Photonics – a critical Key Enabling Technology for Europe

Role and impact of Photonics in H2020

Report

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

Tematys
Exploration of photonics markets

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December 2017

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Photonics21 Secretariat:
VDI Technologiezentrum GmbH
VDI-Platz 1
40468 Düsseldorf, Germany

Phone: +49 / 211 / 6214-401
Fax: +49 / 211 / 6214-159
e-mail: secretariat@photonics21.org

Website: www.photonics21.org
Twitter: https://twitter.com/Photonics21
LinkedIn: www.linkedin.com/company/Photonics21

Data Analysis and Statistical Evaluation:
Tematys, Benoît d'Humières
6, cité de Trévise – F75009 PARIS, France
www.tematys.com

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Sam Young, Head of content and media, Matter PR
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Contents

1 Executive summary

The study was commissioned by VDI Technologiezentrum GmbH (VDI TZ GmbH) – the elected secretariat of the European Technology Platform (ETP) Photonics21 – as one of the actions promoted by Photonics21 to support the preparation of the next European Research & Innovation Framework Programme (FP9). In order to provide the basis for a well-informed discussion and decision-making process, the study assessed the role and contribution of Photonics in past and present H2020 projects.

The study was performed by the company TEMATYS from August to December 2017 and was mainly based on European Commission's open online data (EU Open data Portal). First the methodology included the screening, intelligent reading and analysis of the H2020 projects according to a previously defined set of definitions for "*Photonics related projects*". Second, the selected relevant projects were analysed and clustered along a set of additional criteria related to the value chain position of the developed photonic technology, the photonic function of the developed technology, the criticality of the developed photonic technology in the project as well as the mega-market(s) to be served by the photonic technology developed (application markets).

Out of the 13,643 H2020 projects included in the CORDIS database as of May 2017, 891 *"photonic based projects"* were identified. Furthermore, 122 *"photonic enabler development projects"*, i.e. projects developing technologies that will be critical for the implementation of a Photonic technology, as well as 132 projects for which ***"****Photonics [is] a critical enabler"* were identified. The share of *"Photonics related projects"* in H2020 is therefore about 8.4%. In terms of EC contribution in euros, EC funding for purely "photonic based projects" and for all "photonics related projects" amounts to respectively 6.1% and 7.6% of the total EC funding for H2020 projects. These figures can be put in perspective with the relative share of the Photonics in the European industry in terms of turnover which is around 3.3%. This underlines how much Photonics is a key enabling technology and a particularly research-intensive industry.

In terms of criticality, the photonic development within the photonics related project is the core objective or a critical milestone in more than 80% of the projects.

Photonic related projects can be found in 5 H2020 programmes: in the 3 pillars, "Excellence Science", "Industrial Leadership", "Societal Challenges"; in the "Cross Cutting Activities" and the "Spreading Excellence and Widening Participation" programme. 89.3% of photonic related projects can be found outside the ICT Calls, i.e. calls specifically dedicated to Photonics, revealing the transversal nature of this key enabling technology**.**

The share of Photonics is very high in the "Excellence Science" pillar. 10.4% of European Research Council (ERC) projects are photonic related, with an 8.2% share for the Infrastructure (INFRA) calls and 8.7% for Marie Skłodowska-Curie actions (MSCA). The distribution is as high as 23.3% for Future and Emerging Technologies (FET) projects. As a high-tech hardware industry, Photonics needs intense research to develop innovations. These figures demonstrate the performance of companies and research institutions in very competitive calls like FET OPEN[1].

Looking at the "Industrial Leadership" pillar, as expected, many photonics related projects are funded in the scope of "Information and Communication Technology" (ICT) calls (36.5%), i.e. calls dedicated specifically to Photonics. The share of Photonics in this pillar is also high. As an illustration, Small and Medium size Enterprises (SMEs) have succeeded

89.3%
of photonic related projects can be found outside the ICT Calls, i.e. calls specifically dedicated to Photonics, revealing the transversal nature of this key enabling technology.

8.4%
is the share of *"Photonics related projects"* in H2020.

[1] "EIC FET Open supports the early-stages of the science and technology research and innovation around new ideas towards radically new future technologies. It also funds coordination and support actions for such high-risk forward looking research to prosper in Europe, and FET Innovation Launchpad Actions aiming at turning results from FET-funded projects into genuine societal or economic innovations." Source: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-open, last accessed on 2018/01/15.

At least
50%
of participants of photonics related projects under ICT calls come from the private sector.

better than the average in submitting SME Instrument (SME-INST) projects, especially for the phase 2 calls. Almost 15% of the SME Instrument phase 2 attributed from 2014 to May 2017 were photonic projects. The consistency of the projects submitted by the photonic related SMEs was also recognized: 11.3% of the companies which signed a SME-INST-1 also signed a SME-INST-2, compared to the average 5.6% for all H2020.

What is particularly interesting is at least 50% of participants of photonics related projects under ICT calls come from the private sector. This figure is much higher than the average 37% participation of the private sector in all H2020 photonics related projects. It is likely that this is down to the success of the Photonics PPP for promoting H2020, making it an effective tool for photonic companies which still are very dependent on their research effort.

62%
of all photonics related projects aim to develop "sensing or imaging" equipment.

Taking into account that solutions to "Societal Challenges" might be provided by a variety of technologies from material to computer science, including photonics, the score of photonics in that H2020 pillar might be considered as quite remarkable with 4.6% in project counts. However, given that the photonics industry is still mainly technology-push oriented and not enough market 'pulled', and as integrators of application markets still lack of photonic knowledge, one may assume that there could be scope to increase this percentage in FP9.

Looking at the breakdown of photonics related projects per photonic function, 62% of all photonics related projects aim to develop "sensing or imaging" equipment. The second major function is "transmitting and shaping" (16%) and the third is "processing" (10%). These proportions are in line with the current strengths of the European photonic industry being a global leader in the segments "production technology" (≈50% of the global production share[2]), "measurement and machine vision" (≈35%[2]) as well as "optical components and systems" (≈32%[2]).

The present study demonstrates that *all application markets – covering almost all human activities that use or need "High Tech" – are targeted by a number of photonics related projects*. The volume of support directed to each application market comes from calls dedicated to related topics. For example, SPACE calls from the "Industrial Leadership" pillar will mainly serve the "space and defense" market. But the volume of support comes also from the choice of consortia which will propose to develop photonic equipment in open calls like FET-OPEN or MSCA grants. In other words, these volumes only partially represent priorities decided by the EC and come from the initiative of H2020 participants. "Personalized healthcare" benefits more than any other market as its funding is twice as high as "Industry 4.0", the nearest funded market. The third market targeted by photonic projects is "Smart cities, homes and digital infrastructures".

In terms of funding and participation per country, Germany is leading with almost 600 participations and €357k of funding (almost 20% of the funding of photonic related projects) – followed by the UK, France, Italy, Spain and the Netherlands. This distribution is consistent, compared to the weight of each national photonic industry. There is a strong correlation between the number of participations per country and the funds allocated. In short, the average funding per participant is very close for almost every country, around €520k.

[2] Source: European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH, Photonics21 Secretariat (2017): Market Research Study, Photonics 2017, Brüssel / Düsseldorf / Tägerwilen, May 2017.

Main lessons learned from this study:

Photonics related projects can be found in almost all H2020 programmes. They cover all high relevance application markets for tomorrow's society and economy. Photonics as Key Enabling Technology for providing solutions to tomorrow's major societal challenges is of the utmost importance.

Photonics related projects are very well represented in the "Excellent Science" and "Industrial Leadership" pillars. More than **9%** of the projects are photonics related. Despite its high relevance for coping with major socio-economic challenges of the future, the importance of photonics is not reflected in the H2020 pillar "Societal Challenges" (only **4.6%** of photonics related within the pillar compared to the average for all programmes of **8.39%**) – demonstrating the huge potential to be exploited in the future and, especially to be taken in to account in FP9.

European photonics companies are strongly committed to research and innovation, and Horizon 2020 private sector participation in the photonics segment ranks well above average. The participation of photonics companies in H2020 projects is higher than in other segments: **37%** versus **33.2%** on average. One reason for this high proportion of companies may be found in the 'bottom-up' approach of Photonics21 combined with the relevance of the calls proposed to the EC though the Photonics PPP.

At least **50%** photonics related projects under ICT calls come from the private sector. This figure is much higher than the average **37%** participation of the private sector in all H2020 photonics related projects.

Photonic Small and Medium size Enterprises (SMEs) have had a higher than average success rate in submitting 'SME Instrument' (SME-INT) projects, especially for the phase 2 calls. Nearly **15%** of the projects which were funded under both phases 1 and 2 from 2014 to May 2017 were photonic projects. The consistency of the projects submitted by the photonic related SMEs was also recognized as **11.35%** of the companies which signed a SME-INST-1 also signed a SME-INST-2, compared to the average **5.57%** for all H2020.

2 List of acronyms

CC:	Cross-cutting Activities
EEB:	Energy-Efficient Buildings
ERC:	European Research Council
ES:	Excellence Science
ETP:	European Technology Platform
FET:	Future and Emerging Technologies
FOF:	Factory of the Future
H2020:	Horizon 2020, 8th European Research and Innovation programme
ICT:	Information and Communication Technologies
IL:	Industrial Leadership
IOT:	Internet of Things
INFRA:	Infrastructure
KET:	Key Enabling Technology
MSCA:	Marie Skłodowska-Curie actions
NMBP:	Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing
PPP:	Private-Public Partnership
SME:	Small and Medium-sized Enterprises
SMEINST:	SME Instrument
SPIRE:	Sustainable Process Industry through Resource and Energy Efficiency
SC:	Societal Challenge

3 Context and objective of the study

The study was commissioned by VDI Technologiezentrum GmbH (VDI TZ GmbH) which has served as the elected secretariat of the European Technology Platform (ETP) Photonics21 since its establishment in 2005.

Photonics21 and Photonics Public Private Partnership (PPP)

Photonics21 was launched with the aim of bringing together, stakeholders from industry, academia and policy in the field of photonics for the very first time. Since its establishment, the platform has grown continuously and today includes around 1700 organizations with more than 3000 members. The members are experts in the photonics industry, research organisations and universities and are actively engaged to develop a joint photonics strategy for future research and innovation in Europe. Within the Photonics21 membership, roughly 40% of the affiliations are companies – nearly the best possible share of companies in an innovation platform. The Photonics21 Board of Stakeholders (BoS) – the decision-making body of the Platform Photonics21 – consists of 100 representatives from leading photonics organizations in Europe – half of which come from industry. Therefore, the structure of Photonics21 provides the best possible conditions to ensure an optimal balance between research and innovation promoting activities.[3]

Formally established in 2005, the platform has come a long way since its inception by helping to develop and implement a joint photonics strategy for Europe. Perhaps the most significant step along its lifetime came in 2013 when Photonics21 and the European Commission joined forces to create growth and jobs, leading to the creation of a Private-Public Partnership (PPP) for European Photonics. The aims of the PPP were, and still are today, to:

- "Foster photonics manufacturing, job and wealth creation in Europe through a long term investment commitment by both industry and the European Commission;
- Accelerate Europe's innovation process and time to market by addressing the full innovation and value chain in a number of market sectors where European photonics industry is particularly strong (e.g. lighting, medical photonics, and optical components & systems);
- Mobilize pool and leverage public and private resources to provide successful solutions for some of the major Societal Challenge facing Europe, in particular in healthcare & well-being, and energy efficiency."[4]

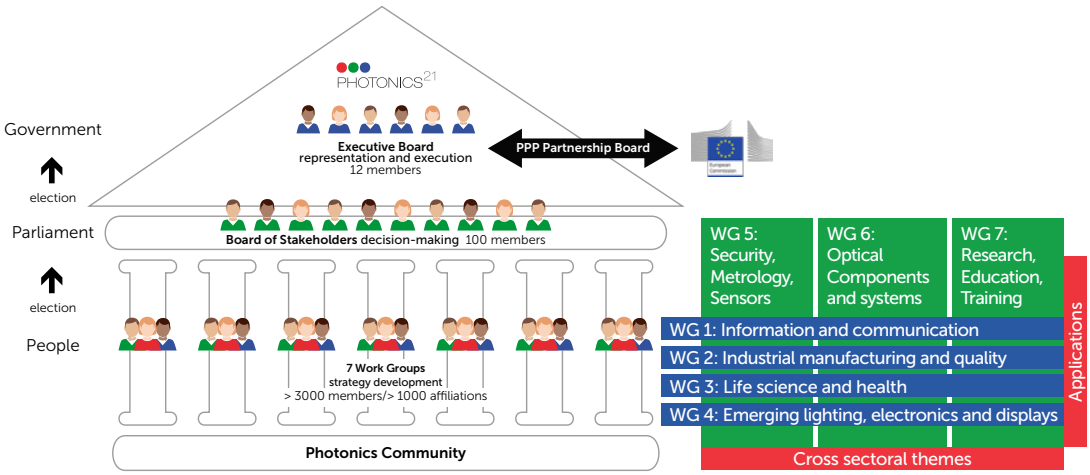
The "Photonics 21 Association", a legal entity under Belgium law, became the private contract partner in November 2013 in a Public Private Partnership (PPP) in conjunction with the EU Commission. This so called "contractual PPP" has clear targets and Key Performance Indicators related to the macroeconomic progress, the creation of leadership positions in the economic ecosystem and the generation of jobs and new markets. Supporting Small and Medium-sized Enterprises (SMEs), as well as entrepreneurs, lies in the heart of the efforts of the EU in this Innovation support programme.

