European Partnerships under Horizon Europe

DRAFT PROPOSAL

for the

European Partnership on Photonics

Photonics for a Healthy, Green & Digital Future

26.05.2020

About this draft

In autumn 2019 the Commission services asked potential partners to further elaborate proposals for the candidate European Partnerships identified during the strategic planning of Horizon Europe. These proposals have been developed by potential partners based on common guidance and template, taking into account the initial concepts developed by the Commission and feedback received from Member States during early consultation[1]. The Commission Services have guided revisions during drafting to facilitate alignment with the overall EU political ambition and compliance with the criteria for Partnerships.

This document is a stable draft of the partnership proposal, released for the purpose of ensuring transparency of information on the current status of preparation (including on the process for developing the Strategic Research and Innovation Agenda). As such, it aims to contribute to

[1] https://www.era-learn.eu/documents/final_report_ms_partnerships.pdf

further collaboration, synergies and alignment between partnership candidates, as well as more broadly with related R&I stakeholders in the EU, and beyond where relevant.

This informal document does not reflect the final views of the Commission, nor pre-empt the formal decision-making (comitology or legislative procedure) on the establishment of European Partnerships.

In the next steps of preparations, the Commission Services will further assess these proposals against the selection criteria for European Partnerships. The final decision on launching a Partnership will depend on progress in their preparation (incl. compliance with selection criteria) and the formal decisions on European Partnerships (linked with the adoption of Strategic Plan, work programmes, and legislative procedures, depending on the form). Key precondition is the existence of an agreed Strategic Research and Innovation Agenda / Roadmap. The launch of a Partnership is also conditional to partners signing up to final, commonly agreed objectives and committing the resources and investments needed from their side to achieve them.

The remaining issues will be addressed in the context of the development of the Strategic Research and Innovation Agendas/ Roadmaps, and as part of the overall policy (notably in the respective legal frameworks). In particular, it is important that all Partnerships further develop their framework of objectives. All Partnerships need to have a well-developed logical framework with concrete objectives and targets and with a set of Key Performance Indicators to monitor achievement of objectives and the resources that are invested.

Aspects related to implementation, programme design, monitoring and evaluation system will be streamlined and harmonised at a later stage across initiatives to ensure compliance with the implementation criteria, comparability across initiatives and to simplify the overall landscape.

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Roadmap: https://www.photonics21.org/download/ppp-services/photonics-downloads/Europes-age-of-light-Photonics-Roadmap-C1.pdf

www.photonics21.org

"Photonics is simply essential for powering the future European digital economy and will underpin as yet undiscovered advances in many other sectors such as health, space, mobility and security."

Gérard Mourou, Nobel Laureate in Physics 2018
Stefan W. Hell, Nobel Laureate in Chemistry 2014
Theodor W. Hänsch, Nobel Laureate in Physics 2005

In an open letter to the European Commission on 20th December 2018. Available under: https://www.photonics21.org/news/Verlinkungen/2019/Nobel-Laureates-Letter-of-Concern.pdf

"Photonics is one of these essential key enabling building blocks for the digital transformation of Europe, which will be based on deep technologies"

In: "Financing the digital transformation: Unlocking the value of photonics and microelectronics", Report by European Investment Bank and European Commission, 2018

"The Photonics SME industry is committed to investing €100 billion in R&I in Europe over the course of the Horizon Europe programme (2021-27)"

On behalf of the Photonics21 Executive Board and the Photonics Industry

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1 General information

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1.4 Summary

Photonics – the technology of light - underpins daily life from smartphones to the internet and medical instruments to laser technology. It is an essential building block for the digital transformation of industry and society and for a green and healthy future in Europe. The new Photonics Partnership will secure Europe's technological sovereignty through photonic innovations and their transfer into applications, raising Europe's competitiveness and ensuring long-term job and prosperity creation.

2 Context, objectives, expected impacts

2.1 Context and problem definition

2.1.1 Sovereignty in Photonics is a sine qua non for Europe's Future

What is the context of the Partnership?

The world is currently undergoing a significant change comparable to the Industrial Revolution of the 19th century. The increasingly rapid digitalisation of entire economies and societies and the uncertain geopolitical framework require a targeted strategic orientation of the European Union.

The President of the European Commission, Ursula von der Leyen, rightly stated in her inaugural address to the EU Parliament that "Europe must lead the transition to a healthy planet and a new digital world" and for this to happen Europe has to "to achieve technological sovereignty in some critical technology areas". In this context, technological sovereignty not only plays a role in Europe's competitiveness but also influences the extent to which the European "way of life" can continue to be lived. The sovereignty in these technologies enables the protection of the personal data of European citizens and companies and their self-determined use. The European Investment Bank recently stated: "Photonics is one of these essential key enabling building blocks for the digital transformation of Europe, which will be based on deep technologies"[2]. A letter of the Nobel Laureates Gérard Mourou, Stefan W. Hell and Theodor W. Hänsch to Commissioner Gabriel and Commissioner Oettinger also emphasised that "Photonics is simply essential for powering the future European digital economy" [3]

Photonics is the key enabler for Europe's ambitions for a climate-neutral, digital economy and society. European initiatives on Industry 4.0, Smart farming, Personal Healthcare, Quantum Computing and Communication, 5G, Artificial Intelligence and many other and strategic areas depend on innovations in photonic platform technologies. These are the critical elements to build up European strategic value chains from the automotive industry to the aeronautics sector and the medical sector. [4]

European companies are world market leaders in numerous fields of photonics such as microscopy, laser technology, machine vision or sensor technology and analytics. The leading position of European companies in light-related technologies results from an ecosystem that is unique in the world, in which suppliers and users work closely together to realise innovations.

Autonomously acting systems such as vehicles or robots that collaborate with humans, so-called 'cobots', require information about their environment, for example 'Is it a truck or a sign gantry?' 'Is it a human being or just its shadow?' Photonic sensors such as cameras or radar systems based on light, also known as LiDAR (Light Detection and Ranging), for optical distance and speed measurement provide this necessary information in close interaction with intelligent data processing.

Optical environment recognition and visual representation also play a central role in assistance systems. For example, applications of VR (virtual reality) and AR (augmented reality) use

[2] "Financing the digital transformation: Unlocking the value of photonics and microelectronics"; 2018, Report by European Investment Bank & European Commission

[3] Mourou G., Hell, S. W., Hänsch, T. W. (2018): An open letter to the European Commission regarding the absence of visibility and support for Photonics Technologies in the next MFF 2021-2027. 20th December 2018. Available under: https://www.photonics21.org/news/Verlinkungen/2019/Nobel-Laureates-Letter-of-Concern.pdf, last accessed on 2019/05/28.

[4] European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH, Photonics21 Secretariat (2019): Europe's age of light! How photonics will power growth and innovation, Strategic Roadmap 2021-2027, Brussels / Düsseldorf, March 2019.

photonics to support people in their activities, such as surgeons in an operating theatre or a service technician maintaining complex systems.

Photonic tools for additive or ablative production as well as 100 per cent quality control are characterised in particular by a high degree of flexibility and automation capability, thus allowing the potential for digitisation to be used, especially in Industry 4.0, to meet changing customer requirements and establish new business models.

For the constantly growing volume of data that has to be transported and processed, photonics opens up further possibilities, in addition to the familiar fibre optic networks, for example by using optical chips to overcome the limitations of microelectronics in data transmission and processing.

One of the great promises of artificial intelligence (AI) is the foresighted analysis of diseases, including their detection at an ever earlier stage. Photonics imaging processes are the very thing that makes AI "see". Photonics also provides an important technical basis for next-generation quantum technologies.

Progress in the field of photonics is essential for securing and expanding the innovative strength and competitiveness of European companies. This applies both to the companies in the photonics sector itself and to many user companies whose innovations are often only made possible by a close interaction between basic technology and concerted application requirements. More often, innovations find another remit outside of technology silos. But only those who master the basis can also achieve progress in application fields. Europe is finding difficulties learning what it means to lose technological sovereignty. The uncertainty surrounding the involvement of companies such as Huawei in the construction of 5G networks or the current supply bottlenecks for medicines are just two examples of how dependent Europe has become. Make or buy - this is a question of strategic importance not only for companies!

Furthermore, value creation networks and business models are changing in the context of digitisation. Those who are still technological leaders today may be cut off from direct customer access by an intermediary tomorrow. ‘Made in Europe’ alone may no longer be enough to secure our prosperity in the future. In the future, ‘Operated by Europe’ will play a central role, because only those who can fill this position will be able to secure long term direct access to customers. Photonics supplies central enablers for this.

Europe is able to operate from a position of strength: Europe can boast four European Nobel Prize winners in photonics in the last decade and an industry of 5000 SMEs, in terms of global market share - second only to China. In contrast to many other technologies, Europe has so far been able to secure its technological independence and leadership in the field of photonics. This strong position in photonics is, on one hand, based on a unique ecosystem that enables effective cooperation between suppliers and users, and, on the other, on technological leadership resulting from continuous R&D activities on basic photonic technologies. In the context of the important role photonics plays as a central enabler and digitisation "game-changer", this position must be maintained and further expanded. Only in this way will Europe have the opportunity to take an active role in driving digitisation in accordance with European values.

Beyond technological sovereignty photonics as key digital technology will be essential for implementing the priorities of the new EU Commission. In particular, those on "A European Green Deal", "Europe fit for the digital age" and "Protecting our European way of life" will depend directly on the development of photonics technologies and their implementation in Europe. More broadly, the United Nations Sustainable Development Goals, "Zero Hunger", "Good Health and Well-being", "Clean Water and Sanitation" and "Decent Work and Economic Growth" will very much depend on advancements in photonics.

For Europe to become a CO_2-neutral society by 2050, the economy and society will need to make a step-change in becoming cleaner and greener on every level. Photonics is a key enabler for making this transition in a sustainable and competitive way. By applying photonics it will be possible to: put an end to the depletion of resources by managing material streams in a circular economy; significantly reduce energy consumption in buildings and public spaces; create efficient industrial processes; develop the next generation of solar power; enable smart mobility and monitor our environment in real-time. Green photonics is a powerful, indispensable toolkit for mastering all these challenges. Photonics has the potential to reduce global CO_2 emissions by up to 3 billion tonnes until 2030.[5]

A new generation of laser-based production systems, including additive manufacturing, will bring forth new manufacturing and inspection processes that are essential for extraordinary energy and resource-efficient solutions, e.g. lightweight construction of cars and aeroplanes.

The global data traffic has been doubling every 2-3 years over the past 15 years. As the growth pace is likely to increase further in the future it is undisputed that developing and deploying optical communication and network technologies are absolutely essential to accommodate this growth in an energy-efficient and sustainable way.

Feeding a world population expected to reach 10 billion people by 2050 will require a dramatic increase in food production. With agriculture already responsible for 70% of the planet's water consumption, 24% of greenhouse gas emissions and environmental destruction, increasing food production with current practices is clearly not sustainable. Still in its infancy, agro-photonics is a rapidly growing field in precision farming and environmental management. Relevant tools include lasers and LiDAR (Light Detection and Ranging), hyperspectral imaging and many other types of sensors, as well as energy-efficient LEDs as a key component for urban farming. These technologies will monitor soil condition, predict protein levels in grain harvests, determine when fruit needs to be picked, prevent over-fertilisation and excessive use of herbicides, monitor water quality and the condition of fish stocks, search for contaminants in products, and – in the case of urban farming – provide sort supply chains with reduced transport losses.

Finally, one of the great challenges facing humanity is to ensure a sustainable energy supply. With photovoltaics, photonics research and industry has already developed an alternative source of energy. However, solar and wind energy production is subject to natural fluctuations. Low-cost and environmentally friendly power storage systems are the next big challenge for a climate-neutral society. The storage of energy in the form of fuels is a very promising option due to its high density (can be 100 times higher than current lithium-ion batteries). Photonic "light to fuel" devices that use solar energy to convert water and carbon dioxide directly into fuels, for example, could further bring the necessary breakthrough innovation for Europe and the world to ensure a sustainable energy supply.

Green photonics – technologies that generate or conserve energy, produce light or reduce emissions or pollution – is already one of the largest and most important sectors of the European industry. With the exception of conventional photovoltaics, which have become a commodity industry based mainly in Asia, the European photonics industry is excellently placed to help decarbonising European Industry while creating new jobs and driving growth.

2.1.2 It is time to shape future ecosystems now

Why is this initiative being proposed now?

[5] Study „Light as a key to global environmental sustainability“, SPECTARIS & Messe München GmbH, 2019

As mentioned above, Europe has a leading position in photonics – thanks to a unique ecosystem that allows suppliers and users to drive innovation in close interaction between application requirements and the appropriate basic technology. However, the European photonics research and innovation landscapes are highly fragmented. Unlike other sectors where large companies often serve as a pacemaker to structure the research and innovation landscape, in photonics, the 5000 SMEs have neither the capacity nor capability to do so. Like other deep technologies Photonics is highly capital and R&I intensive. A quota of Research & Innovation spending of about 10% of turnover on average and a Capex of additional 4-5% of sales per year puts photonics in a leading position in terms of industrial R&I investments. The sum of these SME investments in Photonics R&I in Europe is very significant and will amount to over 100 billion euros over the next ten years. It is fundamentally important for Europe's competitiveness and for the development of solutions to the major societal challenges that these investments are coordinated and targeted, following a community-backed Strategic Research Agenda. A dedicated Horizon Europe Partnership in Photonics is the only way in achieving this goal. Given that more than 3000 members – representing 1700 industry and research organisations – are already organised in the current Photonics21 partnership (and thus are supporting the planned photonics partnership), illustrates the support for a coordinated approach.

Furthermore, a look at Business to Consumer (B2C) shows how relevant the design and control of ecosystems is for future value creation. For prosperity and growth as well as Europe's technological sovereignty, it will be of central importance to actively shape ecosystems in the B2B sector. In particular, a technology that is characterised by medium-sized technology leaders needs a strong European partnership for this challenge.

Europe must act concertedly and quickly, as competing economies around the world have recognised that mastering photonics may provide the decisive competitive advantage for the future digitalisation of the economy and society. By 2020, the South Korean government will have increased its investment into photonics to €2.8 billion per year[6]. Likewise, China's central government is increasing its spending in photonics by 40% per year to €1 billion in 2020 complemented by regional investments, often a multiple of the central government expenditure.

These countries invest in photonics with the aim of keeping high-value manufacturing jobs onshore and mastering key digital building blocks. Photonics has been classified in the US as a strategic key technology and several photonics-driven fields that are critical to the US competitiveness and the US national security have been identified[7]. For Europe to compete with these regions, joint action by the EC, the member states and the photonics industry will be needed to clear the way to future innovation. This requires a concerted public-private effort that pools Europe's strengths in photonics and actively shapes future ecosystems for photonics and their applications.

2.1.3 A European Photonics partnership under Horizon Europe: Opening the next chapter of this extraordinary European success story

What problems and strategic opportunities will the initiative tackle?

A highly motivated photonics industry and academic community, represented by Photonics21 with its 3000+ members, is behind the Photonics Partnership Proposal for Horizon Europe. This community has shown in the current Horizon2020 Photonics Public Private Partnership that it meets its expectations. The photonics industry, which is characterised by SMEs, has

[6] "Political Steering Processes in Asia Aimed at the Photonics Industry" (2015), BMBF, VDMA and Spectaris.
[7] National Research Council. 2013. Optics and Photonics: Essential Technologies for Our Nation. Washington, DC: The National Academies Press. https://doi.org/10.17226/13491.

kept its word and achieved, among other performance indicators, an investment leverage of 5. With an overall annual investment of more than 10 billion Euros in R&I in Europe, the industry is extremely committed to Europe. However, this is only the beginning of a success story that Europe can write in the development and use of this deep technology.

The future European Partnership on Photonics is committed to build on these strengths and further develop the key table stakes to create impact such as:

- further strengthening of core photonics technologies with the most impact of EU's competitiveness and technical sovereignty
- further integration and enhancement of the Photonics Ecosystem in Europe in digital innovation hubs which will secure cross-links with other deep technologies and up- and downstream industries
- broadening and deepening the involvement of downstream industries in the definition and priority setting of Photonics core technologies to secure economies of scale, more market focus and thus faster development

Thereby the proposed Photonics Partnership aims to tackle the following problems and opportunities:

1. **Structural Challenge and Opportunity**
   The photonics industry is characterised by SMEs. Large pacemakers like those found in the automotive industry are not present. On the other hand, Europe has a unique ecosystem that enables, in principle, close cooperation of suppliers and user industries. In order to address this problem and at the same time make the best possible use of the situation, it is necessary to align fragmented R&I activities along a common roadmap. The close and trusting involvement of the users of photonic technologies is an essential factor for success because the potential of photonic solutions for specific applications is raised in the most effective way when a systemic or holistic approach is followed.
2. **Economic Challenges**
   Digitisation leads to changes in value creation. Smart products and data-based product-related services are gaining in importance as well as the need to design ecosystems and to occupy checkpoints. Technology leadership is necessary but not sufficient. In the future, economic success will also depend on whether it is possible to create an ecosystem with a large network effect. While the B2C sector is dominated by American and Chinese companies, Europe has an excellent starting position for the B2B sector thanks to its pluralistic industrial structure. To use this and not fall behind, however, a concerted approach is required. For the photonics industry and its users, the proposed European Partnership offers the necessary platform for such an approach.
3. **Deployment Challenge**
   Faster Photonics deployment is crucial for ultra-competitiveness. Despite many photonic solutions already existing that improve European competitiveness in different sectors, there are still barriers, which impede a photonics-based approach: often related to cost, size, efficiency, output power, or sensitivity that prevent photonic solutions from being widely deployed. These drivers tend to be common across many sectors and respond to market pull. To overcome those barriers and secure a faster deployment, using economies of scale will be at the core of the future Photonics Partnership.
   Support for both market pull and technology push is essential to ensure Europe makes the most of the transformational impact that photonics offers. For this undertaking, it is vital that we understand the trends that are common across all

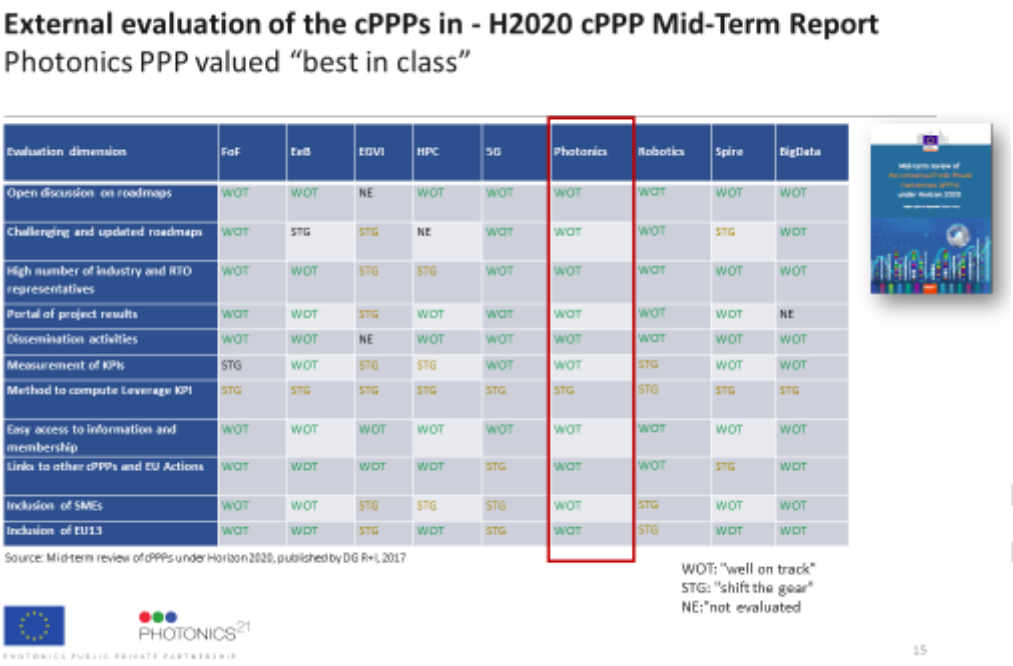
photonics areas. Solving them will enable a number of the challenges highlighted in the following thematic roadmaps. These key trends are:

- Integration: making systems smaller and more robust; dealing with a large number interfaces that can be bulky
- Modularisation and platforms: developing photonics modules to be used as plug-and-play which requires the development of common standards;
- Increasingly interdisciplinary R&D
- Cross-fertilisation from one photonics application area to another

The continuous search for new materials that are more suitable, pushing boundaries on performance and operation across multiple wavebands, has been a trend for many years.

With increasing co-dependence on the advancement of the different photonics areas, the photonics Partnership needs to continue to expand the coordination along the value chains that has led to the decision to restructure our platform to closely cooperate with the value-chain partners and also increase speed to market.

The new European Partnership on Photonics will build on the experiences collected during the recent years of activities, however, it will adapt to the changing needs of the new Horizon Europe framework programme responding to the new challenges the European economy is facing. Under Horizon Europe it will capitalise on the success of the previous Partnership under Horizon 2020 which was recognised by an independent expert group of the EU Commission as “best in class” among all other contractual Partnerships (PPPs) in the scope of the Horizon 2020 mid-term evaluation.



Graph 1: External evaluation of the cPPPs in the scope of the H2020 cPPP Mid-Term Report
Source: *European Commission, DG Research and Innovation, Mid-term review of the contractual Public-Private Partnerships (cPPPs) under Horizon 2020.* [8]

The Partnership under Horizon 2020 has managed to mobilise a strong community of industry and academic representatives, enhancing the number of Photonics21 members to more than 3000 today, of which 40% representing private companies coming from sectors as diverse as manufacturing, medical engineering or information technology. It is this highly-motivated photonics community that is behind the Photonics Partnership Proposal for Horizon Europe.

