Brussels, 23 June 2017

COST 026/17

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "European network for the promotion of portable, affordable and simple analytical platforms" (PortASAP) CA16215**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action European network for the promotion of portable, affordable and simple analytical platforms approved by the Committee of Senior Officials through written procedure on 23 June 2017.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA16215
EUROPEAN NETWORK FOR THE PROMOTION OF PORTABLE, AFFORDABLE AND SIMPLE ANALYTICAL PLATFORMS (PortASAP)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. “Rules for Participation in and Implementation of COST Activities” (COST 132/14);
b. “COST Action Proposal Submission, Evaluation, Selection and Approval” (COST 133/14);
c. “COST Action Management, Monitoring and Final Assessment” (COST 134/14);
d. “COST International Cooperation and Specific Organisations Participation” (COST 135/14).

The main aim and objective of the Action is to develop and promote low-cost instruments and open-source hardware (OSH) capable of sensitive chemical analysis in specific areas and applications where the use of complex laboratory-based instrumentation is not the desired option. This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 64 million in 2016.

The MoU will enter into force once at least five (5) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14.

OVERVIEW

Summary

Research in separation science is a thriving field with dedicated journals and conferences. This research area is dominated by the so-called “big scientific instruments”, which allowed multiple breakthroughs in health, forensics, pollution or agri/food. However, the high cost of such instruments and the need for skilled professionals to operate them are limiting their use to a few social and economic spheres of society. Modern separation techniques are no longer limited to large instrumentation, with numerous studies demonstrating the possibility of achieving fast and efficient analysis using low-cost devices. Such tools would be highly beneficial to SMEs and small organisations that do not have the financial and human resources to afford big and expensive instruments. It is therefore of economic and societal interest to facilitate and promote a wider use of such analyticals platforms. Having low budget organisations in mind, such instruments should be affordable and simple to use, allowing their utilisation by inexpert staff. Ideally, they should also be portable allowing their use on site/in the field and be easily carried around.

The portASAP Cost Action (European Network for the Promotion of PORTable, Affordable and Simple Analytical Platforms) aims to work toward this goal by involving scientists working in separation sciences, engineers, chemometricians and other scientific fields, with end-users without expertise in analytical chemistry and instrument manufacturers. PortASAP will provide a platform where analytical needs in applied areas can be matched with expertise. It will also provide formation and promote awareness regarding the potential of low-cost analytical techniques.

Areas of Expertise Relevant for the Action	**Keywords**
● Chemical sciences: Analytical chemistry ● Chemical sciences: Chemical instrumentation ● Chemical sciences: Electrochemistry, electrodialysis, microfluidics, sensors ● Chemical sciences: Spectroscopic and spectrometric techniques	● Lab-on-a-chip ● Capillary electrophoresis ● Forensic ● Agri/food ● Hardware

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

<u>Research Coordination</u>

● To coordinate intersectoral, international and interdisciplinary studies in complex environments to test and validate OSH tools. This objective will involve citizen science initiatives (i.e. water quality in the The Venetian Lagoon and Irish loughs).

● To provide detailed reports on existing open-source hardware and their field of application and assess their limitations. this will be done by maintaining a database of open-source hardware, to present and demonstrate their fabrication (video tutorials) and to validate each instrument with interlaboratory studies.

● To identify the areas in need of significant scientific or technologic advancement.

● To stimulate the creation of new open-source hardware relevant to chemical analysis.

<u>Capacity Building</u>

● To become a recognised Pan-European platform at the crossroads of SMEs, end-users, multidisciplinary analytical scientists, engineers and instrument manufacturers.

● To encourage research facilities and SMEs to use open-source hardware.

● To structure and develop small consortia able to apply or develop OSH via public-private partnerships

and research and development proposals (H2020), leveraging further funds to build upon PortASAP initial objectives.
● To attract and facilitate the mobility and the multidisciplinary training among the different protagonists of the Action, during which attention will be drawn to maximise the benefits for all participants.

1) S&T EXCELLENCE

A) CHALLENGE

I) DESCRIPTION OF THE CHALLENGE (MAIN AIM)

Chemical Analysis is a complex research field that is pertinent to the monitoring, detection and determination of compounds in almost every major sector. Applications span from agri/food and pharmaceutical manufacture to environmental analysis and forensics.

Over the past decades, separation and detection of target compounds have been performed using large and bulky laboratory based instruments costing from a few thousand to millions of euros. Benchtop instrumentation is a very dynamic field with constant new developments allowing users to set new limits in forensic analysis, air and water quality standards, food analysis and much more. Nonetheless, much of analytical instrumentation is not only expensive but can also be difficult to operate, requiring specialised skills and training, which often precludes its use by micro, small and medium-sized enterprises (SMEs) and small governmental or non-governmental organisations (N)GOs. Such instruments often require dedicated facilities, further increasing the installation and operational costs, limiting the range of analysis, delaying the response or even decreasing the reliability of the analysis due to possible sample degradation or contamination during transport. Over the past two decades, there has been a growing need for highly flexible, robust and low-cost portable systems that also allow field measurements and real time (in-situ) monitoring, and are capable of fast and sensitive analysis, which are however as versatile and functional as the more expensive laboratory-based equipment. Such mobile systems not only offer a significant cost reduction but also provide exciting possibilities for connection to smart infrastructures, providing up to date and real-time information. Low-cost instrumentation is a field with a tremendous potential for research organisations, SMEs and civil society. In the past decade, microfluidic platforms, chemical sensors and biosensors were successfully developed. However, because of the substantial development and productions cost, those tools were only adopted in areas that require enough analysis to justify industrial scale production.

