Brussels, 24 March 2020

COST 048/20

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "European Network for assuring food integrity using non-destructive spectral sensors" (SensorFINT) CA19145**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action European Network for assuring food integrity using non-destructive spectral sensors approved by the Committee of Senior Officials through written procedure on 24 March 2020.

Funded by the Horizon 2020 Framework Programme of the European Union

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA19145
EUROPEAN NETWORK FOR ASSURING FOOD INTEGRITY USING NON-DESTRUCTIVE SPECTRAL SENSORS (SensorFINT)

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 REV2);
b. “COST Action Proposal Submission, Evaluation, Selection and Approval” (COST 133/14 REV);
c. “COST Action Management, Monitoring and Final Assessment” (COST 134/14 REV2);
d. “COST International Cooperation and Specific Organisations Participation” (COST 135/14 REV).

The main aim and objective of the Action is to create a multidisciplinary group of experts in NDSS, from COST and non-COST countries, involving researchers and industry, that can accelerate its implementation within the food industry and can disseminate knowledge about these emerging and innovative technologies and their application for the real-time in situ control of critical food integrity attributes. 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 56 million in 2019.

The MoU will enter into force once at least seven (7) 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 REV2.

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 REV2.

TECHNICAL ANNEX

OVERVIEW

Summary

There is an increasing need for the food industry to provide information on their products in order to satisfy quality standards and to protect their products from food fraud. Recent developments in technology, and advances in big data analytics, provide the opportunity for step-changes that can transform the role of food integrity assurance from one of just strictly conformance to one that addresses a wide range of business critical concerns, including quality, safety and authenticity solutions. Non-destructive Spectroscopic Sensors (NDSS), such as NIR Spectroscopy, Fluorescence, Raman or Hyperspectral imaging, enable rapid, non-destructive and environmentally-safe assessment of multiple parameters in a variety of food products. Most applications of these technologies in the food industry are made at-line. Industry requires them to be deployed *in situ* and preferably on-line for full process control over the entire food chain. These requirements introduce constraints on sensor design and calibration development which do not normally apply to laboratory-based instruments. Long-term stability of instruments, robustness of the calibrations, sensor integration in production environments, transferability of data and the building of real-time decision-making systems are critical issues to be considered. SensorFINT will create a vibrant network, combining experience in research, manufacture, training and technology transfer in relation to NDSS. The Action will operate by developing generic solutions to existing and emerging problems in non-invasive food process control building an "smart food control system" as well as developing a cadre of well-trained young researchers who will convert scientific results into a reality that matches industrial needs.

Areas of Expertise Relevant for the Action	**Keywords**
● Other engineering and technologies: Databases, data mining, data curation, computational modelling for food science and technology ● Chemical sciences: Spectroscopic and spectrometric techniques ● Physical Sciences: Optics, non-linear optics (theory) ● Biological sciences: Physical chemistry of biological systems ● Animal and dairy science: Food chemistry	● Spectral sensors, big data and ICTs ● Smart food control system/Non destructive in situ analysis ● Food Integrity/ Food Fraud ● Multivariate processing and modelling ● Decision Support Systems and real-time decision making

Specific Objectives

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

Research Coordination

● Determination of key points and critical parameters for quality, safety, authenticity and performance control at each stage of the food production process in some selected food industries, particularly focused on high quality and high added-value European food products (meat products, olive oil and fruit & vegetable).

● Evaluation of miniaturised, low-cost, portable or handheld spectral sensor systems with reference to their performance compared to laboratory instrumentation.

● Development, fine-tuning, validation and implementation of in situ control methodologies based on NDSS to meet the rigors of use in a food processing plant.

● Exploration of the potential and advantages of the combination of spectral sensors for relevant integrity issues in the agro-food sector.

● Development and evaluation of statistical and chemometric methods for real-time processing of spectra/images and prediction data at the high production line speeds.

● Development and evaluation of protocols, interfaces and software for efficient cloud-based decision support systems linked to systematic preventive approaches, decision support systems linked to the control board and other quality and safety assurance schemes.

● Innovation in the labelling systems based on ICT, providing real-time detailed information about quality, safety, production and authenticity of an individual piece of food.

Capacity Building

● Providing well-trained young researchers and professionals in new and emerging technologies, for the innovation in the food integrity and process-control, allowing the alignment of scientific progress and industrial demands.

● Fostering the exploration and implementation of new training routes and methodologies, some of them based on an e-learning environment, with the particular aim of widening career prospects of highly specialised researchers, in the development and use of innovative spectral sensor technologies for increasing the competitiveness of the European agri-food industry.

● Stimulating new ideas and innovative methodologies in an open innovation framework to address generic control problems faced by the European food industry, extrapolating and disseminating results to other industry sectors.

● Fostering the involvement of teams from less research-intensive countries across Europe, promoting their inclusiveness, through the sharing of new knowledge in NDSS generated by the other European and International partners with higher research developments.

● Ensuring the right integration, dissemination and exploitation of the knowledge and outptus from SensorFINT Action among all the research groups of interest, industry sectors and stakeholders.

TECHNICAL ANNEX

1 S&T EXCELLENCE

1.1 SOUNDNESS OF THE CHALLENGE

1.1.1 DESCRIPTION OF THE STATE-OF-THE-ART

There is an increasing need for the food industry to provide information on their products in order to satisfy quality standards and to protect their products from food fraud. Historically, producers have undervalued and under-exploited their internal quality assurance data, seeing it as of transient value. Recent developments in technology, and advances in big data analytics, provide the opportunity for step-changes that can transform the role of quality assurance from one of just strictly conformance to one that addresses a wide range of business critical concerns, including quality and authenticity solutions. Non Destructive Spectral Sensors (NDSS) combined with data analytics offer for the first time to provide cost effective, added value solutions to a range of food industry problems as well as, at the same time, opportunities for better understanding their products and ingredients.

Scientific literature and research dealing with NDSS food applications has been increasing considerably over recent years. Nevertheless, at present time, there is a large gap between scientific feasibility studies and the actual implementation of these sensors within the EU food industry.

The increasing complexity of food supply chains has provided more opportunities for food fraud, resulting in many food crises over the years (BSE-Bovine Spongiform Encephalopathy, melamine, horse meat, fipronil in eggs, etc.) which reduce the confidence of the consumers in the industry, inspectors and policy makers. These scandals have placed increased focus on developing measures to ensure the integrity of the food in the whole chain, and thereby reduce the incidences of food fraud. Consumers demand foods of high “integrity,” which is a comprehensive term for nutritive, healthy, tasty, safe, authentic, traceable, as well as ethically, safely, environment-friendly and sustainably food product. To verify integrity in marketed products it is necessary to update the current analytical and sampling control systems, through the develoment of modern and cost-effective analytical methods. This situation has forced food businesses to rethink their risk mitigation processes, especially as food fraud is opportunistic and can be difficult to detect through classical analytical methods that look for specific components in the food. A new strategy is to adopt “non targeted” methods that are able to analyse the product, and produce a food fingerprint, that can provide information on quality and authenticity. The nature of NDSS, combined with specific data processing techniques, fits perfectly with this strategy.

