approach integrates smart contracts to provide users with a unique way to monetize their flows and storyline creations as non-fungible tokens.

	- The cloud infrastructure community can benefit from the promotion of flow-programming, leading to innovative applications.	which promotes creativity and teamwork. It encourages the use of flow-programming in more sectors of the economy, opening up new avenues for cooperation and creativity. Monetization Strategy: InQbit will follow a monetization plan that includes advertising income, in-app purchases, transaction fees for blockchain-based services, platform subscription fees, and data monetization in order to realize the value generated by the creative solutions.	

What is the Innovation of the Component with respect to the state of the art and the state of the market?

This component offers a gamified platform for the purpose of instructing and training users and developers in the field of flow programming. It presents an intriguing novel approach to facilitating learning sessions by engaging the user in storylines that encompass multiple objectives to complete. The platform also integrates smart contracts blockchain technology to provide users with a place to monetize their storyline and flow creations as non-fungible tokens.

What are the Innovation Opportunities for your component?

- InQbit is focusing on expanding the reach and impact of the gamified platform by partnering with educational institutions in Greece and Romania, developing industry-specific training modules and translating the platform into multiple languages. These strategies will allow the platform to reach a wider audience of potential users, make it more valuable to businesses and organizations and increase its global accessibility.
- InQbit is aiming to monetize their platform and attract new customers. By exploiting blockchain technology, the company aims to create new business models such as a marketplace for flow-programming creations, a smart contracts service and decentralized applications.
- InQbit is planning on the immediate future to apply for the Innovation Radar, an initiative of the European Commission that identifies and promotes high-potential innovations. This recognition can enhance the platform's visibility, attract further investment and secure additional support from third parties.

4.1.8 Innovation Sprint

Innovation Sprint is creating the eHelath-related services to be deployed as functions using PHYSICS and is running a use case, utilising technology other partners build. Innovation Sprint is running the eHelath pilot, producing services for ML use cases on patient inference, patient phenotyping and synthetic data generation. The services are implemented as Node-RED flows, having at their center Python scripts implementing the ML part.

Table 10-Innovation Sprint Innovation components.

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

What is the Innovation of the Component with respect to the state of the art and the state of the market?

N/A – Innovation Sprint runs eHealth pilot.

What are the Innovation Opportunities for your component?

N/A – Innovation Sprint runs eHealth pilot.

4.1.9 Red Hat Israel & Red Hat SL

Cluster Onboarding component.

Cluster Onboarding uses new models (serverless, event-driven applications) to perform different actions when a cluster joins a set of clusters (OCM). The Cluster Onboarding is in charge of performing certain actions upon a new cluster joining the OCM group of managed clusters. More specifically, it creates some artificial load on the remote cluster and deploys the semantic component in there. Then it calls the semantic component with the information about the benchmarking load, and the centralize component (Reason Framework) so that it knows how to retrieve information form the remote cluster via the semantic component.

The component is new and follows the best practices from the K8s world. The cluster onboarding makes use of event-driven framework (serverless) and describes an easy and extendable way of managing remote cluster to install PHYSICS components. It can be easily adapted to other components and other events, knative[xi] community, highlighted the benefits of that approach.

The target audience is multicluster management and can therefore use by both application developers (to easily deploy components across cluster) and cloud service provider (to help them in the way the operate their hybrid cloud infrastructures).

WorkflowCRD Operator.

It offers a new API/Abstraction to be able to register functions easily, when used together with multicluster management tools, such as OCM. The WorkflowCRD extends the k8s API to offer a new object type that allows to define the functions and their interactions. It includes the operator that react to those new object types and execute the needed actions: call the OW API to register the functions.

The component is new and follows the best practices from the K8s world. The WorkflowCRD operator, a similar model has been already followed by knative community, highlighted the benefits of that approach.

The target audience is also multicluster management and can therefore use by both application developers (to easily deploy components across cluster) and cloud service provider (to help them in the way the operate their hybrid cloud infrastructures)

Table 11-Red Hat Innovation components.

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

s. For new components without upstream project the TRL could be a bit lower (TRL 6).		Physics use cases and needs. The work done in testing/debugging/fixing other lower layer components, such as microshift or submariner[xii] is also valuable as it allows Red Hat for further testing and quickly fixing bugs that could affect customers	

Cluster Onboarding:

What is the Innovation of the Component with respect to the state of the art and the state of the market?

Allows to install and configure Physics components in clusters that are joining the set of clusters (OCM spokes) and connecting them to the relevant components in the main cluster (OCM hub). This provides a more automated and multicluster native approach for configuring given components across clusters, based on events, compared to the state-of-the-art approaches which follows more static approach where you define the set of steps in a non-event driven approach.

What are the Innovation Opportunities for your component?

It follows the best practices from Kubernetes as well as an event driven approach, allowing to save resources since there is no need to have it running all the time, just when events happen. This component provides a guideline of how to define these multicluster actions in an event driven manner, which will allow other projects (e.g., EU projects) to easily integrated their components and configured them across clusters based on their needs.

WorkflowCRD:

What is the Innovation of the Component with respect to the state of the art and the state of the market?

Extends the K8s API to offer abstraction to manage sequence of functions, independently of the underlaying Function as a Service Framework (Knative or OpenWhisk), as well as offer extra information needed by other cluster components to perform a better scheduling/collocation of functions.

What are the Innovation Opportunities for your component?

Thanks to the cooperation with upstream Knative community some of the functionality offered by the WorkflowCRD may be adapted and integrated into Knative offerings, in fact a similar thing is being now provided by Knative sequences (https://knative.dev/docs/eventing/flows/sequence/) but with no extra information for in cluster operators.

4.1.10 Ryax

Global Continuum Placement Component.

Ryax has implemented an independent component responsible perform the placement of workloads on multiple interconnected clusters, considering the needs of applications and the resources availabilities. Furthermore, Ryax has implemented intelligent multi-objective scheduling algorithms based on linear programming. It performs the workload placement of FaaS applications upon a group of multiple edge and/or cloud clusters of the continuum. It provides the main intelligence of the management of the Edge-Cloud continuum using multiple objectives such as energy and performance. Under particular circumstances it can be a product on its own but in typical situations it provides a service that can be used in combination with other services.

The target audience is the developers, admins or operators of the Edge-Cloud continuum, the infrastructure operators and/or those using the particular infrastructure.

Local Cluster Scheduling Aglorithm.

Ryax has implemented a new scheduling algorithm for local Kubernetes clusters, which minimizes the cold start delays for FaaS executions. The algorithm is pushed to the upstream of Kubernetes and the Ryax company currently waiting for it to be adopted by the community. The algorithm is called Layers Locality Scheduler. It performs the placement of a pod on a particular node within a Kubernetes cluster favoring nodes that already have layers of the particular container to be deployed. This minimizes the download time of the container, hence reducing the cold start delays. It minimizes the download time of containers of pods which is very important especially for FaaS applications since the execution time may be smaller than the download time of the container in some cases. So, minimizing the download time which takes place during cold start means that the execution will be performed faster. Hence, minimizing the cold start delays for FaaS applications improves the overall performance of the system.

Kubernetes is the defacto standard in Cloud orchestration and it is used also as orchestrator in the context of FaaS by a lot of platforms. A new scheduling algorithm for Kubernetes will be used by developers, admins and operators of Kubernetes clusters along with infrastructure and service providers for FaaS.

Table 12-Ryax Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact

TRL 5-6	The end-user using the schedulers will benefit from the performance improvements. The infrastructure provider or service operator will be also benefited by the energy and performance improvements. The improvements will have a direct impact on the cost of the service to both the end-user and the cost of ownership to the infra provider or service operator. The direct client may be either the infrastructure provider/service operator if we sell RYAX platform to them to operate their systems; or the end-user directly if they use RYAX as SaaS directly.	Both scheduling innovations that we have implemented in the context of PHYSICS project will bring an important value for the company. It will offer better performance and energy efficiency of our solution hence improving the final cost of infrastructure ownership of our clients. We are going to continue the current business model that we have which is to offer our platform as open-source and propose support, maintenance with paid licenses along with services for specialized custom developments. The innovations will be part of our platform and they will be brought forward in order to make the product more performant, energy efficient and overall, more attractive	The proposed innovations enable energy consumption minimization and performance improvements which has an impact to the cost of services and infrastructure ownership.

What is the Innovation of the Component with respect to the state of the art and the state of the market?

As far as our knowledge there are various software that enable workflow management based on FaaS applications for the edge/cloud continuum such as Nextflow[xiii], Streamflow[xiv], Apache Nifi[xv], etc but none offer multi-objective optimizations at the global continuum level and cold start delay optimizations at the local scheduling level like the ones we developed in PHYSICS.

What are the Innovation Opportunities for your component?

The innovations are very important for the particular components because they enable cost impact optimizations. Since both innovations are central to this type of platforms for FaaS applications to edge/cloud continuum infrastructures they cannot be proposed individually but they will be part of a broader product. Hence it is more straightforward to propose them as enhancements to existing products/services.

4.1.11 ATOS

Deployment Orchestrator

Together with RedHat we have implemented a connection between open cluster manager and openwhisk. This involves several components: translator, operator, proxy, crd, that work together to solve this interaction. It helps to translate and deploy open whisk functions as if they were Kubernetes resources and facilitate its use in multicluster environments.

It involves an integration solution. It does not offer a completely new product but leverage present solutions and Kubernetes resources.

The target audience serves the Physics platform.

Table 13-Atos Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 3-4 for the current release. TRL 5 in case it is finally integrated with E2CO.	More oriented to XaaS providers who owns their own infrastructure or brokers between application providers and infrastructure providers, as the Orchestrator easiest the deployment of FaaS workflows in Kubernetes multicluster infrastructures.	Main innovation is the extension of functionalities from existing tools, such as OCM, Submariner or Openwhisk, that allows them function orchestration and adaptation based on QoS metrics. All these components will be released as open source and can be offered as a service as part of the overall PHYSICS platform business model.	The Orchestrator is an adaptable software component allowing the combination of technologies, while simplifying FaaS adoption.

Result Name: Deployment Orchestrator

What is the Innovation of the Component with respect to the state of the art and the state of the market?

Taking into account that there are several platforms into the market (AWS, Lambda, Azure Functions, Google Functions, etc.) there is not a single tool to manage functions over multiple infrastructures. There are solutions like KubeVela[xvi], but it cannot be applied to FaaS. On the other hand, there are other solutions like Knative, but they are tight to the underlying technology. The solution developed within PHYSICS goes one step further providing an interface that provide FaaS functionalities to be extended in different platforms.

What are the Innovation Opportunities for your component?

The Deployment Orchestrator is a new service, agnostic of the platform, that allows the development of applications that can be managed across different FaaS environments and multiple clusters.

4.1.12 HPE

Design Environment (DE) - HPE has taken the responsibility of the component improvements in P2, with the support of GFT personnel. It provides (through a unified web-based application) multiple functionalities such as: importing already developed FaaS functions from external systems (external docker registries) inside of the Faas (OWhisk); creating new FaaS functions starting from the development of the flow through the integrated Node-RED tool, to its build and deploy on FaaS frameworks (OWhisk), with also the capability

of testing it with a performance results reporting in one essential but effective graphical UI. DE is developed through a microservices methodology, so every single macro function is performed within PHYSICS by a specific container. Using such approach also enables to integrate the DE with other software components such as Jenkins (used as DE orchestrator), Gogs (as integrated GIT server), MinIO (as object storage) and Mongo[xvii] (as no-sql DB) which allowed to create a complex but easy to develop and maintain environment. Through the DE the user can request the creation of a graph by selecting and ordinating the built flows and also make the request to the reasoning framework to build and deploy it. DE is a hybrid solution because it is composed by a core that has been developed from scratch and its functionality has been built extending well known and widely used open-source software's (e.g Node-RED). Moreover, the DE provides to the user a unified and comprehensive solution to create, deploy and test local or imported FaaS functions.

The target audience that the component is going to serve are Node-RED platform and FaaS applications developers.

Table 14-HPE Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
At the time of writing, it is reasonable to expect a TRL of about 5 or 6 (with respect to H2020 TRL levels).	The knowledge gained in PHYSICS will be appropriately fed into the best-suited services to gain a strategic advantage over the competitors in the Edge to Cloud market, and consequently the customers of such business unit which span in different market sectors (Telecoms – Public Sector – Finance – Manufacturing - Energy – etc.)	The main beneficiary of HPE outcomes will be the HPE Services business unit portfolio, and the revenue generating services delivered to the b.u. customers.	The proposed innovation asset aims at overcoming limitations of existing development FaaS frameworks available in the market to effectively support organizations and developers in reaching the goal of promptly delivering to the market business applications that leverage the FaaS approach to overcome the complexity introduced by continuum (edge-to-cloud) business domains.

What is the Innovation of the Component with respect to the state of the art and the state of the market?

To the best of our knowledge, currently on the market there are no functionally complete solutions such as the Design Environment. For example, considering the functions orchestration through workflows, the market-leading hyperscalers propose a code-first approach (JSON, YAML or ASL) and discourage the use of graphical tools, even if available, like AWS Step Function, GCP Workflow and Azure Logic Apps.

What are the Innovation Opportunities for your component?

The asset and the knowledge gained by the HPE Services Italy team are expected to drive further work within the company for additional engineering and go-to-market of the proposed asset through a pay-per-use business model, i.e., with a possible integration into the portfolio service catalog.

4.1.13 Harokopio University of Athens (HUA)

Performance Evaluation Framework and Performance Pipeline

Performance Evaluation Framework offering a number of capabilities (e.g., load generation, classification, APIs) as functions easily adaptable to the FaaS concept. The PEF helps identify performance issues of a FaaS platform as well as of a created function. The component aids in evaluating executions against a target cluster, thus evaluating the functions themselves as well as the cluster setup and available resources. It can be used as a standalone, but it is also exploited in the context of a performance pipeline inside the PHYSICS platform, thus enhancing the operation of the cluster itself.

The target audience that the component is going to serve is application developers in order to evaluate potential Openwhisk installations and platform providers in order to evaluate the setup and parameterization of their infrastructure.

PHYSICS Patterns Collection of Node-RED flows

The collection offers a set of reusable Node-RED-based flows that can be used in a variety of cases (from interacting with Openwhisk and beyond). They can be used to augment a function or workflow creation with new functionality as well as supporting services. The collection extends the baseline Node-RED flows repository, and it is also an integral part of the PHYSICS Design Environment. The target audience that the component is going to serve is IoT developers of the Node-RED platform as well as FaaS application developers (like the project use cases).

