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<th>Description</th>
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<tr>
<td>ARTIST</td>
<td>Italian ITS reference Architecture</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>H&amp;IW</td>
<td>Hazard &amp; Incident Warning application</td>
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<td>HMI</td>
<td>Human Machine Interface</td>
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<td>IRIS</td>
<td>Intelligent CoopeRative Intersection Safety SP5 application</td>
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<td>LDM</td>
<td>Local Dynamic Map</td>
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<tr>
<td>OA</td>
<td>Organizational Architecture</td>
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<td>RIS</td>
<td>Road Intersection Safety SP4 application</td>
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<td>RSU</td>
<td>Road Side Unit</td>
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<td>Speed Alert SP5 application</td>
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<td>UC</td>
<td>Use Case</td>
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<td>V2V</td>
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<td>VASP</td>
<td>Value Added Service Provider</td>
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<td>VANET</td>
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EXECUTIVE SUMMARY

The deliverable presents a preliminary version of the SAFESPOT Organizational Architecture developed by BLADE within WP6.3.

This work package aims to define an efficient Organizational Architecture for the ITS applications being developed and implemented within the SAFESPOT project. The purpose is to qualify a possible way to deliver the Safety Margin Assistance service which is functional to the value generation, by identifying roles, responsibilities and necessary means.

The Organizational Architecture design derives from a structured process during which the elementary activities are mapped on the value chain of the service, together with the roles of the involved actors and their responsibilities and means. The methodology, that is derived from the Italian reference ITS architecture (ARTIST) and adapted for the SAFESPOT environment, is made of six steps of analysis.

Instead of focusing directly on the overall SAFESPOT service, the methodology starts considering a collection of single selected Applications; in the following step the Global System Organizational Architecture is built as the union, or “overlap” of the single applications structures; this approach allows to focus more deeply on the different aspects of the analysis performed along this subproject; moreover, in this way it is ensured the consistency with the modular structure of SAFESPOT, where different combinations of applications may be implemented on a single site or vehicle, according to particular conditions of location, driving environment, morphology, or business evaluations.

The final result of the analysis is an overall flowchart representing the system in terms of sequence of the activities to be performed in order to supply the service, mapped on the roles of the identified actors; a deep analysis of the single roles in terms of responsibilities, levers and criticalities completes the work.

This job required a strong collaboration with two different SP6 working groups: the one regarding the development of the SAFESPOT Business Model, for the Value Chain definition, and the Legal Aspects task, especially for the definition of the roles inter-relations. Also, a strict correlation was kept with the other SAFESPOT subprojects, in particular SP7 for the global architecture, SP4 and SP5 for the specific V2V and V2I applications.

The work carried out and described in this report will serve as a basis for the next stage of this WP (task 6.3.3), when the preliminary organizational architecture, here defined, will be refined and consolidated, based on the results and considerations that will come out from the other subprojects and from the other BLADE work packages (business models, assessment, responsibility mapping).
1. Introduction

This deliverable presents a preliminary version of the SAFESPOT Organizational Architecture (OA) developed by BLADE within Work Package 6.3.

A large number of ITS applications/systems/services, though well designed on the functional level, do not have applications in the real business market because of shortcomings in their organizational structure. It is well known that the successful implementation of ITS applications/systems/services is at least equally dependent on the correct interaction and separation of responsibility between the involved actors, than on the adopted technical solutions. An efficient deployment therefore can start with the definition of the most efficient organizational scheme for the ITS applications/systems/services implemented.

Work Package 6.3 is structured in three tasks. This document reports the activities of task 6.3.1 and 6.3.2. The aim of this stage of the work is firstly to outline the methodology to be adopted and to adapt the case-tool chosen for the definition of the SAFESPOT Organizational Architecture (task 6.3.1). The second aim is then to select a set of applications being developed in the technical subprojects and define for each of them a preliminary Organizational Architecture where the main roles of the actors involved in the operational level of the SAFESPOT system are identified together with their responsibilities, and the major relationships among the main functionalities are highlighted in an organizational view (task 6.3.2). From the single Organizational Architectures, the Global System organizational structure is then obtained, as the union of the single applications; this approach intends to be consistent with the modular structure of SAFESPOT, where different combinations of applications may be implemented on a single site or vehicle, according to particular conditions of location, driving environment, morphology, or business evaluations.

The purpose of the report is to offer an initial view of the organizational aspects that need to be faced during the deployment phase for ensuring an efficient use of the SAFESPOT applications. The report contains also some preliminary considerations concerning the organizational issues, with the aim to highlight the main criticalities that could arise during the deployment and the main questions that need to be taken into account to guarantee an efficient implementation. A further goal of this report is to permit an exchange of information and views with the other subprojects of SAFESPOT. While working on the organizational structures, some points regarding important aspects were raised and later discussed and solved with the different application and sub project leaders.

This work package, in effect, is strictly correlated to the other sub projects where the applications/systems/services are defined and developed (especially SP7 for the global architecture, SP4 and SP5 for the specific V2V and V2I applications). A constant monitoring of the SAFESPOT activities related mainly to the functional architecture aspects has been intensively carried out through direct contacts, deep analysis of deliverables and working documents, participation to meetings and conference-calls.

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1 A research on the latest developments of some EU IP projects (CVIS, PREVENT) has been performed within this WP in order to check for possible analysis on the organizational structure for the corresponding services: at the time being no information emerged on this topic within the projects documentation.
The Organizational analysis of the system carried out in WP 6.3 is related with other
Work Packages of BLADE, where the legal aspects and the business models are
treated. As for the Business Model work package (WP 6.6), the link is represented by
the value chain definition, which serves as an input for both areas of study (Business
Model and Organizational Architecture). On the Legal Aspects work package side
(task 6.4.2), the continuity is represented by the definition of the roles and
responsibilities of the actors, as well as the needed cross-interactions among them in
terms of information exchange. In this case, the Organizational analysis is in charge to
find out the needed relations between the entities taking part to the system, with an
eye on the legal implications of these inter-relations; in the dedicated deliverables, the
Legal Aspects working group will deepen the research and investigate the possible
implications of the whole aspects of the service.

1.1. Innovation and Contribution to the SAFESPOT Objectives

As pointed out in the Preliminary Analysis and Initial Deployment Programme report
(D6.2.1), the implementation of the SAFESPOT Organizational Architecture can be
considered as an unquestionable innovation in the area of the European research
projects regarding ITS systems.

In fact, among all the projects that were analyzed at that time, only one (the E-CALL
project) deals with the implementation of an Organizational Architecture following a
standardized methodological approach. In most projects, instead, the
organizational/business concepts of Value Chain and Actors Roles and
Responsibilities are sometimes dealt in the sections related to the Logical and
Functional Architecture and Business Models, but never in an organic way; other
concepts typical of the Organizational Architecture, as Efficiency, Value Levers, Cost
Drivers are not considered at all.

The reason for this lack of focus has to be attributed to the fact that in most ITS
national reference architectures, as well as in the European one (FRAME), the
organizational aspect is completely omitted. A significant exception is represented by
the Italian ITS reference architecture ARTIST, which contains a special section
dedicated to the development of the ITS services organizational structures. The
methodology proposed by ARTIST has therefore been adopted within SAFESPOT to
develop the Organizational Architecture of the service.

The profits brought by the development of the system Organizational Architecture
include the possibility to interpret services and Logical and Physical Architecture
functions in a business viewpoint; the innovative, although straightforward, underlying
idea is that the correct functional service supply is not guaranteed by the simple
implementation of the processes/functions - though these may guarantee its
effectiveness, but has to be supported by a business analysis aimed to its efficiency,
and by an evaluation leading to define clearly the roles and responsibilities of the
single actors needed to implement the service.

The work carried out and described in this report can be considered as an essential
input to other working groups of BLADE, in particular those dealing with the Legal
Aspects and the Business Analysis. A clear, even if not yet consolidated, proposal for
the organizational structure that would put in place the SAFESPOT service represents
an important basis for further research on these topics.
This work will contribute to raise criticalities, implications, weakness points of the system as currently specified by the technical sub-projects. The challenge is to trigger an iterative and collaborative process between BLADE and the SAFESPOT partners developing platforms and applications, leading to a continuous improvement of the system towards a more and more efficient deployment.

On WP6.3 side, this virtuous process will result in the next stage of the work (task 6.3.3), when the preliminary organizational architecture, here defined, will be refined and consolidated, based on the results and considerations that will come from the other subprojects and from the other BLADE work packages (business models, assessment, responsibility mapping).

1.2. Deliverable structure

After a short paragraph introducing the reader to the concept of Organizational Architecture (Reader’s guide), the six steps methodology is described in detail in chapter 2. A description of the case-tool software that was used for the study is also reported in paragraph 2.3.

The following chapter 3 is dedicated to the Organizational analysis of the selected applications; one paragraph is dedicated to each process step, reporting the results and the comments.

Chapter 4 is dedicated to the Global SAFESPOT System Organizational Architecture, based on the single applications analysis and following the same paragraph structure.

Chapter 4.2, finally, contains a brief analysis of the Legal Aspects related to the contracts formalizing the interaction between the different SAFESPOT actors during the service operation, and to the fulfillment of their responsibilities.

The conclusions are reported in chapter 5, including the considerations on the overall results of this preliminary Organizational Architecture and the plans for the following activities that in the next months will lead to the consolidated one.

1.3. Reader’s guide

This short guide aims to introduce the reader to the concept of Organizational Architecture and to help to get familiar with the steps of the analysis described in this report.

1.3.1. What is the Organizational Architecture of an ITS system?

The Organizational Architecture design is a structured process during which the elementary activities (or functions) of an ITS system are mapped on the roles of the entities involved in the operation of the system.

The basic input to perform this analysis, based on the Italian ITS Reference Architecture (ARTIST) guidelines, is the Functional (or Logical) Architecture of the system. This gives in fact the information on the functionalities to be performed in order to put in place the service.
The core of the analysis can be summarized as defining "who does what" in order to operate the system, where "who" means the roles identified for that particular system and "what" means the basic functionalities of the system itself.

This investigation is made of a sequence of steps, including the definition of the Roles and the Logical Functions involved in the service and the representation of the Value Chain. The final result is an overall flowchart representing the service in a map in terms of the activities to be performed in the service supply on the roles of the identified actors. The relationships (graphically represented by arrows) indicate a passage of information from an actor to another. In general, if an arrow links two functions in charge of two different roles, it includes a form of agreement between the actors covering those roles. A deep analysis of the single roles in terms of responsibilities, levers and criticalities, finally, completes the work.

1.3.2. What is the scope of the OA in SAFESPOT?

Although, in general, the deployment of an ITS service includes a series of different activities, including those needed to physically build, sell, install and maintain it, the Organizational Architecture intends to analyse exclusively the activities that are performed in order to operate it within the context of the functional architecture (the logical functions). In practical terms, this means that the OA does not include functionalities belonging to the marketing, installation, maintenance, support, insurance and administration areas, which instead are analyzed within other contexts (legal, business model).

1.3.3. How the OA diagrams are obtained?

This analysis is described in detail in the following paragraphs. Instead of focusing directly on the overall SAFESPOT service, the BLADE subproject working group decided to adopt a "bottom-up" approach and start from a set of selected applications, covering both the V2V and V2I scenarios. In the following step the overall SAFESPOT organizational scheme is then built, following an overlapping procedure.

A common structure was adopted for the single applications analysis chapters: for each of them a brief description of the application, derived from the related SP4/SP5 specifications documents, is reported ("Background" paragraph), other than a summary of its logical Process Steps, the list of the Logical Functions used for the OA representation, the Value Chain, the final Organizational flowchart and the Roles analysis.

In the SAFESPOT applications study, starting from the SP4/SP5 applications functional specifications the point of view was enlarged to the platforms, which provide the functionalities for feeding the applications with data; extra considerations were also added to the analysis, mainly based on the global system architecture defined at IP level (the "Guyancourt" diagram). As the final result, a set of logical functions was obtained for each application, with the needed degree of generalization required for this kind of investigation. Within these sets, a number of functions are common to different applications.
2. Methodology

2.1. Main concepts for the Organizational Architecture

Although several countries have developed their own ITS reference architecture in recent years, not much concern has been given so far to the organizational aspect of such systems and services, rather concentrating the standardization efforts on the logical and physical system schemes. The European methodology FRAME itself does not provide any clear references to develop the system from the point of view of the roles and responsibilities structure among the entities in charge of operating the ITS services.

A significant exception is represented by the Italian ITS reference architecture ARTIST, which contains a special section dedicated to the development of the ITS services organizational structures. The ARTIST Organizational Architecture offers a methodology to interpret services and Logical and Physical Architecture functions from a business viewpoint; in fact, the correct functional service supply is not guaranteed by the simple implementation of the processes/functions (though these may guarantee its effectiveness), but has to be supported by a business analysis aimed to its efficiency.

For this reason, the application of that methodology can be a profitable investment for any ITS application/system/service. In addition, the design of the organizational architecture acts as a first test-bed to the functional architecture created for the specific application/system/service and helps to identify its possible bugs and gaps.

The core idea of the ARTIST methodology is the definition of the "value chain" of the ITS service of interest, which is made of the sequence of processes/functions/tools/end-activities oriented to the production of the service. Within this context, the general concepts are structured according to the specific objective of identifying how telematics services are deployed, determining the value path and therefore estimating the real feasibility of the service. In this way a value analysis is performed along the chain; for each process of the chain, the system developer detects the levers that allow to create value by increasing the efficiency and reducing the process costs adopting the so-called "business vision" of the service.

In order to apply this methodology in a situation where data on individual business units is not available, the principle of added value is adopted and customized for ITS. This principle states that the overall value produced by a business activity (illustrated as a value chain) is equivalent to the sum of the values of each of the single activities plus the marginal value. The principle is customized for ITS by focusing the value chain analysis on the definition of roles, activities, responsibilities and relationships in order to guarantee the generation of the expected value from the service offered.

It is important to point out clearly what the Organizational Architecture area of analysis is within SAFESPOT: although, in general, the implementation of an ITS service is made of a series of different activities, including those needed to physically build, sell, install and maintain it, the Organizational Architecture intends to analyse exclusively the activities belonging to the functional area of the system. That is, those deriving from the functional (or logical) architecture. In practical terms, this means that the OA does not include functionalities belonging to the marketing, installation, maintenance, support, insurance and administration areas, which instead are analyzed within other contexts (legal, business model).
A further "non-functional" aspect must be mentioned to this end, that is the certification of the single applications in relation to the communication protocol. In fact, SAFESPOT is a cooperative system based on a communication network that is shared, and therefore public; a certifying body will be needed in order to guarantee that when new applications making use of the CALM protocol are introduced, the compatibility with the system is kept.²

The Organizational Architecture design derives from a structured process during which the elementary activities are mapped on the value chain of the service, together with the role of the actors involved and their responsibilities and means. The result is an overall flowchart representing the system in terms of sequence of the activities to be performed in order to supply the service, mapped on the roles of the identified actors. The relationships between the activities and the identified roles give an overall outline of the organizational problems, highlighting weak points, needs for further means, cost drivers, room for added activities, needs for regulations, and so on.

The link between the different roles and activities is put in evidence with this methodology, in order to underline "who shall make what" and which are the levers at disposal of the different roles to produce the value expected from the chain, given that often the same actor may hold more roles or, in the same role, carry out more activities along the same value chain.

The methodology defined by the ARTIST project, which is consolidated and valid for a generic ITS service, was adapted to the SAFESPOT environment in order to be easily and effectively applied. This customization process was performed on the basis of some considerations: first of all SAFESPOT is a "modular" system made of a number of applications, and only a subset of them will likely be implemented on the same single sites, according to the sites type (motorway, urban, rural) and other evaluations made by the specific service provider. Secondly, in case the ideal system containing all applications is considered, it would turn out to be difficult to obtain the global organizational architecture in one single step.