Additive manufacturing (3D printing) is becoming widely available allowing anyone to manufacture highly complex objects at very low cost. 3D printing is not only increasingly present in industry and research facilities but also in many households. The production cost of 3D printed objects is extremely low; additive manufacturing is particularly suitable to design prototype or in niche markets where expected sell does not justify large-scale manufacturing. Moreover, low-cost and the “fun factor” of 3D printing favoured the emergence of a community of “makers” that develop new objects using 3D printing in an Open Source attitude. In hardware, this led to the Open-Source Hardware (OSH) concept; those consist of physical artefacts of technology where all information necessary to replicate it (CAD files, mechanical drawings, integrated circuit layout…) are publicly available. OSH philosophy facilitates user’s feedback and innovation, as well as the adoption of new technology by society. Many examples highlighted that Open-Source Software and Open-Source Hardware is not necessarily in conflict with economic interest. The is perfectly exemplified by Linux, an open source operating system, that is now used by many companies around the world, including IBM, Google or Amazon. OSH is attracting much attention as a mean to produce affordable labware for research facilities (Nature (2014) doi:10.1038/505618d; Nature Photonic (2014) doi:10.1038/nphoton.2014.241; Nature (2016) doi:10.1038/531147a; Nature (2016) doi:10.1038/532313d). Not only OSH can be used to better equip research centres, but the peer-review approach that is inherent in open source allows to highlight possible instrumental flaws that are normally hidden with proprietary hardware. OSH for labware was popularised by Dr J. Pearce´s book (Elsevier, 2013), 'Open-Source Lab, how to build your own hardware and reduce research cost'. Quoting Dr Pearce ("Laboratory equipment: Cut costs with open-source hardware", Nature 2014), "Federal funding agencies could join forces to fund open-source scientific hardware to accelerate its development. A free online database of tested and validated tools should be set up, and governments should give preference to funding such hardware purchases." The PortASAP Action aims to work toward this goal for chemical analysis by (1) comparing and validating existing OSH with traditional analytical instrumentations, (2) promoting OSH tools in industrial and societal contexts and (3) contributing to the development of new hardware.

The PortASAP will be a unique platform for sharing expertise and offer educative elements for PhD students and researchers in early stages of their career. The key focus of the Action is to promote the emergence of small consortia which can develop relevant analytical solutions to meet some of the European societal challenges defined by the H2020 framework (especially in environmental and climate change issues, in health, demographic change and wellbeing, food security, sustainable agriculture and forestry, marine, maritime and inland water research, in the advanced material processing and in the bio-economy). These groups will target specific areas and applications where the use of complex laboratory-based instrumentation is not the desired option. Thus, this Action will favour networking based on the development and exchange of know-how and expertise, and actively help participants to apply for Horizon 2020 calls or to promote the formation of spin-offs to realise the full potential of low-cost portable instrumentations.

II) RELEVANCE AND TIMELINESS

From pregnancy tests to glucometers, from food labelling to water pollution and doping, analytical devices are an integral part of modern life. They allow us to understand and control our environment as well as rationalise decisions in industry, health or environmental settings. Rising government spending on pharmaceutical R&D in emerging nations, increasing public and private life science R&D expenditure, growing food safety concerns, and progressing drug discovery and clinical diagnostics, are feeding the demand for analytical instruments from many sectors. However, the high cost of instruments and the need for skilled professionals are factors limiting applications for SMEs, small (N)GOs or unskilled individuals. A democratisation of functional, versatile and affordable analytical tools will have a profound beneficial effect on European competitiveness, security and wellbeing for the population. For instance, a potential application will be in the agri/food sector where polyphenol and amino acid fingerprinting could be used to improve the organoleptic and ageing quality of wine and beer as well as the inherent benefits of their nutraceuticals. In environmental pollution, the availability of selective and sensitive analytical tools for governmental, non-governmental organisations or even citizens are extremely helpful in correctly evaluating the critical contaminants and areas of exposure, which are the basic parameters for the development of environmental risk assessment studies.

The Open-Source Lab initiative demonstrates that the combination of open-source 3D printing and open-source microcontrollers running on free software enables scientists, engineers, and lab personnel in every discipline to develop powerful research tools at unprecedented low cost. One of the key features in the Open-Source Lab initiative is the use of open source licensing allowing anyone to use, test and modify the design. Examples of a wide range of open-source labware (e.g. centrifuges, pipette holders, stands, pipettes) can be found in open repositories (GitHub, Appropedia.org/Open-source_Lab or opensourcelaboratory.com for example). Complex analytical tools start to be published (Open-Source Photometric System for Enzymatic Nitrate Quantification, Micro Free-Flow Electrophoresis Device, and Raman Spectrometer). Such affordable tools are highly relevant in today's economic context. While low-cost analytical devices should not necessarily be open source, an open approach encourages collaborative design, promoting interactions with society and favouring multidisciplinary and intersectoral collaboration. Open access is compatible with commercial applications; it has the potential to help spread technological innovation. Open Source hardware will also contribute to many of the current priorities of the H2020 Work Programme, including Open Science, Science with and for Society and many of the Societal Challenges (Health, demographic change and well-being; Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy; Climate action, environment, resource efficiency and raw materials; Secure societies - Protecting freedom and security of Europe and its citizens).