NDSS enable rapid, non-destructive, accurate and cost-effective analysis of large numbers of samples and the measurement of multiple parameters in a variety of products and processes. One of its main advantages is related to the large amount of products that can be analysed when it works in continuous, *in-situ* mode. Among the available spectral sensors, Near Infrared Spectroscopy (NIRS) is currently one of the most suitable for the implementation within the food industry.

The most recent developments and applications of NIRS, and of NDSS in general, are based in on-line/*in situ* analysis. Although, such analyses have obvious financial benefits — that problems can be identified before the product leaves the factory/business — its implementation is not easy. There are several factors that make implementation of NIRS applied in a non targeted way difficult. The main impediments are:

- the heterogeneity of many food matrixes.
- the existence of multiple agri-food ingredients in a single formula (sometimes more than ten in a dairy feed or at least four in a baby food for example).
- the chemical and physical variability of each ingredient caused by multiple agronomic factors such as soil, variety, irrigation, etc.
- the ingredients’ behaviour when they are heated, pressed, wet, etc.
- the perishable nature and high moisture content of some of these food products.

The complex nature of food is a challenge requiring sophisticate sampling accessories and mathematical data processing. The large variability found between the food products, in terms of different sizes, shapes, textures, composition and properties, in general, requires the development of specific and product-dedicated databases for each type of product. Nevertheless, there are common treatments, chemometric tools, technologies, procedures and ultimately ways to solve the problems encountered in the development and implementation of NDSS food solutions. SensorFINT will focus in these specific tips, recipes and generic guidelines, useful for all NDSS applications, and at the same time will develop specific applications for some products used as cases of study.

Before NDSS can be implemented as a profiling tool in the food industry, a number of key steps must be evaluated, such as the decision on the most suitable instrument/s, scan speeds, measurement distances, ratio of signal to noise, and others related to the optimal algorithms for processing the on-line spectral and imaging data. In what follows, the current knowledge and the main challenges related to NDSS and food applications - divided in the three main aspects identified as essential for this Action – are described.

1.- Instrumentation development

NDSS are extremely well suited for portable or handheld use. Their simplicity, speed, selectivity and ability to operate without sample preparation, make them ideal to be used outside the laboratory in more challenging environments. Miniaturisation of spectrometers and advances in single and multiplexed fibre-optic devices make NDSS a powerful analytical tool, when robust systems in hostile environments or flexible *in situ* and on-line measurements are required. During the last decade, several companies have exhibited prototypes and/or new miniaturised devices, which make real-time *in situ* measurements feasible and affordable. The portability of these miniaturised systems makes it feasible to apply to food quality and authentication control in a wide range of applications, e.g. milk, fruits, animal carcasses at the slaughterhouse or fish at processing plants. However, most of these miniaturised sensors and fibre-optics have been designed for process control within the pharmaceutical and chemical industries, and not for food applications where complex nature of the food matrix is a particular challenge. It is only relatively recently, that their possible implementation in real food industry situations has been recognised at a research level, but specific developments and adaptations are needed before they can be adopted by the food industry. Moreover, the industry needs to understand the benefits and opportunities that this technology can provide before it can make decisions on its implementation.

2.- NDSS fusion

NIRS, Fourier Transform (FT-NIRS), Fluorescence, Raman, Thermal and/or Time-resolved Spectroscopy are among the candidate NDSS technologies, and are becoming increasingly available, in smaller and more affordable instrumentation. Most of these methods can be combined together and, with multi-spectral imaging, enable extremely powerful sampling of the full surface of a product/product stream. The spectral data contains useful and relevant information, enabling determination in food of: chemical composition, structure, oxidation, authenticity, adulteration detection, safety issues, etc.

Often, one technique alone does not provide enough sufficient information. However, NDSS can be combined with other sensors that can provide complementary information. Hyperspectral imaging systems (HIS) combines the advantages of spectroscopy and machine vision in addressing food quality, authenticity and safety problems. HIS is capable of taking measurements in several ways and regions of the electromagnetic spectrum (NIR reflectance, Raman, fluorescence and thermal spectral regions), increasing the inspection potential. The advantage of combining information from several regions of the electromagnetic spectrum, with imaging, is that while a monochrome camera, using the visible range (the traditional technology used for fruit inspection), can produce high spatial resolution, it does not provide spectral information; however a HIS (VIS + NIR – Visible + Near Infrared) system provides a complete spectrum at each pixel location in the product sample. Here, signal processing and data management are more complex, since very large amounts of data are obtained (big data management), and the linkage of different optical sensors is challenging. In the specific case of HIS, although there is abundant scientific literature on spectral imaging (most of it coming from the remote sensing field) using the short wavelength infrared region up to 1100 nm, there is a lack of knowledge and experience of using the full NIR region up to 2500 nm to determine quality/safety/performance parameters in food process control.

3.- Data treatment and transmission

Extracting relevant information from complex, and often high-dimensional sensor signals, requires expertise and a substantial amount of work to develop quantitative and qualitative models that can be applied to unknown samples. As stated previously, the complex nature of the food matrix is more challenging in terms of developing robust models than for pharmaceutical sector. To make this technology works in the food industry, robust and accurate models are needed, which will work reproducibly across a network of instruments, thus leveraging the efforts expended in calibration development. Scientific knowledge on methodologies for building, maintaining and transferring robust calibrations exists, but their transfer in the industrial world will require further research.

Authenticity modelling, i.e. compliance with labellling, which encompasses evaluating absence of adulteration, to origin assessment, together with raw material and food process control, are issues where optimal integration of NDSS and chemometric methodologies (e.g. class modelling and multivariate process monitoring) are required to succeed. Moreover, new approaches for data processing, based on the development of conformity tests, definition of standards and deviations and the use of the spectral information to design early warning alert systems, provide additional benefits and business cases for implementing NDSS.

This Action will contribute to the two main directions which need to be undertaken to increase the level of methods standardization: 1) increasing the knowledge of basic chemometric (educational issue) and 2) dissemination of reference guidelines and best data analysis practices, in particular, concerning model validation and long term model assessment (system challenge).

The variability encountered in even one food product dictates the need for large numbers of samples to represent all possible sources of variability in calibration models. This, combined with the fact that the measurement data from a single sample is already in a multivariate form, means that another major issue impeding uptake of the technology, is the need to cope with the large amount of data that just one sensor can generate. Big data processing methodologies must be applied. There are also issues arising from the increased frequency of measurement that becomes possible with such sensors. To shift from half-hourly manual sampling and a simple control chart, to a system with multiple sensors measuring almost continuously requires an investment in ICT (Information and Communication Tecnologies) systems and, in particular, in decision-support systems. Little advice is currently offered to industrial end-users and manufacturers on how to deal with the problem of building robust multivariate models for practical use in food production. Even for the most well established NIR spectroscopy applications, there are few official guidelines. The scientific literature describes many laboratory-based feasibility studies and more recently on-line/*in situ* applications, nevertheless, the implementation level within the industry is very limited, despite the obvious advantages.