The PPP is the basis for a common Research and Innovation strategy and more broadly for an industrial strategy in photonics for Europe. On a regular basis, stakeholders from industry, the science community and policy come together in workshops, as well as on PPP Annual Meetings to develop future research priorities in photonics.

[3] 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.

[4] European Technology Platform Photonics21 (2013): A Photonics Private Public Partnership in Horizon2020, Brussels, Available under: www.photonics21.org/download/Photonics21_Association/A_Photonics_Private_Public_Partnership_Photonics_PPP_proposal_final-final.pdf, last accessed on 2017/03/16. p.18.

Figure n°1: Governance structure and decision making process of the Photonics PPP.
Source: VDI TZ GmbH.



The way towards the next European Research & Innovation Framework Programme 9

At the halfway point through 8th European Research & Innovation Framework programme Horizon 2020 the European decision making bodies were already starting to prepare for the following framework programme FP 9, a research and innovation framework programme intended to follow the Horizon 2020 from 2021 onwards for a period of 7 years. Photonics21 aims to support the preparation of the next European Research & Innovation Framework Programme (FP9) by providing the basis for a well-informed discussion and decision-making process.

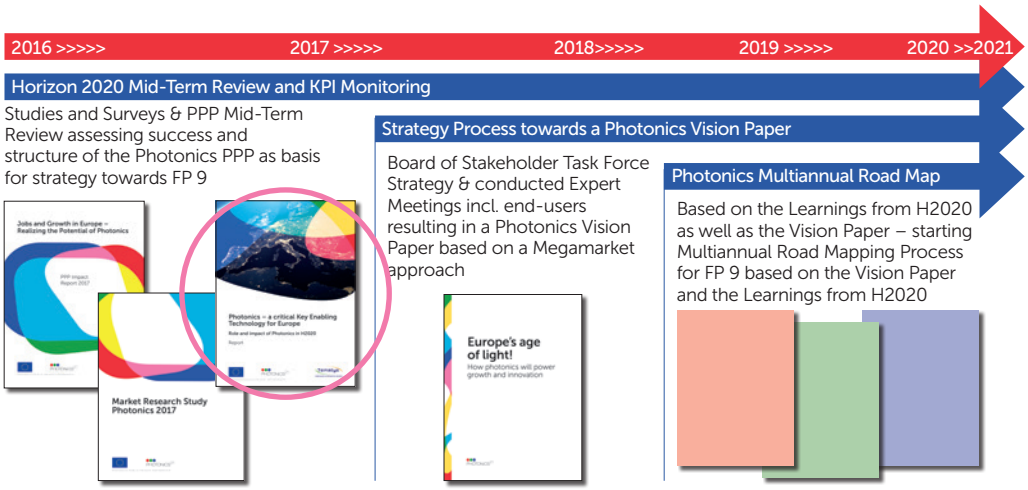
As part of this endeavour, the role and contribution of Photonics in past and current H2020 projects will be assessed. In particular, the issue should be examined whether, in Horizon 2020 (and not only in H2020 Photonics PPP Projects), Photonics plays the role of an enabling technology for new and innovative products, services and developments in areas far beyond obvious lighting application fields.

There were two main aims of the study:

- analyse and highlight Photonic-based projects across all pillars of H2020
- cluster Photonic-based H2020 projects along the thematic areas currently prepared by Photonics21 in preparation of FP9.

The study was performed by the company TEMATYS from August to December 2017.

Figure n°2: Towards FP 9 – Photonics PPP Actions and Input Papers for Assessments.
Source: VDI TZ GmbH.



4 Methodology

4.1 Definitions

4.1.1 A very clear definition of "Photonics"

For this study, the following precise definition of Photonics was adopted:

"Photonics": Photonics includes the sciences and techniques that generate, emit, detect, collect, transmit, modulate, amplify photon beams, from the terahertz band (min: 200 Gigahertz) to X-rays.

In addition, in order to stick with the perimeter of Photonics used Photonics21 by and the European Commission in H2020, Photovoltaic related projects were excluded from the selection.

4.1.2 What is a "Photonic based project"?

For searching and screening "Photonic projects", a very precise definition was needed. The following was used:

A "Photonic based project" is a project targeting the development of photonics core technologies as well as the development of whole products and systems based on photonic components. (Solid State Photovoltaic is excluded).

During the screening phase, we realized that a certain number of projects are not strictly "photonic based". Some are dealing with technologies that are critical for the implementation of a Photonics like a data processing algorithm for spectroscopy or a dye for fluorescence imaging. That is why we proposed to consider also:

"Photonic enabler development projects", namely those projects that develop technologies that will be critical for the implementation of a Photonic technology.

Last but not least, some projects will not develop a photonic technology but are obviously related to Photonics as the core technology used is photonic. For example, an astronomic study mainly based on telescope observation will not be regarded as a "Photonics based project". For this reason a third definition was proposed:

"Photonics as a critical enabler projects" that project which do not develop a Photonic technology but where Photonics is absolutely critical.

Of course, any project that would use a regular microscope would not be selected as a "Photonics as a critical enabler project". Similar to astronomic observation, Photonics must be an absolute critical enabler in such a project.

The following analysis focuses on "Photonics related projects", including the three categories defined above: "Photonic based projects", "Photonic enabler development projects" and "Photonics as a critical enabler projects".

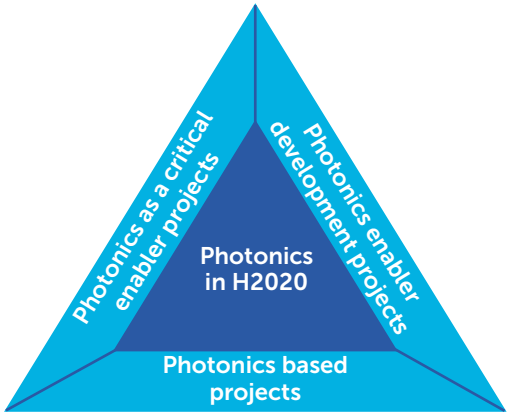


Figure n°3: Different types of Photonics related projects in H2020. Source: VDI TZ GmbH.

4.2 Screening methodology

This study is mainly based on open data made available on line (https://data.europa.eu) by the European Commission. Two files on H2020 projects and their participants were used and completed manually.

The project file was dated May 2017. It contained 13,643 projects already signed at that time. First, an extraction has been made through a list of 87 photonic keywords (see Annex 10.1) such as "photonics", "spectroscopy" or "infrared", etc. When every new keyword would only extract projects that were already extracted, the search would end. This process resulted in 2,096 projects.

Next a manual selection was performed. Each abstract was carefully examined, selecting only "photonic" projects, "photonic technology enabler" projects and "photonic as a critical enabler" projects. Through this process, 891 "photonic projects", 122 of the second and 132 of the third categories above respectively were selected.

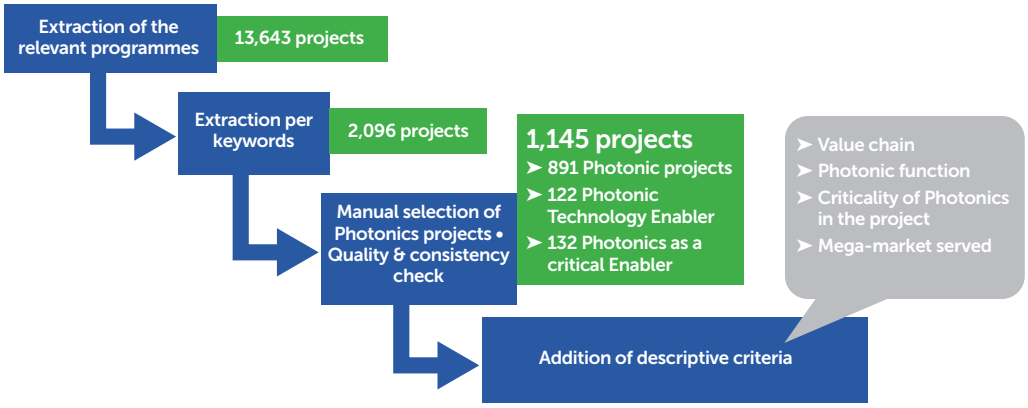


Figure n°4: Extraction and screening process. Source: VDI TZ GmbH / Tematys.

In addition, each selected project was analysed and completed with extra descriptive criteria dealing with:

- The value chain position of the developed photonic technology, from process equipment, material components to systems
- The photonic function of the developed technology
- The criticality of the developed photonic technology in the project
- The mega-market(s) to be served by the photonic technology developed.

See Annex 10.2 for more details – the criteria and all the screening methods are detailed. The errors and limitations of the methods are also estimated and analyzed (see Annex 10.2 and Annex 10.3).

Figure n°5: Market segmentation used in the study. Source: VDI TZ GmbH / Tematys.

Application areas of Photonics: Digitisation is made possible because of high-speed optical transmission systems; Analysis of the building blocks of life using fluorescence spectroscopy; Eco-friendly Lighting Systems using semiconductors and LED; Monitoring soil health and hydrology and ensuring safer and more efficient food processing using lasers, LiDAR, hyperspectral imaging and energy-efficient LEDs; Optimising surgical techniques using accurate and minimally invasive imaging systems; Laser becoming an universal tool in Manufacturing; Automated driving, photonics-based IT and telecommunications for driving assistance and transport networks leading to connected mobility; Additive manufacturing processes becoming an integral part of tomorrow's smart manufacturing industry; Optimising man/machine and/or machine/machine interaction as well as machine control, autonomous driving in the smart city is thriving because of photonics sensing systems.

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5 The share of photonics in H2020

5.1 Breakdown per programme

Of the 13, 643 projects in the database, 891 were purely photonic – 6.5% of the total. To include all 1,145 photonics related projects, the percentage rises to 8.4%. The total EC contribution for all H2020 projects reached €23.15bn. Focussing exclusively on photonic projects, this amounted to €1.42bn of European financial support. For all photonic related projects, the support reached €1.76bn with respective percentages of 6.1% and 7.6%.

These figures can be compared to the relative share of the Photonics in the overall industry manufacturing in terms of turnover which is around 3.3% (Production volume of the European photonics without Photovoltaics in 2015: €66.6bn compared to €1,978bn overall turnover in the European industry in 2015)[5]. This difference shows the consideration of Photonics by the EC as a key enabling technology and how much Photonics is a research-intensive industry, even if it is not possible to estimate the respective weight of those two statements.