Recent analyses and market studies confirmed that the efforts made under Horizon 2020 have contributed to ***increase the production capacity and to strengthen the competitive capabilities of Europe's photonics industry***. The European photonics industry demonstrated a 62% growth in the last 10 years and the European Photonics production growth was by far outgrowing the EU GDP growth by 3.5 times and was also outgrowing global GDP by a factor of 2. The Photonics contractual Public Private Partnership (cPPP) has had a positive impact on job creation – according to recent estimations based on a 2019 survey done together with Tematys amongst the 100 Partnership Photonics Project partners (2014-2018), about 3550 jobs were created either during a Partnership project or as a direct follow-up of a project.

Behind this macroeconomic success, the photonics Partnership under Horizon 2020 has ***contributed to create and consolidate a strong Europe-wide Photonics innovation ecosystem*** by linking the various players such as National Platforms, Regional organisations and clusters, developing Core Photonics Technologies, components and systems to become and act as real photonics platform technologies for the next levels in the value chain and supporting upstream photonics technology distribution by supporting the building of demonstrators and pilots centres – for Photonics Start-ups and Photonics SMEs on their way to market, as well as Photonics-enabled and Photonics using Start-ups and SMEs in order to disseminate core

[8] https://publications.europa.eu/en/publication-detail/-/publication/6de81abe-a71c-11e7-837e-01aa75ed71a1/language-en, last accessed on 2020/03/18.

photonic technologies towards OEMs and end-users. Partnership pilot lines and prototyping projects have boosted industry's digital innovation capacities and helped to bridge the valley of death. According to Photonics Partnership project participants, having participated in a Partnership project has contributed to accelerating the time-to-market in the innovation process. Furthermore, the Partnership has started to build cooperative downstream structures to define their needs and specs on photonic components and systems early on and so improve time-to-market. The positive effects of a European partnership have been shown in the running Photonics cPPP, which has helped to increase the R&I spending quota of the photonics industry in Europe to 10% of sales and fostered additional 4-5 % of sales in CAPEX. This has resulted in an annual €10 billion Euro investment by the European photonics industry research and innovation and an investment leverage of 5 in the scope of the Horizon 2020 Partnership. More specifically, the Photonics cPPP has contributed to increasing the share of SME participation in Horizon 2020 projects to 27% - compared to 20.4% for all SMEs in Horizon 2020 projects and 23.3% in all projects resulting from ICT Calls (without SME instrument). Additionally, the Photonics cPPP has demonstrated positive impacts on Photonics SMEs – the backbone of the European photonics industry. On the one hand, the cPPP has been a very valuable instrument to mobilise SMEs and promote their involvement in R&D projects. On the other hand, the cPPP calls, which were the result of extensive discussions involving all Photonics21 stakeholders, have actually met the needs of SMEs, leading to a larger participation. Moreover, SMEs involved in Photonics cPPP projects expected an average growth of 7% p.a. – compared to an average growth of about 3% in the overall photonics industry – as well as the creation of 7.2 jobs in average per project. 85% of the SMEs involved in Photonics cPPP Projects expected the project results to positively affect other areas of their company's activities.

The ***public-private partnership was vital for directing these investments along a well-coordinated strategy***. Over the period 2007-2013, the European Technology Platform Photonics21 coordinated two strategy processes, leading to 2 strategic roadmaps published in 2010 and 2013, *Lighting the way ahead*[9] and *Towards 2020 – Photonics driving economic growth in Europe*[10]. These roadmaps have played an essential role when designing the orientation of European funding policy in photonics and have contributed to secure financial support for Photonics R&D under both the 7th Framework Programme for Research (2007–2013) and Horizon 2020 (2014–2020). Photonics-related projects could be found in almost all Horizon 2020 programmes and covered all application markets of high relevance for tomorrow's society and economy from personalised healthcare, industry 4.0, smart cities to securing the digital society, connected mobility – to name but a few.

Furthermore, strong ties were forged between research institutions, companies and policymakers across the EU and beyond through a combination of agenda-setting events, training programmes, workshops, publications and many other channels of communication.

However, this is only the beginning of a success story that Europe can write in the development and use of this deep technology.

2.1.4 Making European photonics funding future-proof: Leaving the technology silo, create more impact and shape ecosystems

What are the causes ("drivers") of the problem and their relative importance?

For far too long, Europe has not managed to utilise and implement results from deep technology research as quickly as in other parts of the world. There is a structural problem in Europe that

[9] European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH (2010) Lighting the Way ahead, Strategic Research Agenda in Photonics, Düsseldorf, 2010.

[10] European Technology Platform Photonics21 c/o VDI Technologiezentrum (2013) Towards 2020 – Photonics Driving Economic Growth in Europe (Multiannual Strategic Roadmap 2014–2020), Brussels

these technologies are often developed in silos and the involvement of end-users in strategic planning happens far too late. In other words: Europe has a unique ecosystem consisting of leading photonics suppliers and user industries, but it does not exploit the full potential of this ecosystem. There is an essential need for co-working and collaborating along the value chain, also between competitors.

As light technologies are so critical for many strategic industries and sectors: from the health sector to the food chain, manufacturing, mobility, digital infrastructure to safety, security and defence it is imperative that the future Photonics Partnership seeks an even more close co-working with our impacted end-user industries.

This partnering along those value chains and developing common road maps and innovation priorities will be essential to the future Partnership to secure a focused, efficient and fast development of impactful innovations. Their needs will define future development of the basic and core photonics technologies that can be synergistically used in future applications areas of various segments.

The new Photonics Partnership will, therefore, tear down traditional boundaries and seek joint strategic R&I planning and projects with Horizon Europe program parts representing future mega markets and societal relevant application areas.

To better match those needs of co-working but also synergistically and cost-effective develop new technologies, the future Photonics Partnership will adapt its structure and governance of working (cf. §3.7).

Clearly, the successful development of photonic core technologies remains an absolutely essential basis for providing ground-breaking solutions for future applications. Therefore, the Photonics Partnership is based on two pillars: the **development of photonic core technologies**, which must prove early on that they are relevant for serving several mega-markets and their **rapid integration through joint R&I projects with future application fields (other programme areas)**. This new partnership approach relies on an open, transparent and inclusive structure and governance (cf. §3.7). The proposed new Photonics Europe Partnership is well-positioned to implement this. In terms of processes, openness and transparency, the new partnership can build on the experience collected from the current Photonics Partnership under Horizon 2020.

In addition to technology development and its rapid implementation, Europe needs to provide favourable conditions for the development and implantation of new business models to address changing mechanisms of value creation. Data-based services play an important role, especially for photonics, since its sensors deliver a wide range of data and information. Also, photonic devices using VR or AR can provide context-based information to assist humans in various situations. In this context it is expected, that value-added shares will shift from hardware to data-based services.[11] It is apparent from B2C, shaping data ecosystems works best if there is one big player. This leads to a situation where the 'winner takes all'. But, this is not appropriate for the SME-characterised European photonics sector. A market failure, therefore, arises here from the fact that shaping data ecosystems requires close cooperation of companies. The proposed photonics partnership provides a platform for initiating such cooperation.

Furthermore, Europe needs a new approach to young people's education. In order to gain a competitive edge over other high tech economies in the long term, Europe needs a dedicated plan to train enough young people in deep technologies such as photonics and light technology-related fields of application. This goes beyond photonics alone and also requires close cooperation with other research and industry sectors, as well as with member states. The Photonics Partnership – and the Digital Europe Programme in particular - can play a decisive

[11] „Digital business models for Industrie 4.0", Plattform Industrie 4.0, 2019

role here. Training must be interdisciplinary and extend beyond various traditional areas and areas of application. The combination of hardware and software skills is a decisive competitive advantage in the ever-increasing digitalisation of societies.

2.2 Common vision, objectives and expected impacts

2.2.1 General objectives of the proposed Photonics Partnership under Horizon Europe

Photonics will be essential for implementing the priorities of the new EU Commission. To exploit the potential of photonics for Europe's healthy, green & digital future as well as for a competitive economy the proposed European Partnership on Photonics will:

- foster a focused, continuous and synergetic development of key photonics technologies, components and systems in Europe
- push – by a close and early collaboration with up-and-downstream industries – for the rapid diffusion into the various sectors that critically depend on innovative photonics solutions
- provide a framework for the shaping of ecosystems to address changes of value creation

Hence, the overall objectives of the proposed Photonics Partnership under Horizon Europe are:

***Objective 1*: Fully exploit the potential of photonics for a digital, green and healthy future in Europe** by providing critical components and systems and processes for next generation's applications, products and processes relevant to societal and economical challenges.

***Objective 2:* Securing Technological Sovereignty for Europe** by maintaining leadership in core photonics technologies as well as in the application of photonics through ensuring common strategic research and investment commitment by the Photonics Industry, the downstream end-users and European Commission.

Objective 3: Raise the **International Competitiveness** of Europe's economy and ensure **Long-term Job and Prosperity creation** in Europe, not only for the photonics industry itself but also the up- and downstream enabled industries utilising photonics technologies. In this context, the need to increase the uptake of technology and its translation into new products and services is also addressed.

It is crucial for Europe's competitiveness and for the development of solutions to the major societal challenges that investments are coordinated and targeted, following a community-backed Strategic Research Agenda. A dedicated Horizon Europe Partnership in Photonics is the only way to achieve this goal since it builds on more than 3000 members – representing 1700 industry and research organisations – that are already organised in Photonics21 at present.

By this, the new Photonics Partnership will massively contribute to Europe's ambitions and programs for Industry 4.0, Smart Farming, 5G, Artificial Intelligence, fighting cancer, increasing health, enabling new forms of mobility, contributing to digital and technological security and to sustainability by fostering reduced-emission processes and products and technologies in many innovative applications and systems. Here, the proposed partnership pools additional private and public R&I investments on EU priorities (additionality) and aligns them towards common objectives (directionality).

2.2.2 Derived specific Objectives

In order to achieve progress towards the overarching objectives set out above, SMART objectives are derived in this chapter in the sense that they are specific, measurable, achievable, realistic and, timely or time-bound.

***General Objective 1*: Fully exploit the potential of photonics for a digital, green and healthy future in Europe**

- Integration of relevant stakeholders representing downstream science and end-user industries as well as societal challenges
    - By 2022 new stakeholders account for 30% of the members of the Application Workgroups
    - By 2024 specific joint research priorities are identified in the Application Workgroups in the sense that R&I on a combination of photonics and other technologies are addressed
    - By 2027 a significant number of new R&I cooperation agreements, that involve photonics and application partners are established
- Joint calls with other European Partnerships
    - By 2022 each Application Workgroup of the Photonics Partnership has established a continuous exchange with at least one other European Partnership
    - By 2025 each Application Workgroup has prepared R&I priorities for at least one joint/collaborative call with another European Partnership
- Increase the uptake of photonics technology and its translation in up- and downstream value chains into solutions for societal and economic challenges (contributes also to General Objective 3)
    - By 2022 specific areas for action are identified and prioritised to further build up prototyping services and manufacturing pilot lines aiming to speed up the market entry and roll-out of innovative Photonics technologies and photonics-enabled solutions.
    - By 2024 relevant players from the key digital technologies have committed to building up a European wide lab-to-fab infrastructure (Digital Innovation Hubs) supported by the European Commission. This infrastructure implements testbeds, as well as low-threshold access to R&I infrastructure and co-working spaces that, in particular, support SME and entrepreneurs

***General Objective 2:* Securing Technological Sovereignty for Europe**

- Identify critical technologies and corresponding parts of value chains
    - By 2022, the Photonics Partnership – together with the value chain partners - has identified and prioritised critical technologies, applications and systems which gain from photonics technologies and systems and develop proposals for measures to safeguard European sovereignty in these areas and to secure the relevant parts of the corresponding value chains.
- Educate and train tomorrow's specialists today
    - By 2023 the Photonics Partnership – together with its value chain partners in the application-oriented workgroups has elaborated a coordinated public-private plan to define relevant skill sets and curricula for professions in photonics and its value chain partners. It aims especially for
        - strengthening advanced skills in photonics and relevant corresponding fields and a close exchange on a systems-level (e.g. in the respective Digital Innovation Hubs),
        - supporting the design of trainings for SMEs, Entrepreneurs and the affected workforce,

        - supporting the design of long-term training and master's courses for students, and
        - fostering life-long learning as well as on-the-job training and traineeships for the workforce of the photonics and photonics enabled industries
- Commitment to a close cooperation
    - By 2024, relevant players in Europe – representing industry and research institutions as well as politics, NGO and citizens – have committed to an agenda that aims for securing technological sovereignty in photonics and safeguards relevant parts of the corresponding value chains

General Objective 3: **International Competitiveness and Long-term Job and Prosperity creation**

- Speed up the uptake of technology and its translation into new products and services (as already mentioned above but with a focus on economic challenges here). In addition to the above-defined specific objectives:
    - By 2022 specific areas for action are identified to build up ecosystems that support the enhancement of photonic and/or photonics enabled products, applications and processes by data-based services, e.g. providing parameters for laser material processing based on huge data pools or the collaborative condition monitoring based on photonic sensors.
    - By 2022 in the above-mentioned context furthermore, modifications to the regulatory framework are proposed, e.g. in the context of data usage or the cooperation of competitors.
- Join forces of the many SME in the fragmented field of photonics by a commitment to joint strategic research agendas in the different application areas
    - By 2021 first drafts based on the broad involvement of relevant stakeholders are presented.
    - By 2022 measures are proposed that aim for enhancing the SME quota participating in funded R&I projects, e.g. by lowering the threshold, reducing bureaucracy and raise the success rate especially for SME when applying for funding and by close cooperation with the EIC.
    - By 2022 the Photonics Partnership has achieved the commitment of 50 new industrial stakeholders on these Joint Strategic Research Agendas in the different application areas in the sense that the high leverage effect of today's Photonic21 community is maintained.
    - By 2025 this commitment involves 100 new industrial stakeholders and thereby acts as a pacemaker for photonics SME in Europe.
- Boost opportunities for entrepreneurship in the photonics sector
    - By 2022 propose specific measures to improve the access to risk finance, e.g. by establishing a Europe-wide fund or funds for deep technology Start-up's, SMEs, Industries in growth status and/or in close cooperation with the EIC and EIB
    - By 2025 secure public measures to incentivise and leverage additional private venture capital.

As shown in the Photonics 21 Vision Paper, there is a solid base formed by the Photonics 21 community. This community provides an excellent starting point for achieving the above objectives and for joining forces for the next chapter of a European photonics success story.

2.2.3 Common Vision and Raised Ambition of the Photonics Partnership

To take Europe's photonics industry to 2030 and beyond, it will not be sufficient to focus solely on individual research projects. While the EU support for these projects has been of outstanding value and should be continued, our future focus will be even more closely on creating the ecosystems and markets of tomorrow today. That means enabling the transfer of breakthroughs in photonics technology into successful products and services that create new jobs, resolving our most important societal challenges and improving the lives of European citizens.

Clearly, the next wave of photonics core innovations is most likely to arise from emerging fields such as integrated photonics, micro- and nanophotonics, plasmonics, metamaterials, quantum optics and – perhaps most importantly – new concepts like digital photonics, which also spans 3D sensors and computational imaging. Thus, a holistic approach is needed to keep the photonics pipeline full and ensure Europe's competitiveness in these new emerging technologies and markets. However, there is also a huge potential for innovations at the interface between photonics core technologies and their application areas. A holistic approach that addresses photonic technologies and application-specific aspects as well as relevant improvements in other fields is simultaneously crucial to realise those innovations. Therefore, the photonics community seeks and strives for new partnerships.

It is imperative for Europe to maintain an overarching strategic approach towards technological development if the ambitious missions staked out by the European photonics community – and discussed in the subsequent sections of this document – are to be realised.

The envisaged partnership will gain leadership in photonic technologies. This ambitious objective requires a dedicated European road mapping process involving all relevant actors. Research activities in photonics are highly demanding in terms of infrastructure and expertise and take decades to build up and reach world-class performance. If implemented in normal Horizon Europe actions there would be a significant risk that continuity is not preserved.

Moreover, without a joint European roadmap and implementation in collaborative projects, the photonics community in Europe will lose synergies and coordination and will fall behind its global competitors.

The new European Photonics Strategic Roadmap 2021-2027[12] published and handed over to the European Commission on 27th March 2019 alongside the Photonics Partnership Annual Meeting 2019, will provide the backbone of the proposed Photonics Partnership under Horizon Europe. (cf. §4). The Roadmap is the outcome of a comprehensive strategy process carried out in 2018, involving more than 300 European photonics experts. It follows a back-casting approach identifying the steps to be taken today to turn the vision 2030 into reality. These objectives are ambitious – and the European photonics community's commitment to join forces to make them reality, is unrivalled.

In particular, the Photonics Strategic Multiannual Roadmap identifies the following research and innovation challenges for the coming years:

- **In information and communication, a new programmable optical infrastructure will be the 'central nervous system'** upon which the digital society, industry and European economy will heavily rely. Photonics communication technologies are the optical lifelines of our modern society and economy, transporting data at an ultrafast pace in millions of extended fibre-optic networks around the globe to every home.
- **Highly-integrated, accurate and fast photonic sensors with multi-sensor data fusion are the sense organs of the digital society**. These light-based technologies,

[12] https://www.photonics21.org/download/ppp-services/photonics-downloads/Europes-age-of-light-Photonics-Roadmap-C1.pdf

therefore, feed new Artificial Intelligence algorithms to enable autonomous driving, smart cities, industry 4.0 as well as a comprehensive understanding of our climate or breakthroughs in medicine and healthcare.

- The thematic roadmap associated with industrial manufacturing and quality addresses the Industry 4.0 challenges by planning for a future where a fully-digital value chain, from supplier to customer, will introduce new forms of collaboration, customisation, new services and new business models – all of which will strengthen Europe's industrial base. **New laser systems and the integrated use of sensor technologies for process and condition monitoring, as well as 100% quality control, will be at the heart of completely digital and connected value chains, allowing companies to move quickly between the mass production of identical parts and the manufacture of individualised products**.
- Significant challenges for Europe in life sciences and health are an ageing society, the increase of age-related diseases, and increasing costs of the healthcare system. **The development of mobile, wearable photonic devices (combined with advanced biosensors for instant point-of-care diagnostics and treatment which measure the wearer's medical condition and wellness)** will contribute to **early detection and diagnosis of diseases as well as earlier and more focused treatment**. There is a broad international consensus among (public) health experts that this will make an important contribution to reducing healthcare costs, therefore ensuring the sustainability of public health systems in the future – while, of course, improving the wellbeing of European populations. Affordable photonic-based real-time diagnostics to classify disease status, and to monitor and assess treatment responses, will open doors to the practical implementation of precision medicine, improving the effectiveness of treatments. Future light-based developments may help to search for new biomarkers and develop promising treatments for currently incurable diseases, as well as a greater understanding of brain functions.
- **New technologies in lighting, electronics and displays will be the "intelligent backbone" of the Internet of Things (IoT) and enable information and communication technologies to become pervasive and ubiquitous**. Micro-Displays in glasses and even contact lenses will offer personalised information via augmented reality, making complex work more accessible. Classical navigation and information systems will be replaced by information which can take into account the preferences and habits of every individual. Lighting, electronics and displays will also play a crucial role when coping with future challenges related to energy efficiency, wellbeing and food security.
- **Monitoring the occupation of buildings and the subsequent switching off of heating, lighting and electrical devices in unoccupied areas through sensor-based lighting control could significantly reduce energy consumption.** Such systems will be omnipresent in new buildings and be used for retrofitting existing buildings. Developing human-centric lighting that improves our wellbeing and reduces accidents will become a standard feature in private and public spaces. In farming, the use of artificial light specifically tuned to enhance plant growth combined with light-based sensorics will be essential to increase yields and food quality, mainly for urban farming where space and light are at a premium.
- The Internet of Things (IoT) revolution, where machines will sense, operate, decide and communicate without our intervention is transforming our society. **With a significant cost of the IoT systems relating to sensor subsystems, the communities of photonics security, metrology and sensors are at the heart of this transformation.**

- Underpinning all of the previous areas is the design and manufacturing of optical components and systems. While many components and systems need to be tackled, one technology that provides key benefits across all areas is the development of photonic integrated circuits and devices. Success in this area will lead to reduced cost and size, and improved robustness of photonics systems. **New, enhanced photonic integrated circuits will enable the full deployment of photonics technologies across many sectors and will play an essential role in the European digital transformation**. Demand for integrated photonic devices also comes from the emerging field of quantum technologies, specifically quantum computation and communication, suggesting an urgent need to develop both technologies in parallel.

As a deep technology, photonics naturally has complementary technology approaches to other partnerships and initiatives, which must be implemented as efficiently as possible. For example, some subareas of Integrated Photonics, namely some areas of silicon photonics, will be transferred to the KDT partnership when a certain technology readiness level is reached and the route to mass manufacturability is foreseeable. However, the research and development of basic technologies for silicon photonics as well as other aspects of micro photonics will continue to be carried out within the framework of the Photonics Partnership as this is the best nurturing place to test new ideas and approaches in this field[13]. Similarly, close cooperation and clear transfer points between the Photonics Partnership and other partnerships and EU initiatives (Made in Europe, or Quantum Flagship, for example) where photonics is critical, will be defined and implemented in cooperation with the respective areas.

Another important area for the future of photonics is the education and training of the next generation of professionals. They will need the necessary skills to successfully and innovatively exploit the great potential that photonics technologies have to offer. In the future, innovative approaches will be needed to attract students towards STEM disciplines and photonics studies. Disruptive fundamental and applied research will continue to be the basis for future technological development that will allow us to tackle problems that currently appear unsolvable. Similarly, **the active cooperation between academia and industry needs to continue, which, in the past, has successfully translated many photonics-based research outputs into the market and has been a very successful strategy**.

Owing to the increased deployment of photonics technologies in the automotive and transport sector, a thematic roadmap for this area was produced. The key light technologies that will play an important role here are photonics-based sensors, communication and lighting technologies as well as advanced human-machine interfaces. The advancement of these technologies and automated driving will contribute to solving four main challenges: improved road safety, cleaner mobility, congestion-free road transport and the digitisation of the automotive industry.