1.1.2 DESCRIPTION OF THE CHALLENGE (MAIN AIM)

Efficient analytical tools and control systems, able to be used along the entire food chain, are needed to guarantee food integrity, including safety, quality, authenticity and traceability — key aspects for EU policies and consumers interested in preventing or avoiding new food crises and frauds. The type of food frauds changes rapidly, and traditional methods are not able to detect them in routine analysis. Currently, the use of non-targeted methods — as NDSS — is being highlighted as a way to prevent a new unknown food fraud, providing a food fingerprint of a food product and that alerts the factory when that product fingerprint has been significantly changed.

Moreover, the analytical needs for the agri-food industry are linked not only to compliance with regulations, but also to the need to control their processes ”intelligent quality control”, along with knowing the variability of raw materials and the final product for increasing its competitiveness. Inaccurate or uninformative quality and safety assessment methodologies are detrimental to producers, processors and ultimately to consumers of food products. Traditional methods of analysis are too slow and expensive to facilitate adequate production control, but NDSS, such as NIRS, Raman, fluorescence or time-resolved spectroscopy, among others, and their implementation in multispectral and hyperspectral imaging formats, are ideal.

The main aim of SensorFINT COST Action is to create within Europe a multidisciplinary group of experts, from COST and non-COST countries, involving researchers and industry, in NDSS, that can accelerate its implementation within the food industry. Furthermore, it will generate and disseminate knowledge about these emerging and innovative technologies and their application for the real-time *in situ* control of critical quality, safety, authenticity and performance attributes for raw and in-process materials, i.e. in the entire food chain, allowing to increase the transfer of knowledge from academia to the industry and, therefore, to improve European food industry competitiveness.

1.2 PROGRESS BEYOND THE STATE-OF-THE-ART

1.2.1 APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE-OF-THE-ART

Some of the main challenges in NDSS for research and innovation, still unaddressed or at least, in some cases, only partially addressed, are:

- The potential of NDSS as non-targeted methods for the individual control of an item of product, providing a product fingerprint as an excellent tool for food authentication and fraud prevention.

- Integration of several spectral sensors "Fusion" (NIRS, fluorescence, Raman, etc.), especially combined with imaging systems, to solve critical issues in the agro-food sector.

- The role of NDSS for the massive sampling of bulk products and batches, highlighting one of their main advantages – not fully exploited – i.e. the possibility of reducing the sampling error and therefore the total analytical error, having a more precise answer.

- To develop and implement in the agri-food industry a ready to use analytical system based on the integration and combination of low-cost, portable and miniature NDSS and information and communication technologies (ICT) for process control and voluntary labelling, to guarantee the integrity and international image of European high added-value products.

- Development of advanced mathematical algorithms and new chemometric tools for increasing the robustness of the prediction models obtained and for instrument cloning procedures, allowing the use of the information generated in an industrial situation, and therefore taking decision in real-time through the design and development of decision support systems linked to the control board (SCADA - Supervisory Control And Data Acquisition).

- The development of interfaces linked to cloud computing and mobile applications for getting the results instantaneously, improving labelling and consumer information.

SensorFINT Action will manage the challenges related to NDSS for food industry demands, advancing in the state-of-the-art in the studied field and contributing to advance on NDSS applications joining different forces and expertise. The Action will contribute in turning innovative ideas and breakthroughs into new products, solutions and applications. Networking activities of the Action will promote the exchange of information between European and International partners, the dissemination of results and the training of young researchers. SensorFINT includes partners from some of the technologically leading countries from Europe and outside Europe, and will bring their expertise and knowledge to bear on European food industry integrity issues. The Action will address the development of specific NDSS applications adapted to each type of industry studied, answering the demand of on-line/*in situ* quality control for products and processes. NDSS will cover very many different technologies and potential applications. In fact, each NDSS technology is a full research domain and at the same time is a compendium of multiple disciplines. Therefore, the Action tackles the scientific breakthrough necessary for the fusion of NDSS for their implementation in different parts of the food chain, despite the demonstrated development of each technology separately for different food applications. In addition, SensorFINT will explore other potential technologies (Trend observatory) that are in an earlier stage of knowledge and hardware development (eg. terahertz spectroscopy, 3D cameras, etc.). By focusing on production sites rather than laboratories, SensorFINT will provide models, user interfaces and data packages that are more meaningful in terms of real food industry applications.

1.2.2 OBJECTIVES

1.2.2.1 Research Coordination Objectives

To bring the coordinated activities of the group of the scientific and technological network participants, the following Research Coordination Objectives will be achieved:

1. Determination of key points and critical parameters for quality, safety, authenticity and performance control at each stage of the food production process in some selected food industries, particularly

focused on high quality and high added-value European food products (meat products, olive oil and fruit & vegetable).

2. Evaluation of miniaturised, low-cost, portable or handheld spectral sensors systems with reference to their performance compared to laboratory instrumentation.

3. Development, fine-tuning, validation and implementation of *in situ* control methodologies based on NDSS to meet the rigors of use in a food processing plant.

4. Exploration of the potential and advantages of the combination of spectral sensors for relevant integrity issues in the agro-food sector.

5. Development and evaluation of statistical and chemometric methods for real-time processing of spectra/images and prediction data at the high production line speeds.

6. Development and evaluation of protocols, interfaces and software for efficient cloud-based decision support systems linked to systematic preventive approaches, decision support systems linked to the control board and other quality and safety assurance schemes.

7. Innovation in the labelling systems based on ICT, providing real-time detailed information about quality, safety, production and authenticity of an individual piece of food.

1.2.2.2 Capacity-building Objectives

To foster knowledge exchange and the developments expected under section 1.2.2.1, the following capacity-building objectives are:

8. Providing well-trained young researchers and professionals in new and emerging technologies, for the innovation in the food integrity and process-control, allowing the alignment of scientific progress and industrial demands.

9. Fostering the exploration and implementation of new training routes and methodologies, some of them based on an e-learning environment, with the particular aim of widening career prospects of highly specialised researchers, in the development and use of innovative spectral sensor technologies for increasing the competitiveness of the European agri-food industry.

10. Stimulating new ideas and innovative methodologies in an open innovation framework to address generic control problems faced by the European food industry, extrapolating and disseminating results to other industry sectors.

11. Fostering the involvement of teams from less research-intensive countries across Europe, promoting their inclusiveness, through the sharing of new knowledge in NDSS generated by the other European and International partners with higher research developments.

12. Ensuring the right integration, dissemination and exploitation of the knowledge and outptus from SensorFINT Action among all the research groups of interest, industry sectors and stakeholders.

2 NETWORKING EXCELLENCE

2.1 ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

2.1.1 ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

A COST Action, based on an open, growing networking philosophy, is the most suitable tool for supporting SensorFINT Action, enabling the sharing of important interdisciplinary efforts between academia and industry in research and innovation. The main topic — NDSS for food integrity issues — is very innovative and of great interest nowdays.