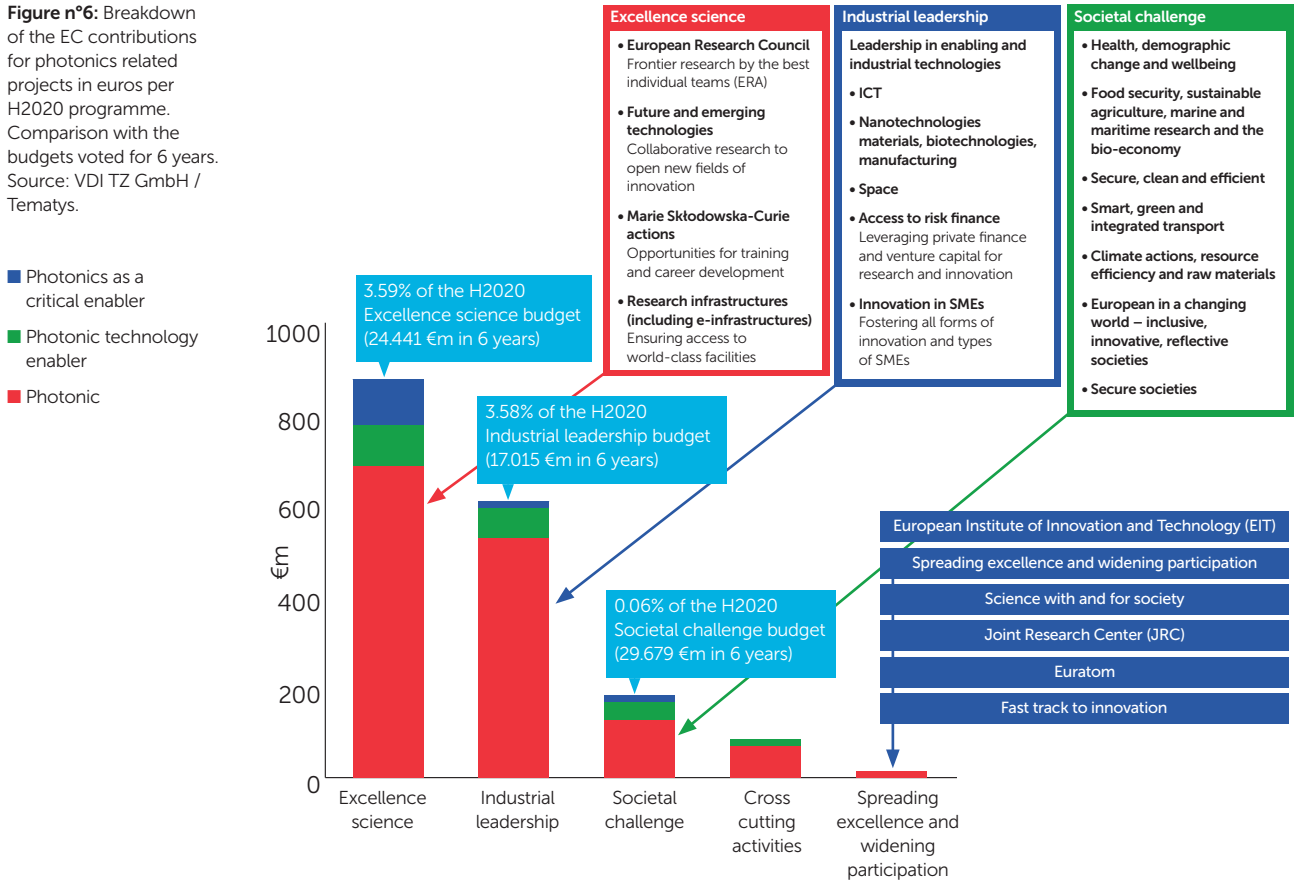


Figure n°6: Breakdown of the EC contributions for photonics related projects in euros per H2020 programme. Comparison with the budgets voted for 6 years. Source: VDI TZ GmbH / Tematys.

- Photonics as a critical enabler
- Photonic technology enabler
- Photonic

Figure n°6 shows a breakdown of the EC contributions in euros per H2020 programme, with particular focus on the 3 pillars: "Excellence Science", "Industrial Leadership" and "Societal Challenge". It was not possible to sort all 13,643 projects by programme so the figures were divided by the budgets voted for the 6 years. The budgets allocated to photonics related projects in Excellence Science correspond to 3.6% of the overall "Excellence Science" 6 year budget. For the "Industrial Leadership" pillar, the percentage is very close (3.6%). The "Societal Challenge" pillar comes in considerably lower at 0.6%. This difference could be explained on a number of factors (see Table n°1 on page 17).

[5] Source: European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH, Photonics21 Secretariat (2017): Market Research Study, Photonics 2017, Brüssel / Düsseldorf / Tägerwilen, May 2017.

[6] For a detailed explanation of the H2020 budget: "Horizon 2020 budget and implementation A guide to the structure of the programme" by the European Parliamentary Research Service (November 2015 — PE 571.312) and "Interim evaluation of Horizon2020" by the Directorate-General for Research and Innovation (2017).

5.2 Share of photonics in each pillar

	Photonic	Photonic technology enabler	Photonic as a critical enabler	Total
Excellence Science				
ES-ERC	235	44	27	**306**
ES-FET	30	2	3	**35**
ES-INFRA	12		1	**13**
ES-MSCA	288	22	86	**396**
subtotal	***565***	***68***	***117***	***750***
Industrial leadership				
IL-EEB	1	1		**2**
IL-ICT	85	9	2	**96**
IL-NMBP	4	2		**6**
IL-SME	14	5	1	**20**
IL-Space	6	2	1	**9**
IL-SMEInst-2	36	5	2	**43**
IL-SMEInst-1	68	16	3	**87**
subtotal	***214***	***40***	***9***	***263***
Societal challenge				
SC-Energy	14	3		**17**
SC-Environment & resources	10	1		**11**
SC-Health	28	3		**31**
SC-Inclusive society			1	**1**
SC-Transport	21	1	3	**25**
SC-Secure society	9	1	2	**12**
SC-Food security	6	1		**7**
subtotal	***88***	***10***	***6***	***104***
Cross cutting activities				
CC-FOF	14	4		**18**
CC-IOT	1			**1**
CC-SPIRE	2			**2**
subtotal	***17***	***4***		***21***
Spreading excellence and widening participation				
Spreading excellence	7			**7**
subtotal	***7***			***7***
Total	**891**	**122**	**132**	**1,145**

Table n°1: Overview of photonics related projects in H2020 from January 2014 to May 2017. Source: VDI TZ GmbH / Tematys.

Table n°1 shows a breakdown of the photonics related projects per programme. There are more projects in the "Excellence Science" pillar (750), followed by the "Industrial Leadership" pillar (263), "Societal Challenge" (104), the Cross Cutting Activities (21) and the "Spreading Excellence and Widening Participation" programme (7).

The table shows that "Information and Communication Technologies" (ICT) calls, i.e. calls dedicated specifically to Photonics, are only a very small part (10.8%) of all projects that develop photonic equipment within H2020. This is another demonstration that Photonics is both a key enabling technology and a solution for almost all other topics covered by H2020.

5.2.1 Excellence science

The share of Photonics is very high in the Excellence Science pillar as shown in table n°2. Photonics, as a high-tech hardware industry, relies heavily on intense research to develop innovations.

Table n°2: Share of photonic projects in the pillar "Excellence Science". Source: VDI TZ GmbH / Tematys.

	Nb Pho	Nb H2020	% (nb)	€ Pho	€ H2020	% (€)
European Research Council (ERC)	306	2,931	10.4%	339,307,665	4,636,468,112	7.3%
Future and Emerging Technologies (FET)	35	150	23.3%	99,541,473	698,385,635	14.2%
Infrastructure (INFRA)	13	159	8.2%	68,888,414	901,695,829	7.6%
Marie Skłodowska-Curie actions (MSCA)	396	4,526	8.7%	176,068,211	2,413,959,463	7.3%

What becomes clear from the table is the performance of companies and research institutions in highly competitive calls like FET OPEN. In calls like ERC-Proof of concept, the share of Photonics is even higher: 16.8%(nb) or 16.5%(€). Funds invested in Photonics are therefore more likely to be exploited as a commercial application.

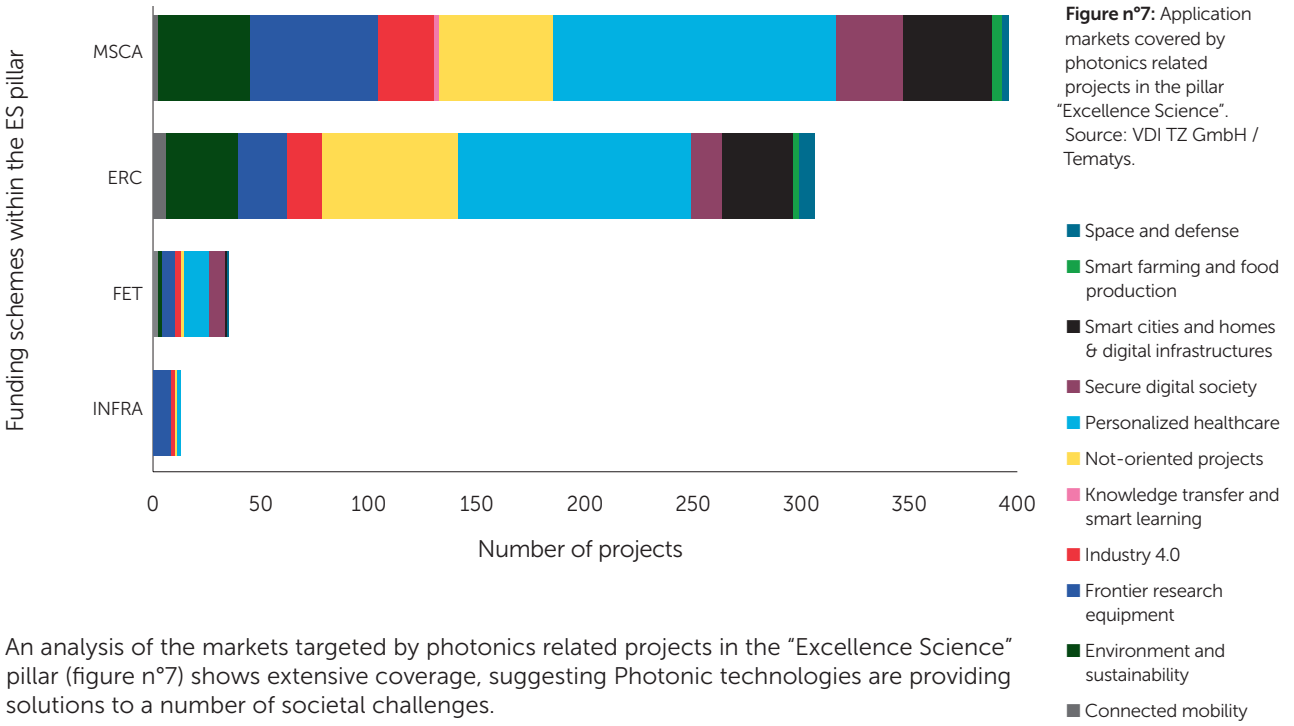


Figure n°7: Application markets covered by photonics related projects in the pillar "Excellence Science". Source: VDI TZ GmbH / Tematys.

An analysis of the markets targeted by photonics related projects in the "Excellence Science" pillar (figure n°7) shows extensive coverage, suggesting Photonic technologies are providing solutions to a number of societal challenges.

5.2.2 Industrial Leadership

Similar market coverage is clear for the "Industrial Leadership" pillar (IL) (fig.8). The "SME Instrument" 1 and 2 calls, as well as those in ICT, have a good deal of projects populating their respective funding schemes. Space is logically more dedicated to two markets i.e. "Space & Defense" and smart cities and infrastructure which cover the telecom market.

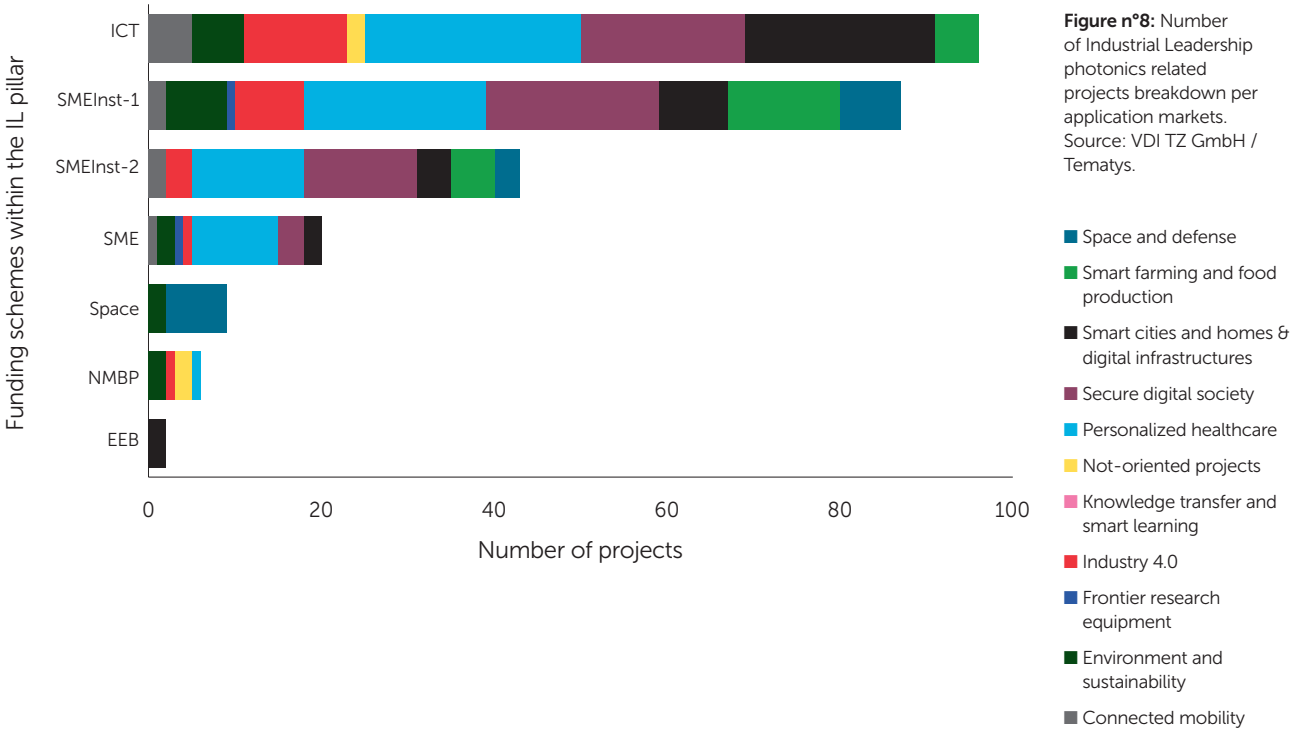


Figure n°8: Number of Industrial Leadership photonics related projects breakdown per application markets. Source: VDI TZ GmbH / Tematys.

