MED Food TTHubs - Trace & Trust Hubs for MED Food

Grant Agreement No 1931

D1.2 Scientific and Innovation Roadmap

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1.04	05/01/2021	JUST	Quality Review
1.05	05/01/2021	INOV	Final version, minor editorial corrections and improvements

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Abbreviations

ACRONYM	DEFINITION
API	Application programming interfaces
B2B	Business to business
CA	Consortium Agreement
DCM	Document Control Management
DoA	Description of Action
EM	Exploitation Manager
GA	Grant Agreement
ICT	Information and Communication Technology
IP	Intellectual Property
IPR	Intellectual Property Rights
ISO	International Organisation for Standardisation
KPI	Key Performance Indicator
LoRaWAN	Low Power, Wide Area (LPWA) networking protocol
MoSCoW	Must have, Should have, Could have, and Won't have
MQTT	Message Queuing Telemetry Transport
PB	Plenary Board
PBI	Product Backlog Items
PC	Project Coordinator
PCR	Polymerase Chain Reaction
PDO	Protected Designations of Origin
PGI	Protected Geographical Indications
PMC	Project Management Committee
PMO	Project Management Office
PPP	Public–Private Partnerships
QA	Quality Assurance
QAM	Quality Assurance Manager
QCC	Quality Control Committee
QP	Quality Plan
RA	Requirements Analysis
RATIS	Reference Architecture for Traceability Information Systems
RDI	Research, Development, and Innovation
SCC	Stakeholders Community Committee
SM	Stakeholder Manager

ACRONYM	DEFINITION
SMEs	Small and Medium-sized Enterprises
SOA	Service-Oriented Architecture
TBD	To Be Decided
TDD	Test-Driven Development
TM	Technical Manager
TMC	Technical Management Committee
ToC	Table of Contents
TRL	Technical Readiness Level
TSG	Traditional Specialty Guaranteed
TTHubs	Trace & Trust Hubs
UI	User Interfaces
VST	Voluntary Scheme of Traceability
WP	Work Package

Executive summary

This report presents the scientific and innovation roadmap for MED Food TTHubs, as well as guidance to manage the scientific and innovation activities. It presents the scientific and innovation objectives and defines the activities, tools, and time plan for conducting the technical and scientific activities.

Based on the objectives set forth in the Grant Agreement, areas of opportunity for scientific publishing are identified, related to the innovative aspects of the project. To address these opportunities a scientific roadmap is proposed, as well as the related scientific management objectives and arrangements.

The innovation roadmap is then described in detail, for each component of the platform, for the system processes, as well as for the setup of the MED Food TTHubs ecosystem. Also, related innovation management aspects are presented, addressing innovation activities, tools, and methodologies.

This report concludes by identifying the main opportunities for research, innovation, and development, as well as the main management issues and risks.

The information elements and artifacts described in this report will provide input for the final evaluation report "D1.3 Scientific Roadmap and Innovation Management Evaluation", that will provide an evaluation of the project roadmap and propose future related work regarding research and innovation.

1. Introduction

This report identifies the scientific roadmap and management of the project, as well as its innovation roadmap and management, in the scope of *Task 1.2 Technical & Scientific Coordination*. This task manages and monitors the development of the project by determining the procedure for management of technical and scientific activities, including the close liaison with all partners. In MED Food TTHubs, the Technical Coordinator is responsible for defining the scientific roadmap of the project, control the work carried out in the related tasks and propose modifications and reallocation of resources, if necessary, for achieving the project objectives. Also, the Technical Coordinator organises and assists WP Leaders and partners on technical and scientific issues to propose solutions and fine-tune scientific orientations whenever necessary [1].

The project's innovations aim to contribute to safer and more sustainable Mediterranean food products, as well as full transparency concerning the traceability from "seed-to-shelf" and authenticity of products and ingredients.

Several innovative aspects of the project may be leveraged for enabling scientific outcomes, namely [1]:

- The project aims at establishing and operating seven pilots "Trace & Trust Hubs" (TTHubs), in each of the countries involved, forming a permanent transnational network, including the recruitment of stakeholders and end-users and delivery of training sessions.
- Implementation of full-path tracing practices in TTHubs, through the whole distribution channel from seed to shelf, targeting Mediterranean agrifood products.
- The design and development of an Electronic Platform that will incorporate already developed modules, which will be extended and adjusted to fit the needs of the platform, supporting the operation of the TTHubs.
- Development and operation of a Voluntary Scheme of Traceability (VST) of Mediterranean foods, including guidelines, audit procedures and KPIs in relation to practices and processes. It will be developed by incorporating state-of-the-art methodologies and approaches from various scientific fields, namely: genetic and genomics, isotope analysis, and molecular identification of DNA / RNA. It also includes developing an optimal business model for the effective and efficient operation of TTHubs, including business conditions and public-private partnership (PPP) arrangements.
- The use of genetic and genomic approaches along with isotope analysis, in the context of the operation of TTHubs, for securing the production chain, as well as revealing fraud and adulteration.
- Business conditions for continuation of the operation of the TTHubs beyond the funding period, based on lessons learned during the setup and operation of the pilots.
- The socio-economical potential of TTHubs and related solutions for gaining access to specialized target markets for certified and verified products.

- Mapping of needs and requirements related to traceability and authenticity control system in the involved countries.
- Implementation of a traceability model based on blockchain technology able to reduce the food fraud vulnerabilities, to shorten the supply chains and to decrease the commercialization costs, along with the development of a Common Authentication and Quality Assurance Protocol.
- Implementation of an open architecture, considering security and user privacy at the forefront, as well as governance of the blockchain (consensus, provenance, immutability, and finality).
- Evaluation results regarding the efficacy of the pilots, solutions, and enablers, namely new operational efficiencies gained by all members of the supply chain, reduced waste by implementing proper handling or rotation based on item-level traceability, and potential revenue growth for all Mediterranean food products.
- Evaluation results regarding the perceived higher value of the selected products, for each stakeholder or groups of stakeholders, through the operation of the TTHubs.
- Evaluation results regarding the increase of confidence of consumers and markets in authenticity of Mediterranean food products.
- Evaluation results regarding the positive impacts in the context of TTHubs, in support of the agrifood industry:
    - Increase companies' interest in food safety and sustainable development.
    - Promote the usage of quality and authentication certificates for raw materials as a competitive advantage.
    - Improvement of transparency and documentation for the origin of the products and their overall characteristics.
    - Improvement of access to information concerning the production processes and the transport.
    - Improvement of re-call management.
    - Potential for improving companies' reputation, namely through integration into the marketing of the company's products.
    - Contribution for covering the requirements of major retailers abroad, as well as compliance with food safety legislation, aiming at increasing market share and revenues.

In section 2, the scientific roadmap, as well as relevant scientific management objectives and arrangements, are described in detail. In section 3, a detailed description is provided for the innovation roadmap, for each component of the system and for the system as a whole. Also, the innovation management aspects are presented, covering the project's innovation activities, tools, and methodologies. Section 4 presents the conclusions regarding the scientific and innovation roadmap, as well as the main management issues and risks.

2. Scientific Roadmap and Management

In deliverable *D8.3 "Plan for exploitation and dissemination of results"* [6], a roadmap was provided on how to communicate, disseminate and exploit the results of the project activities. This report was produced in accordance with the communication and dissemination strategy, as per deliverable *D8.1 "Med Food TTHubs Communication Plan and Communication Activities Report"* [4]. In both documents, KPIs were defined for monitoring the success of dissemination activities, as presented in Table 1.

Table 1: KPIs of dissemination activities

Outputs / KPIs	Measurement Unit	M36 Target
Scientific publications in peer-review journals, international conferences, and workshops	Nº of publications	6
Scientific publications as Open Access	Nº of deposits	3

In Table 1, open access refers to the practice of providing on-line access to scientific information that is free of charge to the end-user and that is re-usable. [6]

Deliverable D8.3 specifies that any dissemination activity will need to be delayed until a decision about possible protection of research, development, and innovation (RDI) results has been made by the funded project consortium [6]. The report also concludes that the dissemination and exploitation plan is a living document that will be updated along the duration of the project, according to the partners´ suggestions and project´ needs. In accordance with this guidance, the following sections provide an updated list of target scientific outlets, based on the requirements of the Grant Agreement [1], as well as deliverable D8.3 [6].

2.1. Scientific Publications

In this section, scientific publications opportunities are presented, covering all the scientific fields that the project may contribute to, leveraging on the innovative aspects described in the introductory section.

The main scientific publication outlets include the presentation of research articles and technical demonstrations at key conferences and fairs, as well as peer-reviewed publications in key conferences and journals. Examples for journals and conferences provided in this document are related to all research fields covered by the project, such as agro-food business, information and communication technology (ICT), agriculture, biosystems, supply chain management, and sustainability.

2.1.1. International and national conferences and fairs

The following table presents key events that are identified as targets for scientific publications.

Table 2: Key events

Event name	Event description
Fruit Logistica	Annually (February) at Berlin Germany. Fresh fruit and vegetable exhibition with approximately 3,000 exhibitors and 70,000 visitors.
EU Fresh Info Forum	Every two years (November) at Netherland. Event for digital professionals in the fresh produce sector in Europe.
Food Africa	Annually (December) at Cairo Egypt. International trade exhibition for food and beverages. Needs of the agro-food sector in Egypt and Africa.
Anuga	Every two years (October) in Germany. Large trade fair: figures of 2017 are 7,405 exhibitors and around 165,000 visitors.
Fruitnet Forum South-East Europe	Annually (November) at Serbia. Information and insight, highlighting international trends, identifying areas where demand is increasing.
MacFrut	Fruits & Vegetables Professional Show.
Food&Science Festival	International trade show for Fruits and Vegetables (Greece)
European Federation for Information Technology in Agriculture Food and the Environment (EFITA)	Biennial conference that facilitates participants from over 25 countries focusing on knowledge sharing and thinking on the future of ICT within the agri-food and bio-resource sectors.
CIOSTA & CIGR V International Conference	The conference aims at promoting the exchange of knowledge on research and innovation for the management of agriculture and forestry.
AgEng Conference	State of the art and future perspectives for agricultural engineering as a motor for the sustainable future of agriculture.

Event name	Event description
Agrotica	Agrotica is the biggest international trade fair in Greece for agriculture. It is held biannually in Thessaloniki and the next one will be in 2022. (https://agrotica.helexpo.gr/en)
IoT Week	Annual event organized by the IoT Forum since 2011 gathering industry and academia representatives from around the world.
IEEE International Conference on Blockchain	Annual conference that provides a high-profile, leading-edge forum for researchers, engineers, and practitioners to present latest advances and innovations in key theories, infrastructure, schemes, and significant applications for the blockchain, as well as to identify emerging research topics and define the future.
FRESKON	Fresh Fruit and Vegetable Trade Event by HELEXPO (Greece-Thessaloniki)
FOOD EXPO	Leading Food & Beverage trade show in Southeast Europe and one of the most significant of its kind in the world (Greece-Athens)

2.1.2. International journals

The following table presents key journals that are identified as targets for scientific publications.

Table 3: Key journals

Journal name	Comments / Open access support
Computers and Electronics in Agriculture	Very good journal Supports open access
Biosystems Engineering	Very good journal Supports open access Publishes research in engineering and the physical sciences
Information Processing in Agriculture	Supports open access Publishes works related to information processing in agriculture

Journal name	Comments / Open access support
Sustainability	Open access journal, very good journal
Journal of the Science of Food and Agriculture	Very good journal but is not open access. It publishes materials in food safety and quality
Review of Agricultural, Food and Environmental Studies	By Springer, but it is not open access
International Food and Agribusiness Management Review	By Wageningen Academic Publishers, for case studies research
International Journal of Food Science & Technology	Published by The Institute of Food Science & Technology (UK) Open access with high Impact factor
Journal of Food Quality	Very good journal and open access journal
Environmental Impact Assessment Review	Very good journal Supports open access It is an interdisciplinary journal
Journal of Supply Chain Management	Very good journal but it is not open access
Food Control	One of the best journals on food
Food Chemistry	One of the best journals on food
Journal of Food Composition and Analysis	Very good journal
LWT – Food Science and Technology	Very good journal
IEEE Internet of Things Journal	Open access journal (hybrid)
Computers in Industry	Open access journal
IEEE Access	Open access journal
Logistics	Open access journal published quarterly online by MDPI.

2.2. Evaluation Tools and Methodologies

The evaluation process concerning the tools and methodologies, which will be developed within the project, will consist of three discrete phases, the first two phases will focus on the development of the e-tools and the e-platform within WP4, while the third one will be implemented as part of WP6 focusing on the pilot operation of the whole system in real business cases and it will include the evaluation of the processes and protocols that will be developed under WP3 along with the usage of the e-platform in supporting these processes and protocols. So, the three evaluation phases are the following:

1. Software evaluation of e-platforms alpha version
2. Software evaluation of e-platforms beta version
3. Evaluation of pilots

In the following sections the description of each phase will be given.

2.2.1. Alpha version evaluation

Alpha Testing is a type of software testing performed to identify bugs before releasing the product to real users or to the public. This is referred to as an alpha testing only because it is done early on, near the end of the development of the software. Alpha testing is commonly performed by homestead software engineers or quality assurance staffs. It is the last testing stage before the software is released into the real world through a beta version. The main characteristics of the alpha testing approach that will be implemented under sub-task 4.2.4 are the following:

- It will be performed to minimise the failure risks.
- It will be performed by testers who are usually internal employees of the organisations involved in the specific sub-task, namely: GP, CERTH, INOV, ENG.
- It will be done before beta testing and pilot testing.
- It will ensure the quality of the product before forwarding to beta testing.

The alpha version of the prototype will be tested through the implementation of testing scenarios covering different cases in the framework of all processes and business models in collaboration with all the partners. Members of research teams will act as facilitators to supervise and facilitate the whole process. The evaluation criteria will cover issues such as the interoperability with other databases, e.g., METROFOOD-RI, functional requirements fulfilment, performance, and usability and last but not least functional requirements of security and privacy. A detailed report on the results and conclusions of the internal pilot testing of alpha version will be produced.

The purpose of the software alpha version testing procedures will be the correct and proper operation of the e-tools and the overall e-platform in accordance with the systems' specification requirements, which will be elaborated within Task 4.2.

To achieve the best result, a number of quantity and quality tests will take place in order to identify both the technical and operational malfunctions of the various components. The combination of the following three types of tests is considered to exhaust all types of problems.

- Tests on the proper operation and functionality, which aim to confirm that the software works properly and that it is complete insofar as operational requirements as described in Deliverable D4.1 "Software design document" are covered.
- Application performance tests certify the ability of the e-platform and its components to perform specific actions at specific time depending on the loading degree of the application at the specific time the test is performed.
- Application usability tests certify the effectiveness of applications and examine information suitability and usability of functionalities based on user's selections and performance

More specifically on the tests we will include the following:

Proper operation and functionality test

System's testing and validation includes a number of steps that should be followed. Both the required testing steps and validation of the system are listed below.