The final thematic roadmap, focusing on agriculture and food, addresses the global challenge of food security in the light of climate change and population growth. **This roadmap examines the need for food production to be economical, less wasteful and environmentally and socially sustainable. Light technologies have much to offer to this area through monitoring and measuring tools, on farms, in food processing plants and the consumer's hands**. While there are already examples of photonics being deployed successfully, the biggest challenge the thematic roadmap addresses is the need to produce solutions that are low cost

[13] This approach is supported by the member states: European Partnerships under Horizon Europe: results of the structured consultation of Member States *Draft Report for the meeting of the Shadow Configuration of the Strategic Programme Committee on 27 June 2019*

and easy to implement and that address the specific needs of the European agri-food community.[14]

For further details please view the complete Photonics Strategic Roadmap 2021-2027 in the annex to this partnership proposal. (cf˝. §4)

Consistent to the objectives listed in the previous chapter, Photonics Partnership also strives for improvements in the implementation of innovations and in innovation management, which is assumed to be critical for a successful public and private partnership. These have also been set out in the Vision Paper:

- **Digital Innovation Hubs: Build a truly European lab-to-fab infrastructure for accelerating innovation and competitiveness**. Europe needs to increase the uptake of technology and its translation into new products and services. One of Europe's greatest strengths is mastering photonics technologies, so we need to continue building here in order to create disruptive new products and market opportunities. The further buildout of prototyping services and manufacturing pilot lines would help SMEs across Europe to speed up their innovation processes, as would shared assets in research and manufacturing. At the same time, EU and national R&D programmes should have a sharper focus on prototyping and market entry. Here, we aim to build and extend Digital Innovation Hubs for Photonics – but also form a close cooperation landscape with other deep technologies and their respective end-users.
- **Boost opportunities for entrepreneurship in the photonics sector.** Access to risk finance must be improved by establishing a Europe-wide fund for photonics start-ups, growth and bridge capital. This could take the form of public matching funds that incentivise and leverage private venture capital.
- **Educate and train tomorrow's specialists today.** As outlined in the European Commission Digital Europe programme it will be important to strengthen advanced digital skills, to provide training for entrepreneurs and workforces, to support the design of long-term training and Master's courses for students as well as to foster on-the-job training and traineeships for students. The measures of the new Photonics Partnership should complement Digital Europe activities in this field and should include a coordinated public-private plan to define skill sets and curricula for professions in photonics. The harnessing of light should be a flagship science in schools, universities and throughout the entire education system.

The mission statement laid out in the Photonics Vision Paper 2030 impressively demonstrates **the raised ambition of the photonics community**. This Vision Paper for European photonics in 2030 entitled *Europe's age of light! How photonics will power growth and innovation*[15], is the outcome of an extensive normative foresight process. It describes how a Photonics Partnership will create impact in 8 different areas and what benefits for the partners and the society at large could be achieved by the proposed additionality and directionality of the public and private R&I investments:

1. **Instant diagnosis of major diseases**
   By 2030, healthcare will be fast, precise and cost-effective. Advanced diagnostics, pervasive monitoring and innovative e-health applications will be able to detect body signals, symptoms and diseases early on. Treatment will be highly targeted, minimally invasive and increasingly effective, reducing disability and mortality from cancer, strokes and other major diseases. Diagnosis and treatment will be delivered instantly at the point of care, thanks to the new science of "theranostics." With the

[14] Photonics21, Strategic Roadmap 2021-2027, 2019. P. 16-18.
[15] Photonics21, Vision Paper, 2017.

help of these and other innovations, Europe will keep an ageing population healthy and fit.

2. **Quality food from farm to fork**
   By 2030, we will have the technology to feed the world, push back food-borne illness and reduce the environmental footprint of agriculture, fisheries and aquaculture. Photonics will help supply safe, nutritious and affordable food for all and establish a sustainable value chain from farm to fork. By using ever more precise sensors and measuring devices, farmers, food processors and ordinary consumers will be able to monitor and certify the safety, quality, content and even the origin of food – anytime and anywhere.
3. **Accident and congestion-free road transport**
   By 2030, our mobility will be based on multimodal transport. Driving will be automated, connected and electric to maximise safety, efficiency and comfort. Photonics provides essential components, systems and production tools for all aspects of connected mobility, from driver assistance and traffic monitoring to photonics-based IT and telecommunications.
4. **A truly circular economy**
   By 2030, Europe's economy will be cleaner, greener and far along its path towards decarbonisation. Photonics technology will help put an end to the depletion of resources by managing material streams in a circular economy, reducing energy consumption in buildings and public spaces, creating efficient industrial processes, developing the next generation of photovoltaics, enabling smart mobility and monitoring our environment in real-time.
5. **A million new jobs**
   By 2030, European factories will be fast, green and flexible. Photonics technology, including lasers, sensors and 3D displays, will revolutionise industrial production and working environments, making manufacturing more innovative, cost-competitive and resource-efficient. A fully digital value chain from supplier to customer will birth new forms of collaboration and customisation, new services and new business models – all of which will strengthen Europe's industrial base.
6. **10% higher productivity**
   By 2030, digital connectivity will create an entirely new quality of urban life. Photonics technology, including lighting, sensors and optical IT, will supply the infrastructure for smart homes and thriving cities, thereby enabling us to live and work in attractive, secure and productive environments tailored to our individual needs.
7. **Zero downtime in a terabit economy**
   By 2030, our societies and economies will be fully digital. To make our digital society work and to safeguard trust, comfort and privacy, photonics is the key tool for delivering the necessary performance, resilience and security in data services and network infrastructures. To handle vastly greater flows of data, IT systems will be much more powerful than today while using less energy, thanks to the emerging shift to high-performance optical and quantum computing.
8. **Photonics as a flagship science for innovation**
   By 2030, photonics will be a pillar and driver of the knowledge society, playing an instrumental role in the creation and dissemination of knowledge and ideas. At the same time, educators, students, governments, companies and ordinary citizens across all disciplines and sectors will be increasingly aware of the opportunities and potential inherent in utilising light for the benefit of humankind.

As stated above, these eight ambitious objectives are the outcomes of a normative foresight process, meaning that they present eight facets of a *desirable* future – in other words, eight

desirable goals helping to define actions to be undertaken *today* in order to make this vision turn to reality.

In this sense, this common vision for European Photonics by 2030 describes what photonics *may achieve* or contribute to achieving by 2030 *provided* we make the right decisions and take the right steps *today* in terms of photonics research and innovation policy.

2.2.4 Expected Impacts of the next Photonics Partnership

Looking at the five areas for missions under Horizon Europe as well as at partnership areas, the potentially large contribution photonics has to offer is obvious – as shown in the table Photonics Contribution to EU wide Missions and Partner Area.

Harnessing the power of light will enable Europe to cope with the greatest global challenges of our time. The new European Partnership on Photonics will contribute to providing solutions to these challenges.

Therefore the European Photonics community – together with external experts from the downstream industries – has been engaged over the last two years in an important strategy and road mapping process. This process, paving the way into the next decade, led to the previously mentioned Vision Paper for Photonics as well as to the strategic roadmap for Photonics in the period 2021-2027 (cf. §4)[16].

"Photonics is one of these essential key enabling building blocks for the digital transformation of Europe, which will be based on deep technologies" – this is the key statement in the recent 2018 European Commission and European Investment Bank report on "Financing the digital transformation".[17] This statement outlines that photonics as a key enabler and will provide future technologies for Industry 4.0, smart farming, 5G, artificial intelligence and many other applications. Light technologies, components and systems, are further critical elements for many European strategic value chains from the automotive industry to the aeronautics sector. In addition to this, a resilient photonics capacity is vital to European sovereign security interests.

Therefore, a European Partnership on photonics will strongly benefit the European society and economy as it will:

- join forces to contribute to solve complex global and European societal and industrial challenges and provide innovative solutions for the digital transformation, as well as for a secure, healthy and green Europe
- foster growth and innovation in many end-user markets and applications and thereby secure a global leadership position
- provide a critical mass for future photonics-based innovations
- contribute to creating new jobs along the value chain from suppliers to end-users
- enhance and promote digital skillsets
- help to combine photonics with other key technologies and integrate them into new systems
- foster start-ups and the long-term sustainable growth of SMEs along the value chain

[16] Photonics21, Strategic Roadmap 2021-2027, 2019.

[17] 2018 European Commission and European Investment Bank report on "Financing the digital transformation: Unlocking the value of photonics and microelectronics", which states that "..the Photonics sector is an essential key enabling technology and represents an important building block of the next digital revolution, which will be based on deep technologies".

More specifically the following sections describe the new Photonics Partnership that will have an impact on Key European Objectives.

Missions	Miion Areas for Horizon	Photonics Areas of Impact	Photonics Measures / Targets	Measurable Applications
	Adapting to climate change, including societal transformation	Metrology, contribution to lower material use, higher yield, less waste, lower energy usage for production	Photonic sensor systems - embedded photonics for IoT meeting the requirement of systems - not components, miniaturisation, multi analyse, maintenance free, platform concepts, cost-effectiveness, robustness, low power	Field tests in selected high potential markets for smart, multi-analyse photonics systems with build -in AI/ML data interpretations (cloud free) Maintenance Free. Self-calibrating fault tolerant self-diagnostic multi-analyse photonics sensors
	Cancer	Photonics Screening and guiding 3-D imaging methods DNA sequencing in less than 10 minutes and combine analysis of proteomics, genomes and metabolomics in one instrument High throughput Screening: parallel testing of pharmaceuticals > 200 3-D imaging with a full (organ level) deep view (> 1cm) Mobile devices not exceeding 1 cm3 In Vivo Sensors	New "Photonic tools for real-time proteomics, genomics, metabolomics" will enable DNA sequencing in less than 10 minutes and combine the analysis of proteomics, instrument. Also, these tools could find the first application in genomics and metabolomics into a single instrument. Also, these tools could find the first application in metabolomics-guided treatment or rehabilitation.	emerging 3D imaging methods, which will in future be capable of combining subcellular resolution with a systemic field of view, encompassing entire organs, small animal models or even the complete human body.
	Healthy oceans, seas, coastal and inland waters	Metrology / Sensors and Photonics Components Photonics in Agriculture		
	Climate-neutral and smart cities	Low Power devices - sensors, LED, organic PV Urban Farming (Light) Energy Savings by LEDs	Light accounts for 12,4 % of electricity in member states = 132 mio. tonnes of CO2 - here	Real time and latency (bandwidth, reliability, speed) Adaptive Driving Beam fir mainstream vehicles Sensing capabilities LIDAR / Sensors / Free Space optical solutions Virtual Displays, Augmented Reality Light solutions / Night vision (
	Soil health and food	via Metrology / Sensors Photonics in Agriculture Photonic son a chip / ASPIC- self calibrating, fault tolerant, self diagnosing, multi-analytic	More small farms Photonics in Forestry	

Table 1: The contribution of photonics to the European Missions

Source: *Photonics21 Secretariat – own evaluation*

2.2.4.1 Enabling the digital transformation in a sustainable and prosperous way

Simply put, Photonics is indispensable for driving Europe's digital transformation and coping with future most essential issues in the fields of ICT, health, mobility, energy, security.

Without photonics, these technologies will struggle to grow or may not even develop at all. It is crucial to recognise the interconnection of technologies and the skills needed to understand them:

- ***AI widely depends on photonics technologies for delivery**:* For AI to be useful, software solutions and computers will not be practical on their own: they will need to connect to the physical world through sensors and communication links. Many of the sensors that will be deployed in smart cities, cars, production units depend on photonics, such as cameras, or LiDAR for example, because they provide detailed information at an affordable cost that a safe and deployable transport system requires. Data will need to flow to the computing unit or units that run the AI algorithms, and at present, this information is carried via fibre optic cables. However, as sensing and measurement technologies are increasing in their capabilities and deployment, higher communication bandwidths will be required to transport that data. In many applications, such as autonomous vehicles, the communications need to work in real-time, and latency is a real issue. This means that some of the wireless links will have to use free-space optical solutions since radio-frequency technology is not capable of meeting the bandwidth needs.
- Photonics is at the core of a transition in computing technology that will see more traditional silicon circuits make way for optical computing: future computing hardware may be based on photonics or photonics-enabled quantum computers. Light-transmitting circuits will enable significant advances in computing speed, creating entirely new digital services.
- ***The Internet of Things needs the speed of photons and many photonics components:*** In the future, more data will be generated and transferred as a result of more devices being connected. Requirements on data capacity, speed and security of data will increase, putting additional demands on an optical communication system. Fast and real-time data communications require transportation at the speed of light, as part of a fibre-based core network. In addition, photonics-based sensors such as cameras, infrared sensors, and hyperspectral imagers will enable IoT. The predicted rollout of Industry 4.0 will drive innovation in the manufacturing sector. The laser processing community will utilise IoT to connect their machines to sensors to enable them to control their processes more accurately. For many advanced laser processes such as additive laser manufacturing, it is necessary to achieve consistent quality.
- ***Photonics will contribute to increasing cybersecurity by using photons to reduce vulnerability**:* With the proliferation of smart devices and the increased deployment of IoT-enabled devices, we will be more vulnerable to security attacks. Many photonics technologies, e.g. Li-Fi or quantum secure communication, aim to increase cybersecurity. In anticipation of the "post-quantum" era, where quantum computers will become strong enough to break codes in a short space of time, photonics-based hardware solutions based on the generation and detection of entangled single photon pairs may increase cybersecurity.
- ***The emerging field of quantum technologies depends heavily on photonics technologies:*** Photons are often used to probe the quantum device: within quantum clocks, quantum-based probes for brain scans or quantum computing, usually lasers and detectors are involved. Of course, many quantum technologies directly use photons such as in quantum communication. To bring these applications to market needs the development of photonics technologies ranging from single-photon detectors and

sources to amplifiers for quantum communications. Quantum computation based on photonics builds on integrated photonic devices and systems. Equally, atom-based quantum gravimeters that are at present slightly smaller than a bedside table could be miniaturised and the cost reduced by utilising integrated photonics. Another issue for quantum technologies is the need for specific lasers which are at present mainly scientific lasers and too expensive for an extensive rollout. To bring quantum technology to the market requires the parallel development of enabling photonics technologies.

Specific technological challenges, objectives and milestones are listed in the Photonics Partnership Multiannual Strategic Roadmap 2021-2027 "Europe's age of light" – page 54/55.

2.2.4.2 Contributing to a wealthier and healthier life

The number of people older than 65 relative to those of working age is assumed to increase by a factor of two by 2045. Since age is one major factor for an increased probability of becoming ill, a large increase of corresponding illnesses like type 2 diabetes, many cancer subtypes, dementia and macular degeneration is anticipated. However, age is only one factor for death by disease: Worldwide the number of corresponding incidences exceeds 30 million people per year just from the ten leading conditions like Cerebro- and cardiovascular diseases, cancer, sepsis and obstructive pulmonary disease (COPD).

Furthermore, the prevention of diseases, early risk assessment, as well as improvements to well-being, are important and persistent challenges that need to be addressed. This starts with diagnosis, therapy and interventions in utero, at birth and after for conditions whose social burden is increasing as the society ages, for example, premature birth and congenital malformations.

In addition, the patients' burdens have to be decreased. The healthcare systems already struggle to keep up with the ever-increasing costs, which already amounted to 9.6% of GDP in Europe in 2018 – with upwards tendency.[18]

Photonics for Instant Diagnosis – the Imperative for a Predictive, Preventive, Personalized and Participatory Medical Approach

Given this context, a major trend for health systems is the so-called P4 medicine (Predictive, Preventive, Personalised and Participatory), for which instant diagnosis of major diseases is an imperative and for which Photonics has to offer significant tools:

1) Advanced Photonic tools for life science industry, as well as end-users (e.g. medical doctors, research), comprise:
   - Photonic tools for real-time proteomics, genomics and metabolomics.
   - Accelerating and enabling photonic tools for pharmaceutical industry, understanding, regenerative medicine, personalised medicine, high throughput high content screening
   - Photonic tools for understanding the origin of diseases beyond risk factors, finding pathways for treatment, photonics for health (nutrition, lifestyle, environmental influences, toxicity)
2) Affordable photonics-based real-time diagnostics to stratify and classify disease status such as:

[18] Health at a Glance: Europe 2018 (OECD, European Commission).

- Monitor and assess treatment response for the practical implementation of precision medicine.
- Optogenetics for the treatment of brain, heart diseases etc.;
- Photonics for physiological treatment or photonic-assisted physiological treatment.
- Photonics for interventional guidance (augmented reality).
- Multiscale access to the body (depth of penetration/optical resolution)

3) Mobile photonics devices and advanced biosensors for instant point-of-care (-use) detection/diagnostics and treatment, that measure the patient's medical condition and wellbeing, transportable photonic devices for monitoring environmental parameters

Prevention is better than cure is actually an ancient knowledge, which is not only more patient-friendly but also relieves the burden on the health care system. Here, Photonics can offer a wide range of enabling products and processes:

- **Mobile Biosensors – identifying and measuring risk factors for disease prevention:** In the long term, healthcare needs a paradigm shift away from the diagnosis and subsequent treatment of already acute diseases towards the detection of diseases before their onset, i.e. before first symptoms occur. This includes identifying and measuring risk factors for disease prevention. In addition, it can aim to monitor non-invasively physiological parameters to provide feedback on healthy nutrition and lifestyle habits as well as to generate detailed datasets of in vivo parameters for understanding the origin of diseases.
  These long-term data may be evaluated by artificial intelligence-based methods in order to find deviations from normal patterns as early as possible. Photonics solutions should allow monitoring at least one important health/disease parameter over time periods which permits the accompanying software solution either to make prognoses and/or to adjust intakes of, e.g., food or food supplements, drug doses etc. to avoid acute phases of an already semi-acute or chronic disease. It is conceivable that a combination of a mobile station with wearables connected to this location, which would act as sensor elements.
  What is required is the development of portable and affordable instruments which ideally allow the checking of a number of different health/disease parameters in parallel. This could potentially be realised in a non-invasive way (for example via breath, sputum, urine analysis or data provided by low-cost genomic tests or using wearable devices for sensing tissues) or minimal invasive ways for home use in order to obtain reliable long-term data from potential patients.
  Light impacts many other areas for a healthy life – healthier food and a "feel-good" with tailored human-centric lighting.
  There are also other areas where Photonics has an impact and can contribute to a healthier population, for example, photonics applications for a healthy food chain. Light applications can play a major role in behavioural feel-good factors and produce an increase in productivity.
- **"Optimal Light Nutrition" for improved health and well-being and next steps in energy efficiency:** Global trends in consumer behaviour show that people are increasingly looking for highly-tailored products that bring human benefits. In professional environments, health and wellbeing is seen as an enabler for growth. **C**reating huge opportunities for lighting, these trends can unlock this extraordinary potential, therefore it is crucial to understand how light impacts human life.
  Environmental health and wellbeing not only relates to the lighting quality but also to the quality of the environment itself (temperature, air quality or noise level).
  Human-centric lighting design provides several benefits: the visual, emotional, and

biological effects of light help us to see, feel, and function better. Light is the most powerful regulator many bodily functions, such as our day-night rhythm. Natural light delivers the positive combination of the light our bodies need, with the spectral content at the right time.
Furthermore, the lighting infrastructure is perfectly positioned to host sensing devices related to the environmental quality that affect our wellbeing. Lighting infrastructure is everywhere, organised in a grid, and based upon recent advancements like connected IP based lighting. The lighting infrastructure is best suited to enable devices which monitor environmental quality.
Specific technological challenges, objectives and milestones in the course of the years are listed in the Photonics Partnership Multiannual Strategic Roadmap 2021-2027 "Europe's age of light"

2.2.4.3 Photonics for a greener and more sustainable society and economy

Photonics can contribute to a greener economy in many ways. There are aspects in saving energy by using Photonics products – such as LED light or less energy-consuming laser processes. There are also aspects of fighting the waste of resources by more efficient processes and material treatments or methods to better sort waste for an optimal recycling process. Photonics can help to monitor the environment be used to produce energy – whether it is in the area of photovoltaics or in approaches from light to fuel.

Smart Cities, Smart Farming, Vertical Farming are themes that may show how photonics can contribute a circular economy. To highlight areas of impact listed below are some examples from the strategic roadmap.

Towards a Truly Circular Economy: Optimised Resource Treatment

Reducing Resources Use: Another aspect of the 'circular' economy is the saving of resources: in particular, energy in production facilities. Here, light may be considered in different ways.

- While intelligent and efficient lighting may lead to a reduction in annual utility costs, photonics technology in quality control, employed across the entire manufacturing chain may also support the reduction of scrap, thus implicitly enhancing the efficiency of resource input in production.
- An additional benefit could be created via the local generation of electricity (photovoltaics in facades, greenhouses, buildings), even reducing the need to transport energy from its source to its user.
- Further research challenges concerning how to reduce the need of water in plant growth by proper lighting and how to reuse of photonics components to improve the eco-balance will need to be examined.

Energy Saving: Lighting accounts for 10 to 12% of national energy usage and up to 30% of the domestic electricity bill. Saving energy will not be restricted to higher efficiency (conversion rate) of single light sources, but will be looked at in a much broader societal sense. Sensor-based lighting control – embedded in building automation systems - will be omnipresent in urban installations, new buildings and used for retrofitting existing buildings.

Urban Farming: In a population with rapidly increasing urbanisation, 'vertical farming' will become increasingly important[19], and perhaps even mandatory to provide sustainable food production. Light technologies are essential building blocks: adjusted light can make plant production much faster, produce less waste, decouple heating from lighting and reduces the need for chemicals and genetically modified plants. Additionally, local photovoltaics in the windows and building facades can reduce the CO2 footprint compared to conventional production.

Environmental Monitoring: Photonics will be needed for a fast, real-time and also cost-effective monitoring. The value proposition lies in Remote Data Analysis; lab-independent substance monitoring; and flexible surveillance infrastructure. Network connected photonics enable such environmental monitoring systems - e.g. for multi-point or mobile air quality surveillance with on-line readout and data analysis functionality – which secure high measurement rates, high reliability and self-calibration capabilities beyond the state-of-the-art.