There is a very broad and rich body of knowledge and experience among participants of the proposed Action in several international research programs (FP5-FP7, H2020, Erasmus+, etc.) and network shemes (International Platforms, COST, etc.). However, the topic has been only partially explored in other EU projects and Cost Actions (specific ones are not cited for lack of space), but none is focused in the integral and specific approach based on NDSS described in this Action. SensorFINT will enhance synergies between research activities in on-going projects throughout Europe and, additionally, will enable development of future joint projects among the participants. The collaboration, exchange of knowledge, and practical experiences of industrial members will lead to scientific excellence in fundamental and applied research in food integrity and process control using NDSS and, consequently, in competitive projects that will contribute to the EU2020 and Horizon Europe Strategies. SensorFINT will also find synergies among existing European initiatives, such as on going projects, considering also the inspection and legislator bodies related to food integrity activities. The Action will also work closely with pan-European organizations to ensure maximum impact and complementarity.

A COST Action is the right funding mechanism to give momentum to encourage open innovation in NDSS for ensuring food integrity and food process control, to the benefit of the actual and future SensorFINT partners, since the flexibility of the structure, dynamic and nature of COST enable and promote the coming together of partners with different expertise, at different stages of the project timeline, and this will be especially useful for the Inclusiveness Target Countries or for partners that are not considered for other EU funding mechanism/programmes.

Moreover, the COST Action has other advantages over other EU funding mechanism/programmes: a) the expansion of NDSS in the food sector is severely limited by the shortage at all levels, but especially at young graduate and doctoral level, of professionals well-trained in the scientific, technological and entrepreneurship skills needed for a real food industry implementation. SensorFINT will allow many young researchers to be trained in the implementation of NDSS in a diverse range of agri-food industries. b) NDSS technology is by nature multidisciplinary, involving chemistry, physics, mathematics and computing, photonics, micro technology, ICT (Information and Communication Technologies), PAT (Process Analytical Technologies), food engineering and more. SensorFINT will join experts from all those disciplines. COST framework is the ideal mechanism for favouring the knowledge exchange between them, stimulating new ideas and innovative methodologies to address the problems faced by the European food industry c) European expertise in the design, patenting and commercialization of low cost portable instrumentation for the food industry is more limited in comparison to other international countries.

Clearly, the required level of communication requires a framework like a COST Action. Additionaly, COST Actions promote mobility and multidisciplinary training environment. The networking, strengthened by the organization of working groups, workshops and international conferences, Short-Term Scientific Missions (STSM), interaction with and visits to innovative companies, training and development for professionals as well as under- and post-graduate students in COST countries, COST Inclusiveness countries and COST Near Neighbouring countries, will initiate new scientific collaborations and knowledge exchanges between partners. For the moment, these are limited to some national/international collaborations but in small consortia of two or three partners, not enough for making a sustaible way of improvement and development in this field. Networking will add value to existing national and EU research budgets. It must be stressed that the Action partners are involved in research or technology transfer projects currently running, and they have facilities available for research in NDSS (latest generation equipments, pilot plants, labs, technicians, etc.), and this will contribute to advances in the scientific objectives of this Action.

2.2 ADDED VALUE OF NETWORKING IN IMPACT

2.2.1 SECURING THE CRITICAL MASS AND EXPERTISE

Networking is critical to achieve the objectives defined in this Action, even more taking into account that the use of NDSS for food integrity is essential for the innovation in the food industry. In particular, the exchange of knowledge, latest scientific results and technological developments among the Action partners, both from academia and industry and from COST and non-COST countries, will be critical and will also identify further research needs, enabling the development of appropriate grant applications to national and EU-funded research programmes. This will create a critical mass of research, application and dissemination capability. The Action will focus on collaboration, dissemination of current knowledge, acquisition of new knowledge, mobility of researchers (especially ECI-Early Career Investigators) and training. The backbone of the Action covers expertise on all key aspects, from theory to experimental and practical aspects of NDSS focused in the food integrity. The obvious complementary lines in the proposal are (1) NDSS instrumental expertise, (2) knowledge in food technology, processing and quality control and (3) multivariate data processing methods and decision support systems expertise. The stimulation of knowledge exchange between these three lines will unquestionably improve research and innovation in each one. Bringing together researchers from different scientific disciplines, as well as agents of the industry, will enhance a better understanding of the issues and will support the basis for future research. SMEs (Small and medium-sized enterprises) in Europe can directly benefit from this COST Action through training and knowledge exchange. Indirectly, technologies used by big companies may be filtered down to SMEs.

SensorFINT will bring together a core group of scientists and professionals (more than 20 partners) from across Cost countries from the north, south, east and west and International Partners to combine their research and development interests to generate and disseminate knowledge on NDSS which will not be covered in a similar time-frame by any other funding mechanism. This will allow the exchange of knowledge inside and beyond Europe, considering the participation from the beginning of several Inclusiveness Target Countries (ITC), and aiming for the involvement of more to enable the dissemination of the generated knowledge to less research-intensive areas.

The inclusion in the Action of participants from IPC will bring their expertise and knowledge to bear on European food integrity issues; thus their expertise in new and leading technologies NDSS will be very important to develop new approaches, providing the Action with a non-European perspective on the problems. On the other hand, participants from NNC (Near Neighbour Countries) and IPC International Partner Countries) involved in the Action will be pivotal to diffuse the results promoted by the Action in their respective countries, with the aim of helping the improvement of the local agri-food industry.

Furthermore, the network is based on a close collaboration between academia and the industry, focussing on answering to real demands of the latter. The second pillar of the network is the education and training by research of young professionals and scientists in NDSS field, promoting their mobility and exchange. Additionally, the Action will promote the involvement of young researchers, supporting the leaders as co-leaders, and women in the management activities.

2.2.2 INVOLVEMENT OF STAKEHOLDERS

The outcome of this Action will be of interest to different categories of end-users and stakeholders including universities and research institutes, big companies and SMEs related to instrument manufacturers and food production, inspection bodies, retailers, innovation stakeholders, policy makers, regulatory authorities and, finally, consumers. SensorFINT will provide an enhanced framework for cooperation of researchers, industrial partners, users and consumers of innovative solutions for NDSS, promoting the transfer of knowledge through the tasks proposed in the Action (workshop, conferences, meetings, dissemination activities, etc). The continual interaction with end-users is also ensured by the fact that some of them have already supported this COST proposal. This Action will encourage the current partners to promote the involvement of new SMEs, big companies (some of them already involved), authorities and food companies, when the Action is running. It must be highlight that companies and authorities representatives, including EC bodies, EFSA, FAO, European Technologies Platforms and other producing and trade associations will therefore invite to participate in the meetings, workshops and Training Schools. In addition, to capture the attention and invovement of the stakeholders, SensorFINT will equip the public website with relevant information available; social media nets; specific “Users Meeting Sessions” during the workshops; STSM organized to apply established techniques to industrial/societal problems, prioritising SMEs; reports and papers with the important achievements and prospective results related to the impacts and benefits of NDSS in the food sector. Finally, demonstration studies in companies interested will be performed.

2.2.3 MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

As it has been reported previously, the inclusion in the Action of International Partner Countries will bring their expertise and knowledge mainly in new and leading technologies in NDSS, and this will enhance the development of new approaches from a non-European perspective on the problems. In the other hands, the Cost members of the Action can provide the IPC with crucial information about the European food industry and the integrity requirements, usually higher than in other countries, making possible the collaboration to build together new innovative systems for assuring food integrity.