B) SPECIFIC OBJECTIVES

I) RESEARCH COORDINATION OBJECTIVES

The core research coordination objectives are 1) to create a transnational network allowing multidisciplinary scientists to work alongside end-users towards novel, selective, sensitive affordable and portable analytical solutions, 2) to adapt analytical techniques and paradigms to current needs and constraints and 3) to promote the design and use of modern analytical tools in Europe by SMEs. The Action would not only facilitate inspirational networking of pioneers but would also assure the growth of the scientific strength of the work panel and promote the role of the Action. The following specific research coordination objectives are planned:

1. **To coordinate intersectoral, international and interdisciplinary studies in complex environments.** The analytical tools will be tested in a societal and economic setting of importance for members of the COST Countries. This includes assessment of the water quality in the Venetian lagoon, monitoring of over the counter drugs in European water bodies, and drug counterfeit in developing countries, for example. Such studies will allow assessing OSH analytical capabilities in real environments as well as the need for information technologies (data transmission), data analysis (chemometrics) or software.

2. **To provide detailed reports on existing OSH and their field of application and assess their limitations.** One of the key objectives is to maintain a database of open-source hardware, to present and demonstrate their fabrication (video tutorials) and to validate each instrument with interlaboratory studies

3. **To identify the areas in need of significant scientific or technologic advancement.**

4. **To stimulate the creation of new OSH relevant to chemical analysis.**

II) CAPACITY-BUILDING OBJECTIVES

The core capacity-building objective is to gather a critical mass of interacting participants all over Europe. Specific objectives will be:

1. **To become a recognised Pan-European platform** at the crossroads of SMEs, end-users, multidisciplinary analytical scientists, engineers and instrument manufacturers. Dissemination actions will be particularly necessary to fulfil this

objective and will aim to: 1) raise awareness of the potential of analytical science in many areas and 2) attract new scientists and engineers interested in finding practical applications to modern problems. This will involve dissemination of outputs in scientific publications, websites, social networks, and conferences, and participate and be closely associated with European structuring initiatives such as those promoted by the European Technology Platforms

2. **To encourage research facilities and SMEs to use OSH**.

3. **To structure and develop small consortia** able to apply or develop OSH via public-private partnerships and research and development proposals (H2020), leveraging further funds to build upon PortASAP initial objectives.

4. **To attract and facilitate the mobility and the multidisciplinary training among the different protagonists of the Action**, during which attention will be drawn to maximize the benefits for all participants. This objective target more specifically early career investigator (ECI - up to 8 years from the date of obtaining the PhD/doctorate) by promoting trans-national and trans-sectorial mobility. This will develop strong links between industry and academia at an international level and promote a trans-boundary transfer of knowledge.

C) PROGRESS BEYOND THE STATE-OF-THE-ART AND INNOVATION POTENTIAL

I) DESCRIPTION OF THE STATE-OF-THE-ART

Open source hardware (OSH) for laboratory equipment is already having a significant impact in Education by engaging students in creative, multidisciplinary projects. Graduate students from five departments from the University of Cambridge (UK) are involved in the Open Microscope project that is aiming to design a scientific-grade microscope for US$800, less than 5% of the cost of a commercial alternative. A group from the University of Akron (Ohio, United States) designed an UVvis spectrophotometer using 3D printed parts and a smartphone to be used as teaching tools. If a smartphone is available, such a simple design costs less than 10€, and is not only of great interest as teaching help but can also have important applications in societal challenges. UV-vis spectroscopy and colorimetry are two of the main analytical tools in many areas such as food science, environmental analysis and health.

Within the past three years, OSHs have been developed to target specifically significant problems. A group led by Professor Wittbrodt from Michigan Technological University (Houghton, USA) developed an Open-Source Photometric System for Enzymatic Nitrate Quantification for an estimated cost of US$65, 15% of the price of a commercial alternative. Thus, the device can allow widespread testing for nitrate with significant environmental repercussion. An open source mobile water quality-testing platform that allows measuring the biochemical oxygen demand and turbidity has been proposed by the group of Wijnen from Michigan Technological University (Houghton, USA), the instrument costing 10% of a commercial alternative.

Professor Gallegos, from the University of Illinois (USA), used smartphones and 3D printed parts to build detection instruments for label-free photonic crystal biosensors. Various smartphone uses for immunoassay analysis have been reported in the literature. For example, the group of Zangheri from the University of Bologna (Italy) focussed on cortisol in saliva using chemiluminescence. The group of Coskun (University of California, USA) used a smartphone to measure Albumin in urine using fluorescent assays. The group of Laksanasopin (Columbia University) devised a smartphone-based enzyme-linked immunosorbent assay (ELISA) for diagnosis of infectious diseases (HIV antibody, treponemal-specific antibody for syphilis, and nontreponemal antibody for active syphilis infection). In this device, the smartphone not only was used as a detector but also as the power source.

Additive manufacturing has also been used to print a micro free-flow electrophoresis device by the group of Sarah Anciaux from the University of Minnesota (USA) that succeeded in separating fluorescein from rhodamine 110 and 123. In this case, the detection was done using fluorescence imaging. The cost of the device was estimated at around US$0.20. Other microfluidic devices were also 3D printed opening the possibility of design full analytic platform that can incorporate sample preparation, separation and detection. A mobile phone can be used as a detector, microcomputer, power source and for wireless data transmission.