- Software Testing Procedure and Validation

  The purpose of the system testing procedure is to ascertain that the software requirements are met and the system is complete. The purpose of software validation is to determine that the function of the software is proper and consistent with the environment for which it is intended.

  The testing procedure and validation of the software consists of the following individual steps:

  1) **Data Testing** – It includes data input in the system via interfaces. Testing data cover all possible cases of actions. Based on the input data we examine whether the expected output data arise. Data input is based on scenarios that cover the services offered by the application.

  2) **Procedure Testing** – This process includes the identification and testing of all procedures involving the application. The examination of the procedures is carried out on the test data.

  3) **Structures Testing** – In this testing all the implementation details of the application are considered known, namely the system is obtained as White-Box. During this test the behaviour of the different modules of the application is examined in detail. The examination of the procedures is carried out on the test data.

In order to carry out the tests mentioned, the development of Testing Data and Scenarios documents is necessary. These are documents reflecting the various data import scenarios in the system and indicative data forms to be imported. They also include a detailed description of the expected results of each scenario. In the following table the structure of such a document is given.

Table 4: Alpha test document structure

Alpha test document structure	
1	Code of use case scenario
2	General description of use case scenario
3	Epic which is tested
4	Stories which are incorporated in this use case scenario
5	Specific form which is tested
6	Functional requirements which should be fulfilled by the scenario
7	Evaluation using a predefined scale
8	Actual results
9	Comments
10	Things to be done

According to the specifications identified in deliverable D4.1 ‘use case scenarios’ will be created that will analyse the applications’ functions that implement specific standards. For every “use case scenario" a set of "control scenarios" will be created which provides detailed guidance on the steps to be performed and expected results of the tests made. There should be a clear correspondence between "use case scenario" and "control scenarios" for each "use case scenario". Overall, during the process of creating the “control scenarios" all possible different control modes will be identified in order to create an as complete as possible set of "control scenarios".

With the above method a set of test scenarios for each specification will be created, the performance of which, will determine the rate of compliance of the application with respect to the particular specifications.

Performance Test

Through this test the speed concerning the entering of the required data is evaluated for a proper implementation of the corresponding scenario. The speed of the system response is also evaluated. A predefined scale (Very fast, Satisfactory fast, Should be redesigned) will be used and comments can be also entered.

Usability Test

The usability testing will be based on valuation control (assessment test), which is the most common and safest example of usability testing, as it is simpler and easier to be carried out. A predefined scale (Very user-friendly, Changes shall be made, Should be redesigned) will be used and comments can be also entered.

The valuation control evaluates the effectiveness of the implementation and examines the control information regarding the adequacy and usability of functionalities based on user's choices and performance.

The usability control has the following characteristics:

- **Methodology:** The proposed methodology is based on user's observation, during which an observer records the user's reactions in detail. The ultimate goal is to highlight specific components of the e-platform that help or hinder usability. In this way, the observer is watching and trying to understand user's behaviour and explain any of his queries or questions without interfering. The thinking aloud protocol (think aloud) will be followed, in order to understand better the user's behaviour. During this protocol, users have to describe every act and express their views on the website. In addition, specific software will be used, which will record all events in the user's screen. This methodology was preferred in this case over others, as it provides the richest and safest results.
- **Users**: Users will be employees of the involved partners.
- **Guided use cases:** The usability of e-platform and its modules proposed to be considered with guided use cases, which are intended to test the adequacy of the information. They also aim at enhancing the usability or user-unfriendly of the application's functionalities. These use cases will be selected based on semantic criteria, aimed to better highlight usability issues.

Quality issues, which may arise from the usability testing, have to be corrected during the phase of the beta version of the e-platform and its modules.

Testing GUIs

Nowadays, almost without exception, the graphical user interfaces (GUI) are created by reusable components (components). These reusable components are provided either by the development platform or by the partners from other projects (reusable). It is also true that nowadays the interfaces are similar in most projects as they consist of the same components. However, due to the criticality regarding user satisfaction (user experience), which is the most crucial factor in the acceptance of a system, interfaces with the user should always be checked.

The following are some of the instructions for testing, that the development team of the partners are required to implement:

- **Web forms**

  In applications with GUI, using extensively windows, the following parts are checked:

  - Whether a window is opened as needed, regardless of where or how it is called (command, menu etc.),
  - If the window behaves as a window (move, scroll, resize etc.) and if it has the required functions,
  - If the data in the window can be managed by the permissible ways such as: mouse, function keys, keyboard, arrows etc.,
  - If it behaves normally when it is overwritten, i.e. correctly restored etc.
  - If the window has ingredients such as: pull-down menus, toolbars, scroll bars, dialog boxes, buttons, icons etc., whether or not it behaves as expected,
  - If the windows keep their name when they appear a lot together and if the active one is differentiated (eg highlights),
  - if any handling errors (e.g., mouse) in the window have unexpected results
  - If the window closes properly (in every respect, not only on the screen) etc.

- **Menus and Mouse**

  Given the importance of both the mouse and the menus (especially pull down) to modern interfaces the following shall be tested as appropriate:

  - Whether the menu bar appears as and where required,
  - Whether application menus present important information for work (time, date, name, etc.)
  - Tests (all the options) of pull-down menus, that at least they call and execute the correct function and the same as the corresponding command (command text based),
  - If the toolbars are working properly,
  - If the "decorative elements" (colour, intensity, fonts, etc.) are correct and in accordance with the standards adopted for the application,
  - If the active elements differentiate correctly from the inactive, particularly with different user categories Systems (roles),
  - If there is and how effective is the “help” (a subjective criterion, a subject of dispute often with end users or between them)

- if the interface is well organized and functional and "financial movements" at the same time, e.g. how many "clicks" for each major function, how many for secondary, auxiliary,
- If used and which buttons of the mouse and whether this (in addition to proper operation) makes it easy to operate and use, e.g. if some work is done only with the right button, etc. The company as a general principle uses the extra buttons only for ancillary functions.

- **Data Entry**

The correct data entry to the system (e.g. RDBMS) by a modern interface (e.g. Web based) is not always simple (as in old applications by simple terminals). So, we recommend precision inspections, especially when new components to the interfaces are used, to be carried out for:

- Proper transfer of data (data entry) imported into the screen in the system (typically an RDBMS),
- Whether the graphic data input modes (sidebars, pick lists etc.) work properly
- If unacceptable data (e.g. outside acceptable limits or form) are perceived, are discarded and if the system helps the user to correct them,
- Whether guidance, advice and the sequence that the data will be entered are rational and understandable etc.
- Whether guidance, advice and the sequence that the data will be entered are rational and understandable etc.

For all these reasons the partners will choose modern development platforms that include many of the above (and many others) controls so that development be done quickly, the result be functional, and receivables tests be restricted (if possible) regarding the operation accuracy. So, we aim the tests to focus on whether the deliverable is what was designed and mostly what the end user wants.

- **Structure of pilot testing document**

The following structure is proposed to be used for the collection and representation of the results of the testing of the various use case scenarios at form level:

Code of use case scenario		**Epic which is tested**	
General description of use case scenario			
Stories which are incorporated in this use case scenario			

Test Cases			
Specific forms which is tested			
Functional requirements	**Totally fulfilled**	**Partially fulfilled**	**Significant deficiencies**
….			
….			
….			
….			
Comments			
Performance evaluation	**Very fast**	**Satisfactory fast**	**Should be redesigned**
Speed?			
Comments			
Usability evaluation	**User-friendly**	**Changes shall be made**	**Should be redesigned**
User-friendly?			
Comments			
Things to be done			

The deliverable D4.2 “Alpha version evaluation report” will be elaborated, containing the results and the feedbacks of the internal pilot testing of e-platform’s alpha version. The conclusions of this deliverable will lead to the development of the beta version.

2.2.2. Beta version evaluation

Beta Testing is performed by real users of the software application in a real environment. Beta testing is one of the types of User Acceptance Testing. Beta version of the software, whose feedback is needed, is released to a limited number of end-users of the product to obtain feedback on the product quality. Beta testing helps in minimization of product failure risks and it provides increased quality of the product through customer validation. Usually, it is the last testing stage before the software is released into the real world. The main characteristics of the alpha testing approach that will be implemented under Task 4.3 are the following:

- It will be performed to further minimise the failure risks.
- It will be performed by end users.
- It will be done before the large-scale pilot testing.
- It will ensure the quality of the product before issuing the final version of the platform.

The fully functional version of the e-Platform (beta version) will be tested through the implementation of real-world cases scenarios by parties that are not members of the consortium and which are operating in the food supply chain. These parties will be the same that will participate in large-scale pilots within WP6. The scenarios will cover different aspects in the framework of various business models in collaboration with JUST and UPM. Members of GP and ENG partners will act as facilitators in order to supervise and facilitate the whole process. The purpose of the software beta version testing procedures will be the correct and proper operation of the e-tools and the overall e-platform in accordance with the systems' specification requirements, which will be elaborated within Task 4.2. based on the actual experience of the end-users.

The evaluation criteria will cover issues such as functional requirements fulfilment, performance and usability. The tests that will be performed are a sub-set of the tests that will be performed during the alpha testing. More specifically these tests will be the following:

- Usability test
- Performance test

The procedures of these two tests will be the same as the ones described under alpha testing. A detailed report on the results and conclusions of the pilot testing of beta version will be produced. The feedbacks from the pilot application of the beta version will be analysed and adjustments will be made as necessary to modules and the Platform. The Platform will be ready to be used for the pilots in WP6.

2.2.3. Evaluation of pilots

Finally, *Task 6.4 Evaluation process* will assess the pilot operation. Based on the experience that will be gained through the running of the pilots, an evaluation process will be undertaken which will lead to proposed improvements of the protocols and the e-Platform. Deliverable *D6.3 "Evaluation report"* will include the overall evaluation conclusions concerning pilot execution [1].

Pilot testing is the next step after a successful beta testing. It is defined as a type of testing that verifies a component of the system and the entire system under a real-time operating condition. The purpose of the pilot tests is to evaluate the feasibility, time, cost, risk, and performance of the results of the project.

The objectives of the pilot testing are:

- To evaluate the feasibility, cost and other attributes of the processes/protocols and e-platform.
- To better utilise time and resources for applying the proposed system in real time.
- To find end users reaction towards the system.
- To find whether whole system is successful or not.
- To provide another chance for development team for final adjustments.

The methodology that will be used for information gathering from the participants of the pilots will be based on questionnaires-inventory form, that will be especially designed for this purpose based on satisfaction and user acceptance criteria that will be given below. The questionnaire-inventory form will include qualitative information concerning the main characteristics of the actions, the progress of implementation, partnership, innovation, expected results, problems etc. Especially, the qualitative information collected will cover the following issues: a) Improvement of efficiency, b) Easiness of applying the processes/ protocols, c) Easiness of use of the platform and tools, d) Intensive time consumption, e) Need for other costs, and f) Lack of skills. In addition, the inventory form will contain open questions for recommendations and proposals of the partners in order to be improved the conditions for the implementation of the system. This qualitative information can help to identify the success factors and/ or the obstacles that result from the assessment of effectiveness, efficiency and relevance of the developed system.
The criteria and sub-criteria concerning the satisfaction and acceptance level of the participants will be the following (Table 5):

Table 5: Satisfaction/acceptance criteria/sub-criteria

Criteria	Sub-criteria
Improvement of efficiency	Improvement of receiving, configuring, entering and validating orders
	Improvement of reserving inventory and determining delivery date
	Improvement of loading product & generating shipping docs
	Improvement of shipping products (scheduling and tracking)
	Improvement of receiving and verifying product by customers (less claims)
	Improvement of product recall
Easiness of applying the processes/ protocols	Easy to apply the Origin Authentication Processes
	Easy to apply the Species Authentication Processes
	Easy to apply the Nutritional Analysis Profile Processes
	Easy to apply the Quality Assurance Processes
	Easy to apply the Full-path Traceability Protocol
Easiness of use of the	Easy to use Farm App Module
	Easy to use IoT Module
	Easy to use Quality Module

Criteria	Sub-criteria
platform and tools	Easy to use Isotopic Profile Module
	Easy to use DNA Markers Module
	Easy to use Nutritional Profile Module
	Easy to use External Tracing Module
	Easy to use Internal Tracing Module
	Easy to use B2B App Module
	Easy to use Consumer App Module
	Easy to use the e-Platform in total
Intensive time consumption	The actions that are related to the application of the Origin Authentication Processes is time consuming
	The actions that are related to the application of the Species Authentication Processes is time consuming
	The actions that are related to the application of the Nutritional Analysis Profile Processes is time consuming
	The actions that are related to the application of the Quality Assurance Processes is time consuming
	The actions that are related to the application of the Full-path Traceability Protocol is time consuming
Need for other costs	Significant costs (besides labour costs) are needed for the application of the protocols.
	Significant costs (besides labour costs) are needed for the usage of the platform.
Lack of skills	Extra skills are needed for applying the protocols
	Extra skills are needed for the operation of the e-tools and the platform.

The major advantage of a survey measuring the satisfaction and acceptance of the participants in the pilots is to provide an overall efficiency for the whole system. Thus, the project consortium can see whether the provided services meet the expectations of the beneficiaries. The analysis of the data should be able to identify critical dimensions of satisfaction should be improved and ways in which to achieve this improvement.

After thoroughly reviewing the various existing theories and strategies for measuring end-user's satisfaction, the MUlticriteria Satisfaction Analysis (MUSA) method was selected, in order to measure users' satisfaction level from the tools developed within the project. A questionnaire including the satisfaction and acceptance criteria will be composed and published through an on-line survey system. The data that will be collected will be thoroughly analysed by applying MUSA method and valuable conclusions were drawn concerning users' satisfaction level from the specific tools.

As an answer to the need for a method that would integrally deal with the satisfaction measurement, Grigoroudis and Siskos (2002) created the MUlticriteria Satisfaction Analysis (MUSA) method [7], which is a preference disaggregation model that follows the principles of ordinal regression analysis (inference procedure). The MUSA method is used to evaluate the satisfaction level of a set of individuals based on their values and expressed preferences, as it aggregates the different preferences in unique satisfaction functions, while fully considering the qualitative dimension of users' opinions and preferences. The evaluation of users' satisfaction level takes place both globally and partially for each of the characteristics of the provided service, while a complete set of results that analyse in depth users' preferences and expectations.

The required information for the application of the MUSA method is collected via a simple questionnaire in which the users evaluate the provided service, i.e. they are asked to express their opinion, their global satisfaction, as well as their satisfaction level concerning the set of discrete criteria. A pre-defined ordinal satisfaction scale is used for the users' judgements.

A main characteristic of MUSA's rationale is a hierarchical structure of the satisfaction criteria, as shown in Figure 1.