These issues have lead the SAFESPOT Organizational Architecture working group to approach the problem by analyzing separately some single applications. Four properly selected applications (two from the vehicle platform and two from the infrastructure) were therefore submitted to the architecture development, and individual diagrams were worked out; for the applications flowchart schemes, that can be considered as the final pictures of the analysis, the most possible similar structure in the layout was adopted, with the objective to finally merge them into a representative organizational scheme for the global SAFESPOT system.

This job does not aim to be all-comprehensive, because a deep analysis on this subject would need elements and data not easily, and not yet, available; what is proposed here is a tool to "read" SAFESPOT service on the underlying business frame, to supply the ideal reference also for different applications, to address the evolution of the existing ones and to supply an environment for high level considerations on the organizational needs of the service, also for future developments.

² At the time being, AT4 wireless, formerly CETECOM Spain consortium, is producing a first certification spec and selecting test partners
2.2. The six steps of the Organizational Architecture

The methodology for the Organizational Architecture definition, that was adapted for the SAFESPOT environment, consists of six activities: two preliminary steps regard the whole system (steps 1. and 2.), while the following four specific steps regard the single applications (3. to 6.). The six steps are listed below and successively described in the following paragraphs:

1. **Roles preliminary definition.** The set of roles involved in the operations of the SAFESPOT system is preliminarily determined, based on an initial analysis of the service.

2. **Definition of the global SAFESPOT system Value Chain (macro-process),** applying the traditional arrow diagram to represent the high-level processes involved in service delivery.

3. **Identifying the set of functions,** derived from the Functional Architecture of the single applications, which form the sequence of operations needed to run the service.

4. **Mapping the sub-processes on the macro-process activities** identified in the preliminary steps. The functions listed in the previous step can be seen as the subdivisions of each macro-process in the global system value chain.

5. **Designing the overall process flowchart** representing the whole set of sub-processes positioned under the roles identified in the preliminary analysis.

6. **Describing the roles and their means/responsibilities.** Bearing in mind the roles and relevant sub-processes, the responsibilities are identified with reference to service commitments (both towards the other roles mapped on the value chain and towards the end user). The same is done to identify the instruments for achieving efficient service delivery (e.g. commercial agreements, technological infrastructure, professional skills and abilities, etc.). This step includes, as well, the detection of the management levers for each role, allowing to create value by increasing the efficiency of the service and reducing the process costs.

The relationships between the activities and the roles identified give an overall outline of the organizational problems, highlighting weak points, needs for further means (personnel, equipment, etc.), cost drivers, room for added activities, needs for regulations, and so on; through the six steps mentioned above and described in the following sub-paragraphs, the **organizational architecture** is defined.

A particularly delicate step is the definition of the activities flow mapped by roles; this is done using the MEGA software, with a technique that allows to have also the macro-data that are shared during the service flow. The diagrams of the organizational architecture are made in the typical form of *swimming lane diagrams* where the following graphical elements are used:
In the following paragraphs the description of the six steps is provided.

2.2.1. Step 1: Roles preliminary definition

Although they are better specified and described in the last part of the analysis of the single applications, where they are better outlined by the Organizational analysis previous steps, the roles involved in the operations of the SAFESPOT system are preliminarily determined. This selection is based on an initial analysis of the full SAFESPOT service and on the general ARTIST literature. It is worth mentioning once again the difference between the concept of "role" and "actor". While the role is the general function within the service (e.g. Road Manager), the actor is the actual entity, organization, company etc. covering the role (e.g. ANAS SpA). This important distinction brings some significant implications: the same actor, for example, can cover more roles (e.g. ANAS SpA is the Road Manager for a portion of road network and also the Service Provider for a certain ITS application). On the other hand, the same role can be filled by more entities (e.g. two different companies act as Content Provider for a certain service).

2.2.2. Step 2: Value Chain definition

The fundamental concept of "value chain" was introduced for the first time by Michael Porter. The Value Chain analysis was originally developed to address a single company "business unit", including the activities inherent to planning, production, marketing, distribution and maintenance of products or services. Breaking down the business unit into its main strategic activities makes it possible to distinguish the behavior of costs and the associated generated value. This provides a starting point in identifying a possible action plan. A company can either control its "cost drivers" and service levels better than competitors and/or restructure its value chain in order to emphasize the strong points of its core business. In this context, the general concepts are transposed in order to reach the prefixed objective: providing a general vision on how the telematic services are supplied, and to detect the path of the value generation, thus evaluating the real feasibility and possibility to supply the service.

The analysis of the value chains was born to be addressed to the single business unit of a company. The partitioning of the business unit in its activities of strategic relevance makes it possible for the manager to understand the behaviour of costs and added value, and suggests the input for a possible diversification: the company can keep under control its "cost drivers" (the set of parameters whose variation defines the different cost scenarios) and its business parameters, and can reset the value chain to
capitalize its strong points. Through the analysis of the value chain it is possible to answer to many questions:

- Where can the organization take profit?
- Where do the suppliers take profit? Why?
- Is there room for the integration of value activities forward or backward in the chain?
- Should the "value activities" be split?
- Which are the key factors for the success in the market segment?
- Which are the levers that we need to generate the expected value?

The best level to apply this concept is the level of the activities of a single business unit in a certain sector, while the requested analytical detail depends on the strategic hypothesis. Here the principle of the added value is applied, meaning that the value of the entire chain is equal to the sum of the values of the single activities plus the marginal value.

As mentioned, the Organizational Architecture study within SAFESPOT has been applied with the purpose to analyse exclusively the activities that are performed in order to put in place the logical functions described by the functional architecture of the applications.

In literature the value chain is graphically represented as an arrow composed by as many sub-arrows as the activities of the production cycle. This representation puts in evidence the sequence of the activities in order to make more explicit the dependencies and correlations.

The analysis of the value chain involves specific benefits:

- provides a structure to perform competitive analysis by separating the steps that generate some value;
- helps along the identification of the cost drivers (if a detailed economic analysis for the single chain mail is available), of the needed levers and of the activities adding no value;
- by the comparison of the cost drivers and levers it is possible to identify the areas that can be improved or the potential competitive advantages;
- the integration opportunities can be verified by including final customers and suppliers in the value chain.

The analysis of the value chain requires a considerable data collection that are not immediately available; the detection of the key cost drivers, the identification of the links between the activities and the calculation of the margins of customer and supplier: Moreover, the comparison with the competitors is often difficult because public data for private companies are not available and the information about controlled companies is often aggregated with the controllers’.

Basically the fundamental purpose is to offer to an actor interested in the telematic transport services business the right conditions to evaluate the business frame beyond the service supply, and to make some simple considerations:
- is there room for an added value activity inside this chain, by re-adapting any existing activity, adding new ones or re-interpreting them with new technologies?,
- which are the main functionalities and drivers of the activity?,
- which are the responsibilities to be taken in charge?,
- which are the responsibility and pertinence limits of the single actor of the chain and which are the possible criticalities?,
- which are the levers needed to provide the service in an effective and efficient way, generating value for oneself and for his customer?

The definition of a macro-process or value chain is a preliminary step leading to the service supply, and is important in order to formalise the fundamental phases.

The following picture shows the value chain of the macro-process with the typical arrow-diagram.

![Figure 1. Global system value chain](https://example.com/image.png)

2.2.3. Step 3: Identifying the sub-processes

The next step is the first performed separately for every single application, and consists of splitting every single chain mail (the processes) into sub-processes/activities (or functions of the Logical Architecture).

Each macro activity of the macro process value chain, can be divided into sub-processes/activities, corresponding to what is set by the Logical Architecture. This partition is needed for the correct assignment of the activities to a certain chain mail and thus to a certain role. Within SAFESPOT, this step started from the analysis of the single applications Functional Architecture logical functions.

The functional architecture diagrams, provided by the applications developers of SP4 and SP5, show the basic functionalities of the system and the way they are related to each other in terms of input and output, via the proper data exchanges. The Data Flow Diagrams, that represent these relations, are composed of functional blocks (square boxes) and data flows (arrows). In principle, these functional blocks should be directly used in the Organizational Architecture as the basic components. In practice, in order to simplify the graphical representation (see step number 5) and to make the Organizational Architecture schemes uniform in view of being overlapped for the global architecture, some adaptations are made:

- first of all some functions are grouped as to form blocks containing more functionalities; this is done in case all the grouped original functions are in sequence and in charge of the same role;
- secondly, some original functions are re-named in order to share a common terminology between all applications and especially between the two platforms (infrastructure and vehicle);

- finally, some functions are added to those included in the functional architecture. On one hand this is done to make the representation of the different applications uniform, and on the other hand in order to include all the operational parts of the system which are functional to the represented application, although not included, for understandable reasons, in the application functional description provided by the SP4 or SP5 developer. In addition to the functionalities strictly related to the application, the diagrams show therefore the functionalities related to the data acquisition (deriving from the infrastructure and vehicle platforms) function names including the term "provide", to the Local Dynamic Map access and update, to the alert management.

- Another important reference was the already mentioned Global System Architecture (SAFESPOT Infrastructure component architecture – Guyancourt diagram). The set of functional blocks used to build the OA is adapted also in order to be compliant with the overall architecture defined at the SP7 level.

Regarding the source of the needed functionalities, the following labels are used for the Organizational Architecture functional blocks in order to track their origin:

- from application functional description

- from platforms functional description

- added within the Organizational Architecture analysis

- added on the basis of the global architecture (Guyancourt)

Every function is identified with a unique name and a numerical code, and no functions are allowed with different names and the same main meaning. The detailed description of each single functionality derives from the information included in the SP4 and SP5 applications description (for those strictly related to the applications themselves), from the SP1 and SP2 platforms specifications and from other considerations made inside BLADE on the basis of the general system logics.

**2.2.4. Step 4: Mapping the sub-processes on the macro-activities**

After the simplification and "harmonization" process is performed on the logical functions of the applications, the detected sub-processes/activities are positioned on the value chain, to build what will be called "sub-processes diagram".

The diagram depicts the value chain and all the activities or sub-activities positioned on the single rings of the chain.

**2.2.5. Step 5: Roles-Activities mapping**

Once the functionalities to be supplied and the involved roles are defined (respectively at steps 1 and 3), the flow of activities needed for the service supply at the single application level can be designed, grouping the functionalities by roles, hence putting in evidence the pertinences.
This vision is a deepening of the concept of value chain. This dedicated diagram, where for each role the corresponding Value Activities are assigned, is built in order to make the relationship between Roles and Value Activities immediately usable; that is the main purpose of this work, and represents a basis for the definition of the levers and responsibilities.

The Diagram, that will be called "Flow Chart of the service", contains the activity flows with the exchange of the macro-data that are related to the corresponding macro-functions, as a guide for the correct sequence of the activities; in particular the functions that were listed in the decomposition of the macro-process are linked to the roles, by assigning to each role the functionalities under his pertinence.

### 2.2.6. Step 6: Roles and Responsibilities description

In this step the roles needed for the implementation of the activities inside the chainmails (i.e. the single elements of the value chain) are better defined, considering the inter-relationships that have emerged in step 5 and the different functionalities in charge of each one.

The **responsibilities** are detected such that each role has to implement its own activities, and the levers to make his job operationally effective. The possible **criticalities** to physically fulfil these responsibilities are also searched.

In this context the term "responsibility" is used in its widest meaning, that is as the moral or legal duty of a person or company to answer for the harmful effects of his or others' actions; specifically the term responsibility is used to refer to the commitments of a service supply to the next role of the chain or the final user.

The responsibilities are grouped according to the following views:
1. Institutional normative responsibility; attaining to the responsibilities deriving from the definition of the normative/procedural frame that rules the service/role field
2. Management Responsibility (Governance); attaining to the responsibilities in terms of correct management of the business levers determining the expected value.
3. Commercial Responsibility; attaining to the responsibilities to supply the services/products required by the market according to the user needs.
4. Delivery Responsibility; attaining the responsibilities in terms of services/products supply in line with the service and quality levels determined at a contractual stage.

This kind of approach allows to evaluate the crossover between activities (functions) and responsibilities and to define consequently the corresponding roles, which are the basis of the following definition of the levers.

The detected levers can be of economic, politic, legal, technological nature, but also professional skills and workforce.

Moreover, in the analysis of the whole value chain it is clear that some activities depend on data and information (inputs) coming from terminators that are external to the chain itself.

Since the roles analysis (as well as steps 3 to 6 in the methodology) is carried out following the “modular” approach, that is starting from the single selected applications and then overlapping the results in order to obtain the global one, the reader may encounter some repeated content in the roles description sections of the single applications compared to the global one. Moreover, as mentioned, the roles are based on some common functionalities shared between all applications; this explains further replications in the single applications roles description paragraphs as well. However, this allows the single applications analysis chapters to be self-consistent.

### 2.3. The software tool

The software selected for the Organizational Architecture development is the MEGA® suite, an object case-tool, based on the UML language, allowing to model the data flows and functions in a way that is compliant with the project.

The choice was driven by its high level of diffusion across Europe, for the telematic architecture management. In fact, the MEGA software is used as well for the Italian national reference ITS architecture (ARTIST), the French one (ACTIF), the European one (FRAME).

The MEGA tool was customized in order to extend its graphical representation functionalities to the Organizational Architecture diagrams. Moreover, for the architecture modelling a part of the pre-defined MEGA objects was used, with the following correspondences:
### MEGA object | Architecture entity
--- | ---
Actor | Terminator
Actor | Role
Data Base | Data Base
Message | Message/Interface
Operation | Logical Functions
Procedure | Organizational Architecture Container

**Table 1. Correlations**

The MEGA case-tool includes the following components:

- the data meta model, defining conceptually objects, relations, associations
- the Warehouse, containing the objects
- the graphic editor for the data input
- tools for the data analysis
- tools for the automatic generation of the documentation
- tools for the environment customization

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**Figure 3. The case-tool used for the Organizational Architecture**
3. Organizational Architecture of the Applications

The following chapter is dedicated to the Organizational analysis of the selected applications; one paragraph is dedicated to each process step, reporting the results and the comments.

3.1. The selected Applications

As mentioned in the methodology description section, a set of applications implemented in SAFESPOT (SP4 and SP5) was selected by the BLADE team, in order to perform specific organizational analysis. This allowed to focus and concentrate more deeply on the different aspects of the investigation performed in this subproject. The following step was to build a Global System Organizational Architecture as the union of the single applications structures; this approach is consistent with the "modular" structure of SAFESPOT, where different combinations of applications may be implemented on a single site or vehicle.

Due to the large effort required to carry out the organizational structure analysis of the single applications, also in terms of collaboration with the corresponding technical subprojects, the original selection of six applications was reduced to four.

The applications have been selected taking into account the V2I and the V2V scenarios for the Safety Margin Assistant and the selection was made choosing comparable applications specified in subprojects SP4 and SP5. The selected applications belong to the two main clusters of Safe Urban Intersection and Speed Alert and Road Departure Prevention and are reported in the table below.

<table>
<thead>
<tr>
<th>Safe Urban Intersection</th>
<th>Infrastructure-based (SP5)</th>
<th>Vehicle-based (SP4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRIS_01</td>
<td>Co-operative Intersection Collision Prevention - Basic application</td>
<td>LATC_1.1 Road intersection safety</td>
</tr>
<tr>
<td>SPA_02</td>
<td>Speed Alert - Critical Speed Limit</td>
<td>LONC_2.3 Speed limitation and safety distance General Use Case</td>
</tr>
</tbody>
</table>

Table 2. The selected applications for the preliminary Organizational Architecture

Because of this strict "applications-related" approach, the Organizational Analysis was carried out with the support of the single Applications Leaders. During the work progress these were consulted for support on the functional structure interpretation and for their view on the "organizational" implications possibly caused by the implementation of their applications. The outcome of the organizational analysis was finally submitted to the single working groups, which, in all four cases, gave their approval and validated the SP6 proposal.