A special focus has been made on the SME Instrument calls (table n°3). Photonic SMEs submitting an SME Instrument project are well represented. With 7.3% of all SME Instrument 1 projects signed since the beginning of H2020 and 11.6% for the SME Instrument 2, this shows the importance placed on SMEs and their popularity in general.

The consistency of the projects submitted by the photonic related SMEs was also recognized as 11.3% of the companies which signed a SME-INST-1 also signed a SME-INST-2 (compared with the entire H2020 average of 5.6%).

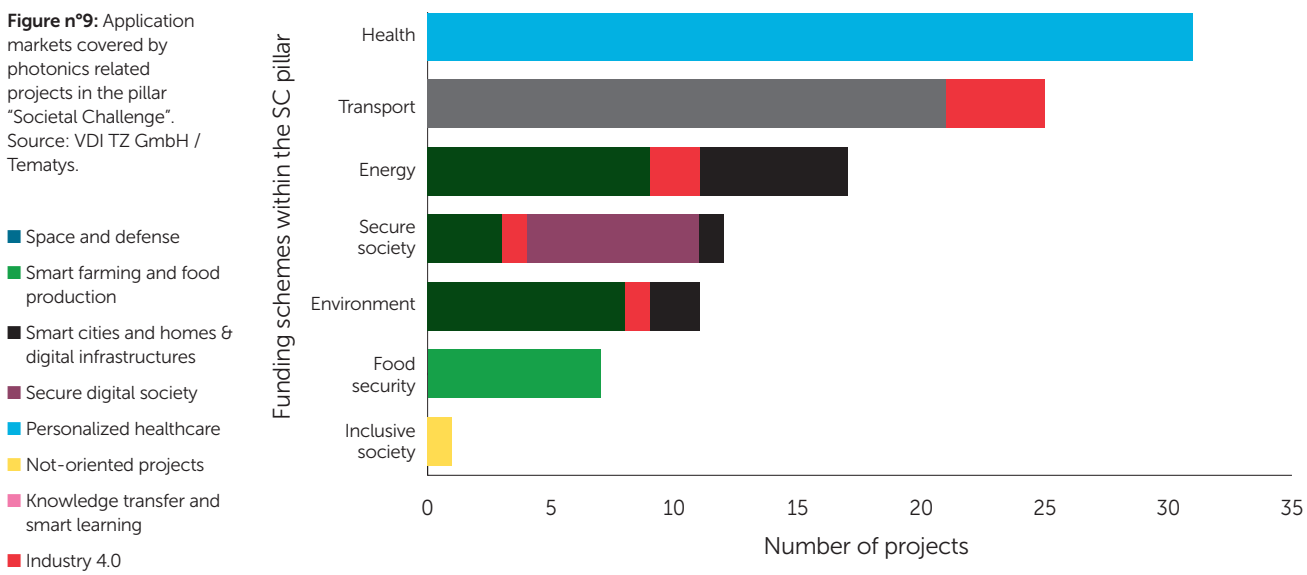
Table n°3: Performance of photonic SMEs in the SME INSTRUMENT Programme. NB: the SME INSTRUMENT calls are funded through the "Industrial Leadership" budget. A smaller part, however, comes from the "Societal Challenge" budget. These figures take in account all SME INSTRUMENT whatever the funding source. Source: VDI TZ GmbH / Tematys.

Focus on SME Instrument	H2020 (nb)	Photonic projects (nb)	%
SME1	1922	141	7.3%
SME2	481	56	11.6%
SME1->SME2	107	16	14.9%
(SME1->SME2)/SME1	5.6%	11.3%	

5.2.3 Societal Challenges

The market coverage in the "Societal Challenges" pillar (SC) is less distributed than expected. However, the coverage is consistent with the targeted markets being relevant to the "Societal Challenges" topics.

Figure n°9: Application markets covered by photonics related projects in the pillar "Societal Challenge". Source: VDI TZ GmbH / Tematys.



On a quick glance, the SC pillar "Health, demographic change & wellbeing" clearly stands out with the highest number of projects. 'Health' is closely followed by "Smart, green & integrated transport" in second place.

In this SC, the distribution of submarkets is representative of photonics as Key enabling Technology (KET), with 12 projects in aeronautics, 6 in automotive, 4 in railways, 2 in naval and one dedicated to processes to be used in all transport industries.

As shown in Figure n°6, the share of photonics in the "Societal Challenges" pillar was considerably lower than that in other pillars. It is possible that photonics is not a solution for every issue and challenge of these application markets. They also need a lot of new technology or materials, chemistry, biology, electronics, mechanics, design, software, non-photonic sensors etc. Therefore it is logical that only parts of the challenges covered by the SC calls are to be solved simply by the development of a photonic solution, even if the majority could integrate an existing photonic component or subsystem.

The second possible reason is that these figures should not be regarded as 'low'. Rather, it is the share of photonics in the other pillars that is very high compared to the weight of photonics in the industry. In fact, if the optical industry is one of the oldest industries in history, the photonics industry could still be considered a nascent technology. As such, the photonics industry is still "technology push" oriented and maybe not "market pulled" enough at this moment in time.

Another explanation could be the relatively young developmental stage, or 'youth' of photonics. Application markets do not yet know enough about the potential of photonics as a solution to their challenges and issues.

Perhaps we should consider the question: "Where photonics should be placed in the value chain?" This poses a major challenge for the photonic industry. Of course, it will depend on each market and application, but a photonic solution hardly ever exists without other technologies: mechanics, electronics, software, Human Machine Interface, and experience of the targeted field that will bridge photonics with the specific application.

Photonics is often integrated as a component or subsystem in a larger operating system or equipment by existing integrators, such as automotive, aerospace, medical device manufacturers etc. Some of these end users whose products are not primarily photonic based have yet to engage with photonics and understand how to make use of it. The photonic industry will not replace these integrators as front-end providers even if there are many niches where photonics companies can be the solution provider.

Nevertheless, the low "Societal Challenges" pillar figures should serve as a reminder that the photonics industry needs to increase awareness about the potential of photonics and dramatically improve its "market pulled" attitude.

5.3 Year by year budget

Figure n°10 shows a breakdown of the project budgets per call year. The budget decreases from 2014 to 2015 and 2016 by 28% (in red) along with the same range of decrease for the whole H2020 (in green).

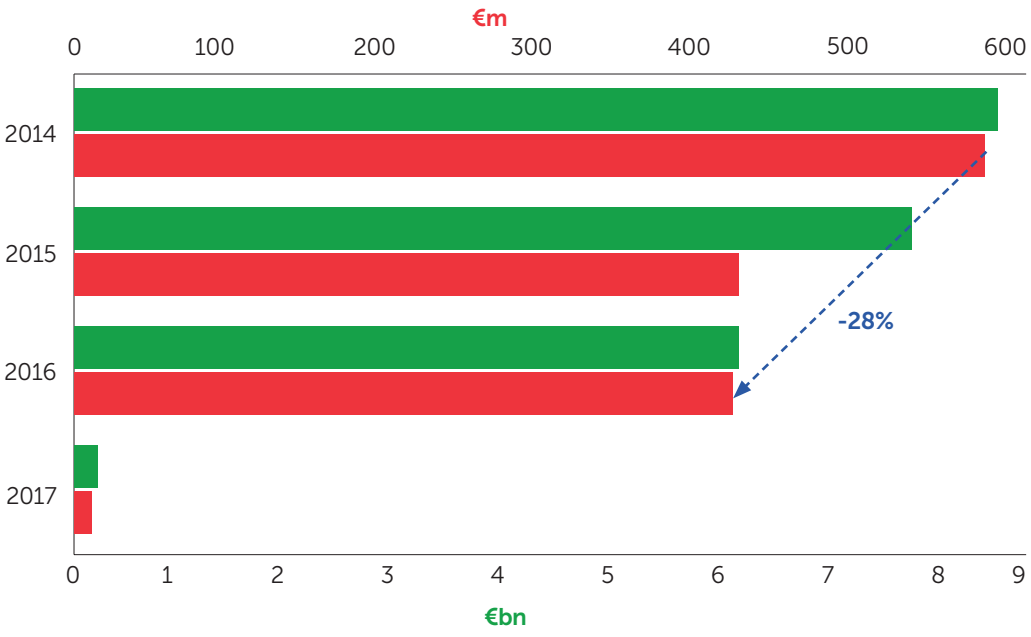


Figure n°10: Yearly breakdown of budget allocated to H2020 calls and photonics related projects signed under these calls. Source: VDI TZ GmbH / Tematys.

€ (Photonics)

€ (All H2020)

5.4 Breakdown per photonic function

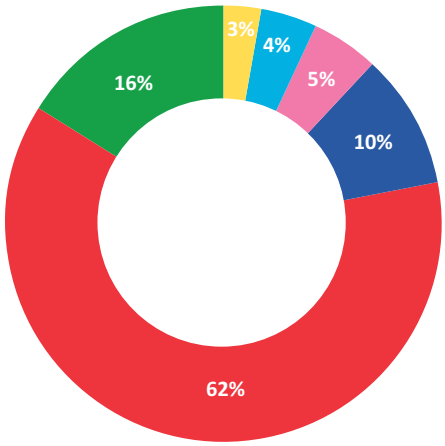


Figure n°11: Breakdown of all photonics related projects per photonic function. Source: VDI TZ GmbH / Tematys.

- Delivering and storage
- Energy collecting and providing
- Light providing
- Processing
- Sensing and imaging
- Transmitting and shaping

The biggest share of photonic functions is in 'Sensing and Imaging' with 62% of all photonics related projects aiming to develop sensing or imaging equipment. The second major function is "transmitting and shaping" (16%) closely followed by "processing" (10%) in third. As expected the "energy collecting and providing" category is quite low given that all crystalline photovoltaics has been left out of the database.

With the exception of 'production technology and lighting' the breakdown above provides a good reflection of the strengths and weaknesses of the European photonic industry. Figure n°12 shows the global Photonics EU average share. Europe leads the way in processing, sensing and imaging. However, it has lost its leadership in communication and is almost out of displays.

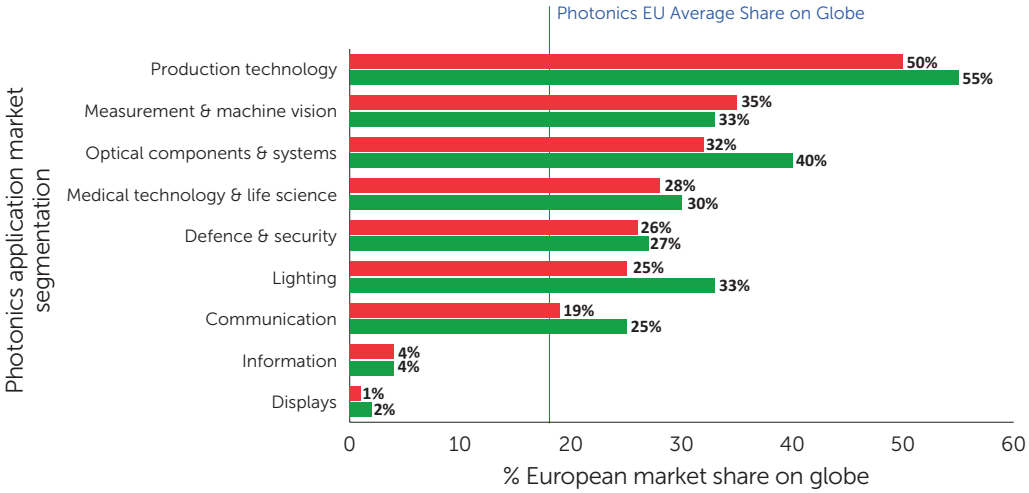


Figure n°12: Global Market Share of European Segments 2011 and 2015. Source: VDI TZ GmbH.