High-performance sensing solutions: Photonics high-performance non-contact sensing solutions for the NIR/MIR/FIR spectral range will be part of a valuable toolbox to create powerful solutions for a wide range of applications including medical, environmental, agricultural, food and manufacturing quality control. In medical applications, many laboratory analyses can be done at the point-of-care. In environmental applications, a large number of distributed IoT sensing nodes can provide reliable, dense and real-time information about the current conditions and potential threats, so that preventive measures can be taken with immediate effect. In agriculture, the use of fertilizer, pesticides, fungicides and water can be optimised even locally in a field. In the food domain, every consumer will be able to check the safety, nutritional value and presence of potentially hazardous substances in their food products.

Specific technological challenges, objectives and milestones in the course of the years are listed in the Photonics Partnership Multiannual Strategic Roadmap 2021-2027 "Europe's age of light" (cf. §4).

2.2.4.4 Filling the Pipeline- Photonics Core Technologies along the TRL chain

Considering the core photonics technologies, according to their proximity to the market and their market readiness, we highlight four challenges that affect the ability to fulfil the objectives of fighting for a leadership position, technological sovereignty and act as a trendsetter. To do this in a sustainable way it is important to focus on the development of components and products. Only disruptive product ideas do not secure jobs today – and only market-ready products will not secure the jobs of tomorrow. So looking at the maturity chain and pipeline of photonics and their development need the following should be highlighted:

- ***Established in the market but with room to develop – Setting the future scene for sovereignty.*** For example, displays, lighting and photovoltaics where device-level manufacturing is well established in the Far East. However – under the light of sovereignty and future developments there is still a role for Europe to take the lead in setting the direction of new developments such as the emerging trend of digitisation of lighting through the integration of sensors and light-based communication (Li-Fi).
- ***Operating in a developing market –Driving competitiveness****:* the current lead that Europe has is often at risk if there is no strategic coordination of R&D directions in place. High power lasers, for example, are already up and running in machine shops

[19] http://publica.fraunhofer.de/eprints/urn_nbn_de_0011-n-5069445.pdf

and enabling new methods for cutting, joining and surface treating. These machines allow for new design freedoms, enabling new engineering choices. However, the systematic development of these machines has not been completed, and many opportunities to do more exist: the need to reduce the cost, increase power and improve beam quality, and open up new application areas exists. Developing these tools and techniques coincidentally increases European manufacturing performance in other sectors.

- ***Ready to make an impact – Defend leadership and enter the Markets****:* Many photonics-based technologies form vital parts of future technology markets, but are not yet at commercial readiness levels, for example, LiDAR, the optical equivalent of radar but with much quicker response times and substantially higher resolution. LiDAR has been in use for research and high-end technology applications for many years, but recently LiDAR systems have fulfilled a vital real-time 3D sensing need for autonomous and semi-autonomous vehicles. Venturing beyond the research applications and into affordable mass deployment will call for more R&D. Systems need to meet all the usual smaller, faster, cheaper requirements; however, they will also need to reach new levels of reliability that are maintenance-free.
- ***New research areas – Gain Leadership and technological sovereignty:*** As we move beyond visible light, new markets and new challenges are available. Photonics devices already exploit applications in the Infrared spectrum, but moving further towards Mid Infrared and beyond, and down to UV and X-ray wavelengths will create many new opportunities for new products. If we consider the very promising developments of nano-engineered materials as well as the different quantum effects then many new sensing applications, including medical measurement and therapeutics, can be expected.

2.2.4.5 Enhancing Europe's Competitiveness and ensuring long-term Job Growth

Increasing the international competitiveness and ensuring long-term job and prosperity creation in Europe is an important paradigm of the future Photonics Partnership. This is not only about securing a leadership position in the successful photonics products and applications. It also contains the aim – by nature of a key enabling technology – to enable other key European up- and downstream industries to defend and/or regain a leadership position. This is also imperative to secure Europe's digital and technological sovereignty in the turbulences of a globalised economy that is increasingly less committed to regulations and fair competitive conditions.

Europe is arguably the centre of global photonics innovation today. European companies are market leaders in such sectors as production technology (including industrial lasers), optical components and systems, sensors and automated vision, as well as photonics in medicine and life sciences. The sector directly employs over 300,000 people.[20] Including all individuals whose livelihood depends on the use of photonics – from workers using industrial lasers to doctors performing endoscopic surgery – then 10% of the workforce and as much as 30% of the entire economy already depend on photonics technology.[21] However, competing economies are already implementing plans that will help them exploit the significant opportunities that

[20] European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH, Photonics21 Secretariat (2019): Photonics cPPP Progress Monitoring Report 2019, Düsseldorf

[21] Butter, M., Leis, M. et al. (2011): The leverage effects of photonics technologies: the European perspective. Study prepared for the European Commission, DG Information Society and Media, SMART 2009/0066. Available under: http://cordis.europa.eu/fp7/ict/photonics/docs/reports/photonicsleveragestudy_en.pdf, last accessed on 2017/03/21.

photonics will provide to their economies. As a result of these global investments in photonics, Europe's place as a market leader is not guaranteed and requires immediate, active support.

2.3 Necessity for a European Partnership

In its recent Communication Paper "A New Industrial Strategy" from March 10th, 2020 the EU Commission explicitly lined out the great strategically importance key enabling technologies – with Photonics being one of them – will have for Europe's industrial future.[22]

They all will/ shall be major contributors to reinforce Europe's industrial and strategic autonomy, develop own markets and boost Europe's competitiveness. It also underlined in its chapter 5 of the paper the need of Europe wide integration across value chains and borders and the necessity of increasing links between products and services. It also stresses the request to form strong industrial ecosystems that encompass all players operating in a value chain.

Given this role of photonics as such a key enabler and underlying technology for many end-use markets – forming a European partnership is a no-brainer. It is essential for all Europe's Science and Industry players, as well as for all relevant end-use markets, to have access to the technology, and in turn also give input to the future development of this basic technology.

This argument gains more evidence as from its industry structure the European photonics research and innovation landscape is highly fragmented with SMEs making up for a large majority of the European photonics sector: from approximately 5,000 companies that produce optical components and systems in the EU, fewer than 200 employ more than 250 people. So – unlike other sectors where large companies often serve as a pacemaker to structure the research and innovation landscape - European photonics smaller companies alone are lacking the resources and the capability to fulfil this pacemaker role.

Given the fact that - like other deep technologies - Photonics is also highly capital and R&I intensive and therefore intrinsically risky – even more calls for an effective, collaborative and common approach should be made.

A Europe-wide partnership and network not only helps to raise the visibility towards the value chain partners which serve consumers and markets – it can also support the rollout of this relatively new technology to new applications and systems for new high tech applications and systems and for solving such challenges as personal and digital safety and security, digital transformation and technological progress and sovereignty for Europe. By developing innovations in Europe at a much faster pace, a European Partnership will strengthen a synergetic joint technology development and accelerate spillover of knowledge along the value chain to reach a critical competitive advantage.

Furthermore, the need for a European partnership is not simply about a European Photonics network, now more than ever, the need for a network with other technology partners and with up- and downstream partners is vital. All the solutions required will need to integrate various players, skills, inventions and innovations to achieve market place success and will also need to develop rapidly to be competitive. Fostering strong cooperation with other programme areas, partnerships or missions, will be vitally important during Horizon Europe to accelerate innovation and provide new solutions for health, mobility, security and food challenges, to benefit European society.

The future European Partnership on Photonics will take this responsibility into account by purposely restructuring its current platform to open to new stakeholders to establish industrial alliances. Given that Excellence in Science and Industry - as well in Photonics, other key

[22] https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf

enabling technologies - is fairly widespread across member states, by definition, a Europe-wide ecosystem is needed to meet all those players to secure involvement and build excellence throughout Europe.

Many open structure processes and closer co-working with sectors applying (will and can apply in future) photonics technologies had already commenced during the Horizon 2020 Partnership: The European photonics community developed a variety of core-technologies and market-oriented specs and features that helped to initiate its diffusion in end-user industry sectors which is quite a way to go and an ongoing process for each new technology challenge. In Horizon 2020 a series of end-user workshops began and end-user and downstream partners were invited to contribute to the Photonics vision paper and Multiannual Roadmap as external experts.

Given the above and high-tech hardware developments like photonics the innovation and diffusion cycle are much slower than, for example software-based businesses, a European Photonics Partnership should run from the start of the Horizon Europe programme in 2021 to 2027. An interim assessment will check whether the rationale and the objectives of the partnership are still valid and modify the action accordingly. The exit strategy to phase out EU funding will depend on the maturity of the developed technologies and targeted markets in the relevant application areas as well as their potential to increase the competitiveness of European industry. However, an exit might be envisaged on the one or other end-use applications – but is it difficult to define an "exit" from the development of new photonics technologies itself as new needs of the end-users arise and demand new solutions.

On overall exit strategy of the further development of photonics technologies would certainly depend on the overcoming of the market difficulties this deep technology is facing – whilst aiming for an acceleration and shortened path to innovative applications: One the one hand here we find the high and lengthy capital intensity and capital commitment, which often makes it difficult to find sufficient seed and venture capital on the market. And on the other hand create forms of cooperation and networking which allows the be highly fragmented photonics industry with its many SMEs to seek synergetic and strategic cooperation for pushing the technology and gain an equal and eyes-on cooperation along the value chain with OEM and end-users being often much bigger and powerful. Both of those conditions aiming thus also accelerating and shortening the path to application.

The Partnership proposal includes measures to address and mitigate or solve these market-related problems, such as close cooperation with the EIB and ERC and cooperation with venture forums. And on the other hand a closer, earlier-on and collaborative cooperation with the value chain partners and end-user industry within the new structure in the application-oriented working group to drive and speed-up innovations time to market.

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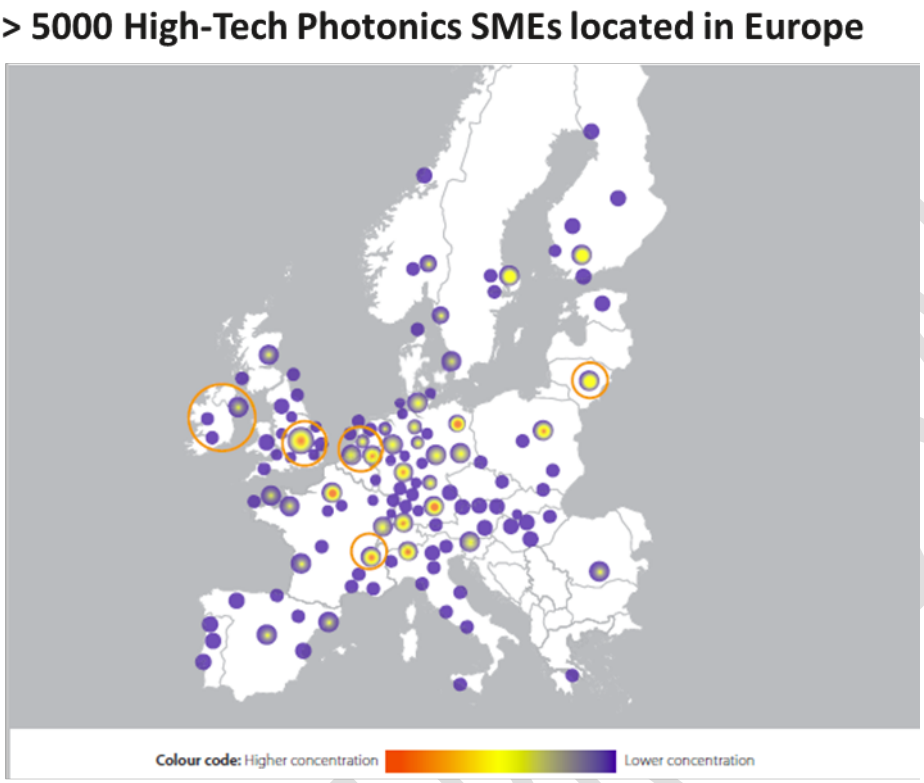
2.4 Partner composition and target group

2.4.1 Partner composition and target group - Build upon the existing strength

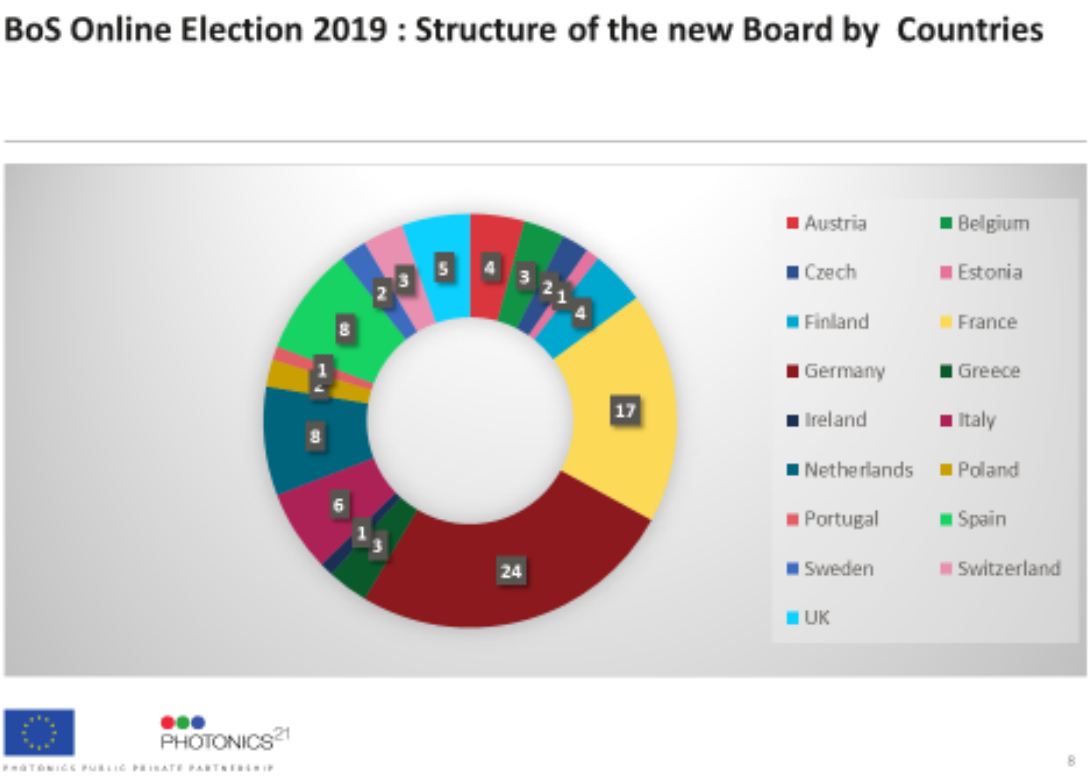
The future Photonics Partnership will build upon the existing strength of the current European technology Platform Photonics21 which represents more than 3000 personal members and about 1700 European different photonics affiliations such as companies, research & technology organisations, universities, representatives from the national platforms, clusters and from industry organisations.

In the graph below, the private side of the platform is spread across Europe with around 5000 High Tech SMEs located across Europe with the personal members of the Platform representing all EU member states.



Graph 2: Location of Photonics SMEs in Europe
Source: European Investment Bank (2018)

A broad country representation also can be seen in the structure of the Board of Stakeholder (BoS) members – the highest decision making body of the platform - where the 94 current members come from 17 EU States.



Graph 3: Composition of the BoS Members by countries
Source: Photonics21 Secretariat – November 2019

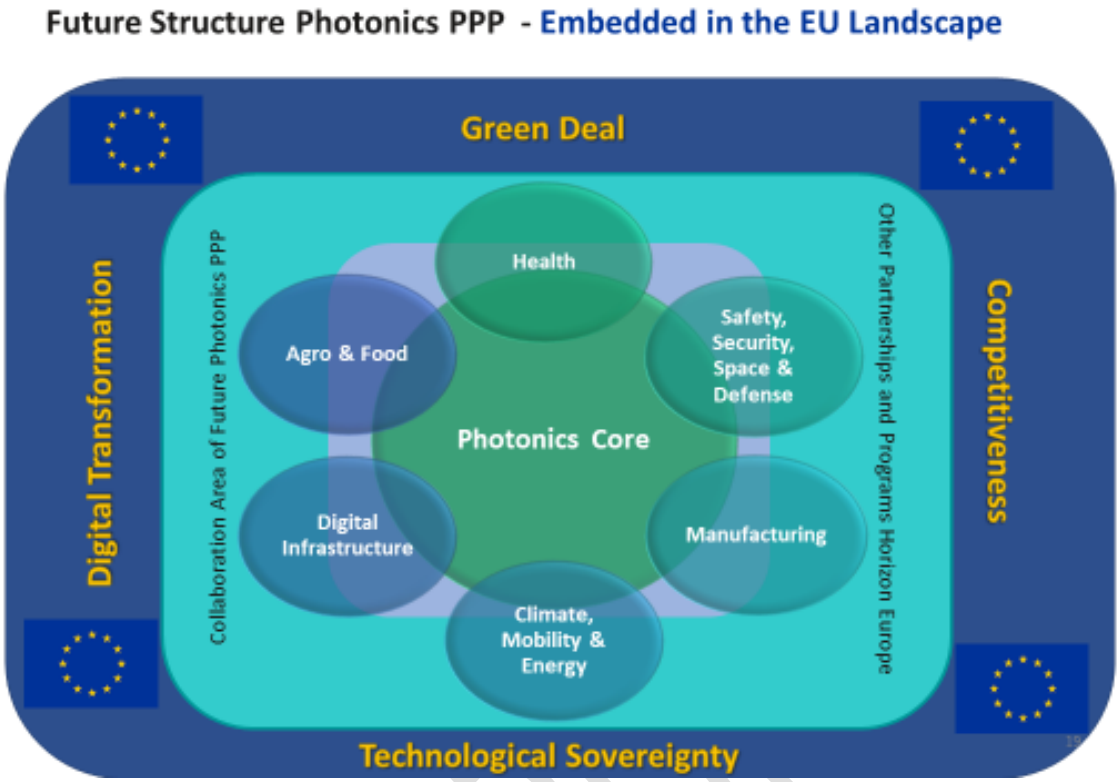
2.4.2 Partner composition and target group – Reaching out to new stakeholders

Increasingly - and motivated by the inclusion of the two new work areas Automotive & Mobility and Agro & Food in the creation of the Photonics Vision Paper – the Photonics aimed to engage new stakeholders from the downstream value chain joining as experts. Aside from the expert workshops held where end-user representatives had been invited to join and contribute to the Vision Paper – a closer exchange with the value chain partners was also subject of the end-user workshops which were initiated in the various countries by the European Nextpho21 partners.

This approach of including value chain partners in the organisation and workflow of the future Photonics Partnership finally led to the current efforts to re-structure the platform Photonics21 as well as the future Photonics Partnership in a way, that more easily and prominent reach out to other partnerships and programmes (see graph below).

The future new structure of the Photonics Partnership envisages forming six application-oriented workgroups which actively seek integration and/or collaborations with new stakeholders representing the respective value chains. The exact format of those collaborations will be subject to further discussions and needs and can come in form of MoUs with other partnerships, work agreements, joint efforts and/or integration of Co-Chairing, shared financial contributions.

These six application-oriented workgroups will closely interact with the Core Photonics Working Group which targets to develop necessary photonic component, products and systems which are serving best the needs and specs of those application areas.



Graph 4: Structure of the Future Photonics Partnership
Source: Photonics21 Secretariat – March 2020

These future collaborations with up- and downstream partners secure input from external experts and should therefore secure a faster (setting the right specs and increase knowledge about the needs) and more focused (looking for multi-application areas of usage) route to market.

The extended and new collaborations should eventually be industry-driven, but not limited to industrial partners. The list of potential new stakeholders also comprises all representatives from the science and research community, foundations, associations, political partners from governmental as well as non-governmental representatives as well as representatives from the financing and investment community.

It is important that the new Photonics Partnership benefits from broad and solid ecosystems and secures photonics expertise from the various regions involved to effectively contribute to EU-wide solution findings and real impact on the big challenges such as Green Deal, Digitisation, Technological Sovereignty and Competitiveness.

Those ecosystems should include more than photonics technologies and communities: they should include close cooperation with other key-enabling technologies and end-user industries which are vitally important to future success and impact generation, and should be the aim of integrated digital innovation hubs.

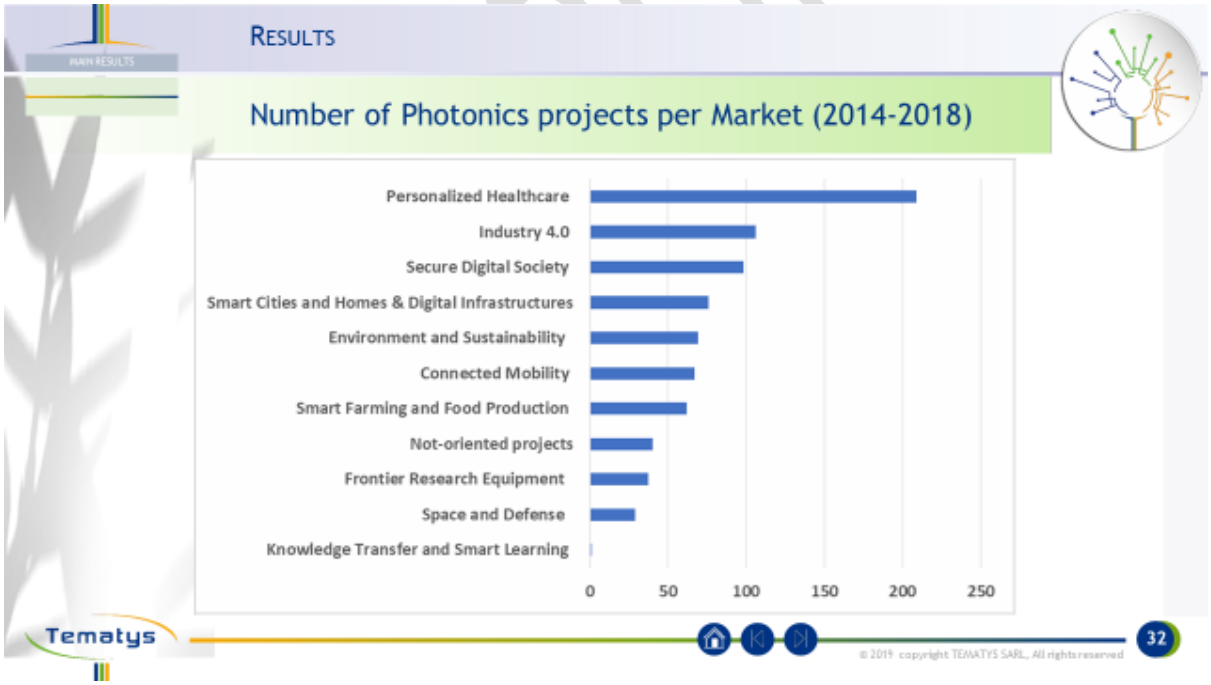
As for international cooperation, photonics will always act in close exchange with international photonics organisations, international research and science structures and through the global activities of its industrial partners. However, given the objective of enhanced technological sovereignty of Europe the collaboration to some extent is limited in the research arena.