3 This same set of applications is under analysis also by the Legal Aspects task
In the SP4 and SP5 specification documents the applications are described considering a number of sub-items for each of them; these are named use cases in the SP4 documents and sub-applications in SP5. Since, in general, a general case is always specified for every application (General Use Case within SP4, Basic Application within SP5), for convenience this is adopted to carry out the Organizational analysis.

### 3.1.1. The roles for the selected applications

Although the roles are better specified and described in the last part of the analysis of the single applications, once they are better outlined by the Organizational analysis, the set of roles involved in the operations of the SAFESPOT system is preliminarily determined. The six roles are derived from the list of stakeholders defined in the previous part of the sub-project (see D6.4.1)⁴, but some significant changes have been brought to that list according to a preliminary analysis of the system, in order to make it fit with the system organizational structure research area. The six roles belonging to the new list are:

- **Public Authority.** This role has the responsibility for the transport network and an interest in the safety of the traveling public as a whole (e.g. Ministry of Transports).

- **Infrastructure SAFESPOT Service Provider.** This role has the task of managing the SAFESPOT system on a certain portion of road network, and possibly, but not necessarily, is covered by the same entity acting as the infrastructure manager/owner. This includes running the infrastructure platform system operations and ensuring its functionality.

- **Vehicle SAFESPOT Service Provider.** The actor covering this role will be responsible for managing the data coming from the vehicles, including taking in charge the on-board vehicle system and the communications with the rest of the system. At this stage of the project, it is still not clear what possible entity will likely be covering this role; this will depend on several factors, for example regarding the sale/installation of the on-board units (by the vehicle producer only or also as a retrofit product?). The possibility that this role may be covered by the Infrastructure SAFESPOT Service Provider, should also be discussed. This may be an issue given that, in the long term, the vehicle on board units are supposed to comply with different SAFESPOT-infrastructured road networks along Europe.

- **Infrastructure Manager/Owner.** Body or organization (public or private) responsible for managing the road infrastructure, i.e. motorway operator, road authority, etc.

- **Map Provider.** An organization responsible for collecting, processing, certificating and providing Geo-referenced Data. The Map Provider is the supplier of the static LDM layer.

- **Value Added Service Provider.** An organization responsible for providing transport-related services, which are external to SAFESPOT, to road users.

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⁴ The stakeholders list included the following items: Public Authority, Road Manager, Service Provider, Content Provider, System Producer, Probe Vehicle Driver, Driver, Vulnerable Road User.
These can include the safety-related services as well as general information, emergency support for drivers, monitoring services, weather information, etc.

The main outcome of this preliminary roles analysis was the introduction of two different Service Providers, the Infrastructure Service Provider and the Vehicle Service Provider. This separation was needed in order to take into consideration different scenarios that in the present moment are not yet clarified; in fact the information needed by the cooperative system comes from the infrastructure sensors and from the probe vehicles; it may happen that the two parts of the system are managed by different entities. For example, the same entity covering the Infrastructure Manager role may act as the Infrastructure Service Provider, and in this case this entity be responsible for the data managed at the Infrastructure level (roadside sensors, roadside alert system, etc); on the other hand, another entity (for example the car maker, or a dedicated company⁵) may take in charge the data and the systems on the vehicle side.

The other significant change was to introduce the role of Map Provider and VASP (Value Added Service Provider). These two roles correspond to the ‘Content Provider’ stakeholder of the mentioned list: basically these are the two possible entities providing content to the system, other than the System Providers themselves, through their roadside or in-vehicle sensors.

Special attention should be paid to the aspect of the **communication means** management in the SAFESPOT system organization. Communications play a fundamental role in vehicle-to-infrastructure and vehicle-to-vehicle cooperative systems and can be considered as a horizontal layer under the functional diagrams describing the operations to be put in place. This is the reason why the proposed Organizational Architecture does not list explicitly the provision of the communications service as a functionality, but rather considers it as implicitly charged on the other roles in the single situations. As a consequence, a dedicated role for the communications supply is not included.

This last aspect is explained also by a second consideration: in general, all the information exchange between the different roles (see AO diagrams in the next chapters) relies on a communication mean; two media should be distinguished:

- short-range, wireless media for all links where the vehicles are involved (the VANET, Vehicle Ad-hoc NETwork);
- long range wireless or wired media, for the links involving ‘stationary’ roles only (e.g. Road Manager-Map Provider).

Among these, the short range media, i.e. the VANET can be considered as the ‘core’ communication mean for the SAFESPOT operations; the VANET, however, does not foresee any telecommunication operator, because it is be based on the short range communications included in the CALM protocol based on the 802.11p channels, which operate in the 5.9 GHz range and can be freely operated by the SAFESPOT service providers with no intermediation of an external provider.

For the long range communications, on the other hand, SAFESPOT would be connected to other external systems in order to extend its action field, to get safety

⁵ Similarly, for example, to the satellite burglar alarm systems providers
related data or updates on static information (e.g. the maps). This, however, would be a limited traffic compared to the whole information exchange within the entire system, and, in any case, is considered as rather external to the core SAFESPOT environment. In the selected applications, in fact, it is the back network to be in charge of the communication from the external world to the Road Side Unit. This can be a network provided by a telecommunication operator (e.g. GPRS), but, likely, also a private network owned by the road manager. The conclusion is that, in principle, no extra-role for the communications provision is needed.

### 3.1.2. The Value Chain

Following the description of the Value Chain concept reported in the methodology chapter (paragraph 2.2.2), the SAFESPOT system value chain was worked out. Making reference to the considerations on the functional view of the system made in the technical subprojects, the system can be divided into a few main "blocks" this vision is well depicted by the following scheme, illustrating the SP2 reference model for the Infrastructure Platform.

The main functional steps of the system are depicted, including the acquisition of the data needed to "observe" the road (A), the processing of these data in order to recognize any safety related event (B), and the production of the alert to be provided to the driver (C and D).

![Figure 4. Reference model for the Infrastructure Platform(from D2.2.2, D5.2.3)](image)

This information path is a very appropriate representation of the steps that the product of the SAFESPOT system, that is the safety related information, undergoes from its lowest level stage (rough information from the sensors, as well as static
information, e.g. the maps or the updates on the circulation rules) to its finite form (safety alert presented to the driver). The SAFESPOT Value Chain obtained on the basis of these considerations is depicted in the following scheme. Three "chain mails" are identified, named respectively Detection, Processing and Alert. As in the general Value Chain concept, the business unit (in this case, the SAFESPOT service) is broken down into its main strategic activities, making it possible to distinguish the behavior of costs and the associated generated value.

The Value Chain represents the connection of the Organizational Architecture development, dealt in WP3, and the Business Model, dealt in WP6. As defined in the technical annex, the Organizational aspects and the Business and Service models are strongly related according to the basic idea that an appropriate business model with a clear organizational orientation is a fundamental enabler for SAFESPOT innovation and competitiveness; the common objective is to find out the organizational and business aspects in order to make sure the services functionally described in the Logical Architecture can effectively be provided.

In order to clarify this connection, it is important to bear in mind that the single elements of the Value Chain represent, within WP3, the macro activities, while in WP6 they represent the stakeholders, as described in the upcoming D6.6.1. This choice was made mainly in order to have a twofold point of view, at the same time avoiding to duplicate the activities within the two work packages.

Also, this double view will help, in the next steps of WP6, to select the best Business and Service Model for SAFESPOT, being an added evaluation element to the other results of WP3 and to the analysis about costs, market, legal aspects, risk evaluation. In order to help the reader in the interpretation of this dual view of the Value Chain, since there is no 1-to-1 correspondence between the roles of WP3 and the stakeholders of WP6, the match described in the previous paragraph (3.1.1) is recalled; moreover it is reminded the area of analysis of the Organizational Architecture, which, as mentioned, is limited to the functional operations of the service and not to the whole system deployment, while this is the case of the Business Model study.
3.2. Safe Intersection - Intelligent coopeRative Intersection Safety (SP5 - IRIS_01)

3.2.1. Background – Application functional description

Prior to performing the analysis of the application addressed to the value chain and the logical functions, it a brief description is reported about the way the application is planned to work (ref.: SF_SP5_D5.3.3_Specifications for IRIS_v0.7.doc)

![Figure 6. Cooperative Intersection Collision Prevention functional architecture](image)

The objective of the basic version of the Cooperative Intersection Collision Prevention System is to identify potential red light violators and warn them or others, support right turning vehicle drivers in being aware of pedestrians and cyclists and support left turning vehicle drivers without a separate signal stage.

The following functional process steps are performed within the application:

1. Receiving vehicle trajectories. Within this process the following data of the vehicle is received: Time, Position, Velocity, Deceleration rate. This set of data has been named, within SP6, as Vehicle Dynamics

2. Integrate vehicle trajectory and traffic light planning. Within this process the red times are compared with the vehicle trajectory. Purpose of this process is to determine whether the vehicle will pass the stopping line when the light is red or green.

If passing when green:

3. Analysis of conflict areas along trajectory. When crossing an intersection a vehicle passes a number of conflict areas. A conflict area is the location where two or more driving lines cross and vehicles can collide if they arrive at this spot at the same time. Within this process the conflict areas along the trajectories of the vehicle are identified.

4. Conflict areas occupied within pre-defined limits. Once the conflict areas along the trajectory of the vehicle are identified it has to be determined whether they will be occupied at the time of arrival or not. Therefore, some kind of filtering mechanism has to monitor if there are road users with trajectories with a similar...
time-space curve, and thus a match of time and location within a predefined range. The latter indicates the significance of not only identifying collisions, but also near collisions and/or hazardous situations.

![Figure 7. Example of conflict areas right turning vehicles](image1)

![Figure 8. Example of conflict areas left turning vehicles](image2)

*If passing when red:*

5. Calculate time to stop. Using the position of the vehicle and the stopping line the distance to the stopping line is calculated.

6. Calculate required deceleration. The appropriate deceleration is calculated.
7. Calculate if vehicle is able to stop. According to the result of the comparison between required deceleration and actual deceleration rate, the proper warning is produced: warning to other road users in case the vehicle is not able to stop in front of the stopping line, recommendation to the vehicle to slow down because of the danger violating the red light, recommendation to keep a look at the traffic lights. Note: Within this state no road surface conditions are considered. This could be done by using the adhesion coefficient for calculating the possible deceleration rate.

8. Threat assessment. Assessment of the situation at hand will be based on a real-time risk analysis. Generally, risk is defined as the product of probability and impact.

9. Decision. For decision purposes three manoeuvring stages are defined: warning (decision support), prevention (preventive warning) and mitigation (reactive warning).

10. Generation of appropriate warning / message. For each situation that may occur an appropriate warning or scenario has to be generated. Such a warning can possibly be extracted from some kind of message tree with predefined messages/warnings. Messages can be communicated via two channels, either in-car (optic, acoustic, tactile (skin, e.g. vibrating chair), and/or haptic (forces, e.g. active gas pedal)) or at the road side (optic and/or acoustic).

A message could be sent to the violator, to the user affected by the rule violation, or to all other users.

Messages could be displayed on Information Panels above roads or underneath the traffic lights. Pedestrians and cyclists could be warned by an acoustic signal. Moreover, the warning message to other road users should include the direction from where the violator or threat is coming.

### 3.2.2. The Logical Functions

As mentioned, the logical functions are derived from the functional architecture of the applications and platforms, as well as on the basis of more general evaluations. When deriving directly from the application functional architecture, in general, before being used for the OA, they undergo to the proper aggregation/renaming operations to make them uniform with the OA schemes of all applications.

In order to track their origin, they are labelled according to this terminology (see Methodology paragraph).

- from application functional description
- from platforms functional description
- added on the basis of the global architecture (Guyancourt)
- added within the Organizational Architecture analysis

**SF.01 Update circulation rules** *(added within the Organizational Architecture analysis)*

This function consists of communicating to the Road Manager any change in the traffic regulation with effects on the road safety of an administrative area (municipality,
region, state). The change can be either a long-term/final one (e.g. a change in the highway code), or a temporary one (e.g. traffic restrictions in an urban area)

**SF.02 Provide circulation rules** *(added within the Organizational Architecture analysis)*.

Passing the information on (updated) circulation rules to the SAFESPOT system, once they have been received from the Public Authority.

**SF.03 Provide vehicle dynamics from infrastructure** *(from platforms functional description)*

Detecting the vehicle dynamics (position, speed, acceleration) via the roadside sensors

**SF.04 Provide vehicle dynamics from vehicle** *(from platforms functional description)*

Detecting the vehicle dynamics (position, speed, acceleration) via the on-board sensors (GPS, speedometer, etc.)

**SF.06 Provide static road geometry & ITS devices** *(added within the Organizational Architecture analysis)*.

Passing the information on (updated) road geometry and position/ dimensions/ characteristics of static ITS devices or relevant permanent static objects.

**SF.07 Provide events info** *(added within the Organizational Architecture analysis)*.

Passing the information of events detected or acquired by systems that are installed on the infrastructure (sensors, communication media) but do not belong to the SAFESPOT system

**SF.08 Provide external safety-related info** *(added within the Organizational Architecture analysis)*.

Sending the information produced by services external to SAFESPOT to the system, in order to improve the robustness of the available information (e.g. VASP, other safety systems like CVIS, etc.).

**SF.13 Data fusion & update LDM-RSU** *(from platforms functional description)*.

The data coming from the sensors and from other possible sources (messages from the VANET, external applications, static information providers, etc.) are fused in order to obtain ready-to-use information for applications, and loaded on the RSU LDM. According to the specific applications, different functionalities are activated; in the IRIS case, the vehicle dynamics data coming from vehicles and roadside sensors need to be combined; this fusion is performed by the Cooperative Pre Data Fusion module of the SP2 Data Fusion. The Cooperative Pre-Data Fusion (CPDF) is an environment perception sub-system, providing information about objects in vicinity of the roadside-installed Laserscanner system (road intersection) to the main INFRASENS data fusion system. It fuses vehicle information transferred to the infrastructure (V2I communication data) with static map information and Laserscanner data at sensor level for a more reliable and robust tracking and classification (total number of objects tracked and classified, position of tracked objects relative to the static map, velocity of tracked objects relative to the static map, object classification information, object size). Other than the moving objects dynamics, the TLC planning information is loaded on the LDM in order to be accessible by the IRIS application.
The SF.13 functionality, finally, takes in charge the output of the SP5 applications and load them onto the LDM as to make them available to the message generator for the message to the VANET (see Guyancourt architecture).

**SF.14_Data fusion & update LDM-VEH (from platforms functional description).**

This is the Data Fusion taking place in the vehicle unit. The purpose is the same than the Data fusion & update LDM-RSU functional block. In the IRIS case, this block is in charge of producing and storing on the LDM the information on the vehicle dynamics derived from possible different sensors.

**SF.15_Query LDM-VEH info (from application functional description)**

The in-vehicle application sends the request for the needed data to its LDM. The LDM executes the query and provides the results to the application.

**SF.16_Query LDM-RSU info (from application functional description)**

The SP5 application sends the request for the needed data to the LDM (vehicle dynamics and TLC planning). The LDM executes the query and send the results back to the application.