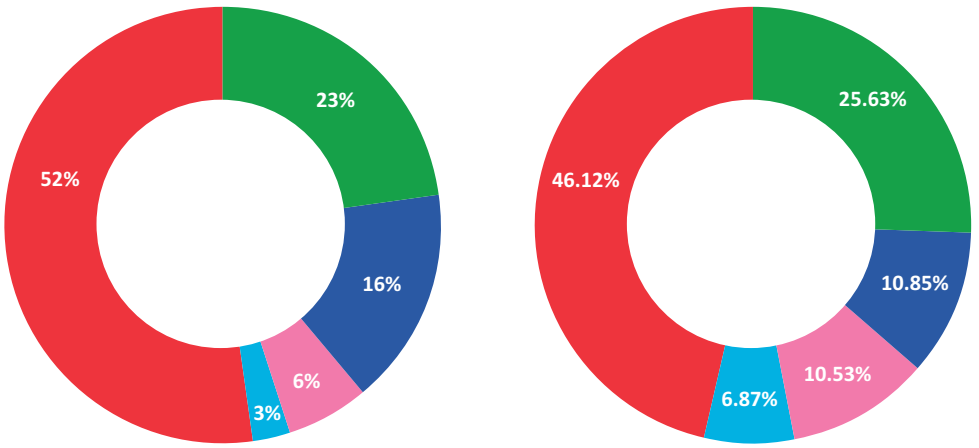
- 2015
- 2011

Data source: European Technology Platform Photonics21 c/o VDI Technologiezentrum GmbH, Photonics21 Secretariat (2017): Market Research Study, Photonics 2017, Brüssel / Düsseldorf / Tägerwilen, May 2017.

It should be noted, however, that this study only analysed the first years of H2020. For example, some ICT calls of April 2018 have targeted lasers for production and therefore it is highly likely that this segmentation will be different at the end of H2020.

6 Analysis per value chain

A breakdown of the photonics related projects per value chain shows that the photonic equipment developed were predominantly systems and subsystems (all tagged "systems" in the database) followed by components and materials (figure n°13 a) and b)). Some research facilities were also funded. These types of projects are more heavily funded than what could be considered the 'average project'. The share of research facilities projects, in terms of euros, is more important than the share in numbers.



a) Breakdown by number of projects

b) Breakdown by allocated funding in €

Figure n°13: Breakdown of the photonics related projects per value chain: a) by number of projects b) by allocated funding in €. Source: VDI TZ GmbH / Tematys.

Most developed systems – in terms of photonic function (figure n°14) – are sensing and imaging equipment. This can be explained by the fact that a greater number of components are designed for transmitting and shaping photons.

Some materials are developed for harvesting energy. As all crystalline photovoltaic projects have been excluded, these projects mainly deal with organic material designed for collecting energy.

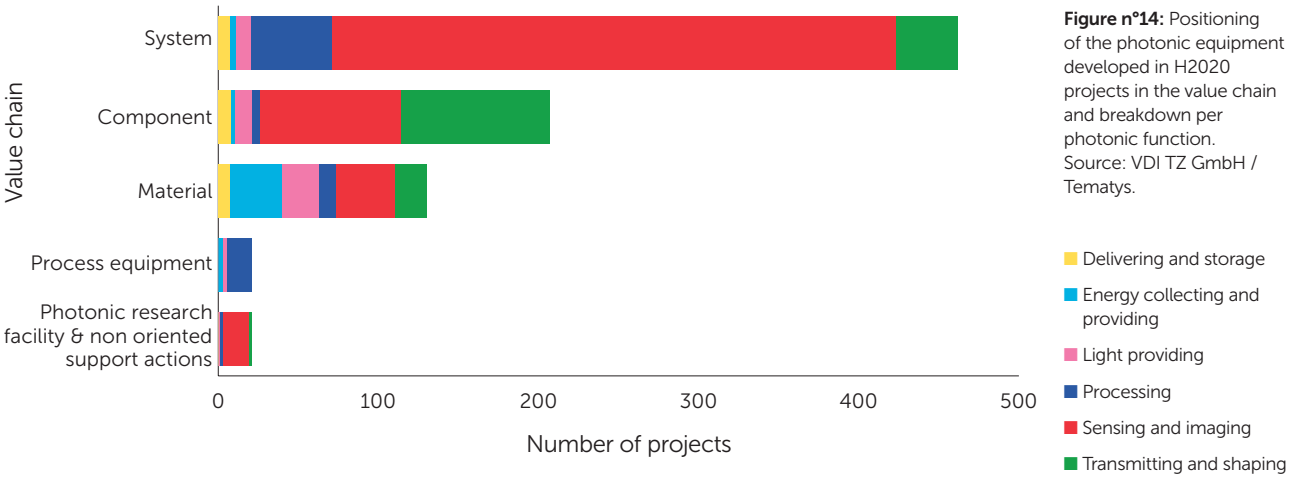


Figure n°14: Positioning of the photonic equipment developed in H2020 projects in the value chain and breakdown per photonic function. Source: VDI TZ GmbH / Tematys.

7 Focus on ICT calls

A focus on ICT calls, where the photonic calls are published, reveals that a greater proportion (49%) of projects aims to develop components (fig. n°15) compared to other photonics related projects (19%).

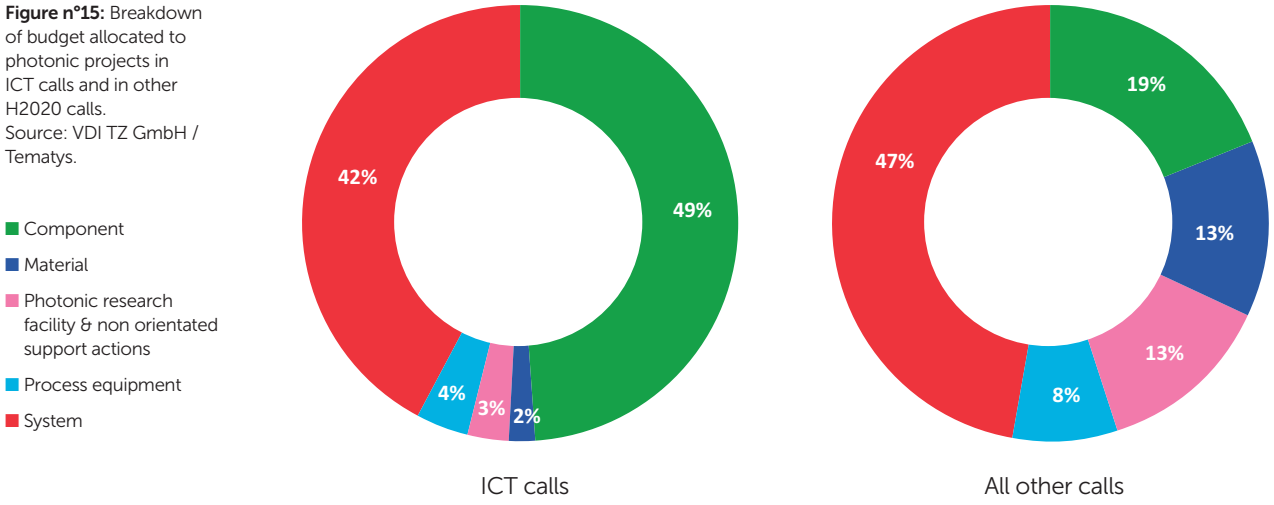


Figure n°15: Breakdown of budget allocated to photonic projects in ICT calls and in other H2020 calls.
Source: VDI TZ GmbH / Tematys.

ICT projects specify that their consortia contain more private companies than the average (figure n°16). 50% of the participants are from the private sector.

However, taking into account the part of participants called "others", i.e. private international groups, it could be said that more than 50% participants of ICT calls are from the private sector.

For all Photonics related projects, the percentage is only 37%. This might underpin the success of the Photonics PPP for promoting H2020 and make it an effective tool for photonic companies which are still very dependent on their research effort.

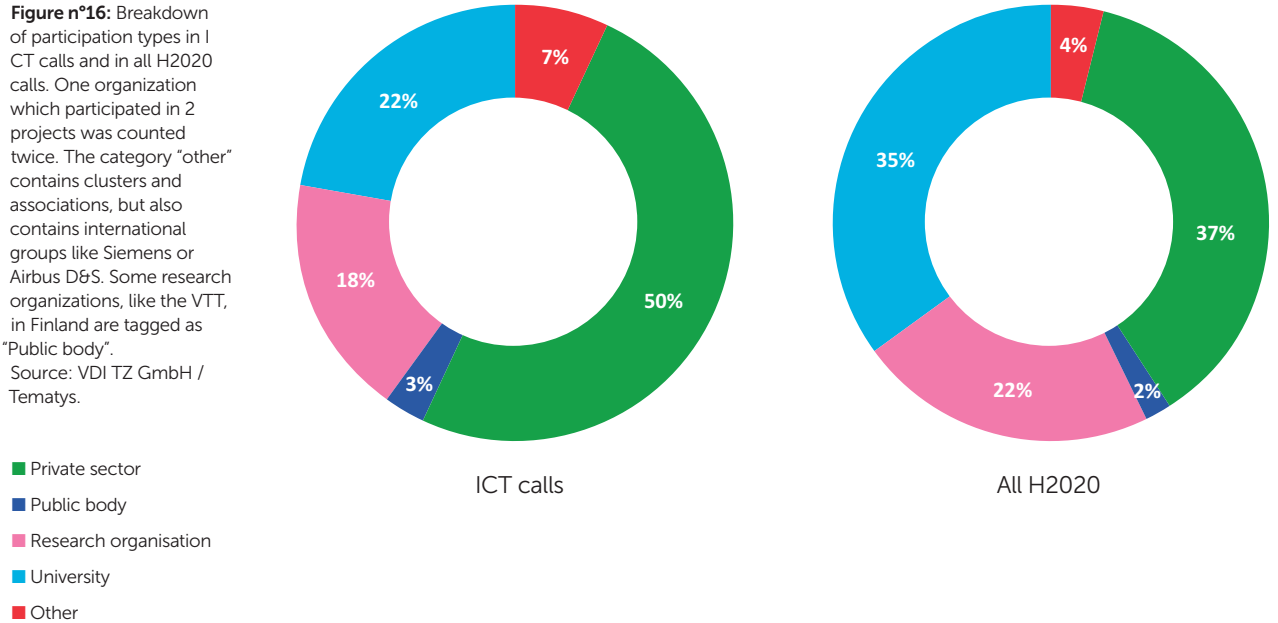


Figure n°16: Breakdown of participation types in I CT calls and in all H2020 calls. One organization which participated in 2 projects was counted twice. The category "other" contains clusters and associations, but also contains international groups like Siemens or Airbus D&S. Some research organizations, like the VTT, in Finland are tagged as "Public body".
Source: VDI TZ GmbH / Tematys.

8 Analysis per mega-market

8.1 Most funded markets through photonic projects and submission strategy

This study has already demonstrated that all application markets are targeted by a number of photonics related projects. Figure n°17 shows the breakdown of support directed to each application market through the funding of photonic projects. The "Personalized healthcare" benefits market is bigger than any other, probably because of its funding is more than double its nearest pursuer, "Industry 4.0".

The third market targeted by photonic project is "Smart cities, homes and digital infrastructures".