In addition, participants from IPC involved in the Action will be pivotal to diffuse the results promoted by the Action in their respective countries, with the aim of helping the improvement of the local agri-food industry. International Organitations as WHO, FAO, and specifics dedicated platforms, will be contacted to encorauge this aspect.

3 IMPACT

3.1 IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAK-THROUGHS

3.1.1 SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

SensorFINT has a great potential for the innovation of the European food industry, monitoring of products and processes through NDSS applications, including relevant breakthroughs at scientific, technological and socioeconomic level, being the unique Action and project with an integrated vision dedicated to the optimization of NDSS for fast inspection along the entire food chain. The main benefit will be at the scientific and technological level to demonstrate the feasibility of better food integrity and process control based on NDSS, enabling the increase of confidence and credibility of consumers from EU and from non-EU large potential importer countries. In addition, the Action will enable the evaluation of the exploitation capability of existing and emerging NDSS, and a rethink of our education and technology transfer structures to ensure they are fit for purpose in driving innovation in new and emerging NDSS technologies for food integrity (quality, traceability, authenticity, safety) along the whole chain. The Action has invested great efforts to include relevant scientists with expertise in NDSS from IPC, to bring their technological knowledge and point of view to our frontiers. These strategies will contribute to the strengthening of EU research and capacities, resulting in a high socioeconomic impact. Therefore, this Action is aimed both at European economic and societal needs and at scientific and technological advance.

It is difficult to estimate precisely the potential benefits from introducing NDSS for assuring food integrity and improving food process control in the European food industry, but the financial figures could be considerable. Generally speaking, the benefits of the Action will be spread over European research, inspection bodies, the food industry, instrument companies and consumers. Collaboration between the scientific parties will decrease fragmentation of research groups, enhancing cooperation within Europe and beyond to build a basis for global collaboration in NDSS for food integrity, quality, traceability and safety purposes. Direct outcomes from the Action will include the following expected impacts. In the short-term, the Action will provide:

- Identification of research needs, gaps and priorities to assure food integrity using NDSS, in particular focused on meat, olive oil and fruit products.

- Boost the volume and quality of research on NDSS in Europe.

- General tips and recipes for developing more accurate, precise and suitable applications for assuring food integrity (non dependent to the food matrix analysed) using spectral sensors (alone or in combination).

- To set up the scientific and technical specifications to extend non-invasive *in situ* NDSS to other relevant European food commodity issues according to the consumers and producers needs and in terms of applicability to small and large industries.

- Better process control systems to food manufacturers through more intensive sampling and more accurate measurement of food properties, together with the ability to measure the characteristics of food materials *in situ*, where currently it is done at-line, improving decision-making in real time. Specific applications for meat, olive oil and some selected fruit&vegetables.

- Inclusiveness of ITC and ECI in the use of the most innovative and emerging technologies for assuring food integrity.

- Training opportunities on NDSS.

- Encourage capacity building and dissemination of knowledge to all stakeholders on more efficient tools for assuring food integrity.

In the long-term, the Action will contribute to implement a new culture and demand in the area of food integrity and process control based on spectral sensors, in line with the digital transformation revolution of the food sector and the industry 4.0 concepts. This is expected to significantly improve production efficiency, set new quality standards in relation to food composition and reduce the number of complaints from consumers. It will provide industry with a cost effective solution to many of the food frauds that could potentially effect them. In addition, this will improve competitiveness and quality of European food industries, increasing consumer confidence in the integrity of European food products, both in the Europe and other international markets, as a result of an improved analytical and control regime.

In summary, SensorFINT proposes a revolution in the way to understand and perform food integrity and process control (intelligent food control), based on NDDS, providing more information and more guarantees for the consumers, and a way to increase the efficiency and the competitiveness for the industry and the European food economy.

3.2 MEASURES TO MAXIMISE IMPACT

3.2.1 KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

As it has been mention before, SensorFINT Action main goal is directly related to the creation and transfer of knowledge in the application of NDSS for food integrity and process control issues. The application of NDSS needs the joining of efforts in different topics (chemometrics, big data, food control, ICT, instrumentation developments, sampling and a big list), many of them are linked with powerful state-of-the-art technologies. The basis of the Action is the creation of shared knowledge and value for the innovation in the food industry. Moreover, the Action enables a technical platform providing guidelines and scientific information for legislators and regulatory bodies to understand what is or is not possible and to facilitate inspection tasks, trying to avoid in the future new episodes of food adulteration and fraud by implementation of extremely fast screening and non-invasive methods at several key points in the entire food chain, for example at receiving and shipping points or at the slaughterhouses. The use of NDSS as non-targeted methods will be developed and exploit, as an emerging and very novelty approach for smart control of food products and processes. From the beginning, first results will provide an effective link to bridge the gap between scientific research and industry for implementation of NDSS, and between countries (EU, non EU, ITC, IPC, etc.) in the development of NDSS specific applications and adapted devices. This will have socio-economic impacts creating opportunities for high-technology European SME in this field, make more efficient the use of the scientific know-how inside Europe through increased networking at the top level and enhance open innovation. In addition, the Action will provide well-trained young researchers in innovative and emerging technologies for food integrity and process control, through an extensive program including exchanges, workshops and training schools, allowing the alignment of scientific progress and industrial demands. STSM will potentiate the development of specific applications matching with industry demands, i.e. real applications to give solutions to existing food integrity problems. The novelty and potential of the application of NDSS for assuring food integrity may derive outstanding results that will be published in high-impact journals and patented if it is suitable. More details are given in 3.2.2 section.

3.2.2 PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

Dissemination of the results and outcomes of the Action are recognised as critical since the main aim of the Action is to build an European network of experts in NDSS which can generate and disseminate knowledge about suitable, versatile and affordable systems for the improvement of food integrity and process control for the food industry. In addition to partners in the Action, other target audiences for dissemination of the results include: • European and international researchers working or interested in working with NDSS, including students and ECI; • Universities interested in providing education about NDSS, related to their application development, instrumentation design and data processing; • Quality control laboratories; • Primary producers; • Food industries; • Instrument developer companies, SME and future spin-off companies; • Technology Platforms; • Innovation stakeholders; • Consumers, Government policy makers and inspection bodies. This will be achieved through various means to reach different target audiences:

- Initially a dedicated website and a logo for the Action will be designed to build the Action identity. The website will comprise two sites: a private site, restricted to partners, only for the purposes of project management and exchanging confidential information, and a public site. To ensure the Action website will serve the dissemination purposes effectively as well as facilitating communication, it will include the following information: 1.) List of the official members and all other participants, giving their contact details and a brief statement of interests. 2.) Structure and activities of the Action. 3.) Previous and forthcoming events, including meetings, conferences, workshops, Training Schools and the STSM calls. 4.) Materials of the Action, reports, articles, etc. 5.) Links to other websites (e.g. research projects, Cost Actions, European Technological Platforms, participant websites, etc.) 6.) A discussion forum about NDSS and others. But undoubtedly a website is not enough for dissemination and to spread the Action outputs without frontiers. For this reason, considering which is currently the more efficient way of transfer information, social network profiles will be created (Facebook, LinkedIn, Twitter, ResearchGate).

