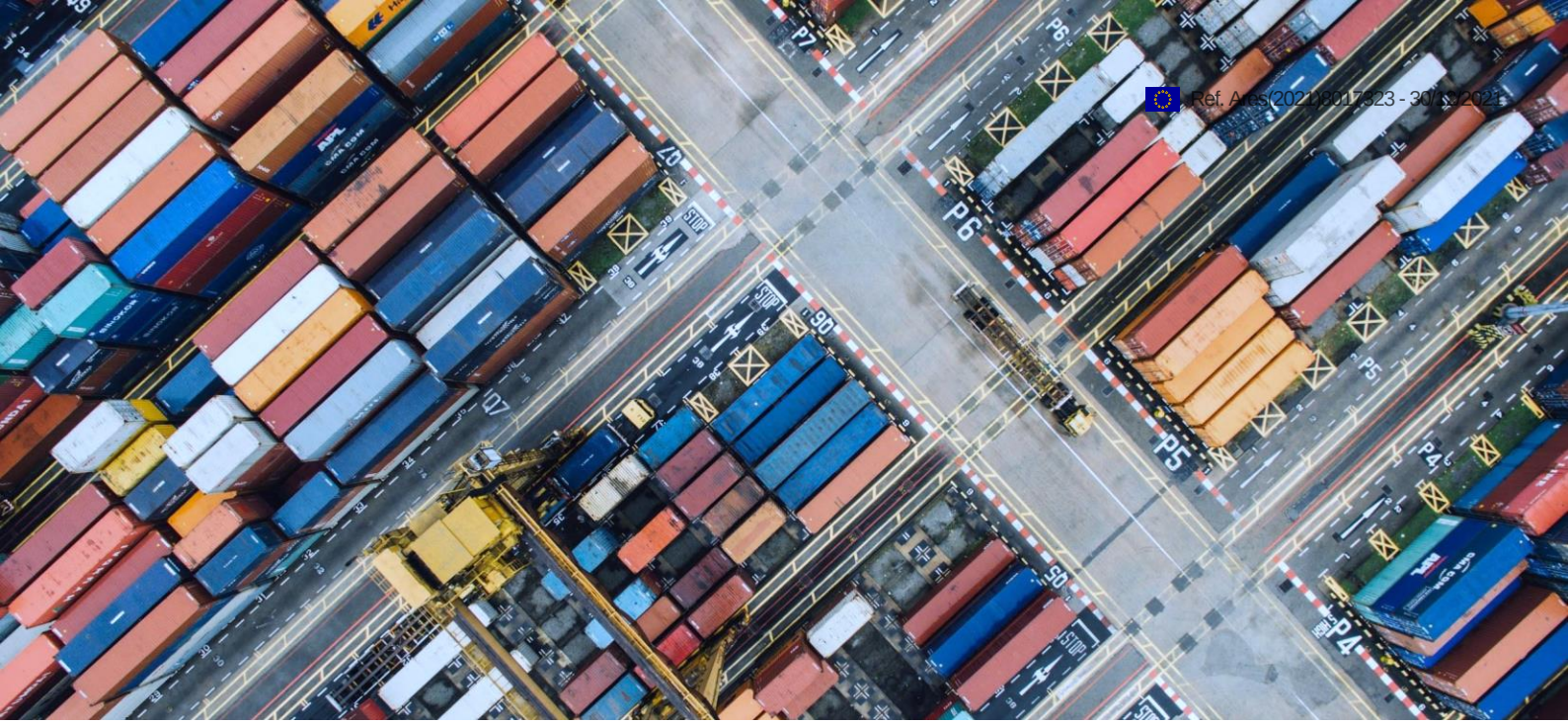

AWARD
Scaling autonomous logistics

D10.2
Innovation Management Monitoring and Assessment Methodology

—

Lead: Enide

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2.0	23/12/2021	Loha Hashimy	Enide	Final version ready for submission

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List of acronyms

Abbreviation	Description
ADAS	Advanced Driver Assistance systems
ADS	Autonomous Driving System
AGTS	Automated Guided Transport Systems
AV	Autonomous Vehicles
D	Deliverable
EC	European Commission

EEAB	External Expert Advisory Board
EU	European Union
HDV	Heavy-Duty Vehicles
HDV	Heavy Duty Vehicles
IAI	Innovation Ability indicator
ICI	Innovation Capacity Indicator
IEI	Innovation Environment Indicator
IM	Innovation Manager
IMI	Innovation Management Indicator
IMI	Innovation Management Indicator
IPI	Innovation Potential Indicator
IR	Innovation Radar
IRI	Innovation Readiness Indicator
IS	Innovation Solution
JRC	Joint Research Centre
KPI	Key Performance Indicator
LIDAR	Light Detection and Ranging
LOFM	Logistic Operation & Fleet Management
ODD	Operational Design Area
PM	Project Manager
PU	Public
SD	Standard Deviation
TRL	Technology Readiness Level
WP	Work Package

1. Executive Summary

Sound innovation management assists EU-funded projects in achieving their objectives, assessing the contribution (positive or negative) of innovation to social and economic goals, and monitoring and evaluating the effectiveness of their efforts. The AWARD project, which is funded by the European Union's Horizon 2020 Framework Programme, is aiming at developing and enabling to deploy a safe autonomous transportation system in a wide range of real-life use cases in a variety of different scenarios. This encompasses the development of autonomous driving system (ADS) capable of handling adverse environmental conditions such as heavy rain, snowfall, fog. The ADS solution will be based on multiple sensor modalities to address 24/7 availability. The ADS will then be integrated into multiple vehicle types used in low-speed areas.

Task 10.3, innovation management and impact monitoring, is part of the management and coordination WP and This task intends to pave the way from project achievements towards innovation meeting the expected impacts of the EU. To do so, throughout the project's life cycle, partners involved in this task will keep a close eye on market demands and technological advancements. It will also ensure that the project work plan is updated as needed such that the project's outcomes are implemented and that they best satisfy the market's demands.

Deliverable 10.3. defines the methodology used to manage, monitor and assess innovation in the project This deliverable also lays down the baseline to prepare deliverables D10.3 (Intermediate Innovation monitoring and assessment) and D10.4 (Final innovation monitoring and assessment-Long Term Roadmap).

After the introductory chapter, this report provides various definitions of innovation, a brief explanation of innovation models and different methodologies used to manage innovation. The project uses the definition of innovation provided by the European Commission, which is "the effective production, absorption, and exploitation of novelty in the economic and social realms" (European Commission, 1995).

The methodology used in AWARD to manage innovation is based on existing models in the literature as Pentathlon Framework and CEN/TS 16555-1 standard for innovation management combined with open innovation practices. Using this methodology, the project aims to fulfil its three innovation ambitions which are:

- Design and development of a safe, low speed ADS for 24/7 availability
- Demonstration of ADS integrated in different heavy-duty vehicles in real-life logistics operations
- Validation of efficiency increase of fleets using trucks with ADS

To achieve these ambitions, 20 innovation solutions have been identified and a monitoring system based on certain measuring key performance indicators is designed to track the innovative components of the project and how it advances. Measurement necessitates a comprehension of what needs to be measured as well as an awareness of what can be measured accurately. Timing, technological readiness level, deviation from objective, number of ideas, and number of intellectual properties identified and protected are the KPIs by which the progress is measured.

An innovation committee is formed to oversee the innovation aspects of the project, identify innovation solutions and assess the innovation potential and capacity using innovation radar, a widely used innovation assessment framework for the European funded projects.

2. Introduction

The ambitious goal of AWARD is embedded in two complex landscapes of Cooperative and Connected Automated Mobility (CCAM) and Connected and Automated Driving (CAD), which are now being shaped by a variety of actors, stakeholders, research groups, and policies. AWARD is a flagship project with a total budget of € 26 398 799,01 that aims to develop and deploy a safe autonomous transportation system applicable to a wide range of real-life occurrences and scenarios. Specifically, the project will provide an autonomous driving system capable of confronting adverse environmental conditions such as fog, heavy snow and rain. The solution will rely on multiple sensor modalities offering 24/7 availability and a new fleet management system for optimized logistics. Finally, these vehicles will be deployed, integrated and operated in four real-life use cases to validate their value in the application and identify any limitations: forklift (un)loading in warehouses and industrial plants, hub-tohub shuttle service on open road, automated baggage dispatching in airports, container transfer operations and vessel loading in ports.

A consortium of 29 organizations with different backgrounds (business, research, policy, and planning) from 12 countries have teamed up and committed to collaboratively make this innovation ambition a reality. However, in such a large-scale and strategic initiative, in addition to overall project coordination and management, the innovation must be managed and monitored properly to ensure the project's success in achieving the EU's expectations regarding the impact of the project. Thus, a specific task in WP10 (Project management and Coordination) is dedicated to innovation management, monitoring and assessment. This task is run throughout the project life cycle.

2.1. Purpose and Scope of Task 10.3

Innovation is the change that outperforms previous practices and is based on new knowledge and know-how offering benefits to society and economic opportunities. It is therefore important to monitor during the project cycle how innovation is developed and managed to achieve the foreseen results. T10.3 intends to pave the way from project achievements towards innovation meeting the expected impacts of the EU.

In this task, the following activities will be performed:

- The monitoring on a continuous basis of the internal and external risks related to the project. This will consider the responses to risk situations and unexpected outcomes identified in the risk analysis contingency plan (see Table 3.2b).
- The analysis of the scientific and technological achievements in order to identify the weak points, assess the usability of the results including beyond the context of the project and identify the competing technical approaches; in particular, replication strategies of the project results by third parties will be identified.

- Continues monitoring of the evolving socio-economic context including stakeholder and user needs (T2.3), overall market trends and competitive landscape (T8.1), regulatory framework (T8.4), and standardization (T4.1)
- Assessment of the innovation potential of research results.
- Liaise with project management and take corrective measures if needed, to ensure that market needs are best met.

This task will include dedicated work sessions and questionnaires involving project partners, Advisory Board and Stakeholders Group members. The conclusions of these work sessions will be presented in and updated roadmap/strategic plan toward the expected impacts.

In the first year, the methodology is defined and reported in D10.2 (Innovation monitoring and assessment methodology). The aim of this methodology and the report is to create a structured, yet flexible mechanism and related procedures that will pervade all project operations for the duration of the project, ensuring that the project's innovation objective is realized as planned and defined in the Grant Agreement (GA). Thus, D10.2 describes the methodology used to manage, monitor and assess the innovation related aspects of the project. In the two remaining years this methodology is implemented, and the results will be reported in D10.3 (Intermediate Innovation monitoring and assessment) and D10.4 (Final innovation monitoring and assessment-Long Term Roadmap).

2.2. Relationship with other WPs

WP10 is the most crucial WP in the project. The key achievement of WP10 is to implement the appropriate methods and tools to meet the project objectives and obtain the expected impacts, consistently with the respective legitimate interests and business foresight of the beneficiaries. Thus, this WP oversees the activities of all other WPS and receives inputs from them. T2.3 (Innovation monitoring and assessment) will closely work with other tasks in this WP namely, T10.1 (Strategic Decision Making) and T10.2 (Operational management) to ensure that innovation ambitions of the project are met within the predefined time and budget. Moreover, it assists in achieving the two aims of WP10 which are:

- Defining and maintaining the decisional and operational framework within which the project strategy is decided and implemented.
- Informing all beneficiaries on how the activities are monitored and controlled, and how the results are assessed and reported throughout the project life cycle.

The technical solutions will be developed in WP3, WP4, and WP5. These solutions will enable the project to reach its innovation ambitions. T10.3 provides tools and methodologies to manage innovation withing these WPs and monitors their activities to ensure that the solutions are developed within the planned time frame. Also, T10.3 along with T9.3 (Exploitation roadmap of the results and IPR) will identify the Innovation Solutions (IS) developed within the project. While T9.3 takes care of the exploitation and Intellectual Property issues related to IS, T9.3 monitors and assess the maturity and innovativeness of the results. WP2 provides inputs regarding the stakeholder and end-users needs and requirements. T10.3 monitors if these needs are met by IS developed withing the project. Moreover, T10.3 leader will monitor and analyse the inputs received from WP8 on overall market trends and competitive landscape (T8.1), emerging business and operating models

(8.2), as well as regulatory framework (T8.4). Based on demonstration results in WP6 and the results of WP7 (impact assessment), T9.3 monitor and assess the usability of the proposed solution and its economic viability along with T8.2 (Cost benefit analysis). Based on the results of all WPs, T10.3 will develop a roadmap and a guide towards the long term vision of connected and automated heavy-duty vehicles for logistics operations, including the AWARD results and defining the pending stages (D10.4).