To sum up: the above-mentioned adaptions of the future Photonics structure:

- more easily allows to team up and cross-work with other mission and application-driven partners from the Horizon Europe program and by that speed up the way to innovation and to real impact on ecological, economic and societal challenges
- allows for faster market access of innovations and pull through the TRL levels inventions by envisaging even stronger cooperation along the value chain
- secures an increased focus of the photonics core technology fields by seeking areas of funding which will serve more than one application, product or process areas and by that increases the efficiency of funding

2.4.3 Partner composition and target group – Potential new partners

The nature of photonics as a key enabling technology mean there are many overlaps and potential future co-working areas with other industry segments and societal processes. The survey completed during Horizon 2020 it has become obvious, that photonics has many cross-cutting topics with a number of mega-markets and innovation areas. This has driven the need for much closer cooperation along the value chains and has led to a new structure, which more seeks closer involvement of the external expertise in the Photonics Partnership via the Application-oriented Workgroups.



Graph 5: Number of Photonics projects per Application Market
Source: Tematys Study 2019 - Photonics in H2020

As already started in the current Horizon 2020 frame, Photonics is actively seeking collaborations with other EU partnerships and is constantly exchanging information and participating at other meetings (e.g. Robotics, HPC, BDVA, AI/Robotics). At the Annual meeting 2019 Photonics21 already invited several of the Horizon 2020 partnerships (BDVA,

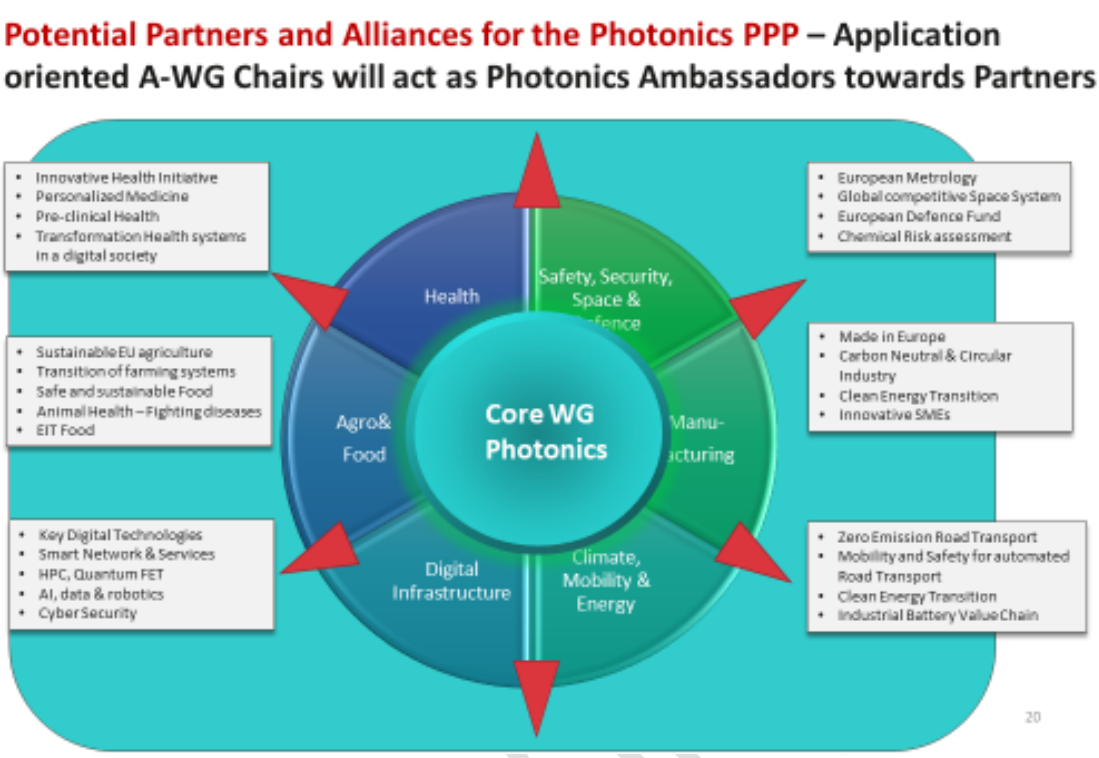
Robotics, ECSEL, Smart Cities, Green Cars, Cybersecurity et.al.) to start sharing the thoughts for future collaborations. It is envisaged to establish 7-10 operational collaborations, e.g. through joint or coordinate calls and partnering community activities, with other partnerships.

Table 4: List of potential future partnerships and Programmes

Industry areas - Horizon Europe Partnerships	Horizon Europe Cluster addressed	Partner industry association(s)	Critical photonic technologies for the sector (exemplary)
Industrie 4.0 - "Made Europe"	Digital, Industry and Space	European Factories of the Future Association	- Photonic sensor systems and image processing, e.g. low latency control or autonomous inspection - Laser material processing, subtractive as well as additive - Low latency photonic componentes for AR/VR devices - Integrated/embedded micro- and nanophotonic systems - …
Artificial Intelligence & Robotics – "AI, data and robotics"	Digital, Industry and Space	Big Data Value Association (BDVA) euRobotics AISBL	- Photonic sensor systems and image processing, e.g. low latency and high reliability recognition for robots/autonomous systems - Smart camera platforms with embedded image processing - …
Microelectronics, Embedded Systems & Software - "Key Digital Technologies"	Digital, Industry and Space	1. ARTEMIS Industry Association 2. European Technology Platform on Smart Systems Integration Association	- Integrated/embedded micro- and nanophotonic devices and systems - Photonic integrated circuits (PICs) - …
High Performance Computing – "European High Performance Computing"	Digital, Industry and Space	1. European Technology Platform for High-Performance Computing (ETP4HPC) Association 2. Big Data Value Association (BDVA)	- Photonic integrated circuits (PICs) - Optical data transport and processing
Digital infrastructures - "Smart Networks and Services"	Digital, Industry and Space	5G-Infrastructure Association	- Optical data transport and processing - Networked photonic sensor systems - Integrated/embedded micro- and nanophotonic systems
Process Industries - "Carbon Neutral and Circular Industry"	Digital, Industry and Space	A.Spire Industry Association	- (Networked) Photonic sensor systems, e.g. low latency control, autonomous inspection or distributed condition monitoring) - Low latency photonic components for AR/VR devices (e.g. assistance systems for maintenance engineers) - Integrated/embedded micro- and nanophotonic systems

Space - "Global competitive space systems"	Digital, Industry and Space	Eurospace - AeroSpace and Defence Industries Association of Europe	- Photonic sensor systems and image processing, e.g. low latency and high reliability recognition for autonomous space stations - Laser material processing of advanced materials, subtractive as well as additive manufacturing of complex structures - Integrated/embedded micro- and nanophotonic systems - Cosmic radiation proof photonic integrated circuits (PICs) - Optical data transport and processing …
Health - "Innovative Health Initiative"	Health	1. MedTech Europe Association 2. European Federation of Pharmaceutical Industries and Associations	- Photonic sensor systems and image processing - Low latency photonic components for AR/VR devices (e.g. assistance to the surgeon - Integrated/embedded micro- and nanophotonic systems (e.g. minimally invasive diagnosis) - Advanced (hyperspectral) sensors and microscopes for the life science
Road Transport - "Towards zero-emission road transport"	Climate, energy and mobility	European Road Transport Research Advisory Council (ERTRAC)	- Photonic sensor systems and image processing, e.g. low latency and high reliability recognition for autonomous vehicles - Laser material processing of advanced materials, subtractive as well as additive manufacturing (e.g. light weight structures) - Low latency photonic components for AR/VR devices (e.g. assistance systems)
Air Transport - "Clean Aviation"	Climate, energy and mobility	Clean Sky Association	- Photonic sensor systems and image processing, e.g. low latency and high reliability recognition for autonomous inspection - Laser material processing of advanced materials, subtractive as well as additive manufacturing (e.g. light weight structures) - Low latency photonic components for AR/VR devices (e.g. assistance systems)
Quantum Technologies - "Quantum Flagship"	Digital Industry and Space	Quantum Flagship Coordination Office @VDITZ	- Photonic sources and integrated micro- and nanophotonic systems as key enabling technologies for quantum systems

Putting this into context to the envisaged new structure, the picture of the future Partnership could resemble the scenario in the graph below:



Graph 6: Potential Partners and Alliances for the Future Photonics Partnership under Horizon Europe

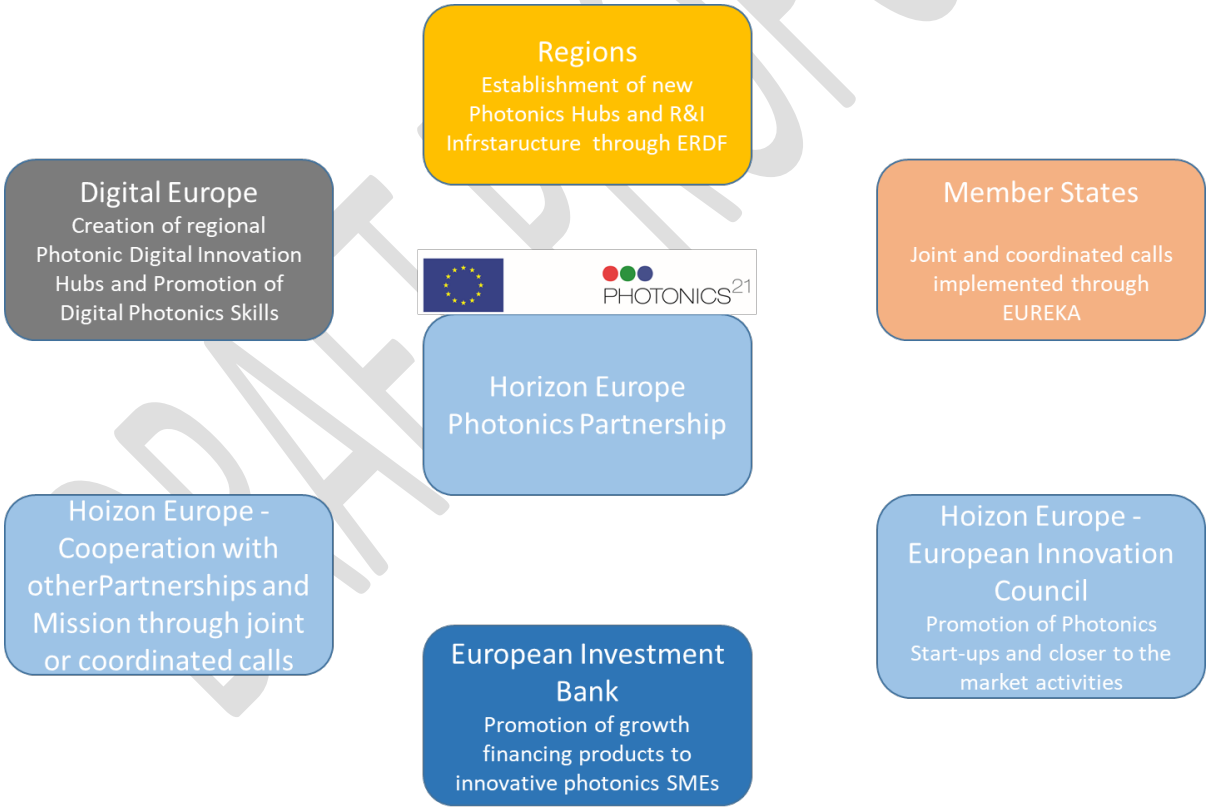
Source: Photonics21 Secretariat March 2020

3 Planned Implementation

3.1 Photonics Partnership under Horizon Europe

Looking at the current situation, the challenges facing the global economy, and world societies, Horizon Europe and the Photonics Partnership will commence in a complex and challenging environment. The President of the European Commission, Ursula von der Leyen, stated in her inaugural address to the EU Parliament that "Europe must lead the transition to a healthy planet and a new digital world" For this to happen Europe has “to achieve technological sovereignty in some critical technology areas”. We stand on the brink of an industrial and societal revolution that will fundamentally change the way we live and work. In its scale and complexity, the transformation will be unlike anything humankind has experienced before. Digitalisation, the convergence of technologies, further increasing global innovation dynamics, the trend to urbanisation, smart anything everywhere and resource scarcity will completely change business models and will dramatically disrupt every industry.

For the Photonics Partnership this means also acting in a complex environment, not only in an environment of major challenges for which solutions must be found, but also in a complex network of actors seeking such solutions.



Graph 7: Environment of the Photonics Partnership;
Source: Photonics21 Secretariat March 2020

For photonics as a key technology, and the broad Photonics community in Science and Industry, this means to closely cooperate with other key technologies as well as with the value chains to provide those best solutions. It also means maintaining a broad and Europe-wide network: on the one hand with the photonics platforms, companies and research institutions in

the member states, the ministries, regions and clusters there - but also with all those partners in the value chain who can contribute to finding the best possible solutions and bringing them to market.

3.2 Portfolio of Activities

The Photonics Partnership will pursue broad measures to achieve its goals and desired impact. Activities will range from R&I projects to the development of prototype and pilot production services, to dedicated measures in the area of Photonics Digital Skills. Special attention will be given to how the financing situation of deep tech companies in Europe can be improved, especially in the start-up and growth phase because this has proven to be a roadblock in the past. The photonics partnership will not be limited exclusively to Horizon Europe but will seek and develop ties with complementary programmes at EU level (such as Digital Europe, , Structural Funds, InvestEU) as well as at national/regional level and with private investors.

The close cooperation between the Photonics Partnership and the member states is crucial to achieve the expected impact. On the one hand, joint calls (e.g. under the EUREKA programme) will be developed together with the member states, based on the strategic roadmap of the partnership. The aim here is not necessarily that all Member States should always participate, but that a flexible approach should be adopted according to the respective needs and strengths.

For example, a joint call on digital photonic manufacturing may be launched by countries with particular strengths in the production sector (such as France, Italy, Germany, Slovakia, and Lithuania). The Photonics Partnership aims to kick off at least one transnational call per year. The already existing Photonics21 mirror group – consisting of national ministries - is the place where transnational call topics will be discussed an agreed.

Furthermore, the Photonics Partnership will closely link the Digital Innovation Hubs, which are currently established and jointly funded by the Photonics Europe programme and member states, with the activities of the Photonic Partnership to create a truly pan-European network of photonics pilot lines and prototyping services for SMEs.

A remaining key issue for Europe towards the industrial deployment of Photonics / Key Digital Technologies though is how it can promote and provide the access to financing for the development of a sustainable photonic resp. digital industry. The lack of growth financing for European Photonics / Key Digital Technology start-ups and SMEs was already a major challenge for Europe in the past[23], as it is very cost-intensive and does not offer a quick return on investment. It is foreseeable that the current COVID 19 pandemic and the resulting economic crisis will only exacerbate this situation. The supply of growth capital for these companies should therefore be a dedicated priority for Europe at this stage, in particular to avoid state controlled foreign investments forcing European photonic companies to sell majority stakes or even relocate to other regions of the world. For this reason, the partnership will work closely together with the Commission and Member States to establish a dedicated industrial investment programme on Key Digital Technologies as part of the InvestEU investment plan. Such a dedicated InvestEU programme would be able to mobilise public and private investment through an EU budget guarantee that will back the investment projects of the European Investment Bank (EIB) Group and other financial partners, and increase their risk-bearing capacity. In the context of a dedicated industrial investment programme on Key

[23]“ Financing Europe’s Digital Transformation: Unlocking the value of photonics and micro-electronics”, European Investment Bank, 2018

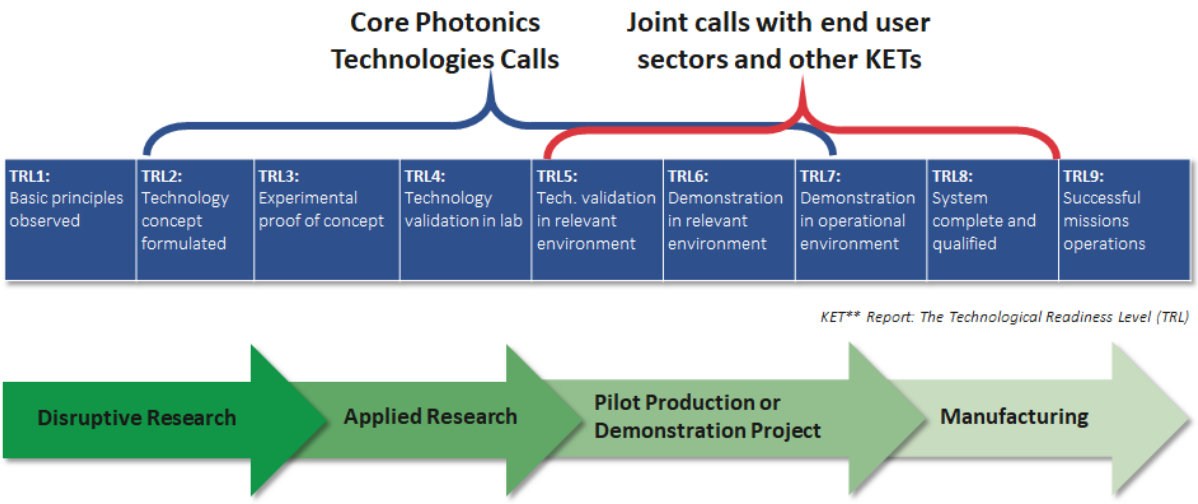
Digital Technologies, Member States would be asked to add to the EU guarantee's provisioning. In return, Member States will benefit by attracting significant private investment to Europe's local Photonic / Digital Industry.

In terms of R&I strategy, the Photonics Partnership will break new ground by leaving its deep technology silo and establishing close cooperation with key European end user industries and their communities in the early stages of R&I priority setting. This will significantly advance the digitization in these sectors and thus the competitiveness of Europe. Consequently, parts of the budget of the Photonics Partnerships will be channelled into these joint and cross-thematic coordinated calls for proposals with other Horizon Europe areas. However, for successful implementation, the European Commission must ensure from the outset of Horizon Europe that the timing of calls is coordinated across sectors and that smooth implementation does not fail because of bureaucratic hurdles.

The result of such well-coordinated cooperation will be outstanding: the partnership will be able to make food production in Europe more efficient, safer and more environmentally friendly for the benefit of citizens. European road traffic can become accident-free through the use of photonics solutions in transport and thereby save thousands of lives. Through the use of photonic technologies in medical technologies, serious illnesses can be diagnosed immediately instead of waiting for days or weeks, leading to earlier treatment and a longer and healthier life. New, highly efficient photonic production technologies linked with intelligent photonic remote process control will create thousands of new digital manufacturing jobs and therewith will make Europe competitive on a global scale. The current partnership in Horizon2020 has already launched more than 30 joint strategic activities with the end-user industry and countless innovations have been developed.

3.3 Collaborations and synergies

The profound basis of the photonics partnership lies in the development of photonic core technologies, which are indispensable for the digitisation of European society and economy. The strength of European photonics lies in the close integration of scientific and industrial research. So far, however, the degree to which these innovations have spread to other sectors has not been sufficiently successful. This partnership aims to achieve a significant social impact by overcoming these shortcomings.



Graph 8: Photonics calls and TRL
Source: Photonics21 Secretariat March 2020

Photonics has not yet nearly exhausted its potential as a key enabler for solving major societal challenges and addressing future mega-markets:

- Prototyping and pilot production services will be broadly made available to photonic and non-photonics industries, especially SMEs, to develop and test new digital products and services.
- This can be achieved by setting up a European Digital Innovation Hub prototyping, testing and pilot line infrastructure. However, to achieve a significant impact and to leverage synergies and increase effectiveness, it should be noted that Digital Innovation Hub infrastructures are set up and coordinated in a cross-cutting manner – for example, for more than one Key Enabling Technologies and/or major EU themes within Horizon Europe.
- As in the past, the infrastructure should provide a single entry point for service requests with clear process descriptions and costs for SMEs. The current Photonics Innovation Hub project Actphast 4.0 provides a good role model for such an overarching infrastructure and process approach. Even more in the future, the Digital Innovation Hubs should also look into the scope of offers to SMEs, founders and entrepreneurs. It might be valuable to extend the offers beyond the technical infrastructural services and extend them to marketing, financial or collaboration fostering service offers.
- So far, efforts to establish Digital Innovation Hubs across Europe have lacked this coordination and therefore fall short of impact expectations. Successful implementation of European Digital Innovation Hubs requires close coordination and dovetailing of European funding with national and regional initiatives.
- Establish a cooperation platform for Member State funding authorities to launch cross-national photonics calls. While EU member states and regions are not part of the Partnership, they have always connected to Photonics21 from the beginning.
    - One core activity of this group is the preparation and the implementation of transnational calls for funding, each by several member states and regions particularly well-positioned and/or interested in the specific area with additional funding coming from the Horizon 2020 Photonics KET calls.
    - The Photonics Partnership has already established a large number of successful joint funding initiatives with member states under the ERAnet Cofund and the Eureka instrument.