The innovation potential is demonstrated in the development of a new network with specific characteristics (enabling the use of new business models for adaptive technical solutions) through using existing well-known technologies (3D printing, smartphones, sensors connectivity). The combination of a smartphone and 3D printed parts is clearly the winning partnership to design affordable analytical platforms. Such tools can be invaluable in many socioeconomic areas, as well as in developing countries. In this respect, their design as an Open-Source Hardware will facilitate their adoption by a wider community, foster innovation and creativity and participate in the re-appropriation of science by citizens. Such approach also ensures that tools can be developed independently of perceived economic incentives (application in orphan disease for example). The aim of this Action is to promote the use of those tools as a reliable and affordable solution.

II) PROGRESS BEYOND THE STATE-OF-THE-ART

The PortASAP Action is very ambitious in its interdisciplinary and cross-sectorial nature. The original network cluster stakeholders involved in chemical instrumentation and analysis, information technologies, big data, electronic engineering, environmental engineering, food science. This exchange of information between those areas is crucial for the success of this Action but will generate significant progress in various areas. Breakthroughs are expected in:

1. **Information technology (IT), data mining and chemometrics**. Low-cost smartphone-based UV-vis spectrometers are already functional. Those will be tested and improved for field experiments. For such simple instruments, it will be particularly interesting to send data to remote computing facilities where they can be made available to everyone. The connection of simple UV-vis spectra with chemometrics tools can be particularly attractive. For example, an Argentina team differentiated Sauvignon Blanc Wines by UV spectroscopy and chemometrics (e.g. principal component analysis, cluster analysis). Such approach would greatly beneficiate from a normalised data format that can be transmitted to a computing centre where they will be available in Open Access. For this, it will be necessary to develop applications and software. Such a data repository will also allow data mining allowing to extract meaningful correlations or accurate mapping.

2. **Simplification of analysis, sampling and sample preparation**. Cheap, portable solutions allowing selective extraction and sensitive detection of target analytes from complex matrices will be a priority. Microfluidic platforms would be excellent candidates since they can allow for integration of a wide range of analytical operations such as sample clean up, immobilisation, derivatisation, pre-concentration, and separation. Solid phase microextraction can also be a very interesting possibility.

3. **Development of new OSH using specific technologies.** This Action should also promote alternative detection and separation approaches. For example, near-infrared spectroscopy could be an interesting approach. LEDs can be used in this range, and the spectra are often more specific than UV-vis spectra, facilitating chemometrics methods. NIR radiations, unlike UV, are also harmless.

III) INNOVATION IN TACKLING THE CHALLENGE

Analytical chemistry is becoming increasingly important in our modern society. Cheap, easy to manufacture and portable instruments will profoundly modify society in the next decades. For SMEs, modern analytic devices are a key technological advantage by providing faster analysis at a reduced cost. However, many SMEs do not have the resources to follow the speed of development in this area and are left behind.

PortASAP aims to address this need, by promoting the use and development of portable, affordable and simple analytical platforms, and at the same time encourage a direct communication between SMEs, scientists and instrument manufacturers. The PortASAP Action is built upon the work of many researchers, some already part of the Action that designed alternative low-cost solutions for sampling, sample treatment and pre-concentration, separation or detection. The main challenge of this Action is to integrate these different steps in a single robust and durable platform whose main features are efficiency, sensitivity and that it can be used without advanced training. The solution will be on a case by case basis, depending not only on the field of application but also the critical performances required for a given application.

The partnership includes multidisciplinary fields, which are fundamental for related technology advance in portable and low-cost analytical platforms for environmental and health applications. The combination of analytical chemistry, engineering, separation science, microfluidics, electronics and programming and so forth will allow tackling the challenge. The variety of expertise available within the network will also enable devising a series of potential solutions that can be used in a case by case basis depending on the end-user needs and requirements. Moreover, the PortASAP Action, by providing a management and discussion platform between the different disciplines of engineering and science, will create a synergy to tackle new issues. The direct outcome will be the development of specialised analytical tools able to cope successfully with the identified problems. It is one of the goals of the Action to promote commercial applications. Thus, intellectual property rights between members will be addressed at a very early stage.

D) ADDED VALUE OF NETWORKING

I) IN RELATION TO THE CHALLENGE

Networking and collaboration are at the core of the Open Source Hardware movement with dedicated websites (http://www.oshwa.org/ - the Open Source Hardware Association), web tutorials and repositories (GitHub, Thingiverse and Appropedia). Those initiatives aggregate a dynamic and creative community of makers that are passionate about collaborative and open projects. Despite the tremendous potential of OSH, those initiatives remain anecdotic outside the maker’s community. This is probably due to 1) the multidisciplinary nature of OSH that requires competencies in electronic, design and programming and 2) the lack of confidence toward DIY hardware in contrast to commercial alternatives.

The PortASAP Action will tackle those issues in the specific area of analytical chemistry. Workshops, tutorials and training schools will allow initiating many researchers and citizens to

OSH with simple yet powerful designs (smartphone based spectrometer, for example). The multidisciplinary expertise required for this Action is already reflected in the network of proposers. While the core of the team consists of chemical engineers and scientists with strong competencies in instrumentation, experts in IT, electronics and optics are also present. The network also encompasses end-users in the form of SMEs, NGOs and citizen initiatives that urgently need such tools. The Action also aims to raise awareness on the potential of OSH in chemistry as well as to participate in a better education in science. 3D printers and DIY projects are particularly attractive to the young generation and allow them to learn invaluable skills in engineering, programming and chemistry. PortASAP Action can be used as platform for promoting Science Technology Engineering and Mathematics (STEM) education and philosophy. For this reason, training schools that target undergraduate and graduate students will be organised. Those could take the form of hackathons, intensive sprint-like events lasting for a few days, to tackle specific societal problems.