**SF.17_Generate msg for VANET roadside (from global architecture)**

The Message Generation component contains the rule set determining when and what messages to send to the VANET. These rules are defined at design phase by the applications. These rules define under what situations and conditions which messages are to be sent to other nodes via the VANET router. The messages generated by the road-based system within this application are essentially the alerts generated by the application and sent via the VANET to the applications in order to be processed and finally displayed on the HMI.

**SF.18_Generate msg for VANET onboard (from global architecture)**

This function includes the generation of messages to be routed towards the VANET from the SAFESPOT vehicles. In the SP5 IRIS application, the messages generated by this function contain the dynamics of the vehicles.

**SF.19_In-vehicle SP5 application client (from global architecture)**

This application was not planned in the SP5 application functional description. However, since it is unlikely that the alert message from the SP5 IRIS application to the vehicles is sent straight to the HMI, it is assumed, until clarifications from the SP5 specifications are published, that the following path is likely to happen (see also the SP5 Speed Alert chapter):

- the alert message from the IRIS application is sent to the VANET
- the vehicles collect the message and put it into the LDM via the vehicle Data Fusion module
- a dedicated application (or the SP4 Road Safety Intersection application?) process this information and possibly sends it to the HMI through the Alert driver on board functionality (see below)

The other option is that the alert message from the IRIS application is managed directly by the Alert driver on board functionality. In this case this extra in-vehicle application does not exist and the message generated by the Generate message for
VANET onboard is directly linked to the Alert driver on board functionality. (this is the configuration that may be put in place on the Application test site).

**SF.20_Send msg to VANET from roadside** *(from global architecture)*

This function includes the message routing towards the VANET from the RSU router. The messages are those generated by the SF.17.

**SF.21_Send msg to VANET from veh** *(from global architecture)*

This function includes the message routing towards the VANET from the vehicle router. The messages are those generated by the SF.18.

**SF.22_Update static map** *(added within the Organizational Architecture analysis / global architecture)*

This function is referred to the periodic update of the LDM static layer. This update is performed following up changes in the road geometry, location of ITS devices or relevant permanent static objects, etc.

**SF.23_Alert driver on board** *(from platforms functional description)*

Prioritizing the messages plus the final visualization of the warning on the vehicle HMI.

**SF.26_Provide TLC planning info** *(from platform functional description)*

Passing the traffic light planning info from the traffic lights control system manager to the SAFESPOT system.

**SF.27.Validate SF TLC actuation** *(added within the Organizational Architecture analysis)*

This function verifies that the SAFESPOT request for red prolongation is compliant with the Infrastructure Manager’s own ITS systems in terms of conflicts and priority.

**SF.28_Actuate TLC** *(from application functional description)*

Activates the red traffic light prolongation.

**SF.51_Determine safety margin IRIS_01** *(from application functional description)*

This block represents the core of the application and is made of the sequence of operations described by the application functional architecture functions from Match trajectories and TLC planning to Generate message/warning.

### 3.2.3. The Value Chain

After the simplification and harmonization process is performed on the logical functions of the applications, the detected sub-processes/activities are positioned on the value chain, to build what will be called sub-processes diagram.

The diagram depicts the value chain and all the activities or sub-activities positioned on the single rings of the chain.
As mentioned in paragraph 3.1.2, the **Detection** chain mail contains all the activities performed in order to introduce information into the system; this may come from sensors (dynamic information), but can also be "static" or "quasi-static" information, as for example the updates on the circulation rules or the static map. The **Processing** element is associated to the functionalities involved with the platforms processing (data fusion), the interface with the LDM (query mechanisms), the Applications and the Message Generation; this last activity, involving the process of data coming from the Detection step of the "secondary actor" (or even the RSU), is considered as a processing activity; however, in principle, it could also be considered as a Detection activity, since it produces data for the main Driver Support Applications. The same can be said for the function of message routing to the VANET (SF.20).

The **Alert** chain mail contains two functions managing the traffic light control actuation and the warning provision to the driver on board.

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### Figure 9. The value chain for the SP5 IRIS application

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Detection</th>
<th>Processing</th>
<th>Alert</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF.01_Update circulation rules</td>
<td>SF.16_Query LDM-RSU info</td>
<td>SF.27.Validate SF TLC actuation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td>SF.15_Query LDM-VEH info</td>
<td>SF.28_Actuate TLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.02_Provide circulation rules</td>
<td>SF.13_Data fusion &amp; update LDM-RSU</td>
<td>SF.23_Alert driver on board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.03_Provide vehicle dynamics from infrastructure</td>
<td>SF.14_Data fusion &amp; update LDM-VEH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.04_Provide vehicle dynamics from vehicle</td>
<td>SF.51_Determine safety margin IRIS_01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.06_Provide static road geometry &amp; ITS devices</td>
<td>SF.17_Generate msg for VANET roadside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.07_Provide events info</td>
<td>SF.18_Generate message for VANET on board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.26_Provide TLC planning info</td>
<td>SF.21_Send msg to VANET from veh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.08_Provide external safety-related info</td>
<td>SF.19_In-vehicle SP5 application client</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td>SF.20_Send msg to VANET from roadside</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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*BLADE*
3.2.4. The Organizational scheme

Figure 10. Safe Intersection’s SP5 IRIS (Intelligent coopeRative Intersection Safety) organizational scheme
3.2.5. Roles analysis

Once the match between the roles and the functionalities (or activities) has been obtained through the organizational flow chart, the full picture of the Application under analysis is complete and all the elements are available to provide a complete description of the involved roles.

a. Public Authority

Functionalities

Within the IRIS SP5 application, the Public Authority is in charge of the activity:

- SF.01_Updating circulation rules

This functionality includes to provide and communicate to the Infrastructure Manager/Owner any update on the rules affecting the traffic circulation on the portion of road network covered by the SAFESPOT service. For the Safe Intersection applications area, this kind of updates may regard traffic restrictions (in time or for certain vehicles categories for example) in the SAFESPOT area, provided by the local government.

The fulfillment of this functionality would likely require to establish an apposite form of agreement between the two entities, in order to guarantee that the Infrastructure manager promptly communicates any change to the Road Manager/Owner. This kind of communication may be only theoretic in most cases, due to the fact that the body covering the role of Public Authority (e.g. the local government) may coincide to the body managing or owning the road; in other cases the change in the circulation rules may be agreed between the Public Authority and the Road Manager before it is put in place.

Responsibilities

The responsibilities linked to the Public Authority activity within the application belong basically to the Institutional/Regulatory category and to the Delivery one. The first aspect, however, will be external to the SAFESPOT system (i.e. the Public Authority issues a new circulation rule independently from the SAFESPOT system); what has more impact on the SAFESPOT service is the delivery responsibility; the data delivery needs to be well-timed and correctly defined in all its aspects (spatial, time - in case the new circulation rule has a limited duration, limited vehicle categories involved, etc.).

Levers

The levers in service of the Public Authority delivery responsibility will be in most cases any form of contracts to guarantee the well-timed and complete update of the circulation rules. Also any automatic procedure for the update would reduce time, costs and improve the added value for this step.

Criticalities

The lack of an agreement regulating the correct communication of updated circulation rules in the SAFESPOT area may jeopardize the correct functioning of the IRIS application.
b. Infrastructure SF Service Provider

Functionalities

The functionalities in charge of the Infrastructure SF Service Provider include:

- SF.03_Provide vehicle dynamics from infrastructure
- SF.13_Data fusion & update LDM-RSU
- SF.16_Query LDM-RSU info
- SF.51_Determine Safety Margin ï CICPS_01
- SF.17_Generate message for VANET roadside
- SF.20_Send message to VANET from roadside

The first functionality is dedicated to the detection of the measures needed by the system from the road sensors (vehicle dynamics from the Laserscanner system or the camera-based object detection module). The next two functions are dedicated to the interaction with the RSU LDM (processing, upload and extraction). SF.51 includes processing the detected data in order to determine the condition under which to send the request for red-prolongation at the traffic lights. The last two functional blocks regard the transmission of the information about the danger to the VANET, as to send the message to the single vehicles on-board HMI.

The Infrastructure Service Provider role will be covered by any entity taking in charge the management of the SAFESPOT road-based part of the system on a certain portion of road network. In most cases this entity would likely be the Infrastructure Manager, but there may also be the option it is a different organization, for example a separate company managing the ITS systems in a city area.

Responsibilities

This role shares with the SF Vehicle Service Provider the fundamental responsibility of Delivery of the service (red prolongation, safety alert on board) to the final user (driver); in fact a significant part of real-time information feeding the application (the vehicle dynamics), is detected via the roadside sensors, processed by the Road Side Unit, and sent to the VANET from the RSU router. The responsibility Delivery of safety information to the driver can be seen as decomposed into the single steps from one single ring of the system chain to the following one: the detection system to the RSU, the RSU to the router and to the traffic lights control system, the router to the vehicles. In general the Delivery responsibility is a delicate issue, since timing plays a fundamental role in the safety related alert provision. An average and maximum delay will need to be defined from the moment the safety related event happens to the moment the driver is alerted. Also, the Infrastructure Service Provider shall be able to quantify the delivery timing of the critical information provided to the following steps within the system information flow sequence, in order to monitor its compliance to the limit delays. A particular critical steps under the timing point of view is the query mechanism to extract the needed data from the RSU.

Since input data may come not only from the SAFESPOT sensors but also be communicated by external organizations, the way this exchange of information is ruled is also very important. The RSU receives information (that may also be real-time) from the VASP role, therefore proper agreements will be needed for this data transfer; a periodic update needs to be provided also by the Map Provider, from which the
Infrastructure Service Provider will need prompt update in case of static road geometry changes. More information may come from the Infrastructure Manager as well; this would imply extra agreements on this information exchange.

Another important aspect to be taken into account for the Delivery responsibility is data reliability; the information should comply defined limits of precision and accuracy when delivered from detection systems to the RSU, from the RSU to the SF.51 function and to the VANET.

The Infrastructure Service Provider, finally, is charged of a major Management responsibility of the system, since the main physical devices\(^6\) and external organizations upon which the system relies are under its control.

**Levers**

The main levers for the Delivery responsibility are technical-related. The timing and reliability of data will strongly depend upon the efficiency of the technological supports, the processing techniques, the communication devices.

The other important lever for the Delivery responsibility, both in terms of timing and data reliability, are the contracts set up between this role and those acting as information suppliers (VASP, Map Provider, Infrastructure Manager, Vehicle Service Provider) and information clients (Vehicle Service Provider through the VANET and Infrastructure Manager for the request of red prolongation). Any synergies with other safety systems installed on the same platform (e.g. CVIS) would significantly decrease the costs and therefore improve the value.

**Criticalities**

The critical aspects for this role are those involving the supply well-timed and reliable information to the driver. The Infrastructure Service Provider, together with the Vehicle Service Provider, is the interface between the system and the user; moreover, the SAFESPOT system will be successful inasmuch as the driver will modify its behaviour according to the alert messages. Since this will happen proportionally to the confidence that the he will have in the reliability of the messages he will receive, it is easy to understand that a major focus has to be given at all levels, included the organizational one, in order to reach the highest possible level of trust of the driver towards the system. Several aspects will be involved in this goal other than the timing and the reliability of the alerts: the homogeneity of the warning in time and space, the information on the current functioning status of the system; on the other hand, the risk of over compliance of the driver towards the system may have dangerous effects as well.

**c. Vehicle SF Service Provider**

**Functionalities**

The functionalities in charge of the Vehicle SF Service Provider include:

- SF.04_Provide vehicle dynamics from vehicle
- SF.14_Data fusion & update LDM-VEH
- SF.15_Query LDM-VEH info

\(^6\) excluding the probe vehicles
- SF.18_Generate message for VANET onboard
- SF.19_In-vehicle SP5 application client
- SF.21_Send message to VANET from veh
- SF.23_Alert driver on board

The first function is dedicated to the detection of data needed for the application from the vehicle (vehicle dynamics). Functions SF.14 and SF.15 are in charge of the input data processing and interaction with the LDM, in parallel to the roadside platform. Two functions are then dedicated to the generation and sending of the messages from the probe vehicles to the VANET, with the information grabbed by SF.04 and processed by SF.14.

Responsibilities

This role (see paragraph 3.1.1) is charged of a Delivery responsibility, similarly as the SF Infrastructure Service Provider, both from a global service point of view and as for the single steps of information delivery within the system. For the data coming from the external sources, the vehicle SAFESPOT system is able to receive data exclusively from the VANET, therefore all data would pass through the RSU. The only exceptions are the static map updates, that might come from the Map Provider directly to the Vehicle Service Provider. This periodic update shall be ruled by a proper commercial agreement.

Even though the IRIS application is run at the Infrastructure Level, the on-board visualization of the alert plays a significant role in the overall effectiveness of the system; in fact no alert visualization is planned roadside, being the red prolongation the only output used within the SP2 platform.

The Management responsibility, shared by this role with all the different Infrastructure SF Service Providers, includes ensuring that the in-vehicle SAFESPOT system is compliant with different SAFESPOT-equipped infrastructures.

Lever

As for the SF Vehicle Service provider, the main levers are represented by the technological capabilities of the system. In terms of data acquisition and processing, and alert visualization.

Moreover, being the communication with the infrastructure fundamental for this Application, the agreements with the entities managing various SAFESPOT-infrastructured portion of roads will be fundamental for a successful provision of the service. As for the Infrastructure SAFESPOT Service provider, an extra value would be brought to the system supply in case the data and the technologies provided to the system would be shared with other safety systems installed on the same platform (e.g. CVIS).

Criticalities

The major organizational challenge in cooperative systems is represented by the need to manage the interaction between the two platforms (vehicle and infrastructure). Considering that, as mentioned (see par 3.1.1), so far it is not completely clear how the role of Vehicle SF Service provider will be covered, it results rather difficult to envisage all possible organizational implications. In any case, being in the future the SAFESPOT service distributed over the whole European road network, a strong
standardization level among the technologies and communication procedures will be needed on behalf of all possible different Infrastructure and Vehicle SAFESPOT Service Providers.

d. **Infrastructure Manager/Owner**

*Functionality*

Functional blocks in charge of the Infrastructure Manager:

- SF.02_Provide circulation rules
- SF.06_Provide static road geometry & ITS devices
- SF.07_Provide events info
- SF.26_Provide TLC planning info
- SF.27.Validate SF TLC actuation
- SF.28_Actuate TLC

The role of Infrastructure Manager includes a series of functions for the data supply, either quasi-static (updates on circulation rules from the Public Authority, updates on road geometry) or dynamic (traffic lights status, events or measures detected by safety systems installed on the infrastructure other than the SAFESPOT system).

The other group of functions is related to the management of the red prolongation at the TLC system level.

*Responsibilities*

As the supplier of part of the data needed to run the application (SF.06, SF.07, SF.26), the Infrastructure Manager holds the responsibility to deliver data in the required time and with the required reliability (Delivery responsibility). The same responsibility is assigned to this role when the red prolongation is implemented. In fact, in case other TLC control systems are operating on the same portion of network, the Infrastructure Manager will use automated procedures in order to verify if the red prolongation is compliant with possible other actions on the same TLC system, and, if needed, set the proper priorities.

*Levers*

As for the information detection side (first three functions), the main lever at disposal of the Infrastructure Manager in order to fulfill its Delivery responsibility is the ownership of the original data, allowing the control on the information timing and reliability. As for the red-phase prolongation, the Infrastructure manager role holds the last “filter” before the TLC actuation is put in place (SF.27.Validate SF TLC actuation), therefore he can adjust the level of “impact” of the SAFESPOT system according to the situations.

*Criticalities*

An important critical point has to be considered for this role. Introducing a new system for road safety on a certain portion of network may be regarded with some distrust by a road manager correspondingly to the responsibility that would be imputed to him in case of malfunctioning of the system, possibly causing any damage to drivers. Although this issue is deeply dealt within the legal aspects analysis, it shall be considered as a major concern also for its implications on some organizational
aspects, in particular on the contracts regulating the exchange of information between this role and the other actors.

