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PROJECT FINAL REPORT

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Section A: Final publishable summary report

1. Executive Summary

ASPICE (Action to Support Photonic Innovation Clusters in Europe), a Cooperation and Support action funded under the EU FP7 programme, has been established to develop and identify best practices in collaboration and cooperation across clusters. Such practices were focused in the application of photonics to the societal challenges of "Healthcare in an Aging Society" and "Safety and Security of Europe's citizens" based on value chain analysis.

The foundation for cluster collaborations has been laid with the ASPICE project. Over the three years, ASPICE has brought cluster managers together regularly and helped build relationships. The relationships developed will be useful to continue the work that ASPICE has started. It would be good however, if there was a means for a large group of cluster managers to meet regularly to encourage cluster collaborations, especially since those depend on personal interactions and trust. In addition, it is vital that clusters representing end-users of the technology are involved.

In addition to this, ASPICE provided a platform for photonics clusters to meet regularly, which enabled trust building and has resulted in cluster collaboration. These types of projects are important to enable trans-European collaboration. Collaboration between clusters provides a means to engage with SMEs who may be left out of European activities because of their limited reach.

In summary, the ASPICE project has looked at different elements that enhance cluster collaboration: cluster excellence, value/supply chain and the gaps in the supply chains, methods and tools for enabling cluster collaboration and finally, testing and improving those tools. We found that all these elements are important to initiate projects between clusters.

The most valuable outcomes from ASPICE are:

- Prezi tool
- Heat maps of cluster engagement in value chain
- Method of checking cluster excellence
- List of clusters
- Photonic value chains for medical imaging, food safety, and air & gas monitoring
- Value chains structure
- Photonics cluster brought together by facilitated networking to bring about new collaborative discussions and exchanges during the ASPICE workshops
- Raising awareness about different cluster collaboration programmes and projects amongst cluster managers

The ASPICE project has enabled clusters to make stronger connections and it will most certainly lead to further cluster collaboration. Further details can be found at the ASPICE website http://www.fp7-aspice.eu/

2. Summary of Project Context and Objectives

ASPICE, a Cooperation and Support action funded under the EU FP7 programme, has been established to develop and identify best practices in collaboration and cooperation across clusters. The project targets practices focused on the application of photonics to the societal challenges of "Healthcare in an Aging Society" and "Safety and Security of Europe's citizens".

The ASPICE consortium comprises of:

1. ESP Central Ltd (Coordinator)
2. Opticsvalley (Association promouvoir la vallée de l'óptique)
3. OptoNet e.V.
4. Southern European Cluster in Photonics and Optics
5. Foundation for Research and Technology – Hellas
6. National University of Ireland, Galway
7. Wroclaw Research Centre EIT+

Best practices in Photonics Innovation Clusters and Platforms

The ASPICE project has established a qualified database of European photonics clusters, including their current levels of activity in internationalisation initiatives. Following a workshop in October 2012 involving representatives from Europe's photonic clusters and the responses to a questionnaire and a reference guide on current best practices was compiled.

ASPICE maintain that cluster collaboration between photonics clusters would take place best when the clusters were complimentary, and can therefore fill some, if not all the gaps in a value/supply chain. The ASPICE team carried out value chain analysis, focusing its efforts on cluster collaboration in the application of photonics to Healthcare; and Safety and Security. The initial work was focused on defining the scope and boundaries for photonics in these areas.

Healthcare in an Aging Society

There are many different photonic-based technologies utilised in healthcare, and therefore a degree of focus was required. For this purpose the following selection criteria were established:

- Prevalence of illness
- Cost of illness (in terms of treatment and to society)
- Improvement of quality of life
- European priorities
- Technologies in cluster organisations
- Market size and growth

Following a literature survey, it was decided to focus on technologies that deal with the following main chronic diseases that impact Europe's aging population namely:

- Cardiovascular diseases
- Cancer

- Neuropsychiatric diseases e.g. Alzheimer's, Parkinson's.
- Diabetes
- Low vision

In the second stage of the market segment analysis, photonic technologies were identified that would be of major benefit to sufferers of the chronic diseases listed.

These technologies are:

- Multimodal and optical medical imaging technologies,
- Biomarkers used for Imaging,
- Lasers technologies for surgery, manufacture of implants, UV sterilisation and therapeutic applications
- Communication Technologies for e-Health.

The third stage of the process was the analysis of market size and market growth potential for each of the above technologies with the application to the priority healthcare sectors. Preferred candidates were technologies that had a good market size and growth rate. Most attractive in this analysis were technologies with a large market size and high market growth potential, followed by technologies that currently only reached a small market but had very good growth potential.

Based on the above approaches, ASPICE identified optical imaging systems as the area to focus on. ASPICE then developed an industry value/supply chain populated with companies and their associated clusters where possible. This information was represented in a cluster vs. value/supply chain heat map. This methodology was the first step in the process of identifying where there are gaps and strengths in a value/supply chain and which photonic clusters should collaborate in order to build European expertise in the gaps identified.

Safety & Security for Europe's citizens

An extensive initial scoping was executed on Safety and Security for Europe's citizens, however it was concluded that security would be a difficult area in which to establish cluster collaborations due to its inherent information restrictions/closed communities. A recommendation was accepted to focus the scope on the application of photonics to food safety and air quality / gas monitoring. The scope and boundaries of these two areas are defined as follows:

- Food safety: from agriculture activities to food distribution via food process activities
- Air and gas monitoring: urban air quality monitoring, indoor air quality, industrial gas monitoring, fine particles detection

In the aftermath of this decision, food safety and traceability erupted as a major concern for Europe's citizens and national governments, and the EU is seeking to put in place robust food safety procedures and the ability to identify easily and quickly the traceability of food from the "farm to the fork". Europe designated 2013 as "year of air" with the EU's two most important environment directives, "ambient air quality" and "national emissions ceiling", being revised within the next 12 months, so the refinement of scope was timely.