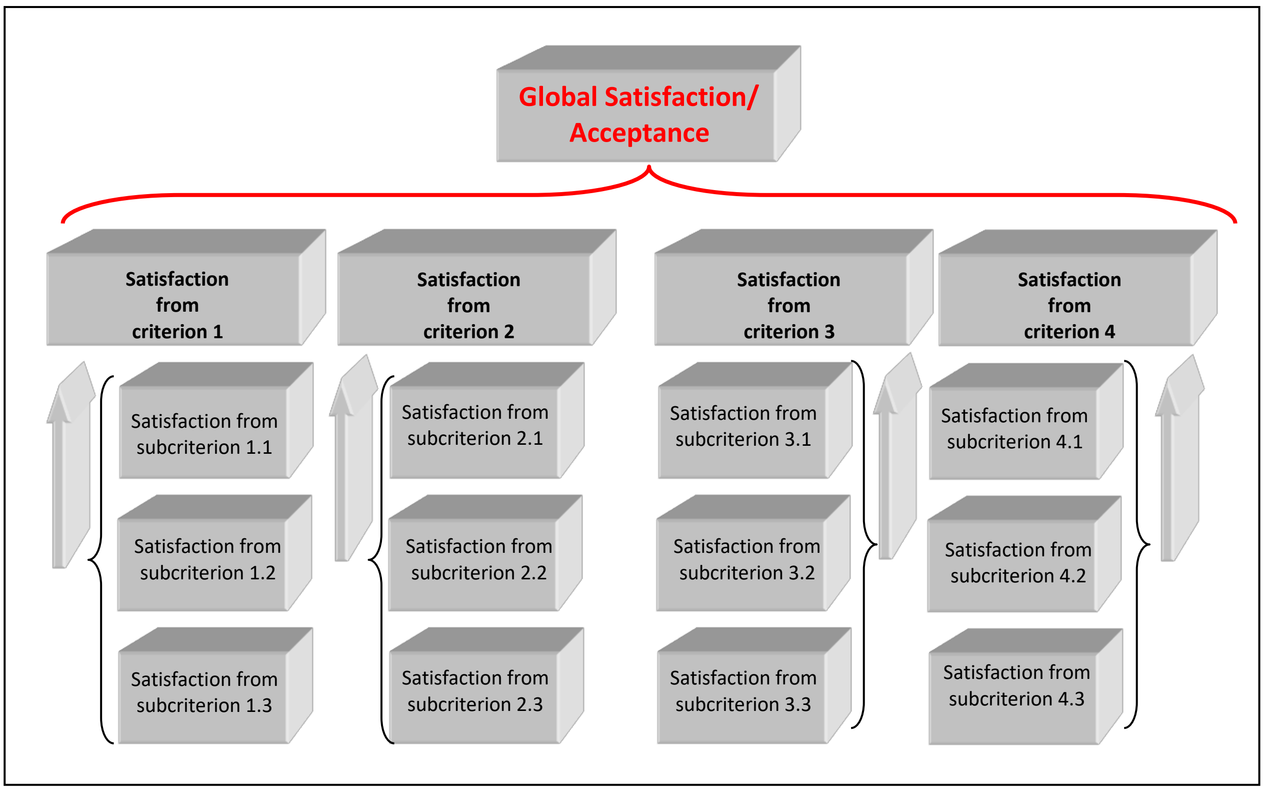

Figure 1: MUSA's hierarchical structure of the satisfaction criteria.

The main objectives of the MUSA method are:

- The evaluation of users' satisfaction level, both globally and partially for each of the characteristics of the provided service.
- The supply of a complete set of results that analyse in depth users' preferences and expectations and explain their satisfaction level.

Satisfaction analysis results, in more detail, consist of:

- Global satisfaction index: it shows in a range of 0-100% the level of global satisfaction of the users; it may be considered as the basic average performance indicator for the system.
- Global demanding index: it shows in a range of -100%-100% the demanding level of users, according to the following:
  - demanding index 100%: extremely demanding users
  - demanding index 0%: "normal" users
  - demanding index -100%: non-demanding users
- Criteria/sub-criteria satisfaction indices: they show in a range of 0-100% the level of partial satisfaction of the users according to the specific criterion/sub-criterion, similarly to the global satisfaction index.
- Weights of criteria/sub-criteria: they show the relative importance within a set of criteria or sub-criteria.
- Demanding indices: they show in a range of -100%-100% the demanding level of users according to the specific criterion/sub-criterion, similarly to the global demanding index.

Combining weights and satisfaction indices, a series of "Performance/Importance" diagrams can be developed (Figure 2). Each of these diagrams is divided into quadrants according to performance (high/low), and importance (high/low), that may be used to classify actions:

- Status quo (low performance and low importance): Generally, no action is required.
- Leverage opportunity (high performance/high importance): These areas can be used as completive advantage of the system.
- Transfer resources (high performance/low importance): Partner's resources may be better used elsewhere.
- Action opportunity (low performance/high importance): These are the criteria/sub-criteria that need attention. Special actions shall be undertaken for the final version of processes/protocols and for the e-platform.

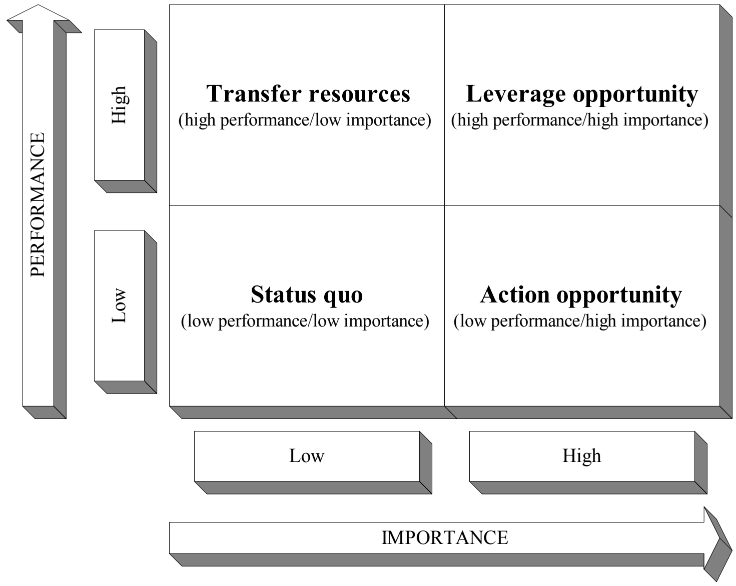

Figure 2: MUSA's Action diagram.

The action diagrams can indicate which satisfaction dimensions should be improved, but they cannot determine the output or the extent of the improvement efforts. For this reason, combining the average improvement and demanding indices, a series of improvement diagrams can be developed.

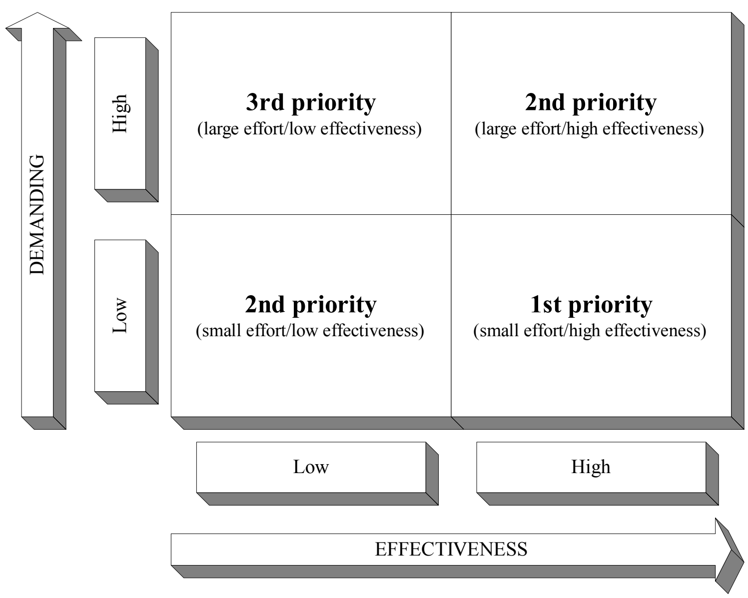

Figure 3: MUSA's Improvement diagram.

As shown in Figure 3 each of these maps is divided into quadrants according to demanding (high/low) and effectiveness (high/low) that may be used to rank improvement priorities:

- *1st priority*: this area indicates direct improvement actions since these dimensions are highly effective and users are not demanding.
- *2nd priority*: it includes satisfaction dimensions that have either a low demanding index or a high improvement index.
- *3rd priority*: it refers to satisfaction dimensions that have a small improvement margin and need substantial effort.

The main objectives of our research are:

- Examine how high the users' expectations from each one of criteria/sub-criteria are, (the degree of demandingness regarding each medium separately)
- Examine the degree of satisfaction - or dissatisfaction - each one of the elements under question can cause to the users
- Investigate how an improvement in some of the elements of the overall system would satisfy the users and would therefore lead to an increase of their use.

Further details concerning the evaluation of the criteria and sub-criteria will be provided under Task 5.2 "Assessment of the tools and indicators".

3. Innovation Roadmap and Management

The project's innovations comprise several aspects, namely:

- The MED Food TTHubs e-Platform: a system composed of ten modules, each module itself will be upgraded to a higher technical readiness level (TRL).
- The MED Food TTHubs processes: a set of five processes, covering origin authentication, species authentication, nutritional analysis profile, quality assurance, and full-path traceability.
- The MED Food TTHubs pilots: the MED Food TTHubs e-Platform and processes will be implemented, demonstrated, and evaluated in real-world scenarios using innovative partnership arrangements.

The innovation potential of the project is leveraged by its multidisciplinary character, involving several scientific and technical disciplines, by including both theoretical and applicative points of view, as well as by adopting a stakeholder centred approach.

3.1. Innovation Management Activities

The innovation management activities are coordinated in the scope of the work package *WP1. Co-ordination and management*, led by CERTH. This WP includes *Task 1.2 Technical & Scientific Coordination* that manages and monitors the development of the project by determining the procedure for management of technical and scientific activities, including the close liaison with all partners. In MED Food TTHubs, the Technical Manager is responsible for defining the scientific roadmap of the project, control the work carried out, and propose modifications and reallocation of resources, for achieving the project objectives. Also, the Technical Manager manages technical and scientific issues, namely proposing solutions and scientific orientations whenever necessary [1].

3.2. Innovation Management Tools

Several innovation management tools will be used to ensure that best practice is adopted, that processes are consistent and kept under control, and that the scientific and technical outcomes are maximized.

3.2.1. Focus groups

Innovation management is a process that requires an understanding of both markets and technologies in order creative ideas to be transformed successfully into new products. Fostering innovation in a coordinated and structured way will have high priority in MED Food TTHubs. In order to facilitate a structured process with clear responsibility, the dedicated Focus Groups set up in each of the participating countries will be leveraged. Their main goal is to inform the involved stakeholders on the project's activities and more importantly to receive feedback from the Focus Group members in order to foster and steer innovation and exploitation of project results, ensuring their application. In essence, MED Food TTHubs Focus Groups will provide the collaborative framework for developing mechanisms to stimulate and harvest innovative ideas and developing processes and structures for effectively managing innovative ideas.

More specifically, Focus Group meetings will be utilised to receive insights from the involved participants on general issues concerning Med Food TTHubs outcomes, such as the implementation of the platform. Group dialogue tends to generate rich information, as participants' insights tend to "trigger" the sharing of others' personal experiences and perspectives in a way that can more easily or readily tease out the nuances and tensions of complex topics and subjects – a dynamic that is not present during key informant interviews. Thus, national Focus Groups will monitor the status of the innovations generated by the MED Food TTHubs project, providing the guidance for aligning and fine-tuning them with the main interest areas of the real market. Besides that, Focus Group members will facilitate evaluation of the project's findings, helping the consortium partners to decide the best approach for linking MED Food TTHubs and food traceability practices with the future market needs.

3.2.2. Requirements analysis

In the Requirements Analysis (RA) phase we will be using the experience in the field of collection and classification of requirements gained in the large number of Research Projects carried out by ENG both as Coordinator and Participant. The collection of Requirements will start from the analysis of answers to the specific survey realized in the project and sent to a varied audience of actors involved in the traceability ecosystem. In the proposed survey, technical questions related to "essential", "desirable" and "unnecessary" functionalities have been proposed to understand the interaction between the user and the platform and what kind of traceability information the end user expects to find in this solution. Functionalities made available by the portal https://ec.europa.eu/eusurvey will be used in terms of answers' extraction and download of pdf or excel documents. Also, results of Focus Groups realised in each country involved in the Consortium will concur in the definition of requirements. In this way, different points of view, will be reflected in the definition of the e-Platform. Within the Focus Groups, farmers, policy makers, consumer associations, standards maker and also SMEs manufacturers of food products have been involved in very rich and constructive discussions allowing to collect important feedback regarding the desired requirements for the traceability e-Platform. Finally, requirements will be collected also through Epics and User stories. The RA will include the MoSCoW classification of requirements in order to define priorities for functionalities to be developed within WP4.

3.2.3. Agile development

According to the Agile Alliance (https://www.agilealliance.org/), “Agile” is the ability to create and respond to change. It is a way of dealing with, and ultimately succeeding in, an uncertain and turbulent environment. The authors of the Agile Manifesto chose “Agile” as the label for this whole idea because that word represented the adaptiveness and response to change which was so important to their approach. It’s really about thinking through how you can understand what’s going on in the environment that you’re in today, identify what uncertainty you’re facing, and figure out how you can adapt to that as you go along.

Agile software development is an umbrella term for a set of frameworks and practices based on the values and principles expressed in the Manifesto for Agile Software Development and the 12 Principles behind it.

The development work of the e-platform and its modules will be carried out according to “Scrum” and “Test-Driven Development (TDD)” agile methodologies – which have been successfully exploited by the partners involved in this WP for developing other complex software platforms.

3.2.3.1. Scrum

Scrum is a process framework used to manage product development and other knowledge work which is allocated between development teams. Scrum is empirical in that it provides a means for teams to establish a hypothesis of how they think something works, try it out (alpha, beta and pilot testing), reflect on the experience, and make the appropriate adjustments. That is, when the framework is used properly. Scrum is structured in a way that allows teams to incorporate practices from other frameworks where they make sense for the team’s context. Scrum is best suited in the case where cross functional teams are working in a product development setting where there is a non-trivial amount of work that lends itself to being split into more than one 2 – 4 weeks iteration.

The 2 main practices of scrum process are Events and Artifacts.

Events

- **Sprint**: The Sprint is a timebox of one month or less during which the team produces a potentially shippable product Increment. Typical characteristics of Sprints:
  - Maintain a consistent duration throughout a development effort
  - A new Sprint immediately follows the conclusion of the previous Sprint
  - Start date and end date of Sprint are fixed
- **Sprint Planning**: A team starts out a Sprint with a discussion to determine which items from the product backlog they will work on during the Sprint. The end result of Sprint Planning is the Sprint Backlog. Sprint Planning typically occurs in two parts. In the first part,

the product owner and the rest of the team agree on which product backlog items will be included in the Sprint. In the Second Part of Sprint Planning, the team determines how they will successfully deliver the identified product backlog items as part of the potentially shippable product increment. The team may identify specific tasks necessary to make that happen if that is one of their practices. The product backlog items identified for delivery and tasks if applicable, makes up the Sprint Backlog. Once the team and product owner establish the scope of the Sprint as described by the product backlog items no more items can be added to the Sprint Backlog. This protects the team from scope changes within that Sprint.