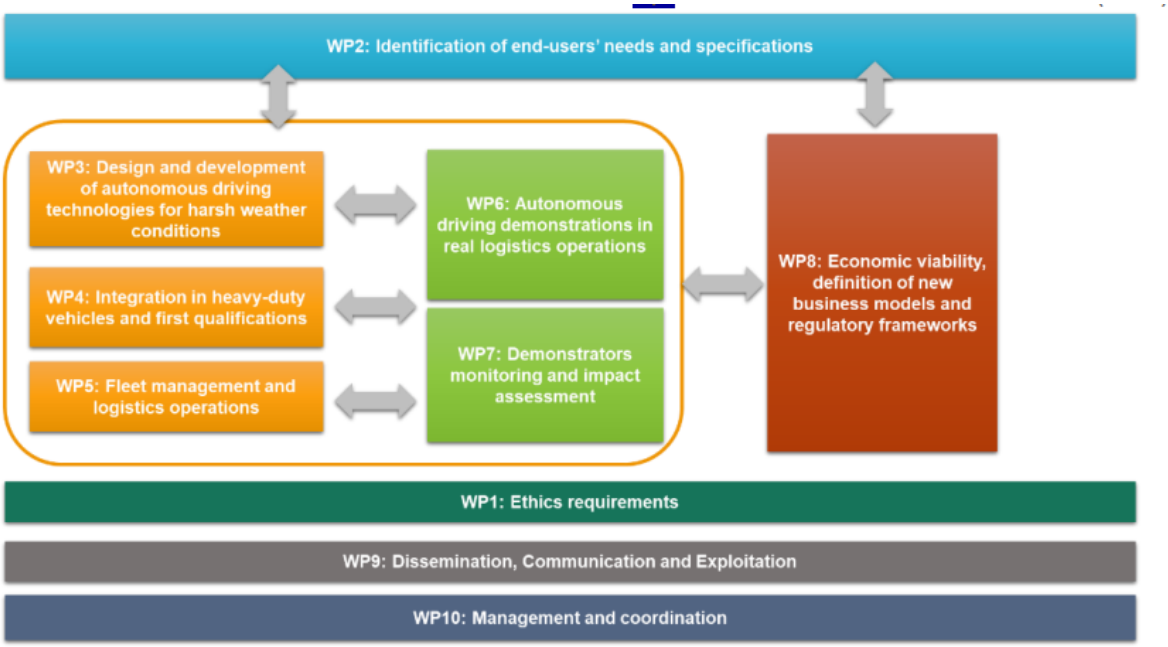

Figure 1 Relationship of T10.3 with other WPs

2.3. Intended Audience

This deliverable is communicated both internally within the project consortium and externally to any interested parties outside the project. The dissemination level of D10.2 is public (PU) and not limited to Consortium members. The main goal is for all project participants to understand the methodology used in the AWARD project to manage, monitor, and assess innovation. It may also serve as an informative document for those external parties interested in various areas of the project's innovation potential and progress.

2.4. Structure of the document

The executive summary is provided in section 1. The remaining parts of the report are structured as below.

- Section 2 – explains the purpose and scope of the task, its objectives, its relationship with other WP and intended audience.
- Section 3 – provides background information on innovation, innovation process and available frameworks to manage innovation.
- Section 4 – explains the innovation management framework used in AWARD, and the innovation ambition

- Section 5 – provides a detailed explanation of the system used to monitor project activities, the innovation solutions and the KPI indicator to measure the performance of the project.
- Section 6 – details the innovation assessment methodology, including a comprehensive explanation of innovation radar and roles and responsibilities of the innovation committee.
- Section 7 – concludes the report.

3. Background

3.1. Innovation

The term "innovation" has grown to imply many different things to many different people. While the term is derived from the Latin noun innovatus and first appears in literature in the fourteenth century, its more contemporary application and definition can be traced back to the famous economist Joseph Schumpeter and his publications in the 1930s (Schumpeter, 1934). Schumpeter defines "Innovation as "new combinations" of new or existing knowledge, resources, equipment, and other elements. He emphasized that innovation should not be confused with invention. He considered innovation as a distinctive social activity, or "function", carried out inside the economic arena and with a commercial goal, whereas invention can be carried out anywhere and with no commercial motive. According to Schumpeter, innovation involves the whole process from opportunity identification, ideation or invention to development, prototyping, production marketing and sales, while entrepreneurship only needs to involve commercialization. He argued that innovation comes about through new combinations made by an entrepreneur, resulting in:

- a new product,
- a new process,
- opening of new market,
- new way of organizing the business,
- new sources of supply.

On the other hand, the Oslo Manual defines innovation as "*a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (*OECD/Eurostat, 2018).

Myers and Marquis (1969) saw Innovation as *"not a single action but a total process of interrelated sub processes. It is not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all these things acting in an integrated fashion".*

In a similar manner, various authors differentiate the concept of Invention from Innovation. Benoît Godin emphasizes **three core concepts** to **understanding innovation**, and introduces two other related concepts, imitation and invention, as intermediate phases of innovation process (Godin B, 2008).

Key difference between Innovation and invention is also defined and illustrated with a **following equation** (Roberts E, 1987):

Innovation = Invention + Exploitation

In other words, invention represents creation of a novelty based on research and/or through creative processes. Invention itself, without a practical application, is still only an invention, and cannot be considered as innovation. Exploitation, represented in this equation as utilisation and application of the idea (invention), giving it a usability and market value.

In this sense, Innovation is widely recognized, both in academic circles, as well as in industry, as *"a vital competitive advantage enabler for any organization that desires to remain competitive, sustainable and grow"* (P. Drucker, 1985).

In the AWARD project, we base ourselves on the European Commission's definition of innovation, which is "the effective production, absorption, and exploitation of novelty in the economic and social realms" (European Commission, 1995). From this standpoint, innovation provides new answers to issues and reacts to both individual and societal demands.

3.2. Innovation Models

Various Innovation models have been developed over time, evolving from simpler, linear, and sequential models to more complex ones. Innovation models emerging over time can be analyzed through five generations of innovation framework models developed by Rothwell (1994).

Based on similar characteristics of different innovation models, for purpose of this deliverable, we can look at several types of innovation models:

- Linear model of innovation
- Simultaneous Model
- Interactive Model
- Network Model
- Open Innovation Model.

3.2.1. Linear model

Linear model was one of the first frameworks developed for understanding the relation of science and technology to the economy. The Linear Model is based on the assumption that innovations emerge from the elaboration of practical applications of new fundamental knowledge (Godin B, 2006). The linear models have dominated the industry for decades, mainly due to their simplicity and easy of understanding and application. Two key variations of linear models have been developed, the technology push and market pull (Figure 2).

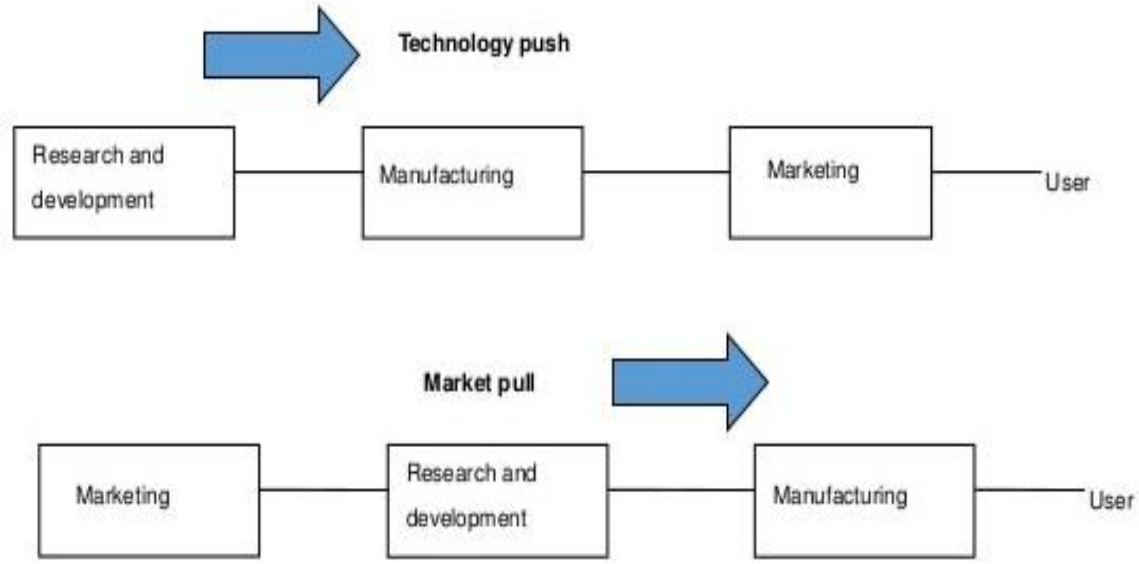

Figure 2 Linear model of Innovation

3.2.2. Simultaneous Model

Within the simultaneous model, the point of commencement for innovation is not known in advance. The result of the simultaneous coupling of the knowledge within all three functions that will foster innovation. This model differs from the linear in the relationship between the three functions: marketing, manufacturing, and R&D (Figure 3).

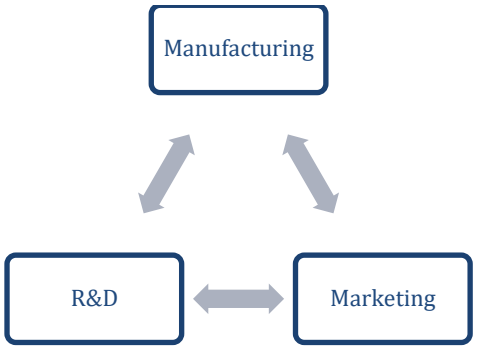

Figure 3 Simultaneous model of Innovation

3.2.3. Interactive Model

This paradigm connects the technology-push and market-pull concepts. It is founded on the premise that innovation is created via the interplay between the marketplace, the scientific background, and the capabilities of the company (Figure 4). Similarly to the previous model, the beginning point of the invention process is unknown, giving organizations far more freedom and flexibility. The flow of knowledge and information must not be linear and continuous, which is a distinguishing feature of this approach. As shown in the diagram below, the science base and the marketplace communicate not only with the firm's R&D and marketing departments, but also with the others.

In other words, the innovation is seen as the process that consists of a complex non-linear sequence of phases. In this model, the innovation can happen at any stage of the process. As such, the interactive model stresses systemic relations between actors and processes. The emphasis is on a variety of knowledge types and the links between them, which is regarded

as the most valuable resource in the interactive model, and interactive learning is regarded as the most important process (Johannessen, 2009).

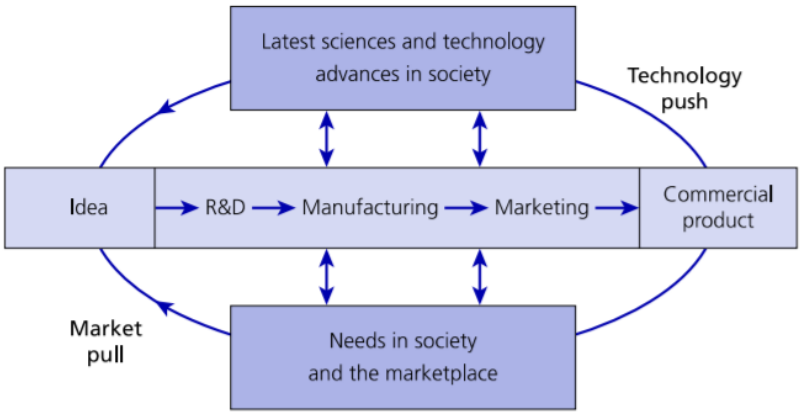

Figure 4 Interactive model. Source: Trott Paul (2017)

3.2.4. Network Model

The model originated from the 1900s and were trying to let people see through the complexity of the innovation process. The basics of this model are the interactions with the firm's external environment and the communication with external players (Figure 5). Thus, this model suggested that there is a strong relationship between the internal and the external "stakeholders" of the firm in the innovation process. Most of the early network models were closed networks, which meant that new developments were made within the firm's boundaries (Keresztes G, Endresz MG, 2020).

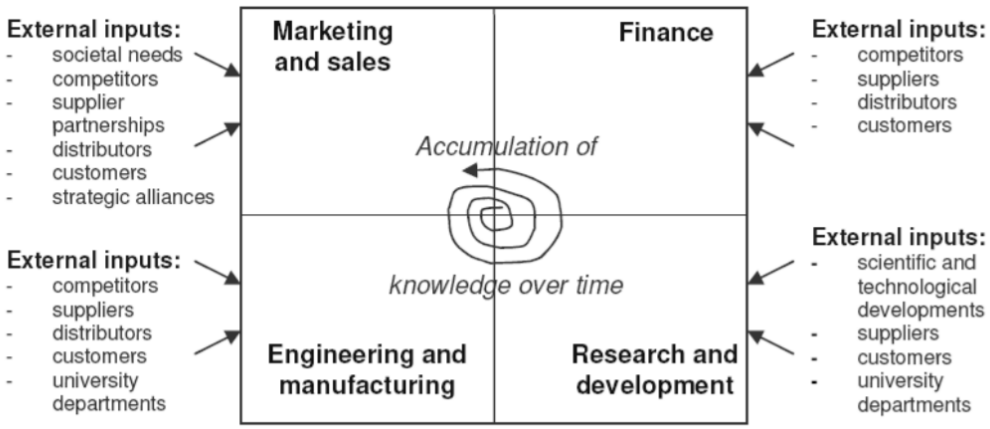

Figure 5 Network Model. Source: Preez N.D. et al (2009)

3.2.5. Open Innovation Model

The open innovation paradigm is comparable to the network model. Instead of being closed, these networks are already open (Figure 6). The fact that these open innovation networks have a far larger base from which to source information and expertise is a big benefit.