In examining the application of photonics to food safety the focus has been primarily on the manufacturing stage of the supply chain. This is also the stage where technology and innovation are most prevalent and where connections with technology supply chains are of considerable importance. Food safety testing is

primarily concerned with the detection of contaminants such as pathogens, pesticides, Genetically Modified Organisms (GMO) and toxins. Traditional wet chemical methods have been used in the food industry for many years but with the driver for more rapid testing, photonic techniques such as fluorescence and luminescence based measurements, photonic sensors (X-ray – THz), spectroscopy and surface plasmon resonance are being increasingly utilised.

Air quality is concerned with the presence of particulates, chemicals and bacteriological contaminants in the environment and the impact they have on humans, other living organisms and our natural / built environment. The prime focus in the task was on exterior air quality. In Europe there is stringent legislation in place regarding the levels of contamination primarily with regard to exterior air, therefore it is essential that the presence of contaminants is monitored and controlled. Photonics has a major role to play in achieving this through a wide variety of techniques that detect and measure the contaminants. Exterior air quality can be segmented into 3 areas:

- Industrial and greenhouse gases
- Ambient air
- Source emissions

Photonics based equipment will be used in these air monitoring systems and will employ techniques such as fluorescence, spectroscopy, LIDAR, IR imaging and fibre optic sensing Photonic technologies are most relevant to automatic and continuous monitoring instruments, efforts were concentrated on exterior air value chains with a focus on Continuous Emission Monitoring Solutions.

Testing the theories

Over the period of the project, 3 workshops were organised for photonic cluster representatives and their views were obtained on the tools and guides that had been developed. In between each workshop, documents and tools were refined based on the feedback received and then tested at the next workshop.

3. Outputs of the project

In addition to the aforementioned cluster analysis, market segmentation and heat maps, ASPICE also developed a strategy document for transnational cluster collaboration during the second year of the project, investigating various cluster initiatives that were either on-going or will be funded in the near future. We aimed to establish if and how they support on-going cluster collaboration and how they could support and sustain the ASPICE project. We have found that there are a growing number of programmes that enable transnational cluster collaboration and support cluster excellence programmes, however none of them entirely fit with the ASPICE project to allow seamless continuation.

The ASPICE project also produced a blueprint document for value chain leverage and cluster collaboration, giving guidelines on how to practically approach and derive the value/supply chains and map cluster strength. The blueprint is based on the findings of earlier ASPICE cluster strength analysis in the 2 chosen application areas. We found that there are many similarities in these areas and that the value/supply chains do not differ significantly, except in the final stages of sub systems and product/systems. This gave us the confidence to develop a single blueprint document that could be relevant across a range of different application areas for photonics technologies.

The production of these documents led to the final output of the project, a tool that would enable a match-making B2B value/supply chain service.

The Prezi tool

The tool is in the form of a Prezi presentation because it is easy to use and can be embedded into different websites. This allows the outcome of project to be available and sustained well beyond the end of the project. The tool can be accessed online at http://www.fp7-aspice.eu. It provides directions for clusters on how to create successful cluster collaboration. It is deliberately generic to not limit its application to photonics clusters.

The tool highlights different stages of building cluster collaboration that are likely to lead to successes, namely:

1. Assess readiness
2. Identify opportunities
3. Create a clear collaboration strategy
4. Implement training and development
5. Identify partners
6. Start matchmaking procedure
7. Develop trust and projects
8. Implement projects
9. Measure success
10. Sustain the networks

Each step is briefly described and most importantly, practical examples and guidelines are given as well as references to the relevant ASPICE reports.

To test the tool matchmaking events were organised based on H2020 calls around the topics of healthcare and safety across a large range of clusters. One was solely addressing photonics communities, inviting a large number of clusters without specific cluster engagement. The second event, closely aligned to the ASPICE tool, was targeted at cross sector communities: photonics and forensics with three clusters involved representing the UK photonics and forensics community and non-UK photonics communities. The second event also resulted in more direct interactions between organisations and follow-on activities. The result of the experiment supports the conclusion that following the steps and advice of the ASPICE Prezi tool may lead to a more successful outcome in cluster collaboration.

4. Main S & T Results and Foregrounds

Potential Economic and Social Impacts

The outcome of work packages and deliverables achieved in the ASPICE project will have the following impacts:

1. Economic

   - The matchmaking tools and their incorporation into the Prezi format has never been carried out for assisting clusters before. The approach adopted and developed by the team offers an easy to follow mechanism for clusters to partner better with other clusters to achieve better internationalisation within their organisation.
   - The matchmaking tools provide an alternative regional perspective to research and innovation in a key enabling technology. The tools extract value for the Smart Specialisation Platform and the clustercollaboration.eu resource.
   - Increased collaboration between EU photonic clusters will stimulate new product development with their member SMEs, which will generate new job positions and strengthen European competition in the world market. It may also lead to joint developments new technologies between European companies, which in return will increase/maintain competitiveness of European photonics sectors in the global market.
   - Cluster collaboration will also focus resource along the Regional Smart Specialisation programme because it will enable companies to use resource in other regions in Europe to their benefit.
   - The precise study of the value chains developed by ASPICE, tracing gaps and points of high added value could be a strong leverage tool for Photonic clusters and new SMEs, to enable them to maximise their production agenda into a key area of the market minimising supply risks and maximising profits.

2. Social

   - The suggested networking approaches and utilisation of EEN will help clusters and other users of the developed tools to enhance their ability to engage with potential new partners.
   - The face-to-face matchmaking tools promote simple strategies for enhanced interregional cooperation based on business roaming agreements and roundtable discussions.
   - After 3 ASPICE workshops we can declare (using our consortium experience and feedback received from participants) that EU photonic clusters know each other better, and have established new contacts that will facilitate this collaboration in the future. Additionally, the ASPICE consortium has attracted attention from national and European level politicians and governments due to the concept and importance of photonic clusters and their collaboration at international levels.
   - APSICE has focussed on European societal needs, namely an aging population and secure food supply as well as air quality. ASPICE has established cluster - value/supply chain heat maps which clusters and companies could use to identify potential networks where they might find partners for joint developments of products that will address those societal needs.
   - The implementations of the results of ASPICE by related Photonic, Health and Safety/Security Clusters can catalyse commercialisation time of valuable technologies into a horizontal and vertical markets that primarily targets oppressive social needs.