**e. Map Provider**

*Functionalities*

This role has in charge the functionality

- SF.22_Update static map

The Map Provider periodically collects the possible changes in the static information contained in the Local Dynamic Map (road geometry, speed limits, objects position) based on the inputs from the Infrastructure Manager and, possibly, from in-house surveys. The update is then communicated to the Infrastructure Service Provider for its own RSU-LDM update, and to the Vehicle SF Service Provider, that in its turn, will take care of updating the equipped vehicles systems. The contracts that will define this periodic exchange of information will include the time mode (e.g. one update every change or one update every fixed period) and the physical procedure for the data exchange.

*Responsibilities*

This role will have exclusively a responsibility on the data delivery; static maps represent an essential part of the whole mechanism.

*Levers / Criticalities*

In order to supply well-timed information, the Map Provider can rely on the contracts setup with the Infrastructure Manager/Owner for the data supply, as well as on its internal availability of resources to collect extra information and/or validate the received data. Depending on the way the updates are distributed to the RSU and vehicles LDMs (e.g. making use of a wireless connection), another important lever may be represented by the technological communication means used.

Timing will be a major issue, but also an important value contribution, due to the fact that safety related information may not be reliable in the period of time between the change and the update. For planned interventions on the road geometry by the Infrastructure Manager, optimized procedures may be introduced in order to minimize this time (e.g. the communication may be given in advance to the Map Provider), or at least to put the system in “down state” in order to avoid misleading warnings.

**f. VASP**

*Functionalities*

The Value Added Service Provider is assigned the following function:

- SF.08_Provide external safety-related info

This role may or may not be present in the application scenario according to the single sites. Typical actors for this role are traffic coordination centers, fleet monitoring systems, roadside assistance services, first aid or emergency operative centers, and, in general, all organizations external to SAFESPOT that may have at their disposal useful safety-related information. The only link of this source towards the SAFESPOT environment is the Infrastructure SAFESPOT Service Provider; proper dedicated
standard operating procedures have to be established to rule this exchange of information and make it continuous and reliable over time.

Responsibilities

Once a VASP agrees on a standard procedure for the information exchange, it will be charged with the responsibility of providing the committed information according to a defined timing and level of accuracy. Also, the management of the possible different sources of information will be under the VASP responsibility.

Levers

The added value brought by this role to the SAFESPOT service will lever on the technical means to deliver the information and the resources dedicated to the collection, verification and communication of real time information to the SAFESPOT system.
3.3. Safe Intersection - Road Intersection Safety (SP4 - 1.1)

3.3.1. Background - Reference model for the SP4 applications

Within SAFESPOT, several applications are normally running on each vehicle system. According to the general architecture, the vehicle platform has access to the sensors by means of a dedicated gateway and the dynamic representation of the environment surrounding the vehicle is stored inside a dedicated database (the Local Dynamic Map). SCOVA applications access the information inside the LDM and perform the appropriate operations. The applications also decide on the information that is exchanged between different systems, i.e. different vehicle systems or a vehicle and the infrastructure. The Vehicular Ad Hoc Network (VANET) is in charge of establishing and keeping the network connectivity for the V2V and V2I communications.

A distinction exists between the data, available to the node, that need to be used locally (not transmitted to the VANET) in order to warn the driver of the ego vehicle (primary actor), and the data that need to be transmitted to the VANET (by a secondary actor) in order to enable the operations of an application running on a different node. Only the second type of data has an impact on the usage of the communication channel, since these parameters are the single ones involved in the co-operative approach.

To obtain safety-related recommendations, the application running on a certain vehicle (the primary actor) needs to get information from the surrounding vehicles. This information is easily available on the CAN bus of these vehicles, but these actors (the secondary actors), normally do not broadcast all parameters they have. They know (and need) to transmit this information only as a consequence of the awareness of being part (with a passive participation and role) of an applicative scenario where the assistance effects - warnings - are exclusively for the benefit of the primary actor.

Since it is assumed the communication channel should not be used to explicitly request information by any of the actors involved the Use Cases, all of the secondary actors need to perform a specific analysis of the scenario in order to know when and how (or better, with which repetition rates) to deliver their parameters and data to the primary actor.

In order to implement this model of minimal transmission channel occupancy, some high level strategies will be implemented by the system developers for enabling the secondary actors to place data on the VANET only when such data are explicitly needed by some primary actor. In the adopted approach the analysis of a given scenario is executed both in the ego vehicles, with the purpose of driving the driver\'s HMI, and in the secondary actors (and other \[active nodes\]), with the purpose of deciding when and how to deliver on the VANET the specific applicative parameters and information needed by the primary actors.

For the implementation of this functional strategy, four applicative tasks are planned to support the SAFESPOT co-operative applications:

1. **application manager**, running in the SAFESPOT ego vehicles, with the purpose of performing the analysis of the surrounding scenario, and to provide an unified applicative support for all of the driver assistance applications running in the ego vehicle;
2. **driver assistance application**, running in the ego vehicles, carrying out the specific functions of the driving support applications, with the specific purpose of providing an assistance content (warning) to the driver of the ego vehicles;

3. **message manager**, running in the other SAFESPOT vehicles different than the ego vehicle, with the purpose of performing the analysis of the surrounding scenario, and to provide an unified applicative support for all of the co-operative support applications running in the co-operative (non ego) vehicles;

4. **co-operative support application**, running in the co-operative vehicles, implementing the “parameter transmission rules” and carrying out the functions of the co-operative support applications, with the specific purpose of sending to the VANET all of the parameter at the proper time and with the proper repetition rate, to support efficiently the tasks of the driver assistance applications running on the ego vehicles.

The functional mechanism that rules the cooperation of the SAFESPOT vehicles, though being mainly of functional interest, involves the organizational aspect as well. On the Organizational Architecture charts it is represented through a defined loop of functions and information exchange including the functional blocks reported in the following picture:

![Figure 11. The functional mechanism that rules the cooperation of the SAFESPOT vehicles](image)

The “core” of the application is represented by the SF.41 function, in charge of calculating the warning on the basis of the information queried from the LDM and, subsequently to send it to the alert system other that storing it onto the own LDM. A second path describes what happens on the secondary actor vehicle: SF18 queries the needed information from the LDM and, on the basis of a scenario analysis, sends
a message to the VANET; the message id received by the other vehicles, which store it on their LDM as to put it at disposal of their driving assistance applications.

### 3.3.2. Background – Application functional description

The General Use Case for the Road Intersection Safety provides the driver assistance at intersection scenarios, focusing on troubles related to defective crossing lights or to the presence of accidents within the intersection area.

![Pictogram of the RIS General Use Case](image)

In the following paragraphs the functional steps performed within the application are listed, following the applicative tasks scheme described above.

**SCENARIO ANALYSIS (Application Manager) – PRIMARY ACTOR V1**

1. The position of the ego vehicle is associated to the map.
2. If an intersection may be reached by the ego vehicle within a certain distance or time, associate all other vehicles within a certain distance to the intersection to the map.
3. If 2. is true and there is at least another vehicle or an accident, enable Driver Assistance Application UC_1_GC.

**DRIVER ASSISTANCE APPLICATION**

0. Check the status of the traffic lights. If they are defect, inform the drivers.
1. The application checks whether one of the secondary actors/accident probable trajectories are intersecting the ego vehicle\'s probable trajectories (include the starting scenario of the ego vehicle) where the probability for a collision is greater than a fixed threshold.
2. If the condition (1.) is fulfilled, the probability for a collision is greater than a fixed threshold the Safety Margin is modified accordingly (critical/safety/comfort). This modification depends on the ratio of braking distance to the potential collision point as well as time to collision and on the visibility and road friction.
3. The driver is warned accordingly.
4. Associate all vehicles within a certain distance to the intersection to the map.
SCENARIO ANALYSIS (Message Manager) – SECONDARY ACTOR Vx

1. The position of the secondary vehicle is associated to the map
2. If an intersection may be reached by the secondary actor within a certain distance or time, associate all other vehicles within a certain distance to the intersection to the map
3. If 2. is true and there is at least another vehicle, enable Cooperative Support Application UC_1_GC

COOPERATIVE SUPPORT APPLICATION

The Cooperative Support Application, running on a secondary vehicle, is in charge of transmitting on the VANET the vehicle parameters needed by the correspondent application running on the primary actor (V1) in order to warn the driver about the UC_1_GC.

1. The position of the secondary vehicle is associated to the map
2. If an intersection may be reached by the ego vehicle within a certain distance or time, associate all other vehicles within a certain distance to the intersection to the map
3. If 2. is true and there is at least another vehicle transmit all the relevant information to the VANET

3.3.3. The Logical Functions

As mentioned, the logical functions are derived from the functional description of the application and from the related platforms, as well as on the basis of other broader considerations. In order to track their origin, they are labelled according to the following terminology (see Methodology paragraph)

- from application functional description
- from platforms functional description
- added on the basis of the global architecture (Guyancourt)
- added within the Organizational Architecture analysis

SF.01_Update circulation rules (added within the Organizational Architecture analysis).

This function consists of communicating to the Road Manager any change in the traffic regulation with effects on the road safety of an administrative area (municipality, region, state). The change can be either a long-term/final one (e.g. a change in the highway code), or a temporary one (e.g. traffic restrictions in an urban area)

SF.02_Provide circulation rules (added within the Organizational Architecture analysis).

Passing the information on (updated) circulation rules to the SAFESPOT system, once they have been received from the Public Authority.

SF.04_Provide vehicle dynamics from vehicle (from application functional description)
Detecting the vehicle dynamics (position, speed, acceleration) via the on-board sensors (GPS, speedometer, etc.)

**SF.05 Provide vehicle other info from vehicle** *(from application functional description)*

Detecting via the on-board sensors or recording by the in-vehicle system other (than dynamics) vehicle information needed for the application (navigation system recommendations, controls status, lateral position vs lane markings, heading, static info, yaw rate, etc.).

**SF.06 Provide static road geometry & ITS devices** *(added within the Organizational Architecture analysis)*

Passing the information on (updated) road geometry and position/ dimensions/ characteristics of static ITS devices or relevant permanent static objects.

**SF.07 Provide events info** *(added within the Organizational Architecture analysis)*

Passing the information of events detected or acquired by systems that are installed on the infrastructure (sensors, communication media) but do not belong to the SAFESPOT system.

**SF.08 Provide external safety-related info** *(added within the Organizational Architecture analysis)*

Sending the information produced by services external to SAFESPOT to the system, in order to improve the robustness of the available information (e.g. VASP, other safety systems like CVIS, etc.).

**SF.11 Detect road status roadside** *(from platform and application functional description)*

Detect road status through roadside sensors.

**SF.12 Detect weather info roadside** *(from platform and application functional description)*

Detect environmental info through roadside sensors.

**SF.13 Data fusion & update LDM-RSU** *(from platforms functional description)*

The data coming from the sensors and from other possible sources (messages from the VANET, external applications, static information providers, etc.) are fused in order to obtain ready-to-use information for applications, and loaded on the RSU LDM. According to the specific applications, different functionalities are activated.

**SF.14 Data fusion & update LDM-VEH** *(from platforms functional description)*

This is the Data Fusion taking place in the vehicle unit. The purpose is the same than the Data fusion & update LDM-RSU functional block but now the information coming from the ego-vehicle sensors are processed and stored, together with the messages received from the VANET coming either from the RSU or the vehicles acting as secondary actors.

**SF.15 Query LDM-VEH info** *(from application functional description)*

The SP4 application sends the request for the needed data to its LDM. The LDM executes the query and provides the results to the application. This function contains all the SP4 functions named "acquire..."
SF.17_Generate msg for VANET roadside (from global architecture)
This functionality corresponds with the operations performed by the roadside Message Manager module. The Message Generation component contains the rule set determining when and what messages to send to the VANET (containing all the information needed by the in-vehicle application). These rules are defined at design phase by the applications. These rules define under what situations and conditions which messages are to be sent to other nodes via the VANET router. For the RIS application these messages contain the information about road status and weather status.

SF.18_Generate msg for VANET on board (from global architecture /application)
This function includes the generation of the messages which then will be routed towards the VANET from the SAFESPOT vehicles (secondary actors). In the SP4 applications, this corresponds with the operations performed by the in-vehicle Message Manager module. The messages generated by this application contain the dynamics of the vehicles, the other information detected by the on board sensors or recorded by the in-vehicle system (heading, yaw rate, driver commands) and the static information about the vehicles (ID, vehicle type, dimensions, weight, dangerous goods transported).

SF.20_Send msg to VANET from roadside (from global architecture)
This function includes the message routing towards the VANET. The messages are those generated by the SF.17.

SF.21_Send msg to VANET from vehicle (from global architecture)
This function includes the message routing towards the VANET from the vehicle router. The message are those generated by the SF.18.

SF.22_Update static map (added by SP6/from global architecture)
This function is referred to the periodic update of the LDM static layer. This update is performed following up changes in the road geometry, location of ITS devices or relevant permanent static objects, etc.)

SF.23_Alert Driver on-board (from platforms functional description)
Prioritizing the messages plus the final visualization of the warning on the vehicle HMI.

SF.29_Provide TLC status (from application functional description).
Send the information of regular/defective functioning conditions of the traffic light system at the intersection.

SF.41_Determine safety margin RIS_1.1 (from application functional description).
This block represents the core of the application and is made of the sequence of operations described by the application functional architecture functions ĉalculate trajectoresŴ ĉDetect time to collisionŶ ĉEstimate risk areaŴ in the Driver Assistance Application, other than the Application Manager operations.

3.3.4. The Value Chain
After the simplification and ĉharmonizationŴ process is performed on the logical functions of the applications, the detected sub-processes/activities are positioned on the value chain, to build what will be called ĉsub-processes diagramŴ
The diagram depicts the value chain and all the activities or sub-activities positioned on the single rings of the chain.

As mentioned in paragraph 3.1.2, the Detection chain mail contains all the activities performed in order to introduce information into the system; this may come from sensors (dynamic information), but can also be “static” or “quasi static” information, as for example the updates on the circulation rules or the static map. The Processing element is associated to the functionalities involved with the platforms processing (data fusion), the interface with the LDM (query mechanisms), the Applications and the Message Generation; this last activity, involving the process of data coming from...
the Detection step of the secondary actor vehicle (or even the RSU), is considered as a processing activity; however, in principle, it could also be considered as a Detection activity, since it produces data for the main Driver Support Applications. The same can be said for the function of message routing to the VANET (SF.20, SF.21).

The Alert chain mail contains two functions managing the warning provision to the driver on board.
3.3.5. The Organizational scheme

Figure 14. Safe Intersection 1 SP4 RIS (Road Intersection Safety) organizational scheme
3.3.6. Roles analysis

a. Public Authority

Functionalities

Within the RIS SP4 application, the Public Authority is in charge of the activity:

- SF.01_Updating circulation rules

This functionality includes to provide and communicate to the Infrastructure Manager/Owner any update on the rules affecting the traffic circulation on the portion of road network covered by the SAFESPOT service. For the Safe Intersection applications area, this kind of updates may regard traffic restrictions (in time or for certain vehicles categories for example) in the SAFESPOT area, provided by the local government.

The fulfilment of this functionality would likely require to establish an apposite form of agreement between the two entities, in order to guarantee that the Infrastructure manager promptly communicates any change to the Road Manager/Owner. This kind of communication may be only theoretic in most cases, due to the fact that the body covering the role of Public Authority (e.g. the local government) may coincide to the body managing or owning the road; in other cases the change in the circulation rules may be agreed between the Public Authority and the Road Manager before it is put in place.