- Furthermore, it triggered 17 regions across Europe under the Smart Specialisation Platform 'European Photonics Alliance'24, which is supported by the European Commission, DG REGIO to work together in this key enabling technology.
    - The aim of the "European Photonics Alliance"25 is to accelerate the broader use of photonic technologies in Europe by 2030. Serial production is a prerequisite for this continent to remain a global player at a time of Zettabyte communication and 50 billion IoT devices.
    - To achieve this, a formal alliance of European regional clusters with significant activities in photonics is envisaged, which will be supported by their respective regional governments in the coming years. The first focus of the activities will be to optimise the use of the existing infrastructure in the regional clusters by sharing these expensive and specialised resources. Also, we plan to map current research programmes to ensure that they are of optimal benefit to each other and that duplication is avoided.
    - This alliance will be used as a cooperation platform for the Horizon Europe photonics partnership to optimally leverage and link existing programs such as Interreg Europe and the cross-border interregional programs.
- However some of the cross-cutting regional activities currently meet bureaucratic hurdles: pooling of resources possible from for example the ERDF and framework programme turned out to be practically impossible, which hindered an even broader rollout of this initiative. There is, therefore, a strong call from the photonics community towards the European Commission to overcome these obstacles which are currently based mainly on incompatible regulations and rules.

3.4 Implementing the Photonics Strategic Roadmap: Drafting future EC work programmes

Against the background of the goals presented in the Strategic Roadmap 2021-2027, the Photonics21 platform will involve the European photonics community in the definition of potential research priorities for European Photonics. Thereby, a similar democratic, open and transparent procedure shall be used as in the past when defining priorities for work programmes under Horizon 2020: Future potential priorities shall be developed in close consultation with the Photonics21 workgroups and shall be prioritised by the Photonics21 Board of Stakeholders, reflecting needs of the European Photonics industry. This will provide a valuable input to the EC to be used in its research funding policy and policy implementation.26

The European photonics community started the interactive, open and transparent process to define the photonics research and innovation priorities for the Horizon Europe work programme 2021/2022 alongside the Photonics Partnership Annual Meeting 2019. In interactive Photonics21 workshop sessions, the community further discussed and specified the identified R&I topics as laid out in the photonics roadmap. The workgroups worked out their proposals during summer 2019 and the Photonics21 secretariat then shared them with all work group members for further feedback and comments and provided the revised work group proposals again to the workgroups.

[24] https://s3platform.jrc.ec.europa.eu/photonics
[25] https://s3platform.jrc.ec.europa.eu/photonics, please see also the previous paragraph on page 43
[26] European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH, Photonics21 Secretariat (2017): Jobs and Growth in Europe – Realizing the potential of Photonics, PPP Impact Report 2017, Düsseldorf.

The annual priority setting is developed in the Partnership jointly between the Partnership and the European Commission, in consultation with EU Member States, Horizon Europe Associated Countries. A transparent process will be deployed, including an opportunity for public comments as well as from stakeholders, industry, member states and societal interests.

3.5 Monitoring the impact of the Photonics Partnership

Contributing to a more healthy, greener and digital Europe and secure Europe's competitiveness and therefore increasing prosperity and wealth by securing innovation, sustainable growth and jobs lies in the heart of the Horizon Europe's funding scheme objectives. A set of KPIs measuring those impacts and the progress made by the funded projects will be essential to prove evidence towards citizens and tax payers. A first attempt of such a set of KPIs can be found in following table and comprises KPIs on an economic macro-level, a Partnership project level and Horizon Europe programme level.

The base lines and measuring methods will be developed in close cooperation with the respective EU Commission institutions prior to contracting.

Measure Impact, prove evidence and secure sufficient personal and budget resources for an appropriate KPI measuring

As those macroeconomic data mentioned above can be tracked by official statistics and specific photonics related market studies and is a matter of money and sufficient budget included in the respective projects - the more qualitative impact measuring on solving those challenges like a greener and more digital and inclusive society will be more difficult to measure. Or at least – it will be more difficult to prove the evidence which factor of the multiple influence factors was causing which part of the impact.

Here it will make sense to agree – upfront joint calls and the start of the project – on the KPIs applying, the measuring methods and – for doing that - involve content stakeholders and experts in the definition of those overwriting KPIs. By involving experts – also from the Corporate Governance side of Enterprises - it will be assured that the data requested is in line with the publication rules of enterprises and listed enterprises and requests will not end in conflict with those rules like SEC.

Commission Services to actively contribute and support the Set-Up and measuring of a common and comparable set of measurable but non-conflicting KPIs

As the European Commission and its new cross-DG Co-Creating Strategy Teams were stating, it is the aim of the Horizon Europe implementation rules, to introduce common and comparable KPIs for the partnerships (certainly – only where a measure makes sense to apply). It was also indicated that there will be support from EU Services to get to those data – either via surveys amongst project partners or via such experts as available in the ECFIN or the EIB.

Regulatory and legislative support is also targeted for measuring success and securing input from project partners, by including those reporting needs into the contracts prior to the start of a project. Resource support from the EU Commission should also come in providing those Project Details as Budgets, Grants, classification of Project Partners by type of affiliation and size.

The future list of KPIs should include measures from the EU Photonics Industry as a whole as well as from the Photonics Partnership projects (including partnering projects with other

Partnerships) and – where applicable - from other Horizon Europe projects involving photonics as an enabler or critical technology.

The following table provides a first attempt and overview of possible future KPIs being assessed throughout the period of Horizon Europe:

Table 5: Overview of possible KPIs to be assessed throughout Horizon Europe

Photonics PPP - First Attempt to KPIs in Horizon Europe						
KPI / Level of Impact	**Measures which type of performance**	**Publicity / Mainly addressed Target Group**	**KPI Description**	**Frequency of Measuring**	**Type of Measure**	**Source Measuring**
Macro-Level	Industry Performance	Public	Photonics Industry growth versus Global GDP growth	2x period	Quantitative	External Market Study
Macro-Level	Competitiveness	Public	Maintain / Increase the (European) market share - of the global photonics market in total - and specificly market share in the "Core" EU segments	2x period	Quantitative	External Market Study
Macro-Level	Innovation Power	Public	R+I Spending: Quote as % of Sales comprises R+I spending + Capex In total Euros	2x period	Quantitative	External Market Study
Macro-Level	Employment	Public	Increase in number of people employed in Photonics sector	2x period	Quantitative	External Market Study
Macro Level	End Users Market Growth	Public	Growth of Photonics enabled industries & markets	2x period	Qualitative and Quantitative	Segment Reports / Market Study
Photonics PPP Project Level	Leverage Public money	Public	Leverage Effects of EU Grants/Budgets by the Project PartnersVolume of investments on photonics R&I	yearly	Quantitative	Survey amongst Project Partners
Photonics PPP Project Level	Industry and SME relevance	Public	Participation of Industry & SMEs in PPP projects. - Target: Increase industry participation to 50 % in terms of both participants and funding over the 2012 baseline - Share of SME participation > average of Horizon Europe	yearly	Quantitative	European Commission to report on a yearly basis
Photonics PPP Project Level	Future Growth and Investment perspectives	Public	Project contribution to future Growth - Plans for R+I investments within 3 years to come - Plans for increased employment within 3 years to come	yearly	Quantitative	Survey amongst Project Partners
Photonics PPP Project Level	Success and Impact	Public	Success of Project - reaching target and creating impact on issues	yearly	Qualitative	Sucess Stories / Examples
Photonics PPP Project Level	Visibility	Public	Making the EU Projects and their impact more visible to the broader public	2 in period	Qualitative and Quantitative	PR + Marketing measures
Horizon Europe Programme Level	SMEs	Public	SME participation on Photonics and Photonics related Projects	yearly	Qualitative	Horizon Europe Portfolio Study
Horizon Europe Programme Level	SMEs	Public	Increase Access to Risk Capital / Growth Capital from BA, VCs, EIB	yearly	Quantitative	SegmenSupporting Materials such as Segment Reports, Training Materials, Webinars, Executive Advisors
Horizon Europe Programme Level	Broaden Stakeholder Basis	Public	Ability to attract new Stakeholders and form Partnerships with other PPPs / Institutions	2x in period	Qualitative and Quantitative	Internal Survey and Assessment
Horizon Europe Programme Level	Collaboration with Value Chain Partners	Public	Formalize Photonics PPP collaboration agreements with other Partnerships, programmes or institutions and draft SRIAs in the 6 application oriented work groups	yearly	Qualitative and Quantitative	Internal Survey and Assessment
Horizon Europe Programme Level	Photonics Technology Relevance	Public	Photonics Technology relevant foro Horizon Europe Projects: - # of HE projects for which Photonics is relevant - Photonics Impact on end-user markets	2x in period	Quantitative	Horizon Europe Portfolio Study
Horizon Europe Programme Level	Impact and Sucess	Public	Contribution to Missions and Visions of the Horizon Europe Programm Objectives	tbd	Qualitative	tbd. by EU Commission Strategy Group - Success Stories / Expert Panels / External Evaluators
Horizon Europe Programme Level	Next Generation Skill Sets	Public	Next Generation Skill sets - Education, Training, life long-learning, attracting young people	yearly	Qualitative and Quantitative	tbd. Survey amongst Community /HR representatives from companies / Universities / external evaluators
Photonics PPP Project Level	Inclusion of other DGs / Budgets /Joint calls	Internal Community	Ability to reach out to joint calls / other calls / other programme pillars beyond Photonics PPP	yearly	Quantitative and Qualitative	tbd. by EU Commission Strategy Group - Success Stories / Expert Panels / External Evaluators
Photonics PPP Project Level	internal PPP Performance	Community internal	The PPP Project Performancemonitor progress of the PPP implementation and of its RDI strategy			
Photonics PPP Project Level		Community internal	Time to contract	yearly	Quantitative	Reported by European Commission
Photonics PPP Project Level		Community internal	Levels of response to calls	yearly	Quantitative	Reported by European Commission
Photonics PPP Project Level		Community internal	Progress against technology roadmap timetable	yearly	Qualitative	Reported by European Commission
Photonics PPP Project Level		Community internal	Openess and Transparency	yearly	Qualitative	EU Commission analysis of project partners

Source: Photonics21 Secretariat March 2020

3.6 Resources

Horizon Europe Photonics Partnership - Joint commitment to higher investment and growth

For Europe to live up to its ambitions, strong and courageous commitments from both the private and public sectors is needed. We must learn our lessons from the past, where Europe has often been a pacesetter and early investor in the development of new and breakthrough technologies, but where industrial exploitation has taken place elsewhere. There are many examples where we have partially lost high-tech sectors to competing economies, such as microelectronics or the battery industry. But also within photonics we have seen photovoltaics or LED production move away because they have received massive public industrial subsidies elsewhere in the world. The lesson to be learned is that once the technology and production know-how is gone, it is often gone for good. In the case of a strategically important industry and technology like photonics, this must be prevented in the future to the extent possible.

The European photonics industry stands by Europe and is ready to take up the challenge. With investments of 14-15% of turnover in R&D and capital investment, photonics industry belongs to the most innovative industry sectors in Europe and holds a world leading position. However, the European photonics industry cannot compete on its own, if increasing public investment and subsidies are flowing into the sector elsewhere in the world.

Photonics21 estimates that by 2027 a public and private investment of 6-8 billion Euros will be needed to deliver on a European Photonics Research and Innovation Agenda. The European photonics SME industry is committed to cover the largest part of it and to massively invest in Photonics Research, Development and Pilot Manufacturing in Europe. The Photonics Partnership Research and Innovation Agenda will ensure that Europe works together on the R&I challenges and that the photonics research and innovation pipeline remains filled for the near future, but also for the next decade to come. As Photonic components and systems will increasingly play a crucial role in almost all industries and societal challenges, the Horizon Europe Partnership will team up with these sectors (Horizon Europe partnerships and missions) and ask for co-investment in joint R&I challenges. To do so, “photonics enabled” sector roadmaps will be prepared jointly with the end user sector communities, respectively. Moreover, we will need to link up European, national and regional investments and establish a European-wide network of photonics prototyping and pilot lines and hubs to provide hands-on training and testing for European industries. Thus, coordinated investments by member states (through e.g. EUREKA mechanism) and regions (e.g. starting cross regional photonics piloting networks under the Smart Specialisation Scheme) should be started to complement the European Photonics Partnership activities.

In order to implement the ambitious Roadmap and achieve the objectives and expected impacts we believe that a contribution from Horizon Europe is required that is able to launch a portfolio of 25 research projects per year to develop new photonics technology platforms concepts and ideas (e.g. integrated photonic circuits or embedded micro- and nanophotonic systems). The collaborative projects, in which academics and industry partners work closely together, should be in the range of 2-4 million each, have a duration of 3-4 years and should cover Technology Readiness Levels (TRL) from 2-6. Moreover, 5-7 pilot line, demonstration and prototype projects covering the TRL scale from 5-7 per year need to be kicked off by the Horizon Europe Photonics Partnership to create opportunities for phonics and non-photonic industry to test innovative product ideas and services in real world environments. Examples are a holistic approach to photonic sensor systems and efficient data evaluation for use in the health care sector or in flexible, networked cross-company production chains as well as the use of low latency photonic AR/VR technologies to assist e.g. surgeons or maintenance engineers. Due to

the higher technology readiness levels, these require a higher investment, namely between 12-20 million euros per pilot line or prototyping service project.

For the success of the partnership it will be crucial to find the right balance between developing core technologies and platforms on the one hand and the further tailored development and application of these with respective end-users. We believe that 75% of the partnership projects should focus on core photonics technologies and platforms, whereas the remaining 25% of the projects should focus on the spill-over of these to specific end-user sectors. These "spill-over" projects should be implemented through joint or coordinated calls with the respective areas of Horizon Europe.

Next to these technology focussed actions, the partnership will need to improve the innovation ecosystem for photonics in Europe. Bold actions to train photonics experts at all levels are needed to keep the European competitiveness of the sector. We must overcome our national silos in photonics education and training and regard this as a truly European task by analysing and forecasting European demands and the subsequent training of experts. Also, industry needs to take a more active role in this process and new approaches and partnerships will need to be developed. Looking at the photonics skills shortage present in photonics and end user industry today, it is expected that thousands of additional photonics experts need to be trained during the lifetime of the partnership.

Resources contributed by the private side will be:

1. In-kind contributions to the projects funded by the Union contributions (on the basis of non-reimbursed eligible costs), with lower funding rates for higher TRLs;
2. In-kind contribution for additional activities foreseen in the SRIA not covered by Union funding;
3. Investments in operational activities that are spend beyond the work that is foreseen in the SRIA.

The Photonics industry is committed to leverage every Euro spent by the EU Commission in these Photonics Partnership Research and Innovation project level activities with five Euros from industry.

Finally, action must be taken beyond the Horizon Europe Photonics Partnership to provide the photonics industry with growth capital. As the European Investment Bank has noted, there is a massive market failure in Europe in the financing of innovative photonics companies, both in the start-up phase and in the later scale-up phase. The European Investment Bank is called upon to overcome this market failure and to develop equity and credit products in partnership with investors and banks to help the European photonics industry grow and succeed in the global market.

3.7 Governance of the new Partnership

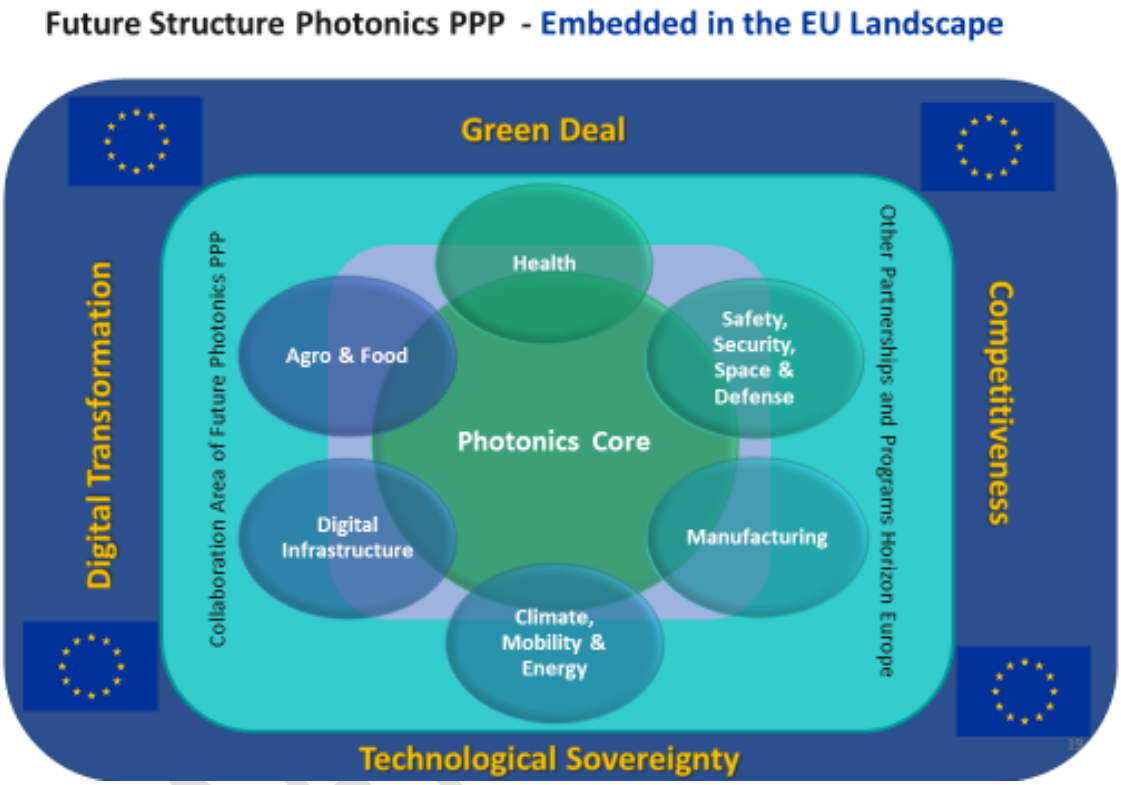
3.7.1 New Structure for Coherence and Synergies

As outlined in chapter 2.4. "Partner Composition and Target groups", the new Photonics Partnership certainly will build in entirely new elements in its organisation and scope.

Those new organisational and governance elements intend to not only secure a better focus on the R&I needs and specifications along the value chain, but also a closer cooperation in Skill Set Development, defining needs for Standards and Regulations, and common look and engagement to ensure Equality and Diversity.

The new structure intends to foster a faster market access of innovations due to targeted developments. It also will put a greater focus on innovations that serve a wider variety of applications and by that enables the use of economies of scale effects of funding Euros.

A major change towards the new Photonics Partnership structure is the set-up of two types of Workgroups with a "Core Photonics Work Group" in the Center and six application oriented work groups in the outer ring – seen as closer to the end-use markets and open for collaborations with new stakeholders from the economic, political and societal value chains.



Graph 9: Future Structure Photonics Partnership
Source: Photonics21 Secretariat – March 2020

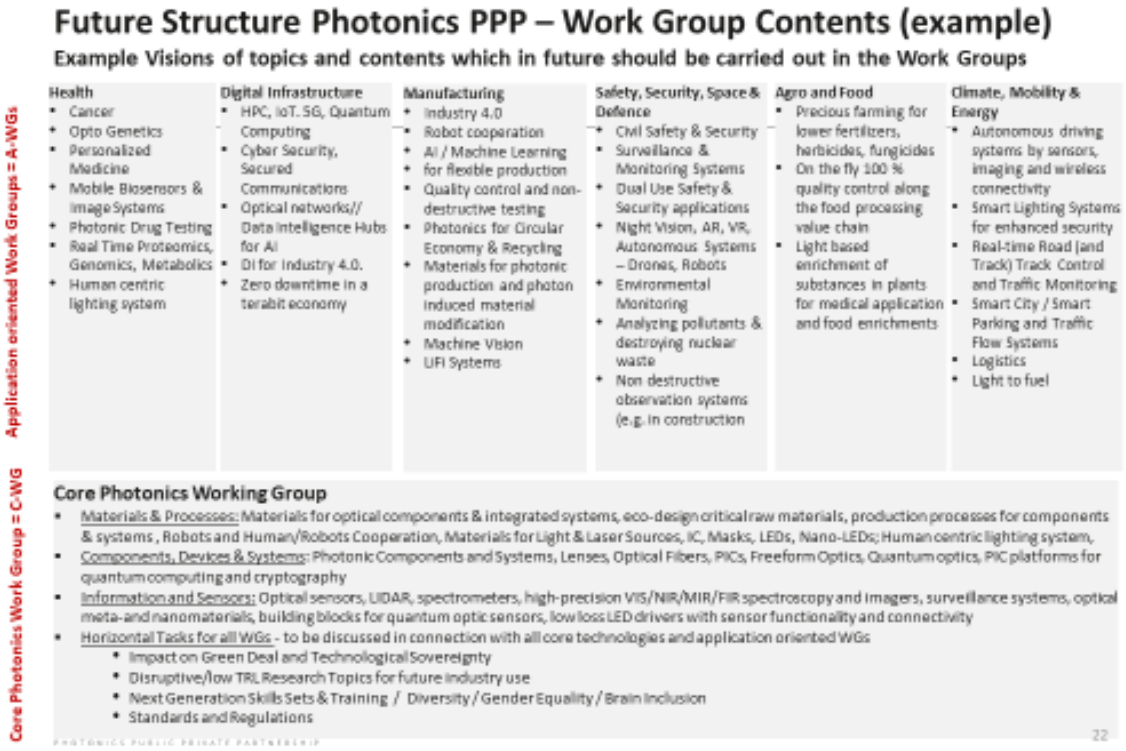
Both Workgroups will clearly have a close interaction and exchange:

The application oriented workgroups (A-WGs) will focus on the concrete today's and future needs and specifications of the industry and society. They will be in close contact with the Photonics Core Platform work group to provide their up- and downstream expertise and needs.