The link with the industry is already stablished in the consortia, but it will promote the dissemination of information to more industries through the involvement in the activities of Technological and Food Platforms and Producers Professional Associations. Demostration activities will also be considered.

Construction and maintenance of the website and social media will be the responsibility of the coordinators of Communication and Dissemination (a senior and a junior researcher). Information shared on the SensorFINT website and medias will be used to expand the network during the course of the Action and identify new participants for future endeavours. Additionaly, articles in traditional media (newspapers, magazines) together with educational material will be considered.

- The organisation of conferences, thematic workshops and meetings on NDSS will be essential elements in the dissemination plan of the Action. Target audiences for workshops and meetings will be: other researchers working in the field, research institutes and academia, ECI and students, the food industry, instrument manufacturing SME. Workshop and conference topics will be organised, when possible, as satellite meetings of some relevant symposia or conferences to facilitate the dissemination of Action activities to a wider scientific audience. Some examples of topics can be: product dedicated (meat product control), specific technologies (sensors as NIRS, Imaging…) or ICT and modelling applied to spectral data. External experts from inside and outside Europe, from academia and industry, will be invited to these meetings in order to encourage multi-disciplinarity on NDSS and to enhance the visibility of the Action. The proceedings of the conferences and material required for these dissemination activities will be available for downloading from the website. Working group and conference/workshop participants will be encouraged to present oral communications and posters and to publish their works, not only in the proceedings but also in articles in peer reviewed scientific journals. In addition, they will be encouraged to provide non-technical summaries. The network will coordinate and facilitate collaborations between different groups, for example by Short Term Scientific Missions. So, it is expected that in the course of this Action outstanding results will be obtained that can be disseminated in a number of joint, high- impact publications and patents. This is a realistic aim, given the novelty and potential of the research area, and will increase the visibility of the Action.

- Meeting reports will be used to communicate results between members and to ensure that all members are up to date on Action activities. Meeting reports will also be used to periodically review the timeline and milestones of the Action and reassess and reschedule if needed. In addition, journalists and EU Commission staff will be invited to the final meeting so as to communicate the results of the Action to the public. Video summaries will also be considered.

- The Action will encourage Training schools (TS) and mobility of ECI and scientists between partners involved in the Action and others. Training schools and scientific exchanges will be used to train researchers in the methods developed and implemented during this Action, with an emphasis on young researchers from different countries. These will be encouraged to undertake PhD or Masters Theses and to publish the results in scientific journals together with senior scientists as a result of the exchange. Regarding the training schools, together with the NDSS sensor training, one of them will have a dedicated module for training in entrepreneurship skills to enhance the skills of young researchers, accompanied by a network of teachers/researchers, providing practical training on the setting up of businesses of high scientific and technological orientation, increasing their future employment opportunities and contributing to the growth of the European technological sector. One distinctive feature of SensorFINT Action will be the use of a free virtual platform for creating an e-learning environment for intensified and continued learning in NDSS. Recruitment, calls and topics of the training schools and STSM will be led by the coordinator of Training and Education in accordance with the Steering Group (SG), and supervised by the Managment Committee (MC).

Dissemination of results and applications to the related industries (food and feed, instrument developers, software and ICT) will be achieved by stimulating bilateral collaborations and contacts between scientific participants and industrial partners inside and outside the network, making use of existing contacts in on-going national and international research programs. Dissemination to a broader range of stakeholders will be used to ensure that results achieved are not only of interest and use to the Action members but can be extended to a broader user group that can take advantage of this work. Feedback received from different forms of information dissemination will be used to make improvements or adjustments to both research and dissemination plans if needed and can be used to help focus specific activities and acquire additional funding in the future.

Intellectual property and patent rights will be discussed at a very early stage to try to avoid problems in the future, considering a sharing regime. Thus, when more than one Party jointly generates knowledge, the Parties shall have joint ownership and the intellectual property rights (IPR). In such cases, the Parties concerned shall agree between themselves arrangements for protection of intellectual property rights, assigned to each other etc. Provision shall be also made for granting of Access Rights to third parties. Knowledge will be exploited upon agreement of all Parties concerned (including, where applicable, the owner of any pre-existing know-how), in line with the requirements of the European Commission. European legal documents such as non-disclosure agreements will be available on the website and intellectual property short courses will be organised.

4 IMPLEMENTATION

4.1 COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

4.1.1 DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

SensorFINT will achieve its scientific objectives through 5 inter-related Working Groups (WG) (Figure 1), responsible for carrying out the scientific tasks. The WG will aim to promote scientific debate and consequent synergy on the listed topics. Research costs are covered by the running projects developed by the Action partners.

A Management Committee (MC) led by the MC Chair and Vice-Chair will coordinate SensorFINT. Both will be designated at the kick-off meeting, together with the representatives of each country to the MC. The MC will meet at least once a year, usually in conjunction with other meetings, to review progress, discuss and coordinate future activities and ensure satisfactory integration of the objectives laid out in this proposal. The Action will run over 4 years in 5 WG aligned with the scientific programme. Sub-groups within or across WG will be designated as necessary to undertake specific missions relating to a specific activity. The MC will elect the leaders of the 5 individual WG (two co-leaders for each WG, one junior and one senior will be proposed, as a part of the plans for including Early Career Investigators in the implementation of the Action). In addition, a high ratio of COST Inclusiveness Target Countries will be considered for the WG leader designation. WG leaders will be selected in order to lead the scientific and technical discussions, coordinate the activities of the sub-projects and provide the Chair with a brief yearly written report. The participants in the Action will be invited to join one or more WG, depending on their research and technological activities. The scientific programme will be carried out in close cooperation between all WG and strong overlap between the members of these groups is expected in all fields of interest, promoting exchange of knowledge and interdisciplinarity. One specialist team dedicated to Training & Education will support the SC. The Training & Education coordinator will manage Short-Term Scientific Missions and training schools among others. In order to reduce overall costs, a Steering Group of the MC will be established. The SG will prepare a concerted and detailed work program to be approved by the MC taking into account the research needs and objectives of the Action. The programme will also consider expertise, facilities, and interests of the participating institutions. The research facilities available within the consortium and on-going research projects on NDSS will be evaluated and taken into account when elaborating and implementing the final detailed work programme. The SG will be composed of WG leaders, coordinator of the supporting group, plus the chairperson and the vice-chair of the MC. The SG will meet as often as required for the performance of the work programme, at least twice a year; video-conferencing will be promoted. Nevertheless, the MC can adapt WG and management structure during the Action lifetime.