Responsibilities

The responsibilities linked to the Public Authority activity within the application belong basically to the Institutional/Regulatory category and to the Delivery one. The first aspect, however, will be external to the SAFESPOT system (i.e. the Public Authority issues a new circulation rule independently from the SAFESPOT system); what impacts more on the SAFESPOT service is the delivery responsibility; the data delivery needs to be well-timed and correctly defined in all its aspects (spatial, time - in case the new circulation rule has a limited duration, limited vehicle categories involved, etc.).

Levers

The levers in service of the Public Authority delivery responsibility will be in most cases any form of contracts to guarantee the well-timed and complete update of the circulation rules. Also any automatic procedure for the update would reduce time, costs and improve the added value for this step.

Criticalities

The lack of an agreement regulating the correct communication of updated circulation rules in the SAFESPOT area may jeopardize the correct functioning of the Road Intersection Safety application.

b. Infrastructure SF Service Provider

Functionalities

The functionalities in charge of the Infrastructure SF Service Provider within this application include:

- SF.11_Detect road status roadside
- SF.12_Detect weather info roadside
- SF.13_Data fusion & update LDM-RSU
- SF.13_Data fusion & update LDM-RSU
- SF.17_Generate msg for VANET roadside
- SF.20_Send message to VANET from roadside

The first two functionalities are dedicated to the detection of the measures needed by the system from the road sensors (road status and weather). The next function is dedicated to the interaction with the RSU LDM (processing, upload). The last two functional blocks regard the transmission of the information collected by the roadside sensors to the VANET, as to send the message to the single vehicles on-board LDM.

The Infrastructure Service Provider role will be covered by any entity taking in charge the management of the SAFESPOT road-based part of the system on a certain portion of road network. In most cases this entity would likely be the Infrastructure Manager, but there may also be the option it is a different organization, for example a company managing the ITS systems in a city area.

Responsibilities

This role shares with the SF Vehicle Service Provider the fundamental responsibility of Delivery of the service (safety alert on board) to the final user (driver); in fact a part of the real-time information feeding the application (the road status and weather information), is detected via the roadside sensors, processed by the Road Side Unit, and sent to the VANET from the RSU router. The responsibility Delivery of safety information to the driver can be seen as decomposed into the single steps from one single ring of the system chain to the following one: the roadside detection system to the RSU, the RSU to the router, the router to the vehicles. In general the Delivery responsibility is a delicate issue, since timing plays a fundamental role in the safety related alert provision. An average and maximum delay will need to be defined from the moment the safety related event happens to the moment the driver is alerted. Also, the Infrastructure Service Provider shall be able to quantify the delivery timing of the critical information provided to the following steps within the system information flow sequence, in order to monitor its compliance to the limit delays.

Since input data may come not only from the SAFESPOT sensors but also be communicated by external organizations, the way this exchange of information is ruled is also very important. The RSU receives information (that may also be real-time) from the VASP role, therefore proper agreements will be needed for this data transfer; a periodic update needs to be provided also by the Map Provider, from which the Infrastructure Service Provider will need prompt update in case of static road geometry changes. More information may come from the Infrastructure Manager as well; this would imply extra agreements on this information exchange.

Another important aspect to be taken into account for the Delivery responsibility is data reliability; the information should comply defined limits of precision and accuracy when delivered from detection systems to the RSU, from the RSU to the VANET.
The Infrastructure Service Provider, finally, is charged of a major Management responsibility of the system, since some of the physical devices7 and external organizations upon which the system relies are under its control.

**Levers**

The main levers for the Delivery responsibility are technical-related. The timing and reliability of data will strongly depend upon the technological supports, the processing techniques, the communication devices.

The other important lever for the Delivery responsibility, both in terms of timing and data reliability, are the contracts set up between this role and those acting as information suppliers (VASP, Map Provider, Infrastructure Manager, Vehicle Service Provider) and the only information client (Vehicle Service Provider through the VANET, receiving the road status and weather information).

**Criticalities**

The critical aspects for this role are those involving the supply well-timed and reliable information to the driver. The Infrastructure Service Provider, together with the Vehicle Service Provider, is the interface between the system and the user; moreover, the SAFESPOT system will be successful inasmuch as the driver will modify its behaviour according to the alert messages. Since this will happen proportionally to the confidence that the he will have in the reliability of the messages he will receive, it is easy to understand that a major focus has to be given at all levels, included the organizational one, in order to reach the highest possible level of trust of the driver towards the system. Several aspects will be involved in this goal other than the timing and the reliability of the alerts: the homogeneity of the warning in time and space, the information on the current functioning status of the system; on the other hand, the risk of over compliance of the driver towards the system may have dangerous effects as well.

c. **Vehicle SF Service Provider**

**Functionalities**

The functionalities in charge of the Vehicle SF Service Provider include:

- SF.04_Provide vehicle dynamics from vehicle
- SF.05_Provide vehicle other info from vehicle
- SF.14_Data fusion & update LDM-VEH
- SF.15_Query LDM-VEH info
- SF.18_Generate message for VANET onboard
- SF.21_Send message to VANET from veh
- SF.23_Alert driver on board
- SF.41_Determine safety margin RIS_1.1

The first function is dedicated to the detection of data needed for the application from the vehicle (vehicle dynamics and vehicle controls status). Functions SF.14 and SF.15 are in charge of the input data processing and interaction with the LDM, in parallel to

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7 excluding the probe vehicles
the roadside platform. Two functions are then dedicated to the generation and sending of the messages from the probe vehicles to the VANET, with the information grabbed by SF.04 and SF.05 and processed by SF.14. This information can be either the messages from the secondary actors (vehicle dynamics and vehicle controls status) that the primary actor will use for the Driving Assistance Application, or possibly the controls status messages that will be used by the Infrastructure SAFESPOT Service Provider to infer the road status or the weather.

**Responsibilities**

This role (see paragraph 3.1.1) is charged of a Delivery responsibility, similarly as the SF Infrastructure Service Provider, both from a global service point of view and as for the single steps of information delivery within the system. For the data coming from the external sources, the vehicle SAFESPOT system is able to receive data exclusively from the VANET, therefore all data would pass through the RSU. The only exceptions are the static map updates, that may come from the Map Provider directly to the Vehicle Service Provider. This periodic update shall be ruled by a proper commercial agreement.

The Management responsibility in charge of this role, shared with all the different Infrastructure SF Service Providers, includes ensuring that the in-vehicle SAFESPOT system is compliant with different SAFESPOT-equipped infrastructures.

**Levers**

As for the SF Vehicle Service provider, the main levers are represented by the technological capabilities of the system. In terms of data acquisition and processing, and alert visualization.

Moreover, being the communication with the infrastructure fundamental for this Application, the agreements with the entities managing various SAFESPOT-infrastructured portion of roads will be fundamental for a successful provision of the service.

**Criticalities**

The major organizational challenge in cooperative systems is represented by the need to manage the interaction between the two platforms (vehicle and infrastructure). Considering that, as mentioned (see par 3.1.1), so far it is not completely clear how the role of Vehicle SF Service provider will be covered, it results rather difficult to envisage all possible organizational implications. In any case, being in the future the SAFESPOT service distributed over the whole European road network, a strong standardization level among the technologies and communication procedures will be needed on behalf of all possible different Infrastructure and Vehicle SAFESPOT Service Providers.

d. **Infrastructure Manager/Owner**

**Functionalities**

Functional blocks in charge of the Infrastructure Manager:

- SF.02_Provide circulation rules
- SF.06_Provide static road geometry & ITS devices
- SF.07_Provide events info
The role of Infrastructure Manager includes a series of functions for the data supply, either quasi-static (updates on circulation rules from the Public Authority, updates on road geometry) or dynamic (traffic lights status, events or measures detected by safety systems installed on the infrastructure other than the SAFESPOT system).

The other group of functions is related to the management of the red prolongation at the TLC system level.

**Responsibilities**

As the supplier of part of the data needed to run the application (SF.06, SF.07, SF.26), the Infrastructure Manager holds the responsibility to deliver data in the required time and with the required reliability (Delivery responsibility). Differently from the other three selected Applications, here the Infrastructure Manager has no responsibility on the roadside alert or actuation, since the only warning planned for the SP4 RIS is the on-board warning.

**Levers**

As for the information detection side (first two functions), the main lever at disposal of the Infrastructure Manager in order to fulfill its Delivery responsibility is the ownership of the original data, allowing the control on the information timing and reliability.

**Criticalities**

An important critical point has to be considered for this role. Introducing a new system for road safety on a certain portion of network may be regarded with some distrust by a road manager correspondingly to the responsibility that would be imputed to him in case of malfunctioning of the system, possibly causing any damage to drivers. Although this issue is deeply dealt within the legal aspects analysis, it shall be considered as a major concern also for its implications on some organizational aspects, in particular on the contracts regulating the exchange of information between this role and the other actors.

e. **Map Provider**

**Functionalities**

This role has in charge the functionality

- SF.22_Update static map

The Map Provider periodically collects the possible changes in the static information contained in the Local Dynamic Map (road geometry, speed limits, objects position) based on the inputs from the Infrastructure Manager and, possibly, from in-house surveys. The update is then communicated to the Infrastructure Service Provider for its own RSU-LDM update, and to the Vehicle SF Service Provider, that in its turn, will take care of updating the equipped vehicles systems. The contracts that will define this periodic exchange of information will include the time mode (e.g. one update every change or one update every fixed period) and the physical procedure for the data exchange.
Responsibilities

This role will have exclusively a responsibility on the data delivery; static maps represent an essential part of the whole mechanism.

Levers

In order to supply well-timed information, the Map Provider can rely on the contracts setup with the Infrastructure Manager for the data supply, as well as on its internal availability of resources to collect extra information and/or validate the received data. Depending on the way the updates are distributed to the RSU and vehicles LDMs (e.g. making use of a wireless connection), another important lever may be represented by the technological communication means used.

Criticalities

Timing will be a major issue due to the fact that safety related information may not be reliable in the period of time between the change and the update. For planned interventions on the road geometry by the Infrastructure Manager, optimized procedures may be introduced in order to minimize this time (e.g. the communication may be given in advance to the Map Provider), or at least to put the system in "down state" in order to avoid misleading warnings.

f. VASP

Functionalities

The Value Added Service Provider is assigned the following function:

- SF.08_Provide external safety-related info

This role may or may not be present in the application scenario according to the single sites. Typical actors for this role are traffic coordination centers, fleet monitoring systems, roadside assistance services, first aid or emergency operative centers, and, in general, all organizations external to SAFESPOT that may have at their disposal useful safety-related information. The only link of this source towards the SAFESPOT environment is the Infrastructure SAFESPOT Service Provider; proper dedicated standard operating procedures have to be established to rule this exchange of information and make it continuous and reliable over time.

Responsibilities

Once a VASP agrees on a standard procedure for the information exchange, it will be charged with the responsibility of providing the committed information according to a defined timing and level of accuracy. Also, the management of the possible different sources of information will be under the VASP responsibility.

Levers

The added value brought by this role to the SAFESPOT service will lever on the technical means to deliver the information and the resources dedicated to the collection, verification and communication of real time information to the SAFESPOT system.
3.4. Speed Alert - (SP5 – 4.2)

3.4.1. Background – Application functional description

The Speed Alert application aims at providing a recommended speed to drivers on the basis of real-time evaluation of parameters such as: the weather status, road surface conditions, topology of the road, traffic flow speed and any events like road works, traffic jams, and deviations. Starting from the idea that the driver is the main responsible and the unique decision maker on the vehicle, the strategy implemented is based on warning and not on intervention.

Three sub applications are foreseen in the frame of Speed Alert applications:

1. SpA_01 Legal Speed Limit: the goal is to warn drivers on excessive speed with respect to the legal speed limit

2. SpA_02 Critical Speed Warning: which also warns drivers on excessive speed, but the speed limit is now dynamic and takes into account the environment, traffic condition. This application collaborates with the Hazard and Incident Warning Application.

3. SpA_03 Excessive Speed Alert: the objective is to define a speed limit with respect to the road; the road definition and the road status. Furthermore, it warns a driver at the vicinity of a black spot

These applications interact with SP5 applications, SP3 applications, and external actors:

1. SP5 applications: some use cases in the definition of speed alert applications are in common with Hazard and Incident Warning applications. SpA applications require parameters that are watched by H&IW applications: both applications have to cooperate in the definition of their alerts. Moreover, the SpA application is a first step in the prevention of road departure (RDep), as it defines a speed limit according to the infrastructure. It has a strong interaction with the RDep application.

2. SP3 applications: data needed for the SpA application will come from the LDM. SpA has to define the accuracy of these data. The location is also a critical aspect. SpA requires the location of a vehicle at different levels of detail: from lane position to road position. On the other side, SpA delivers warnings to the driver using different vectors such as LDM and Vanet.

3. External actors also interact with the application and have interest in it: for instance, local authorities may decide to change the driving rules on a road because of an event.

The speed alert message can reach the road user via the infrastructure or the on-board alert devices. In the first case, several road-based systems are planned, ranging from LED speed signs to VMS, Speed Advice systems and so on.

In case the alert is sent to the on board unit of the vehicles, the application will have its impact on the road user at two levels, based on the intrusion on the driving task:

1. The lowest implication of the Speed Alert application is to define and update the speed limit in the local dynamic map by using inputs from sensors and alerts
sent by the H&IW application. At this level the intrusion of the application on the driving task is low, as the application does not send messages to specific vehicles but warns instead an area.

2. The second level of implication includes the first one but also tracks vehicles in order to send specific message. The intrusion of this application on the driving task is greater. In this case the SP5 group has highlighted the need of a vehicle tracking sub-application, which was named SpA_00, whose task is to get data from the vehicles and to warn them in case they are recognized as possible targets. In fact, this application acts as a gateway between the LDM and the Speed Alert applications. Many parts of this function can be handled by the LDM, but at the moment this report written no final decisions have been taken yet.

A quite complex and critical point, which is worth highlighting also because of its implications on the Organizational Architecture, is the path that the warning message goes through in the case it is sent to the on-board alert system. An explanatory scheme (figure 10) is reported in the mentioned SP5 Speed Alert specification document D5.3.1, page 11, which can be assumed as valid also for the other infrastructure based applications. The red arrows indicate the information flow above the global SAFESPOT architecture diagram (Guyancourt diagram).

As shown in the picture, the Speed Alert message generated by the Road Side Unit and sent to the VANET is received by the vehicle, processed by the Data Fusion module, loaded onto the vehicle LDM and then sent to the HMI via a special SP5 application client application running on the vehicle itself.

Figure 15. The path of the SP5 alert messages inside the SAFESPOT vehicle

From VANET to HMI.
Among the Speed Alert applications, sub-application number 2 (Critical Speed Warning) has been selected for the Organizational Architecture by the SP6 subproject. In the following a brief description of this application is provided; for the complete specification, the reader should refer to the related SP5 specification document (SF_D5.3.1_SpeedAlert_Draft_v1.2.doc).

The objective of SpA_02 is to enhance static definition of speed limit with a dynamic content, in interaction with H&IW applications. It extends warning message from H&IW with speed recommendation.

Figure 16 shows the functional architecture of the SpA_02 application. Three sub-applications are clearly defined in this figure. First, the rEvent Detector that watches the LDM, acquires new event in relation with SpA_02 use cases (the event can also come directly from H&IW application ). Then, the second component defines new driving rules and transmits them to H&IW and the LDM. Finally, a message is generated and sent through the rSmart Signalling Component.