The focus of the Photonics Core work group (C-WG) will be on the further development of photonics components, systems and processes – however to a large extend – but not only - steered by the requirements of the downstream needs being defined in the SRIAs of the A-WGs The future rule that those application needs for photonics core technologies will be in focus, which serve at least two major application areas or a really large market will secure the most efficient usage of public and private money to drive the European economy and society.

Looking into the new structure the Chart below gives an overview which themes and areas will be covered by the A-WGs – and which processes, products and systems are covered in the Core-Group

It is also new that horizontal tasks such as Standards and Regulations, Skill Sets, Impact on Green Deal and Technological Sovereignty and disruptive research are no longer covered in separate workgroups but are integrated tasks in each work group.

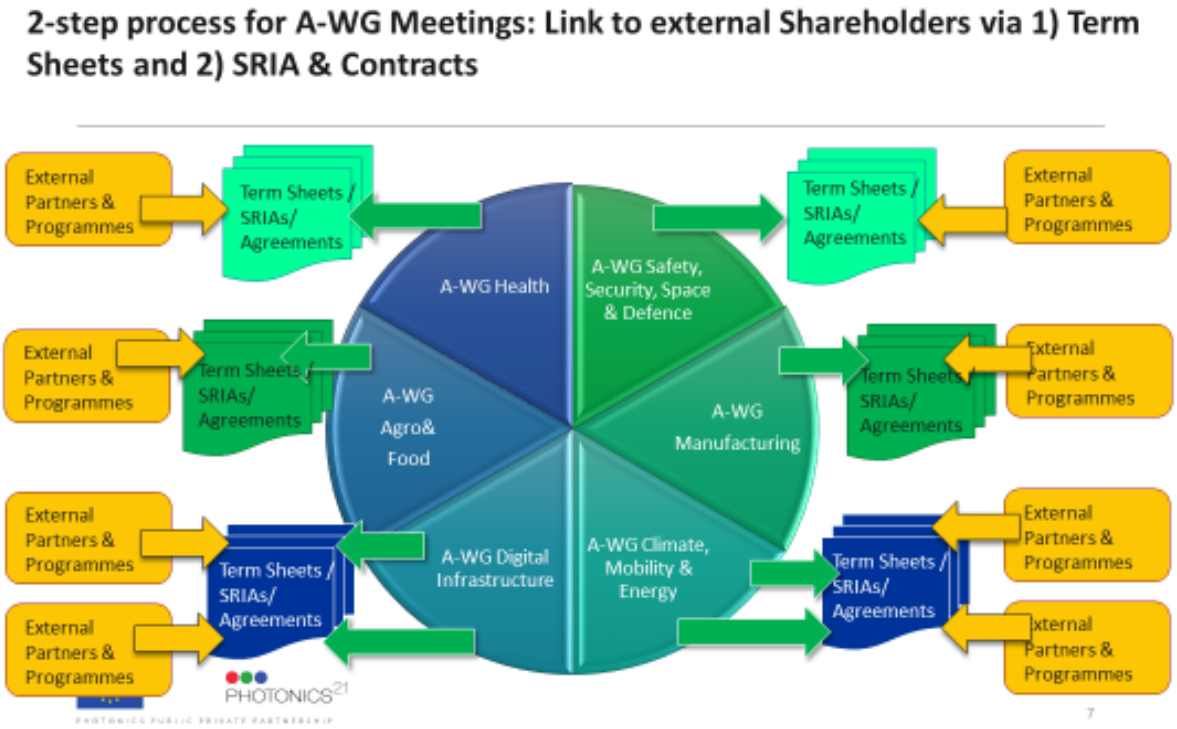


Graph 10: Future Structure of the Photonics Partnership and Work Groups
Source: Photonics21 Secretariat – March 2020

3.7.2 Governance and management of the new structure

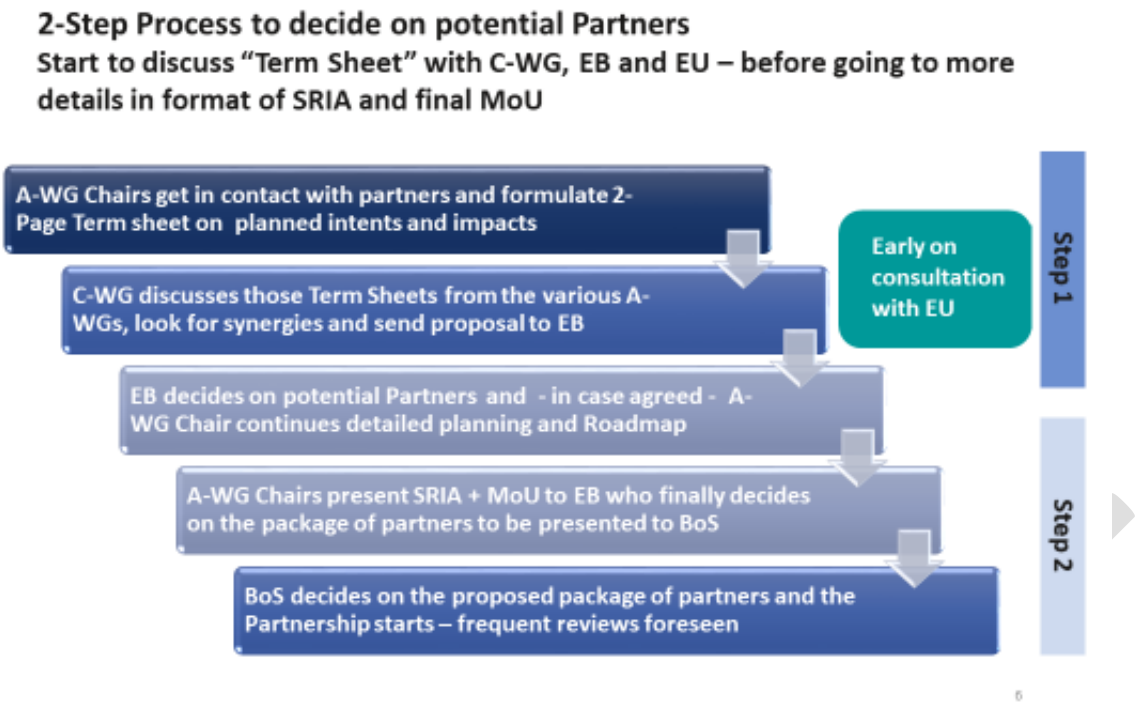
a. A Core Technology Workgroup (C-WG) will be established at the heart of the Photonics Partnership and will consist of the WG Core Chair as well as the WG Chairs from the application areas. This will ensure to have the input from both – the – photonics expertise but also the needs of the application areas represented.
b. To secure a clear priority and impact relevance a basic rule will be that at least 2 application areas – or a major and large market - need to support a Photonics Core priority.
c. Application Workgroups (A-WG) – representing end-user industries and mega markets, missions as well as societal challenges. The Photonic Work group Chairs here will act as a kind of ambassadors for Photonics towards those other partnerships and application areas where close cooperation and co-working is foreseen to contribute to a faster problem solving – e.g. in terms of better climate protection, long-lasting sustainability, increasing prosperity and health. The industry-driven A-WGs will define the research and innovation needs of the specific areas and set the specs for the C-WG in format of a SRIA.

Internally – in the sense of the current Photonics Partnership - this structure will secure an enhanced and better exchange of core photonics technologies, systems and components, which are often slightly biased in the existing workgroups. Externally – meaning towards the current Photonics Partnership – the structure will lay the organisational basis for external alliances and cooperation in an 'embracing' manner.



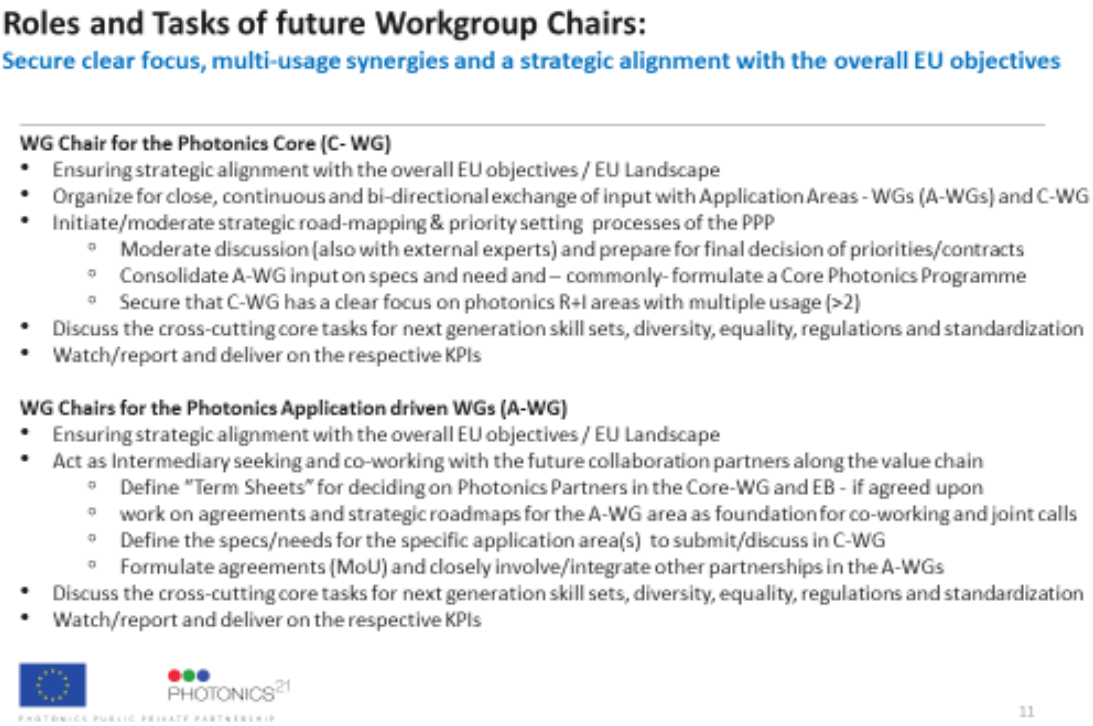
Graph 11a: Collaboration with Partners in the Partnership
Source: Photonics21 Secretariat – March 2020

To define which partnerships will be in the focus of the new Photonics Partnership a 2-step process (see next chart) is foreseen to decide on such collaborations. The A-WG Chairs are asked to discuss a "Term Sheet" with the potential partners which will be subject for decision in the Board. After that the partners will start to finalize a MoU and a common SRIA which defines the content and procedures of the collaboration.



Graph 11b: Collaboration with Partners in the Partnership
Source: Photonics21 Secretariat – March 2020

The future role of the two sets of Work Groups and their chairs is displayed in the chart below. As it can be seen – there is a broad set of common responsibilities reaching from Strategic Alignment with the overall EU objectives to common horizontal tasks.



Graph 12a Overview of Roles and Tasks of Future Workgroup Chairs
Source: Photonics21 Secretariat – March 2020

The core activity of the A-WGs consists of

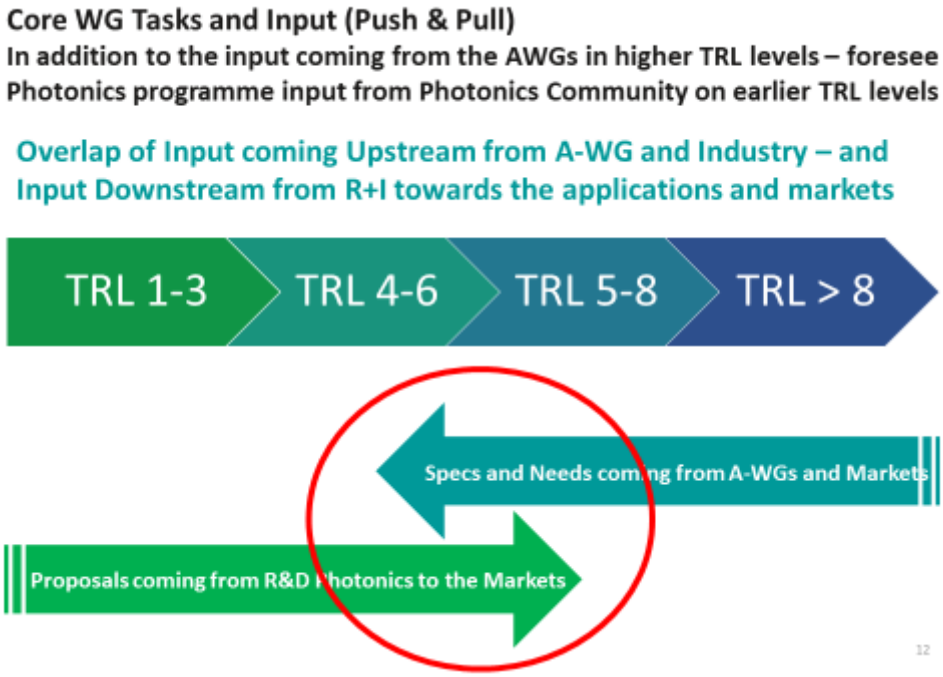
Act as Intermediary seeking and co-working with the future collaboration partners along the value chain

- Define "Term Sheets" for deciding on Photonics Partners in the Core-WG and EB - if agreed upon
- work on agreements and strategic roadmaps for the A-WG area as foundation for co-working and joint calls
- Define the specs/needs for the specific application area(s) to submit/discuss in C-WG
- Formulate agreements (MoU) and closely involve/integrate other partnerships in the A-WGs

The activities of the C-WG are two fold – mainly associated to the stage in the TRL

- Discuss and Consolidate the Input from the A-WG Chairs
- Formulate out of this a Core Photonics Programme
- Foresee – in addition to the input coming from the A-WG Input - also Core Photonics topics in the earlier TRL stage which are not (only) based on the input from A-WGs

It is important to provide necessary room for "Upstream" input from Market and Applications to Photonics Core but also allow "Downstream" Input from R+D topics impacting the Market



Graph 12b: Core WorkgroupTasks – along the Value chain
Source: Photonics21 Secretariat – March 2020

The basic idea of the improved working process is that the Work Group Chairs/Ambassadors of the A-WGs will come together in the "Core" Group to exchange the specifications and needs (defined in the Application-oriented Work Group in close cooperation with Value Chain partners) and seek synergies and cross-application working areas. Only core technologies, materials, systems and devices would be prioritised for funding if they match the needs of > 2 application areas or challenges – or solve a major problem in the priority scale of the EU economy and society. This will support a more rigid priority setting process for the Partnership to create real impact on the European economy and society.

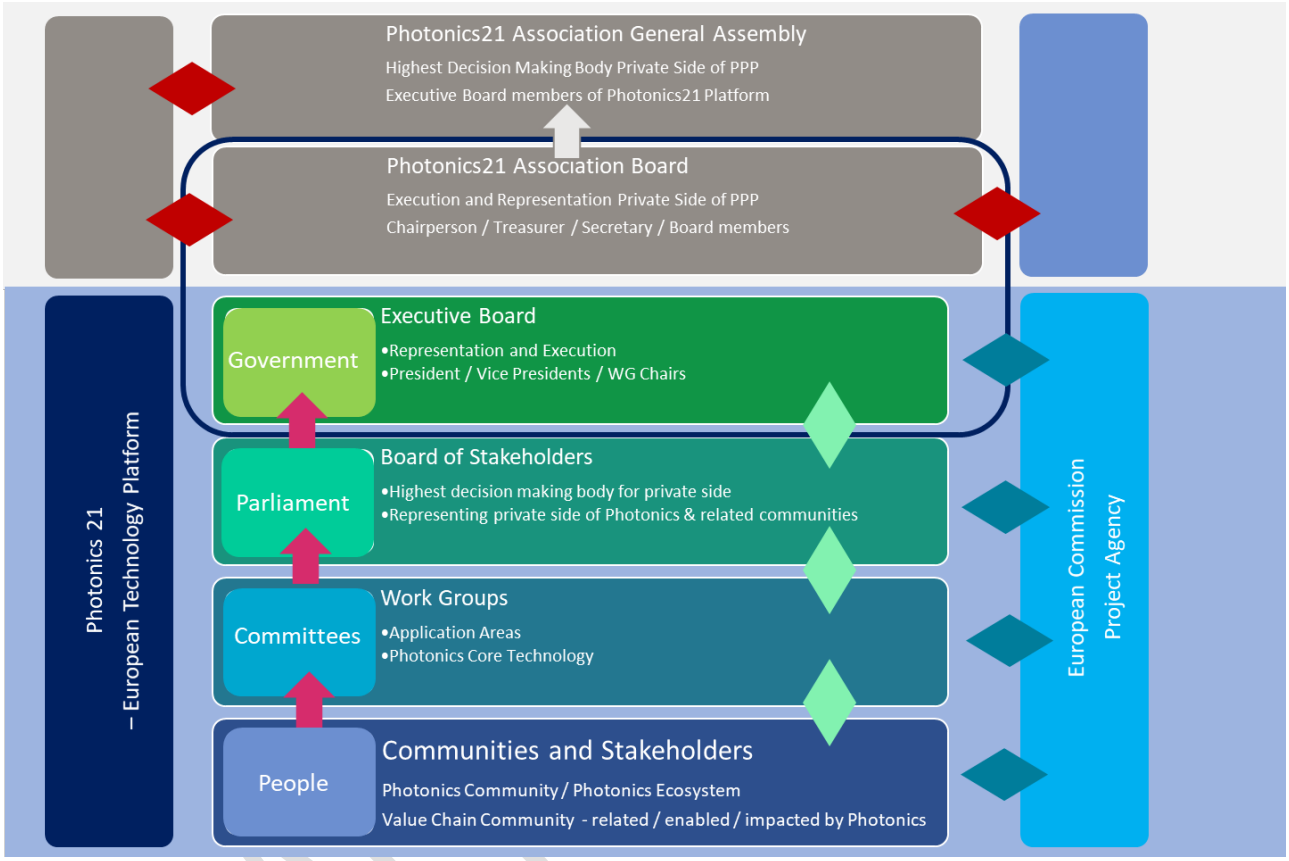
Whereas the core technology area of the photonics partnership is financed exclusively through partnership funding, the application-related topics of the partnership will be carried out through joint funding activities with other Horizon Europe (or other) programme areas. This should significantly increase the speed of innovation and the transition from technology to prototype development in the real environment. For example:

- New types of lasers and optical process control for 3D printing applications will be developed to the component or photonics systems level in the Core Technology part of the partnership (reflecting already key requirements of end-user stakeholders) whereas the system or production line integration will be jointly conducted with the "Made in Europe" partnership.
- New sensors will be developed that allow a much faster analysis of cancer cells in the blood (reflecting already key requirements of medical doctors and clinicians). Testing and integration into the clinical environment will be done jointly with the Mission on "Cancer".
- Silicon photonics was very successfully developed by the photonics stakeholders in Europe up to small scale production. In future, it may be further explored jointly with the KDT (Microelectronics) partnership to prepare for high volume manufacturing.

3.7.3 Managing the Platform

The graph below demonstrated the working principle and the deep bond of the European Technology Platform Photonics and the Photonics Partnership. Since this will last in the new organisations there will be an add-on of new stakeholders.

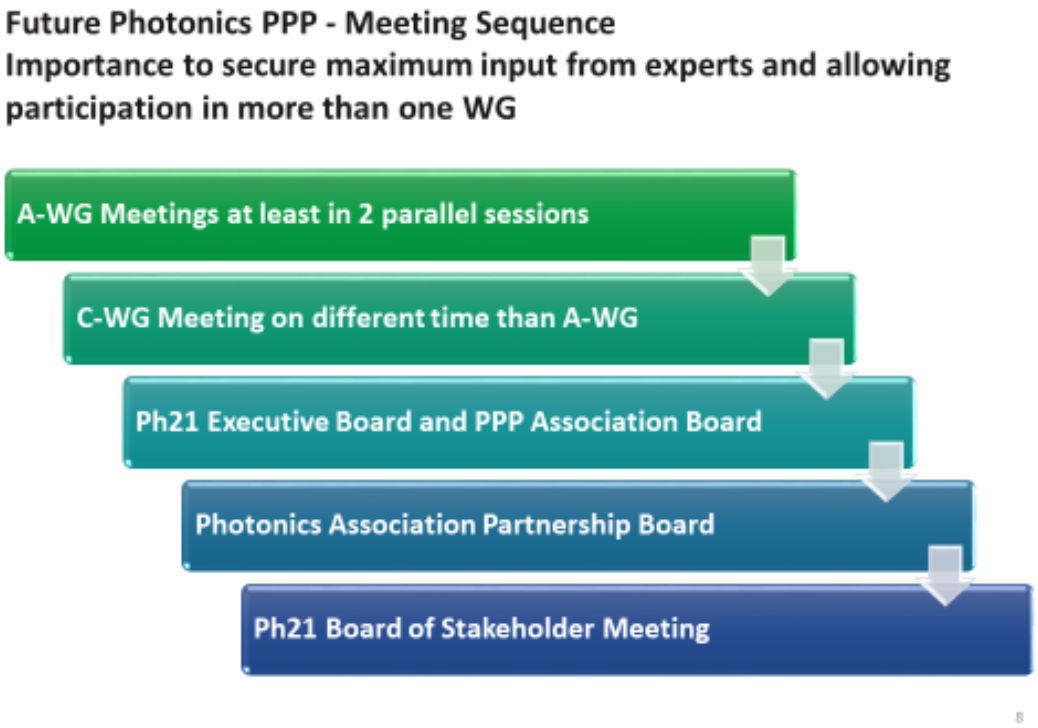
Principle Governance Structure of the Photonics Partnership



Graph 13: Principle Governance Structure of the Photonics Partnership
Source: Photonics21 Secretariat – March 2020

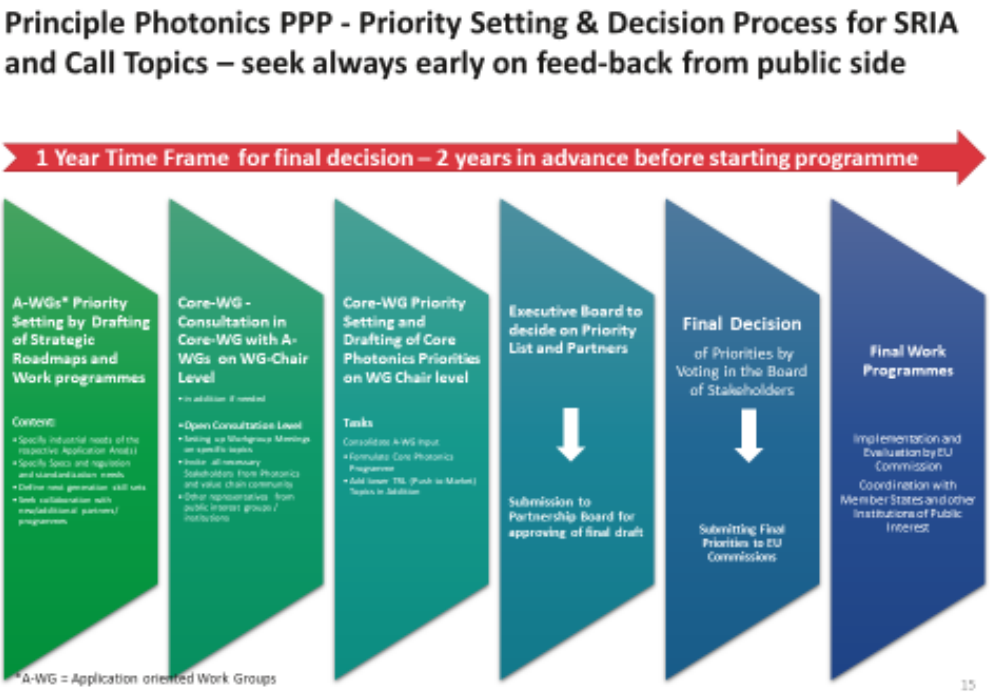
The involvement of external partners in the priority setting is currently under development. The model foresees the input in form of a MoU and a Strategic Roadmap, which defines the tasks, the specs and requirements on Photonics Core Technology development and the associated necessary steps.