Table 15-HUA - Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
TRL 5 (PEF)	FaaS platform providers can utilize the artefacts in order to generate load and monitor/evaluate the condition of the cluster, its configuration etc. FaaS platform provider/services can use the monitor in order to dynamically configure the cluster parameters during runtime (e.g., scale up/down) Function developers for evaluating the runtime performance of the function, the associated costs and potential performance	In the serverless domain, given that cost estimations are more difficult in the case of FaaS, accurate performance predictions of function runtime can be critical for a user to understand how they will be billed following a migration to the FaaS paradigm. From a provider point of view, the evaluation of different strategies with relation to resource management, scheduling etc. may need constant and	• Multiple performance metrics including system, network and function related ones • Easy application of the load generation through a pluggable function load generator • Combination of both low-level resource usage metrics and high-level function performance on a cluster (e.g., average duration, wait time, initialization etc) • Categorization of a function to an abstract resource profile regarding resource usage (low/medium/high) for all major resource types (cpu, storage, RAM, network)

	changes between different versions/implementations of a function	easy evaluation of the applied techniques. Furthermore, function computational profile may enable better internal management of provider resources in order to minimize overheads and competition between concurrent functions.	
TRL 5	Faster application development, incorporation of ready-made patterns, adaptation to the deployment specification of FaaS, easier application composition through visual workflows for application/function developers	Faster development times, lower testing times, more complex application workflows with less development time, lower learning curve for FaaS migration	Implemented parametric patterns that can be used in arbitrary workflows to extend their functionality

Performance Evaluation Framework and Performance Pipeline

What is the Innovation of the Component with respect to the state of the art and the state of the market?

FaaS is a growing computing and programming paradigm. The specific component ensures a more detailed operations management of a FaaS provider.

Furthermore, a provider that includes the processes defined by the PEF framework is able to offer an extra performance analysis-oriented service, that can help the end users/developers to better understand the computational behavior of their functions. It can also help the providers themselves better manage the internals of their infrastructures and minimize the experienced overheads from multitenancy and resource contention aspects.

What are the Innovation Opportunities for your component?

Offering of the process as a service (load generation and/or classification)

Embedding in the overall PHYSICS platform

Design Patterns & Annotations

What is the Innovation of the Component with respect to the state of the art and the state of the market?

In terms of major open source FaaS platforms, these typically do not come with a UI for workflow definition, with the exception of Apache Airflow that also includes the incorporation of operators to include typical

cloud services or processes. One drawback of Airflow is that these operators are typically provider specific and thus cannot be reused, while amplifying the vendor lock-in. Also, they do not include advanced and abstracted cloud design patterns. Fission workflows are mainly programmatically defined. Proprietary solutions also exist with an extensive list of accompanying services such as the IBM Cloud[xviii] (formerly Bluemix) environment (and Blueworks), AWS Step Functions as well as Google Composer.

What are the Innovation Opportunities for your component?

- Inclusion in the Node-RED flows repository for usage in FaaS or in general Node-RED flows
- Combination of abstracted flows in order to create more complex workflows
- Extension of workflow capabilities on top of FaaS platforms
- New service to create or adapt workflows based on different use cases or needs

4.1.14 Universidad Politecnica de Madrid

Co-location component analyzes the functions running in a cluster and provides a set of affinity and anti-affinity rules to be used by the K8s scheduler to place a new pod (function). The component uses information on the resources needed by the function to be deployed and the functions currently running at each node in a cluster and historical information regarding previous executions of the function in the cluster and based on that generates affinity and anti-affinity labels. The added value is the performance gains in terms of execution time of function. It is used by any function executed in the platform and the target audience response is the PHYSICS platform.

Table 16-UPM - Innovation components.

TRL	Who is the Customer/User/Beneficiary?	Which will be the benefit of the innovation?	Key Innovations Creating Impact
Two components TRL 3-4	As a research institution, UPM does not have direct customers. The components developed by UPM are part of the PHYSICS platform. These components may be transferred to interested companies to increase their TRL and make a product out of them. Other users are researchers that can use these prototypes for their own research or to add new features to those software components.	The benefit of the DMS innovation is the automatic reconfiguration of the datastore based on the load each partition processes. This improves the performance of the datastore. The co-location component considers several resources in order to suggest the most adequate nodes for a function to be deployed in a cluster. There is no business model plan. The exploitation of UPM assets is done mainly	The components can be integrated after increasing their TRL in FaaS platforms to offer data management services and avoid performance degradation considering the usage of several resources.

		through technology transfer agreements with interested parties.	

Co-location component

What is the Innovation of the Component with respect to the state of the art and the state of the market?

The co-location component provides hints to the Kubernetes scheduler on the most suitable nodes to deploy a new function (pod). It uses the resource consumption information of benchmarked functions, the cluster load and other resource consumption of other functions running in the cluster. The innovation is the usage of information from several resources (including storage and network) and the lightweight protocol that is suitable for low duration functions (a few minutes execution time).

Co-location is done by cloud providers. The techniques used are not transparent and are managed by the cloud providers. This component can be used in any cloud provider and at any company that manages its own cloud. The goal is to minimize execution time of functions.

What are the Innovation Opportunities for your component?

The component enhances an existing product, a Kubernetes cluster used to execute the TaaS platform.

Distributed Memory Service

What is the Innovation of the Component with respect to the state of the art and the state of the market?

The Distributed Memory Service (DMS) provides in memory storage for data. It provides replication of data for high availability and fault-tolerance. The main innovation is the integration of automatic data balancing features in a cluster based on the load. The automatic distribution of data based on the load is a new feature not available on other products. This process is done manually, stopping processing. Therefore, it has a high impact on the system availability and performance during data balancing process. In-memory services that may automate this process (e.g., KeyDB) move data randomly (assuming the load in partitions is uniform) instead of taking into account the load on the partitions. This process is fully automated.

What are the Innovation Opportunities for your component?

The component enhances an existing product, KeyDB in order to provide better performance and automatic reconfiguration. The protocols implemented for enhancing the component can be used with other datastores that provide data partitioning.

Overall, during the whole duration of the project information on innovations was retrieved and accessed in close cooperation with all the involved project partners. These activities resulted in the formulation of the project Innovation Profile.

The PHYSICS H2020 project has 20 innovation components and 9 of them have TRL more than 5, All of the aforementioned innovation components are in good synchronization with the exploitation stage of the project.

5. EXPLOITATION PATHS

From the beginning of the project, an analysis on the FaaS market in terms of size, growth, profitability, cost structures, trends and critical success factors identifying gaps and potential for impact was performed. This serves as a basis for the development of the exploitation phase. To keep the exploitation activities on track, annual Exploitable result workshops have been organized for PHYSICS project, the first one took place on the 29/09/21, the second, which also covered aspects concerning standardization and open access, as well as a cooperative session about the Handbook development, was held on the 30/09/2022, and the last one, on the 09/06/2023, analyzed the Project Officer and experts suggestions and highlighted the way forward. The main objective of these sessions was to discuss as a group what results we are envisaging to reach by the end of the project and how they interact with each other.

5.1 Outline of the exploitable results

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

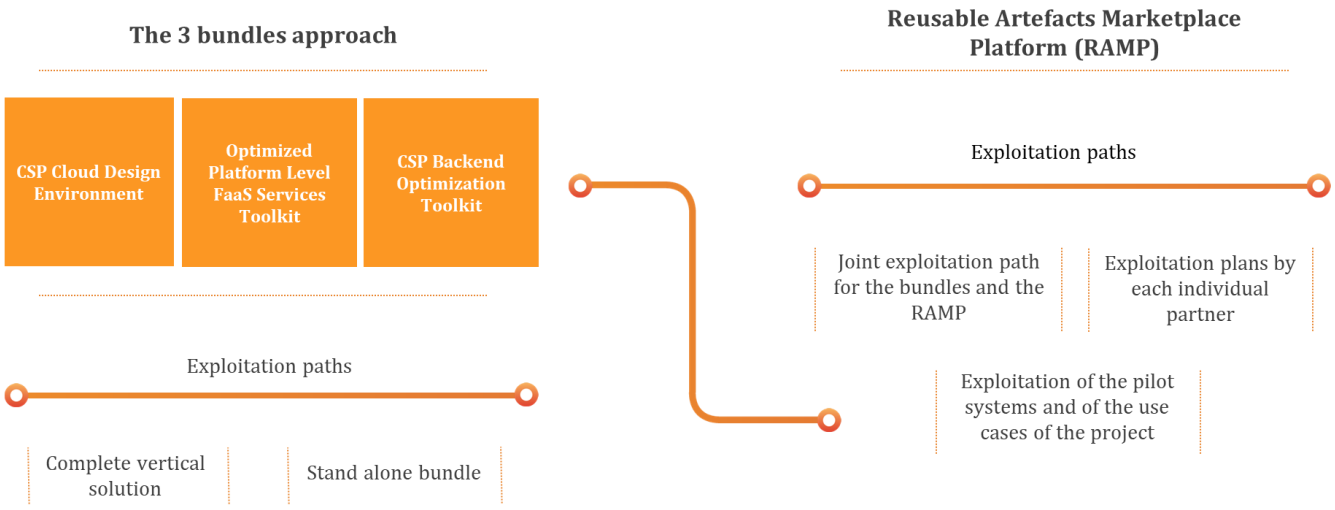


Figure 11 - PHYSICS exploitable results

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

B) the Optimized Platform Level FaaS Services Toolkit and

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

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

The 3 bundles approach

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

A - CSP Cloud Design Environment

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

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

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

B - Optimized Platform Level FaaS Services Toolkit

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

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

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

C - CSP Backend Optimization Toolkit

The Backend Optimization Toolkit that includes developments in WP5 targets primarily

- CSPs that have an IaaS service that they need to extend with Kubernetes as well as enrich it with specific functionalities and management approaches for FaaS support (e.g., specialized scheduling strategies)
- The overall K8S[xix] and OpenShift[xx] 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 PLATFORM

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

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

Reusable Artefacts Marketplace Platform (RAMP)