5. Project Overview

The project involved the work packages contained within Figure 1, the progress for each of the work packages follows this figure.

Work package number	Work package Title
1	Best Practices in Photonic Innovation Clusters and Platforms
2	Value Chain Leverage in Photonics for 'Healthcare in an Aging Society'
3	Value Chain Leverage in Photonics for 'Safety & Security for Europe's citizens'
4	Advanced Processes and Tools for Implementing Photonics Clusters Co-operation
5	Photonics Value/Supply Chain Matchmaking Service
6	Dissemination
7	Project Management

Figure 1 – ASPICE work packages

Work Package 1 - Best Practices in Photonics Innovation Clusters and Platforms

This work package delivered a survey of photonic innovation clusters and platforms across Europe, a reference guide of best practices and thus gives a basic input for the other work packages of the project. The 3 objectives from this section of work were to:

- Create a database of photonic clusters and key contacts across Europe
- Survey these clusters to discover best practices
- From this survey produce a priority list of these best practices to be shared with all clusters.

Starting with a table-top research on the basis of existing lists and databases, an ASPICE database draft was developed. Taking into account the project´s perspective, the database includes three different kinds of clusters:

- Clusters in the field of Healthcare
- Clusters in the field of Safety and Security
- Photonic clusters.

After validation and exchange, this research initially gave the team 100 networks from Healthcare, 9 networks in the field of security and 44 Photonic networks from 27 European countries. Particular attention was paid to partners using photonic technologies as a key solution provider in the fields of Healthcare, and Safety and Security, and as a result 13 clusters were removed from the ASPICE database as their technology areas were too unrelated for this project. An interactive cluster map can be found on the ASPICE website http://www.fp7-aspice.eu/results.aspx

One crucial indicator in the database was to identify strong clusters, thus enabling the ASPICE team to give confidential feedback to clusters on areas they might want to look to improve in the future, targeting specific weaknesses. Measuring a variety of different characteristics for each cluster to include maturity, level of cluster activities, website profile, international activities, etc. ASPICE were able to deliver a robust (albeit confidential) overview of the photonic clusters across Europe. The completed database now serves as the basis for further inquiries for other work packages in the project. The results of the cluster excellence analysis were presented in an anonymous format at the ASPICE workshop in October 2013.

Full details of the methods used can be found in the second deliverable for this work package, Deliverable D1.2 “Methodology and tools” which describes the methods and tools for cluster mapping and identification of best practices in cluster actions and collaborations. This deliverable serves as a guideline for the identification of methodologies to identify best practices in collaboration between European photonic innovation clusters, especially those with key competencies in Healthcare, in the context of an Aging Society, and Safety, specifically focusing on food safety and air/gas monitoring.

One of the most important outcomes of the project is the identification, the promotion and the dissemination of best practices for transnational collaborations along the value chains in the fields of healthcare, food safety and air/gas monitoring.

The final deliverable (deliverable D1.3) for these work packages was a “Reference guide on best practices in Photonics Innovation Clusters and Platforms”. This guide covers three areas:

- Identification of best practices
- Promotion of best practices
- Dissemination of best practices

The best practices identified have been presented using the Cluster Internationalisation Journey concept developed under the PRO INNO Europe initiative in the TACTICS (Transnational Alliance of Clusters Towards Improved Cooperation Support) project. This project uses the concept of a journey to outline the steps a cluster needs to undertake in order to successfully engage in cluster collaboration. Under each of these steps we have listed the best practices identified in ASPICE and appropriate to that stage of the journey. Details are shown below in Figure 2.

The adoption of the logical flow of Figure 2 increases coherence with previous studies, while directing the efforts of the ASPICE consortium.

Figure 2 – International Cluster Cooperation – The Journey

Work Packages 2 and 3 - Value chain leverage in 'Photonics for Healthcare in an Aging Society' and 'Safety & Security for Europe's citizens'

These work packages set the foundation for cooperation between clusters active in life sciences, health, safety and security. These work packages include:

- Definition of the scope and boundaries
- Analysis of the applications and markets
- Questionnaire and list of targets
- Value/supply chains and cluster mapping analysis
- Opportunities for cooperation.

Both work packages are described below together – after an initial attempt to work on each topic individually, the ASPICE consortium learnt that using the same methodology for both topic areas was far more fruitful.

Scope and boundaries

Photonics for healthcare is a large area with many different applicable technologies. The scope and boundary task developed a framework for WP2 activities. Quite early in the programme the consortium agreed to concentrate on few technologies that fitted certain criteria, for example:

- Photonics needs to be essential to the technologies
- That it is an important technology for Europe
- That it addresses the five most important illnesses and conditions in an aging society in Europe.

We studied this subject comprehensively from technology and societal needs. We composed a report and proposed that this provided a solid basis for the next tasks.

An extensive initial scoping was executed on Safety and Security for Europe's citizens, however it was concluded that security would be a difficult area in which to establish cluster collaborations due to its inherent information restrictions/closed communities. A recommendation was accepted to focus the scope on the application of photonics to food safety and air quality / gas monitoring. The scope and boundaries of these two areas were defined as follows:

- Food safety: from agriculture activities to food distribution via food process activities
- Air and gas monitoring: urban air quality monitoring, indoor air quality, industrial gas monitoring, fine particles detection

Analysis of Applications and Market

We identified key photonic technologies for our identified sectors for which we would also establish the value/supply chain. The following tasks were undertaken:

1. Categorisation of photonic technologies
2. Establishment of how they are used to diagnose/treat key diseases (for Healthcare) and in the food safety and air & gas monitoring communities
3. Determination of the market size and market growth
4. Identification of technology strength in Europe.

This data was used in a weighted matrix to select key technologies. We concluded that the data was difficult to access; some related data could possibly be obtained through expensive professional market reports, though these were not pursued using the limited resources of the project and the generic character of the overviews of markets. An internal method was developed using the network and expertise available to the ASPICE partners. This method first identified the key challenges, and then the relevant technologies – particularly for healthcare this was not an easy task, as the opportunities for photonics are not readily perceivable for many medical complaints. This led to the creation of a matrix on which the discussions were continued in this task.