The new set-up requires an adaption in the sequence of meetings and decision making to secure a bi-lateral flow of information and opens up the possibility for attending more than one workgroup - a request by many during the survey conducted among BoS members.



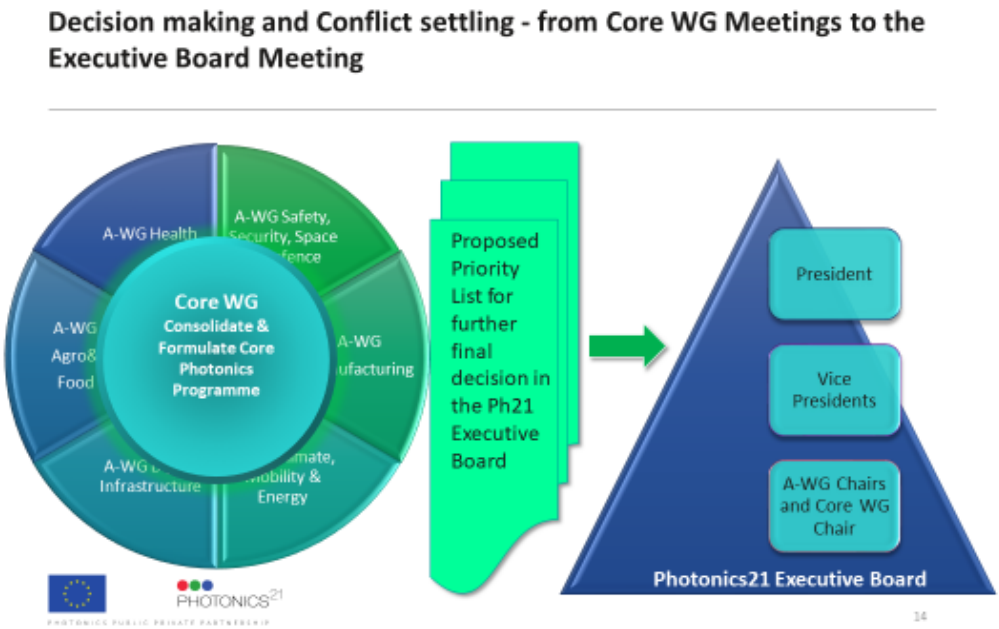
Graph 14: Timing and Sequence of Workgroup Meetings
Source: Photonics21 Secretariat – March 2020

A slight adaption of the proven and already transparent and open decision making processes for Strategic Roadmap(s), Vision Papers and Work Programmes is also foreseen. The one flow chart below demonstrates how this could be organised as an example vision for the priority setting process.



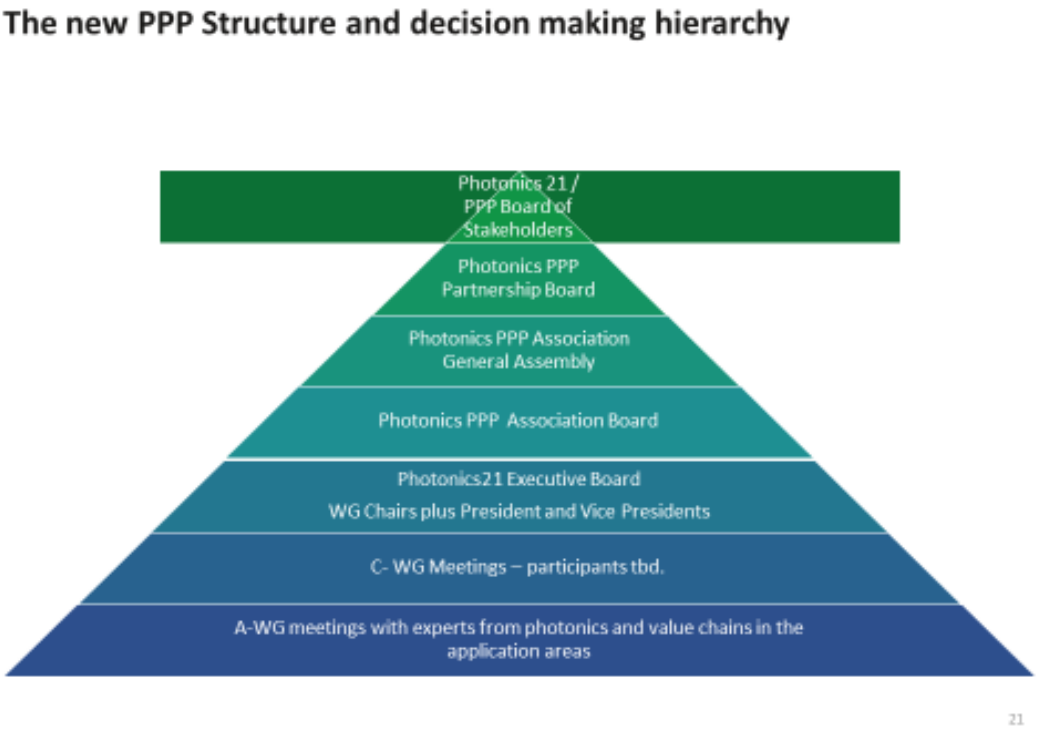
Graph 15a: Priority Setting and Decision Process within the Photonics Partnership
Source: Photonics21 Secretariat – March 2020

The other chart below demonstrated the role of the Executive Board in the decision making process and the conflict settling



Graph 15b: Priority Setting and Decision Process within the Photonics Partnership
Source: Photonics21 Secretariat – March 2020

More generic, the below 'bottom-up' chart shows the involvement of the private and public stakeholders in the decision process.



Graph 16: Decision Making Hierarchy within the next Photonics Partnership
Source: Photonics21 Secretariat – March 2020

3.7.4 Involvement of the Commission and the EU public interest

As shown in the chart above on Governance Structure, the EU Commission is intrinsically involved in all processes – as an expert in the workgroup meetings, as guests and presenters on the Board of Stakeholders, as a public partner in the Partnership Board of the Photonics Partnership and also as an convenor to various EU Commission events from ICT proposer days to Consultations or Innovation Conferences.

For the daily work, frequent and close cooperation on operational tasks exist with the Photonics Unit with weekly update calls, common briefing sessions in the PR sector, exchange and common participation at important events in the EU scene, exchange of data and surveys where applicable, and publicly feasible (as well as common efforts) for measuring KPIs of Photonics projects.

The future involvement with the EU Commission and its executive agency managing the projects of the partnership will need to be extended to cover a greater remit than our current photonics area but also mirror the efforts of the EU Commission for Horizon Europe in cross-DG collaboration, priority setting and funding within earmarked partnership budgets as well as the ~ 50 % unassigned budgets.

Closer cooperation is required to match the policy and mission-driven EU objectives for a Green Deal, Digital Transformation and Technological Sovereignty. To achieve these targets,

closer cooperation on the private side is required as well as collaboration on the public side and the private-public exchange of ideas on how to fulfil the targets for climate neutrality, circular economies, and take leading role in AI and Digitisation in a smart and efficient way

As we have recently seen in the new "A new Industrial Strategy for Europe", Photonics is one of the key enabling technologies that play a role in multiple applications and products that make up this industrial scenario. However, photonics also needs the support and the consideration from those value chains partners in politics and industry to be able to realise its potential as a technology and receive consideration against former or other mature technologies.

3.8 Openness and transparency of the platform and processes

The openness and transparency of the new Photonics Partnership have built on the existing open and transparent structure of the Photonics21 Platform since its foundation. It was and will continue to be a Key Performance Indicator for all Workgroup Chairs.

As described in the earlier chapter on Resources and Governance, the Photonics21 EU technology platform is an open and voluntary platform where all interested people can subscribe to become a member – without any fees to be paid. All members can also subscribe to workgroups indicating their interest and will be invited to join the Workgroup Sessions, giving their input into future priority setting in funding.

Apart from Science and Research, it is also open for associations, governmental and non-governmental organisations, investors, EU institutions, member state representatives and regional organisations.

This inherently open structure will become even more accessible now as new stakeholders – mainly focussed on the downstream value chain partners – can join in the workgroup sessions and act as experts. Here, they would act and be treated in the same way as the current photonics members. All interested partners would be invited to join their experts in the respective A-WGs meetings. This can be done by becoming a "fee-free" Photonics21 member and tick the workgroup boxes, or by becoming an organised 'information flow' via the other partner organisations.

The workgroup members (including the new stakeholders) will be also included in the priority setting process and the feedback loop (see also chart in sector 3.3. Photonics Partnership – Priority Setting and Decision Structure).

Regarding collaboration with member states, regions and clusters a broad photonics ecosystem exists where we continuously exchange with other national platforms, clusters, regional initiatives, digital innovation hubs, pilot lines, CSAs and other initiatives, for example start-ups, and venture forums.

However, as mentioned in Chapter 2.4., the existing photonics-centric Ecosystem needs to be extended where necessary by partner organisations. EU-wide Digital Innovation Hubs as a "one-stop shop" for companies and researchers to access the various deep technologies will be a good accelerator to raise the information flow also in a more decentralised manner. Photonics is already supporting the development of these Digital Innovation Hubs and will focus more here in the future.

Regarding active recruitment policies it was already described in chapter 2.4 that we have started to include experts from the value chain in our workflow (for example the Vision Paper),

invited industrial experts in workgroup sessions and were running end-user workshops in the various countries.

Moreover, we were already seeking and pursuing close contacts with other relevant partnerships and institutions and will actively approach them for signing in on collaborations. For this process, we also actively pursue our memberships in networking platforms such as Knowledge4Innovation and Science Business. There, we not only raise the visibility of Photonics by attending discussions, workshops and conferences, we also actively take opportunities to meet with other partners and institutions and work together on horizontal and common topics (for example the Pact of Innovation with K4I – or the White Paper "12 milestones for Horizon Europe" by Science Business).

For financing innovation, supporting the industry (especially the SMEs for getting access to risk capital), we continue and re-iterate the collaboration with the EIB and intend to work closely with the newly-installed EIC in the future. We will also continue our efforts to make contact with (and stay in contact with) the hard-ware interested investors and VCs in the various countries via our CSA project.

Finally and on an increasing manner – we intensified the PR activities towards the end-user media as well as to the more economic and political driven Business and Brussels Media.

For the latter we have recently joined a Media Partnership with EurActive which gives us access also to other Business Media via their Media-Network. It also acts as an excellent channel for submitting our media releases, as also is done by the Science Business News sector and the frequent K4I Newsletter. All these channels reach out to other partners, to institutions, to value-chain partners, to new stakeholders and to end-user markets.

Running our own Website as a "Platform Concept" for all of our interested partners in the Ecosystem – onto which everyone can submit their events and relevant news, is another instrument. However, in the new structure we will need to broaden the approach to become inclusive also for our partners by setting clear links and sharing news, common position papers and strategic papers. In turn, we also need to make sure that those chosen partners promote Photonics and act as channels for our messages.

3.9 Lessons learnt from Horizon 2020: New paths for a Partnership under Horizon Europe

The new European Partnership on Photonics will build upon the experiences collected during the recent years of activities by taking the new strategies and policies of the new Commission into account. The obvious strengths of the Photonics Partnership will be retained and further boosted, however, some weaknesses or shortcomings on the private and public side as well as in the collaboration between Partnerships need to be improved and overcome when designing and implementing the new partnership.

The obvious strengths of the Photonics Partnership will be retained and further boosted – however, some weaknesses or shortcomings should be improved and overcome when designing and implementing the new partnership.

3.9.1 Achieving KPIs and measure impact

The Photonics Partnership has led to measurable, positive impacts on competitiveness, wealth, innovation and societal well-being. The Horizon 2020 mid-term report, as well as our yearly activity and monitoring reports and associated studies and surveys, underline that the efforts made to improve competitiveness and innovativeness of the photonics industry as well to

develop photonics-based solutions for some major socio-economic challenges have paid off. The vast majority of the objectives of the Photonics cPPP under Horizon 2020 – as measured by the Key Performance Indicators defined during the course of Horizon 2020 – were achieved.

Beyond these quantitative measurable impacts, the creation of a Photonics Partnership under Horizon 2020 has had many significant (albeit not quantifiable) positive effects. From a qualitative point of view, the Photonics Partnership has led to

- an even more close cooperation with the EC in defining and implementing the work programmes derived from the strategic roadmaps and vision papers, as well as translating those in yearly calls for funding, focusing on the needs and challenges faced by end-user industries and the large amount of SMEs.
- an increase of the image/perception of Photonics in the photonics community as well as downstream – being a Partnership of Europe (as well as being nominated as a KET) helped a lot to increase the member base and attract people to join the Partnership workshops and end-user days:
    - Photonics21 membership stands now at 3000 members – increasing from a starting point of 60 in 2005 to about 1500 when the Horizon 2020 programme started.
    - On average 400-600 interested people signed up for the Workgroups and Work areas – and also provide their input for the roadmap and the bi-yearly work programmes.
- The Partnership contributed to attracting many end-users to join the workshops in the countries as well as in the expert groups when discussing the vision paper in 2017. Turning from a pure technology insight to a "user" perspective and a "mission accomplished view" attracted many people, also worked exactly in the direction of a more jointly, and by that more focused development of R + I priorities.
- Other contractual Partnerships – i.e. potential partners for taking a common approach to tomorrow's challenges – have demonstrated a growing interest in the work carried out by the Photonics Partnership / Ph21 and, the other way round, Ph21/Photonics Partnership was invited for collaboration and synergy checking events with other Partnerships.
- Being a Partnership of the EC opened doors in the contact with member governmental representatives in the member states and the regions and also supported clusters and national platforms when approaching ministries, permanent representations, MEPs in Europe or Parliamentarians in member states, countries and cities.
- The European Photonics Partnership has contributed to a better linkage of national and pan-European efforts as well as to an increase in the visibility of European activities at global level, leading for instance to invitations to join global meetings on market research in photonics and to discuss, on a global level, the issue of raising the visibility of Photonics as key technology.

3.9.2 Improvement requirements in the new Photonics Partnership

Looking back over the last four years and the experience of the Photonics Partnership, there are certainly some areas requiring optimisation – both from the private side of the Partnership as well as the EC.

A major improvement area on the private side concerns the new structure (see chapters 2.4 Partners, 3.2 and, 3.3, on Governance and Resources) and even more open processes.

Other improvement areas relate to the public side and the successful implementation of the new strategies supported by the new and improved instruments in cross-cutting collaboration

on the private and public side in providing access to Risk Capital and in measuring the impact by setting KPIs.

Access to Risk Capital

- Designing appropriate financing mechanisms for start-ups and medium-sized companies. The EIB pursued many efforts and was also very supportive to help to figure out how Photonics SMEs could gain from the Juncker Plan and the associated instruments. However, experience shows that most of the instruments were not adapted to the Photonics21 community: Photonics SMEs often sought support in the range of 1-5 million whereas the EIB offered instruments > 20 or even 50 million.
- Allowing real risk sharing – meaning also failures, which is not in the mentality and statutes of the EU Banks – the DGs were asked to finance the risks of failures….which finally has not led to a result.
- Better support new enterprises beyond the start-up status, since many Photonics SMEs and Entrepreneurs – as seen at other deep technology enterprises also according to the EIB/InnovFin Report Access to Finance for KETs – Brussels, March 2016) – lack sufficient and risk capital to grow or grow fast enough.

Cross-Cutting Collaborations

- Promoting cross-cutting collaborations – across DGs, other partnerships, programs, with member states, clusters, regions or downstream along the value chain and downstream in terms of TRL. There was a clear understanding in Horizon 2020 that collaboration could increase the impact and the time and cost efficiency from the innovative idea to the market. However, the current set of programs and instruments did not allow for implementation in such ways.
- Promoting "common calls" with other DGs and other partnerships – requiring that, at least to some extent, some kind of budget sharing between DGs / Partnerships.
- Finding ways to further smoothly accompany a Partnership project either in regions/clusters or downstream the value chain to build a demonstrator or pilot (for instance beyond TRL 7 or 8) without increasing the admin burden.

Another area of improvement lays in the formulation and measuring of future KPIs:

- KPIs should be clearly defined from the beginning of the partnership to ensure correct reporting by all project partners.
- For comparability and to make the best use of resources – as well as to ensure acceptance by all the partners - a set of common KPIs – relevant to all partnerships – should be also defined from the beginning and laid down in the project contracts to increase support by all project participants.
- Some problems occurred under Horizon 2020 when monitoring the KPIs related to practical aspects, requiring some re-thinking for the next Framework Programme – for instance: when referring to a timeline which is too short to measure any impact (for example most Partnerships were in an area where it usually takes about 7-10 years from the idea to the innovation) or when reporting dates did not match with reporting dates of enterprises, respectively the publishing of statistical data by ECFIN.
- Further concerns dealt with the inadequacy of some KPIs, requiring confidential information from the industry, which – by definition – could not be collected or leading to potential conflicts with other rules (for example SEC rules of reporting on segments and forbidding Pro-forma segmentation).

- To increase efficiency and make the KPIs a very valuable instrument for comparison and evaluation, it would be of high importance to ensure close cooperation with EC services which have many – not publicly available – funding data. In particular, strong support may be required coming from ECFIN when collecting data to measure macroeconomic impacts.

In total the public and the private side need to be commonly define where qualitative and where quantitative KPIs (see table 5 under §3.5) are applied to measure impact and success of the funding in the partnerships.

3.10 Implementing the Partnership: Co-Working with the EU Commission

As in the overall structure, the co-working with the EU Commission will build on the successful co-operation structures and proven processes of the past. However, as in the Governance Structure for the Private Side there will be a need for adaption to the new challenges and tasks.

These new challenges and tasks are mainly due to the new Objectives and Instruments and Pillars and the composition of the Horizon Europe Budget Structure (mainly) in pillar 2, which will assign much less earmarked money to the Partnerships than was the case in Horizon Europe. It is also driven by the fact that the new decision-making structure in the EU Commission where (and to which extent) to spend taxpayers money for Innovation will be completed in a "co-working area" and cooperation process across DGs (and also includes more DGs than we have experienced in the former H2020 programme). Therefore, not only should the private side enlarge and enhance their Stakeholders and Partners and cross-cutting collaboration efforts – but the Public side should also follow suit.

Consequently any future governance process on, and among, both sides will require new structures of collaboration, both in the preparation and the implementation phases and in the daily operational processes for work programmes and calls.

In the future, the photonics industry will seek even stronger cooperation with the EU Commission DGs to successfully bring photonics-related research and innovation topics into the other part of the budget outside the earmarked budget for the partnerships. Essentially, the meaning of cross-cutting (either jointly and/or collaboratively organised) coordinated calls between the clusters of Pillar II – but also beyond the pillar II (e.g. with EIC or the Defence programme) - will be a cornerstone of successfully implementing the Horizon Europe objective to increase the impact (and also the speed-to-market) to make the visions and missions of the new EU Commission for successful green and digital transformations and enhanced sovereignty in the global competition become a reality.

These co-working and joint approaches to funding schemes will be highly important on many levels. They will be important on the "pathfinding" side (seeking and consulting the right partners), during the implementation phase of setting up common Visions, Missions, Road Maps and Budgets, and throughout the "Measuring Phase" of controlling progress and impact of the partnerships and funding spent.

4 Annex: Links to important documents:

1) Multiannual Strategic Roadmaps:

"Europe's age of light! – How photonics will power growth and innovation" – Strategic Roadmap 2021–2027

https://www.photonics21.org/download/ppp-services/photonics-downloads/Europes-age-of-light-Photonics-Roadmap-C1.pdf

2) Photonics Vision Paper

https://www.photonics21.org/download/ppp-services/photonics-downloads/Photonics21-Vision-Paper-Final.pdf

3) Study Photonics - Light key for sustainable environment

https://www.photonics21.org/download/ppp-services/photonics-downloads/Study_GreenPhotonics_2020_final.pdf

4) And in general Download Sector of Photonics21 Website:

https://www.photonics21.org/ppp-services/photonics-downloads.php