- **Daily Scrum**: The Daily Scrum is a short (usually limited to 15 minutes) discussion where the team coordinates their activities for the following day. The Daily Scrum is not intended to be a status reporting meeting or a problem-solving discussion.
- **Sprint Review**: At the end of the Sprint, the entire team (including product owner) reviews the results of the sprint with stakeholders of the product. The purpose of this discussion is to discuss, demonstrate, and potentially give the stakeholders a chance to use, the increment in order to get feedback. The Sprint Review is not intended to provide a status report. Feedback from the sprint review gets placed into the Product Backlog for future consideration.
- **Sprint Retrospective**: At the end of the Sprint following the sprint review the team (including product owner) should reflect upon how things went during the previous sprint and identify adjustments they could make going forward. The result of this retrospective is at least one action item included on the following Sprint's Sprint Backlog.

<u>Artifacts</u>

- **Product Backlog**: The product backlog is an ordered list of all the possible changes that could be made to the product. Items on the product backlog are options, not commitments in that just because they exist on the Product Backlog does not guarantee they will be delivered. The Product Owner maintains the product backlog on an ongoing basis including its content, availability, and ordering. Based on the experience of the partners, it is strongly suggested to split the Product Backlog Items (PBIs) into Epics, Stories, Technical Tasks, Bugs.
- **Sprint Backlog**: The Sprint Backlog is the collection of product backlog items selected for delivery in the Sprint, and if the team identifies tasks, the tasks necessary to deliver those product backlog items and achieve the Sprint Goal.
- **Increment**: The increment is the collection of the Product Backlog Items that meet the team's Definition of Done by the end of the Sprint. The Product Owner may decide to release the increment or build upon it in future Sprints.
- **Definition of Done**: The definition of done is a team's shared agreement on the criteria that a Product Backlog Item must meet before it is considered done.

The basic roles in scrum approach are the following:

- **The Product Owner**: The product owner is a role team responsible for managing the product backlog in order to achieve the desired outcome that the team seeks to accomplish. The product owner role exists in Scrum to address challenges that product development teams had with multiple, conflicting direction, or no direction at all with respect to what to build.
- **The Scrum Master**: The scrum master is the team role responsible for ensuring the team lives agile values and principles and follows the processes and practices that the team agreed they would use. The name was initially intended to indicate someone who is an expert at Scrum and can therefore coach others. The role does not generally have any actual authority. People filling this role have to lead from a position of influence, often taking a servant-leadership stance.
- **The Development Team**: The development team consists of the people who deliver the product increment inside a Sprint. The main responsibility of the development team is to deliver the increment that delivers value every Sprint. How the work is divided up to do that is left up to the team to determine based on the conditions at that time.

Scrum is a framework that allows development team's flexibility to respond to changing situations. This framework has sufficient control points in place to ensure the team does not stray from the desired outcome, and that issues can be identified and resolved and process adjustments made while the effort is still underway. The Scrum Lifecycle starts with a prioritized backlog, but does not provide any guidance as to how that backlog is developed or prioritized.

The Scrum Lifecycle consists of a series of Sprints, where the end result is a potentially shippable product increment. Inside of these sprints, all of the activities necessary for the development of the product occur on a small subset of the overall product. Below is a description of the key steps in the Scrum Lifecycle:

1. Establish the Product Backlog.
2. The product owner and development team conduct Sprint Planning. Determine the scope of the Sprint in the first part of Sprint Planning and the plan for delivering that scope in the second half of Sprint Planning.
3. As the Sprint progresses, development team perform the work necessary to deliver the selected product backlog items.
4. On a daily basis, the development team coordinate their work in a Daily Scrum.
5. At the end of the Sprint, the development team delivers the Product Backlog Items selected during Sprint Planning. The development team holds a Sprint Review to show the customer the increment and get feedback. The development team and product owner

also reflect on how the Sprint has proceeded so far and adapting their processes accordingly during a retrospective.

6. The Team repeats steps 2–5 until the desired outcome of the product have been met.

3.2.3.2. Test-driven Development

“Test-driven development” (TDD) refers to a style of programming in which three activities are tightly interwoven: coding, testing (in the form of writing unit tests) and design (in the form of refactoring).

It can be succinctly described by the following set of rules:

- write a “single” unit test describing an aspect of the program
- run the test, which should fail because the program lacks that feature
- write “just enough” code, the simplest possible, to make the test pass
- “refactor” the code until it conforms to the simplicity criteria
- repeat, “accumulating” unit tests over time

The expected benefits of adopting TDD are the following:

- many teams report significant reductions in defect rates, at the cost of a moderate increase in initial development effort.
- the same teams tend to report that these overheads are more than offset by a reduction in effort in projects’ final phases.
- although empirical research has so far failed to confirm this, veteran practitioners report that TDD leads to improved design qualities in the code, and more generally a higher degree of “internal” or technical quality, for instance improving the metrics of cohesion and coupling.

Common pitfalls of adopting TDD consist of individual and teams mistakes.

Typical individual mistakes include:

- forgetting to run tests frequently
- writing too many tests at once
- writing tests that are too large or coarse-grained
- writing overly trivial tests, for instance omitting assertions
- writing tests for trivial code, for instance accessors

Typical team pitfalls include:

- partial adoption – only a few developers on the team use TDD
- poor maintenance of the test suite – most commonly leading to a test suite with a prohibitively long running time

- abandoned test suite (i.e. seldom or never run) – sometimes as a result of poor maintenance, sometimes as a result of team turnover

TDD is particularly necessary for efficiently developing "almost-bug-free" large software platforms like Med Food TTHubs e-Platform because it is a programming methodology oriented to code "reliable-by-design" software. Tools and elements already developed by consortium partners (GP, TCA, ENG and UPM), as introduced in Table 6, will be used for a more rapid development.

3.2.4. Business model canvas, or similar analysis tool for the business model

We will be using the experience of the pilot operation of the TTHubs. For this purpose, the agribusiness hubs model will develop collaboration and engage a partnership between the public and private industries to form the one-stop-shop services of traceability and authenticity as a business model. The business model and its deliverable would be a case study that can be published in a peer-review journal, along with the potential collected data and analysis of the project. Furthermore, the seven work packages tasks will be used for one business plan document to build a business model in each country. The contemplated business plan will include the canvas model for the centre.

3.2.5. Knowledge management and IPR protection

The knowledge generated before as well as during the MED Food TTHubs project is the basis of innovation. In this context, it is crucial to identify and document these aspects, thus ensuring that the generated Intellectual Property (IP) can be adequately secured, while an exploitation strategy can be effectively implemented. Thus, the proper management of knowledge and IPR generated or involved in MED Food TTHubs constitutes an integral part of the project. In this respect, an efficient knowledge and IPR management methodology will define the procedures under which newly innovative results will be handled within the lifespan of the project.

More specifically, under the frame of MED Food TTHubs, innovation, knowledge and IPR management will be constructed on the pillars of identifying a common understanding concerning the background, foreground, ownership, access and usage rights, dissemination and exploitation during and after the project development. To this end, both the Grand Agreement and the Consortium Agreement provide an overview of several issues related to knowledge and IPR management, representing a reference point for IPR issues. Besides that, and taking into account the underlying provisions, IP handling procedures will be applied within the consortium partners in order to organise results/assets management of the project. Especially, the focus will be on foreground identification, assets' ownership, access rights, and protection, as well as the exploitation and commercialisation of the project's outcomes. The MED Food TTHubs IPR management, as it will be described under deliverable D1.4 "MED Food TTHubs IPR Plan & IPR

Management", will emphasis on establishing robust handling procedures of the IPR issues that will set the basis and facilitate further exploitation of the project's results.

Furthermore, in order to optimise the development of the Med Food TTHubs project, a process of knowledge management will be implemented. This process will provide the consolidation of the knowledge spiral, enable cooperation and allow the creation of new knowledge. More specifically, the knowledge management process is divided in different steps: First of all, the information will be gathered and shaped. After that, it will be indexed in order to be correctly disseminated. This will be followed by an appropriation period, which provides the creation of new knowledge. In addition, some tools dedicated to knowledge management will be set up to support social interactions, knowledge processing (e.g. files will be organised thanks to semantic links to facilitate future searches) and intelligent distribution of knowledge (e.g. push and pull actions to optimise the distribution of knowledge). In this respect, a Data Management Plan (D1.5) will be developed, fully addressing the lifecycle and public availability of research data generated by the project.

3.2.6. Technology readiness levels

Finally, technology readiness levels (TRL) are used, as a method of estimating technology maturity (see Table 6).

3.3. Innovation Roadmap

Med Food TTHubs aims at increasing the TRL from available technologies, methodologies and tools that have been developed within various projects, namely [1]:

- "Development of on-line application in FIWARE for fresh produce trade" (Funded: FInish Accelerator- FP7).
- E-MENSA – "e-Platform technologies for the European agro-food supply chain" (FP6 SSA-007124).
- RDI-TAC "Traceability and supply chain analysis for Agriculture Competitiveness" (Collaboration with NSCE in Egypt).
- SMAP – "Demonstration Project on Strategies to Combat Desertification in Arid Lands with Direct Involvement of Local Agropastoral Communities in North Africa", Contract Reference Number ME-8/B7-4100/2001/0132/SMAP-5, SCRE/111206/C/G, presented to the European Commission and supported by the Ministry of Foreign Affairs, under the financing Europe Aid Co-operation Office.
- SMAP III – "Plan of Action for an Integrated Coastal Zone Management in the area of Port Said (Egypt)" (n. MED/2005/112-172).
- TRACEBACK – "Integrated system for a reliable traceability of food supply chain" (FP6 IP-036300).

3.3.1. MED Food TTHubs e-Platform modules

The objectives for TRL improvement of the modules of the Med Food TTHubs e-Platform are presented in Table 6.

Table 6: TRL improvements.

Technology	Partner	Starting TRL	Ending TRL
Farm App Module	GP/CERTH	5	7
IoT Module	GP	6	7
Quality Module	UoP	5	7
Isotopic Profile Module	UoP	5	7
DNA Markers Module	CERTH	5	7
Nutritional Profile Module	UPM	6	7
External Tracing Module	ENG/TCA	6	7
Internal Tracing Module	ENG/TCA	6	7
B2B App Module	GP	6	7
Consumer App Module	GP	6	7

3.3.1.1. Farm App Module

The Farm App is a web and mobile application, dealing with the management of detailed information concerning the crops farms (crop history, soil analysis, irrigation and fertilizers applications, plant protection, crops, photos, etc.) and the livestock farms (breed, nutrition, manure, photos, etc.). It supports the planning and the monitoring process by keeping record of all farming activities during the cultivating season. Detail tracking of quantities and cost of all inputs and resources, such as workers, machines, seeds, fertilizers, plant protectants. It uses predefined farming task templates and schedules or create new, user-based templates. The user can view his/her activities on the calendar and track them on the map.

Figure 4: Current version of Farm App

At its current version it includes the following features:

- View fields, cultivations and tasks on the map
- Complete database of pesticide products
- Document uploads
- Register lab results for soil, water and leaf analysis
- Custom backup and restore points
- All reports are available to Excel, Word and pdf format

Moreover, the mobile app has the following features:

- View, track and create tasks events, set notifications
- Take photos via the mobile camera and attach them to fields
- Receive notifications for delayed tasks and reminders
- Use mobile GPS in order to track farming activities
- Smart tools for farming calculations

The TRL of the current version is at level 5, given the fact this module has been validated in a simulated environment. Through the MED Food TTHubs project, the Farm App Module will be enriched and enhanced moving from TRL5 to TRL7 throughout the Hubs network as follows:

- Develop additional features concerning the automatic connection of activities with places, where the activities take place.

- Develop an interface with IoT Module and relevant API for automatic data reception.
- Integration with the MED Food e-Platform. The different modules of the e-Platform will receive necessary information from the Farm App module through APIs.
- Test and validation of the Farm App Module in an operational environment including the 7 TTHubs located in 7 Mediterranean countries, with the involvement of relevant stakeholders and key actors.

3.3.1.2. IoT Module

Towards the automatic capturing of "big data" directly from the farm, GP has developed an IoT Platform, the GP Core IoT. GP Core IoT is consisted of open APIs, which have been developed using JSON and REST services as part of a telemetry system. This system uses the libraries that are provided by the manufactures of the sensor devices. The team of GP has developed an effective telemetric system, which satisfies the need for seamless collection and transfer of data from different sources in an effective manner. Its effectiveness could be evaluated against the criteria of: (i) easy to be installed, (ii) easy to use, (iii) minimum requirements for maintenance, (iv) extensibility and connectivity, (v) interoperability, and (vi) cost of operation.

The GP Core IoT supports data reception and management (on cloud), visualization of data and reporting generation. It also includes a web App for interfacing with the users as well as a set of APIs for exchanging data with third parties' systems.

An integrated telemetric network was implemented bringing together various IoT technologies, namely meteorological and other sensor devices, devices attached on farm equipment, multispectral cameras and LIDAR systems. The telemetry network is the point of gathering, pre-processing and transmitting data and events from all connected devices through the usage of the appropriate APIs. These APIs will have dual roles. The first one will be the provision of access to data that it's acquired by the devices and the second one will be the management of the devices, supporting simultaneously the monitoring and the configuration of connected devices. For the development of these APIs, libraries that might be provided by the devices' manufactures will be used.

More specifically, for the IoT devices specific standards will be followed to manage the information they provide:

- **MQTT (Message Queuing Telemetry Transport):** MQTT protocol provides a model of recording and publishing messages with an extremely small amount of data. It is useful for remote site connections, where a small footprint is required.
- **API Integrations:** All components provide gRPC and / or REST APIs for integration with external services. By default, all application data is published to a MQTT broker, however integrations are available for various providers, databases and visualization platforms.

- **Multi-tenant:** The LoRaWAN application-server supports the creation of multiple organizations to which (administrator) users can be assigned. By integrating the user-accounts into the MQTT broker authentication, organizations will only see their own data.
- **Live frame-logging:** The LoRaWAN application-server provides live frame-logging per gateway and device. It will display all the RX / TX meta-data, together with the raw LoRaWAN PHY Payload in a readable format.
- **Adaptive data-rate:** When the end-device has ADR enabled, the ChirpStack LoRaWAN network-server will ensure that the device will operate using the most efficient data-rate and tx-power. This will not only save energy at the device-side but will also optimize the usage of the radio spectrum, lowering the risk of collisions.

The structure of the GP Core IoT telemetry network is shown in Figure 5.