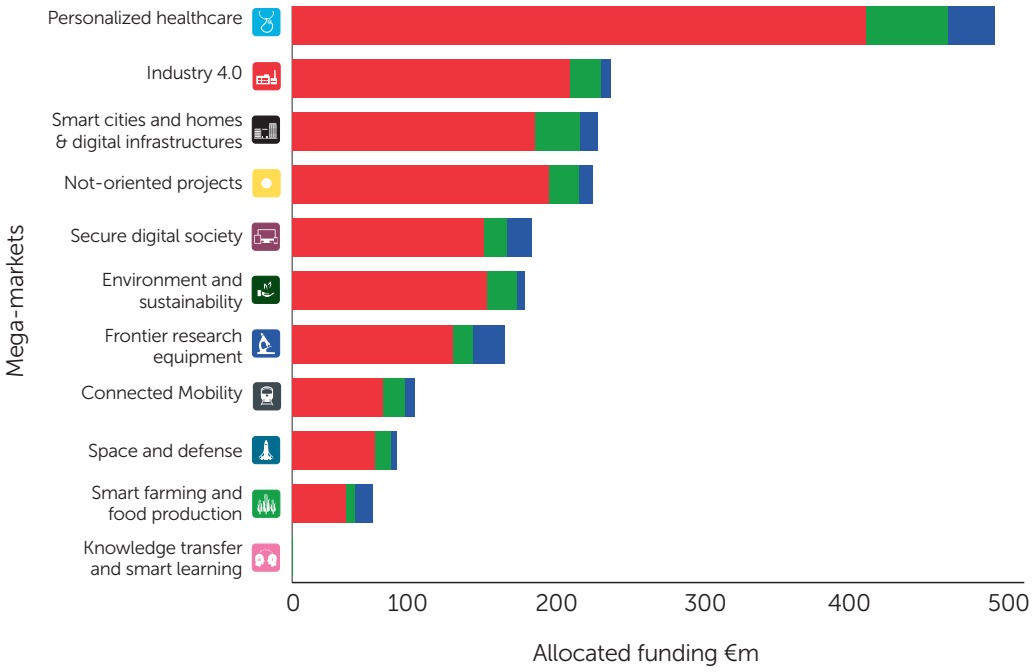


Figure n°17: Breakdown of support directed to each application market through the funding of photonic projects. Source: VDI TZ GmbH / Tematys.

The volume of support directed to each application market comes from calls dedicated to related topics. For example, SPACE calls from the "Industrial Leadership" pillar will mainly serve the "space and defense" market. However, the volume of support also comes from the choice of consortia which will propose to develop photonic equipment in open calls like FET-OPEN[7] or MSCA[8] grants.

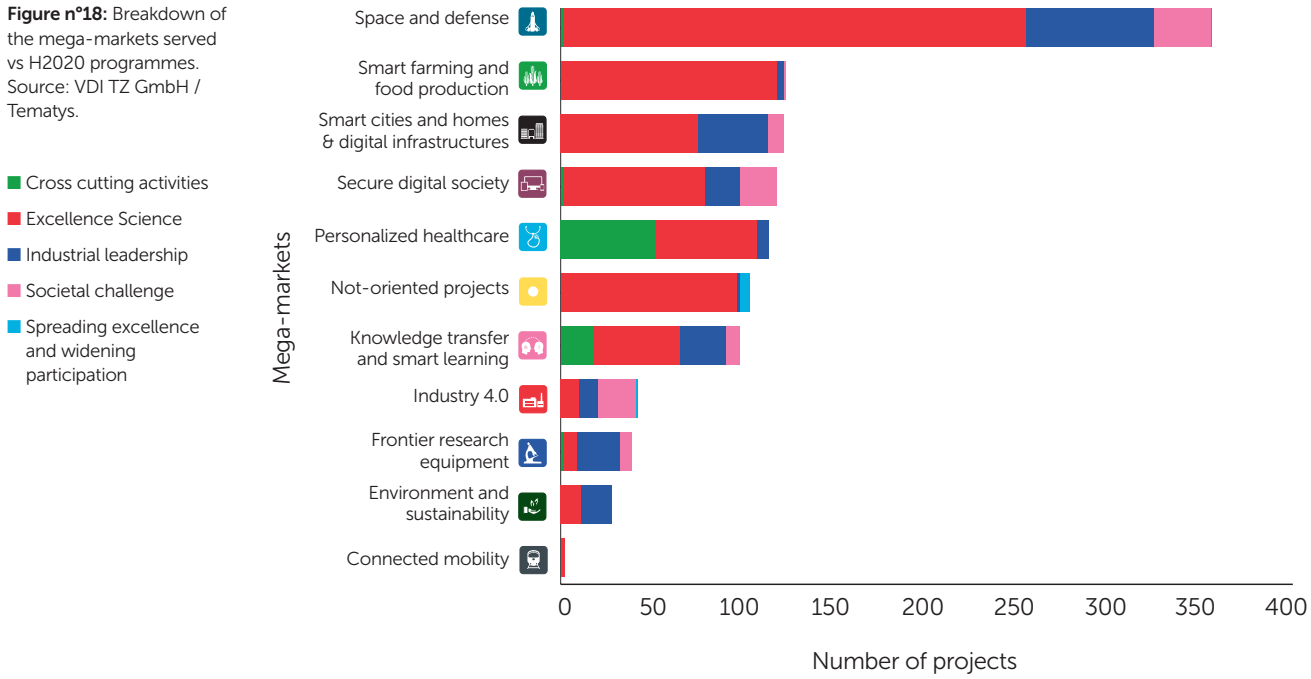
In other words, these volumes represent only partial priorities decided by the EC all the more because fewer than 11% of the photonics related projects have been supported through dedicated ICT calls.

This is clearly visible in figure n°18. Around 70% of the projects which target a market within "Personalized healthcare" come from the "Excellence Science" pillar, mainly constituted of open calls (ERC, MSCA...). The predominance of the application market "personalized healthcare" comes from the fact that most advanced instrumentation that will help achieve progress in biological science is photonic based, like new methods of microscopy or fluorescence imaging. To go further, it is possible that, since most calls from the "health" Societal Challenge section were dedicated to drug development and new therapies, research teams involved in instrumentation moved back to the more open "Excellence Science" calls.

[7] "EIC FET Open supports the early-stages of the science and technology research and innovation around new ideas towards radically new future technologies. It also funds coordination and support actions for such high-risk forward looking research to prosper in Europe, and FET Innovation Launchpad Actions aiming at turning results from FET-funded projects into genuine societal or economic innovations." Source: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-open, last accessed on 2018/01/15.

[8] MSCA: Marie Skłodowska-Curie actions.

Figure n°18: Breakdown of the mega-markets served vs H2020 programmes. Source: VDI TZ GmbH / Tematys.



The percentage of open calls is much lower for application markets like "Space and defense" or "Industry 4.0". However it is still high for "Smart cities" and "environment and sustainability". For personalized healthcare", it is highly likely that, since these application markets are very wide-ranging in terms of issues and fields of study, all consortia did not find a suitable call for their projects and adapted their strategy to fit into the H2020 structure.

8.2 Photonic function and mega-markets

The present study established in § 4.4 that a major part of photonics related projects in the database used aimed to develop sensor and imaging equipment. In figure n°19, a breakdown by the application markets show that "sensing and imaging" are especially predominant in "personalized healthcare", "space and defense" and "connected mobility".

Most projects that develop "transmitting and shaping" equipment are found in "smart cities, home and digital infrastructures" (which include telecoms and datacenters) and "secure digital society" (which contain "Internet of Things"– IOT).

Most "processing" projects target the "industry 4.0" (laser processing) market as well as personalized healthcare (laser based therapy). Lighting projects are dedicated to the "smart cities, home and digital infrastructures".

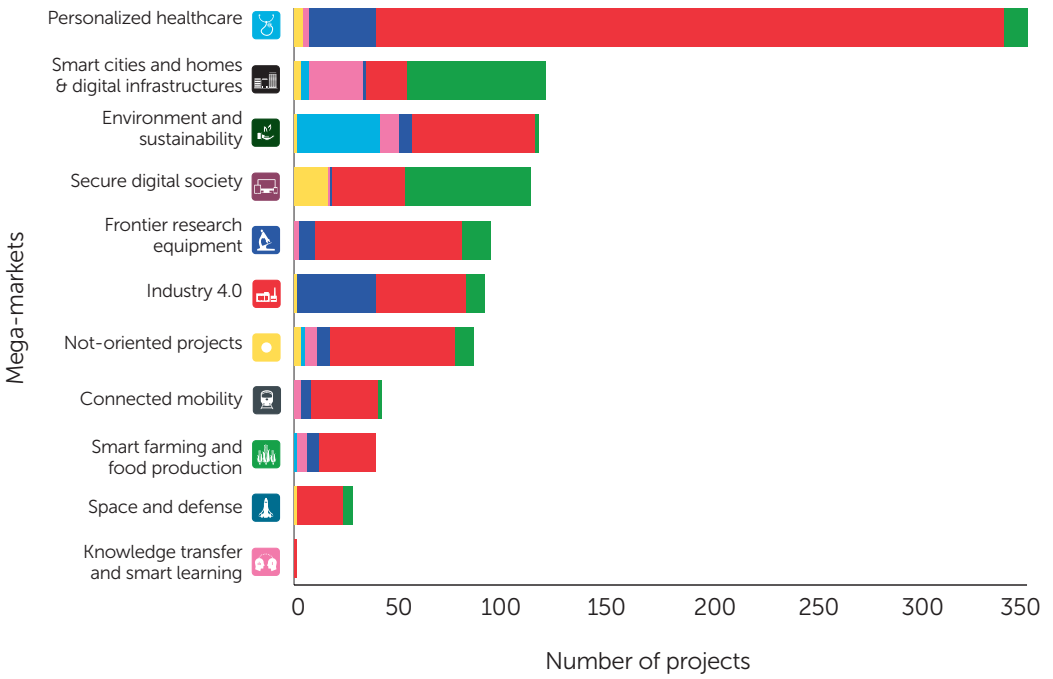


Figure n°19: Mega-market served vs photonic function. Source: VDI TZ GmbH / Tematys.

In terms of criticality, in every market, the photonic development within the photonics related project is the core objective (1) or a critical milestone (2) in more than 80% of the projects.

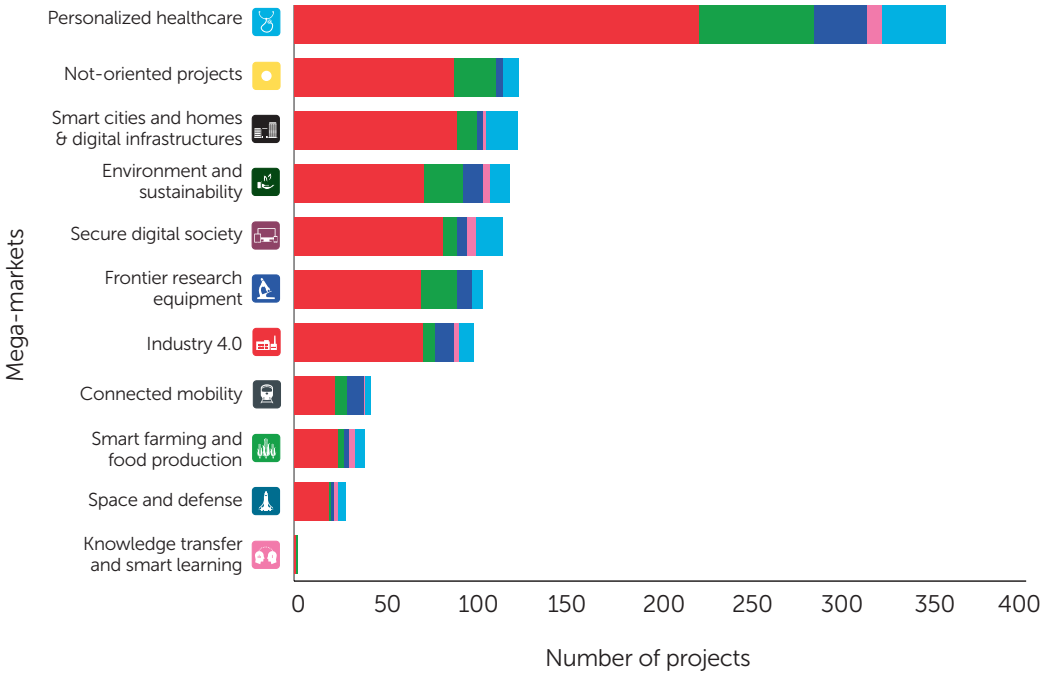


Figure n°20: Mega-market served vs criticality of the photonic development within each project:

- 1. The development of the equipment is the core objective of the project
- 2. The photonic equipment developed is a critical milestone (i.e. no results without the equipment and no alternative)
- 3. The photonic equipment developed is an important milestone (i.e. there are alternative with existing equipment)
- 4. The photonic equipment developed is only a bonus for the project
- 5. The technology developed is not photonic but an enabler of a photonic technology.

Source: VDI TZ GmbH / Tematys.