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

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

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

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

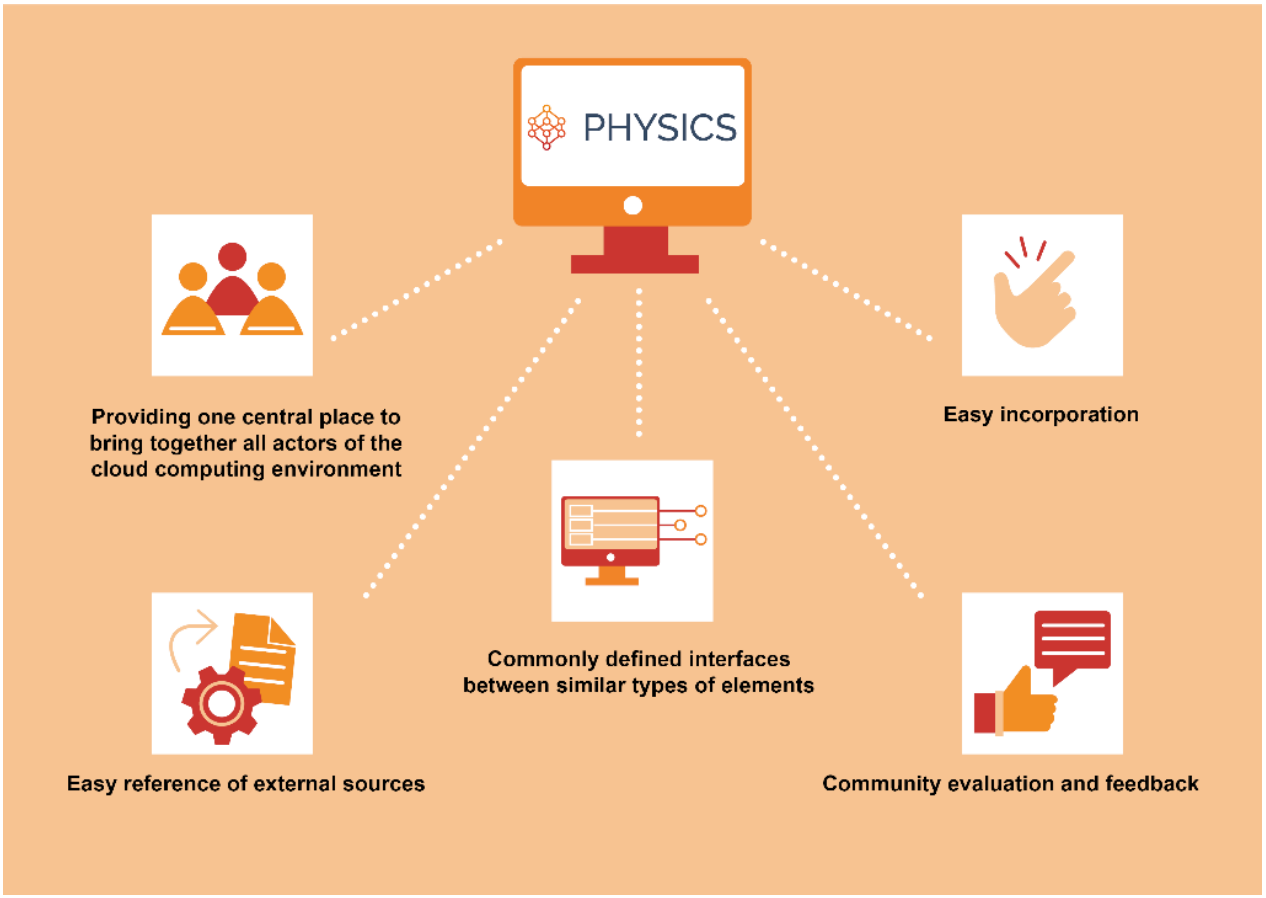


Figure 12 - RAMP

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

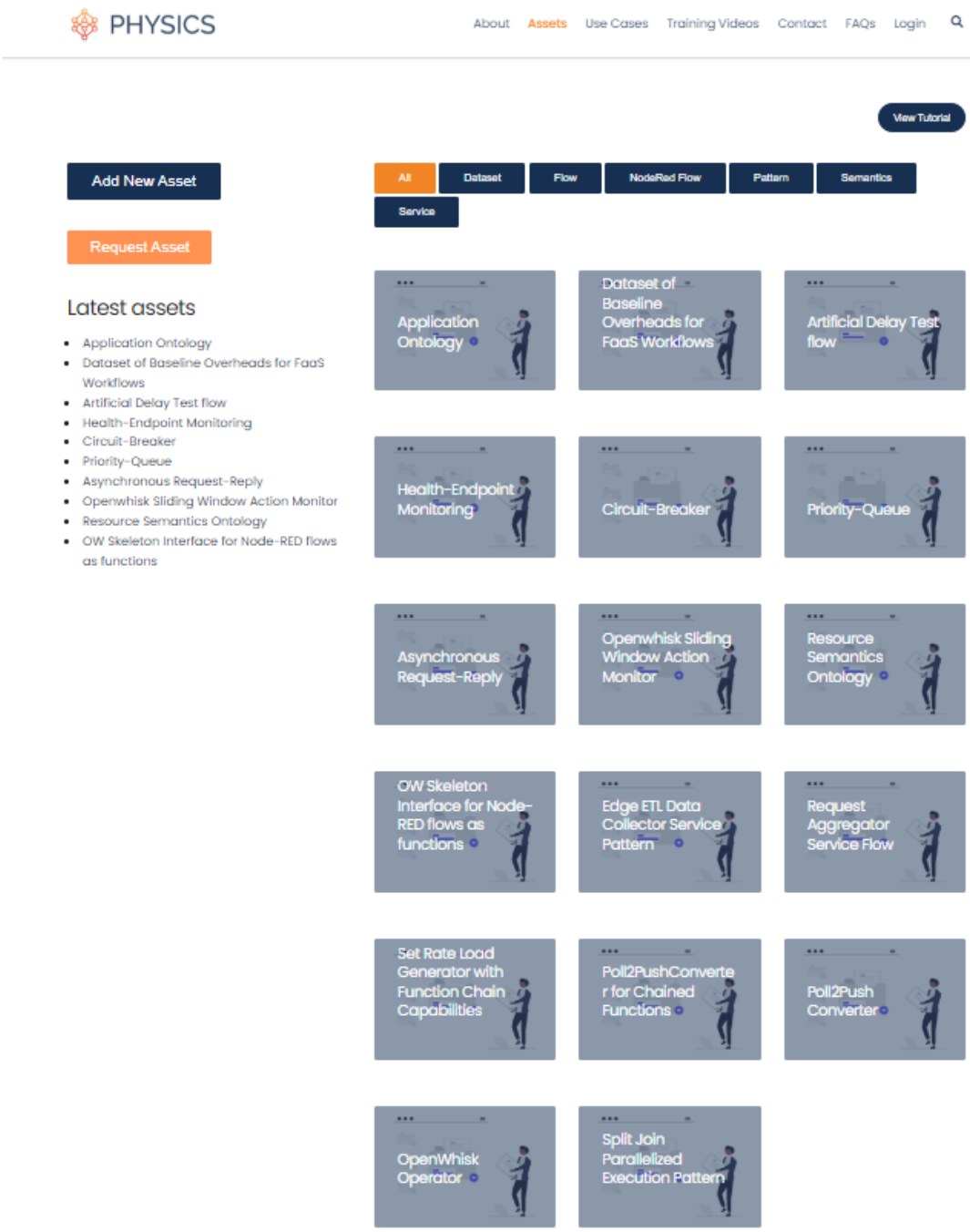


Figure 13 - RAMP asset catalogue

As of December 2023, there are currently 28 assets published on the Marketplace, 8 external contributors, 32 externally provided artefacts (1 RAMP artefact has 26, and the others are individual entries), over 50 external users, and 3 use cases. RAMP does not require registering for viewing or downloading the assets. To ease the use of the platform, 6 training videos (https://marketplace.physics-faas.eu/training) have also been created and uploaded.

5.2 Commercialization Strategy pursued by the consortium

Below it is exemplified how each partner worked toward the reaching of the PHYSICS project business targets.

Figure 14 - PHYSICS business targets addressed by the consortium.

What appears clear from the image above is that all the business targets have been tackled by one or more of the consortium partners.
A strong focus was put on providing FaaS design and platform management services with commercial relevance through technical development and strong contacts. In parallel with that, collaboration with key initiatives and projects was pursued at individual and consortium level, through one-to-one exchange, participation to public cooperative events and stakeholder conferences and workshops. In establishing a strong relationship with vendors of functional programming tools and approaches as well as key open-source communities, strong efforts were put by RedHat, HPE, HUA and GFT, as they have a solid foundation of strong contributors.

Considering that, the exploitation paths for the exploitable results previously identified have been drafted below.

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 developed the Reusable Artefacts Marketplace Platform to include standalone cross-platform artefacts. Various stakeholders among large enterprises, small and medium enterprises, and research partners, show great interest and show promise of an exploitation path for the RAMP. Furthermore, similar or converging strategic interests appear between the commercial stakeholders of the PHYSICS project. One of these strategic interests regards consulting services. Indeed, large companies such as Atos, GFT, HPE or Fujitsu for instance, show interest in the consulting and training services associated with the marketplace. In fact, synergies can exist between the RAMP and the services provided by some of the commercial partners. Because of the large number of artefacts available on the RAMP and the knowledge of the platform acquired during its development, companies delivering consulting services can provide clear, tangible solutions for the processes of their clients in the form of specific artefacts and integrate these artefacts in larger macro strategies. Even smaller companies such as RYAX see an exploitation approach through the

commercialization of proprietary features potentially on the RAMP, and additional consulting and training services. Other stakeholders of the PHYSICS project, and more specifically of the RAMP, see in this platform the opportunity to increase their knowledge, know-how, and integration capacities. Companies and/or research partners such as BYTE, Innov or HUA intend on using the outcomes of the PHYSICS project and the RAMP to improve existing products, or to integrate the outcomes in different programs.

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

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

Exploitation path:

a) Creation of an exploitation agreement and a legal entity for the RAMP platform project (See the Annex).
    i) All parties (contributors/providers and the operator of the marketplace) enter into an agreement on the supply of used artefacts, the distribution of artefacts, and all the parameters pertaining to a potential commercial agreement.
    ii) Agreement over non-profit or commercial nature of the platform among other decisions to be taken.
    iii) Responsibilities of each party are clearly defined (governance, rules, obligations, rights)
    iv) Open-source actors are included in the process, their contribution and role are adapted to their particular nature.
b) Definition of the platform' content.
    i) Stakeholders of the project agree on the nature of the services the platform will offer.
c) Definition of a clear business model and business plan for the platform.
    i) Identification of all potential stakeholders, and decision on the acquisition model of platform users, both supply and demand side.
d) Definition of the monetization strategy to be adopted for the platform.
    i) Depending on the agreement previously established.
e) Development of the platform and its content
    i) The platform is created, each used artefact is categorized and described according to its nature, function, usage, price, interoperability and so on.
    ii) A significant number of various artefacts are added to the platform to ensure an adoption of the platform by various players in the cloud computing ecosystem.
    iii) Developers and actors can be incentivized to fill the platform to ensure commitment along the development of the platform.

f) Development of a customer service application within the platform to accompany clients through their acquisition processes, and developers through their contribution processes.
    i) Customer service and more generally, a platform help desk, can guarantee the good functioning of the platform and the positive experience of contributors, whether they are on the supply or demand side of the RAMP.
g) Launch of a heavy marketing and business development campaign to explain the benefits of the platform.
    i) The marketing campaign can enhance the platform's visibility in the cloud computing ecosystem. It can also bring many users to the platform.
    ii) Business development is necessary to convince and stimulate external contributions to the platform, and to create a holistic RAMP experience.
    iii) The proactivity of the stakeholders in these matters is crucial to spread the platform's professional credibility across all actors of the cloud computing ecosystem.
h) Monitoring of the performances of the platform after its launch and test launch.
    i) Collection of feedback from demand and supply side to understand the different pain points of RAMP.
    ii) This monitoring can result in turn in strategic discussions among the platform operator and other invested stakeholders on the next strategic turn that the platform should take, or on new iterations to be brought to the RAMP project.

5.2.2 CSP Cloud Design Environment

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

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

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

Exploitation path:

a) Agreement drawn between the different stakeholders of the PHYSICS project.
    i) Stakeholders determine before starting the design of the first bundle, what they want to make out of this top-level application environment. This includes the attribution of responsibilities for different characteristics of the end product.
b) Definition of the content of the new cloud design environment.
    i) Typically, this new environment should be designed to include the strengths and weaknesses of all CSPs participating in the project.
c) Elaboration of an individual business model for this bundle in case it should be used separately from bundles 2 (CSP Optimized Platform Level FaaS Services Toolkit) and 3 (CSP Back-end Optimization Toolkit) as well as separately from the RAMP.
d) Design of the common environment under the PHYSICS project.
    i) PHYSICS' stakeholders create a common environment for CSPs including reused abstracted programming flows.
    ii) This environment comprises various designs, ready-made functions, and common patterns among other things.
    iii) Function as a Service approach is integrated in this new environment.
    iv) Ready-made functions and patterns are integrated in a specific repository which will be available with the new front-end environment.
    v) This new environment will be designed and created with a user-centric approach, in order to make it easy to adopt for developers with different skills.
    vi) The repositories and libraries of this new environment are the abstractions that hide complex processes, and which contribute to the fast and easy adoption of the new environment.
    vii) The new cloud design and its reusable flows also abstracts GDPR-compliant processes such as data portability and security. This characteristic of the first bundle can encourage the adoption across the European cloud computing environment.
e) Definition of additional services and customer services that can be added to the bundle.
f) Development of marketing and business development activities around the cloud design environment

5.2.3 CSP Optimized Platform Level FaaS Services Toolkit

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

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

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

Exploitation path:

a) Agreement between stakeholders involved is in the continuation of the agreement orchestrated around the first bundle
   i) Responsibilities are attributed to different parties, risks are identified and spread among the parties involved and so on.
b) Definition of the optimized platform-level FaaS Services toolkit, and its content and function
   i) This process must take into account the work previously executed for the first bundle (CSP Cloud Design Environment)
c) As for the first bundle, parties involved can prepare an alternative business plan, should this business plan be commercialized or at least used independently from the other bundles
d) Design of the CSP Optimized Platform-Level FaaS Services Toolkit
   i) This platform-level toolkit can allow cloud service providers of the PHYSICS project to bring new roles to their platforms.
   ii) Tools of the toolkit will help with the implementation of the new platform roles.
   iii) New roles and tools can include for instance spawning and orchestration of services across provider offerings.
   iv) This platform-level toolkit can transform application workflows to functional sequences in the FaaS model.
   v) This platform support also includes services and functionalities to enable component semantics, services benchmarking and evaluation, adaptation of application specifications to the necessary deployment language as well as deployment optimization and definition, spanning across different and diverse providers and services.
e) Definition of additional services and customer services that can be added to the bundle
f) Development of marketing and business development activities around the FaaS service platform-level toolkit

5.2.4 CSP Back-end Optimization Toolkit

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

targeted as a recipient for the research conducted under the PHYSICS project. Hewlett Packard Enterprise is also poised to leverage, in the techno-economic environment, the benefits of the research conducted under the PHYSICS project.

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

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

Exploitation path:

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

of its placing on the market. The individual exploitation plans have been updated in this second year of the project, after the review meeting and the multipurpose workshop.

5.3 Individual Exploitation Plans

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

5.3.1 GFT

GFT's approach to service integration strategically leverages AI, Cloud, IoT, and Big Data solutions across diverse applications. The company is poised to capitalize on the outcomes of this project, aiming to broaden its service portfolio. The focal point will be the promotion of the PHYSICS platform to its current clientele through established marketing channels.

In addition to targeting existing accounts, GFT envisions extending its reach by exploring the creation of private cloud instances anchored in the PHYSICS vertical solution. This initiative is designed to facilitate promotion and sales to private sector customers. Another avenue of exploitation involves seamlessly integrating the project's tools into the digital innovation labs of the company. This integration is anticipated to pave the way for the expansion of PHYSICS solutions into new market segments within both private and public sectors. Notably, this expansion includes segments beyond the established client base of the GFT Group.

5.3.2 ATOS

ATOS, as a global leader in digital transformation, has a strong focus on delivering cutting-edge technologies for its customers. From hardware, including the whole range of Bull Sequana solutions, to software, integrated in its hardware or as an independent solution, ATOS provides a plethora of services from the edge up to the cloud, including cybersecurity or AI, to different verticals. As part of the ATOS ADVANCE 2021 strategic plan, edge computing is considered as a key pillar for the company itself and a pivotal opportunity for expanding its businesses. Through the participation in PHYSICS, ATOS expects to improve one of its main key novel assets, the edge-to-cloud meta-orchestrator, identified by the ATOS Innovation Board, adding new functionalities for operating FaaS solutions.

The main goal of the team involved in this project, part of the New Media, Edge and Software Unit within the Research and Innovation Group, is to develop nearly close-to-market solutions that can be used internally, as part of the infrastructure management offering of the company, or externally, integrated within key ATOS commercial products, like Canopy Orchestrated Hybrid Cloud or Atos Codex, for data analytics, offered to its customers.

Furthermore, ATOS will use internally the knowledge gained in PHYSICS to enhance the techno-economic analysis about circular economy and decarbonization strategies, supervised by the Steering Board, to position itself in the emerging Continuum market developing new strategies.

5.3.3 HPE

A significant part of HPE Services (formerly Pointnext) A&PS (Advisory & Professional Services) offering portfolio is focused on Hybrid Cloud-enabled and Edge-connected solutions, with specific competence and know-how on related infrastructure topics. The expected solution framework resulting from PHYSICS perfectly fits in the HPE portfolio and will be proposed as a base for several of the above-mentioned bespoke solutions. In particular, PHYSICS will provide key expertise acquisition to enhance HPE capabilities and methodologies towards novel Edge-to-Cloud Design tools and techniques targeted at Edge to-Cloud

environments. HPE expects its participation in PHYSICS project, in synergy with other H2020 (and now Horizon Europe) innovation projects like ACCORDION and CHARITY where HPE is partner, to significantly boost its business opportunities in the Edge & Cloud domains.

Overall, since the HPE Services unit mission and focus is mainly on technology advisory and consulting, and is not a product development division, HPE Italy major exploitation of PHYSICS results is planned not be based on the development of specific products. It will instead go through the HPE Services advisory service portfolio, where the knowledge acquired in PHYSICS will be duly injected in the best-suited services to get a strategic advantage in the Edge to-Cloud market with respect to the competition.

Furthermore, HPE will exploit innovative outcomes into techno-economic models for sparse resource/infrastructure pools, to enhance its services and reinforce its competitive advantage.

In all the aforementioned potential exploitation areas, a general roadmap for the planned exploitation activities have been depicted, structured in three main phases.

- The first phase has been dedicated to a joint assessment among people who participated to the PHYSICS project and the interested teams in the respective different business units (internal HPE stakeholders), with the final goal of identifying use cases, services and solutions where such project teams can take advantage from the integration of the PHYSICS results and technologies.

Current status: this phase is going to be finalized in the final period of the project, taking into account and leveraging the final available results of the PHYSICS project.

- The second phase addresses the evaluation of the final results of the PHYSICS project by the different teams (internal HPE stakeholders). In the specified period, such results will be also considered with respect to the effective and evolving business needs of the respective business unit at that time. This phase will be the most critical one, since it will propose a recommendation for the "go/no go" decision about the following short-term exploitation steps. Moreover, in addition to internal HPE stakeholders' proposition, the HPE PHYSICS team will also approach external HPE stakeholders (HPE existing customers or potential new prospects) in order to properly disseminate the PHYSICS value proposition for generating possible business opportunities.