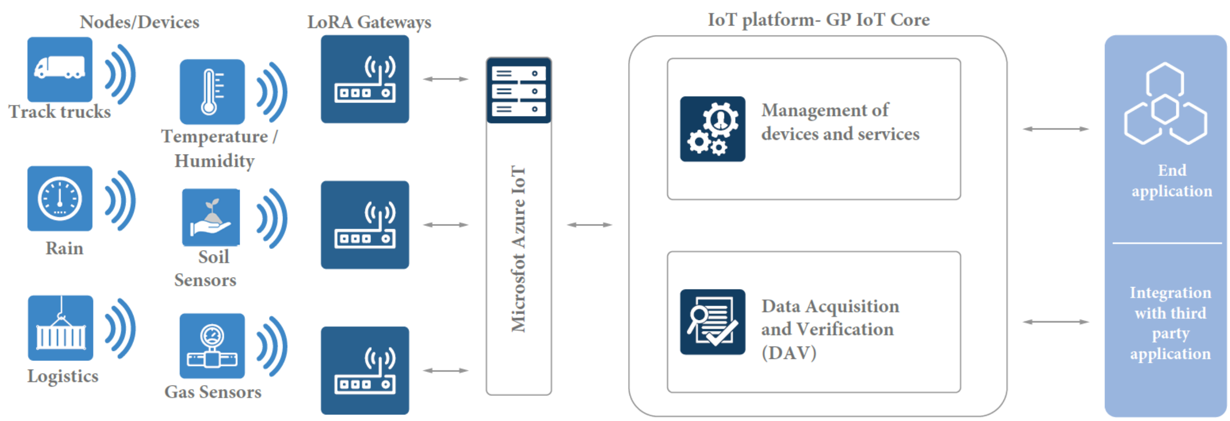

Figure 5: GP Core IoT infrastructure architecture (Adapted from LoRa Alliance, 2015).

In terms of communication between devices and the Data Logger two different networks operate, based on the needs concerning the data rates. The IoT devices communicate through a LoRaWAN network using the Low Power Wide Area Network protocol at 863 to 870 MHz for Europe, which has as its main feature the wide range of coverage (signal transmission at a distance from 20 km to 100 Km in rural areas) with very low power consumption and with no operational costs (no GSM or Satellite operator is needed). The rest of the devices, namely the LIDAR, and Multispectral Camera, given their needs for high data rates (>27 kbps), they communicate with the data logger through a LAN using either WiFi or Ethernet technologies.

The IoT Telemetry system is accessible to the users through an e-platform using HTTPS protocol providing to them data management and device management capabilities. The main areas of the platform are the following:

- Map: Provides navigation to the maps in order to find the locations where devices are placed.
- Charts: Showing measurements of various devices using timeline approach for evaluation of situation and for comparison.
- Gateways: From this section all LoRa gateways are found and corresponding details per gateway are shown
- Nodes: From this section all sensor nodes are found and corresponding details per device are shown
- External Apps: This section provides access to all external apps such as apps which monitors the operation of the autonomous PV systems.
- Notification system: The proper operation of each device is continually monitored and emails are sent to the users whenever a malfunction is occurred. These notifications are also stored at device level.
- Ticketing system: For each malfunction of the system the user may initiated a ticket in order to follow up the service procedure. The tickets are characterised with specific type of malfunction and by their status.

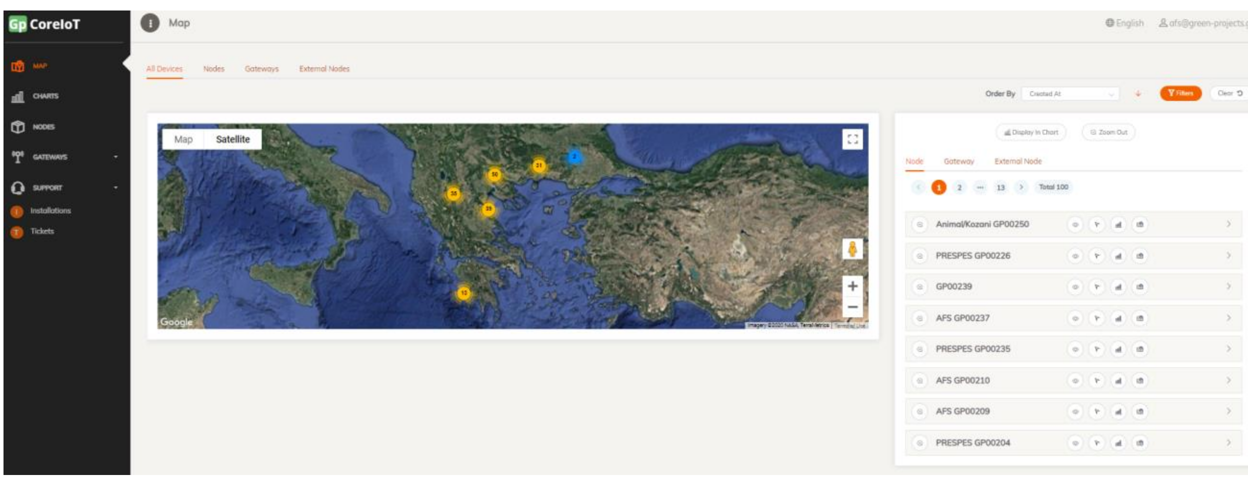

Figure 6: GP Core IoT screenshot.

The TRL of the current version is at level 6, given the fact this module has been validated in small use cases. Through the MED Food TTHubs project, the IoT Module will be enriched and enhanced moving from TRL6 to TRL7 throughout the Hubs network as follows:

- Develop an interface with IoT Module and External Tracing Module and relevant APIs for automatic data reception.

- Integration with the MED Food TTHubs e-Platform. The different modules of the e-Platform will receive necessary information from the IoT Module through APIs.
- Test and validation of the IoT Module in an operational environment including the 7 TTHubs located in 7 Mediterranean countries, with the involvement of relevant stakeholders and key actors.

3.3.1.3. Quality Module

The quality module, in order to encapsulate all quality aspects and dimensions that affect the trade of the agricultural products, will be based on 4 quality axes – priorities.

- Cultivating Techniques – axis, i.e., GLOBAL GAP certification.
- Processing Techniques – axis, i.e., HACCP /ISO 22000 certification.
- Standards – axis, i.e., UNECE Standards.
- Geographic Indication – axis, i.e., Geographic Indication Labels.

Producers of agricultural products and food stuffs in order to participate in the e-platform should provide a quality data sheet including information for all four axes. Some of this information will be LOT specific and some others concern generic procedures and certifications. All this information will be available for all users of the e-platform.

3.3.1.4. Isotopic Profile Module

The isotopic profile module allows the validation of geographic origin of agrifood products throughout the network of the MED Food TTHubs. This module includes the general approach, presented as an algorithm, to create an isotopic fingerprint database.

In order to build up an isotopic fingerprint database, stockholders and producers willing to participate in such a geographic authentication module should provide the appropriate number of genuine samples of their products in order to create a product and region specific “isotopic fingerprint” database. Such databases afterwards would be used to inspect unidentified samples in order to determine their authenticity though bivariate or multivariate statistical methods.

At the point it should be mentioned that Isotopic methods are official standards for EU. However, now there are only a few official databases that could be used for authenticity monitoring such as the official European isotopic wine databank for the controls in the wine sector and the database for the Italian PDO/PGI extra-virgin olive oils. Databases, for the rest of the products, are essential for geographical origin evaluation.

3.3.1.5. DNA Markers Module

An initial version of DNA Markers Module has been developed by GP which includes a basic workflow of validating authenticity of species and varieties of food components consisting of a step-by-step wizard. The components of the module are being validated at simulated environment (TRL 5).

Within the project a more detailed workflow of the processes, which will support the implementation of the common protocol concerning the authentication of geographic origin and of species, as well as the quality assurance of Mediterranean food, will be developed following a step-by-step traceability procedure, is shown in the following diagram (Figure 7):

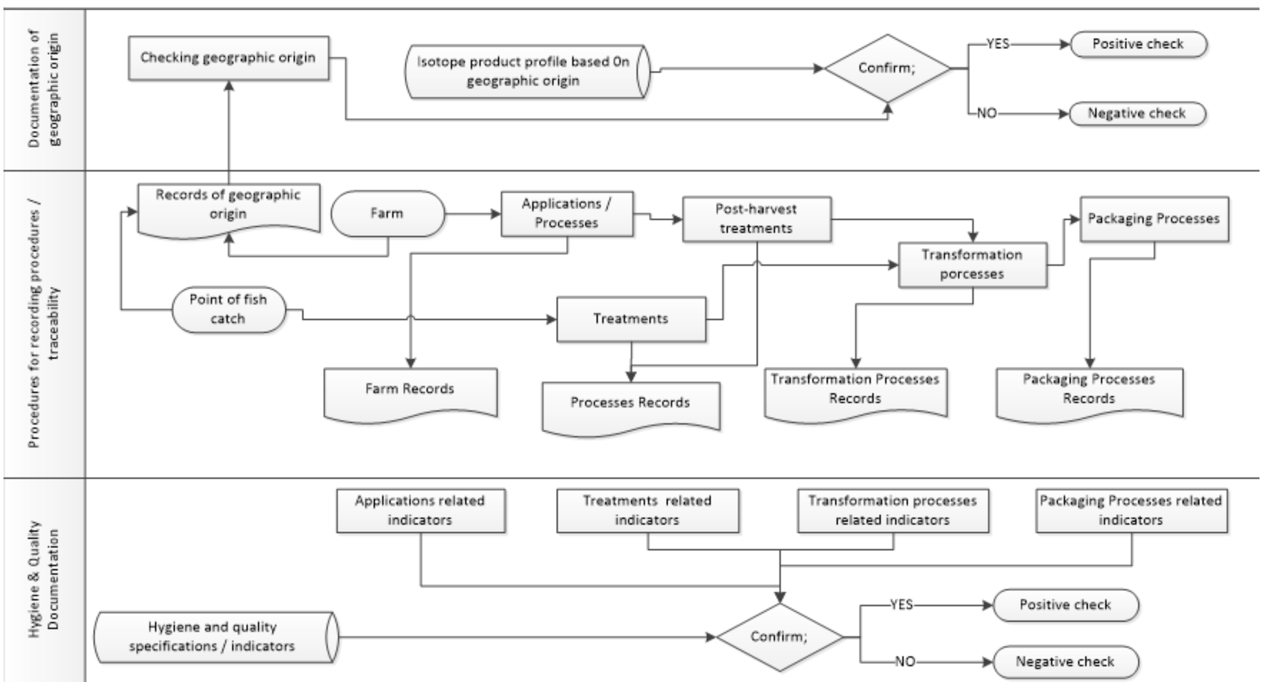

Figure 7: General overview of the processes to be supported

Furthermore, within the project specific PDO, PGI, or where not possible important agricultural products from each country will be selected. DNA will be extracted, and then universal DNA barcoding markers or microsatellite molecular markers will be applied through polymerase chain reaction (PCR). If DNA barcoding is used, then the PCR products will be sequenced. Both results will be used and will constitute the molecular marker of the product. The above work will be applied both at the source of the product as well as at the final destination were possible in an attempt to authenticate and monitor the product along the supply chain thus ensuring its integrity.

During the project new markers specific for the selected products and the correlation of the markers with the quality data and the digital data used through the supply chain in the traceability and authenticity control of traditional Mediterranean foods.

3.3.1.6. Nutritional Profile Module

The Nutritional Profile Module is in charge of the management of nutritional profiles of products intending to not only inform about the products (e.g. wine) but also to recommend specific products with Protected Designation of Origin (e.g. Cune Imperial, Rioja PDO - Spain). It supports the whole process of requesting nutritional analysis and the creation of new profiles based on the special characteristics of food components throughout the network of the TTHubs.

This module will be composed of two main elements: a nutritional profile and a MED Food TTHubs Nutritional Label.

- A nutritional profile, which incorporates micronutrients and macronutrients but must be adapted in case of willing to give solutions to certain exceptional situations that arise in the process of classification of food products. For example, this would affect dietary products, foods for weight control and foods for athletes.
- A MED Food TTHubs Nutritional Label (see Figure 8) which is a graphic element that shows in a synthetic way the characteristics of a food product. The label will contain all the relevant information of the product. Also, it would include a colour to indicate in an easy way a quality indicator.

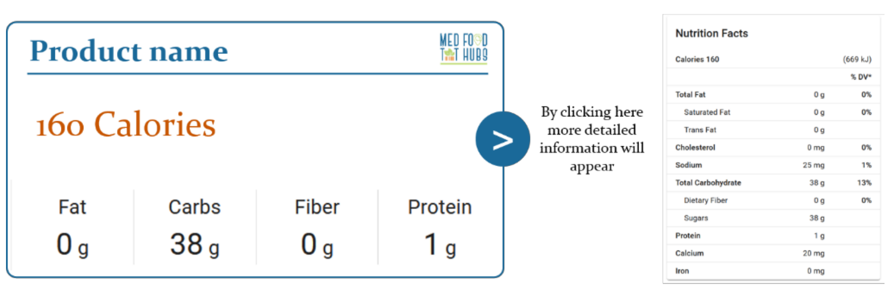

Figure 8: MED Food TT Hubs · Nutritional Label

Before the MED Food TTHubs project, the Nutritional Profile Module is a TRL6 technology, which means that it has been tested and validated in relevant environment. Concretely, this module has been validated in a clinic dedicated to combating obesity, as part of a system aiming to ensure a complete wellbeing by means of nutrition, physical activity and mindfulness in Madrid, Spain. This module is feed by several Spanish Nutritional databases, Nutritional profiles, and Healthy food labels to create the nutritional profile of different Spanish food products. To obtain a nutritional profile of a food product, an algorithm analyses the most relevant information (e.g. food component values) provided by the different collected information.

Through the MED Food TTHubs project, the Nutritional Profile Module will be enriched and enhanced moving from TRL6 to TRL7 throughout the Hubs network as follows:

- Increase of the food products to be analysed. The MED Food TTHubs project is formed by 7 hubs, so it will be necessary to include nutritional databases, nutritional profiles and healthy food labels from all the hubs to obtain the information of all their specific Mediterranean food products.
- Integration with the MED Food TTHubs e-Platform. The different modules of the e-Platform will provide different information about the food product that can be used as input of the algorithm of the Nutritional Profile module in order to improve the quality and details of the nutritional profile.
- Improvement of Nutritional Profile module flowchart. Algorithm and decision tree will be adapted to the needs of the project and redesigned to include all the new food products as well as the relevant information provided by the other modules of the e-Platform.
- Addition of a MED Food TTHubs Label. In addition to the creation of the nutritional profile, a coloured label will be included as a result of the flowchart to indicate all the relevant information of the product as well as its quality.
- Test and validation of the Nutritional Profile Module in an operational environment including the 7 TTHubs located in 7 Mediterranean countries, with the involvement of relevant stakeholders and key actors.

3.3.1.7. External and Internal Tracing Modules

The experience gained in the field of Research Projects relating to food traceability has allowed ENG to develop a Reference Architecture (RA) and a web platform for the integrity of the supply chain to be applied to the agro-food context for “external” and “internal” traceability. The *external traceability module* is a tracing framework covering all kind of check-in, check-out events (departing, transporting, arriving) from point-to-point at the supply chain, supporting tracking and monitoring of conditions of each shipment in real-time. The *internal traceability module* is a tracing framework that involves all products transformation using GS1 global standards. Open architecture with connection user interfaces (UI) to production lines for batch and label generation based on sorting and weighing.