Undoubtedly, the required level of communication will not happen without a COST Action. In this case, the COST Action will also promote a mobility and multidisciplinary training environment that will particularly benefit ECI. PortASAP will encourage a closer relationship between the academic and non-academic communities. In this regard, networking-based research is mandatory to achieve the proposed objectives and a COST framework is essential to integrate the current capabilities of the many groups that will be involved. The Action Challenge will require combined efforts made by different groups as the objectives are beyond the possible research of a single group.

Moreover, the strong connections and collaborations established within the Action will certainly continue beyond its duration and will result in the submission of proposals for Horizon 2020 calls and other international programmes, such that the capacity building and other benefits derived from the funding for the network provided by the scheme will be long lasting.

II) IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

The Action is highly innovative and aims to inspire, drive and promote Open Source Hardware for chemical analysis. Chemical instrumentation is of high importance for EU excellence and competitiveness. This is proven by the large number of funded projects within FP7 and H2020 funding platforms. For example, in health and related areas, the projects MULTISENSE CHIP (FP7), DiaChemo (H2020), NAMDIAT REAM (FP7), positive (FP7) and MODUL (FP6) proposed microfluidic, LoC and/or portable based analytical platforms as analytical solutions. Similar approaches were proposed in forensics (CRIM-TRACK, FP7; ROSFEN, FP7; CUSTOM, FP7), agro-food (HEATSENS_S, H2020; ENVIGUARD, FP7; LOVE-FOOD, FP7) or pollution control (RIANA, FP4; SEA-ON-A-CHIP, FP7, SENSEOCEAN, FP7). For this Action, the use of smartphones and 3D printers will allow cutting production cost significantly while having flexible instruments. The Open Source Hardware approach in this Action will allow reaching a large community of users that can participate, give feedback or use such analytical tools.
Important resources will be dedicated to network with EU and International Citizen Science Project initiatives. Those are becoming increasingly popular and cover Open Science in which citizens participate in scientific research. This Action will permit the emergence of tools allowing to collect chemical data relevant for environmental, health or food related projects. By working together with associations that aim to unit and favour citizen science (ECAS - European Citizen Science Association; OPAL – Open Air Laboratories network; citizenscience.org), the Action will allow developing useful analytical platforms.

2) IMPACT

A) EXPECTED IMPACT

I) SHORT-TERM AND LONG-TERM SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS

Short-term impact. Instrumentation is increasingly important in many areas; this Action will drive the development of low-cost alternatives. Such tools will participate to better scientific equipment in research facilities and SMEs. This will contribute to enhancing European competitiveness in many aspects.

PortASAP gathers a large community of individuals from different countries and professional sectors. Mobility within the network will provide Early Career Investigators (ECIs) with training in cutting-edge facilities and instrumentations, training schools, participation in workshops and conferences and the opportunity to reinforce the researchers' expertise, enhance their leadership skills and reach a position of professional maturity. It will increase their employability due to the experience gathered in different professional environments, added to a looked-for practicality. For the industrial partners and scientists outside the analytical field, it will allow them to stay up-to-date with modern devices that could be used in their line of work.

Long-term impact. Open Science is a global vision for the future of the society. Making results more accessible will contribute to improve science, speed-up innovation and favour economic growth. The connection of this Action with Citizen Science will contribute to a society that is better educated and more involved in tackling global problems. This Action, by developing and promoting Open Source Hardware, will provide higher transparency in scientific instrumentation as well as favour their use by the society. It will promote a better understanding of chemical instrumentation and favour emergence of a large-scale monitoring of our environment. Competing in the global, knowledge-based economy and adjusting to the digital age are long-term challenges Europe must continue to address. The high-quality STEM education training provided by PortASAP will contribute to sustained economic growth, as well as sustainable development by fuelling R&D, innovation, productivity and competitiveness.

B) MEASURES TO MAXIMISE IMPACT

I) PLAN FOR INVOLVING THE MOST RELEVANT STAKEHOLDERS

PortASAP aims to unite diverse stakeholders such as scientists and engineers working in separation science and related analytical fields, instrument manufacturers and end-users from several areas, including agro-food, forensics and environmental pollution. Currently, the consortium includes scientists with different expertise and from both genders from all over Europe, instrument manufacturers as well as non-governmental agencies. The collaboration of stakeholders from outside the analytical chemistry field should be reinforced to reach a critical mass that will trigger fruitful discussions. Policymakers, regulators and funding agencies will get the access to the latest research results, and they may support this work for specific environmental and medical control. In a first stage, traditional means of dissemination will be used, such as a dedicated website, presence in social media (Facebook, LinkedIn) and scientific production (posters and oral presentations in highly ranked international conferences, for instance). Those classical mean of dissemination will be implemented in the first year of the Action and will aim to raise awareness about the potential of open-source hardware as well as attract new stakeholders.

However, although efficient within the scientific community, such approaches have a limited impact on attracting new industry-related stakeholders. These will be reached by actively participating in meetings and events from different European Technology Platforms (ETPs).