Current status: the timeframe of this phase is also started in the final period of the project and will continue in the months immediately after the project termination.

- The third and final phase, which will be carried on only after a formal approval from the business unit management (vs both internal and/or external stakeholders), will consist of an iterative cycle; a plan to design and implement the identified use cases, services and solutions will be defined, in order to use the lessons gained during the previous steps to improve the design and implementation of the next ones. HPE will also leverage other exploitation channels that are commonly used by the company for opening new business opportunities and to enlarge the base of customers in the different markets. The most important ones are the HPE Italy Technology Show Room Centre and the HPE Marketing Business Unit taskforce.

5.3.4 REDHAT Israel & Red Hat SL

REDHAT development methodology is based on working on upstream projects while later productizing them to enterprise level products. The exploitable results and contributions of the project's outcomes in the related upstream projects will land into RHT's saleable products.

For the Physics project we have identified the next upstream projects where we plan to contribute: Kubernetes/OpenShift, Submariner, OpenClusterManagement (Red Hat Advance Cluster Manager), Knative and Kepler. In addition, we started a new project for low footprint OpenShift for edge/IoT: MicroShift (https://github.com/redhat-et/microshift), that we plan to build a community around.

As a result of the work done in PHYSICS (e.g., collaboration with Knative in relation to WorkflowCRD operator, or Kepler enhancement) and the collaboration between partners, Red Hat engineers and

upstream communities, we have matured projects that Red Hat has recently included into its portfolio. Red Hat plans to keep maturing, maintaining and enhancing those: e.g., Kepler, Knative, and MicroShift.
Other projects were already part of the Red Hat portfolio before the PHYSICS projects, but the contributions made from PHYSICS will be valuable (e.g., the new k8s scheduler for FaaS use cases) as well as the bug fixes. Red Hat plans to keep maintaining and evolving those projects: Kubernertes, OCM, and Submariner.

5.3.5 FUJITSU Services

FUJITSU will use the developed technology and expertise gained within this project to address use cases and develop business relevant solutions in the manufacturing and automotive industry, in particular providing extended services from Germany or Europe. Moreover, Fujitsu will upstream this gained expertise to develop sellable FaaS consulting services and/or Products.

5.3.6 RYAX Technologies

RYAX is mainly responsible for designing and implementing the two levels of scheduling that takes place within the PHYSICS platform. The 1st scheduling layer named Global Continuum Placement allows the selection of most adapted cluster to schedule a certain task considering aspects such as performance, energy, etc. The 2nd scheduling layer named Local Scheduler enables the selection of the most adapted node in a cluster considering FaaS related optimizations, etc. RYAX will make use of the scheduling components developed in PHYSICS along with possibly other parts as well such as the resource management controllers, the performance evaluation framework, etc. in order to enhance its open-source low-code workflow-based automation platform which is commercialized and enables the customers of RYAX to leverage on Cloud technologies and FaaS runtimes in production. Furthermore, it will enable RYAX to open up its services towards the edge-cloud continuum and allow users to design and deploy their application seamlessly on the edge-cloud continuum.
Both components that RYAX is developing are open-source software components which are both important components of the software stack of PHYSICS. RYAX has currently implemented its first versions which enable efficient scheduling already, but further optimizations are currently being developed and will be available for the final solution of PHYSICS. In parallel, since they are independent components, they can be used in similar contexts and in particular they will be used as schedulers in particular contexts of the open-source RYAX low-code workflow-based automation platform.

5.3.7 InQBit

InQbit is focusing on expanding the reach and impact of the gamified platform developed in PHYSICS by partnering with educational institutions in Greece and Romania, developing industry-specific training modules and translating the platform into multiple languages. These strategies will allow the platform to reach a wider audience of potential users, make it more valuable to businesses and organizations and increase its global accessibility. InQbit is aiming to monetize their platform and attract new customers.

By exploiting blockchain technology, the company aims to create new business models such as a marketplace for flow-programming creations, a smart contracts service and decentralized applications. InQbit is planning in the immediate future to apply for the Innovation Radar, an initiative of the European Commission that identifies and promotes high-potential innovations. This recognition can enhance the platform’s visibility, attract further investment and secure additional support from third parties.

5.3.8 iSPRINT

Having evaluated PHYSICS in the eHealth pilot and having understood the performance and flexibility benefits of serverless computing, iSPRINT aims to enhance its core business product, Healthentia, by including cloud and edge computing features, based on the FaaS/Serverless Computing paradigm. Specifically, using the PHYSICS platform, we aim to be future proof in terms of scalability and performance to cost ratio when it comes to enabling advanced online AI prediction models for the end-users of our digital therapeutics' products.

5.3.9 INNOV

INNOV-ACTS is responsible for the development of the Reasoning Framework of the PHYSICS platform. Reasoning Framework (RF) is a service responsible to perform semantic matching between FaaS-based applications and resource services. Notably, leveraging custom ontologies, semantic rules, and knowledge graphs, RF filters the available computational clusters (e.g., cloud, edge) to them that meet the specific requirements of each function/workflow of the given application. This process facilitates the hybrid and multi-cloud deployment of FaaS applications in a timely manner.

INNOV expects to be able to exploit the following results:

A) Development & Consulting Using PHYSICS Tools: INNOV is involved in the design, specification and development of the semantics for internal data transfers in the PHYSICS system, as well as in the development of the inference engine. Hence, we will have a deep understanding of the PHYSICS FaaS middleware and tool. INNOV will use the later for its own FaaS solutions development in other research, commercial and consulting project.

B) Technology transfer and Training on FaaS: INNOV will use PHYSICS results to enhance its technology transfer and training portfolio with advanced FaaS cloud concepts and serverless computing case studies;

C) Joint Exploitation over PHYSICS Open Source : INNOV will actively participate to PHYSICS joint exploitation efforts, including the offering and monetization of value-added services (e.g., training, solution integration, technical support) over the open source results of the project.

5.3.10 CYBELE

CYBELE will use the PHYSICS validated technology to empower its actual and future commercial solutions based on edge computing for greenhouse growers and demonstrate it in annual presentations towards 50-100 growers. Furthermore, the PHYSICS solution may be expanded to their other products for forestry/breeding optimization.

5.3.11 HUA

HUA will exploit its activities and outputs from the participation in PHYSICS in order to enhance its research portfolio of tools stemming from R&D in order to provide consultation towards the Greek public and private sector. Candidate tools for this purpose are the Performance Evaluation Framework of T4.2 as well as the patterns development in WP3. Especially for the latter, reusability, adaptation or extension of the provided patterns may be a direct goal of exploitation. Furthermore, HUA will utilize the foreground of the project in order to enhance its academic activities (including pre and post graduate courses enrichment). Indicatively it has enriched its Web Engineering M.Sc. program (that also represents a large portion of the institution's externally acquired funding) with a new course on Cloud services development, including specific FaaS based concepts, patterns and resource management approaches. Other targets of exploitation include the production of quality publications (including 10 conference and journal publications during the project) as well as contributions to existing open-source repositories (e.g., node-red flows repository). Moreover, HUA

has exploited the knowledge and research in PHYSICS to participate in the SPEC Cloud WG, through which a number of high visibility opportunities have arisen (such as the participation in the 20201 Dagstuhl Seminar on Serverless Computing) as well as the EUCloudEdgeIoT TF3 working group. HUA has also participated in one hackathon and organized another, giving the opportunity to its students to get engaged with state-of-the-art issues and attract them to research oriented careers. HUA has also supported 1 B.Sc. thesis, 2 M.Sc. thesis as well as 3 candidate PhD students during the course of the project. Furthermore, HUA is able to participate in any post-project agreements in which joint exploitation may be performed and provide support and extensions for the implemented components during the project lifetime under its supervision.

5.3.12 DFKI

DFKI The SmartFactoryKL lab at DFKI premises uses bleeding-edge technologies and integrates them in its Industry 4.0 demonstrator to test the latest developments. The solutions developed by the PHYSICS project will add new novel functionalities to the demonstrator which are then going to be introduced to the lab's 50 collaboration partners from academia and industry. The project results are going to be used in the future projects and possible follow-up projects. The scientific approaches used to reach the goals can also be used in the lectures for bachelor and master students at the Kaiserslautern Technical University.

5.3.13 BYTE

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

BYTE will exploit the accumulated expertise from PHYSICS on semantic representations, ontologies and the systems that surround the FaaS paradigm to enhance both current products and services and the R&D process to discover potential shortcomings and develop new. All of the PHYSICS outcomes will be tested against business requirements leading to a Minimum Value Product regarding FaaS functionalities.

5.3.14 UPM

The exploitation plan of UPM will consist in increasing its research portfolio. This includes software prototypes developed in the project that can be transferred to industry. The knowledge gained in the project is exploited in consultancy services and lectures to master students. The research will continue in new projects and PhD thesis. The performance evaluation of the in-memory data service and its integration with some of the pilots will be used as a demonstrator for companies UPM collaborates with.

5.4 Joint Exploitation agreement

This path ensures the sustainability and uptake of the project's jointly created artefacts and exploitable results. All PHYSICS partners worked collaboratively and intensively in community development around this joint exploitation path, building on established partner networks and customer accounts in the cloud, edge, service, and application related markets. For this purpose, hackathons, webinars, and multi-projects events have been organized, reaching out to the relevant communities. The exploitation and long-term viability of PHYSICS will be initially pursued through an exploitation agreement that covers the PHYSICS produced Artefacts Marketplace (RAMP) and aims to cover all the PHYSICS outcomes. More on this in Chapter 8.

5.5 Exploitation of the use cases of the Project

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

Partners involved take advantage of the main exploitable items of PHYSICS as specified above (3 bundles, RAMP and platform) 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 has deployed and demonstrated a set of FaaS use cases in its SmartFactoryKL lab. DFKI will exploit the developed demonstrator in two complementary directions:

   (i) Development of a FaaS lab for industrial use cases and deployment of PHYSICS technologies in more demonstrators. This direction involves the development of more FaaS demonstrators and their use for dissemination and training of the members of the SmartFactoryKL lab;

   (ii) Technology Transfer of the demonstrator to the industry, based on its deployment in real production lines. In this direction, DFKI will replicate the demonstrator in production lines of the industrial members/partners of SmartFactoryKL. As a first step, presentations of the Use Case to the industrial partners of DFKI & SmartFactoryKL will be planned. Specifically, presentations to a minimum of five (>=5) partners will be pursued. Accordingly, a deployment plan of the Use Case to the selected production lines (e.g., through support for their devices and automation platforms) will be prepared and executed.

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). 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 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 agrifood sector. It will provide low-latency functionalities such as real-time plant health diagnostics as a service.

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6. BUSINESS MODELS FOR SOLUTIONS

6.1 Business Models for Solutions Insight to the FaaS Business Model

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

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

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

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

6.2 The Main Common Industry Elements of the Business Models

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

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

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

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

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

6.3 Business model validation

6.3.1 Increased Productivity

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

6.3.2 Operational Risk Assessment

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

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

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

6.3.3 Pricing and Profitability

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

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

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

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

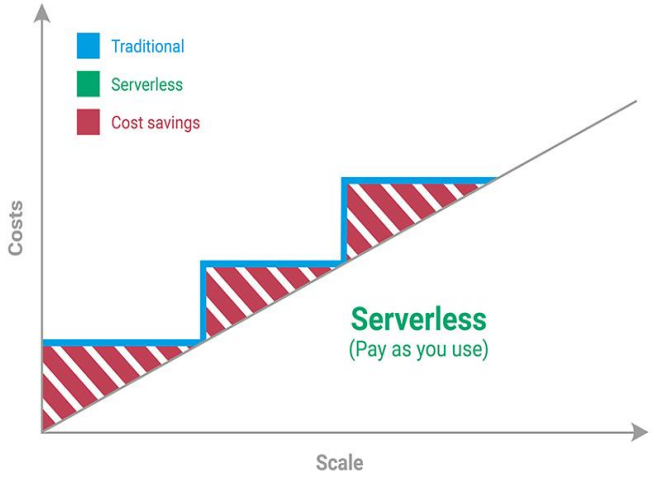
With respect to the predictability of expenditures which leads to a more accurate profitability assessment, the FaaS model both leads to cost reductions and an improved opportunity to oversee fees due to the variable cost based on usage. As operations expenditures are proportional to use, the general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

6.3.4 Cost Structure Analysis

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

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

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



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

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

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

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

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

6.3.5 Market Analysis

Overview of the main market sectors

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

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

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

Banking / Financial Services

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

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

Telecommunication and ITES

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

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

Consumer Goods and Retail

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

Healthcare and Life Sciences

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

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

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

Government and Public Sector

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

6.3.6 Competitor Analysis - Overview of the main cloud service providers

This section will perform a market analysis of the main providers focusing primarily on the structural sources and execution capabilities at the core of the services provided by AWS Lambda[xxiv], Google Cloud Functions[xxv] and Microsoft Azure Functions[xxvi]. 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[xxvii], Fission[xxviii] and OpenWhisk, allows us to deploy and run FaaS on users' hardware. In this reality of open-source frameworks, most of them use licenses such as MIT and Apache 2.0, which allow users to use the software for any use with minimal limitations. OpenFaaS, for example, uses an MIT license, which allows users to use code for any purposes, even if the code is part of proprietary software, with the only limitation of including the original copy of the MIT License.

Amazon AWS Lambda

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

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

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

Microsoft Azure

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

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

Azure also agreed on a substantial contract with the NBA and Blackrock, the world's most prominent asset management firm for its well-known Aladdin platform. The long-term agreement sealed with AT&T is another significant move from Azure which can be mentioned as Microsoft is moving fast in the cloud universe.

These milestones emphasize how Microsoft can benefit from its existing products such as Windows and other Microsoft tools and software to build on these existing partnerships that it can leverage for its Azure

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

Azure benefited from Microsoft Software-as-a-Service (SaaS) footprint it has earned throughout the years on an external site. Also, it helped Azure internally as, from an execution and technology perspective, the learning curve from Windows has been a critical success factor according to Microsoft Azure EVP Jason Zander.

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

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

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

6.3.7 Google Cloud Services

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

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

The current industry leaders are implementing APIs in various ways to develop their business, with 55% of them using API as a revenue stream. The examples of companies with API-based business models, including Google with Google Maps, Analytics, Calendar, Contacts, or Facebook, Spotify or PayPal, are mainly API-based, connecting their services to millions of third-party websites and apps. Also, Japanese Sony has an API for developing applications integrated into their devices (Vector ITC, 2019). The main benefits of introducing API to Google's offer was to improve its cloud offering focused mostly on corporate

clients (Trefis Team, 2016) by providing the following advantages to their service. The main benefit of adding API Apigee to Google Cloud is accelerating moving the customers into high-quality digital interactions. The service will allow faster and easier APIs implementation and publishing with excellence (Greene, 2016). That means that the customers will be able to, for example, enable their developers to work on the code of their application while maintaining the stable interface in the apps and services.