Considering the complexity of this kind of software system, the first implementation aspect considered is the definition of the RA. The Reference Architecture for Traceability Information Systems (RATIS), developed within the project TRACEBACK[1] “Integrated system for a reliable

[1] https://cordis.europa.eu/project/id/36300/it

traceability of food supply chains [FP6-FOOD - Food Quality and Safety: Thematic priority 5 under the Focusing and Integrating Community Research Programme 2002-2006.], defines and describes what services can be considered as logical building blocks of a traceability system, how they are supposed to interact, which functionalities are supposed to use or provide, which information are supposed to exchange and share, and so forth. Therefore, RATIS aims at supporting and guiding the development of collaborative service-oriented information systems enabling traceability-related processes and functions. The main reason to define a reference architecture is to solve a problem (traceability) in general and define a set/family of solutions for such a problem by providing how each specific solution (i.e. concrete architecture) and its components should look like, guidelines and best practices for defining specific solutions, and other experiences to exploit.

RATIS is a coordinated set of specifications of:

- **External services:** what services a company traceability information system is supposed to both expose and provide so as to implement traceability at the level of the entire supply chain. These services are supposed to make several parties and their traceability information systems interoperable among one another. This includes services such as supply chain configuration, management of information about external traceability, and so forth;
- **Internal services:** what services a company traceability information system, developed according to RATIS, is supposed to require and expose against other internal information systems already owned by food players. These services are supposed to make RATIS-based traceability systems (or parts of them) and services interoperable with the existing systems owned by food companies. This includes services that are supposed to be "logically" provided by data acquisition tools, such as (micro-)devices;
- **Third party services**: what new services (logically external to food players) are needed to manage and implement traceability at the level of the entire supply chain. Examples of such services concern with security, data storage, data analysis and processing, etc., which, within a service-oriented economy, can be offered by third party service providers, preventing food companies implementing them, and saving resources (i.e. the costs of using these services should be less than the costs of developing and managing them). Of course such services might be directly and internally hosted and managed by food companies

The main features of the proposed RATIS -based solutions to traceability are:

- **Integration**: information systems for supply chain traceability become a service integration activity, aimed at exploiting and reusing existing services, useful to meet specific (and / or emerging in the future) needs, constraints, opportunities, configurations and objectives;
- **Reusability**: the goal is to reuse what already exists and is useful in order to manage supply chain traceability;

- **Flexibility**: support is provided to change / adapt the configuration and behaviour of already developed services, replacing old services with new ones (e.g. more performing, or of better quality, or at a lower price, etc.), choosing where to install the services, what is the best way to access them, and so on;
- **Composition of services (distributed):** the composition of services is proposed and supported to create new value-added services, providing high-level, higher quality and better performing functions, etc.
- **Web-based:** Internet and the Web as the reference operating system for traceability information systems. Indeed, people are supposed to use Web-based (rich) user interfaces to access RATIS-based applications, while companies' information systems are requested to interact between one another through Web-based standards and technologies (i.e. Web services);

The key issue in traceability systems is to have a continuous flow of information among parties along the supply chain, in order to create and manage the links between all relevant entities and so RATIS aims at providing an asset base for collaborative and distributed service-oriented traceability information systems, covering some required aspects that every traceability information system should cope with. These aspects are:

- creation, acquisition, and recording of relevant traceability data along the entire supply chain. Data creation and acquisition operations are as automatic as possible, by using automatic identification and data capture devices, tools and technologies, even though non-automatic or manual data acquisition will be considered as well.
- storage of traceability data in a central repository. That is, regardless how supply chain partners store traceability information (i.e. where, with which structure, etc.).
- semantically-sound exchange and sharing of traceability information among parties (and then among their own information systems and ICT infrastructures) within "collaborative" supply chains, in which information flow anticipates or is parallel to the flow of goods. This is achieved by means of specialized data management services that provide several facilities to retrieve and synchronize traceability information;
- exploitation, browsing and querying of traceability information, in order to provide users (e.g. food players, end consumers, and other external stakeholders) with relevant information about food flow, quality, transportation and storage conditions, etc. On the basis of such information, many applications and added-value services can be foreseen, ranging from querying traceability data to exploiting such data to manage crisis or assess risks related to traceability, to performing high-level data analysis or providing relevant information to regulators or auditors, for certifications, and so forth.

Starting from RATIS, a web based portal for "Internal" and "External" tracing activities has been developed and its main components are:

- **Source Integration Framework:** collects heterogeneous data from data sources connected to the system and performs an initial extraction of information from the collected data.
- **Event Extraction and Integration**: starting from information extracted or provided by integrated systems, the platform generates events characterized by relevant data and extracted information (useful info).
- **Situation Extraction and Context Awareness**: this is the level at which the processing and analysis of information and relevant events are carried out aimed at raising awareness of the current situation.
- **Traceability Apps and Services**: represents the level at which the services and applications are created, this is the interface between the traceability portal and all final users.

The platform provides basic services to ensure the delivery of content on enabled channels and manage interfacing with external systems. It allows the editing and organization of content in a simple and quick way, by a variety of users, organizations and different groups, while still guaranteeing access rights through application profiling based on roles.

The Platform adopts the concept of event as the atomic information unit because of it well represents a phenomenon that occurs within the observed reality, providing the conditions for associating this phenomenon with information relating to the specific domain, to the time, place and context in which the phenomenon was observed. An event-based architecture also guarantees a high ability to adapt to different levels of abstraction, as you can refer to a generic event or even a more specific one, you can compose simple events to create more complex events. It can analyse a single event or a specific sequence (possibly describable through complex patterns), and so on. The events are described through the Event Information Model which describes the taxonomy and structure of the events in the agro-food chain of interest managed through the traceability portal. The term event represents the result of a sequence of operations that lead to the generation of consolidated information starting from the raw data extracted or generated from the information sources integrated into the platform. Events are divided into 3 categories: Base Events, Internal Events and External Events.

The base event contains the essential information characterizing all the events: a unique identifier and a time stamp that represents the instant in which the event took place.

All events involving the same actor in the supply chain are Internal Events and they represent the salient events that describe the internal tracing process. They are described in the following tables.

Table 7: Internal Events

Event Name	Event Description
Storage	This event concerns repository of information relating to the storage of raw materials, semi-finished or finished products
Movement	This event stores information regarding the movement of goods within the company (e.g. from the production line to the warehouse or from one warehouse to another).
Destruction	This event aggregates information related to the destruction of a raw material or product.
Production	This event aggregates information related to the completion of a production phase.
Splitting	It stores the information associated with the division into smaller parts of a raw material, an ingredient or a product (e.g. from a pallet we obtain several cartons, etc.).
Aggregation	It stores information related to an aggregation process in which multiple raw materials, multiple ingredients or multiple parts are combined (e.g. when several cartons are stacked to form a pallet, etc.).
Mixing	This event stores information relating to the selection of various items to create a new one following which it will no longer be possible to distinguish the different parts (e.g. when I add preservatives or sweeteners in a preserve).
Grouping	This event stores information associated with dividing an element into multiple groups (for example, subdividing an element by colour or by size).
Packing	This event stores information associated with the product packing / wrapping process.
Repacking	This event stores information associated with the repacking process intended as the packing of items already packed (for example a package containing individually packed items).

Inspection	This event stores information related to the inspection process of an element (where required, e.g. inspection of raw materials in input to the production process).
Measure	This event stores information related to a measurement of a physical quantity (e.g. monitoring of a physical property).

External events concern different actors involved in the production process, in particular these events are linked to the operations that starting from raw materials allow to obtain finished products. They are described in the following table.

Table 8: External Events

Name	Description
Receive	This event stores information associated with the receipt of a good or product.
Despatch	This event stores information of the process related to the shipment of a product (often associated with the creation of a delivery note).
Transport	This event stores information associated with the transport between two companies (or between two factories of the same company) of a good / product.

In order to guarantee traceability and manage non-conformities, ensuring the safety of consumers and the transparency of communications towards them and to make the system as compliant with the legislation as possible, it has been chosen to identify the products within the portal following the GS1 standard, the most popular product coding system in the consumer goods sector worldwide. Thanks to a common language, companies will be able to work more efficiently and with less costs and the entire producer-distributor-consumer cycle will be positively affected.

During MED Food TT Hubs project the traceability modules described above will reach the TRL 7 by integrating them in a global and common platform available for Mediterranean countries and they will integrate, in turn, other applications and functionalities related to traceability of agro-food products.

3.3.1.8. B2B App Module

B2B App is a module, which aims to facilitate online B2B collaboration between sellers of fresh produce and traders concerning the exports of vast quantities of fresh fruits and vegetables focusing on traceability from farm to fork. B2B App effectively supports the brokering operation between traders and sellers, as well as the whole set of logistics functions of such transactions.

The whole process for the buyer is described in the following steps:

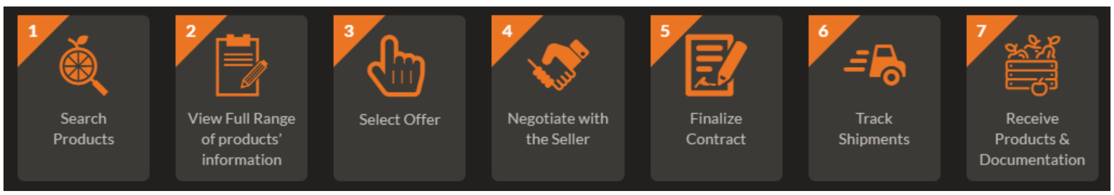

Figure 9. B2B processes supported by B2B App Module

B2B App provide real time information to wholesalers concerning:

- Availability of quantities of fresh products (yearly, mid-term & spot sales)
- Full range of products' information (variety, quality class, size, photos, etc.) following global standards (UNECE)
- Information about the farms (exact location- Google Earth ™)
- On line RFQs, price negotiation and contract issuing
- Detailed and transparent pricing for products, handling and transport
- Creation of LOTs and dispatchments
- Contracts monitoring and placing of orders
- A single place for all necessary trading documents
- Full-path tracing from farm to wholesaler using international standards (UNECE, GLN, GPC, GTIN, SSCC)

The TRL of the current version of B2B App is at level 6, given the fact this module has been validated in small use cases. Through the MED Food TTHubs project, the B2B App Module will be enriched and enhanced moving from TRL6 to TRL7 throughout the Hubs network as follows:

- Support more products, such as meat and fish products, processed fruits and vegetables.
- Incorporate a blockchain architecture to support the whole B2B process and the chain of custody.
- Integration with the MED Food TTHubs e-Platform. The different modules of the e-Platform will exchange necessary information with the B2B App Module through APIs.

- Test and validation of the B2B App Module in an operational environment including the 7 TTHubs located in 7 Mediterranean countries, with the involvement of relevant stakeholders and key actors.

3.3.1.9. Consumer App Module

Through the Consumer App, consumers from around the world can access detailed product information from ground to mouth, by using KalaΘos TraceID or KalaΘos QR code. The process is very simple: on each fruit (or on a package) the consumer may find the 6-digit KalaΘos TraceID and enter it in the app in order to retrieve detailed and accurate information about the specific product, from variety characteristics to nutritional profile and preservation tips.

The real story of each fruit or vegetable includes the following:

- Full profile of the product (product characteristics, variety, PLUs, etc.)
- Details from the farm to the shelf (when it was harvested, when its journey started, etc.)
- Details of each product’s nutritional values in comparison to personalized nutritional needs based on the profile of each consumer
- Information about the exact origin of each product (producer, exact farm through Google Earth™, photos and videos.

The ability to provide the above information to the consumer is feasible due to the “end-to-end” traceability processes of the supply chain of fresh produce that is followed by combining internal and external tracing procedures, so that each operator is able to locate the immediate source and the immediate recipient of each product. KalaΘos traceability procedures are based on the "one step up, one step down" principle to provide effective traceability in the supply chain. More specifically, each distinct product is recognised globally and in a unique way so that it can be identified upstream and downstream of the supply chain.

All participants in the distribution network are able to use the system to implement internal and external traceability practices, and in addition, internal traceability is applied in such a way as to ensure that the necessary connections between inputs and outflows are maintained. The consumer can even rate the specific product through Consumer App, so the producer may receive feedback directly from the consumer following a crowdsourcing approach.

The TRL of the current version of Consumer App is at level 6, given the fact this module has been validated in small use cases. Through the MED Food TTHubs project, the Consumer App Module will be enriched and enhanced moving from TRL6 to TRL7 throughout the Hubs network as follows:

- Support more products, such as meat and fish products, processed fruits and vegetables.
- Incorporate the use of GS1 Cloud services via application programming interfaces (APIs).

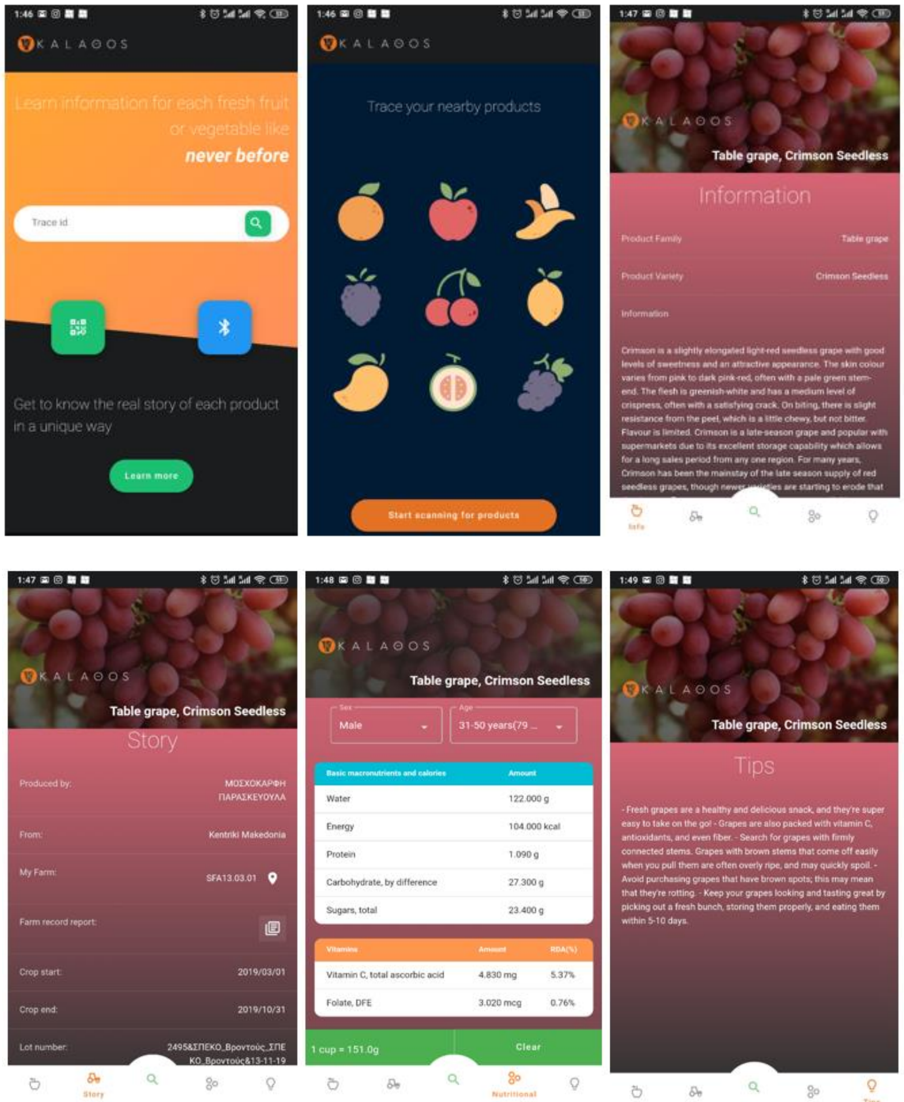

Figure 10. Screenshots from Consumer App

- Enrich the information provide to the consumer through the connection with the Nutritional Profile Module. The provided detailed and accurate information about a specific product will focus on health and on nutritional elements (support personalised nutrition needs served by Mediterranean diet menu building).
- Enrich the information provide to the consumer through the connection with the Farm App Module and External & Internal Tracing Module. The provided detailed and accurate information about a specific product will focus on environmental issues (detailed products and processes footprint per specific product).