This application uses mainly information from the vehicle tracking process or the H&IW application. However, some specific data could be helpful in the application:

- Vehicle data: steering angle in order to detect lane change manoeuvres and so to manage specific messages.

![Figure 16 - SpA_02 functional architecture](image-url)
• Road description: number of lanes on the considered road.
• Location specification: The application must be given the end of the area defined by Hazard and Incident Warning. Moreover, the longitudinal location on the road must be accurate enough to define the different area associated with level of deceleration. Longitudinal location accuracy must be below 10m. The location application also has to locate vehicle at the lane level.

As for the messages, they inform of the vicinity of a close hazard, and the crash can be avoided by the right choose of speed. The planned messages are:

• ŦÈVER SAFETY SPEEDô
• ŦÈDER SAFETY SPEEDô

The ŦÈDER SAFETY SPEEDô message is used on a motorway, when a vehicle runs too slowly comparative to other surrounding. This message can be also used if a vehicle is after an obstacle (sharp curve, tunnel entrance or exit, top of a hillé), and another vehicle arrives at a high speed. A crash can be avoided by an acceleration of the first one.

3.4.2. The Logical Functions

As mentioned, the logical functions are derived from the functional architecture of the applications and platforms. In general, before being used for the OA, they undergo the proper aggregation/renaming operations to make them uniform with the OA schemes of all applications. In order to track their origin, they were labelled according to this terminology (see Methodology paragraph)

- from application functional description
- from platforms functional description
- added on the basis of the global architecture (Guyancourt)
- added within the Organizational Architecture analysis

SF.01 Update circulation rules (added within the Organizational Architecture analysis).

This function consists of communicating to the Road Manager any change in the traffic regulation with effects on the road safety of an administrative area (municipality, region, state). In the Speed Alert case, this function includes the update of the speed limits in the portion of network managed by the SAFESPOT system

SF.02 Provide circulation rules (added within the Organizational Architecture analysis).

Passing the information on (updated) circulation rules to the SAFESPOT system, once they have been received from the Public Authority. In the Speed Alert case, this includes the speed limits in the portion of network managed by the SAFESPOT system.

SF.03 Provide vehicle dynamics from infrastructure (from platforms functional description)
Detecting the vehicle dynamics (position, speed, acceleration) via the roadside sensors.

**SF.04 Provide vehicle dynamics from vehicle (from platforms functional description)**

Detecting the vehicle dynamics (position, speed, acceleration) via the on-board sensors (GPS, speedometer, etc.)

**SF.06 Provide static road geometry & ITS devices (from application functional description).**

Passing the information on (updated) road geometry and position/dimensions/characteristics of static ITS devices or relevant permanent static objects.

**SF.07 Provide events info (added within the Organizational Architecture analysis).**

Passing the information of events detected or acquired by systems that are installed on the infrastructure (sensors, communication media) but do not belong to the SAFESPOT system.

**SF.08 Provide external safety-related info (added within the Organizational Architecture analysis).**

Sending the information produced by services external to SAFESPOT to the system, in order to improve the robustness of the available information (e.g. VASP, other safety systems like CVIS, etc.). In the Speed Alert application case, the external safety related information may regard weather status.

**SF.13 Data fusion & update LDM-RSU (from platforms functional description).**

The data coming from the sensors and from other possible sources (messages from the VANET, external applications, static information providers, etc.) are fused in order to obtain ready-to-use information for applications, and loaded on the RSU LDM. According to the specific applications, different functionalities are activated. This block, moreover, takes in charge the output of the SP5 applications and loads them on the LDM as to make them available to the message generator for the message to the VANET (see Guyancourt architecture).

**SF.14 Data fusion & update LDM-VEH (from platforms functional description).**

This is the Data Fusion taking place in the vehicle unit. The purpose is the same than the Data fusion & update LDM-RSU functional block but now the information coming from the vehicle sensors (dynamics and other info, see functions SF.04 and SF.05) are processed and stored on the vehicle LDM. Once in the LDM, they will be polled by the message generation module (SF.18) and sent to the VANET to be used by the core Speed Alert SP5 function. On the other hand, this block is in charge of receiving the alert messages sent through the VANET by the SF.54 in order to be put at disposal of the SF.19 which will process them and send to the vehicles HMI.

**SF.15 Query LDM-VEH info (from application functional description)**

The in-vehicle SP5 application client (SF.19) sends the request for the needed data to its LDM. The LDM executes the query and provides the results to the application.
SF.16_Query LDM-RSU info *(from application functional description)*

The SP5 application sends the request for the needed data to the LDM (vehicle dynamics and TLC planning). The LDM executes the query and send the results back to the application.

SF.17_Generate message for VANET roadside *(from global architecture)*

The Message Generation component contains the rule set determining when and what messages to send to the VANET. These rules are defined at design phase by the applications. These rules define under what situations and conditions which messages are to be sent to other nodes via the VANET router.

SF.18_Generate message for VANET onboard *(from global architecture)*

This function includes the generation of messages to be routed towards the VANET from the SAFESPOT vehicles. In the SP5 Speed Alert case, the messages generated by this application contain the dynamics of the vehicles.

SF.19_In-vehicle SP5 application client *(from global architecture/application functional description)*

In charge of processing the alert coming from the road-based Speed Alert application (SF.54) via the VANET and sending it to the HMI. In other words, it enables the SAFESPOT vehicles to interpret the warning message and display it through the onboard HMI.

SF.20_Send message to VANET from roadside *(from global architecture)*

This function includes the message routing towards the VANET from the RSU router. In the Speed Alert case, the message generated by this application is the alert towards the vehicles.

SF.21_Send message to VANET from veh *(from global architecture)*

This function includes the message routing towards the VANET from the vehicle router. In the SP5 Speed Alert case, the message generated by this application is the dynamics of the vehicles.

SF.22_Update static map *(added within the Organizational Architecture analysis)*.

This function is referred to the periodic update of the LDM static layer. This update is performed following up changes in the road geometry, location of ITS devices or relevant permanent static objects, etc.

SF.23_Alert driver on board *(from platforms functional description).*

Prioritizing the messages plus the final visualization of the warning on the vehicle HMI.

SF.24_Display warning on VMS *(from application functional description)*.

Enabling the visualization of the warning on a roadside alert device.

SF.25.Validate warning *(added within the Organizational Architecture analysis)*.

This function verifies that the SAFESPOT message is compliant with the messages generated by the Infrastructure Manager's own ITS system in terms of content and priority.
SF.53_Determine safety margin H&IW_02 *(from application functional description)*.

The Hazard and Incident Warning SP5 application makes an early detection of potentially dangerous events and conditions on the road and provide warnings to approaching vehicles. Its output is sent to the SP5 Data Fusion module in order to be loaded on the LDM and put at disposal of the SP5 Speed Alert application.

SF.54_Determine safety margin SPA_02 *(from application functional description)*.

This block represents the core of the application and includes on one side the vehicle tracking functionality, whose task is to get data from the vehicles and to warn them in case they are recognized as possible targets, on the other side the critical speed calculation and the warning generation.

### 3.4.3. *The Value Chain*

After the simplification and "harmonization" process is performed on the logical functions of the applications, the detected sub-processes/activities are positioned on the value chain, to build what will be called "sub-processes diagram".

The diagram depicts the value chain and all the activities or sub-activities positioned on the single rings of the chain.

As mentioned in paragraph 3.1.2, the Detection chain mail contain all the activities performed in order to introduce information to the system; this may come from sensors (dynamic information), but can also be "static" or "quasi static" information, as for example the updates on the circulation rules or the static map. The Processing element is associated to the functionalities involved with the platforms processing (data fusion), the interface with the LDM (query mechanisms), the Applications and the Message Generation; this last activity, involving the process of data coming from the Detection step of the "secondary actor" vehicle (or even the RSU), is considered as a processing activity; however, in principle, it could also be considered as a Detection activity, since it produces data for the main Driver Support Applications. The same can be said for the function of message routing to the VANET (SF.20).

The Alert chain mail contains two functions managing the warning provision to the driver on board and roadside through the Variable Message Sign.
Table 1. Main Service flows

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Detection</th>
<th>Processing</th>
<th>Alert</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF.01_Update circulation rules</td>
<td>SF.16_Query LDM-RSU info</td>
<td>SF.25.Validate warning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td>SF.15_Query LDM-VEH info</td>
<td>SF.24_Display warning on VMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.02_Provide circulation rules</td>
<td>SF.13_Data fusion &amp; update LDM-RSU</td>
<td>SF.23_Alert driver on_board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.03_Provide vehicle dynamics from infrastructure</td>
<td>SF.14_Data fusion &amp; update LDM-VEH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.04_Provide vehicle dynamics from vehicle</td>
<td>SF.54_Determine safety margin SPA_02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.06_Provide static road geometry &amp; ITS devices</td>
<td>SF.54_Determine safety margin SPA_02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.07_Provide events info</td>
<td>SF.17_Generate msg for VANET roadside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.08_Provide external safety-related info</td>
<td>SF.18_Generate message for VANET on board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td>SF.21_Send msg to VANET from veh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.19_In-vehicle SP5 application client</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.20_Send msg to VANET from roadside</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 17. The value chain of the SP5 Speed Alert application
3.4.4. The Organizational scheme

Figure 18. Speed Alert - SP5 SpA (Speed Alert) organizational scheme
3.4.5. Roles analysis

a. Public Authority

Functionalities

Within the IRIS SP5 application, the Public Authority is in charge of the activity:

- SF.01_Updating circulation rules

This functionality includes to provide and communicate to the Infrastructure Manager/Owner any update on the rules affecting the traffic circulation on the portion of road network covered by the SAFESPOT service. For the Safe Intersection applications area, this kind of updates may regard traffic restrictions (in time or for certain vehicles categories for example) in the SAFESPOT area, provided by the local government.

The fulfilment of this functionality would likely require to establish an apposite form of agreement between the two entities, in order to guarantee that the Infrastructure manager promptly communicates any change to the Road Manager/Owner. This kind of communication may be only theoretic in most cases, due to the fact that the body covering the role of Public Authority (e.g. the local government) may coincide to the body managing or owning the road; in other cases the change in the circulation rules may be agreed between the Public Authority and the Road Manager before it is put in place.

Responsibilities

The responsibilities linked to the Public Authority activity within the application belong basically to the Institutional/Regulatory category and to the Delivery one. The first aspect, however, will be external to the SAFESPOT system (i.e. the Public Authority issues a new circulation rule independently from the SAFESPOT system); what impacts more on the SAFESPOT service is the delivery responsibility; the data delivery needs to be well-timed and correctly defined in all its aspects (spatial, time - in case the new circulation rule has a limited duration, limited vehicle categories involved, etc.).

Levers

The levers in service of the Public Authority delivery responsibility will be in most cases any form of contracts to guarantee the well-timed and complete update of the circulation rules. Also any automatic procedure for the update would reduce time, costs and improve the added value for this step.

Criticalities

The lack of an agreement regulating the correct communication of updated circulation rules in the SAFESPOT area may jeopardize the correct functioning of the Speed Alert application.

b. Infrastructure SF Service Provider

Functionalities

The functionalities in charge of the Infrastructure SF Service Provider include:

- SF.03_Provide vehicle dynamics from infrastructure
- SF.13_Data fusion & update LDM-RSU
The first functionality is dedicated to the detection of the measures needed by the system from the road sensors (vehicle dynamics from the Laserscanner system or the camera-based object detection module). The next two functions are dedicated to the interaction with the RSU LDM (processing, upload and extraction). SF.51 includes processing the detected data in order to determine the condition under which to send the request for red-prolongation at the traffic lights. The last two functional blocks regard the transmission of the information about the danger to the VANET, as to send the message to the single vehicles on-board HMI.

The Infrastructure Service Provider role will be covered by any entity taking in charge the management of the SAFESPOT road-based part of the system on a certain portion of road network. In most cases this entity would likely be the Infrastructure Manager, but there may also be the option it is a different organization, for example a company managing the ITS systems in a city area.

Responsibilities

This role shares with the SF Vehicle Service Provider the fundamental responsibility of Delivery of the service (red prolongation, safety alert on board) to the final user (driver); in fact a significant part of real-time information feeding the application (the vehicle dynamics), is detected via the roadside sensors, processed by the Road Side Unit, and sent to the VANET from the RSU router. The responsibility Delivery of safety information to the driver can be seen as decomposed into the single steps from one single ring of the system chain to the following one: the detection system to the RSU, the RSU to the router and to the traffic lights control system, the router to the vehicles. In general the Delivery responsibility is a delicate issue, since timing plays a fundamental role in the safety related alert provision. An average and maximum delay will need to be defined from the moment the safety related event happens to the moment the driver is alerted. Also, the Infrastructure Service Provider shall be able to quantify the delivery timing of the critical information provided to the following steps within the system information flow sequence, in order to monitor its compliance to the limit delays. Two particular critical steps under the timing point of view are the query mechanism to extract the needed data from the RSU and the process of dispatching-validating-displaying the alerts on the VMSs. In this latest case the role of Infrastructure Manager/Owner is involved as well (see OA diagram).

Since input data may come not only from the SAFESPOT sensors but also be communicated by external organizations, the way this exchange of information is ruled is also very important. The RSU receives information (that may also be real-time) from the VASP role, therefore proper agreements will be needed for this data transfer; a periodic update needs to be provided also by the Map Provider, from which the Infrastructure Service Provider will need prompt update in case of static road geometry changes. More information may come from the Infrastructure Manager as well; this would imply extra agreements on this information exchange.

Another important aspect to be taken into account for the Delivery responsibility is data reliability; the information should comply defined limits of precision and accuracy.
when delivered from detection systems to the RSU, from the RSU to the SF.51 function and to the VANET.

The Infrastructure Service Provider, finally, is charged of a major Management responsibility of the system, since the main physical devices and external organizations upon which the system relies are under its control.

**Levers**

The main levers for the Delivery responsibility are technical-related. The timing and reliability of data will strongly depend upon the efficiency of the technological supports, the processing techniques, the communication devices.

The other important lever for the Delivery responsibility, both in terms of timing and data reliability, are the contracts set up between this role and those acting as information suppliers (VASP, Map Provider, Infrastructure Manager, Vehicle Service Provider) and information clients (Vehicle Service Provider through the VANET and Infrastructure Manager for the request of red prolongation). Any synergies with other safety systems installed on the same platform (e.g. CVIS) would significantly decrease the costs and therefore improve the value.

**Criticalities**

The critical aspects for this role are those involving the supply well-timed and reliable information to the driver. The Infrastructure Service Provider, together with the Vehicle Service Provider, is the interface between the system and the user; moreover, the SAFESPOT system will be successful inasmuch as the driver will modify its behaviour according to the alert messages. Since this will happen proportionally to the confidence that the he will have in the reliability of the messages he will receive, it is easy to understand that a major focus has to be given at all levels, included the organizational one, in order to reach the highest possible level of trust of the driver towards the system. Several aspects will be involved in this goal other than the timing and the reliability of the alerts: the homogeneity of the warning in time and space, the information on the current functioning status of the system; on the other hand, the risk of over compliance of the driver towards the system may have dangerous effects as well.

c. **Vehicle SF Service Provider**

**Functionalities**

The functionalities in charge of the Vehicle SF Service Provider include:

- SF.04_Provide vehicle dynamics from vehicle
- SF.14_Data fusion & update LDM-VEH
- SF.15_Query LDM-VEH info
- SF.18_Generate message for VANET onboard
- SF.19_In-vehicle SP5 application client
- SF.21_Send message to VANET from veh
- SF.23_Alert driver on board

---

8 excluding the probe vehicles
The first function is dedicated to the detection of data needed for the application from the vehicle (vehicle dynamics). Functions SF.14 and SF.15 are in charge of the input data processing and interaction with the LDM, in parallel to the roadside platform. Two functions are then dedicated to the generation and sending of the messages from the probe vehicles to the VANET, with the information grabbed by SF.04 and processed by SF.14.