With cluster mapping in mind, each ASPICE consortium partner identified photonic technologies from the list that are important to their cluster or region, as well as technologies that are strong in Europe. We then used this information to map the supply and value chains for these technologies.

Healthcare

Key findings from the analysis are:

1. The main chronic diseases that impact Europe's aging population are:
    - Cardiovascular diseases
    - Cancer
    - Neuropsychiatric Diseases e.g. Alzheimer's, Parkinson's.
    - Diabetes
    - Low Vision.
2. The key photonic technologies that will address one or more of the above diseases are:
    - Multimodal and optical medical imaging technologies
    - Biomarkers used for imaging
    - Lasers and light technologies for surgery, manufacture of implants, UV sterilisation and therapeutic applications
    - Communication technologies for e-Health.
3. The key European photonics technologies are:
    - Optical sensor technologies
    - Medical imaging technology,
    - Laser technologies.

We identified two technologies that were present within networks of the ASPICE consortium and we selected those for the value chain and cluster mapping analysis.

These technologies were:

- Optical Medical Imaging Technologies
- Optical Sensing Technologies.

Safety and Security

An extensive initial scoping exercise was executed on Safety and Security for Europe's citizens, with the topics below being investigated:

- Airport security (THz and multiwaveband imaging)
- Explosive detection
- Air surveillance
- Camera surveillance
- Biometric Identity Management Systems
- Mobile traffic management
- Automotive safety – advanced driver assistance
- Nuclear safety
- Fire Detection
- Border surveillance
- Food safety
- Water surveillance
- Document protection
- Gas detection.

However, it was concluded that security would be a difficult area in which to establish cluster collaborations due to its inherent information restrictions / closed communities. A recommendation was accepted to focus the scope on the application of photonics to food safety and air quality / gas monitoring. The scope and boundaries of these two areas are defined as follows:

- Food safety: from agriculture activities to food distribution via food process activities
- Air and gas monitoring: urban air quality monitoring, indoor air quality, industrial gas monitoring, fine particles detection.

In the aftermath of this decision, food safety and traceability erupted as a major concern for Europe's citizens and national governments, and the EU is seeking to put in place robust food safety procedures and the ability to identify easily and quickly the traceability of food from the "farm to the fork". Europe designated 2013 as "year of air" with the EU's two most important environment directives, "ambient air quality" and "national emissions ceiling", being revised within the next 12 months, so the refinement of scope was timely.

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Air quality is concerned with the presence of particulates, chemicals and bacteriological contaminants in the environment and the impact they have on humans, other living organisms and our natural / built environment. The prime focus in the task was on exterior air quality. In Europe there is stringent legislation in place regarding the levels of contamination primarily with regard to exterior air, therefore it is essential that the presence of contaminants is monitored and controlled. Photonics has a major role to play in achieving this through a wide variety of techniques that detect and measure the contaminants. Exterior air quality can be segmented into 3 areas:

- Industrial and greenhouse gases
- Ambient air
- Source emissions.

Photonics based equipment will be used in these air monitoring systems and will employ techniques such as fluorescence, spectroscopy, LIDAR, IR imaging and fibre optic sensing Photonic technologies are most relevant to automatic and continuous monitoring instruments, efforts were concentrated on exterior air value chains with a focus on Continuous Emission Monitoring Solutions.

Questionnaire and list of targets

One of the deliverables for work packages 2 and 3 was to develop a questionnaire to help map the clusters. The questionnaire was sent out to the clusters identified in work package 1. The response to the questionnaire was low and incomplete. Particularly problematic was obtaining information about the number of companies operating in a particular value chain segment. The information we obtained from strong clusters was more comprehensive than from weak clusters. Eventually, we collated information by using the list of cluster members and identified their product line and target sector through company websites.

Value and Supply chain mapping

ASPICE agreed a model for the value chain, which is the model that was used by the Photonics21 European Technological Platform and illustrated within "**The Leverage Effect of Photonics Technologies**" report[1]. These value chain segments are

- R&D
- The manufacture of materials
- Components
- Systems
- End user products
- Test and manufacturing applications.

We mapped the photonic products to each segment of the value chain for optical imaging systems, food safety and air quality / gas monitoring. We identified high value-add activities and key players in Europe for each value chain segment. Part of this exercise included the creation of a list of hundreds of companies in the EU that are active in the value chain. From that, we also created a database of cluster activity for each segment and produced a map showing the activity level in each segment.

[1] THE LEVERAGE EFFECT of Photonics Technologies: the European Perspective, Photonics21,Final Report March 2011.

We concentrated on ophthalmic applications for the *Healthcare* work package because blindness is a key inhibitor for wellbeing in an aging population and because other health conditions and diseases may be detected through eye examination protocols. Ophthalmic instruments were chosen for healthcare as this

1. Is the biggest application area, and

2. Used particularly for an aging population. We have highlighted key technology and market trends as well as market barriers. This information could be used in deciding themes for cross-cluster networking activities.

We then expanded the area to make it broader than ophthalmology, and included imaging needs in research, cancer and cardiovascular diseases.

The healthcare key findings are listed below:

1. There are a few, albeit large companies, which are active in material manufacture and also produce end user products. Europe has key players in both these segments of the value chain

2. There are many companies, in particular many SMEs, who produce components and systems

3. Many companies identified in the value chain do not belong to a managed cluster

4. Many clusters are very active in optical component manufacture and in diode laser, LED and semiconductor amplifier manufacture

5. Only a few clusters are active in material manufacture (except coatings), end user device manufacture, adaptive optics, optical coherence tomography modules as well as scanning devices.

The *Safety & Security* work package objective was to identify those clusters that have real strengths at the different levels of each value/supply chain. In order to make such an analysis, we divided the work into 5 different tasks:

- The preponderance of spectroscopic technology in food safety and in air quality monitoring

- Analysing the value chains for food safety and for air quality monitoring, and identifying key challenge areas for those sectors (technological trends and market trends)

- Investigating the areas in the value chains with the highest value-add components

- Identifying where Europe has particular strength in the value chain but also a great potential to grow

- Mapping the cluster strengths in the value chains.