In a closed model, new ideas may only enter one way: from the firm's research and technology basis. The ideas and concepts are then screened, with some being discarded and others being pushed through to become a marketable product. In an open innovation paradigm, on the other hand, ideas and initiatives might emerge in a variety of forms and in different phases. Even the way in which the items are introduced to the market might differ (N.D. Preez et al., 2009).

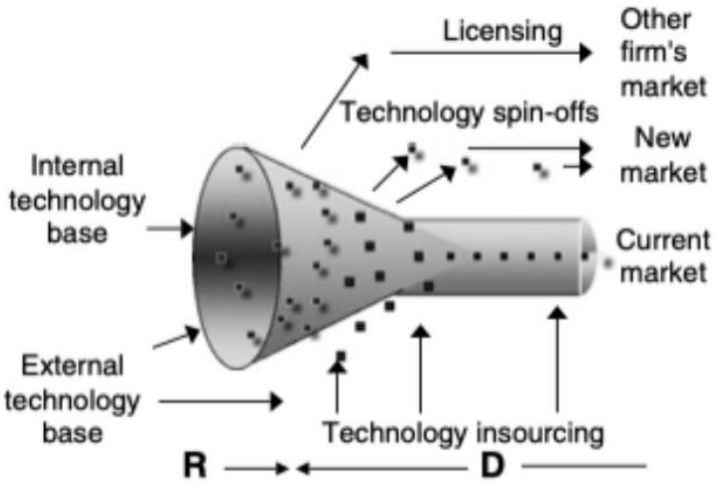

Figure 6 Open innovation. Source: Chesbrough Henry et al. (2006)

3.3. Innovation Process

Different models of innovation divide the innovation process into stages (Palmberg, 2006). The skills that can affect the innovation process can be grouped in two categories:

- Strategic skills as long-term view; ability to identify and anticipate market trends; ability to collect, process and assimilate technological and economic information.
- Organizational skills such as mastery of risk; internal cooperation, and external cooperation with public research, consultancies, customers and suppliers; involvement of the whole firm in the process of change, and investment in human resources.

The core tasks that enable the formation of ideas for new product and process development, as well as the management of the whole innovation process, are universal to all innovation processes. Though, the following activities are the bases:

- Generation of ideas which potentially could become new products or processes after implementation,
- Acquisition of knowledge on the generated ideas, and
- Implementation and market monitoring to verify customer satisfaction and after sales.

Spech (2002) divides the innovation process in three stages (Figure 7); technology management encompasses the stages of technology development as well as pre-development activities. Upstream basic research, as well as product and process development, define the discipline of R&D management. Finally, the product and market introduction phase is included in innovation management. He also explains how an invention

can be transformed into an innovation under a well-structured innovation management process.

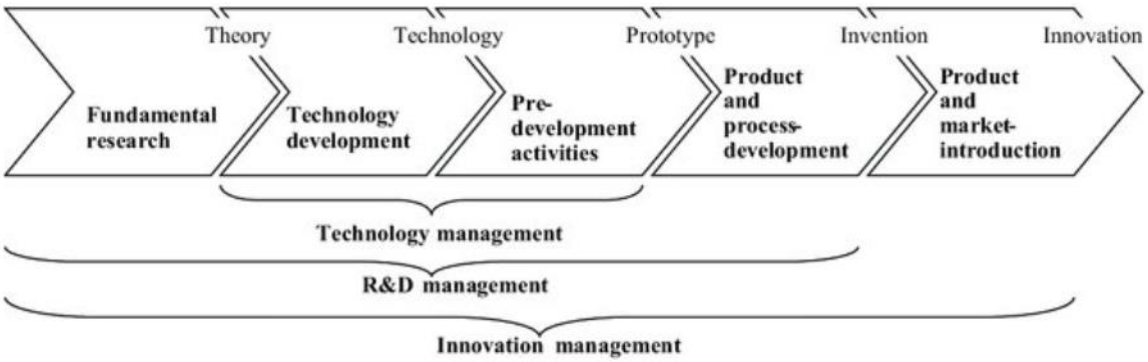

Figure 7 Classification of technology, R&D and innovation management (Specht, 2002)

3.4. Innovation Management

3.4.1. The Innovation Pentathlon Framework

The innovation Pentathlon Framework was developed by Professor Keith Goffin at Cranfield School of Management (Goffin and Pfeiffer, 1999). This innovation framework, as the name suggests, identifies five main interlocking areas or elements of innovation management (Figure 8):

- **Strategy –** an innovation strategy
- **Ideas** – a method for generation of ideas in response to a specific problem(s) or challenge(s)
- **Selection and Prioritization** – A process for Selection and Prioritization of generated ideas
- **Implementation - Implementation** Management
- **People, Culture and Organization** – An adequate enterprise culture.

According to Goffin and Pfeiffer, the pentathlon framework accommodates a wider range of soft organizational issues than the traditional linear innovation model. What makes the pentathlon framework distinctive from earlier models is that it features the human factor in innovation process. This model recognizes the role of organizational climate and value of culture where people are motivated to innovate.

3.4.2. CEN/TS Innovation management system

The European Committee for Standardization (CEN) has created a new Innovation Management System (IMS) to assist enterprises in establishing, developing, and maintaining a framework for systematic innovation management processes. According to this IMS, establishing such a management system would enable any firm, regardless of sector, kind, or size, to become more inventive and successful with their product, service, process, organizational design, and business model advancements. The innovation management system will cover all activities necessary for ongoing innovation generation and can be a stand-alone management system or incorporated into the organization's core operations and

management. The IMS is a Technical Specification (TS) known as CEN/TS 16555-1 that gives assistance on implementing and maintaining an innovation management system inside an organization. Figure 9 depicts the essential aspects covered by the innovation management system described in the CEN/TS 16555-1.

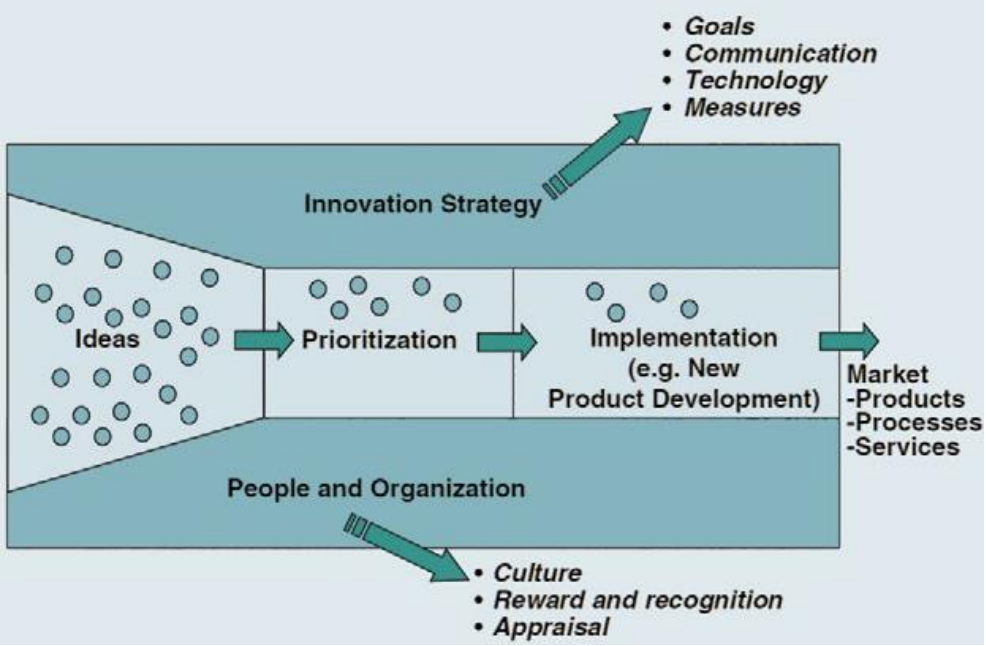

Figure 8 Pentathlon Framework illustration. Source: Goffin & Mitchell, 2010

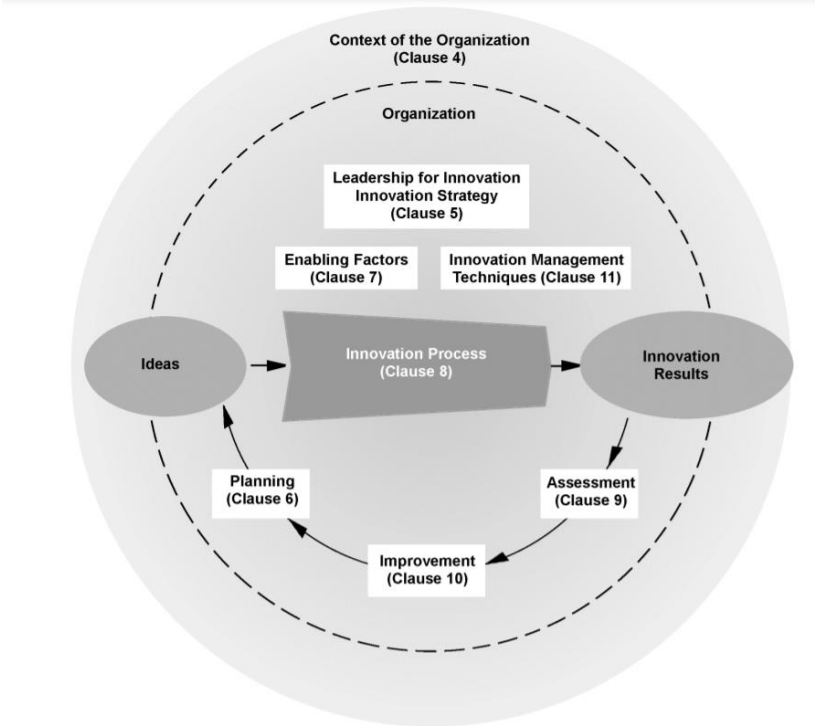

Figure 9 Key elements covered by this innovation management system. Source: CEN/TS 16555-1:2013

According to this standard, IMS is a set of interrelated or interacting elements of an organization to establish innovation policies and objectives as well as processes to achieve

those objectives. The IMS outlined in CEN/TS 16555-1 follows the PDCA structure (plan-do-check-act), so that it can be integrated within other standardized business management systems existing in organizations, e.g. EN ISO 9001, EN ISO 14001, etc.

4. AWARD Innovation Management Methodology

In today's interlinked world, it's hard for businesses to stay isolated, necessitating the integration of internal and external ideas as well as complementing technology. In reality, the European Commission's H2020 initiative encourages collaboration, which is the foundation of the current project. Collaborative methods to the research and innovation process have been proved to improve the outcomes of innovation activities and the profitability of businesses. As the most prominent model, the Pentathlon model has been adapted to address innovation management in collaborative environments and projects such as AWARD. As such, going one step further, the Innovation Management process has been developed based on key elements of Pentathlon Framework, while taking into account specific characteristics of the AWARD project and the innovation management principles based on CEN/TS 16555-1 standard as presented in Figure 10. Moreover, the open innovation practices will be performed throughout the project.

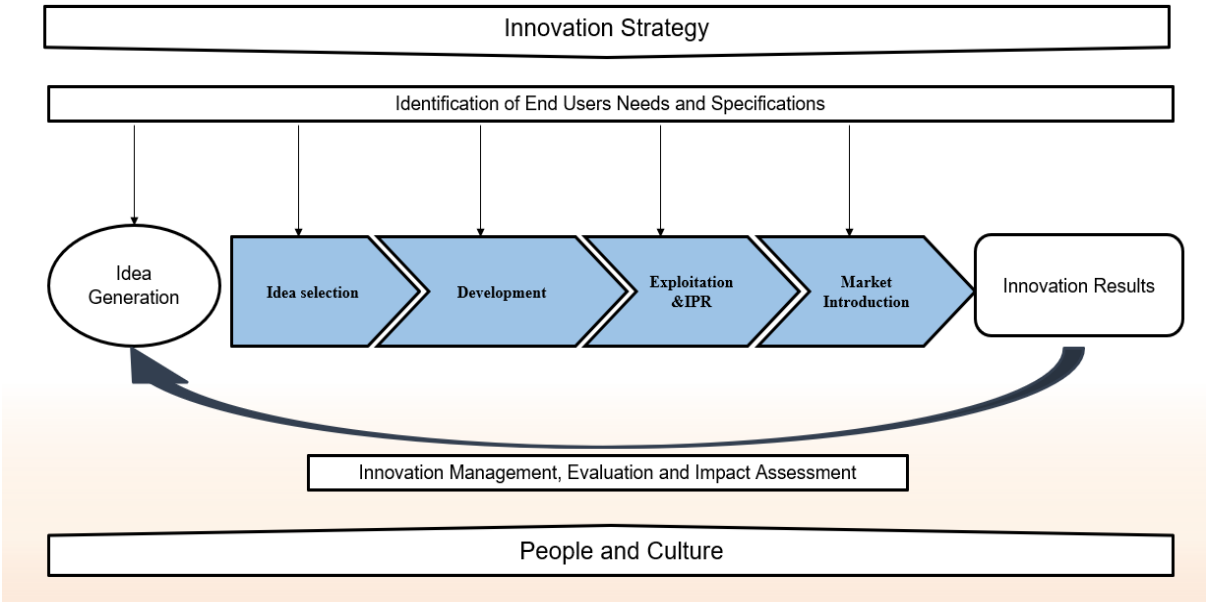

Figure 10 Innovation management methodology of AWARD

The project's ambitious long-term goals for renewal of industrial structures and the formation of new areas of economic activity are defined by the innovation strategy. The capacity of the partners to see market prospects and build commercial partnerships in order to make them commercially viable is similarly tied to innovation. In such a setting, innovation must be ingrained in the project's culture. To meet the consortium's innovation goals, partners must share this culture and vision.