- Integration with the MED Food TTHubs e-Platform. The different modules of the e-Platform will exchange necessary information with the other modules through APIs.
- Test and validation of the Consumer App Module in an operational environment including the 7 TTHubs located in 7 Mediterranean countries, with the involvement of relevant stakeholders and key actors.
- Test and validation of the Nutritional Profile Module in an operational environment including the 7 TTHubs located in 7 Mediterranean countries, with the involvement of relevant stakeholders and key actors.

3.3.2. MED Food TTHubs processes

3.3.2.1. Origin Authentication Processes

All materials, including foodstuffs, consist of chemical elements and these elements are composed of their stable isotopes. Biomass is continuously being transformed from the resources of the environment, where plants are grown or animals bred, thus reflecting local nutrients, fodder, and drinking water. Although isotopic composition does vary within a limited range, which is not usually detected routinely, it can be regarded as remaining constant and is, therefore, an "isotopic fingerprint". This is not comparable with the greater variability of the human fingerprint but reflects its "stability". Recent technical improvements in stable isotope-ratio mass spectrometry (IRMS) mean that this is the method now frequently applied; it is this technique which will be considered in this proposal.

An elemental analyser coupled to a magnetic sector mass spectrometer (EA-IRMS) gives the bulk isotopic composition of a sample. Depending on the specific set up (varies for different products), it is possible to measure isotopic ratios of H, C, N, O and S ($^{2}H/^{1}H$, $^{13}C/^{12}C$, $^{15}N/^{14}N$, $^{18}O/^{16}O$ & $^{34}S/^{32}S$) in a range of solid and liquid matrices.

In combustion mode, C-, N- and S-containing materials are loaded into Sn capsules, which are dropped into a reactor packed with suitable catalysts. O_2 is admitted into the reactor, resulting in flash combustion of the sample to a mixture of N_2, NO, CO_2, O_2, SO_2 and H_2O, depending on the nature of the substances combusted. This gas mix is carried by the He flow to a reduction reactor, where NOx are reduced to N_2, and excess O_2 is eliminated. Water is eliminated in a chemical trap, and the gases of interest separated on a suitable chromatography column.

The pyrolysis mode is employed for the analysis of O and/or H. For oxygen, samples are loaded into Ag capsules and dropped into a ceramic reactor lined by a glassy carbon tube in the inside, and packed with nickelised carbon, where the sample is pyrolysed to CO. As before, water is chemically trapped, and contaminant gases separated by chromatography. H from water samples is obtained by injecting 0.2-0.4 µl via a liquid autosampler onto a reactor packed with Cr.

Dried gases from the combustion system travel to the IRMS detector and are subjected to electron-impact ionization and a succeeding magnetic-sector or electromagnetic analyser, deflecting the generated ions by molecular weight to be subsequently detected by precisely positioned Faraday cups.

The technique of differential analysis of sample and standard permits very small differences in the isotopic composition of test samples to be reliably and accurately determined. Thus, isotopic abundance of a sample relative to a reference is normally expressed by the differential Equation:

$$\delta(‰) = (Rsamp/Rref - 1)*1000$$

Where δ is the isotope ratio of the sample expressed in delta units (‰) relative to the reference material. Rsamp and Rref are the absolute isotope ratios of the sample and reference material, respectively. Multiplying by 1000 converts the value to parts per thousand (‰). The above procedure will be applied voluntary for the products trading throughout the MED Food TTHubs in order to create a database of isotopes analysis that can be used as the “isotopic fingerprint”. After that, the “isotopic fingerprint” could be used to evaluate ‘suspect’ products by comparing and statistically screening their isotope profile with the “isotopic fingerprint”. This procedure could establish the authentication of the participating products.

3.3.2.2. Species Authentication Processes

Methods based on the genetic identification of food by polymerase chain reaction (PCR) are available to identify authenticity and traceability by exploiting the genetic variability of different species and even varieties. Genetic material (DNA) is suitable as a means of traceability as it is an extremely stable biomolecule that can be recovered from a large number of biologicals even if they have not been maintained in ideal conditions. Two basic techniques-criteria of genetic identification are molecular markers (DNA markers) and DNA barcoding (DNA barcoding), which relate to the molecular identification of varieties and species respectively.

Molecular markers

Molecular markers (DNA markers) detect differences in DNA sequence that can distinguish between intra- and intra-specific diversity. The analysis of molecular polymorphism markers finds application in the evaluation and characterization of genetic diversity, the creation of molecular maps, in the isolation of genes and in the protection of varieties.

DNA barcoding

In addition to the nuclear genome, the genome of organelles, such as chloroplasts (cpDNA) and mitochondria (mtDNA), is a means of identification and authentication and is increasingly used in the food industry and in the use of labelling in the food supply chain. The detection of counterfeit fresh and processed products.

Chloroplast DNA is now widely used. The chloroplastic genome is found in multiple copies within each cell and makes it easier to retrieve information even in altered samples or processed products of plant origin. DNA barcoding is a technique used to identify species based on differences in small regions of DNA sequences. Such a sequence, in order to be used as a barcode, must meet the following criteria: (a) the existence of genetic variability at the species level to enable species separation; for the development of universal primers. Seven chloroplastic sites have been proposed to select the most suitable area for barcoding in plants (rpoC1 <rpoB <atpF-atpH <rbcL <, matK <psbK-psbI <trnH-psbA) but the following three have been pre-selected:

- rbcL: it is easy to use but has little resolution
- matK: has higher resolution but less universality
- trnH-psbA: high resolution, good universality but variable size and sequences are stopped by SSRs

The main advantages of the method are that very small quantities of any plant tissue are sufficient, and that due to the small amount of DNA required it is possible to identify species even in commercial products.

Overall specific PDO, PGI or where not possible important agricultural products from each country will be selected. DNA will be extracted, and then universal DNA barcoding markers or microsatellite molecular markers will be applied using polymerase chain reaction (PCR). If DNA barcoding is used then the PCR products will be sequenced. Both results will be used and will constitute the molecular marker of the product. The above work will be applied both at the source of the product as well as at the final destination were possible in an attempt to authenticate and monitor the product along the supply chain thus ensuring its integrity.

3.3.2.3. Nutritional Analysis Profile Processes

The Nutritional Analysis Profile is based on blockchain technology that, as the rest of the processes, will shorten the supply chains and reduce the costs associated with authenticity and quality procedures. The Nutritional Analysis Profile defines the process for creating and validating the nutritional profile of food products, using fortification technologies and nutrigenomics. Its definition comprises 5 phases: research, conceptualization, technologies selection, flowchart definition and validation.

The conceptual schema of the process is depicted in Figure 11. To obtain a nutritional profile of a food product it is necessary to incorporate several nutritional databases including food composition values and other data on the food related to its origin, type of processing, etc.

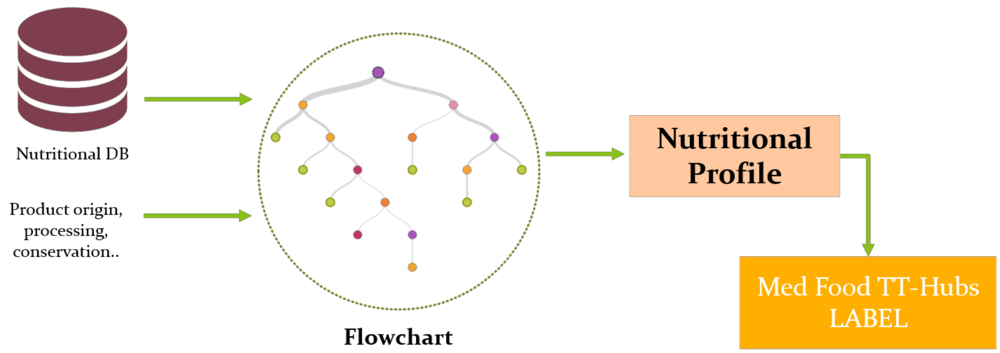

Figure 11. Nutritional Analysis Profile Processes - concept

Additionally, other relevant information provided by the other e-Platform modules will be included in the process for the creation of the profile of the food products. All this information will be deployed in a flowchart, in which a decision tree algorithm will be implemented to obtain two main outcomes: a nutritional profile and a MED Food TTHubs Nutritional Label.

3.3.2.4. Quality Assurance Processes

The quality module in order to encapsulate all quality aspects and dimensions that affect the trade of the agricultural products will be based on 4 quality axes – priorities.

Cultivating Techniques - axis

The first axis of the Quality module will examine quality aspects of the agricultural production itself. In this way, full records of fertilizer and pesticide applications, livestock breeding, use of antibiotics, biochemical analysis of samples, photos and in general pre-harvesting procedures is useful to be reported. The module in this axis will use the GLOBAL GAP certification for certified producers or depending on the product check list of GLOBAL GAP to ensure, a minimum level for the applied cultivation techniques.

Processing Techniques - axis

The second axis of the quality module will examine (if there such a production stage for the examined product) the procession procedures used for the examined product. For this reason, all the Food Quality Assurance systems available for food and foodstuff will be added in this axis. In this way already known systems such as ISO 22000, BRC, IFS, etc. will be available only for stockholders that have acquired and incorporate the relevant certification in their processes.

Standards - axis

The third axis of the quality module will include in the quality module the working procedures of the United Nations Economic Commission for Europe (UNECE). UNECE Standards cover a wide spectrum of agricultural products: fresh fruit and vegetables (FFV), dry and dried produce (DDP), seed potatoes, meat, cut flowers, eggs and egg products. These standards provide a common trading language by illustrating common terms. For example, for many fruits and vegetable consumers and stockholders have heard that there 3 product categories i.e., Extra, Category 1 Category 2 etc. UNECE guides define and illustrate this terminology for each product.

Geographic Indication – Axis

The fourth axis of the quality module will include the quality schemes promoted by Common Agricultural Policy aiming at protecting the names of specific products and promoting this way their unique characteristics, linked to their geographical origin as well as traditional know-how. In this quality module will be included the PDO (Protected Designations of Origin), PGI (Protected Geographical Indications) or the TSG (Traditional Specialty Guaranteed) name of the traded product on agricultural products and foodstuffs. It is known that European Union (EU) quality schemes were associated with a label, which was introduced to allow consumers to perform an informed choice and to protect producers from unfair practices.

3.3.2.5. Full-path Traceability Procedures

The full path Traceability Procedure involves the application of 3 distinct analysis procedures.

Each product and especially PDO, PGI or other designated and important agriculture products possess unique attributes and qualities. The full path Traceability procedure involves the analysis and registration of the nutritional qualities of the different products involved and selected in the project, then the path involves the identification of the species using DNA methods and finally the certification of the geographical origin using the isotopic makeup of each product.

3.3.3. MED Food TTHubs pilots

The MED Food TTHubs pilot cases are based upon food traceability and authenticity services and their impact on supply-chain of food products. Besides that, MED Food TTHubs pilots will also focus on the added value provided on Mediterranean food products in each part of the value chain through the development of an e-Platform, as well as the operation of a transnational network of seven Trace & Trust Hubs (TTHubs) for traceability and authenticity.

The MED Food TTHubs pilots will demonstrate and test new business processes for providing added-value services concerning the traceability and authenticity control through one-stop-shop units, which will act as Hubs between the market and the laboratories. In addition, they will validate tools' use, configure discrepancies from the user requirements, identify challenges and opportunities, while also fine-tune and optimise their usability and exploitability from Mediterranean's food sector. Given that the MED Food TTHubs consortium consists of partners that has expertise on the mot stages of the supply-chain, the pilot cases will be considered at each level, as well as for a range of food products. More specifically, seven cases will be evaluated in real-word scenarios: processed fruits in Italy, fishery products in Greece, processed vegetables in

Egypt, fresh vegetables in Jordan, meat products in Portugal, fresh fruits in Tunisia, while nutritional profile analysis for various food products will be pilot tested and evaluated in Spain.

In this respect, the general workflow will cover the whole “seed-to-shelf” supply chain. Thus, the following stages will be adjusted for each real-world scenario: (i) point of cultivation or breeding, (ii) 1st processing stage, (iii) storage, (iv) final processing, (v) market. In each country, a TTHub will be established bringing together various supply-chain actors and providing adequate training in applying the protocols and using the e-Platform developed under project’s activities. Among the seven pilots a continuous exchange of experience will occur towards the evolution of the whole system for eliminating any problems and improve its efficiency. Finally, based on the experience that will be gained by running the pilots, an evaluation process will be undertaken which will lead to proposed improvements of the MED Food TTHubs protocols and the e-Platform.

3.3.4. MED Food TTHubs e-Platform

A blockchain e-platform technology will be developed and will operate with the support of the Hubs to facilitate the traceability process, the authentication and quality assurance and the nutritional profile of Mediterranean food products. The electronic platform will effectively support the point-to-point tracing using a blockchain approach for increased transparency and building of trust. It will also support the implementation, monitoring and documentation of the Authentication and Quality Assurance Protocol concerning the entire product lifecycle. For the proper and efficient realisation of the aims of the Hubs the electronic platform will support the accurate implementation of a whole set of procedures in a holistic way. The electronic platform will be built in a modular way so that each module can operate independently or in conjunction with other information systems.

All data within the Med Food TTHubs e-Platform will be managed using blockchain technology (shared, permissioned ledger) in order to provide transparency and trust throughout the whole supply chain. In our proposed system, blockchain can act as a shared data layer to enable multiple parties to track the status of a product as it moves across the custodial chain and share information on its provenance and handling in a secure and transparent way. On the top of the blockchain architecture, web-based applications and modules will be interconnected. For the access of these web-based elements, a specific Data Protection approach will be adopted, which will ensure authentication of users accessing the data and, furthermore, confidentiality, access control, and integrity of handled data according to the permissions granted by the data owner. Security and integrity of data will be tackled through a hybrid encryption scheme through the usage of symmetric encryption ensuring confidentiality of handled data and also ensuring the protection of personal data, whereas the application of asymmetric encryption on top of such symmetric scheme enables a better management and distribution of keys.