ETPs are industry stakeholders that are recognised by the European Commission as the major players in driving innovation. Their principal activities are to encourage industries to be involved in Horizon 2020 research and innovation calls, foster partnerships with research actors for public and private entities and provide excellent networking conditions. Within the frame of the Action, one coordinator will be appointed to represent PortASAP as well as its members in various events organised by those ETPs. A specific budget will be allocated for flyers, posters and other means of dissemination. Some ETPs are of interest for this Action, such as the European Aquaculture Technology and Innovation Platform (EATIP), Food for life, Plants for the future and TPOrganics in the agro-food sector, or the European Water Platform (WssTP) in the environmental sector.

This Action will also be complemented by university-based press releases and a strong presence in conferences and related events. Industrial organisations at the local, national and international level will be targeted, and the design of a website and presence in social media will also increase our visibility and help to reach and to bring new members to our cause.

II) DISSEMINATION AND/OR EXPLOITATION PLAN

A Dissemination Officer (DO) will be appointed by the Management Committee (MC). He/she will be responsible for managing (1) the dissemination to the public, (2) the diffusion to the scientific community and non-academic professionals and (3) the exploitation of results.

1. Dissemination to the general public

Within the first three months of the Action, a logo and a website will be designed with the purpose of making PortASAP a brand with a clear and recognisable identity. Social network presences will also be created, including global platforms (Facebook, LinkedIn and Twitter) but also research oriented media (ResearchGate and Mendeley). The main tools for dissemination to the public will be articles in traditional media (newspapers, magazines), educational material and actions in partnership with science museums and schools. The communication departments of the host universities of the PortASAP members will also be used. The results will also be presented at the «Science and Technology Fair for Primary School Students», a large-scale outreach event organised on a year basis at the Technical University of Crete and attracting more than 5000 visitors. This Action will thus act as a STEM Ambassador, by contributing to the creation of new educational pathways for children.

2. Dissemination to the scientific community and non-academic professionals

Dissemination to the research community will be done via presentations at scientific meetings. Whenever relevant, members of this COST Action will be asked to display the logo of PortASAP in their presentation. Dedicated works will also be submitted to general conferences, workshops or open access scientific publications with the aim of making this COST Action known. Members of this Action will also be encouraged to participate in ETPs stakeholder events. These are the ideal location to network with industries. PortASAP will also organise dedicated conferences, which will provide an ideal setting to convey new results, ideas and concepts.

3. Exploitation of results

One of the goals of this Action is that the networking platform, workgroups, meetings and discussion lead to concrete results. Members of the Action will be encouraged to instigate or participate in Horizon 2020 research projects. Members will be supported by the organisation of project writing seminars as well as project writing brainstorming retreats. Similarly, entrepreneurship and creation of start-ups will be encouraged. Intellectual property and patent rights will be discussed at a very early stage to try to avoid problems in the future. European legal documents such as non-disclosure agreements will be available on the website and intellectual property short courses will be organised.

C) POTENTIAL FOR INNOVATION VERSUS RISK LEVEL

I) POTENTIAL FOR SCIENTIFIC, TECHNOLOGICAL AND/OR SOCIOECONOMIC INNOVATION BREAKTHROUGHS

Affordable instrumentation can have a tremendous impact in the society, allowing better and more affordable healthcare, comprehensive environmental monitoring and better citizen control of food and other products of daily consumption. The omnipresence of smartphones, even in developing countries, can solve the problem of portable light-based detectors: they can also be used as a power delivery system, computer and data transmitter. This potential is being recognised as proven by various recent private or public initiatives. For example, ASTech, a collaboration between Trajan Scientific and Medical (Trajan), the Australian Research Council (ARC) and the University of Tasmania (UTAS) was created to explore this domain.

However, chemical analysis is a very demanding sector where accuracy, precision and robustness are key concepts. It is highly important not only to demonstrate but also to convince potential users that affordable instruments can provide the same level of confidence than established techniques.

In this respect, the commitment of this Action to Open Source Hardware will permit a high level of transparency making possible relevant feedbacks from the scientific and makers communities. The connection with Citizen Science initiatives will allow intensive testing of potential tools in challenging environments.

3) IMPLEMENTATION

A) DESCRIPTION OF THE WORK PLAN

I) DESCRIPTION OF WORKING GROUPS

PortASAP Action will be undertaken by six Working Groups (WGs). Dissemination activities are also fundamental to the success of the Action and one specific WG, involving all partners, will work on dissemination and outreach activities to the scientific community as well as stakeholders, industries and end-users. The close collaboration between research groups and industries in specific WGs will allow the most promising systems and applications.

WG1. VALIDATION AND DISSEMINATION OF OPEN SOURCE HARDWARE
Objectives: Objectives of this WG is to review and promote OSH in analytical instrumentation. Participants in the WG will review existing tools, build and illustrate the process via video tutorials, and compare the instruments with commercial alternatives.