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

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

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

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

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

7. BUSINESS MODELS FOR SPECIFIC USE CASES

7.1 eHealth

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

In the current market, more digital health applications enter the market such as Livi[xxx], DoctoLib[xxxi] and the National Health Service[xxxii]. 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[xxxiii]. However, one pivotal factor to consider in e-Health applications is the risk of providing sensitive data to third parties. For this reason, an extra precaution in the design and choice of the cloud is highly relevant. Therefore, the sector could benefit from efficient and secure data management techniques, which are critical for patient management, hospital resources management, doctor-patient relationship management, medical supplies management, and maintaining patients' health record. The industry has shifted into a model that collectively supports and coordinates the workflows and medical information on cloud with the support of FaaS.

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

7.1.1 Value proposition of PHYSICS in eHealth

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

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

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

7.2 Smart Agriculture

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

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

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

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

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

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

7.2.1 Value proposition of PHYSICS in Smart Agriculture

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

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

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

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

7.3 Smart Manufacturing

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

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

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

7.3.1 Value proposition of PHYSICS in Smart Manufacturing

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

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

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

In 2021, Siemens announced a new cooperation with Google Cloud to optimize factory processes and

improve productivity on the shop floor. Siemens intended to integrate Google's specialty in data cloud and machine learning technologies with its factory automation solutions. With this new partnership, manufacturers will be able to harmonize their factory data and run cloud-based AI models with that data. This enables more automated inspection of products or prediction of the wear-and-tear of machines on the assembly line.

8. EXPLOITATION AGREEMENT

In cooperation with the whole consortium, GFT drafted a template for an exploitation agreement to be read and reviewed by the partners to protect the IP developed during the PHYSICS project and insure a long and prosperous cooperation. The agreement is still in its validating phase but an initial version has been reviewed by the partners, covering rules and roles and how to proceed further. The purpose of this Exploitation Agreement is to establish the legal framework under which the partners agree to manage the PHYSICS exploitable results. Specifically, the legal framework covers the establishment of the PHYSICS exploitation agreement and governing committee and the rules under which these may operate. The Exploitation Agreement does not alter any rights already conferred on Parties through which they can exploit the Foreground arising from the Project through the Grant Agreement, Consortium Agreement or any other legal agreement(s) between partners. The Exploitation Agreement shall come into force as of the date of its signature by all the Parties and shall continue in full force and effect for an initial term of two years commencing on the signature date. The initial draft for this agreement can be found in Annex 1.

8.1 Exploitation Agreement structure

The proposed Table of Contents of the key points of the exploitation agreement can be found below. As it can be noticed, it covers the purpose and duration of the agreement, the controlled IP, the roles and members, the governance frameworks, rules and liabilities, and how it can be improved and expanded.

Exploitation Agreement
PHYSICS consortium

Version 1.0

Date: 30/11/2023

Exploitation Agreement structure:

Figure 15 - Exploitation agreement front page

8.2 Exploitation Agreement roles

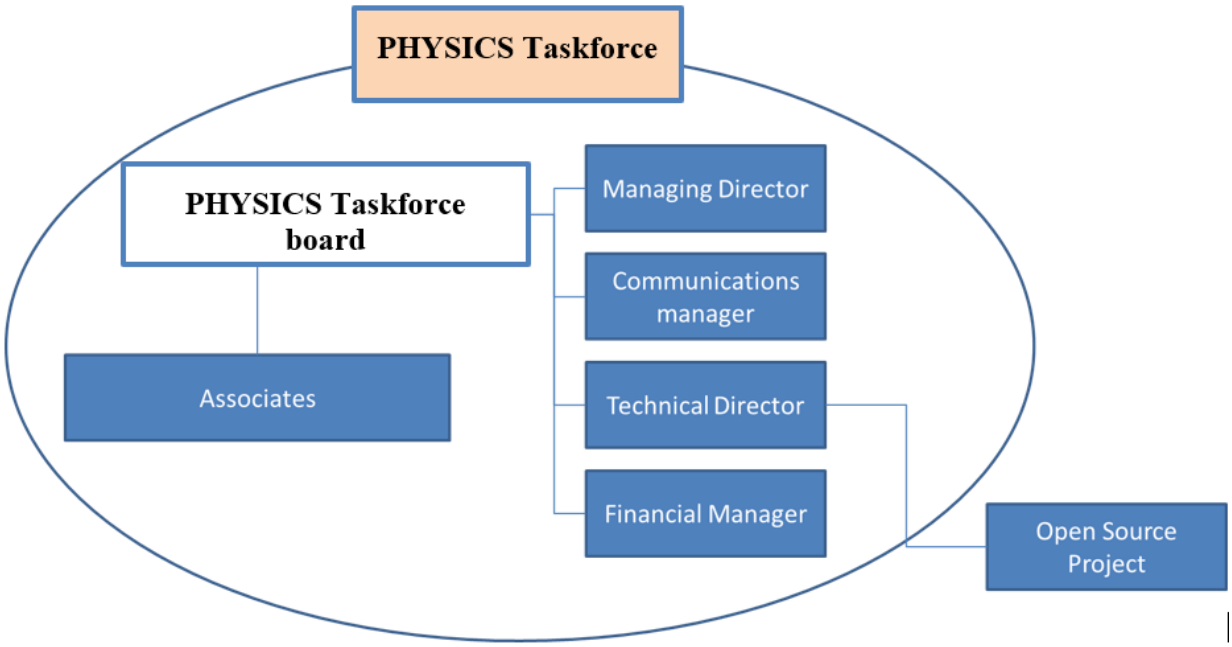


Figure 16 - PHYSICS taskforce

Five roles have been identified for the PHYSICS agreement signatories in the PHYSICS agreement. They are not mutually exclusive. These are:

A: Executive Member

Party who accepts a leadership position in the PHYSICS Taskforce. Only Members can have an executive role.

B: PHYSICS Commercial Provider

Party who provides a service to third parties based on IP maintained, owned or developed by the PHYSICS agreement using the the branding, logo or trademarks of PHYSICS or owned by the PHYSICS consortium. Only Members can be PHYSICS Commercial Providers.

C: PHYSICS Researcher

Party who accesses, uses or develops IP maintained, owned or developed by the PHYSICS using the branding, logo or trademarks of PHYSICS or owned by *PHYSICS agreement signatories* in the context of research.

D: PHYSICS Developer

Party who develops or otherwise modifies IP maintained, owned or developed by the *PHYSICS agreement signatories* using the branding, logo or trademarks of PHYSICS or owned by PHYSICS.

E: PHYSICS Commercial Users

Parties who use IP maintained, owned or developed by the *PHYSICS agreement signatories* for commercial own use, including when this is provided as a service by a PHYSICS Commercial Provider.

8.3 Provisions for dispute resolution and managing breach of Parties

Following a vote of the PHYSICS TASKFORCE BOARD, in accordance with voting rules of Article 4.5. III.b.(b), the PHYSICS TASKFORCE BOARD may declare a PHYSICS TASKFORCE Associate in breach of this Exploitation Agreement if they fail to comply with the Terms and Conditions of access to the Taskforce-controlled IP.

The PHYSICS TASKFORCE BOARD will then give the PHYSICS TASKFORCE Associate written notice and provide a window of twenty (20) days for the Associate to rectify the situation or advise of an exception under Force Majeure (Article 4.7. III).

Should the detected breach not be satisfactorily resolved within the twenty (20) day period, the PHYSICS TASKFORCE BOARD may terminate the Agreement with respect to the PHYSICS TASKFORCE Associate, with resulting loss of Associate status, rights and obligations.

8.4 Liabilities

The PHYSICS TASKFORCE is not a legal entity, partnership or agency. Legal liability resides individually with PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates.

All legally binding decisions required during PHYSICS TASKFORCE operations must be made by PHYSICS TASKFORCE Members or PHYSICS TASKFORCE Associates and cannot be made by the PHYSICS TASKFORCE itself. Where joint actions are needed further legal agreements may need to be established.

The PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates shall have no liability towards each other with the exception of the case of damage caused by a willful act and/or gross negligence. The Parties will assist each other to the extent required to defend claims.

9. HANDBOOK ACTIVITIES

As already stated in previous iterations of WP7 series of deliverables, an open innovation process is followed in order to design a useful handbook that can be reused either internally, by technical partners or use cases, or externally, by any other entity interested in using PHYSICS to address a specific technical and/or business need.

After some internal discussions it was agreed to have a twofold handbook:

- Internally oriented, to provide some short of step-by-step guide that can be followed by any partner aiming to develop a new product or create a spinoff company. This manual follows a typical strategic consultancy procedure, with detailed explanations about the methodologies to be followed and for what in order to develop a successful go-to-market strategy and plan. Some recommendations will be also provided to interpret results. This manual set the basis for supporting decision-making procedures in order to provide enough information whether to invest or not in a business.
- Externally oriented, presenting the available pipelines and the tools involved in each of them in order to make the different possibilities of using PHYSICS easily available, and understandable, for any potential user. In this sense, the pipelines are introduced from a business and technical point of view and complemented with the examples of the PHYSICS use cases that can be followed to have a general idea about how costly, in terms of efforts and resources, is using PHYSICS for addressing a specific need and how much beneficial, in terms of percentages of completeness, it can be. Additionally, some recommendations for using PHYSICS are provided based on the lessons learnt by the partners during the project lifespan. This second part can be extracted from the official deliverable and publish in the RAMP as an introductory document to PHYSICS platform, complemented with the information available in the technical documents with further instructions about how to download, install and integrate the needed tools.

In this way, the planned PHYSICS Handbook is able to cover the requirements from partners in terms of available guidelines for a successful further exploitation of project results and/or to foster the usage of PHYSICS by any potential user.

10. CONCLUSIONS

This deliverable represents a refined and in-depth exploration of the project's exploitable outcomes, marking a continuation of the analyses conducted in the preceding two versions. Various exploitation paths have been meticulously identified and scrutinized, with a specific emphasis on individualized plans, acknowledging the invaluable contributions of each partner. Over the course of 36 months, the project's exploitation efforts have evolved, initially concentrating on assessing the operating market and delineating the unique developments undertaken by project software developers. In the latter phase, spanning the second period, the primary objective has been to bridge the gap between research and market by providing a comprehensive suite of solutions and approaches to problem-solving. This phase also aimed to pinpoint specific cases of exploitation that, in subsequent marketing endeavors, could be transformed into viable products or services. The deliverable meticulously analyzes use cases, elucidating their value propositions.

Within this document, we expound on the Knowledge Exploitation and Results Showcase (KERS), underscoring the clear potential of PHYSICS and its substantial capacity to offer tailored value-added proposals that address customer challenges. Additionally, we present an initial overview of the integrated Intellectual Property Rights (IPR) approach. The partners are steadfastly committed to extending the project's lifespan beyond its official conclusion, establishing a legal framework for result exploitation in the event of a business opportunity.

This final version places a particular emphasis on the innovation potential inherent in the project results. A detailed analysis, partner by partner, delves into expectations by the project's conclusion, thoroughly examining customer impact and benefits. The section detailing individual exploitation plans illuminates the latest strategies of PHYSICS partners in incorporating exploitable results as potential solutions into their business models, affirming the market readiness of proposed solutions.

Furthermore, the exploration of exploitation paths and key results has been intensified. In the project's concluding year, a plethora of assets were seamlessly integrated into the Results Amplification and Management Platform (RAMP). Simultaneously, the dissemination of knowledge pertaining to the PHYSICS framework was expanded within the Function as a Service (FaaS) sector.

The latter part of the document delves into business models for use cases, individual results, and collaborative solutions, all of which are thoroughly explored and validated. In cooperation with the whole consortium, GFT drafted a template for an exploitation agreement to protect the IP developed during the PHYSICS project and insure a long and prosperous cooperation. The document's final section outlines the initial steps and objectives of the PHYSICS Handbook, offering insights into its contents and identifying the target recipients.

DISCLAIMER

COPYRIGHT MESSAGE

ANNEX 1 – EXPLOITATION AGREEMENT

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[xix] 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/

[xx] 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/

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Exploitation Agreement
PHYSICS consortium

Version 1.0

Date: 30/11/2023

Exploitation Agreement structure:

EXPLOITATION AGREEMENT

This AGREEMENT is made on XX/XX/202X

BETWEEN

1. GFT ITALIA SRL (GFT)
2. ATOS IT SOLUTIONS AND SERVICES IBERIA SL (ATOS),
3. HEWLETT PACKARD ITALIANA SRL (HPE
4. RED HAT ISRAEL LTD (RED HAT)
5. FUJITSU SERVICES GMBH (FSDE),
6. BYTE COMPUTER ANONYMI VIOMICHANIKIEMPORIKI ETAIREIA (BYTE),
7. RYAX TECHNOLOGIES (RYAX),
8. INQBIT INNOVATIONS SRL (INQBIT),
9. INNOVATION SPRINT (ISPRINT),
10. INNOV-ACTS LIMITED (INNOV),
11. CYBELETECH (CYBELETECH),
12. UNIVERSIDAD POLITECNICA DE MADRID (UPM),
13. CHAROKOPEIO PANEPISTIMIO (HUA),
14. DEUTSCHES FORSCHUNGSZENTRUM FUR KUNSTLICHE INTELLIGENZ GMBH (DFKI),
15. RED HAT SL (RHTSP)

hereinafter, jointly or individually, referred to as “Parties”

WHEREAS:

(a) The *Parties*, having considerable experience in the field concerned, together with Project Participants not party to this agreement, submitted a Proposal for the *Project* entitled "PHYSICS", hereinafter "the Project" to the *European Commission* under the Horizon 2020 programme.

(b) The *Parties,* together with Project Participants not party to this agreement, entered into a *Contract* with the European Commission, as *Beneficiaries,* and also entered into a *Consortium Agreement* to carry out the *Project* in accordance with such *Contract*.

(c) The Parties now wish to specify the terms and conditions under which they will be entitled to exploit the *Foreground* arising out of the Project, further to the agreements made in the Project Consortium Agreement

NOW THEREFORE IT IS HEREBY AGREED AS FOLLOWS:

Section 1. Definitions

Article 1.1. PHYSICS project:

The PHYSICS H2020 project proposed to apply a unified continuum approach, including functional and operational management across sites and service stacks, performance through the relativity of space (location of execution) and time (of execution), enhanced by semantics of application components and services. PHYSICS applied this scope via a vertical solution consisting of a:

-Cloud Design Environment, enabling design of visual workflows of applications, exploiting provided generalized Cloud design patterns functionalities with existing application components, easily integrated and used with FaaS platforms, including incorporation of application-level control logic and adaptation to the FaaS model.