Most ideas are originated and explored in technical WPs (WP3, WP4, and WP5). Brainstorming and mind mapping techniques are used to generate ideas, while tools and platforms like Miro, Metroretro, and Mentimeter are used to gather and map ideas. In addition, we distributed an

Excel spreadsheet to record and assess the ideas. It also assists us in keeping track of new ideas and evaluating IPR protection measures.

4.1. Innovation Ambition of AWARD

The **overall ambition** is to design, develop and demonstrate a market relevant solution for heavy-duty trucks so that these can drive autonomously at low speed in confined areas thus removing the need of a driver and thereby reducing the overall total cost of ownership of fleets. The solution is targeted to be compliant with ISO26262 and taking into consideration SOTIF recommendations, as well as suitable for harsh weather conditions, thus enabling 24/7 operation. This solution shall be integrated into the logistics operations of numerous fleet operators. A technology readiness level of TRL 7/8 shall be reached.
This as a whole can be defined as beyond state-of-the-art, as no such solution exists today in this entirety.

4.1.1. Ambition 1: Design and development of a safe, low speed ADS for 24/7 availability

Current state of the art and limitations for the whole architecture of the ADS

All ADSs today are developed for specific applications, therefore hardly compliant with other ones, new vehicle types or ODDs. In addition, ADAS sensor technologies can provide valuable inputs to an environmental model. The sensors have ranges and fields of view which are aligned to confined area use cases and ODD, but not at the right safety level for driverless operations. Within the current technologies adopted for that purpose, cameras and LIDARs have detection limitations in foggy and rainy conditions. Radar sensors fare better under these conditions, but do not have the resolution of camera sensors.

Progress proposed by the project for the whole architecture of the ADS

The improvement of multiple redundant sensor technologies improves overall perception in different weather conditions. This in turn improves the input for the trajectory planning, making this safer. In addition, an embedded teleoperation platform helps at handling any “edge case” on the road or high ambiguity situation, by referring to human intelligence that can intervene safely from remote. Redundant backup paths and actuators improve fail operational capabilities. Within this project, this unique architecture will thus offer an innovative autonomous driving system overcoming current limitations. This system, compliant with safety standards, enables the deployment of ADS-DV based on HDV in real logistics operations.

4.1.2. Ambition 2: Demonstration of ADS integrated in different heavy-duty vehicles in real-life logistics operations

Current state of the art and limitations

Low speed AD pilot projects are running in the field of public transportation, deploying shuttles within restricted conditions, such as good weather. Safety drivers are still used in certain cases. Most of the vehicles are not ISO 26262 certified. Low-speed autonomous container transportation is available in a few ports. These follow fixed routes which are defined by

magnetic tags in the tarmac. No consideration is made for avoidance of vulnerable road users since these are not allowed in the confined areas. Current ATS applications involving HDV in outdoor applications are still rarely seen and are most often in highly repetitive use cases within a defined environment (relying on LIDARs that operate at good weather conditions) – the ODD is too small. These solutions are highly customized, inflexible, and thereby expensive and nearly nontransferable even to similar use cases. In addition, the achieved speed in mixed traffic scenarios is not more than 6 km/h. To have a positive cost benefit analysis for possible customers a higher speed of approximately 15 km/h and a high availability of the ATS has to be achieved. The limiting factors are missing sensors and systems of sensors which are able to percept safely and reliably on distance and differing weather conditions in changing environments. There are different ongoing projects which tackle the same problem, but only partly. Here to mention for example the German public funded project Gama focusing on fully automated HDV in mixed traffic on ports, but only on restricted private sites and the German public funded project AutoTruck, focusing on a fully automated HDV in a mixed traffic logistics yard, but with limited availability and a rated speed of 10 km/h.

Progress proposed by the project

The AWARD ADS is interoperable with several HDV which will address a wide range of logistics operations (Table 1).

Table 1 Logistic operations addressed by AWARD ADS system

Use cases	Current state-of-the-art and limitations	Progress proposed by the project
Warehouse/ Production site: Autonomous outdoor forklift loading	Up to now there are only singular AGV solutions for outdoor applications on factory sites or yard logistics. They don't have a common ODD and each has different limitations in usage and bear restrictions to the operator.	At the end of the project, the autonomous forklift should be able to operate the targeted representative logistic flow with the agreed availability for end-users.
Hub-to-hub autonomous logistics shuttle service	The hub-to-hub use case also contains gate entries and public roads to overcome with the challenge of missing regulations. To prevent the vehicle being an obstacle on the public road, a high usability of the vehicle must be achieved. Vehicles are now hardly usable 24/7, which is a requirement for logistics customers to use the autonomous shuttle service as a fully adequate part within the logistic chain.	Through the single stages of the AWARD project a logistic shuttle is to be developed to the special needs and challenges the vehicles must manage during 24/7 operation. The highest possible usability of the vehicle is achieved using 5G based teleoperation and cost beneficial for the customer due to high availability of autonomous driving. Adding an automated charging strategy for the vehicle will be usable for 24/7 use cases and can be well integrated into the logistic value chain
Airport: transport of goods on indoor and outdoor environments, taxiway crossing	Gardermoen is probably the airport in Europe with the most demanding conditions when it comes to freezing rain and fog. "That is the worst airport in Europe", says Knut Backer, daily captain of SAS. Fully automated transport logistics operations with the right safety level are quite challenging.	Gardermoen Airport close to Oslo will host three pilot operations. Avinor plans to implement a fully automated baggage transport system at the airport by 2025. The validation of this demonstration will allow high replicability of the AWARD solutions for airports.
Port: Trailer handling and loading/discharge of trailers on Roll-on/Roll-off vessels	Many of the terminal operations are however "simple" moves of trailers, hub-to-hub or to organize and make loading of vessels faster and more efficient, reducing the overall capacity in the terminals	Demonstration of AWARD automation of the simple terminal tasks will free manned yard tractors to the complex loading and discharging operations, dramatically improving vessel turn-around time and terminal efficiency.

4.1.3. Ambition 3: Validation of efficiency increase of fleets using trucks with ADS

Current state of the art and limitations

Traditional fleet management systems for SAE Level 0 to 4 deliver functionality for:

- Routing – help make logistics decisions based on vehicle position, stops duration, speed, etc.
- Fuel management – track fuel consumption tendencies to minimize idling time, emissions, etc.
- Vehicle maintenance – streamline the process of diagnosing and inspecting, reminds of routine checkups.
- Driver management – store personal profiles and hours of service to analyze productivity and behavior.
- Shipment management – analyze expenses, quotes, licenses and more to optimize delivery, dispatch, and cargo placement.
- Security and safety features – assist drivers with any safety issues on the road.

The range of functions involved in fleet management is highly interrelated and generally integrated. While some services and products can be engaged separately, an overall system that integrates the data from various functions is required for optimal performance. Vehicle tracking systems provide a number of data points regarding engine diagnostics, driving behaviors, and geo-location. But there are a multitude of other data points outside of vehicle tracking systems that significantly impact fleet performance. Fuel transaction data, maintenance repair data, individual vehicle documents such as vehicle registrations, titles and travel permits, supply chain data including vehicle and equipment specifications, warranties, build and delivery data, vehicle identifying data and driver-centric data such as acceptance of fleet policies, completion of required safety training, as well as demographic data on job types all contribute to the fleet data universe. The more specialized the functions a fleet performs, the more systems and data points are involved in integration.

Today's fleet management systems have overlapping functionality with Terminal Operating Systems (TOS) or Warehouse Management Systems (WMS). TOS or WMS perform route planning and optimization of delivery and pickup of goods. The domain and responsibility of TOS, WMS, Fleet management, V2X services, supervision systems and the computer in the vehicles have to be defined to optimize the costs and complexity in each of the layers in this architecture. An example of such complexity is the remote control of an autonomous vehicle. Should this functionality be in the Fleet management system or in the supervision system? What if traffic regulators in an airport decide that all electric vehicles should stop due to gas leakage. Should such a message go to the fleet management system or to the supervision system?

Today’s fleet management does not have functionalities drivers take care of, such as knowledge about the road. Such knowledge could be traffic incidents, road maintenance relating to snow or ice, and other traffic factors around the corner at the opposite side of the road, visible through the window of the shop. Business models related to sharing data from vehicles, and the ability to consume information about road conditions and traffic situations will be a large domain. Moreover, as the level of road automation increases the quality and

timeliness of data, traffic information and services need to be guaranteed at both ends of the real time traffic information and mapping service chain. This requires a certain speed of exchange in the information (traffic and mapping) channeled between Traffic Management Centres (TMC) and Fleet Management. In this respect, Traffic Management Plans should be available at all times, i.e. the TMCs should maintain an open channel for their Traffic Management Plans and related information for those Fleet Management Systems who wish to make use of them in their fusion engine when enhancing their real-time traffic information. As a result, when the real-time traffic information reaches the vehicle via the In-Car Service Providers, the Traffic Management Plans will be already integrated with the traffic information on the road network status. This requirement is even more pressing for automated vehicles. (T M 2.0)

Progress proposed by the project

This project proposes to design an architecture to allow the development of novel fleet management systems build over the top of the agreed architecture and interfaces that consolidates all the available sources of data and information while avoiding any unnecessary overlap, thus streamlining fleet management as a whole. To this effect, the project will contribute to standardized interfaces for efficient and safe communication with vehicles, road infrastructure, logistics systems and other relevant road users allowing the achieved design to be implemented in any desired system.

Progress will be made through a systematic and careful integration of the three main components of any system designed to efficiently steer a complex logistics fleet: the vehicles, the logistics systems, and the road condition infrastructure.

This integration will lead to significantly simplified procedures for managing the fleet, making the processes less time consuming, more efficient, and less prone to errors. Thanks to the active use of data from road units and sensors, there will be fewer unforeseen issues due to for example bad road conditions that would require problem management by a human operator. The vehicle handling time is therefore decreased, and fleet components can be managed automatically and efficiently. At the same time, logistics operations can be planned more precisely, a new level of optimization being made possible by less volatile parameters and more robust data. The fact that road conditions will be known and monitored will also allow adequate preparation of the roads irrespective of current weather conditions, translating directly into increased transport efficiency and also road safety, particularly for vulnerable road users.

In the envisaged new fleet management system, concerted unification of TOS, V2X services and road sensors will lead to a more efficient and reliable fleet, decreasing handling times, emissions and need for human interaction while increasing reliability and safety.

To achieve these innovation ambitions, three technical WPs have been designed to develop technologies and solutions to overcome the current limitations (Table 2).

Table 2 A summary of AWARD innovation ambitions and corresponding WPs

Topic		WP#	Leader
Ambition 1	Design and development of a safe, low speed ADS for 24/7 availability	WP3	Continental
Ambition 2	Demonstration of ADS integrated in different heavy-duty vehicles in real-life logistics operations	WP4	EasyMile
Ambition 3	Validation of efficiency increase of fleets using trucks with ADS	WP5	Applied Autonomy

5. Innovation Monitoring Methodology

In AWARD, innovation monitoring is part of the of innovation management and is based on some Key Performance Indicators (KPI). Innovation monitoring tracks the maturity of innovation solutions as well as the solutions themselves. The defined KPIs give a snapshot of the present state of idea creation and development, as well as measuring the success of an innovation plan. These KPIs are to be followed up closely in relation to the work plan and related tasks. Leadership for monitoring will be facilitated through the Innovation Committee. This team together with partners form the innovation culture and facilitate innovation enabling factors to develop the Innovation Solutions successfully and also to come up with new ideas.