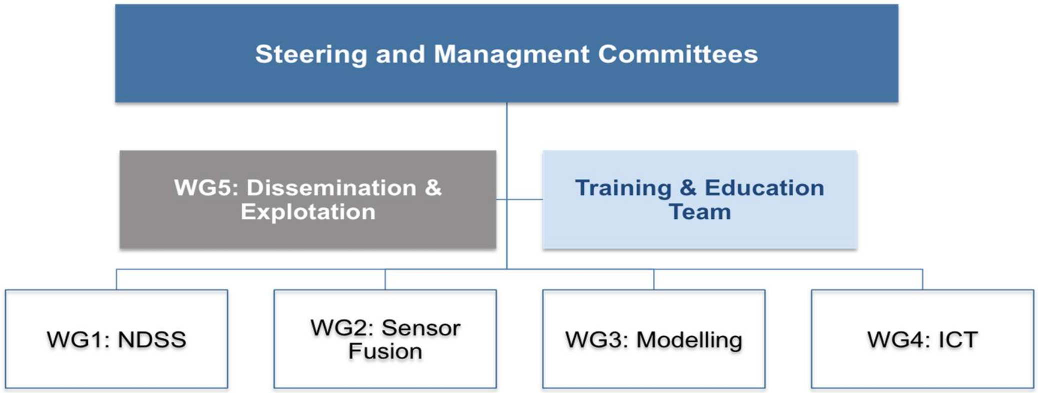

Figure 1. Pert Chart of the Action.

WG1. NDSS for the innovation in process control and labelling in the European food industry.
Description of the work and activities: WG1 is aimed at evaluating and fine-tuning the application of the latest generation of commercial NDSS for *in situ* measurements in a selected range of food applications. The products/applications have been selected using previous experience of the actual network partners in at-line applications (now it is important to be able to move to *in situ* or on-line analysis), the existence of locally funded research projects for *in situ* developments, on the basis of the industry's demands regarding NDSS, together with the great interest for the EU in them for economic or fraud reasons: meat products, olive oil and fruit&vegetables. The studies include the spectral and reference database building, the development of calibrations and validation of the models, the comparison between equipments with different characteristics.The outputs include the state-of-the-art in the design, optimisation, market availability and potential cost-effectiveness of NDSS applications for *in situ* analysis in the selected products, considering critical food integrity issues and process control for the industry. As the network is enlarged, other applications will also be considered.
Matching to Action objectives: 1, 2, 3, 8, 9, 10, 11
Tasks 1.1. Workshop year 1. 1.2. WG1 Research on the state of the art. - WG1 meetings.

WG2. Innovation related to the integration of several NDSS signals for critical issues in food integrity.
Description of the work and activities: WG2 is aiming at exploring the potential of combining several NDSS for solving critical food integrity issues which cannot be solved using one sensor alone. This integration will enable collection of information about composition and distribution, microbial contamination etc., using hyperspectral imaging combined with reflectance or fluorescence as examples. This task will investigate the fusion or integration of signals from several sensors (NIR, hyperspectral imaging, fluorescence, Raman and others), to provide new advantages and challenges in addressing food quality, authenticity and safety problems, unsolved by sensors of any single type. A special focus will be on increasing the potential for inspection of exogenous contaminants, such as faecal and epiphytic pathogens, as well as detecting intrinsic changes in food products resulting from contamination and/or changes in thermal conditions during processing such as overheating, incomplete drying, etc. It is important to highlight the scientific breakthroughs and practical potential related to the development of technologies that allow

integration of different NDSS sensors and their implementation in different parts of the food chain. The Action includes the participation of a partner, world-recognised as a leader in design which has patented a line-scan hyperspectral imaging system for real-time in-line faecal contaminant detection of commercial poultry. The outputs in this WG will be linked to the optimisation of hyperspectral reflectance (with or without fluorescence) portable devices for fast and non-destructive quality/safety control of internal damage and composition of fruit and vegetables. Other applications will also be considered with new partners joining.

Matching to Action objectives: 3, 4, 8, 9, 10, 11

Tasks

2.1. Traininig school 1 (NDSS combination for solving critical issues in the food chain).

2.2. Workshop year 3.

2.3. WG2 Research on the state of the art and specific developments.

- WG2 meetings.

WG3. Novel mathematical algorithms and methods for processing NDSS in real time.

Description of the work and activities:

The main aim of WG3 is the design of novel mathematical algorithms and chemometric methods able to process the multivariate spectral data generated to enable making decision in real time. This reflects the principal mathematical, statistical and chemometric challenges for successful implementation of NDSS in situ or in an industrial situation. The general theme is the need to enable methodologies already developed for the analysis of small quantities of sample in a laboratory to be applied to large bulk samples and to both batch and continuous processes, typically using different and more robust instrumentation. One of the major problems in further advancing the use of NDSS, especially for SMEs, is the level of expertise required to build effective multivariate models. The activities programmed will be able to provide models, user interfaces and data packages that are more meaningful in terms of the specific application and useable by those with less mathematical expertise. The outputs will include: 1. Novel statistical and chemometric treatments for the problem of sampling bulk materials and both batch and continuous processes to estimate major and minor constituents using NIRS. 2. Novel chemometric methods for hyperspectral-NIR and other spectral signal combinations. 3. Novel chemometric methods for building, maintaining and exploiting large NDSS databases and in-process NDSS analysis in the food industry. 4. Novel chemometric methods for cloning instruments and calibration model transfer between instruments of the same type and of different types.

Matching to Action objectives: 5,6, 8, 9, 10, 11

Tasks

3.1. Workshop year 2.

3.2.Training school 2 (advance chemometric tools for processing NDSS data).

3.3. WG3 Research on the state of the art and specific chemometric outputs.

- WG3 meetings in years 1, 2 and 3.

WG4. Use of ICT (Information and Communication Technologies) in building decision support systems for the industrial implementation of NDSS.

Matching to Action objectives: 6, 7, 8, 9, 10, 11

Description of the work:

The main aim of WG4 is focused in the design of methodologies to build decision support systems

(DSS) oriented to implement efficient control systems in the food supply chain. These enable the incorporation of information from different sources and, in particular, from NDSS, and are able to handle flexible information, to incorporate simulation tools, models, sensitivity analysis and interactivity with various stakeholders at various stages in the food supply chain. The WG will be directed to the design of methodologies for using cloud computing to connect key information about a process or product coming from NDSS and other sources using web browsers, mobile apps, cameras, GPS (Global Positioning System), digital signature, QR-code reader (Quick Response), Blockchain and other ICT advances. The output will be focused on: 1.- The development of decision support systems for the agro-food applications previously selected, with graphical user interfaces with different software (R, Matlab, etc.). 2. A web environment for automated predictions of the integrity of the products and android application (APPs) development to access the NDSS web virtual environment from mobile devices.
Tasks 4.1. Workshop year 4. 4.2. WG4 Research on the state of the art and specific apps/interface guidelines. - WG4 meetings.

WG5. Dissemination and exploitation.
Matching to Action objectives: 8, 9, 10, 11, 12
Description of the work: WG5 main objective is to promote dissemination and impact of the Action results, through several routes: Action website, reports, publications, identification of relevant stakeholders, identification of events and specialized media for promoting the knowledge acquired, presence in social networks to increase social awareness, lobbying (reaching policy makers, and EU and national program operators), etc. Thus, main activities will be linked to the coordination, supporting, promoting and assessment of all dissemination activities and exploitation of results of the COST Action, enabling knowledge exchange and providing feedback to the other WG leaders This WG's activity will also facilitate communication, as successful interdisciplinary research requires a mutual understanding between participants with different backgrounds. Face-to-face meetings of specialists from different disciplines sometimes fail to reach this point, because a typical expert relies on a great deal of tacit and implicit knowledge. WG members will work with the other WGs leaders to take part into activities that require strong interdisciplinary exchange. This group will naturally maintain strong links with the Management Committee (MC). The MC will promote an active policy of short-term exchanges of young and more senior scientists, with a priority for PhD students and young post-doctoral researchers. The MC chair will arrange the assessment of the STSM and Training schools by evaluating how effectively they contribute to the scientific aims of Action. As it has been mentioned before, 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
Tasks 5.1. Scientific Action conference I. 5.2. Scientific Action conference II. 5.3 Demostration studies. - WG5 meetings. - STSM.