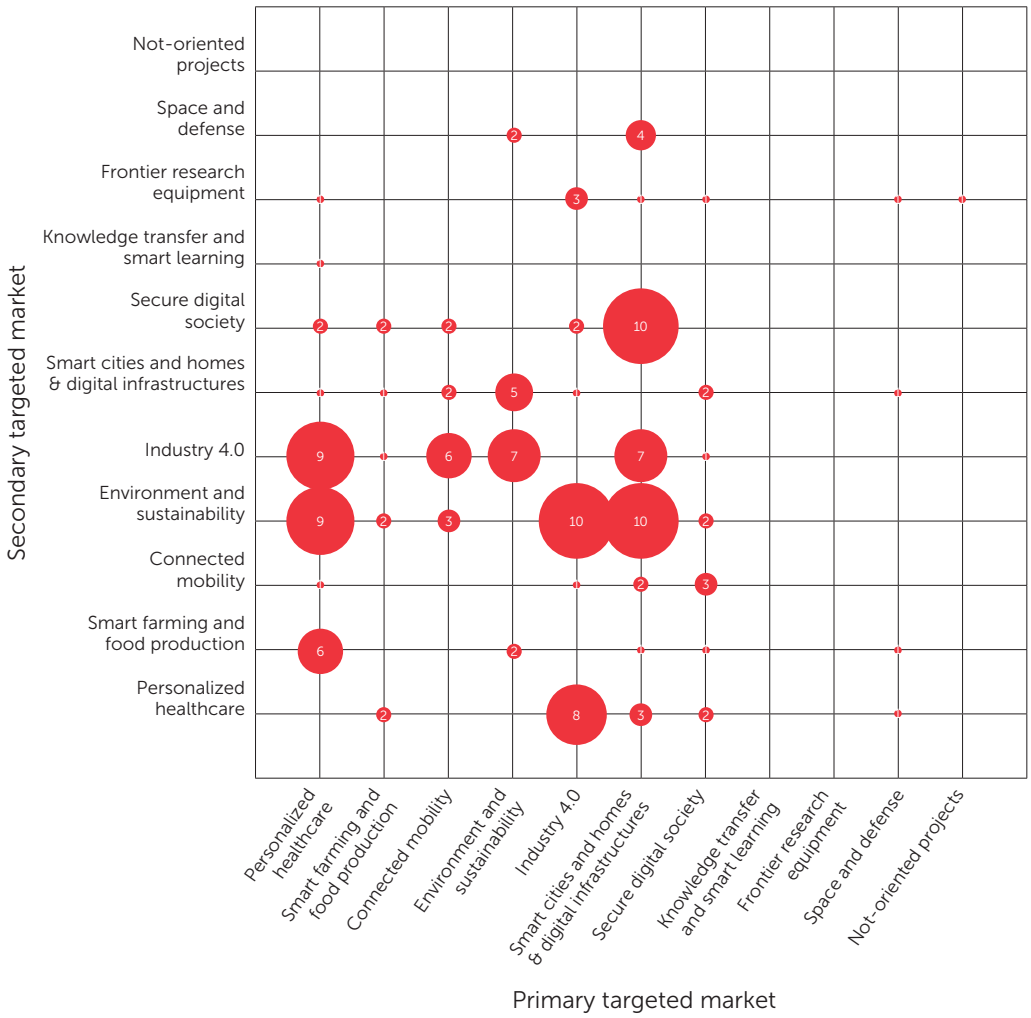


Figure n°21: Projects targeting several application markets. Among the 1,145 projects, 149 can target at least one secondary market. The figure in the bubbles indicates the number of projects which were identified as targeting a primary market (X axis) but also a secondary market (Y axis).
Source: VDI TZ GmbH / Tematys.

Among the 1,145 projects extracted from the database, 149 were not only targeting one primary market, but could also apply to at least one secondary market. Figure n°21 plot counts how many times a primary market was related to a secondary one.

The most interlinked markets are “industry 4.0” and “personalized healthcare”, “smart cities, home and digital infrastructure ” and “environment and sustainability” and “industry 4.0” and “environment and sustainability”.

9 Analysis per country

In terms of funding and participation per country, there are 3 groups of countries (figure n°22). Germany is alone in the first group with almost 600 participations and €357k of funding, closely followed by the United Kingdom (UK), France, Italy, Spain and the Netherlands. All other countries are in the third group. This distribution is consistent, compared to the weight of each national photonic industry.

There is a strong correlation between the number of participation per country and the funds allocated. In short, the average funding per participant is very close for almost every country, around €520k. Italy, Spain and UK are somewhat lower because of the high participation of their SMEs in the SME Instrument, especially SME Instrument 1 where the funding is only €50k (figure n°23).

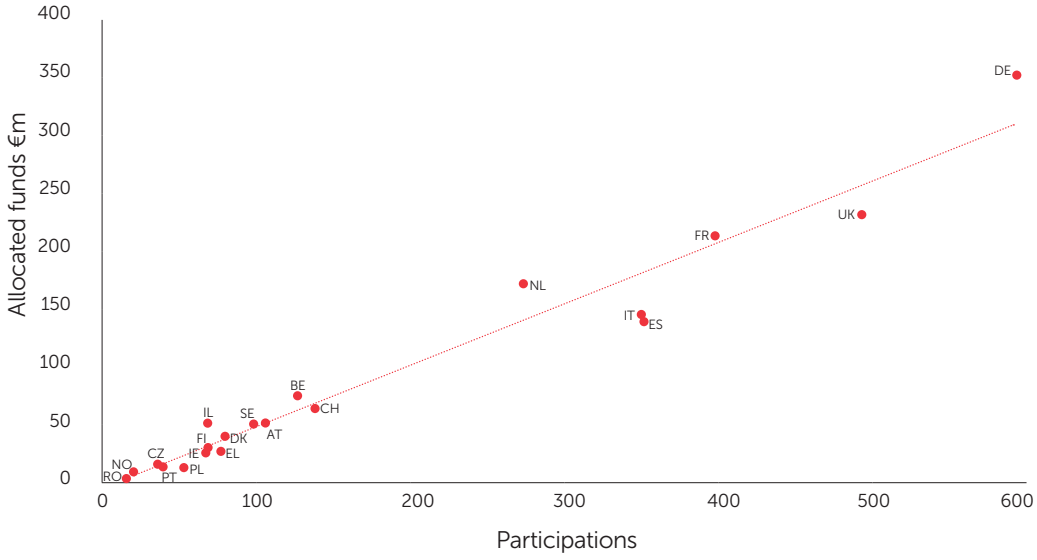


Figure n°22: Number of participants per country vs funding per country. There is a strong correlation between the number of participation per country and the funds allocated. In short, the average funding per participant is very close for almost every country, around €520k. Italy, Spain and UK are somewhat lower because of the high participation of their SMEs in the SEM Instrument, especially SME Instrument 1 where the funding is only €50k. Source: VDI TZ GmbH / Tematys.

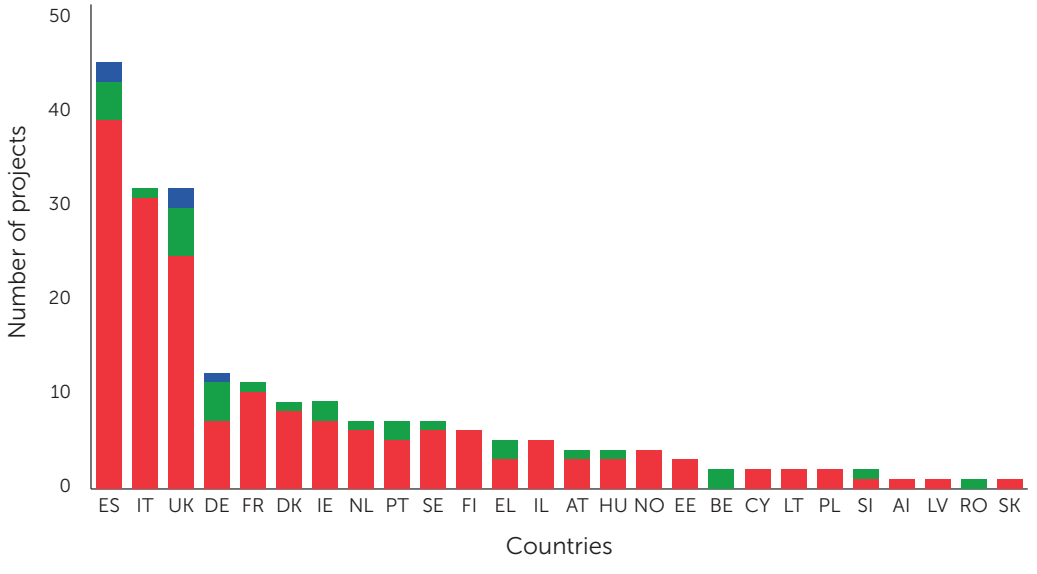
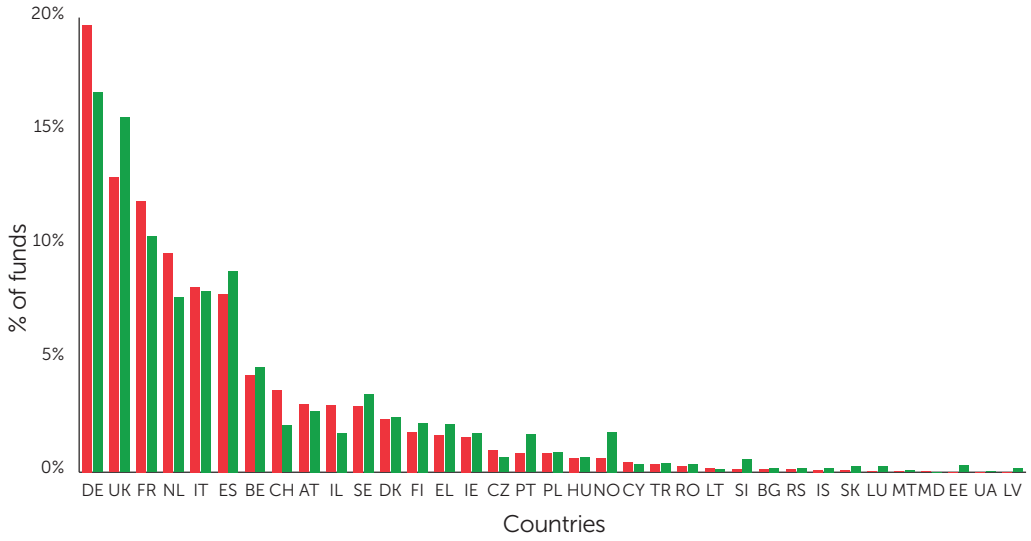


Figure n°23: SME Instrument projects (1 + 2) signed per country. Spanish, British and Italian SMEs have submitted and obtained the more funds. It is probable that the lower number of candidacy in countries, like Germany or France, can be explained by a better attractiveness of the national SME support programmes in those countries. Source: VDI TZ GmbH / Tematys.

Figure n°24 shows the percentage of funds allocated to each country from 2014 to May 2017. Countries like Germany, France, the Netherlands and Switzerland received a higher percentage of funds allocated to photonic projects than for all H2020. On the other hand, for the UK, Spain or Sweden, Finland, Portugal and Norway, the percentage is lower. For Italy, Belgium, Austria, Denmark, Ireland, the percentages are very close.

Figure n°24: percentage of funds allocated to each country from 2014 to May 2017.
Source: VDI TZ GmbH / Tematys.

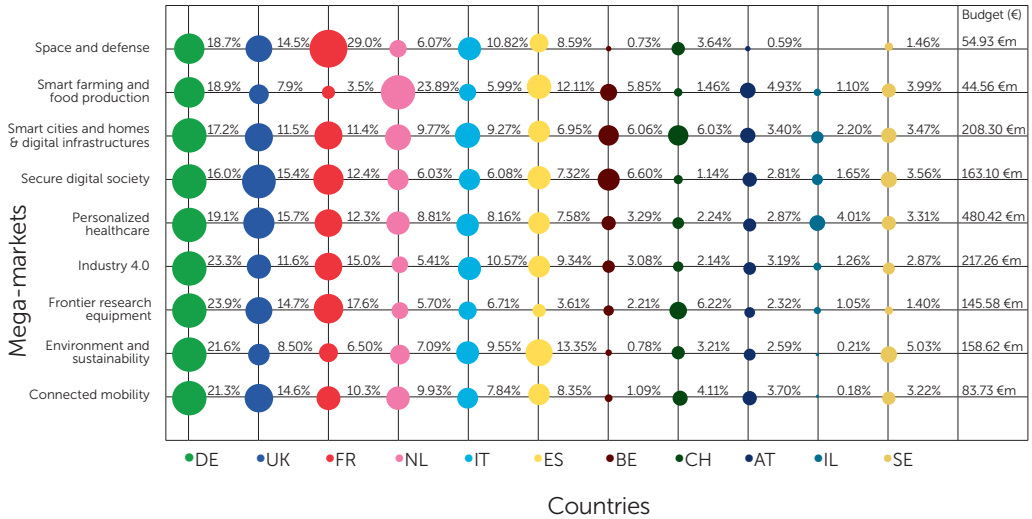


A last plot shows the share of countries in budgets directed to each application market (figure n°25).