The following system will be the main process for monitoring the KPIs:

1. Keep regular audit of (external) state of the art & of (internal) project work:
    a. Keep track of publications, patents and products related to project results.
    b. Organize focus groups/interviews with experts to scrutinize the state of the art, discuss the latest developments and incorporate their suggestions and feedback to the project result.
    c. Make sure there is one responsible partner/person for each innovation solution.
    d. Organize two innovation committee meetings per year to discuss the impact of projects results.
2. In close collaboration with T9.4, ensure favorable conditions for the exploitation of the foreseen innovations in AWARD:
    a. Follow up “Consortium Agreement” for industrial rights sharing protocol, so that a favorable and transparent working environment is formed.
    b. Form a system to resolve and eliminate any possible conflicts rapidly.
    c. Form a virtual system for brainstorming and exchange ideas (Metro Retro, Miro, etc.).
    d. Reserve a certain time during each consortium face-to-face meeting for monitoring innovation solutions and brainstorm on possible new innovation solutions.
3. Check and if needed take necessary actions to ensure that claimed innovations are being developed within AWARD:
    a. Get feedback from Innovation Solutions responsible partners with adequate periods and follow up the development.
4. Identify and promote innovations arising during the course of the project work:

a. Create an innovation registry document to track new ideas, assess their innovativeness and readiness level. A directory in the AWARD internal SharePoint portal has been created to collect new innovation ideas.
b. Innovation Management Team to evaluate the possible applications of the new ideas.

Furthermore, in AWARD the project management structure is designed in a way to allow both internal and external opportunities monitoring and follow-up. Internal opportunities monitoring through the activities progress assessment is performed by the Project Manager (PM) and Innovation Manager (IM).

During each consortium meeting from the second year of the project onwards, project partners will present external information related to project results and potential impacts:

- Project results position in the value chain.
- Key Opinion Leaders and End Users.
- National / European / International initiatives and project in relation with the project.
- National / European / International funding programs in relation with the project thematic.
- Intellectual Property Rights follow-up.

During these meetings, innovation sessions will be meant to elaborate and update a clear view of the external environment linked to project results. These sessions will focus on fostering internal and external communication towards defined targets to strengthen the expected impacts of the project while ensuring a wise protection of Intellectual Property Rights in the exploitation prospective.

5.1. AWARD Innovation Solutions

AWARD uses a system of system approach to achieve its innovation goals. This system of system consists of 4 different subsystems (Figure 11).

Technologies developed in AWARD are either related to Logistics Operation and Fleet Management (LOFM) or Autonomous Driving Vehicles (ADV) These two subsystems by themselves are also consisted of various subsystems including different elements as products (hardware, software, firmware), processes, people, information, techniques, facilities, services and other support elements (for more info please refer to D2.1). The first step is to identify the Innovation Solutions, their unique value proposition and related WP and leading partner. Table 3 details these components.

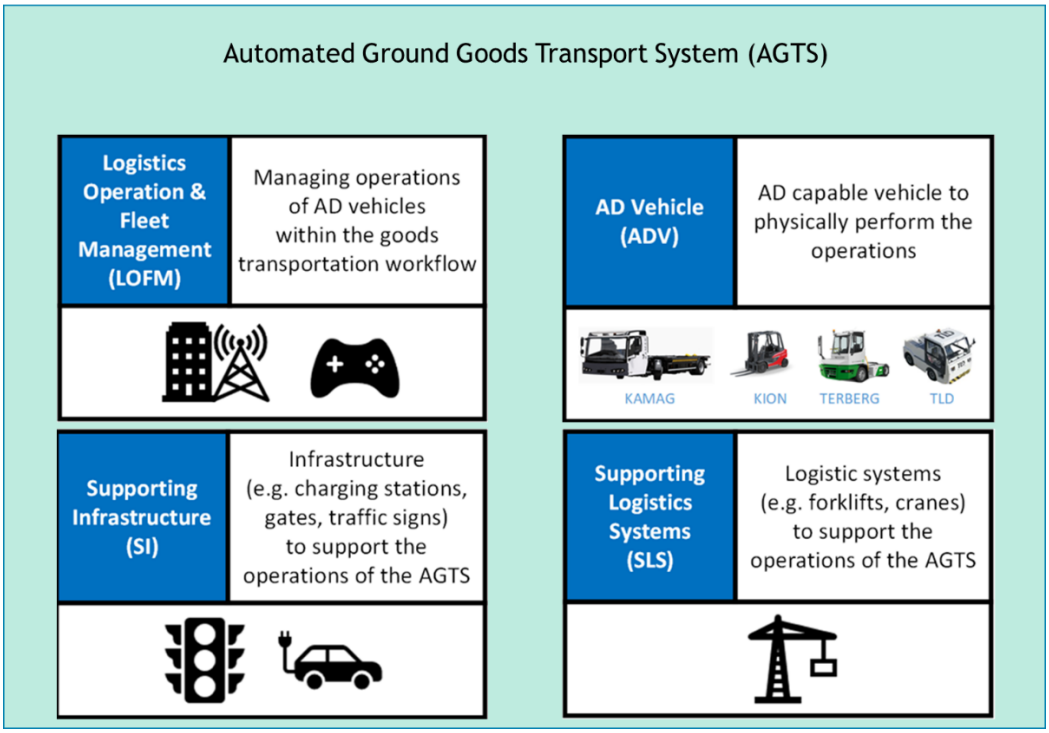

Figure 11 AWARD Automated Ground Goods Transport System and its four sub-systems

Table 3 AWARD list of Innovation Solutions

#	Innovation Solution	Unique Value Proposition	Related WP	WP Lead
1	New ADS stack and new sensor under study	Adapted system architecture to comply with the harsh weather requirements	3	Continental
2	New improved ADS stack, automated vehicle with control-by-wire according to safety standards	Safe and reliable outdoor logistics performance in harsh weather.	4 and 6	EasyMile
3	Combination of sensors, software and machine to create a consistent, safe flow at the end-user	Reduces manual labor needed on end-user's site.	4 and 6	EasyMile
4	Provide the base truck platform according to the necessary requirements and integrate the KION and EasyMile systems	Extend our existing AGV offering. The counterbalance truck allows for less strict road conditions, allowing us to implement projects beyond our existing offering. We will be able to support outdoor (e.g. yarding) applications.	4 and 6	EasyMile

5	For the first time, an integrated HMI environment is available that can help manage the full flow of AGTS operations.	The HMI will improve the interaction with the AGTS. This way, operators will be reliant.	5	Applied Autonomy
6	Integrating all system components into one FMS	Agnostic solution means client avoids multiple layers of integration for different vehicles	5	Applied Autonomy
7	Localization, mapping	Localization improvement => larger ODD available	3	Continental
8	Reliable automation sensor suitable for smaller vehicles, with lower BOM cost so more appropriate for mass production	Miniaturised version of Navtech's market-proven CIR sensor, which is more cost-effective, with a smaller form factor and faster update rate	3	Continental
9	Utilization of LWIR modality and derived technologies capable of detection and classification of objects regardless of the weather and lighting conditions	Solid state LWIR sensor for automotive use, suitable for safety related applications	3	Continental
10	Utilises a multi-spectral stereoscopic vision sensing solution based upon 3D video analysis, advanced algorithms for image processing and sensor fusion from both IR and visible-light cameras.	Safe and reliable mobile and stationary object detection in diverse harsh weather and lighting conditions.	3	Continental
11	Algorithms for the backend of the FMS for AGVs, with the ability to plan the logistics operations (of a day), and to adapt to dynamic changes. Module should be extendable for other companies / use cases.	Dynamic dispatching system for automated logistics	5	Applied Autonomy
12	Know when and where immediate remote assistance is available, to ensure maximum service levels of the autonomous fleet.	Network optimization, dynamic compression, HW agnostic	5 and 3	Applied Autonomy
13	Multiple Automotive Radarsensors + SW Stack	full-stack solution for automotive grade radar technology	3	Continental
14	Automotive Grade Radar Sensors SRR520	Latest usable Short Range Radar sensors deployed to final use cases	3	Continental
15	Centralized Radar Tracker	Improved detection and tracking of traffic participants	3	Continental
16	Dynamic Occupancy Grid	Improved detection and tracking of freespace around the vehicle	3	Continental

17	Precise Localization Framework	Improved and robust localization of the vehicle on feature-based approach.	3	Continental
18	Perform safety analysis, define sensor set up, define interfaces between vehicle platform and ADS to be able to automotize the AV	Deploy and test an autonomous vehicle on a site to optimize logistic flows and improve safety	4	EasyMile
19	Perform safety evaluation according to the accredited certification scheme	Fulfilling the upcoming safety regulation for AVs	4	EasyMile
20	Integration of relevant requirements	AV ecosystem aligned with cybersecurity regulations	5	Applied Autonomy

5.2. Key Performance Indicators

Key performance indicators for Innovation Solutions (IS) are determined as follows:

- Timing
- TRL level
- Discrepancy from objective
- Possible IPR
- Number of new ideas.

The Timing and TRL levels of each IS were identified at an early stage of the project (Table 4). The PM and Innovation manager will monitor the evolution of each IS and follow-up with WP leaders to ensure that the defined KPIs are reached.

Table 4 TRL and Timing KPIs

Innovation Solution	Current TRL	Expected TRL	Timing
New ADS stack and new sensor under study	3-4	7-8	M33
New improved ADS stack, automated vehicle with control-by-wire according to safety standards	4	7	M24
Combination of sensors, software and machine to create a consistent, safe flow at the end-user	4-5	6-7	M24
Provide the base truck platform according to the necessary requirements and integrate the KION and EasyMile systems	5 - 6	7	M24
For the first time, an integrated HMI environment is available that can help manage the full flow of AGTS operations.	3	8	M36
Integrating all system components into one FMS	6	8	M36
Localization, mapping	3-4	7-8	M33

Reliable automation sensor suitable for smaller vehicles, with lower BOM cost so more appropriate for mass production	4	8	M33
Utilization of LWIR modality and derived technologies capable of detection and classification of objects regardless of the weather and lighting conditions	7	9	M33
Utilizes a multi-spectral stereoscopic vision sensing solution based upon 3D video analysis, advanced algorithms for image processing and sensor fusion from both IR and visible-light cameras.	6	8	M33
Algorithms for the backend of the FMS for AGVs, with the ability to plan the logistics operations (of a day), and to adapt to dynamic changes. Module should be extendable for other companies / use cases.	2	5 or 6	M36
Know when and where immediate remote assistance is available, to ensure maximum service levels of the autonomous fleet.	6	8	M36
Multiple Automotive Radar sensors + SW Stack	n/a	n/a	M33
Automotive Grade Radar Sensors SRR520	9	9	M33
Centralized Radar Tracker	5	7	M33
Dynamic Occupancy Grid	5	7	M33
Precise Localization Framework	5	7	M33
Perform safety analysis, define sensor set up, define interfaces between vehicle platform and ADS to be able to automatize the AV	6-7	7-8	M24
Perform safety evaluation according to the accredited certification scheme	n/a	n/a	M24
Integration of relevant requirements	n/a	n/a	M36

We will evaluate the discrepancy from the objective, the number of ideas generated and the possibility to protect those ideas.

Furthermore, for both subsystems indicated in Table 5, some KPIs are defined at proposal stage and need to be monitored.

Table 5 ADS and LOFM sub-system KPIs

Sub-system	Target
ADS	In the framework of this project, we target to have the ADS able to operate: ● In all natural fogs observed (> 10 m, road and meteorological fog) ● In most of natural rains observed (> 70 mm/h) ● Up to what is considered as heavy snowfall and tentatively a little bit above (> 5 mm/h)

LOFM	TRL evolution of the following areas		
	Autonomous Transport System	EasyMile	From TRL 4/5 to TRL 7/8
	Multispectral Stereo Vision System	Foresight	From TRL 4/5 to TRL 7/8
	Thermal imaging	Adasky	From TRL4 to 8/9
	High-Definition Imaging Radar	Navtech	From TRL 4 to TRL 8
	UWB localization	EasyMile	From TRL 4 to TRL 6
	Teleoperation system	Ottopia	From TRL 4 to 8/9
	Fleet Management and control tower for autonomous logistics vehicles operating in mixed traffic	Applied Autonomy	From TRL6 to 8

6. Innovation Assessment Methodology

There are different ways for assessing and evaluating innovation. From identifying potential hurdles to the process and pre-setting criteria for different stages of the innovation project to economic evaluation, there are numerous approaches to assess innovation project performance (Muska et al., 2009). According to L. Morris, (2008), there are two types of innovation metrics. "Soft" metrics are those that are evaluated qualitatively and are based on intangibles like knowledge or vision. "Hard" metrics are those that can be quantified and linked to tangibles and data, such as monetary investment or the number of new items introduced.

There are some good studies that are focused more on building assessment frameworks for innovation in other industry domains, in addition to study on different elements of innovation and its varied metrics. S. Maghsoudi *et al.* (2015) have done a comprehensive review of the literature and have compiled different methods used to evaluate innovation at national, organizational and project level. Some of these methods are detailed in Table 6.

Table 6 Different Innovation Evaluation Frameworks. Source: (S.Maghsoudi, et al., 2015)

Tile of research project	Organization/Author	Description
National Projects		
European Public Sector Innovation Scoreboard (EPSIS), 2013	Hugo Hollanders et al.	The EPSIS project uses a measurement framework similar to the one used for the Innovation Union Scoreboard (IUS). It is aiming at collecting data on seven innovation dimensions ranging from human resources to drivers and barriers to innovation.