Tasks:

- Maintain and participate in open repository for OSH
- Create, maintain and enrich OSH dedicated discussion groups in ResearchGate, Mendeley, LinkedIn and others
- Organise workshops in Schools, Universities and Science Museums to promote OSH in analytical chemistry
- Organise workshops in scientific conferences
- Organise and publish interlaboratory studies to validate OSH tools
- Participate in stakeholder events organised by European Technology Platforms
- Organise a yearly conference open to anyone

Deliverables and Milestones:

- Publication of video tutorials
- Conferences proceedings
- Reports
- Summer schools and other events (Hackathon)
- Publications

Skills and expertise: Communication; Engineering; Additive manufacturing; Analytical Chemistry

WG2. INFORMATION AND COMMUNICATION TECHNOLOGY AND SOFTWARE DEVELOPMENT

Objectives: This WG will focus on everything related to information and communication technology (ICT), in particular open format for the data, apps and software, open data repository, and, if needed, cloud computing facilities.

Tasks:

- Discuss, decide and implement a common open format suitable for all data. It can be based on existing formats (e.g., JCAMP, XML) or a new format.
- Design apps and software allowing to control OSH tools and analyse and/or wirelessly send the data.
- Design and maintain a platform where data and all associated information can be freely accessed
- Discuss chemometrics and data mining tools that can be used for the Actions. Members from WG3 and WG5 should participate in the exchange.
- Communicate the importance and capabilities of ITC in analytical instrumentation to members of the network using internal seminars and Short-Term Scientific Missions

Deliverables and Milestones:

- Publication of the open common format for data
- Functional specifications document for apps and software
- Reviews on chemometrics and data mining tools that are relevant to the Action

Skills and expertise: Programming; IT; Chemometrics

WG3. FIELD TESTS AND APPLICATIONS

Objectives: Various ONGs and Citizen Science initiatives are part of this Action. They are actively looking for low-cost instrumentation that can be used by volunteers or untrained participants and thus were logical partners to this COST. They form active communities of volunteers that will be used to test the instruments in the field as well as provide feedback on the robustness and ease of use. For now, the areas of interests are air quality and water quality monitoring and pharmaceuticals (counterfeit medicine in developing countries). It is one the goals of this Action to further our collaboration with Citizen Science initiatives.

Tasks:

- Organize field testing in collaboration with Citizen Project initiatives and ONGs
- Design and analyse questionnaires for users' feedback (usability, technical problems, robustness, apps)
- Analyse data and recognise potential problems
- Link with new Citizen Projects and other large-scale group users
- Provide detail reports for WG2, 4, 5 and 6.

Deliverables and Milestones:

- Report on the field test campaigns including users' feedback
- Analysis of users' feedback and internal reports
- Publications of results

Skills and expertise: Analytical Chemistry, communication

WG4. SAMPLE TREATMENT AND MICROFLUIDIC

Objectives: Members of this WG will discuss and implement solutions to improve sensibility and sensitivity of OSHs that were reviewed in WG1. Techniques include, but are not limited to, solid phase micro-extraction, sample derivatisation (fluorescent and chemiluminescent tagging), immunoaffinity and electrodriven separations. Those techniques should either be available as a standalone OSH or integrated in a microfluidic platform. A high level of communication is expected between members of this work group and members of WG3 to devise solutions that are specific in a case by case basis. Solutions should be devised as simple tools that are suitable for untrained users. This WG will use STSM to connect with end-users and instrument manufacturers.

Tasks:

- Review existing sample preparation approaches that are easily applicable for field analysis
- Assess analytical needs of end-users in WG3
- Design simple and affordable prototypes that can be tested in WG3

Deliverables and Milestones:

- Reports
- Review and original articles
- Description of potential prototypes

Skills and expertise: Analytical Chemistry, Sample treatment; Microfluidic; Analytical Separation

WG5. NEW INSTRUMENTATION

Objectives: This WG will review results from WG 1 to 4 and initiate a reflection on new OSH tools that will overcome current limitations. Ideas will stem from the identification of problems and active participation of members with very diverse expertise (i.e. chemical engineering, instrumentation, ICT, polymer, electronics, additive manufacturing, photonics, chemometrics).

Tasks:

- Collect and analyse all reports from previous WGs
- Discuss possible innovative solutions that use the common expertise of the PortASAP network
- Design and test prototypes.

Deliverables and Milestones:

- Reports
- Description of potential prototypes

Skills and expertise: Analytical Chemistry; Chemical Engineering; Instrumentation; Optics; Engineering; CAD; Polymers; Additive manufacturing

WG6. EXPLOITATION OF RESULTS.

Objectives: members from this WG will promote and help the members of the consortium to apply for competitive European funds and other international research and innovation grants to further develop prototypes and solutions of interest. They will also deal with intellectual property issues and the commercialisation of results, ensuring that all possible outcomes are maximised. They will help in the dissemination of results to reach a global audience as well as decision makers.

Tasks:

- Organise project-writing seminars
- Provide up to date information on funding opportunities
- Organise entrepreneurship workshops and seminars
- Provide legal advices
- Participate to ETP stakeholder events to further the Action connection with SMEs and decision makers

Deliverables and Milestones:

- Submission of research projects
- Poster and oral presentation in ETP
- Flyers and brochures to present the Action

Skills and expertise: Interpersonal Communication Skills; Grant proposal writing; Laws and regulations