We discovered that Europe is quite active in food safety testing as well as in air quality monitoring. Both segments continue to grow with more stringent regulations (in food and air) and increased consumer awareness and demands for traceability (food).

In conclusion, the areas in the value chains where suggested cooperation could be developed with four or more clusters are:

Manufacturing of materials	Coatings
Manufacturing of Components	Image sensors and detectors Laser diodes and LEDs Fibre Optics Lenses, Mirrors, Filters
Manufacturing of Systems	Optical Assemblies Lasers and Fibre lasers Interferometers, Spectrometers
Final User Products	Spectroscopy
Application domains	Food Safety Air quality monitoring

Opportunities for cooperation

The final area of these two work packages was to produce a guide on how to establish cluster collaboration for a specific theme and based on the value/supply chains.

This document provides context on how the collaboration will fit into an overall development of open clusters and we gave specific advice on some pitfalls in the development. Key points that need to be addressed have been specifically drawn out in this document.

Seven steps were identified to foster cluster collaboration:

1. Identify application areas that have a significant need for technology innovation
2. Establish market needs and growth potential. The need for new partners arises when there is a drive to new technologies that have immature value/supply chains. Links to clusters and other organisations that operate in the selected markets should be sought to help in identifying market needs.
3. Identify technologies that address market needs and that have the highest potential of success.
4. Establish photonics technologies within a value chain. Areas such as sales and marketing, distribution are not part of an industry value chain but R&D activities are. The proposed value chain for photonics is the following:

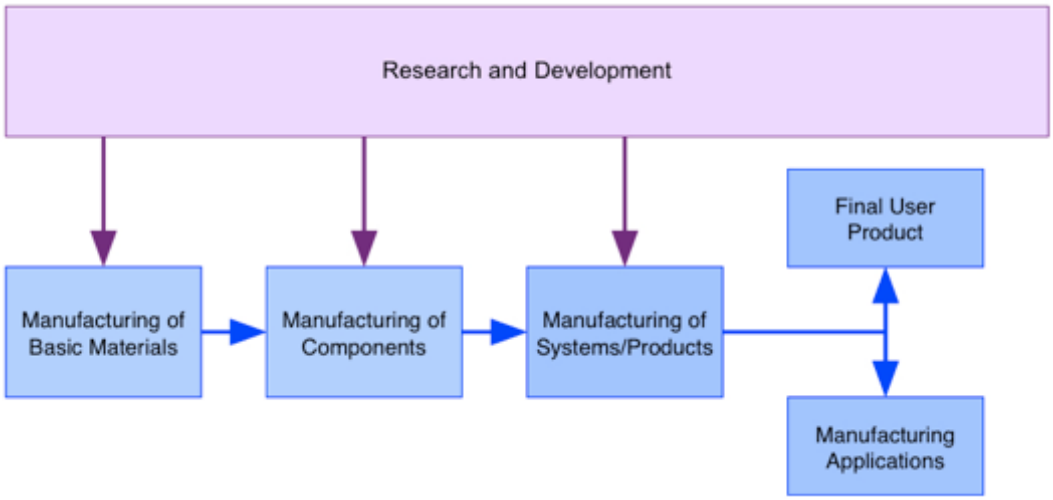


Figure 3: Proposed value chain for photonics

5. Establish cluster strengths and gaps in a value chain. The methodology used to count the number of companies that are active in each segment. A relatively high number of companies indicate cluster strength, at least one company in the segment means cluster is active in the value chain. No company present in a segment shows a gap in the value chain. We used a table, with the value chain segments in columns and companies in rows.
6. Identify clusters that complement the gaps in a value chain. To identify clusters to cooperate with, we asked selected clusters to fill in the same templates and send back information about the number of companies. This information was transferred into a table, highlighting very easily where clusters are active in the value chain.

Cluster	Manufacturing of Materials					Manufacturing of Components					Manufacturing of Systems					Manufacturing of Final User Products					Application				
	Material 1	Material 2	Material 3	Material 4	Material 5	Component 1	Component 2	Component 3	Component 4	Component 5	System 1	System 2	System 3	System 4	System 5	Product 1	Product 2	Product 3	Product 4	Product 5	Application 1	Application 2	Application 3	Application 4	Application 5
Cluster 1	0	0	0	0	0	0	3	2	1	4	2	6	5	1	3	3	1	3	1	0	0	0	0	0	0
Cluster 2	0	1	0	0	0	1	0	1	0	2	1	4	2	1	0	0	0	0	0	1	0	0	0	0	0
Cluster 3	0	0	0	2	3	2	6	10	0	5	5	8	7	1	8	1	9	0	1	4	1	1	0	4	0
Cluster 4	0	1	0	0	0	0	0	0	1	1	0	1	0	0	3	0	0	0	0	0	0	0	0	1	0
Cluster 5	0	0	0	0	0	2	3	3	0	2	2	9	8	1	2	2	0	0	0	1	1	1	1	3	0
Cluster 6	0	0	0	0	0	0	2	0	1	0	0	5	1	0	2	0	1	0	0	0	0	0	0	2	0
Cluster 7	0	0	0	0	0	0	0	0	0	3	4	1	1	0	2	0	1	1	0	0	0	0	0	0	0
Cluster 8	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	2	0
Cluster 9	0	0	0	0	0	0	1	0	0	1	3	2	1	0	0	0	1	0	0	0	0	0	1	0	0

Figure 4: Illustration of template used for cluster information gathering

7. Initiate contact/collaboration. The last step was to initiate cluster cooperation, which is the main objective of ASPICE's work package 5. As part of work package 4, the project partners have set up matchmaking tools and methodology to develop cluster cooperation.

Work Package 4 - Advanced processes and Tools for implementing Photonic Cluster Collaboration

The main objective of Work Package 4 (WP4) is practical engagement of cluster and platform representatives and other relevant stakeholders into a dialogue in order to ensure the 'translation' of the reference guide and the value/supply chain profiles into actionable plans for embedding the more suitable practices into the European Research Area, and to inform the policy makers at both regional and European levels.