The set of the individual modules of the electronic platform are the following:

(i) **Farm App Module**: Detailed information concerning the crops farms (crop history, soil analysis, fertilization applications, plant protection, crops, photos, etc.) and the livestock farms (breed, nutrition, manure, photos, etc.). Interface with IoT Module for automatic data reception.

(ii) **IoT Module:** Farm, livestock and equipment sensors system and interfaces for connection with Farm App Module and External Tracing Module. The platform's module will be consisted of open APIs, which will be developed using JSON and REST services for gathering, pre-processing and transmitting data and events from connected IoT devices [8][9].

(iii) **Quality Module:** Quality monitoring tool which will support the quality procedures according the common protocol as well as established quality systems, using UNECE standards. - Full records of fertilizer and pesticide applications, livestock breeding, use of antibiotics, biochemical analysis of samples, photos (pre-harvesting, after-harvesting, packaging, shipping), etc.

(iv) **Isotopic Profile Module**: Management of isotopic profiles of products. Support the whole process of requesting validation of geographic origin of food components throughout the network of the Hubs.

(v) **DNA Markers Module:** Management of DNA markers. Support the whole process of requesting validation of genetic identity of food components throughout the network of the Hubs.

(vi) **Nutritional Profile Module:** Management of nutritional profiles of products. Support the whole process of requesting nutritional analysis and creation of new profiles based on the special characteristics of food components throughout the network of the Hubs.

(vii) **External Tracing Module:** External tracing tool covering all kind of check-in, check-out events (departing, transporting, arriving) from point-to-point at the supply chain. Supporting tracking and monitoring of conditions of each shipment in real-time.

(viii) **Internal Tracing Module:** Internal tracing tool at the packing-house and process facilities level using GS1 global standards [10]. Open architecture with connection interfaces to production lines for batch and label generation based on sorting and weighing.

(ix) **B2B App Module:** For easier communication with market partners at different points of the supply chain. This app will provide to access to product information concerning traceability and authentication of food products.

(x) **Consumer App Module:** Through Consumer App, consumers from around the world will be able to access detailed product information from seed-to-shelf, by using TraceID or QR codes.

Figure 12 schematically depicts the information entry points of the e-platform along the supply chain at the level of the different entrances along with the interconnected modules and the connection with systems already developed by project partners.

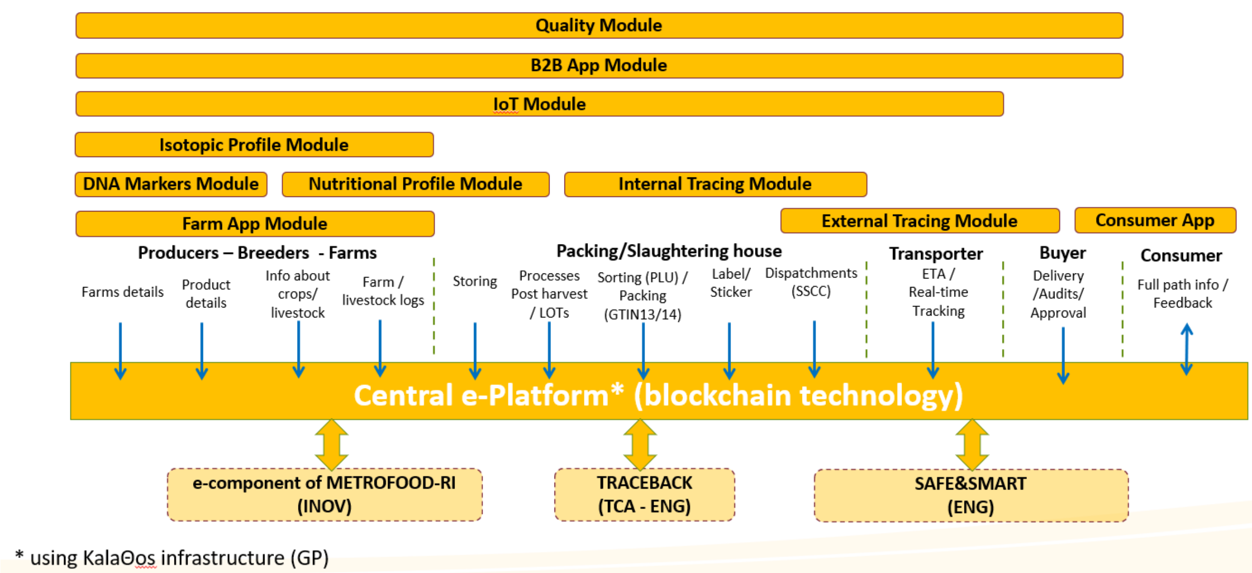

Figure 12 Overview of e-platform – Concept

The e-platform will be based on the architecture of KalaΘos^{TM} platform that has been developed by GP. Through web, smartphones and tablets, real-time information is provided by KalaΘos Main Platform and its complementary Modules, which can operate independently or in conjunction with other information systems. The SOA approach is applied and more specifically JSON implementation is adopted. This open architecture overall approach serves modularity within KalaΘos and total operability with external systems. KalaΘos platform together with its individual modules covers the entire range of production and distribution of fresh fruit and vegetables from the farm to the wholesaler.

3.4. Detailed Innovation Plan

In Table 9, the innovation milestones are presented and related to the Grant Agreement's milestones and WPs, ordered by ascending date.

Table 9: Innovation milestones

Month	Related WP	Related Grant Agreement milestones (MS)	Means of verification
M11	WP2	(MS1) Focus group mapping and requirements formulation	Report of focus group and requirements analysis
M14	WP3	(MS2) Mapping of the full-path traceability procedures	Full-path Traceability Protocol
M17	WP4	(MS3) Software architecture design	Alpha version development during Task 4.2
M19	WP5	(MS6) Development of methodologies tools and indicators to assess the Med Food TTHubs	Report on assessment methodology and indicators
M21	WP4	(MS4) Development of Med Food TTHubs Platform and core modules	Operational and Management tools completed External pilot testing & prototype
M25	WP6	(MS7) Pilot Use Cases Demonstration	Pilot Use Cases Deployment completed
M32	WP8	(MS8) Public Awareness & Dissemination	D8.4 Med Food TTHubs Dissemination Activities Report
M36	WP1 WP6 WP7 WP8	Project conclusion	D1.3 Scientific Roadmap and innovation management Evaluation D1.4 Med Food TTHubs IPR Plan & IPR Management D6.3 Evaluation report D7.3 Roadmap report D8.5 Cost-Benefit Analysis & LCA report

In the following tables, a detailed innovation plan is presented according to the project milestones in Table 9, for each MED Food TTHubs e-Platform module, for the MED Food TTHubs e-Platform as a system, for each MED Food TTHubs process, as well as for the MED Food TTHubs pilots.

Table 10: Farm App Modules: detailed innovation plan

Month	Detailed innovation plan
M12	Requirements formulation in order to identify new functionalities for Farm App to be added
M17	Design of the integration interfaces to include this module into the TTHubs e-Platform alpha version
M20	Refinements and integration of the Farm App Module within the MED Food e-Platform (alpha version).
M26	Improvement of the Farm App Module according to the comments of the project partners. (beta version).
M33	Improvement of the Farm App Module according to the feedback from the pilot application of the beta version.
M36	Final and validated version of the Farm App Module

Table 11: IoT Module: detailed innovation plan

Month	Detailed innovation plan
M12	Requirements formulation in order to identify new functionalities for IoT Module to be added
M17	Design of the integration interfaces to include this module into the TTHubs e-Platform alpha version
M20	Refinements and integration of the IoT Module within the MED Food e-Platform (alpha version).
M26	Improvement of the IoT Module according to the comments of the project partners (beta version).

Month	Detailed innovation plan
M33	Improvement of the IoT Module according to the feedback from the pilot application of the beta version.
M36	Final and validated version of the IoT Module

Table 12: Quality Module: detailed innovation plan

Month	Detailed innovation plan
M12	Design the final components of the module based on the available quality systems available for agricultural products
M14	Finalize the module 's protocol through the supply chain

Table 13: Isotopic Profile Module: detailed innovation plan

Month	Detailed innovation plan
M10	Experimental procedure's design for isotope ratio measurements
M12	Isotope ratio determination of the selected products
M14	Finalise the isotope ratio analysis protocol

Table 14: DNA Markers Module: detailed innovation plan

Month	Detailed innovation plan
M15	Requirements formulation in order to identify new functionalities for DNA Markers Module to be added based
M17	Design of the integration interfaces to include this module into the MED Food TTHubs e-Platform alpha version
M20	Refinements and integration of the DNA Markers Module within the MED Food e-Platform (alpha version).
M26	Improvement of the DNA Markers Module according to the comments of the project partners (beta version).
M33	Improvement of the DNA Markers Module according to the feedback from the pilot application of the beta version.
M36	Final and validated version of the DNA Markers Module

Table 15: Nutritional Profile Module: detailed innovation plan

Month	Detailed innovation plan
M12	Analysis and technical design of the Nutritional Profile Module considering the main results of the WP3 - Authentication and Quality Assurance Protocol focusing on the Nutritional Analysis Profile Processes
M14	Addition of a MED Food TTHubs Label as a result of the flowchart to indicate all the relevant information of the product as well as its quality.
M21	Refinements and Integration of the Nutrition Profile Module with the MED Food e-Platform (alpha version). Internal testing of all modules of the e-Platform (alpha version)
M24	Improvement of the Nutritional Profile Module according to the comments of the project partners. Testing of all modules of the e-Platform (beta version) in real-world cases.
M32	Improvement of the Nutritional Profile Module according to the feedback from the pilot application of the beta version.

Month	Detailed innovation plan
M36	Final version and validation of the Nutritional Profile Module.

Table 16: External and Internal Tracing Modules: detailed innovation plan

Month	Detailed innovation plan
M12	Requirements formulation in order to identify new functionalities for Internal and External tracing modules to be added
M14	Design of the integration interfaces to include these two modules into the MED Food TTHubs e-Platform alpha version
M21	Final version of external and Internal tracing modules integrated into the e-Platform
M24	Deployment of the e-Platform with External and Internal Tracing Modules running

Table 17: B2B App Module: detailed innovation plan

Month	Detailed innovation plan
M12	Requirements formulation in order to identify new functionalities for B2B App Module to be added
M17	Design of the integration interfaces to include this module into the MED Food TTHubs e-Platform alpha version
M20	Refinements and integration of the B2B App Module within the MED Food TTHubs e-Platform (alpha version).
M26	Improvement of the B2B App Module according to the comments of the project partners (beta version).
M33	Improvement of the B2B App Module according to the feedback from the pilot application of the beta version.
M36	Final and validated version of the B2B App Module

Table 18: Consumer App Modules: detailed innovation plan

Month	Detailed innovation plan
M12	Requirements formulation in order to identify new functionalities for Consumer App Module to be added
M17	Design of the integration interfaces to include this module into the MED Food TTHubs e-Platform alpha version
M20	Refinements and integration of the Consumer App Module within the MED Food TTHubs e-Platform (alpha version).
M26	Improvement of the Consumer App Module according to the comments of the project partners (beta version).
M33	Improvement of the Consumer App Module according to the feedback from the pilot application of the beta version.
M36	Final and validated version of the Consumer App Module

Table 19: MED Food TTHubs e-Platform

Month	Detailed innovation plan
M15	Requirements formulation in order to identify the architecture of the MED Food TTHubs e-platform
M17	Design of the integration interfaces to include all modules into the MED Food TTHubs e-Platform alpha version
M20	Refinements of the MED Food TTHubs e-Platform and integration of new versions of the modules (alpha version).
M26	Improvement of the of the MED Food TTHubs e-Platform according to the comments of the project partners (beta version).
M33	Improvement of the of the MED Food TTHubs e-Platform according to the feedback from the pilot application of the beta version.
M36	Final and validated version of the MED Food TTHubs e-Platform

Table 20: Origin Authentication Processes

Month	Detailed innovation plan
M6	Make the list of products for each category
M8	Obtain all species (shared with CERTH)
M10	Experimental procedure's design for isotope ratio measurements
M12	Isotope ratio determination of the selected products
M14	Finalize the isotope ratio analysis protocol
M21	Apply the protocol through the supply chain

Table 21: Species Authentication Processes

Month	Detailed innovation plan
M6	Make the list of products for each species
M8	Obtain all species and share them with UoP
M12	Design the experimental procedure
M14	Authenticate the products through molecular markers
M21	Validate the protocol through the supply chain

Table 22: Nutritional Analysis Profile Processes

Month	Detailed innovation plan
M6	Research on diverse nutritional databases, nutritional profiles, and healthy food labels to obtain the information of all the specific Mediterranean food products.
M8	Redesign of Nutritional Profile module flowchart to include all the new food products.
M12	First adaptation of the algorithms and the decision tree according to the needs of the project.
M13	Second adaptation of the algorithm and the decision tree to include the relevant information provided by the other modules of the Med Food TTHubs e-Platform.

Table 23: Quality Assurance Processes

Month	Detailed innovation plan
M10	Make the list of all quality systems available for agricultural products participating in this program
M12	Design the final components of the module
M14	Finalise the module ‘s protocol through the supply chain
M21	Apply the protocol of the quality module in pilots

Table 24: Full-path Traceability Procedures

Month	Detailed innovation plan
M6	Identify the products
M8	Develop the procedure
M12	Authenticate the products
M14	Obtain data through the supply chain
M21	Validate the protocol

Table 25: MED Food TTHubs pilots

Month	Detailed innovation plan
M6	Selection of Mediterranean products that will be evaluated during the local pilots
M12	Defining the methodologies to assess the MED Food TTHubs e-platform during the pilot period.
M15	Start designing the workflow of each one of the seven real-world pilot scenarios (one for each participating country). Define the final criteria for the companies/organisations that will participate in the pilots.
M16	Finalise the creation of stakeholders and end-users communities. Start developing the training tools for the pilots' participants.
M17	Final selection and training of the participating bodies in the pilots.
M19	In each country, the respective pilot will start running for a 12-months period.
M25	Start the evaluation process of the pilots in order to fine-tune the protocols and the e-platform.
M36	Pilot use-cases deployment completed

4. Conclusions

In this report, we have presented the scientific and innovation roadmap for the MED Food TTHubs project, including guidance for managing the scientific and innovation activities.

The opportunities for scientific publication identified in this document span diverse scientific outlets and allow for advancing the state of the art along technical, social, and economic perspectives, as well as a combined or holistic view of such aspects.

The report presents the scientific and innovation objectives and defines the activities, tools, and time plan for conducting the technical and scientific activities.

A detailed innovation plan was presented for each component of the system, for the system processes, and for the MED Food TTHubs pilots.

No critical issues or high risks were identified regarding the governance and management of the scientific and innovation aspects of the project.

The information elements described in this report will provide input for the final evaluation report “D1.3 Scientific Roadmap and Innovation Management Evaluation”, to be submitted at the end of the project.

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