II) GANTT DIAGRAM

	Year 1	Year 2	Year 3	Year 4
	MANAGEMENT AND GLOBAL EVENTS			
- Kick-of meetings	x			
- MC meeting	x	x	x	x
- General meeting	x	x	x	x
	WORK GROUPS AND SPECIFIC EVENTS			
WG1. Validation and dissemination of open source hardware				
- Video Tutorials				
- Workshops or summer schools	x	x x	x	x x
- Publications	x	x	x	
WG2. ICT and software development				
- Common data format	x			
- Apps design and updates				
- Data repository	x			
WG3. Field test and applications				
- Users' feedback analysis		x	x	x
- Data analysis		x	x	x
WG4. Sample treatment and microfluidic				
- Review of current litterture		x		x
- Prototypes		x	x	x
WG5. New instrumentation				
- Prototype			x	x
WG6. Exploitations of results				
- project-writing seminars		x	x	x
- Grants proposal				

III) PERT CHART (OPTIONAL)

IV) RISK AND CONTINGENCY PLANS

The Managing Committee will be responsible for assessing the progress of the Action yearly. If necessary, they will take corrective and incentive measures to ensure the success of the PortASAP Action within the expected timeline. While it is possible that unexpected problems arise during the project, an indicative list of risks with possible measures is as follows:

- **Risk 1. Failing to grow in number or diversity**. The success of the Action requires a steady growth of the network and a substantial involvement from non-academics. Gender equality and early stage researchers' involvement are also necessary. The communication and dissemination tools will be carefully monitored to verify that they target the right public.

- **Risk 2. Low involvement at all levels and/or low outcomes**. If the Action suffers from little involvement from small partners, proactive measures will be taken to increase interest toward the Action. This can include additional seminars, conferences or new proposal for funds. Extra MC meeting will, in this case, be organised to follow the issue.

- **Risk 3. No intersectorial and/or disciplinary crossover**. The intersectoral and multidisciplinary nature of the network should be fully exploited for the benefit of all. However, there is a risk of poor crossover between the different areas of expertise; this will be detrimental to the success of the Action. If this is the case, motivating measures will be taken. For example, STSM will be temporarily limited to the ones that show intersectional or multidisciplinary aspects.

- **Risk 4. Breach of intellectual property, confidentiality and plagiarism**. The success of the Action requires an open and dynamic discussion environment that can only be achieved via trust and mutual benefit. Proactive measures will be taken to improve awareness of IP rights, confidentiality and plagiarism. When necessary, non-disclosure agreements will be proposed between members of the Action.

B) MANAGEMENT STRUCTURES AND PROCEDURES

The organisation of the Action will respect COST policies as well as the codes of good practice of the different institutions involved. The lead partner is well equipped to coordinate and implement the Action and is supported by the institution's scientific team, secretarial staff, and financial office. The standard COST management procedures will be followed ("COST Action Management, Monitoring and Final Assessment", 2015, COST 134/14).

The day-to-day management plan will be under the responsibility of the Action Chair. A pivotal role in coordination and steering of this COST Action will be played by the first Management Committee (MC), which will direct and structure the Working Groups. The MC will also monitor and organise the progress and the collaborative interactions in the network.

The MC will meet in the initial stage of the Action to discuss and approve several rules, namely those related to the participation, open access policy and associated funds, confidentiality and intellectual property. The different rules will be implemented considering the good practices of all stakeholders' organisations. The priority actions for the first year will be discussed and the Chair and Vice-Chair elected. Two other positions will also be filled: the Liaison Officer (LO), responsible for managing the information between the WGs and the MC, and the Dissemination Officer (DO). The LO will be the first contact with the Scientific Committee (SC) and will embrace the supervision of the progress reports at months 18 and 36. The DO will oversee maintaining a calendar of events and conferences attractive to the Action and find members that can represent PortASAP in those events. He/she will supervise the dissemination of the COST goals and progress and will provide a substantial basis for discussion, allowing flexibility and possible adaptation of the scientific programme to the most recent developments and research outputs.

This structure is based on the initial size of the Action. The management structure will change, if required, to be better suited to the additional needs that may arise during the Action. While it is important to maintain face-to-face meetings between members of the SC, some contacts will be done using video conferences to optimise time and costs. All members of the COST will meet at least once a year in a PortASAP event, in a different country every time. This will be the occasion for MC and WG meetings, networking and presentation of the Action's progress and results. WGs will also present a yearly report to follow the progress of the Action.

C) NETWORK AS A WHOLE

At its initial stage, the PortASAP network consists of 31 proposers from 16 different COST Countries' institutions; 44% of those are COST Inclusiveness Target Countries, including the country of the main proposer. The following COST Countries have shown their interest and joined the network or have actively participated in the drafting of the Action proposal: Bulgaria, Czech Republic, Estonia, Finland, France, Greece, Ireland, Italy, Latvia, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland and United Kingdom. Fourteen of the secondary proposers are early career investigators and nearly 44% are female, who will have leading roles in critical tasks of the project. Women participation will be enhanced during the recruitment stage and encouraged through the project outreach activities.

This project draws together top class researchers from a variety of disciplines, spanning from chemical science (e.g., chemical engineering, instrumentation, chemometrics, polymers), environmental engineering, electrical engineering, electronic engineering, information engineering, environmental engineering and biological sciences. Twenty members work in higher education, three are from governmental Organisations, one from a non-governmental organisation and seven from SMEs. The synergy between the different disciplines of engineering and science will provide a systematic outcome in evidence-based practice. The clear motivation for setting up this interdisciplinary project was the nature of the subject and the need to offer smart and cost-effective analytical platforms to the real world. The presence of governmental and non-governmental organisations will provide, from the initial stage of the Action, challenging applications with high societal relevance. The presence of seven SMEs will ensure a fast development and commercialisation of the most suitable solutions.