Germany has an almost uniform presence in every application market with a share ranging from 16% to 23.9%. A similar trend is adopted by the UK also except for in "environment and sustainability" and "smart farming and food production". France is dominant in "space and defense" and has a good share in "Frontier research equipment", but is even lower than the UK for "environment and sustainability" and "smart farming and food production". This last figure is in contrast to the weight of the French farming and food sector in Europe.

On the contrary, the Netherlands shows a significant share in that field along with its weight in the Dutch economy. Italy's presence is significant in projects targeting "space and defense" as well as "Industry 4.0" markets. Spain is particularly visible in "smart farming and food production" and "environment and sustainability". Belgium's main involvement is seen on digital markets. Switzerland's main sectors are "smart cities, homes and digital infrastructure" and "frontier research equipment". For Austria it is "smart farming and food production", Israel, "Personalized Healthcare" and Sweden, "environment and sustainability".

Figure n°25: Share of countries in budgets directed to each application market.
NB: the size of the bubble is a percentage. The volume of funds directed to each market varies from €44.56m (Smart farming and food production) to €480.42m (personalized healthcare).
Source: VDI TZ GmbH / Tematys.



10 Annex

10.1 List of keywords used for the extraction of photonics related projects

Dated May 2017, the project file contained 13, 643 projects that had been signed at the time. First, an extraction was made through a list of 87 photonic keywords like "photonics", "spectroscopy" or "infrared", etc. (s. Table n°4). The search ended when every new keyword would only retrieve projects that had already been extracted. This process found 2096 projects.

Keywords	Nb	Keywords	Nb	Keywords	Nb	Keywords	Nb
optic	1,042	OLED	115	speckle	1	adaptive optic	13
photonic	429	femtosecond	52	phototherapy	2	petawatt	2
plasmonic	83	picosecond	15	photodynamic	16	Free space optic	2
optronic	2	attosecond	16	optogenetic	109	FSO	7
optical	860	atto-second	-	sequencing	319	quantum dot	58
infrared	182	RAMAN	99	photobiomodulation	-	hyperspectral	19
ultraviolet	31	multiphoton	10	compound semiconductor	7	multispectral	20
terahertz	46	Spectroscopy	347	photonic integrated circuit	23	machine vision	16
THz	57	interferometry	30	ADAS	55	LWIR	4
X-ray	208	microscopy	410	autonomous vehicle	11	phase	1,868
Gamma	59	endoscopy	13	lighting	197	quantum optics	54
wavelength	155	cytometry	43	Light emitting diode	25	intricated	-
visible	176	tomography	143	photovolatic	194	lens	130
optical fibre	37	florescence	204	CIGS	8	focal	92
optical fiber	34	holography	21	CPV	11	photon	652
optical communication	24	camera	186	OPV (organic photovoltaic	14	diffract	73
Laser	543	imaging	1,126	VCSEL	3	surface plasmon	22
QCL	12	LIDAR	62	VECSEL	-	Brillouin	9
MWIR	2	LADAR	4	transceiver	39	bragg	14
microbolometer	1	"optical sensor"	21	Li-Fi	-	polarisation	19
SWIR	11	wavefront	10	Visible light communication	4	Surface enhanced	7
LED	6,667	low-light-level	2	VLC	3		

Table n°4: List of keywords used for extracting projects. Numbers are the number of project extracted from the database using the associated keyword. Source: VDI TZ GmbH / Tematys.

10.2 Screening: details of methodology, quality check and limitations

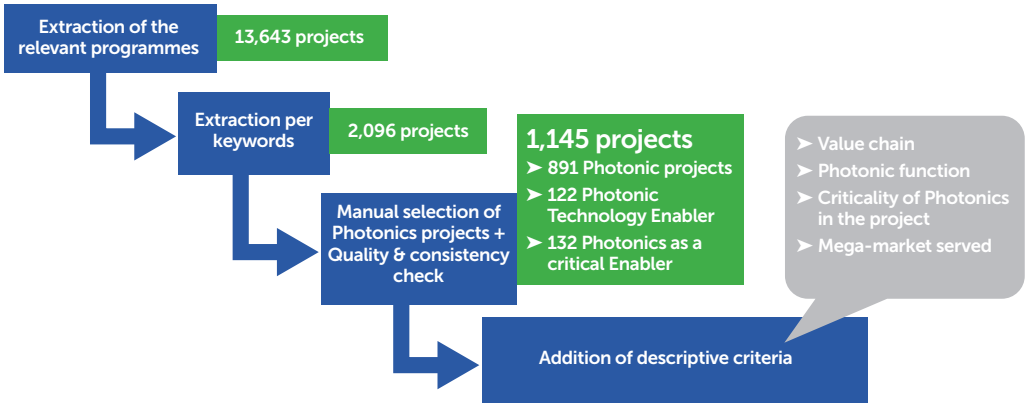
10.2.1 Methodology

This study is mainly based on open data made available on line (https://data.europa.eu) by the European Commission. Two files on H2020 projects and their participants were used and completed manually.

After having used significant keywords to reduce the list of relevant projects to 2,096, as described above in §10.1, a manual selection was performed.

For the manual selection, each abstract was read in order to select only "photonic" projects, "photonic technology enabler" projects and "photonic as a critical enabler" projects. Through this process 891 photonic projects were selected as well as 122 of the second category and 132 of the third.

Figure n°26: the extraction and screening process. Source: VDI TZ GmbH / Tematys.



In addition, each selected project was analysed and completed with extra descriptive criteria (Annex 10.3) dealing with:

- The value chain position of the developed photonic technology, from process equipment, material components to systems
- The photonic function of the developed technology
- The criticality of the developed photonic technology in the project
- The mega-market(s) to be served by the photonic technology developed.

Main source of data

https://data.europa.eu/euodp/en/data/dataset/cordisH2020projects

Files : H2020 Projects.XLSX / H2020 Organisations.XLSX

Modified Date: 2017-05-19

Geographical Coverage: EU28 + associated countries

Language: English

13,643 projects – €23.15bn

Limitations and errors during the screening phase and the exploitation of the database

➤ Errors in Cordis database registration (missing projects, false content and description)
  – Less than 1%

➤ Projects missed because of inadequate keywords
  – Less than 1% thanks to the consistency check

➤ Inexplicit 'work program' and 'objectives description' leading to wrong rejection or wrong acceptance
  – Less than 2% thanks to the consistency and the quality check

➤ Incorrect activity type: the activity type of each participant is done by the participant itself during its registration leading to some errors (ex.: Siemens or Airbus registered as "Other" instead of "Private company" or VTT as "Public body" instead of "Research Organization")
  – Error estimation: < 1%

➤ Incorrect criteria added: the criteria are chosen after the reading of the project abstract which is sometimes completed by navigation on the project website. Some incorrect criteria may be chosen due to a misleading, unclear or incomplete description and/or a bad understanding by the reader.
  – Error estimation: 2%

10.3 Criteria

Four criteria were added to each photonic related project in order to provide analysis on fields not available in the initial database.

10.3.1 Value chain

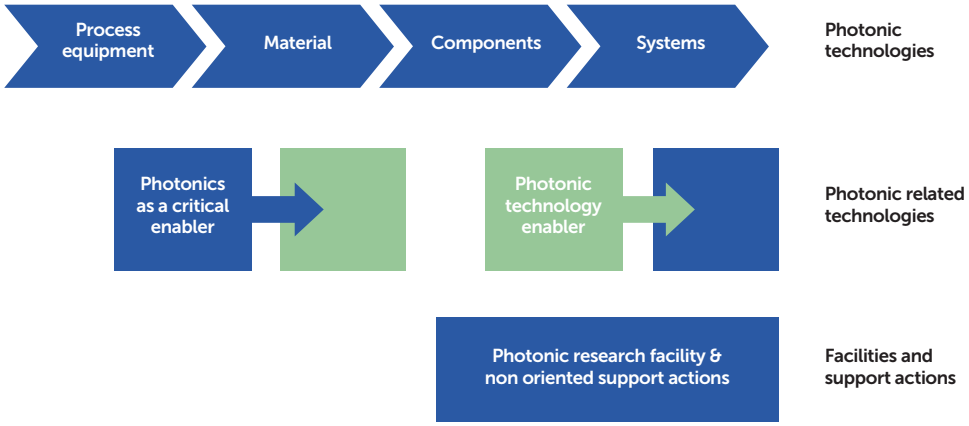


Figure n°27: "Value Chain" criteria used in the study. Source: VDI TZ GmbH / Tematys.

The field "value chain" was segmented into 3 categories:

- the development of a pure photonic technology
  - **Process equipment**
  - **Material**
  - **Component**
  - **System (and subsystems).**

- Photonic related technologies
  - **"Photonic technology enabler"**: not strictly "photonic based" projects. Some projects are dealing with technologies that are critical for the implementation of Photonics, like a data processing algorithm for spectroscopy or a dye for fluorescence imaging.
  - **"Photonics a critical enabler"**: some projects do not develop a photonic technology but are obviously related to Photonics as the core technology used is photonic. For example, an astronomic study mainly based on telescope observation.

- **Photonic research facility & non-oriented support actions**: certain calls like in the H2020-INFRA programmes aim to support the creation or the investment in new photonic facilities (ex. laser research centre or synchrotron). Some others are support actions (CSA) and will not develop photonic equipment but will support photonic companies and organizations.

10.3.2 Photonic functions

The field "Photonic function" was focused on the function to be performed by the photonic equipment develop within the project.

Figure n°28: "Photonic Functions" segmentation used in the study. Source: VDI TZ GmbH / Tematys.

Types of Photonic systems	Sensing & Imaging systems	Communication systems	Screen, displays, projectors	LED, OLED, lamp systems	Photo-volatic systems	Laser & production systems
Photonic functions	Acquiring information	Transmitting information	Delivering information	Light providing	Energy providing	Manufacturing

10.3.3 Criticality of the photonic development in the project

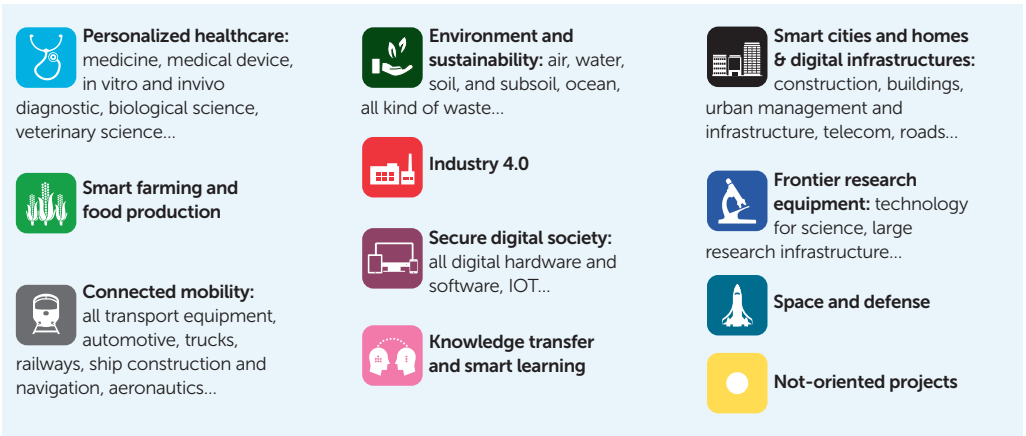
The field "criticality of the photonic development in the project" is a qualitative assessment of the weight of photonics within the "photonic related projects". They were ranked from 1 to 5:

1. The development of the equipment is the key objective of the project
2. The photonic equipment developed is a critical milestone (i.e. no results without the equipment and no alternative)
3. The photonic equipment developed is an important milestone (i.e. there are alternative with existing equipment)
4. The photonic equipment developed is merely a bonus for the project
5. The technology developed is not photonic but an enabler of a photonic technology.

10.3.4 Mega-markets segmentation used in the study

It was necessary to identify the application market targeted by each photonic project. Given that there are so many photonic-application markets, and in order to maintain simplicity, a segmentation was provided by Photonics21 (completed by TEMATYS) with the agreement of Photonics21.

Figure n°29: Market segmentation used in the study. Source: VDI TZ GmbH / Tematys.



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