The Global Innovation Index (GII), 2008-2013	Different authors during six years	The GII is a tool developed in the mid-2000s by the Ministry of Government Administration and Home Affairs, Republic of Korea (South Korea), to gauge the level of innovation of organizations in the South Korean public sector. The GII looks at various areas to determine how well an organization innovates amidst changing environments. Over the course of the last six years, the GII has established itself as a leading reference on innovation for researchers and public and private decision makers. It has evolved into a valuable benchmarking tool to facilitate public-private dialog.
Community Survey (CIS)-2008-2012	OECD	It is a survey of innovation activities of enterprises in Ireland and other EU Member States. The survey collected information about product and process innovation, organizational and marketing innovation and other key variables.
Measuring Public Innovation in the Nordic Countries (MEPIN), 2011	Carter Bloch	It is a project aiming to develop a measurement framework for collecting internationally comparable data on innovation in the public sector in the Nordic countries
Working towards a measurement framework for public sector innovation in Australia (APSII), 2011	Department of Innovation, Industry, Science, and Research	It is aiming to equip public sector organizations with data and indicators to obtain a better understanding of their innovation performance and capability, and to drive decisions to achieve better organizational outcomes.
The Innovation Index: Measuring the UK's investment in innovation and its effects, 2009	NESTA	NESTA measures a broad range of innovative activity, from the R&D that lies behind innovative technologies to the service design and organizational innovations that power the UK's service industries. It links investment in innovation to productivity improvement and economic growth.
Innovation Measurement: Tracking the state of innovation in the American economy, 2008	The Advisory Committee on Measuring Innovation in the 21st Century	This research is not on innovation measurement, but it is mainly focused on developing recommendations to improve innovation measurement. Most of the recommendations are on innovation drivers, impediments, and enablers.
Organizational level/individual projects		
Frameworks for Measuring Innovation: Initial	Athena Alliance	This report extends the previous work and presents two alternative frameworks for measuring innovation. The first framework focuses on measuring innovation activities at the firm/organization level. The second takes a

Approaches, 2009		broader macro-level look at the fundamental investments that allow firms and other organizations to carry out innovation activities.
Innovation Metrics: The Innovation Process and How to Measure It, 2008	Langdon Morris (Innovation Labs LLC)	This research introduces possible metrics to be used at different stages of the innovation process and has a subjective approach to evaluating innovation mainly by proposing different questions.
Innovation management measurement: A review, 2006	Richard Adams, John Bessant and Robert Phelps	This research attempts to develop a holistic framework covering the range of activities required to turn ideas into useful and marketable products by reviewing the literature pertaining to the measurement of innovation management at the level of the firm. This framework consists of seven categories: inputs management, knowledge management, innovation strategy, organizational culture and structure, portfolio management, project management, and commercialization.
Innovation in the UK: Indicators and Insights, 2006	DTI Economics	This is the fourth series of innovation surveys in the UK. The survey sought information on the nature of the business activities involved in innovation as well as the effects of product and process innovation on market position, internal processes and costs.
Innovation Metrics: Measurement to Insight, 2004	Egils Milbergs and Nicholas Vonortas	This project is done at IBM Corporation with the purpose of highlighting the importance of high quality, relevant and more timely innovation metrics in enhancing public understanding, helping policymakers to benchmark the nation's innovation performance, and thereby improving policymaking and business strategies.

Using different components of the existing frameworks in the literature and adapting them to the needs of the project, we have developed our own methodology to assess innovation in AWARD This methodology is two-fold (Figure 12). On one hand, the internal evaluation of the innovation generated in AWARD is done using Innovation Radar, a widely used methodology for the innovation evaluation of EU funded projects. Also the innovation committee will oversees and evaluates the innovation aspects on the projects. On the other hand, joining forces with WP8, we conduct desktop search, market analysis and competitive analysis to understand better the new opportunities and risks related to the project and its impact on the project results. Further, we conduct interviews to get feedback from external stakeholders regarding the future of automated heavy-duty vehicles in logistics and will also engage the external expert advisory board to assess the maturity an innovativeness of the solutions. Based on the results that we get from internal and external assessment, we perform a SWOT analysis to find out the project´s Weaknesses, Strengths, Opportunities and Threats.

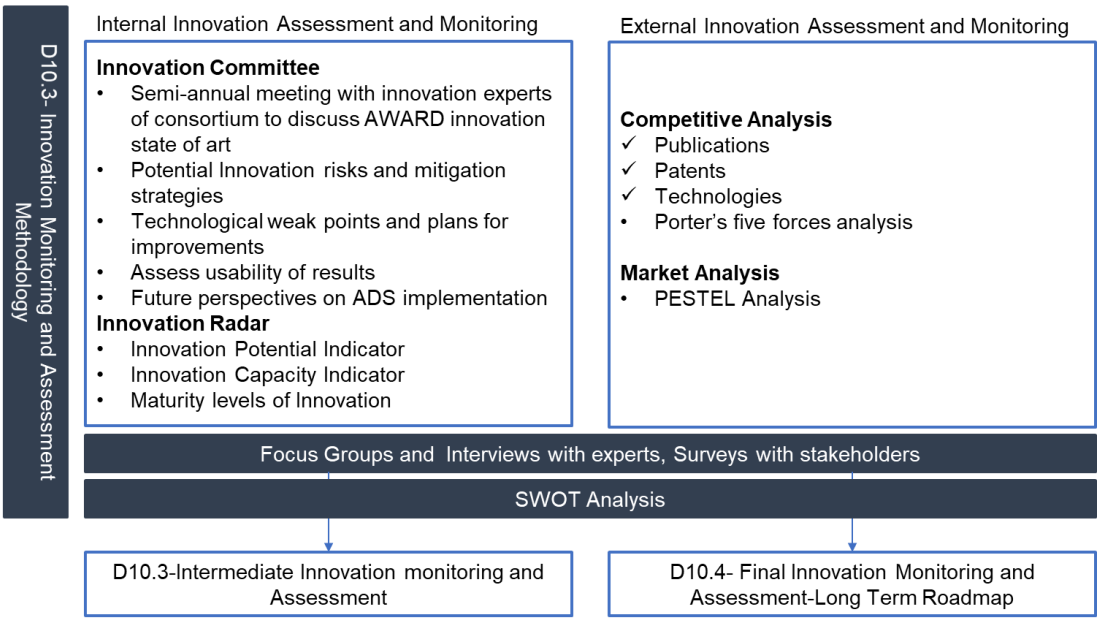

Figure 12 AWARD innovation assessment methodology

6.1. Innovation Committee

The team is composed by the project coordinator, the Work Package Leaders (WPLs) and is coordinated by Loha Hashimy from ENIDE. The team is therefore formed by the following partners (Table 7):

Table 7 The representatives of partners for the "Innovation Committee"

No	Partner	Representatives
1	EasyMile	Magali Cottevieille, Alexandre Troale
2	Enide	Loha Hashimy, Annarita Leserri
3	AIT	Peter Fröhlich
4	IRU	Ted Zotos
5	DFDS	Mads Skovsgaard, Matt Ellis
6	Applied Autonomy	Rebecca Ronke
7	Continental	Julian Ronczka
8	VTT	Sami Koskinen

The Innovation Committee is responsible for the AWARD innovation process, in particular to:

- Make sure that the innovation management methodology is implemented within each WP.
- Monitor the activities of partners and stakeholders to stay on top of end-user demands and the condition of the market's goods and services.
- Evaluate the impact of competitive solutions on the commercialization of the project results.
- Check if the market conditions are favorable for innovation.

- Identify any innovation arising during the course of the project.
- Work with partners to ensure that the planned objectives and KPIs are achieved.
- Track joint innovation developments and assist in developing an IPR strategy that enables exploitation of the results.
- Monitor and evaluate the knowledge produced during the project lifecycle with the goal of successfully implementing innovative ideas.
- Supervise the preparation of the Exploitation plan, including detailed Business Plans.
- Make recommendations to the AWARD Project General Assembly (PGA) on issues of exploitation, including warnings in case of inconsistencies with the market goals.
- Assure the successful implementation of innovative ideas.

Two innovation committee meetings are planned annually (Figure 13). In the first innovation committee meeting (30th of June, 2021) the innovation management methodology was presented and WPL were asked to present their plans and progress. Further, the weaknesses and risks associated to each innovation solution was discussed and some mitigation actions were defined.
It is expected to invite the External Expert Advisory Board (EEAB) to the second innovation committee meeting, where WPL will present the project status and the EEAB members can give some feedback and suggestions to the technical WPs to improve the IS.

In the third innovation committee meeting the KPIs are reviewed, and WP leaders are asked to discuss the potential discrepancies from the initial plans and objectives and how it will impact the overall solution. Also, the maturity levels of innovations are evaluated.

The fourth innovation committee meeting will focus on the innovation potential indicators and innovator capacity indicators. By then, hopefully we will have a better understanding of the market and potential business models.

In the fifth innovation committee meeting, we will re-evaluate the innovation maturity and will go through the KPIs. Moreover, the impact of innovation solutions is discussed and the readiness of technologies to be taken to the market is evaluated.

In the last innovation committee meeting, a roadmap and a guide towards the long-term vision of connected and automated heavy-duty vehicles for logistics operations, including the AWARD results and defining the pending stages is elaborated and discussed.

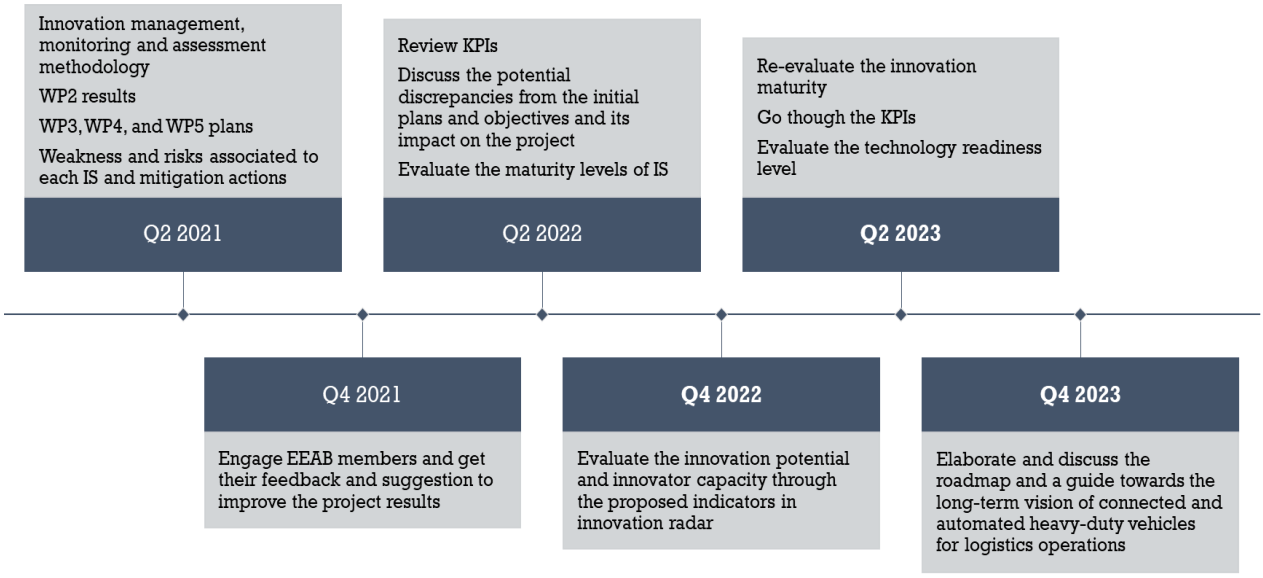

Figure 13 Innovation committee meeting timeline and topics

6.2. Innovation Radar

The methodology used in AWARD to assess innovation is innovation radar. This was originally described in a JRC report published in July 2015. Data underpinning the Innovation Radar stem from a survey developed by DG Connect and the Joint Research Centre (JRC) of the European Commission. Two indicators have been built with the Innovation Radar data. The first is the Innovation Potential Indicator which aims to measure projects' innovation development towards commercialization. The second is the Innovator Capacity Indicator which aims to capture the innovative capacity of the innovators behind these innovations.

6.2.1. Innovation potential assessment framework

The innovation potential assessment framework is the first component of the Innovation Radar. It includes a set of pre-defined criteria and relevant indicators that are expected to assess the strength of each innovation. The assessment framework considers the aspects of innovation readiness, innovation management and market potential. It should answer questions such as: Will it work? Is the innovation ready to be commercialised? How well is the competitive advantage protected?

6.2.1.1. Innovation potential assessment criteria

In order to provide synthetic comparable results for further analysis and interpretation, the innovation potential assessment framework uses three assessment criteria: Market Potential, Innovation Readiness and Innovation Management.

- **Innovation readiness:** Innovation readiness criterion relates to the technical maturity of an evolving innovation. It aims to define the development phase of the innovation, e.g. conceptualization, experimentation or commercialisation. It also takes into account the steps that were taken in order to prepare innovation for commercialisation, e.g. prototyping, demonstration or testing activities or a feasibility study, and to secure the necessary technological resources, e.g. skills, to bring the

innovation to the market. In addition, this criterion takes into account the development stage of an innovation and the time to its potential commercialization.