-Optimized Platform Level FaaS Service, enabling CSPs to acquire a cross-site FaaS platform middleware including multi-constraint deployment optimization, runtime orchestration and reconfiguration capabilities, optimizing FaaS application placement and execution as well as state handling within functions, while cooperating with provider-local policies

-Backend Optimization Toolkit, enabling CSPs to enhance their baseline resources performance, tackling issues such as cold-start problems, multitenant interference and data locality through automated and multi-purpose techniques.

PHYSICS produced an Artefacts Marketplace (RAMP), in which internal and external entities (developers, researchers, etc.) are able to contribute fine-grained reusable artifacts (functions, flows, controllers, etc). PHYSICS validated the outcomes in 3 real-world applications (eHealth, Agriculture and Manufacturing), making a business, societal and environmental impact on EU citizen life.

In addition, PHYSICS platform aims to apply a unified continuum approach, incorporating functional and operational management across various sites and service stacks; a holistic solution that integrates various components to provide a unified approach for designing, optimizing, and managing applications across different cloud environments, with a focus on FaaS, resource optimization, and real-world application validation.

Article 1.2. Additional definitions

"*Consortium Agreement*" means the Consortium Agreement for the Project entered into by the Project *Participants* in respect of the PHYSICS H2020 project.

"*Contract*" means the Contract H2020-2020-2 grant agreement #101017047 (including its Annexes) for the undertaking by the *Participants* of the *Project*.

"*Participant*" or "*Participants*" means a party or the parties to the Contract.

"*PHYSICS TASKFORCE AGREEMENT*" means the agreement established in accordance with Section 3.

"*PHYSICS agreement signatories*", means the signatory Parties and any organisation which has agreed to sign PHYSICS agreement and has been accepted by the [then] current *PHYSICS agreement signatories* as per the governance rules of the PHYSICS AGREEMENT.

"*Defaulting Party"* means a Party which the PHYSICS TASKFORCE BOARD (established in accordance with Section 3) has identified to be in breach of this Exploitation Agreement.

"*Grant Agreement*" or "*GA*" means - after its signature by all Contractors, the contract (including its Annexes) for the PHYSICS Project, for the undertaking by the Parties of the Project; "Grant Agreement" shall, as applicable, also mean any amendment to it.

"*PHYSICS Controlled IP"* means intellectual property that has been designated as so under Article 3.4. of this contract or that is created under the terms of Article 3.5. and Article 3.6.

Section 2. Purpose and Duration

Article 2.1. Purpose

The purpose of this Exploitation Agreement is to establish the legal framework under which the *Parties* agree to manage the PHYSICS exploitable results.

Specifically, the legal framework covers the establishment of the *PHYSICS exploitation agreement* and governing committee (*PHYSICS AGREEMENT BOARD*), the rules under which these may operate.

For clarity, this Exploitation Agreement does not alter any rights already conferred on Parties through which they can exploit the *Foreground* arising from the Project through the Grant Agreement, Consortium Agreement or any other legal agreement(s) between *the Parties*. Additionally, this Exploitation Agreement does not prevent in any way future bilateral agreements between the Parties.

Article 2.2. Duration

This Exploitation Agreement shall come into force as of the date of its signature by all the *Parties* (the Effective Date) and shall continue in full force and effect for an initial term of two (2) year commencing on the Effective Date.

This Exploitation Agreement shall be automatically terminated at the end of the initial term, unless all Parties agree to renew the Exploitation Agreement for 1 (one) successive year. Such renewal must be agreed and signed by all *Parties* in writing.

After that first successive year, the Exploitation Agreement shall be automatically terminated, unless all Parties agree to renew the Exploitation Agreement for one or more successive year periods. After each such successive year period, the Exploitation Agreement shall be automatically terminated, unless all Parties agree to renew the Exploitation Agreement for one or more successive year periods.

If a Party leaves the Exploitation Agreement, the Exploitation Agreement shall be automatically terminated in respect of the said Party or Parties, subject to the provisions surviving the termination under this Exploitation Agreement.

The provisions relating to Access Rights, Confidentiality, Liability, Applicable law and Settlement of disputes shall survive the expiration or termination of this Exploitation Agreement.

Termination shall not affect any rights or obligations of a Party leaving the Exploitation Agreement incurred prior to the date of termination, unless otherwise agreed AMONG the PHYSICS AGREEMENT BOARD and the leaving Party.

Section 3. Agreement Controlled IP

Article 3.1. Definition

Agreement Controlled IP shall refer to the Intellectual property listed under clause 0 or created following the provisions of Article 3.5. and Article 3.6.

Article 3.2. Ownership

Agreement Controlled IP is co-owned in equal share by all PHYSICS Taskforce Members who agree to use it solely under the Terms of Use policy as to be defined by the PHYSICS Agreement BOARD according to Article 3.7.

Article 3.3. Access rights

PHYSICS agreement signatories have the right to access Controlled IP under the Terms of Use (Article 3.7.)

Article 3.4. Transfer of Foreground ownership

Nothing in this Agreement shall be deemed to confer ownership of Foreground on any Party, **with the exception of Foreground listed under this article**.

All Parties agree to transfer ownership of PHYSICS branding, logos, generic website content and URLs and goodwill to the *PHYSICS agreement signatories*, in conditions here under:

I. General

Foreground referred to in this article is that relating to the image and reputation of the PHYSICS brand. It is composed of:

- the PHYSICS logo
- the PHYSICS brand names

  PHYSICS, The PHYSICS Reusable Artefacts Marketplace
- the PHYSICS website URL, including all web pages in the site:

  https://physics-faas.eu/
- any goodwill associated with the brand.

Furthermore this Article includes **all content of the project website**s excepting the following material:

1. logos, trademarks and similar branding of the project participants
2. publications and papers owned by Parties and third parties and merely republished by the PHYSICS website.
3. Open Source Software hosted on the website.

II. The recipients shall designate this IP as Agreement Controlled IP

III. Parts of co-ownership

By the signature of this Exploitation Agreement, each *Party* is transferring its ownership of the Foreground listed in Article 3.4. I in **equal parts** to the PHYSICS TASKFORCE, (as the same shall be constituted at any given time).

IV. Subsequent changes to PHYSICS TASKFORCE membership

For clarification:

> Any PHYSICS TASKFORCE Member leaving the Taskforce will transfer ownership of assets considered as Taskforce Controlled IP to the remaining *PHYSICS agreement signatories* in equal parts. They shall impose no charge for this transfer.
>
> Should a new Member sign the agreement, the other *signatories* will automatically transfer the proportion of their ownership in all TASKFORCE Controlled IP to the new Member, such that the new Member owns an equal share to the other Members. They shall impose no charge for this transfer.

V. Control of the use of such Foreground

The use of Controlled IP shall be controlled by the PHYSICS agreementBOARD through the **Terms and Conditions (Article 3.7.).**

VI. Ownership in the case of extinction of the PHYSICS agreement

Should the PHYSICS agreement expire, the ownership of these assets shall remain with those organisations which were *PHYSICS agreement signatories* at the time of expiry. The Terms and Conditions shall be extinct and each Member will be free to exploit royalty-free the entirety of the agreement Controlled IP without the consent of, or need to provide notice to, the other Members.

Article 3.5. <u>Derivation of controlled IP</u>

Unless otherwise agreed by the PHYSICS BOARD, all derivative work of controlled IP shall also be *PHYSICS agreement signatories* Controlled IP. That is, its ownership shall be equal among Members and its use subject to the Terms and Conditions of use.

Article 3.6. Creation of new Controlled IP

The PHYSICS BOARD may decide to discuss with the *Parties* that they invest resources in generating new software or other Intellectual property. The *Parties* can then agree to handle such new software or other Intellectual property as Controlled IP.

One aspect that will need to be further discussed at the agreement come into force is the on concerning the PHYSICS platform and all the related components. After the project end, they will be migrated on a public platform. The updated agreement for this new IP will cover what is the value for PHYSICS partners after the transfer has been made, based on the possible offer of maintenance and professional services (such as consultancy and training) directly from there.

Article 3.7. Controlled IP Terms and Conditions

The terms and conditions will be drafted by the PHYSICS agreement BOARD. They will be based on the following principles:

I. Context

The IP can only be used in the context of cloud migration and modernisation services with some reuse of some original software, tools, approaches or methodologies originating in the Project, or subsequent derrivatives of that intellectual property.

II. Benevolent

The IP can only be used in a fashion that does not denigrate the *PHYSICS agreement signatories*, Controlled IP, other Members or IP originating in the Project.

III. Non-exclusive

The IP cannot be used in a way that implies that the user has exclusive rights over Controlled IP.

Section 4. Roles, PHYSICS Members and PHYSICS Associates, management

Article 4.1. PHYSICS TASKFORCE Roles

I. Descriptive Roles

Five roles have been identified for the PHYSICS agreement signatories in the PHYSICS agreement. They are not mutually exclusive. These are:

a. A: Executive Member

Party who accepts a leadership position in the PHYSICS Taskforce. Only Members can have an executive role.

The following Executive Member roles are foreseen. The PHYSICS BOARD may refine these roles and their descriptions.

(a) Managing Director - The figurehead of the PHYSICS BOARD.

(b) Technical Manager - An Executive Member appointed as the leader of the RAMP committee during its first two years.

(c) Communications Manager - An Executive Member with responsibility for marketing the PHYSICS results.

b. B: PHYSICS Commercial Provider

Party who provides a service to third parties based on IP maintained, owned or developed by the PHYSICS agreement using the the branding, logo or trademarks of PHYSICS or owned by the PHYSICS consortium. Only Members can be PHYSICS Commercial Providers.

c. C: PHYSICS Researcher

Party who accesses, uses or develops IP maintained, owned or developed by the PHYSICS using the the branding, logo or trademarks of PHYSICS or owned by *PHYSICS agreement signatories* in the context of research.

d. D: PHYSICS Developer

Party who develops or otherwise modifies IP maintained, owned or developed by the *PHYSICS agreement signatories* using the the branding, logo or trademarks of PHYSICS or owned by PHYSICS.

e. E: PHYSICS Commercial Users

Parties who use IP maintained, owned or developed by the *PHYSICS agreement signatories* for commercial own use, including when this is provided as a service by an PHYSICS Commercial Provider.

II. Members and Associates

PHYSICS TASKFORCE Members and TASKFORCE associates have different rights and responsibilities as set out in Article 4.2. and Article 4.3. , respectively. Roles A and B may only be fulfilled by PHYSICS Taskforce Members. Roles C, D and E may be fulfilled only by Members or Associates.

Note. This agreement does not prevent Members, Associates and third parties from accessing intellectual property according the license under which they have received that intellectual property.

III. The parties' participation is as follows:

Partner	Role A – Executive Member	Role B - PHYSICS Commercial Provider	Role C - PHYSICS Researcher	Role D – PHYSICS Developer	Role E - PHYSICS Commercial User	Member	Associate
GFT	X	X	X	X	X	X	
ATOS						X	
HPE						X	
UPM						X	
RH						X	
FTDS						X	
BYTE							X
RYAX						X	
INQBIT						X	
i-Sprint							

Innov-acts							
CYBE							
HUA							
DFKI							

Table 1: Party commitments to PHYSICS TASKFORCE Roles

Article 4.2. PHYSICS TASKFORCE Members

I. Initial PHYSICS TASKFORCE Members

The following organisations are the initial PHYSICS TASKFORCE Members: GFT, ATOS, HPE, UPM, RH, FTDS, BYTE, RYAX, INQBIT, i-Sprint, Innov-acts, CYBE, HUA, DFKI

II. Rights and Obligations

PHYSICS TASKFORCE Members will have the right to be present or represented on the PHYSICS TASKFORCE BOARD (defined under Article 4.5. III).

PHYSICS TASKFORCE Members will have the right to propose themselves as candidates for executive positions (i.e. Members have the possibility of being Executive Members).

PHYSICS TASKFORCE Members have the right (but not obligation) to be listed as Members of the PHYSICS TASKFORCE on the website of the PHYSICS TASKFORCE.

PHYSICS TASKFORCE Members will have the right to use TASKFORCE Controlled IP subject to the Terms and Conditions, including the association of the PHYSICS Taskforce brand to commercial solutions, research and development.

Article 4.3. PHYSICS TASKFORCE Associates

I. Initial PHYSICS TASKFORCE Associates

The following organisations are the initial PHYSICS TASKFORCE Associates; TBD

II. Rights and Obligations

PHYSICS TASKFORCE Associates have the right (but not obligation) to be listed as parties supporting the PHYSICS TASKFORCE on the website of the PHYSICS TASKFORCE.

PHYSICS TASKFORCE Associates will have the right to use TASKFORCE Controlled IP subject to the Terms and Conditions for research, development and own use. The provision of commercial services using TASKFORCE Controlled IP is explicitly prohibited.

Article 4.4. Changes in PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates

I. PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates may withdraw their PHYSICS TASKFORCE Member or PHYSICS TASKFORCE Associate status by informing the managing Director of the PHYSICS TASKFORCE BOARD in writing with at least 30 calendar days before the expected termination date.

II. Upon withdrawal of a PHYSICS TASKFORCE Member, any rights conferred under this Exploitation Agreement to the withdrawing PHYSICS TASKFORCE Member shall lapse at the termination date, without prejudice to ownership held by the withdrawing PHYSICS TASKFORCE Member of the Foreground and/or any derivative work, which remain its property (under Article 3.4.), with the clear exception of the Foreground listed under article Article 3.4. I and in accordance with clause IV of Article 3.4.

III. Upon withdrawal of an PHYSICS TASKFORCE Associate, any rights conferred under this Exploitation Agreement to the withdrawing PHYSICS TASKFORCE Associate shall lapse at the termination date, without prejudice to ownership held by the withdrawing PHYSICS TASKFORCE Associate to its Foreground and/or any derivative work, which remain its property (under Article 3.4.).

IV. The PHYSICS TASKFORCE BOARD will provide a process through which organisations can become PHYSICS TASKFORCE Members or PHYSICS TASKFORCE Associates (pursuant to Article 4.5. III.b.(c)).

Article 4.5. Governance Framework

I. General

The purpose of the Governance Framework (GF) is to define the policies and procedures by which PHYSICS TASKFORCE Members direct and control the PHYSICS TASKFORCE.

The PHYSICS TASKFORCE Members are responsible for managing the TASKFORCE Controlled IP in accordance with the terms of this Exploitation Agreement.

This Exploitation Agreement provides the legal context for the GF defining source policies for rights, restrictions and responsibilities of PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates. The GF must monitor and enforce accountability across legal, operational and financial matters.