The work program will include demonstration studies − pre-commercial activities implemented at a later stage (second half of the Action lifetime) and based on research results obtained − designed and conducted in close co-operation with the industry. These studies will help to fine-tune the applications developed previously under laboratory and pilot plant conditions. The demonstrations are essential to ensure that NDSS will be located in the key control points and so that industry is aware of what can be achieved by implementing NDSS.

4.1.2 DESCRIPTION OF DELIVERABLES AND TIMEFRAME

WG	Deliverables	Time
1	Comparative analysis report with case studies of good practice in the development of new technologies related to NDSS and their role in stimulating the innovation process in the EU food industry	1st semester year 2
1	Protocol and guidelines for recommendations on NDSS placement, sampling and specifications for *in situ* analysis of food products	1st semester year 3
1, 2, 3, 4	Well-trained ECI in the novel and growing field of NDSS applied to food integrity and process control.	Every year
2	Protocol and guidelines for recommendations on NDSS combination for *in situ* analysis of food products.	2nd semester year 3
2	Prospective report on new emerging and innovative technologies for quality and process control in the agro-food industry I.	2nd semester year 1
2	Prospective report on new emerging and innovative technologies for quality and process control in the agro-food industry II.	1st semester year 4
3	Improved algorithms, software, prediction equations and recommendations for data management and NDSS issues.	2nd semester year 1
4	Protocol for the performance of decision support systems based on NDSS for food applications and their connectivity with cloud computing and mobile applications.	1st semester year 4
5	Web platform and Web-site containing scientific and dissemination reports, teaching/training documents, self-learning materials from courses.	Every year, updated periodically
5	Minutes of the MC meeting; Updated annual dissemination plan; Newsletters every year and at the end of the Action; Indexed Articles/papers as a result of the networking; Conference contributions; Progress technical reports; Flyers and brochures to present the Action. Publications. Patents.	Every year, updated periodically

4.1.3 RISK ANALYSIS AND CONTINGENCY PLANS

The management of risks is an essential part of running an Action of this complexity. Therefore, it is an on going activity and there will be regular reappraisal of the risk analysis, especially at the beginning of each new activity/task by the SG. The constant consideration of the importance of protecting intellectual property, through prompt signing of appropriate agreements, will ensure a productive and trustworthy dialogue between the Academia and the Industry; this will greatly impact on new NDSS application/technologies, whilst minimising the risks of misuse of information damaging business for either of the two parties. The role of the MC and SG will ensure coherence in: a) the development of the Action and its activities; b) timely deliverables; c) maximisation of impact, stressing the transfer to the ITC.

The Managing Committee, at the request of the Chair and the Steering Group, 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 Action within the expected timeline. While it is possible that unexpected problems arise during the project, a tentative list of risks with possible mitigation measures or contingency plans is listed below:

RISK	CONTIGENCY MEASURE

1. Low involvement (including companies) at all levels and/or low outcomes	Proactive measures will be taken to increase interest toward the Action, including additional workshops, conferences, bilateral meeting points with companies or training schools. Extra MC meeting will, in this case, be organised to deal the issue.
2. The overview provided in the WG does not reflect the technological advances in the field of spectral sensors and food applications	SensorFINT will be an open and dynamic platform to solve the need of updating the scientific programme with new information and emerging technologies/applications, which may appear during the Action lifetime. So as to better accomplish the final goals, including the increasing of the skills of ECI and transferring the results to different target audiences and communities for the benefit of the European Food and Feed industries, new partners, with high representation of EU countries, especially ITC, EU platforms and international experts in the emerging issues will be invited to join or to collaborate. SG will be in charge of this. After preparing WG final reports, these will continue to be actively updated to reflect the state of the art and progress beyond the networking and actions in case any aspect of the research must be reinforced.
3. Problems of communication between experts from different fields and institutions, and a second major risk related to the times for the delivery of outcomes that require the participation of many members and/or wide discussion (e.g. databases, position papers, protocol, guidelines reports, etc.).	Activities involving all the parties will be performed, such as the general conferences or meetings. Furthermore, the Action Chair will charge the SG members, in particular WG leaders, with responsibility to coordinate the different partners within each WG and to ensure that all milestones are met and reported to the Chair and the MC in due time (at least on an annual basis). Special emphasis will be put on the proper participation of ECI. The monitoring and evaluation of the achievement of objectives will be facilitated by the already existing list of outcomes and deliverables. This list could be updated during the Action and an associated timetable will be produced every year to enable the checking of the timing of expected outcomes. In addition, if unforeseen problems occur, the MC Chair supported by the SG can swiftly decide the corrective actions to be taken. The contingency plan will include the possibility of replacing members of the management structures who do not perform as required.
4. No proper dissemination of STSM results.	The SG will request a short paper for a scientific, technical, professional journal, a scientific congress or other recognized event.
5. Any conflict arising among the Action partners	Management of the conflict through the SG and the MC to find a consensual solution.

4.1.4 GANTT DIAGRAM

The Action will operate for four years. A tentative calendar of events is shown.

ACTIVITY	YEAR 1		YEAR 2		YEAR 3		YEAR 4	
	Month 1-6	Month 7-12	Month -13-18	Month 19-24	Month 25-30	Month 31-36	Month 37-42	Month 43-48
Kick-off meeting	X							
Inicial contact with other Action partner	X							
Website creation and maintenance	X	X	X	X	X	X	X	X
MC annual meetings	X		X		X			X
SG meeting		X		X		X	X	
WG1 meeting	X	X		X		X		X

WG2 meeting	X	X		X		X		X	
WG3 meeting	X	X		X		X		X	
WG4 meeting	X	X		X		X		X	
WG5 meeting	X	X		X		X		X	
STSMs		X	X	X	X	X	X	X	
Task 1.1. Workshop		X							
Task 1.2. Research on the state of the art		X	X	X	X	X	X		
Task 2.1. Traininig school 1 (NDSS combination for solving critical issues in the food chain)				X					
Task 2.2. Workshop					X				
Task 2.3. WG2 Research on the state of the art and specific developments		X	X	X	X	X	X	X	
Task 3.1. Workshop				X					
Task 3.2. Training school 2 (Advance chemometric tools for processing NDSS data).						X			
Task 3.3. WG3 Research on the state of the art and specific chemometric outputs.		X	X	X	X	X	X	X	
Task 4.1. Workshop								X	
Task 4.2. WG4 Research on the state of the art and specific apps/interface guidelines.		X	X	X	X	X	X	X	
Task 5.1. Scientific Action conference I.			X						
Task 5.2. Scientific Action conference II.							X		
Task 5.3 Demostration studies								X	X
Final report									X

STSM 6-10 per year depending on the availability