- **Innovation management:** Innovation Management criterion addresses the issue of the project consortium and its commitment to bring an innovation to the market, an element that is often seen as the most important success indicator of a technology venture. This concept aims to research or confirm the capability of the project's development and/or management team to execute the necessary steps to transforming a novel technology or research results into a marketable product and, finally, to prepare its commercialization. These steps may include, for example, clarifying the related ownership and IPR issues, preparing a business plan or market study, securing capital investment from public and/or private sources, or engaging an end-user in the project.
- **Market potential:** Market potential criterion relates to the demand and supply side of an innovation. Regarding the demand side, it concerns the prospective size of the market for a product and the chances of its successful commercialization. Its aim is to assess how the product satisfies a market sector and to indicate that there is potential customer base. With respect to the supply side, it aims to assess whether there are potential barriers, e.g. regulatory frameworks or existing IPR issues, which could weaken the commercial exploitation of an innovation. In the current undertaking, the focus is placed on the supply side. This is mostly related to the fact that information on markets for individual innovations is not available.

6.2.1.2. Innovation potential assessment indicators

In order to observe and measure the above specified criteria, each of them was matched with relevant questions of the Innovation Radar Questionnaire (Annex I). In this way, a composite sub-indicator for each assessment criteria was created:

- **Innovation Readiness Indicator (IRI)** is an arithmetic aggregate of all relevant information in the domain of innovation readiness as defined in sub-section 6.2.1.1 and scoring system presented in Annex 1 sub-section 9.1.3.2.
- **Innovation Management Indicator (IMI)** is an arithmetic aggregate of all relevant information in the domain of innovation management as defined in sub-section 6.2.1.1 and scoring system presented in Annex 1 sub-section 9.1.3.3.
- **Market Potential Indicator (MPI)** is an arithmetic aggregate of all relevant information in the domain of innovation market potential as defined in sub-section 6.2.1.1 and scoring system presented in Table 8 sub-section 9.1.3.1.

In the second step, the **Innovation Potential Indicator (IPI)** is constructed. IPI is an arithmetic composite indicator which aggregates the values of the three earlier sub-indicators, i.e. MPI, IRI and IMI.

An important issue related to the construction of composite indicators is the one of weighting. Unfortunately, no agreed methodology exists to weight individual indicators (EC-JRC, 2005). In particular the context of the current study does not make the choice of a weighting scheme easy. All three elements are considered equally important for a successful innovation commercialization. Considering this, it is proposed that equal weighting is applied. Figure 14 visualizes this procedure.

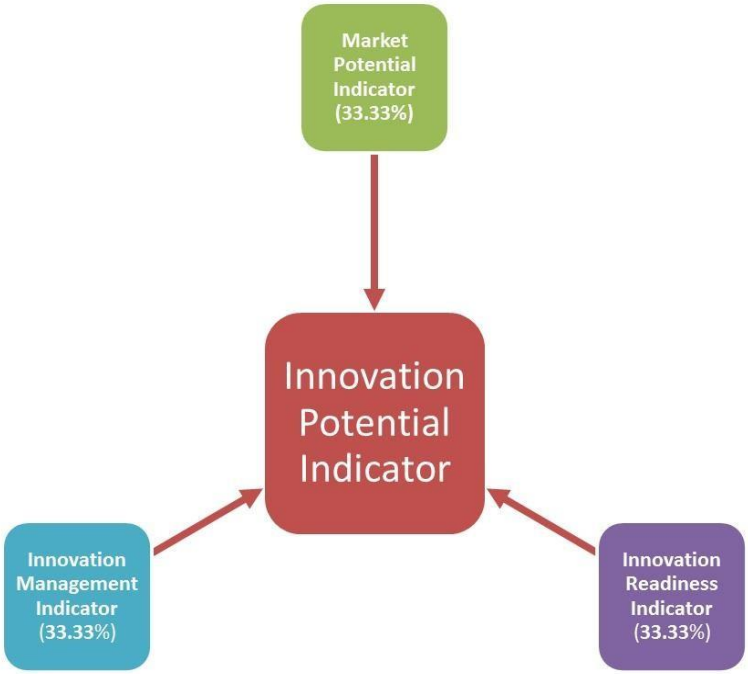

Figure 14 Construction of the Innovation Potential Indicator Source: JRC-IPTS

6.2.2. Innovator capacity assessment framework

The second element of the Innovation Radar is an assessment framework for ranking of innovators. It concentrates on two issues. First, what is the innovation performance of organizations considered as key innovators? Second, in what kind of environment are these organizations located? As in the case of the innovation assessment framework, it includes a set of pre-defined criteria and relevant indicators that are expected to assess the capacity of organizations identified as key organizations in delivering the innovations.

6.2.2.1. Innovator capacity assessment criteria

To provide synthetic comparable results for further analysis and interpretation, two criteria are used to assess the capacity of innovators in projects: innovator's ability and innovator's environment.

- **Innovator's ability:** Innovator's ability relates to the innovation performance of an individual organization that is seen as the key organization behind an innovation. The ability of an organization is measured mainly by its innovative output within the FP7 activities. By output we mean the number of innovations each organization contributes to and the potential of these innovations, where the innovation potential is a product of the innovation potential assessment, as defined in Section 3.1. In addition, while assessing innovator's ability, factors such as a reviewer's opinion about an innovator's potential or the innovator's independence in fulfilling the market potential of an innovation are taken into account.
- **Innovator's environment:** the innovator's environment criterion aims to capture the overall conditions which an innovator faces. It is mainly related to the overall composition and activity of partner organizations, the performance of the project in terms of innovation and the commitment of relevant partners to exploiting the innovation. Moreover, it also takes into account the presence of organizations that are

directly interested in applying or exploiting the innovations, e.g. end-users. It is assumed that a positive environment overall will have a positive spillover effect for the innovator and vice-versa.

In order to observe and measure the above specified criteria, each of them was matched with relevant questions from the Innovation Radar Questionnaire (Annex 1, sub-section 9.1.1).

Innovator capacity assessment indicators

In order to create a measure of innovation potential, we proceed in two steps. In a first step, composite sub-indicators are created, one for each of the above defined criteria: Innovator's Ability and Innovator's Environment. This way, two intermediate sub-indicators are used in order to assess each innovation dimension, i.e.:

- Innovator's Ability Indicator (IAI) is an arithmetic aggregate of all relevant information in the domain of innovator's ability as defined in sub-section 6.2.2.1and scoring system presented in Table 9 in Annex 1,9.1.3.4.
- Innovator's Environment Indicator (IEI) is an arithmetic aggregate of all relevant information in the domain of innovator's environment as defined in sub-section 6.2.2.1and scoring system presented in Table 9 in Annex 1,9.1.3.4.

In the second step, the Innovator Capacity Indicator (ICI) is constructed. The ICI is an arithmetic composite indicator aggregating the values of the two earlier sub-indicators, i.e. IAI and IEI. Like in the case of innovation ranking, equal weighting is applied (Figure 15) .

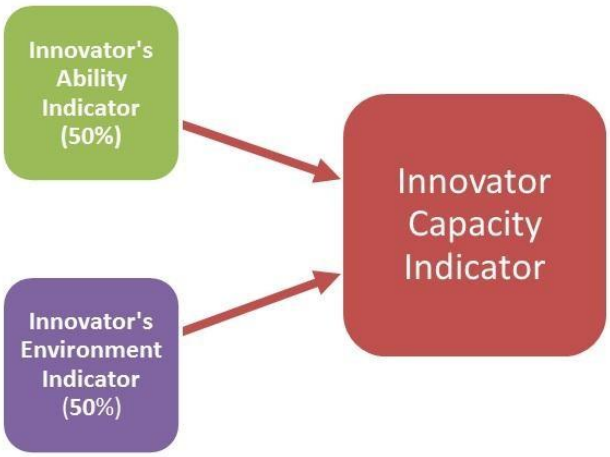

Figure 15 Construction of the Innovation Capacity Indicator. Source: JRC-IPTS

6.2.3. Normalization of indicator values

In order to make the values on each indicator among different innovations and innovators as easily comparable as possible, a normalisation procedure is applied. Observed values of each indicator are brought to the scale between 0 and 100 in the following way:

$$Indicator\ (normalized\ Score) = \frac{Indicator\ (Observed\ Score)}{Indicator\ (Max.Score)} X\ 100 \qquad (1)$$

6.2.4. Categories of innovations and innovators

In order to facilitate the interpretation of the results, the IR study introduces three categories of innovations, i.e. Low, Medium and High Potential Innovations, and innovators, i.e. Low, Medium and High Capacity Innovators (Figure 16). The assignment to a category is based

on mean and standard deviation (SD) values of the IPI for innovations and the ICI for innovators and uses percentile ranks.

Ordering innovations and innovators into three different categories based on percentile ranks allows their performance to be compared very clearly with the remaining innovations and innovators in the sample. The percentile rank of an innovation or an innovator is defined as the percentage of innovations or innovators in the same sample that obtained a score at the same level or below that of the innovation's or innovator's score.

In formal terms, for innovations, this can be expressed as follows:

Low Potential Innovation: $$IPI_i < IPI_{Mean} - IPI_{SD}\,, \quad (2)$$

Medium Potential Innovation: $$IPI_{Mean} - IPI_{SD} \le IPI_i < IPI_{Mean} + IPI_{SD}\,, \quad (3)$$

High Potential Innovation: $$IPI_{Mean} + IPI_{SD} \le IPI_i\,, \quad (4)$$

where i is the observed IPI score of innovation and mean and SD are average and standard deviation of the IPI.

Following the same logic, the assignment of inventors to three categories is based on the following rules:

Low-Capacity Innovator: $$ICI_j < ICI_{Mean} - ICI_{SD}\,, \quad (5)$$

Medium Capacity Innovator: $$ICI_{Mean} - ICI_{SD} \le ICI_j < ICI_{Mean} + ICI_{SD}\,, \quad (6)$$

High-Capacity Innovator: $$ICI_{Mean} - ICI_{SD} \le ICI_j\,, \quad (7)$$

where j is the observed ICI score of innovator and Mean and SD are average and standard deviation of the ICI.

According to this procedure of classifying innovations and innovators, belonging for example to the High-Capacity Innovator category indicates that an organization's percentile rank is 84, i.e. that at least 84% of the organizations in the sample scored the same or less than the organization. In other words, the organization's score belongs to the top 16% in the sample. Similarly, a Low Potential Innovation belongs to the group of 16% of innovations in the sample with the lowest values of the IPI.

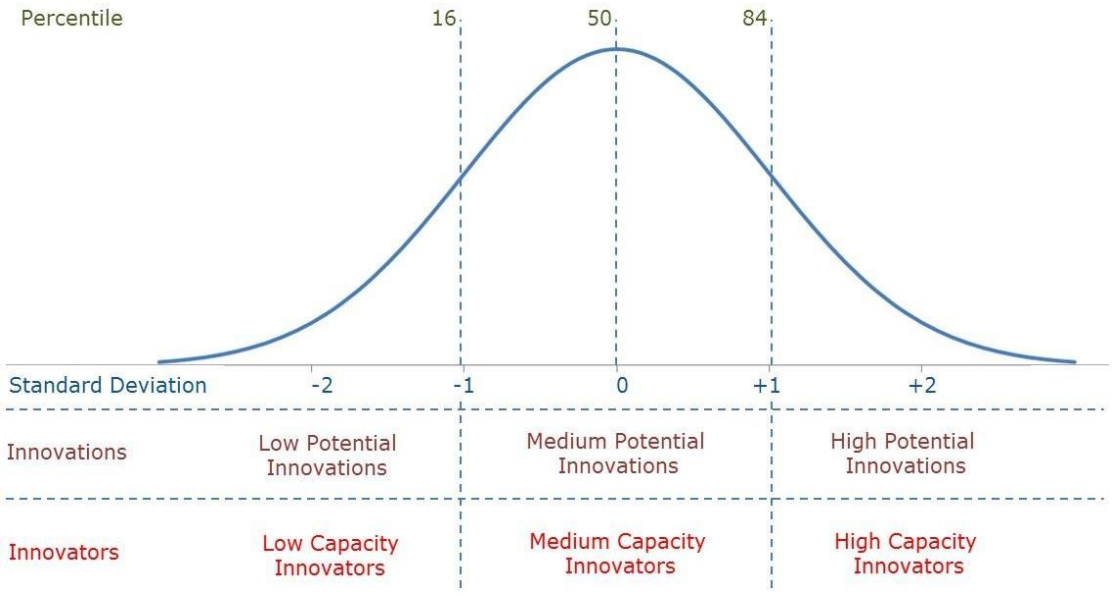

Figure 16 Categories of innovations and innovators, Source: JRC-IPTS

6.2.5. Data

In AWARD, the data will be collected from both internal and external partners to do the assessment. First, the Innovation Radar Questionnaire (Annex 1, sub-section 9.1.1) will be filled in for each innovation solution by the partner leading the innovation. Second, the general questionnaire (Annex 1, sub-section 9.1.2) will be filled in by external expert advisory board, and innovation committee. Then, the matching of survey questions with the assessment criteria will be done. Based on normalization and calculations performed, the innovations and innovators will be categorized.