II. Governance Structure

The governance structure for the PHYSICS TASKFORCE is shown in Figure 1. Parties sign this Exploitation Agreement and as a consequence become either PHYSICS TASKFORCE Members or PHYSICS TASKFORCE Associates depending on their indicated status within the Exploitation Agreement. Members have operational commitments and responsibilities, and participate in the PHYSICS TASKFORCE BOARD.

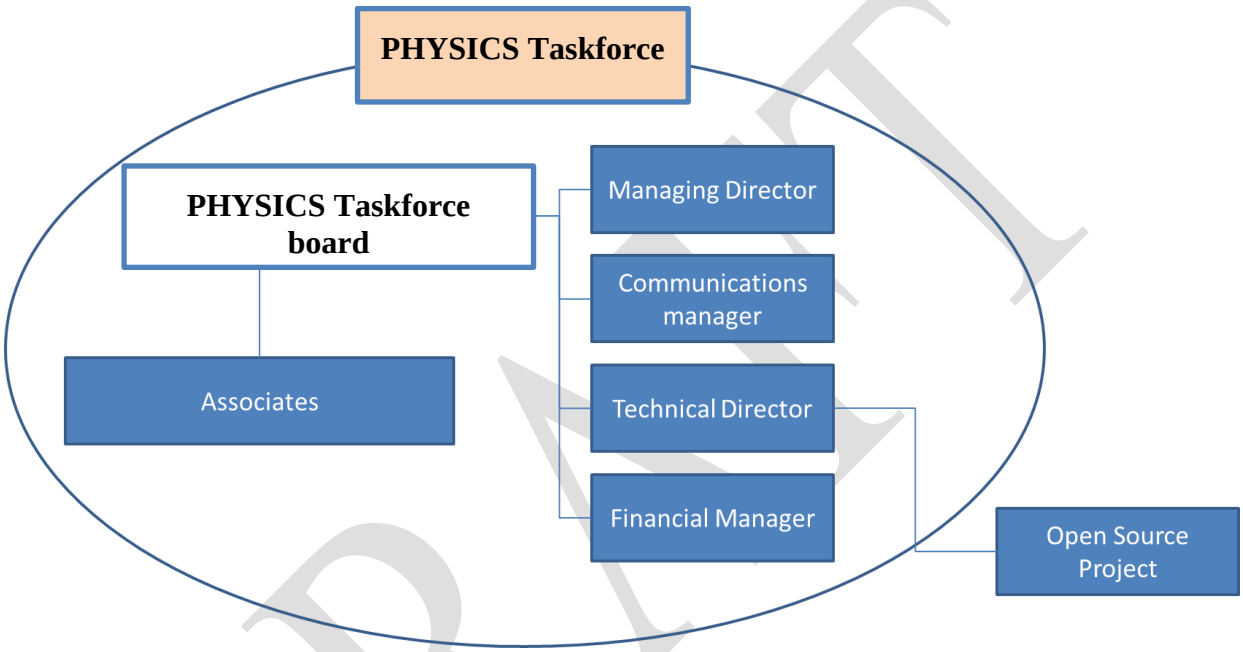

Figure 1: PHYSICS Taskforce Governance Structure

III. PHYSICS Taskforce BOARD

a. Objective

The PHYSICS TASKFORCE BOARD is the main governance body which will be in charge of the supervision of use of TASKFORCE Controlled IP and related decision making.

The PHYSICS TASKFORCE BOARD must enforce the terms of the Exploitation Agreement and implement the Governance Framework including managing PHYSICS TASKFORCE membership, adapting governance, and defining internal and external operational policies. However, it is clear that any decision having as consequence to impose new obligations or remove existing rights of a Party will require the prior written consent of the Party concerned, in accordance with provisions of Article 4.7. “Liabilities”.

b. Members

(a) Each PHYSICS TASKFORCE Member representative shall have a deputy.

The *PHYSICS TASKFORCE Members* shall establish the PHYSICS TASKFORCE BOARD within thirty (30) days after the Effective date of this *Exploitation Agreement*. The *PHYSICS TASKFORCE BOARD* will be composed of one duly authorised representative of each *PHYSICS TASKFORCE Member.*

After having informed the others in writing, each *PHYSICS TASKFORCE Member* shall have the right to replace its representative and/or to appoint a proxy although it shall use all reasonable endeavours to maintain the continuity of its representation.

The *PHYSICS TASKFORCE BOARD* shall appoint Fabrizio Di Peppo, representative of GFT as the managing Director until the first meeting.

Any Member of the PHYSICS TASKFORCE BOARD:

- should be present or represented at any meeting of the PHYSICS TASKFORCE BOARD; and
- may appoint a substitute or a proxy to attend and vote at any meeting; and
- shall participate in a cooperative manner in the meetings.

(b) Voting rules and quorum

The PHYSICS TASKFORCE BOARD shall not deliberate and decide validly unless a quorum of two-thirds (2/3) of its Members are present or represented.

Each Member of the PHYSICS TASKFORCE BOARD present or represented in the meeting shall have one vote.

Defaulting parties may not vote.

Parties may not vote in decisions regarding the declaration of themselves to be in breach or to issue them a written reprimand.

For a decision to be valid, it must be approved by 2/3 of the Members represented at the meeting.

A Member which can show that its own work, time for performance, costs, liabilities, intellectual property rights or other legitimate interests would be severely affected by a decision of the PHYSICS TASKFORCE BOARD may exercise a veto with respect to the corresponding decision or relevant part of the decision.

(c) Introduction of new Members

Should, it be proposed that the addition of a new Member to the PHYSICS TASKFORCE would be beneficial, the PHYSICS TASKFORCE BOARD must agree to this following the PHYSICS TASKFORCE BOARD voting rules of Article 4.5. III.b.(b)).

Prior to this vote a detailed inspection of the risk, operational and financial impact, and IPR considerations will be examined.

If the vote confirms to the entrance of the new partner, the new partner will sign an agreement with all exisitng PHYSICS TASKFORCE Members which will be derived from this Exploitation Agreeement. Following this signature, the new partner becomes a Member of the PHYSICS TASKFORCE BOARD and an PHYSICS TASKFORCE Member.

Upon accession of a new Member ownership of Project Foreground listed in Article 3.4. and any derivations thereof or new TASKFORCE Controlled IP is redistributed in accordance with the provisions of that article.

c. Responsibilities

(a) PHYSICS TASKFORCE BOARD main responsibilities

i. Updating the roles performed by each *PHYSICS TASKFORCE Member,* define strategic objectives, operational roles, responsibilities and policies in the common interest of the Members.

ii. Appointing Executive Members

iii. Oversight of the annual "description of activities" (workplan) for the RAMP during the tenure of an Executive Member as Technical Director of the RAMP committee.

iv. Links with other organisations within and outside Europe in order to:

- Foment the use of the TASKFORCE Controlled IP and the RAMP
- identify possible strategic alliances with other organisations for future deployment.

v. Co-ordinate dissemination actions.

vi. Control the use of the TASKFORCE Controlled IP.

vii. Enforce the terms of the Exploitation Agreement.

viii. Manage PHYSICS TASKFORCE membership, defining new types of roles for the *PHYSICS TASKFORCE Members* (or modifying the current definitions) as well as their associated rights and obligations.

ix. Manage IPR and propose usage agreements between PHYSICS TASKFORCE Members for the use of TASKFORCE Controlled IP.

x. Renew the confidentiality agreement to replace clause 10 of the Consortium Agreement (included here in Annex) prior to its expiry or obselence.

(b) **Meetings and Minutes.**

The PHYSICS TASKFORCE BOARD shall meet at least twice per year at the request of its Managing Director or at any other time when necessary, at the request of one of the PHYSICS TASKFORCE Members – not later than within 15 working days from the request.

Meetings shall be convened by the Managing Director with at least fifteen (15) calendar days prior notice with an agenda and all relevant documents. Any agenda item requiring a decision by the Members of the PHYSICS TASKFORCE BOARD must be identified as such on the agenda. Any Member of the PHYSICS TASKFORCE BOARD may add an item to the original agenda by written notification to all of the other Members not later than five (5) calendar days preceding the meeting.

During a meeting if all of the PHYSICS TASKFORCE Members are present or represented, they can unanimously agree to add a new item to the original agenda.

Decisions may only be executed once the relevant part of the Minutes is accepted according to this Article.

The Managing Director of the PHYSICS TASKFORCE BOARD shall produce written Minutes of each meeting which shall be the formal record of all decisions taken.

S/he shall send the draft to all of its Members within 10 calendar days of the meeting.

The Minutes shall be considered as accepted if, within 10 calendar days from sending, no Member who was in attendance at the relevant meeting or represented has objected in writing to the Managing Director with respect to the accuracy of the draft of the Minutes.

The accepted Minutes shall be sent to all of the PHYSICS TASKFORCE Members and the Managing Director of the PHYSICS TASKFORCE BOARD, who shall safeguard them. If requested the Managing Director of the PHYSICS TASKFORCE shall provide authenticated duplicates to Parties.

Meetings of the PHYSICS TASKFORCE BOARD can also be held by teleconference or other telecommunication means.

IV. The RAMP committee

a. Objectives

The RAMP committee is responsible for the management of the artefacts considered part of the RAMP.

b. Procedure

The RAMP committee will act as a working committee subordinate to the PHYSICS TASKFORCE BOARD during a period of two (2) years from the effective date. The procedures on membership, role allocation, voting decisions and working practice will be agreed by the PHYSICS TASKFORCE BOARD and described in the first annual workplan.

It will be chaired by the Technical Director, an Executive Member appointed by the PHYSICS TASKFORCE BOARD, for a period of two (2) years from the effective date. The PHYSICS TASKFORCE BOARD may replace the technical director.

The procedures on membership, role allocation, voting decisions and working practice will preserve the right of the RAMP committee to elect its own technical director after two (2) years from the effective date.

c. Responsibilities

- monitor technical risks
- maintain a roadmap for software developments including the relationship with other projects
- Monitor progress
- implement and test software releases
- deploy new software releases

V. Intellectual Property Management in the PHYSICS TASKFORCE

a. IPR rules accord with the following general principles:

- Confidentiality is maintained in accordance with Art. 5.1 of this Exploitation Agreement for all information gained from Members and Associates in the course of managing the PHYSICS Taskforce, if this information is not already in the public domain or designated for publication.
- Artefacts and software needed for the RAMP are licensed acording to the terms of the license associated with its publication and Members, Associates and third parties are free to use it under the terms of that license.
- TASKFORCE Controlled IP is managed by the PHYSICS Taskforce BOARD for the interests of the PHYSICS Taskforce.

b. Dissemination Policy

Dissemination activities including but not restricted to publications and presentations shall follow Article II.30 of the PHYSICS Grant Agreement. The time period in Article II.30.3 for notification of dissemination activities is reduced from 45 to 15 natural days. The time period for partners to object to said dissemination is reduced from 30 to 15 natural days.

The Party objecting to a publication has to show that its legitimate interests will suffer disproportionately great harm and shall include a request for necessary modifications.

c. Publication and use of another Party's Foreground or Background

For the avoidance of doubt, a Party may not publish reproduce, use or distribute, or, allow the publication, reproduction, use or distribution of Foreground, Background or Confidential Information of another Party, even if such Foreground, Background or Confidential Information is amalgamated with the Party's Foreground, without the other Party's prior written approval.

VI. Financial Management of the PHYSICS TASKFORCE

The **PHYSICS TASKFORCE has no central budget, costs or financial accountability**. All financial responsibility resides with Members and Associates. Parties are expected to cover their own expenses. At a future date, the PHYSICS TASKFORCE BOARD may agree to a collective budget and assign a treasurer from among the PHYSICS TASKFORCE Members. This role will confer Executive Member Status.

VII. Taskforce Strategy

The PHYSICS TASKFORCE BOARD shall define a set of strategic objectives aimed at achieving the long term sustainability of the TASKFORCE Controlled IP. The PHYSICS TASKFORCE BOARD shall ensure that the Taskforce Action plan and the RAMP work plan is consistent with and considers the strategy whilst it retains oversight of the Technical Director.

The strategic objectives shall be reviewed at least annually by the PHYSICS TASKFORCE BOARD.

VIII. Human Resource Planning

The PHYSICS TASKFORCE BOARD shall establish an action plan describing the activities required to implement the Taskforce Strategy. Activities include, but are not limited to, technical developments, service operations, and marketing.

The RAMP committee shall establish a workplan describing the activities required to Maintain and further develop the marktplace within the project. Activities include, but are not limited to, technical developments, service operations, and marketing.

The PHYSICS TASKFORCE BOARD shall estimate the human resources necessary to fulfil activities in the work plan and shall seek commitment from Members. The PHYSICS TASKFORCE BOARD cannot commit human resources to PHYSICS TASKFORCE activities without agreement from Members who control those resources.

IX. Quality Management and Complaints

Each Member shall be responsible for ensuring activities that they have committed to in the work plan are completed to a satisfactory quality levels. The quality of activities shall be assessed by the PHYSICS TASKFORCE BOARD who is responsible for the Action plan. Where low quality activities are identified the Managing Director will discuss directly with the Member to agree corrective measures. Where corrective measures cannot be agreed the issue shall be referred to the PHYSICS TASKFORCE BOARD for a decision.

X. Annual Action Plan

As stated in Article 4.5. III.(a), the PHYSICS TASKFORCE BOARD will provide an Action Plan detailing the work to be carried out during successive periods of 12 months.

This work will be assigned only to PHYSICS TASKFORCE Members. PHYSICS TASKFORCE Associates will not be assigned work.

The work planned to be carried out by each PHYSICS TASKFORCE Member must be agreed by that PHYSICS TASKFORCE Member before the workplan can be considered operative.

In agreeing to the assigned work of the workplan, the PHYSICS TASKFORCE Member is making reasonable efforts to carry out the work to a suitable level of quality and within an appropriate timeframe.

Variations to the workplan can be made by the PHYSICS TASKFORCE BOARD and with the prior approval of each PHYSICS TASKFORCE Member affected.

Where a PHYSICS TASKFORCE Member foresees deviations to the quality or timing of their assigned tasks, they shall inform the Managing Director of the PHYSICS TASKFORCE BOARD without due delay in order to convene a meeting of the PHYSICS TASKFORCE BOARD for its relocation or alternative measures.

Article 4.6. Provisions for dispute resolution and managing breach of Parties

I. Breach by PHYSICS TASKFORCE Associates

Following a vote of the PHYSICS TASKFORCE BOARD, in accordance with voting rules of Article 4.5. III.b.(b), the PHYSICS TASKFORCE BOARD may declare a PHYSICS TASKFORCE Associate in breach of this Exploitation Agreement if they fail to comply with the Terms and Conditions of access to the Taskforce-controlled IP.

The PHYSICS TASKFORCE BOARD will then give the PHYSICS TASKFORCE Associate written notice and provide a window of twenty (20) days for the Associate to rectify the situation or advise of an exception under Force Majeure (Article 4.7. III).