A second questionnaire was developed focusing on the practical aspects of cluster collaboration and was sent to the cluster database developed in the first work package. The feedback from this questionnaire, along with the input from ASPICE partners lead to the first workshop being developed to look at the following areas:

- Challenges in collaboration
- Strategies for value chain matchmaking through cluster collaboration
- Exploration of best practices in cluster collaboration
- Actions to encourage fluid collaboration

More than 30% of existing European cluster representatives attended the workshop in Paris in October 2012, and their opinion and suggestions together with answers to specific questions were obtained. With information from the first survey questionnaire and from the Consultation workshop, the consortium obtained further input toward key success factors.

Development of Tools for value chain matchmaking

A report was written that reviewed and summarised the two ASPICE value chains on healthcare and Safety & Security, combining the information and results provided by work packages 1, 2, 3 and the first ASPICE consultation workshop, matching the best practices and Key Success factors of inter-cluster collaboration through value chain matchmaking. As part of this report, a comprehensive collaboration agreement template was prepared to facilitate interaction at an international level between clusters that takes into account cluster members' concerns for privacy and confidentiality, but enables collaboration through open innovation.

The value chain matchmaking process is targeted primarily towards international cluster collaboration. The developed tool together with ASPICE consortium services will help companies to quickly find their European collaborators and thus accelerate innovation. Managed clusters will drive this process by providing a common interface and knowledge of their members. Such a matchmaking service requires an expanded form of the normal technological value chain.

In the figure below, the ASPICE value chain is presented, developed specifically for facilitating and promoting cluster collaboration at a European level. Key contact points are included in this value chain and are generally defined by the ASPICE project as: "*European regional photonics cluster with a proven network, relevant companies and/or R&D organisations related with different parts of analysed value chains*".

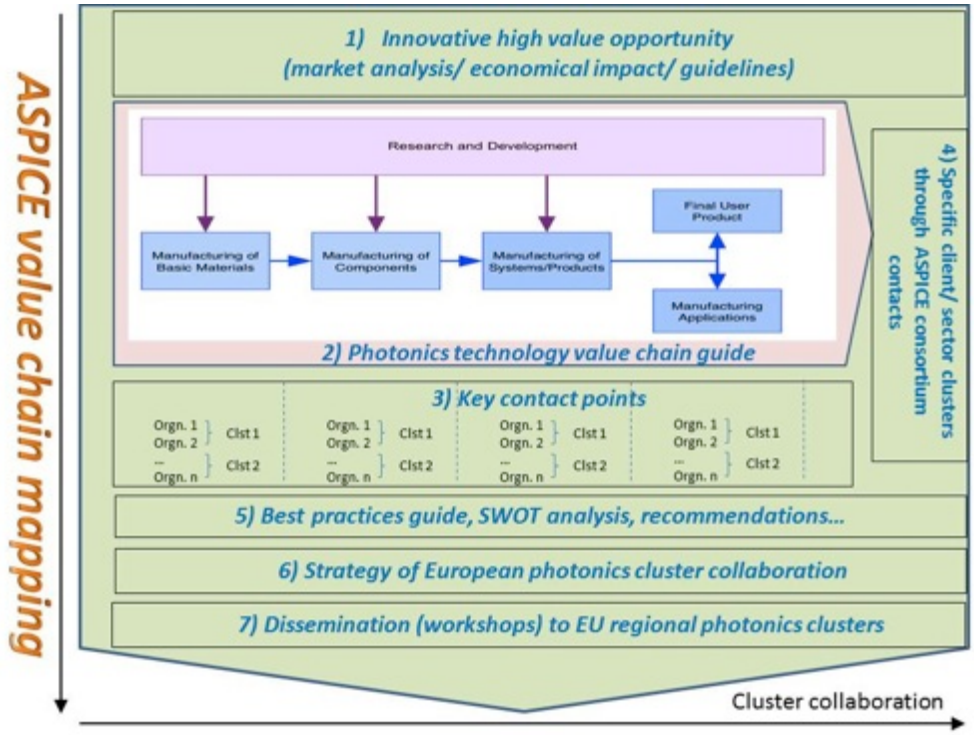


Figure 5: ASPICE value chain mapping

Workshops

ASPICE organised 3 workshops in total. The first, in Paris in October 2012 has already been mentioned. Two additional workshops to disseminate results of the project and more importantly, promote collaboration based on value-chains and high-value opportunities were also run, one in Paris in October 2013, and the final workshop in Brussels in April 2014. Both of these workshops coincided with larger exhibitions to enable cluster managers to make the best value for their time.

Workshop 2, in Paris in October 2013, was split into informative and interactive parts. During the first part two topics were discussed:

1. High value opportunities for photonic clusters/technologies – presentations from European Cluster Excellence Initiative, Clustercollaboration.eu platform and Enterprise Europe Network;

2. Strategies for cluster collaboration in Europe – ASPICE analysis of photonics clusters´ readiness for international collaboration and interim strategy document presentation.

The second part of the workshop was aimed at the collection of feedback from attendees about the ASPICE strategy and possible services to clusters to be provided by the project.

Attendees were split into four groups covering different topics of interest:

1. Online matchmaking tools
2. Cluster to cluster matchmaking
3. Event based matchmaking
4. Demonstrating matchmaking through EU programmes.

The inputs from attendees at the workshops were used for further development of ASPICE services and final strategy documents.

This event was filmed and this can be viewed via the following link: https://vimeo.com/79681976

The final workshop was held on the 15-16th April 2014. A booth at the SPIE Photonics Europe exhibition was contracted for the dissemination of the project results and workshop organisation. During the two days of exhibition the project team disseminated information about ASPICE´s results to the European photonics community as well as organising two specific events about international collaboration in two ASPICE value chains

Participants highlighted their exact collaboration needs related to their market targets, size and dynamics, the difficulties for matchmaking in their regions and exchanged comments on the ASPICE matchmaking tools developed so far. Later, a networking session took place where participants had a chance to introduce themselves and any project or partner needs. This session was a great opportunity to make new contacts to identify possible collaborations in EU projects.

Strategy documents

A final strategy document was produced as the last part of this work package that suggested different paths for international photonics and end user cluster collaboration. The strategy suggests steps and approach of how to:

1. Evaluate if a cluster organisation is ready for international collaboration
2. Analyse the environment and identify the right partners for this collaboration
3. What actions should be done to promote and get positive results for cluster member SMEs from such partnerships.