7. Conclusion

From a technological and business standpoint, AWARD will have a substantial influence on the use of connected and automated heavy-duty vehicles in logistics. To that goal, from the start of the project, an innovation management methodology was established.

This report contains the necessary material and allows the reader to fully comprehend the AWARD project's selected innovation management, monitoring and assessment methodologies. This deliverable will also serve as a guide for consortium members, and it will be updated during the project's development to meet the needs of the innovation activity. The Innovation Management, Monitoring and Assessment Methodology report is viewed as a live document that will be revised as the project progresses.

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9. Annex

9.1. Annex 1

9.1.1. Innovation Radar Questionnaire by EC DG CONNECT

Note: the first 16 questions below are to be answered for each innovation Solution the project develops

1) Describe the innovation (in less than 300 characters, spaces included):
2) Is the innovation developed within the project….: ☐ a) Under development ☐ b) Already developed but not yet being exploited ☐ c) being exploited
3) Characterize the type of innovation (only to be answered if 2b or 2c is selected) ☐Significantly improved product ☐New product ☐Significantly improved service (except consulting ones) ☐New service (except consulting ones) ☐Significantly improved process ☐New process ☐Significantly improved marketing method ☐New marketing method ☐Significantly improved organisational method ☐New organisational method ☐Consulting services ☐Other
4) If other, please specify:
5) Characterise the macro type of innovation (only to be answered if "under development" is selected for Q2): ☐Product

☐Marketing method ☐Organisational method ☐Process ☐Service (non-consulting) ☐Consulting service ☐Do not know yet
6) Will the innovation be introduced to the market or deployed within a partner: ☐a) Introduced new to the market (commercial exploitation) ☐b) Deployed within a partner (internal exploitation: Changes in organisation, new internal processes implemented, etc.) ☐c) No exploitation planned
8) Is there a clear owner of the innovation in the consortium or multiple owners? ☐A clear owner ☐Multiple owners
9) Indicate who is the "owner" of the innovation:

10) Indicate the step(s) already done (or are foreseen) in the project in order to bring the innovation to (or closer to) the market (answer only if 6(a) is selected)

	Done	Planned in Project	Not Planned	Desirable
1. Technology transfer	☐	☐	☐	☐
2. Engagement by Industrial research team of one of their company's business units in project activities	☐	☐	☐	☐
3. Pilot	☐	☐	☐	☐
4. Capital investment (VC, Angel, other)	☐	☐	☐	☐
5. Investment from public authority (national, regional)	☐	☐	☐	☐
6. Business plan	☐	☐	☐	☐
7. Prototyping	☐	☐	☐	☐

8. Market study	☐	☐	☐	☐
9. Demonstration or Testing activities	☐	☐	☐	☐
10. Feasibility study	☐	☐	☐	☐
11. Launch a start-up or spin-off	☐	☐	☐	☐
12. Other	☐	☐	☐	☐

11) If other, please specify
12) Indicate which participant(s) (up to a maximum of 3) is/are the key organisation(s) in the project delivering this innovation. For each of these identify under the next question their needs to fulfil their market potential. Org1: Org2: Org3:

13) Indicate their needs to fulfil their market potential

	Investor readiness training	Investor introductions	Biz plan development	Expanding to more markets	Legal advice (IPR or other)	Mentoring	Partnership with other company (technology or other)	Incubation	Startup accelerator
Org1									
Org2									
Org3									

14) When do you expect that such innovation could be commercialised? (answer only if 6(a) is selected) ☐Less than 1 year ☐ Between 1 and 2 years ☐Between 3 and 5 years ☐More than 5 years
15) Have any of the project partners… (only to be answered if "Done" or "Planned in Project" is chosen for 10.5 "Investment from public authority") a) ☐ already applied for support from private investors

b) ☐ already applied for investment from public authorities c) ☐Planning to start discussions with private or public investors
16) Which partners are in discussion with investors (or are planning such discussions)? (the above questions are to be answered for each innovation developed by the project, up to a maximum of 3 innovations)

9.1.2. General Questions

Note: questions below are to be answered once in the project review, not for each innovation

1) How does the consortium engage end-users?
- ☐ End user organisation in the consortium
- ☐ An end user organisation outside of the consortium is consulted
- ☐ No end user organisation in the consortium or consulted

2) Are there in the consortium internal IPR issues that could compromise the ability of a projectpartner to exploit new products/solutions/services, internally or in the market place?
- ☐ Yes
- ☐ No

3) Please provide specifics of the IPR issues:

4) Which are the external bottlenecks that compromise the ability of project partners to exploitnew products, solutions or services, internally or in the market place?
- ☐ IPR
- ☐ Standards
- ☐ Regulation
- ☐ Financing
- ☐ Workforce's skills
- ☐ Trade issues (between MS, globally)
- ☐ Others

5) Indicate how many patents have been applied for by the project: _____

6) Does the review panel consider the project performance in terms of innovation?
- ☐ Exceeding expectations
- ☐ Meeting expectations
- ☐ Performing below expectations

7) General observations of innovation expert on this project's innovation performance:

8) How would you rate the level of commitment of relevant partners to exploit the

innovation?

- ☐ Very low
- ☐ Low
- ☐ Average
- ☐ High
- ☐ Very High
- ☐ None

9) Please indicate the 1 partner (excluding large enterprises) that the panel considers to be themost impressive in terms of innovation potential:

10) Please enter some tag words (comma separated) to represent what "innovation elements" arestrong in the project:

11) Please enter some tag words (comma separated) to represent what "innovation elements" canbe improved (or are absent) in the project:

9.1.3. Matching survey questions with assessment criteria

9.1.3.1. Innovation potential assessment framework: Market potential

Table 8 presents the results of matching assessment criteria defined in sub-section 6.2.1 with relevant questions of the innovation radar questionnaire.

Table 8 Innovation potential assessment framework: Market potential

Criteria & questions		Scoring
Market potential	**Question code***	**Max: 10**
Type of innovation (if Q2b or Q2c selected): New product, process or service Significantly improved product, process or service New marketing or organizational method Significantly improved marketing or organizational method, other Consulting services	Q3	 1 0.75 0.5 0.25 0
Type of innovation (if Q2a selected): Product or service Process, marketing or organizational method Consulting services	Q5	 0.5 0 0
Innovation exploitation: Commercial exploitation Internal exploitation No exploitation	Q6	 1 0.25 0
External bottlenecks	GQ4	

No external IPR issues that could compromise the ability of a project partner to exploit the innovation	GQ4a	0.5
No standards issues that could compromise the ability of a project partner to exploit the innovation	GQ4b	0.5
No regulation issues that could compromise the ability of a project partner to exploit the innovation	GQ4c	0.5
No financing issues that could compromise the ability of a project partner to exploit the innovation	GQ4d	0.5
No trade issues that could compromise the ability of a project partner to exploit the innovation	GQ4f	0.5
No other issues that could compromise the ability of a project partner to exploit the innovation	GQ4g	0.5
Needs of key organizations	Q13	
No investor readiness training need	Q13a	0.5
No investor introductions need	Q13b	0.5
No biz plan development need	Q13c	0.5
No expanding to more markets need	Q13d	0.5
No legal advice (IPR or other) need	Q13e	0.5
No mentoring need	Q13f	0.5
No partnership with other company (technology or other) need	Q13g	0.5
No incubation need	Q13h	0.5
No startup accelerator need	Q13i	0.5
Number of patents have been applied for by the project	GQ5	
<2		0.25
≥2		0.5

9.1.3.2. Innovation potential assessment framework: Innovation readiness

Criteria & questions		Scoring
Innovation readiness		**Max: 10**
Development phase	Q2	
Under development		0
Developed but not exploited		1
Being exploited		2
Technology transfer**	Q10.1	
Done		1
Planned		0.5
Pilot**	Q10.3	
Done		1
Planned		0.5
Prototyping**	Q10.7	
Done		1
Planned		0.5
Demonstration or testing activities**	Q10.9	
Done		1
Planned		0.5

Feasibility study** Done Planned	Q10.10	 1 0.5
Other** Done Planned	Q10.12	 1 0.5
Time to market Less than 1 year Between 1 and 2 years Between 3 and 5 years More than 5 years	Q14	 1 0.75 0.5 0.25
No workforce's skills issues that could compromise the ability of a project partner to exploit the innovation	GQ4e	1

9.1.3.3. Innovation potential assessment framework: Innovation Management

Criteria & questions		Scoring
Management		**Max: 10**
There is a clear owner of the innovation	Q8	1
Business plan **	Q10.6	
Done Planned		1 0.5
Market study**	Q10.8	
Done Planned		1 0.5
Launch of a start-up or spin-off**	Q10.11	
Done Planned		1 0.5
No consortium internal IPR issues that could compromise the ability of a project partner to exploit the innovation	GQ2	1
Company's business unit involved in project activities**	Q10.2	
Done Planned		1 0.5
Capital investment**	Q10.4	
Done Planned		1 0.5
Investment from public authority**	Q10.5	
Done Planned		1 0.5
End-user engagement End-user in the consortium End-user consulted No end-user in the consortium or consulted	GQ1	 1 0.5 0
Commitment of relevant partners to exploit innovation Above average Average Below average	GQ8	 1 0.5 0

*GQ – general questions

** - Steps **DONE** in the project in order to bring the innovation to the market.

9.1.3.4. Innovator capacity assessment framework

Table 9 presents the result of matching assessment criteria defined in Section 3.2.1 with relevant questions of the Innovation Radar Questionnaire.

Table 9 Innovator capacity assessment framework

Criteria & questions		Scoring
Innovator's ability	**Question code***	**Max: 5**
Number of innovations in the project for which an organization is identified as a key organisation(s) in the project delivering this innovation 1 2 3	Q12	 0.5 0.75 1
Score of innovation for which an organization is identified as a keyorganisation(s) in the project delivering this innovation	Output of the innovation assessment framework	Score between0-1
Organization is considered as the most impressive in terms of innovation potential	GQ9	1
Organization is the owner of the innovation	Q9	1
Total number of needs to fulfil the market potential of an innovation No needs Between 1 and 2 Between 3 and 4 Between 5 and 6 More than 6	Q13	 1 0.75 0.5 0.25 0
Innovator's environment	**Question code***	**Max: 3**
The engagement of end-users in the consortium End user organisation in the consortium An end user organisation outside of the consortium is consulted No end user organisation in the consortium or consulted	GQ1	 1 0.5 0
The project performance in terms of innovation Exceeding expectations Meeting expectations Performing below expectations	GQ6	 1 0.5 0
The level of commitment of relevant partners to exploit the innovation Very High or high Average Below average	GQ8	 1 0.5 0

*GQ – general questions

9.2. Annex 2

AWARD Innovation Registry - innovation registry document to track new ideas

Title	Partner Name	Date Registered	1. Key Needs/Objectives & relevance to project results	2. Innovation Type:	3.Innovation Description:	4. Innovation Justification:	5. Innovation Readiness:	6. Internal Value:	7. External Value:	9. Way forward:	8. Barriers:	10. Project Reference:	11. Impact Relevance:
Title of the innovation/idea	Abbreviated as it appears in the proposal	Date that the innovation is reported or updated in the Registry	What are the primary business/technical/authority imperatives the relevant project innovation(s) are trying to address? How those needs/objectives relate to the one or more project results?	- Significantly improved product • New product • Significantly improved service (except consulting ones) • New service (except consulting ones) • Significantly improved process • New process • Significantly improved marketing method • New Organisational Method • Significantly improved organisational method • Consulting services	Please describe the relevant innovative idea. (200 character(s) minimum)	Why do you consider those ideas as innovative and/or beyond the current state of the art?	Please indicate if your innovation(s) is a) under development, b) already developed but not yet exploited c) already being exploited. If possible, indicate project start and project end expected TRL level *	What is the added value the innovation(s) introduces to your current mode of Operations? e.g. Increased/New Revenue stream, Cost Reduction, Advancement of Knowledge, Reputational Gains, Competitive adv., etc.	Please explain the broader benefits of your innovation(s). For example, benefits for the Society / Industry / Scientific / Research Community / Environment / Broader Economic.	Please describe your envisioned evolution of your innovation(s), milestones and goals, during project lifetime and 3 years after project completion.	Please identify and describe potential barriers to adoption, usage, and/or market entry for your innovation(s)? e.g. in the areas of IPR, Standards, Regulation, Financing, Workforce's skills, Trade issues, etc.	Please indicate the relevant AWARD Work Package and deliverable(s) that documenta the innovation(s).	Impact Relevance: Please briefly describe the relation of the proposed innovation(s) to AWARD´s impact.

*** TRL levels:**
TRL 1 – basic principles observed
TRL 2 – technology concept formulated
TRL 3 – experimental proof of concept
TRL 4 – technology validated in lab
TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7 – system prototype demonstration in operational environment
TRL 8 – system complete and qualified
TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)