Should the detected breach not be satisfactorily resolved within the twenty (20) day period, the PHYSICS TASKFORCE BOARD may terminate the Agreement with respect to the PHYSICS TASKFORCE Associate, with resulting loss of Associate status, rights and obligations.

II. Breach by PHYSICS TASKFORCE Members

a. For failure to provide access rights

Following a vote of the PHYSICS TASKFORCE BOARD, in accordance with voting rules of Article 4.5. III.b.(b), the PHYSICS TASKFORCE BOARD may declare a PHYSICS TASKFORCE Member in breach of this Exploitation Agreement if they fail to comply with the Terms and Conditions of access to the TASKFORCE Controlled IP.

The PHYSICS TASKFORCE BOARD will then give the PHYSICS TASKFORCE Member written notice and provide a window of twenty (20) days for the Member to rectify the situation or advise of an exception under Force Majeure (article (Article 4.7. III).

Should the detected breach not be satisfactorily resolved within the twenty (20) day period, the PHYSICS TASKFORCE BOARD may terminate the Agreement with respect to the PHYSICS TASKFORCE Member, with resulting loss of Member status, rights and obligations.

b. For failure to carry out the work agreed in the Action Plan

As stated in Article 4.5. III.(a), the PHYSICS TASKFORCE BOARD will provide an action plan detailing the work to be carried out during successive periods of 12 months.

Should a PHYSICS TASKFORCE Member fail to apply reasonable efforts to carry out the agreed tasks to the agreed level of quality and schedule, and fail to advise the PHYSICS TASKFORCE BOARD of deviations to the workplan in a timely manner, the PHYSICS TASKFORCE BOARD may, following a vote, issue a written reprimand to the Member, notifying them that they are failing to apply reasonable effort to realise the agreed tasks or to notify the PHYSICS TASKFORCE BOARD of an anticipated deviation.

If in the course of any twelve (12) month period, a given PHYSICS TASKFORCE Member has received two written reprimands and the PHYSICS TASKFORCE BOARD considers that the PHYSICS TASKFORCE Member continues to fail to apply reasonable efforts to realise their agreed tasks, the PHYSICS TASKFORCE BOARD may vote to declare the PHYSICS TASKFORCE Member in breach.

The PHYSICS TASKFORCE BOARD will then give the PHYSICS TASKFORCE Member written notice and provide a window of twenty (20) days for the Member to rectify the situation or advise of an exception under Force Majeure (Article 4.7. III).

Should the detected breach not be satisfactorily resolved within the twenty (20) day period, the PHYSICS TASKFORCE BOARD may terminate the Agreement with respect to

the PHYSICS TASKFORCE Member, with resulting loss of Member status, rights and obligations.

Article 4.7. Liabilities

I. Limitations of Contractual Liability

The PHYSICS TASKFORCE is not a legal entity, partnership or agency. Legal liability resides individually with PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates.

All legally binding decisions required during PHYSICS TASKFORCE operations must be made by PHYSICS TASKFORCE Members or PHYSICS TASKFORCE Associates and cannot be made by the PHYSICS TASKFORCE itself. Where joint actions are needed further legal agreements may need to be established.

The PHYSICS TASKFORCE Members and PHYSICS TASKFORCE Associates shall have no liability towards each other with the exception of the case of damage caused by a wilful act and/or gross negligence. The Parties will assist each other to the extent required to defend claims.

II. Liability towards Third Parties

Each *Party* shall be solely liable for any loss, damage or injury to third parties resulting from its own carrying out of its duties in this Exploitation Agreement.

Each *Party* shall be fully responsible for the performance of any part of its share of this Exploitation Agreement, in respect of which it enters into any contract with a third party (e.g. a Subcontractor) and shall ensure such contracts enable fulfilment of this Exploitation Agreement.

III. Force Majeure

No *Party* shall be considered to be in breach of this Exploitation Agreement if such breach is caused by *Force Majeure* (as defined in *Contract*, Annex II article 40.1). Each *Party* will notify the PHYSICS TASKFORCE BOARD in writing of any Force Majeure as soon as possible. The *Parties* shall discuss in good faith in a meeting of the PHYSICS TASKFORCE BOARD the possibilities of a transfer of tasks affected by the event. Such discussions shall commence as soon as reasonably possible. If such Force Majeure event is not overcome within 6 weeks after such notification, the transfer of tasks shall be carried out on decision of the PHYSICS TASKFORCE BOARD.

Section 5. Miscellaneous Exploitation Agreement Conditions

Article 5.1. Confidentiality

All information of whatever nature or form disclosed by a Party (the "Disclosing Party") to any other Party (the “Recipient”) in connection with this Exploitation Agreement and that:

- is clearly marked "confidential" at the time of the disclosure;
- or, when orally disclosed, was at the time of disclosure indicated to be "confidential" and within thirty days reduced to physical form and marked "confidential" by the discloser,

Shall be deemed ‘Confidential Information’.

The Recipients hereby undertake in addition and without prejudice to any commitment of nondisclosure under the Grant Agreement, for a period of 5 years from the date of entry into force of this Exploitation Agreement (see Art. 2.2 above):

- not to use Confidential Information otherwise than for the purpose for which it was disclosed;
- not to disclose Confidential Information to any third party without the prior written consent by the Disclosing Party;
- to ensure that internal distribution of Confidential Information by a Recipient shall take place on a strict need-to-know basis;
- to return to the Disclosing Party on demand all Confidential Information which has been supplied to or acquired by the Recipients including all copies thereof and to delete all information stored in a machine readable form. If needed for the recording of ongoing obligations, the Recipients may however request to keep a copy for archival purposes only , (which copy shall remain subject to the provisions of this Section 5.1);and
- neither to copy Confidential Information, nor otherwise reproduce nor duplicate in whole or in part where such copying, reproduction or duplication have not been specifically authorised in writing by the Disclosing Party.

The Recipients shall be responsible for the fulfilment of the above obligations on the part of their employees and shall ensure that their employees remain so obliged, as far as legally possible, during and after the end of the Project and/or after the termination of employment. The above shall not apply for disclosure or use of Confidential Information, if and in so far as the Recipient can show that:

- the Confidential Information becomes publicly available by means other than a breach of the Recipient's confidentiality obligations;

- the Disclosing Party subsequently informs the Recipient that the Confidential Information is no longer confidential;

- the Confidential Information is communicated to the Recipient without any obligation of confidence by a third party who is in lawful possession thereof and under no obligation of confidence to the Disclosing Party;

- the disclosure or communication of the Confidential Information is foreseen by provisions of the Grant Agreement;

- the Confidential Information, at any time, was developed by the Recipient completely independently of any such disclosure by the Disclosing Party; or

- the Confidential Information was already known to the Recipient prior to disclosure. The Recipient shall apply the same degree of care with regard to the Confidential Information disclosed within the scope of the Project as with its own confidential and/or proprietary information, but in no case less than reasonable care. The Parties shall impose the same obligations on and shall remain responsible for any breaches on the part of, their Affiliates and subcontractors.

Each Party shall promptly advise the other Party in writing of any unauthorised disclosure, misappropriation or misuse by any person of Confidential Information as soon as practicable after it becomes aware of such unauthorised disclosure, misappropriation or misuse. If any Party becomes aware that it will be required, or is likely to be required, to disclose Confidential Information in order to comply with applicable laws or regulations or with a court or administrative order, it shall, to the extent it is lawfully able to do so, prior to any such disclosure

- notify the Disclosing Party, and

- comply with the Disclosing Party's reasonable instructions to protect the confidentiality of the information.

The confidentiality obligations under this Consortium Agreement and the Grant Agreement shall not prevent the communication of Confidential Information to the European Commission.

It is pointed out that Clause 10 of the *Consortium Agreement* will continue to apply to all Project Particpants in relation to any disclosure of Confidential Information under that Agreement during a period of five (5) years from the effective date of the Consortium Agreement. For reference it is in the Annex.

Article 5.2. Termination

Any Party may withdraw from and terminate this Exploitation Agreement in respect of itself by informing the Managing Director of the PHYSICS TASKFORCE BOARD in writing at least 30 calendar days before the proposed termination date.

Article 5.3. Additional conditions

I. No partnership or agency

Nothing in this *Exploitation Agreement* shall create or imply a partnership or agency or any other kind of formal business grouping or entity between the *Parties* or any of them.

II. Assignment

Except otherwise provided for in this Exploitation Agreement, no Party shall, without the prior written consent of the other *Parties*, assign or otherwise transfer partially or totally any of its rights and obligations under this Exploitation Agreement. Such consent shall not be unreasonably withheld when such assignment or transfer is in favour of an Affiliate of that *Party*.

III. Language

This Exploitation Agreement is drawn up in English, said language governing all documents, notices and meetings among the *Parties* for its application and/or extension or in any other way relative thereto.

IV. Notices

Any notice to be given under this *Exploitation Agreement* shall be in writing to the following addresses and recipients. It shall be deemed to have been served when personally delivered, or, if transmitted by telefax, electronic or digital transmission when transmitted provided that such transmission is confirmed by receipt of a successful transmission report and confirmed by mail.

GFT	ATOS	HPE	UPM
Name and Surname	Name and Surname	Name and Surname	Name and Surname
Email address	Email address	Email address	Email address
Office legal address	Office legal address	Office legal address	Office legal address

XXX	YYY	ZZZ	QQQ
Name and Surname	Name and Surname	Name and Surname	Name and Surname
Email address	Email address	Email address	Email address
Office legal address	Office legal address	Office legal address	Office legal address

or to such other address and recipient as a *Party* may designate in respect of that *Party* by written notice to the others.

V. Applicable Law

This Exploitation Agreement shall be construed according to the laws of Belgium.

Any dispute, controversy or claim arising under, out of or relating to this Exploitation Agreement and any subsequent amendments of this Exploitation Agreement, including, without limitation, its formation, validity, binding effect, interpretation, performance, breach or termination, as well as non-contractual claims, shall be submitted to mediation in accordance with the WIPO Mediation Rules. The place of mediation shall be Brussels unless otherwise agreed upon. The language to be used in the mediation shall be English unless otherwise agreed upon.

Any dispute, controversy or claim not settled by mediation shall be referred to the competent courts of Brussels.

VI. Entire Agreement - Amendments

This Exploitation Agreement constitutes the entire agreement between the *Parties* in respect of control of the TASKFORCE Controlled IP and supersedes all previous negotiations, commitments and writings concerning it.

Amendments to this Exploitation Agreement shall be valid only if made in writing and signed by an authorised signatory of each of the *Parties*.

VII. Counterparts

This Exploitation Agreement shall be executed in eight (8) counterparts, both of which shall be deemed an original, but all of which shall constitute one and the same instrument.

Signatures

IN WITNESS WHEREOF, the *Parties* have caused this Exploitation Agreement to be duly signed by the undersigned authorised representatives on the day, month and year first indicated above.

Authorised to sign on behalf of

Annex: Clause 10 of the Consortium Agreement

This is included for reference purposes

All information in whatever form or mode of transmission, which is disclosed by a Party (the

"Disclosing Party") to any other Party (the "Recipient") in connection with the Project during its implementation and which has been explicitly marked as "confidential", or when disclosed orally, has been identified as confidential at the time of disclosure and has been confirmed and designated in writing within 15 days at the latest as confidential information by the Disclosing Party, is "Confidential Information".

The Recipients hereby undertake in addition and without prejudice to any commitment of nondisclosure under the Grant Agreement, for a period of 5 years from the Effective date:

- not to use Confidential Information otherwise than for the purpose for which it was disclosed;
- not to disclose Confidential Information to any third party without the prior written consent by the Disclosing Party;
- to ensure that internal distribution of Confidential Information by a Recipient shall take place on a strict need-to-know basis;
- to return to the Disclosing Party on demand all Confidential Information which has been supplied to or acquired by the Recipients including all copies thereof and to delete all information stored in a machine readable form. If needed for the recording of ongoing obligations, the Recipients may however request to keep a copy for archival purposes only , (which copy shall remain subject to the provisions of this Section 10);and
- neither to copy Confidential Information, nor otherwise reproduce nor duplicate in whole or in part where such copying, reproduction or duplication have not been specifically authorised in writing by the Disclosing Party.

The Recipients shall be responsible for the fulfilment of the above obligations on the part of their employees and shall ensure that their employees remain so obliged, as far as legally possible, during and after the end of the Project and/or after the termination of employment. The above shall not apply for disclosure or use of Confidential Information, if and in so far as the Recipient can show that:

- the Confidential Information becomes publicly available by means other than a breach of the Recipient's confidentiality obligations;
- the Disclosing Party subsequently informs the Recipient that the Confidential Information is no longer confidential;
- the Confidential Information is communicated to the Recipient without any obligation of confidence by a third party who is in lawful possession thereof and under no obligation of confidence to the Disclosing Party;
- the disclosure or communication of the Confidential Information is foreseen by provisions of the Grant Agreement;
- he Confidential Information, at any time, was developed by the Recipient completely independently of any such disclosure by the Disclosing Party; or
- the Confidential Information was already known to the Recipient prior to disclosure. The Recipient shall apply the same degree of care with regard to the Confidential Information disclosed within the scope of the Project as with its own confidential and/or proprietary information, but in no case less than reasonable care. The Parties shall impose the same obligations on and shall remain responsible for any breaches on the part of, their Affiliates and subcontractors

Each Party shall promptly advise the other Party in writing of any unauthorised disclosure, misappropriation or misuse by any person of Confidential Information as soon as practicable after it becomes aware of such unauthorised disclosure, misappropriation or misuse. If any Party becomes aware that it will be required, or is likely to be required, to disclose Confidential Information in order to comply with applicable laws or regulations or with a court or administrative order, it shall, to the extent it is lawfully able to do so, prior to any such disclosure

- notify the Disclosing Party, and
- comply with the Disclosing Party's reasonable instructions to protect the confidentiality of the information. The confidentiality obligations under this Consortium Agreement and the Grant Agreement shall not prevent the communication of Confidential Information to the European Commission.

Provided that the Receiving Party and its Affiliates do not disclose such Residual Information (as defined below) and, without implying or granting any licence under any patent or copyright of the Disclosing Party and its

Affiliates, the Receiving Party and its Affiliates shall not be in breach of their obligations under this Section 10 in the event of any unintentional use of any idea, concept, know-how or technique contained in the Disclosing Party's Confidential Information unintentionally retained in the unaided memories of any employee of the Receiving Party and its Affiliates who has had legitimate access to the Confidential Information ("Residual Information").

The unavoidable or inherent disclosure of Residual Information by the use, distribution or marketing of any hardware or software product or service into which Residual Information has been incorporated, by the Receiving Party or by any of its Affiliates, shall not constitute a breach of the Receiving Party's or its Affiliates' obligation of non-disclosure relating to such Confidential Information.