Work Package 5 - Photonics Value/Supply chain matchmaking service

Design of value/supply chain services

Many tools were developed and identified that would benefit cluster managers throughout the previous work packages. It was deemed as advantageous that these tools could be housed in one location and delivered in a manner that was easy to follow and applicable to cluster managers, regardless of the maturity or readiness of the cluster. Fundamental to this work package was the need to develop a legacy for the efforts of the project beyond the funding period to ensure the sustainability of the project.

Various tools were looked at to develop a matchmaking service, with ASPICE settling on a tool based in the Prezi. Prezi is frequently the tool of choice for projects and topics that showcase a process or sequence of items, which fits well with the outputs of the ASPICE project. It allowed us to present the objectives, results and outputs of the project in a logical sequence and include printable documents as tools and guidelines to help the user gain more from our project should they wish, allowing users to pick and choose the sections of the tool that are most applicable to their needs.

The guidelines developed within the ASPICE Prezi tool were kept deliberately generic so that it can apply to cluster and platform managers, EU project officers, policy makers and company CEOs, but can also have an application for other projects and to users outside of photonics which will further the sustainability of the project post August 2014.

The Prezi tool involves the following steps and can be found at http://www.fp7-aspice.eu:

1. Assess readiness
2. Identify opportunities
3. Create strategy and action plan
4. Start matchmaking process
5. Develop trust and projects
6. Implement projects
7. Measure success
8. Sustain the networks

Figure 6. ASPICE roadmap for European cluster collaboration represented using the Prezi tool

Moderation of value/supply chains service

The emphasis within this element of the work package was in developing a sustainable method that would still be applicable and accessible at the end of the ASPICE project.

The first version of the Prezi tool was developed and trialled at the event in 3rd ASPICE Cluster workshop held in Brussels on 15th and 16th April 2014. Face-to-face discussions with individual cluster managers were held in order to assist them in cluster collaboration by using the tool. Two topics from future H2020 calls that cover the two ASPICE topics were chosen to provide a focus for assessing the tools for collaboration: namely: call PHC11-2015 "*Development of new diagnostic tools and technologies: in vivo medical imaging technologies*" and ICT 28-2015: Cross-cutting ICT KETs "*Innovation Actions: ICT-KET integrated platforms for the healthcare and food sectors*"

Uptake on the face-to-face discussions was lower than anticipated but provided us with a good assessment of the Prezi tool and suggestions and modifications of the tool that would be of benefit to the cluster managers that trialled it. The matchmaking tools and our development of the Prezi tool were also introduced in the "Finding Partners for Horizon 2020" workshop at SPIE Photonics Europe.

Assessment of service acceptance and effectiveness

The Prezi tool has been assessed by key stakeholders, cluster managers and other contacts involved in photonics. The effectiveness of the tool set is better appreciated in face-to-face meetings or 1-to-1 telephone conversations with the user, as this allows better focus for what the user needs from the tools. The tool set has been generally well received and initial feedback suggesting improvements have already been implemented.

On the whole the feedback of the tool was that the guidance was well received. The case study examples were really insightful in that it provided good evidence for how the matchmaking tools identified could be of direct benefit in particular to an end-user looking for a cluster that would be complementary to them now or in the future. Highlights from the trial;

- The tool would be used to help develop an internal strategy for a cluster
- The tool is a bench mark for how a good cluster should work
- The tool is a roadmap with clear directions for developing and improving cluster collaboration.

The tool will be kept live at **http://www.fp7-aspice.eu** post project closure and any users needing support will be able to contact the ASPICE consortia members, as ambassadors for the tool, for further support or guidance on using the tool ensuring sustainability of what has been developed.

Work Package 6 - Dissemination Activities

Dissemination Strategy Outline

A detailed Dissemination Strategy was developed at the outset of the project. This strategy included:

- "What": Which type of material and results to be disseminated
- "Why": The reasoning and impact of disseminated information
- "To Whom": selecting the audience for ASPICE
- "When": Frequency of information disclosure and dissemination
- "How": Dissemination tools
- "Metrics": Quantifying dissemination efficiency and impact of results

Throughout the ASPICE project we have carried out the following dissemination activities:

1. ASPICE project aims, scope, deliverables and the intended approach for the project work
2. Progress reports or outputs from deliverables

3. Regular newsletters produced on a quarterly basis
4. Guidance and cluster assistance tools
5. Presentations and matchmaking support
6. Workshops and cluster visits

Website and all relevant contact details

The project's website was launched in November 2011 and contain regularly updated information about the project and items of interest. The website can be found at http://www.fp7-aspice.eu/. The ASPICE website remain live until November 2016.

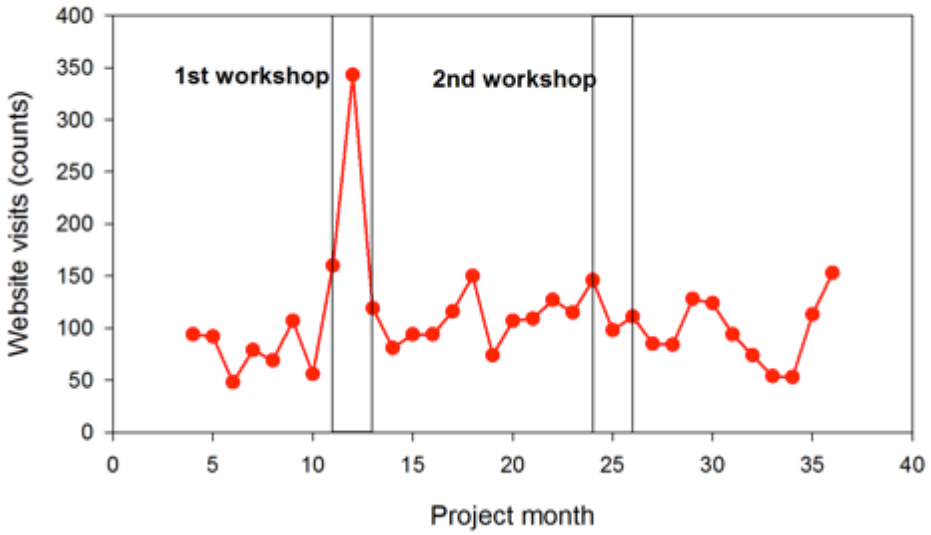
The ASPICE logo was developed

Figure 7. ASPICE logo

The homepage contains the project logo and the logos giving acknowledgment of the funding from the European commission. The home page contains our developed Prezi tool and a description of how to use it and includes links to the following pages:

- Consortium – lists all the partners involved in the project
- Work packages – provides a summary of the 7 work packages within the project
- Results-Reports – provides a photonics cluster map and the deliverables for the project
- Events – gives an overview of the key events involving the ASPICE consortium
- Publications – lists the publications produced as a result of the project
- Media – contains links to presentations from key events and workshops
- Links – provides links to relevant projects or organisations
- Newsletter – contains pdf versions of all the newsletters produced throughout the project
- Contacts – gives details of the project manager and administrator
- Social media – links to twitter and LinkedIn.

Website traffic has been monitored throughout the project as shown in Figure 8.



Following the development of the Prezi tool, this has now been added to the front of the website. The tool can easily be updated by one of the ASPICE team, and can simply be embedded in other websites, meaning any updates will filter through automatically.

Additionally, accounts were set up social media sites including LinkedIn, Twitter and Flickr.

- https://www.linkedin.com/groups/ASPICE-4210094
- https://twitter.com/ASPICE1
- https://www.flickr.com/photos/secpho/sets/72157632430979471/

Quarterly Newsletter

The ASPICE newsletter was issued periodically every 3 months on the project website, via social media promotion on our Twitter and LinkedIn pages, e-shots to our registered subscribers to the newsletter and in hard copy at selected events and workshops. The newsletter contained a variety of topics including:

- Project news and updates
- Progress of project
- Key dates for ASPICE events and other relevant community events
- Interviews with key photonics experts and cluster managers
- Overview and outcome of workshops
- Local cluster presentations
- News
- Contact details for the project

Project Leaflet

A two-page, colour, A4 leaflet was designed and developed to describe the needs of ASPICE project.

Reaching the media

The final piece of work for this work package was to ensure the project reached the media. ASPICE managed to secure a number of press releases, and produced videos of the first 2 workshops, including interviews with key photonic personnel which can be found on the ASPICE website http://www.fp7-aspice.eu/media.aspx

6. Exploitation of Results

There is a willingness of all of the consortia members to further exploit the tools developed within this project. The establishment of the Prezi tool was not completed until the final phase of the project and the team would have liked more time to carry out further assessment of the effectiveness and application of the tools in real examples. With this in mind the team have all agreed to further the dissemination and uptake of the Prezi and indeed the matchmaking tools it contains in the future.

Exploitation will be achieved by:

- Attending and presenting at events to disseminate the outputs of our innovative tool set to the benefit of cluster managers and other interested users
- One-to-one meetings with like minded partners and the demonstration of the tools
- Targeted events with funding calls such as Horizon2020 and assisting clusters or businesses in their travel to regions of interest.

A coordination workshop for European Photonics clusters was held on the 9th September 2014 in London, which was a dedicated workshop building on the work done on the ASPICE project. The workshop organised by the Knowledge Transfer Network under the guidance of ESP Central Ltd, on the Horizon 2020 call on Security "Mobile, remotely controlled technologies to examine a crime scene in case of an accident or a terrorist attack involving CBRNE material", was in one of ASPICE project's key thematic topic areas.

This workshop has resulted in the request for a like-minded event to be held in Berlin in early 2015, which should encourage more cross European collaboration. The ASPICE team will continue to work together to help attract and support cluster managers and SME's in attending this event and will support and initiate similar events when specific applicable funding calls to the photonics community arise.

Wroclaw Research Centre EIT+ has tested the Prezi tool with the Silesian nanotechnology cluster, automotive cluster and life-science cluster, and will continue to feedback this information to adjust the Prezi tool if required.

Opticsvalley will continue to reference the project to local financiers, including the local and regional public authorities and policy makers; ensuring the work remains at the forefront of their thinking about collaboration opportunities.

NUI Galway will target the further development of its cluster model through partnerships partly identified by Smart Specialisation and through a new industry facing MSc in Key Enabling Technologies.

The entire ASPICE team recognise the usefulness of the developed matchmaking tools and the embedded Prezi and will use the tool in their internal organisations to help build collaborations or when supporting other clusters in the future in 1-to-1 meetings.

Conclusion

The foundation for cluster collaborations has been laid with the ASPICE project, addressing the needs for cluster collaboration in Europe. Over the three years, ASPICE has brought cluster managers together regularly and helped build relationships, whilst breaking through barriers that either frustrated interaction, or delayed collaboration between partners due to dissimilar interests, size and dynamics. These relationships will be useful to continue the work that ASPICE has started. It would be good however, if there was a means for a large and well moderated group of photonic cluster managers to meet regularly to encourage cluster collaborations, especially since these depend on personal interactions and trust. In addition, it is vital that clusters representing end-users of the technology are involved.

In summary, the ASPICE project has looked at different elements that enhance cluster collaboration: cluster excellence, value/supply chain structure and the gaps and high value-add points in the supply chains, methods and tools for enabling cluster collaboration and finally, testing and improving and sustaining these tools. We found that all these elements are important to initiate projects between clusters.

In addition to this, ASPICE has provided a platform for photonics clusters to meet regularly, which enabled trust building and has resulted in cluster collaboration. These types of projects are important to enable trans-European collaboration. Collaboration between clusters are a means of engaging with SMEs who may be left out of European activities because of their limited reach.

The most valuable outcomes from the ASPICE project are:

- Prezi tool
- Heat maps of cluster engagement in value chain
- Method of checking cluster excellence
- List of clusters
- Value chains structure
- Photonics cluster brought together by facilitated networking to bring about new collaborative discussions and exchanges during the ASPICE workshops
- Cluster manager awareness about different cluster collaboration programs and projects

The ASPICE project has enabled clusters to make stronger connections and it will most certainly lead to further cluster collaboration.