**Responsibilities**

This role (see paragraph 3.1.1) is charged of a Delivery responsibility, similarly as the SF Infrastructure Service Provider, both from a global service point of view and as for the single steps of information delivery within the system. For the data coming from the external sources, the vehicle SAFESPOT system is able to receive data exclusively from the VANET, therefore all data would pass through the RSU. The only exceptions are the static map updates, that may come from the Map Provider directly to the Vehicle Service Provider. This periodic update shall be ruled by a proper commercial agreement.

Even though the IRIS application is run at the Infrastructure Level, the on-board visualization of the alert plays a significant role in the overall effectiveness of the system; in fact no alert visualization is planned roadside, being the red prolongation the only output used for the SP2 platform.

The Management responsibility in charge of this role, shared with all the different Infrastructure SF Service Providers, includes ensuring that the in-vehicle SAFESPOT system is compliant with different SAFESPOT-equipped infrastructures.

**Levers**

As for the SF Vehicle Service provider, the main levers are represented by the technological capabilities of the system. In terms of data acquisition and processing, and alert visualization.

Moreover, being the communication with the infrastructure fundamental for this Application, the agreements with the entities managing various SAFESPOT-infrastructured portion of roads will be fundamental for a successful provision of the service. As for the Infrastructure SAFESPOT Service provider, an extra value would be brought to the system supply in case the data and the technologies provided to the system would be shared with other safety systems installed on the same platform (e.g. CVIS).

**Criticalities**

The major organizational challenge in cooperative systems is represented by the need to manage the interaction between the two platforms (vehicle and infrastructure). Considering that, as mentioned (see par 3.1.1), so far it is not completely clear how the role of Vehicle SF Service provider will be covered, it results rather difficult to envisage all possible organizational implications. In any case, being in the future the SAFESPOT service distributed over the whole European road network, a strong standardization level among the technologies and communication procedures will be needed on behalf of all possible different Infrastructure and Vehicle SAFESPOT Service Providers.
d. Infrastructure Manager/Owner

Functionalities

Functional blocks in charge of the Infrastructure Manager:

- SF.02_Provide circulation rules
- SF.06_Provide static road geometry & ITS devices
- SF.07_Provide events info
- SF.26_Provide TLC planning info
- SF.27_V erify SF TLC actuation
- SF.28_Actuate TLC

The role of Infrastructure Manager includes a series of functions for the data supply, either quasi-static (updates on circulation rules from the Public Authority, updates on road geometry) or dynamic (traffic lights status, events or measures detected by safety systems installed on the infrastructure other than the SAFESPOT system).

Moreover, as pointed out in D6.4.2 (Legal Aspects of SAFESPOT Systems), the Road Manager may be, within the boundaries set by the national legislator (and international treaties) responsible for setting speed limits for the roads within its jurisdiction (Speed Alert Consortium, 2004). In this case this role will detain as well a Normative responsibility.

Responsibilities

As the supplier of part of the data needed to run the application (SF.06, SF.07, SF.26), the Infrastructure Manager holds the responsibility to deliver data in the required time and with the required reliability (Delivery responsibility). The same responsibility is assigned to this role when the red prolongation is implemented. In fact, in case other TLC control systems are operating on the same portion of network, the Infrastructure Manager will use automated procedures in order to verify if the red prolongation is compliant with possible other actions on the same TLC system, and, if needed, set the proper priorities.

Levers

As for the information detection side (first three functions), the main lever at disposal of the Infrastructure Manager in order to fulfill its Delivery responsibility is the ownership of the original data, allowing the control on the information timing and reliability. As for the red-phase prolongation, the Infrastructure manager role holds the last filter before the TLC actuation is put in place (SF.27_V erify SF TLC actuation), therefore he can adjust the level of impact of the SAFESPOT system according to the situations.

Criticalities

An important critical point has to be considered for this role. Introducing a new system for road safety on a certain portion of network may be regarded with some distrust by a road manager correspondingly to the responsibility that would be imputed to him in case of malfunctioning of the system, possibly causing any damage to drivers. Although this issue is deeply dealt within the legal aspects analysis, it shall be considered as a major concern also for its implications on some organizational
aspects, in particular on the contracts regulating the exchange of information between this role and the other actors.

e. Map Provider

Functionalities
This role has in charge the functionality

- SF.22_Update static map

The Map Provider periodically collects the possible changes in the static information contained in the Local Dynamic Map (road geometry, speed limits, objects position) based on the inputs from the Infrastructure Manager and, possibly, from in-house surveys. The update is then communicated to the Infrastructure Service Provider for its own RSU-LDM update, and to the Vehicle SF Service Provider, that in its turn, will take care of updating the equipped vehicles systems. The contracts that will define this periodic exchange of information will include the time mode (e.g. one update every change or one update every fixed period) and the physical procedure for the data exchange.

Responsibilities
This role will have exclusively a responsibility on the data delivery; static maps represent an essential part of the whole mechanism.

Levers / Criticalities
In order to supply well-timed information, the Map Provider can rely on the contracts setup with the Infrastructure Manager/Owner for the data supply, as well as on its internal availability of resources to collect extra information and/or validate the received data. Depending on the way the updates are distributed to the RSU and vehicles LDMs (e.g. making use of a wireless connection), another important lever may be represented by the technological communication means used.

Timing will be a major issue, but also an important value contribution, due to the fact that safety related information may not be reliable in the period of time between the change and the update. For planned interventions on the road geometry by the Infrastructure Manager, optimized procedures may be introduced in order to minimize this time (e.g. the communication may be given in advance to the Map Provider), or at least to put the system in a "down state" in order to avoid misleading warnings.

f. VASP

Functionalities
The Value Added Service Provider is assigned the following function:

- SF.08_Provide external safety-related info

This role may or may not be present in the application scenario according to the single sites. Typical actors for this role are traffic coordination centers, fleet monitoring systems, roadside assistance services, first aid or emergency operative centers, and, in general, all organizations external to SAFESPOT that may have at their disposal useful safety-related information. The only link of this source towards the SAFESPOT environment is the Infrastructure SAFESPOT Service Provider; proper dedicated
standard operating procedures have to be established to rule this exchange of information and make it continuous and reliable over time.

Responsibilities

Once a VASP agrees on a standard procedure for the information exchange, it will be charged with the responsibility of providing the committed information according to a defined timing and level of accuracy. Also, the management of the possible different sources of information will be under the VASP responsibility.

Levers

The added value brought by this role to the SAFESPOT service will lever on the technical means to deliver the information and the resources dedicated to the collection, verification and communication of real time information to the SAFESPOT system.
3.5. **Speed Alert – Speed limitation and safety distance (SP4 - 2.3)**

3.5.1. **Background – Application functional description**

The General Use Case for the Speed Limitation and Safety Distance application provides assistance for general scenarios such as the one showed in the pictogram below. Recommendations are provided to the driver of the ego vehicle (actor 1 in the figure) in order to keep the proper safety distance from the vehicle in front:

![Pictogram of the SLSD general Use Case](image)

Figure 19. Pictogram of the SLSD general Use Case.

In the following paragraphs the functional steps performed within the application are listed, following the applicative tasks scheme described in the reference model for the SP4 applications (paragraph 3.3.1); the model includes the four applicative tasks of application manager, driver assistance application, message manager, co-operative support application.

**SCENARIO ANALYSIS (Application Manager) – PRIMARY ACTOR V1**

The safety distance is defined depending on several factors: vehicle type, environmental conditions, road status, the speed of the two vehicles, features of the road segment (e.g. the presence of a tunnel, a decrease of lane number), the eventuality of transport of dangerous goods, lane positioning of vehicles and other factors.

1. It checks if it is present a vehicle (V2) in front, to which V1 is approaching.
2. If the condition 1 is satisfied, it verifies if a suggested speed and a suggested distance to keep from the vehicle in front, sent by the infrastructure, are present in the LDM.

3.1 If the condition 2 is satisfied, it enables (or keeps operative, if it has been already triggered) the trigger 1 of the Driver Assistance Application GC.

3.2 Otherwise it verifies if the distance between the two vehicles is less than a given threshold (greater than the safety distance).

4. If the condition 3.2 is satisfied, it enables (or keeps operative, if it has been already triggered) the trigger 2 of the Driver Assistance Application GC.

**DRIVER ASSISTANCE APPLICATION**

**Trigger 1**

At each instant $t$
- the parameters needed by the application to warn the driver, are acquired (i.e. the information sent by the infrastructure about the speed $v_{safe}$ and the distance $d_{safe}$ to keep from the vehicle in front; the ego-vehicle parameters needed to do the comparison between the own speed and distance and the suggested ones).

**Trigger 2**

At each instant $t$

- the parameters needed by the application to warn the driver, are acquired.

- It analyses the safety distance based on vehicle type, on environmental conditions, on road status, on the speed of the two vehicles, on features of the road segment (e.g. the presence of a tunnel, a decrease of lane number), on the potential transport of dangerous goods, on lane positioning of vehicles and on other factors TBD.

**Steps in common between Trigger 1 and Trigger 2:**

- Trajectories of both primary vehicle V1 and secondary vehicle V2 are estimated. Furthermore it identifies the shapes of both vehicles related to each pair of correspondent points (i.e. at same instant) on their estimated trajectories.

- The application estimates the area (comfort/safety/critical) corresponding to the situation of Speed Limitation and Safety Distance GC where V1 lays. To achieve this evaluation, the application verifies if there is an instant $t_c$ when the distance between the vehicle drops below the safety distance. In this case it identifies the (Comfort/Safety/Critical) Area for V1 in relation with the difference between the time $t_c$ and the current time $t_0$; the lower difference is, the more critical situation becomes.

By identifying these three areas (critical/safety/comfort), the Driver Assistance Application can take into account also the information relative to the driver commands; then it evaluates how these commands affect the trajectories of vehicles, before collocating V1 in a given assistance area.

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**Figure 20. SLSD \( \tilde{1} \) estimated trajectories**

**SCENARIO ANALYSIS (Message Manager) – SECONDARY ACTOR V2**

1. It checks if it is present a vehicle (V1), approaching to V2 from behind.

2. If the condition 1 is satisfied, it verifies if an infrastructure is present in the SAFESPOT area where the ego-vehicle lays.

3. If the condition 2 is not satisfied, it verifies if the distance between the two vehicles is less than a given threshold (greater than the safety distance).
4. If the condition 2 or the condition 3 is satisfied, it enables (or keeps operative, if it has been already triggered) the Cooperative Support Application of Speed Limitation and Safety Distance GC.

**COOPERATIVE SUPPORT APPLICATION**

The Cooperative Support Application, running on a secondary vehicle, is in charge of transmitting on the VANET the vehicle parameters needed by the correspondent Driver Assistance Application running on the primary actor (V1) in order to warn the driver about the GC.

The application can adopt several strategies to transmit the parameters. Two examples are mentioned below:

- it transmits all needed parameters at the maximum possible frequency (10 Hz).
- it transmits all needed parameters at an intermediate frequency (between 1 Hz and 10 Hz); it enhances the transmission frequency, until the maximum, when it detects a sharp variation in the acceleration/deceleration or when the distance between vehicles abruptly decreases or when it detects, by the driver commands, significant events related to the evolution of the scenario under analysis.

**INFRASTRUCTURE: SCENARIO ANALYSIS**

The safety distance is defined depending on several factors: vehicle type, environmental conditions, road status, the speed of the two vehicles, features of the road segment (e.g. the presence of a tunnel, a decrease of lane number), the eventuality of transport of dangerous goods, lane positioning of vehicles and other factors TBD.

1. It checks that the two following conditions (1.1 and 1.2) are satisfied at the same time.
   1.1 A vehicle (V1) is approaching.
   1.2 The presence of a vehicle (V2) in front of V1.

2. If the condition 1 is satisfied, it enables (or keeps operative, if it has been already triggered) the application.

**INFRASTRUCTURE: APPLICATION**

At each instant t

- the parameters needed by the application are acquired.
- The application computes the speed and the distance that the vehicle V1 should keep from the vehicle in front. In order to achieve this evaluation, it analyses the static features of two vehicles (type, dimensions, weight), the dynamic data of the vehicles (position, road lane occupied by the vehicles, speed, heading and all the other available), the environmental conditions (visibility, road status, traffic density), the features of the road segment (presence of the tunnel, a decrease of lane number, signs).
- The application, running on the infrastructure, is in charge of transmitting to a VMS, if present, and to the VANET the parameters needed by the Driver Assistance Application running on the primary actor (V1).

Transmitted Parameters:
- suggested speed to keep
- suggested distance to keep from the vehicle in front

3.5.2. The Logical Functions

As mentioned, the logical functions are derived from the functional architecture of the applications and platforms. In general, before being used for the OA, they undergo the proper aggregation/renaming operations to make them uniform with the OA schemes of all applications. In order to track their origin, they are labelled according to this terminology (see Methodology paragraph)

- from application functional description
- from platforms functional description
- added on the basis of the global architecture (Guyancourt)
- added within the Organizational Architecture analysis

SF.01_Update circulation rules (added within the Organizational Architecture analysis).

This function consists of communicating to the Road Manager any change in the traffic regulation with effects on the road safety of an administrative area (municipality, region, state). In the SLSD case, this function includes the update of the speed limits in the portion of network managed by the SAFESPOT system.

SF.02_Provide circulation rules (added within the Organizational Architecture analysis).

Passing the information on (updated) circulation rules to the SAFESPOT system, once they have been received from the Public Authority. In the SLSD case, this includes the speed limits in the portion of network managed by the SAFESPOT system.

SF.04_Provide vehicle dynamics from vehicle (from application functional description)

Detecting the vehicle dynamics (position, speed, acceleration, trajectory, road lane occupied by vehicle) via the on-board sensors (GPS, speedometer, etc.)

SF.05_Provide vehicle other info from vehicle (from platform / application functional description)

Detecting via the on-board sensors or recording by the in-vehicle system other (than dynamics) vehicle information needed for the application (heading, yaw rate, driver commands).

SF.06_Provide static road geometry & ITS devices (from application functional description).

Passing the information on (updated) road geometry and position/ dimensions/ characteristics of static ITS devices or relevant permanent static objects.

SF.07_Provide events info (added within the Organizational Architecture analysis).
Passing the information of events detected or acquired by systems that are installed on the infrastructure (sensors, communication media) but do not belong to the SAFESPOT system.

SF.08_Provide external safety-related info (added within the Organizational Architecture analysis).

Sending the information produced by services external to SAFESPOT to the system, in order to improve the robustness of the available information (e.g. VASP, other safety systems like CVIS, etc.). In the SLSD application case, the external safety related information may regard weather status.

SF.11_Detect road status roadside (from platform / application functional description)

Detect road status through roadside sensors

SF.12_Detect weather info roadside (from platform / application functional description)

Detect environmental info through roadside sensors

SF.13_Data fusion & update LDM-RSU (from platforms functional description).

The data coming from the sensors and from other possible sources (messages from the VANET, external applications, static information providers, etc.) are fused in order to obtain ready-to-use information for applications, and loaded on the RSU LDM. According to the specific applications, different functionalities are activated.

SF.14_Data fusion & update LDM-VEH (from platforms functional description).

This is the Data Fusion taking place in the vehicle unit. The purpose is the same than the "Data fusion & update LDM-RSU" functional block but now the information coming from the ego-vehicle sensors are processed and stored, together with the messages received from the VANET coming either from the RSU or the vehicles acting as secondary actors.

SF.15_Query LDM-VEH info (from application functional description)

The SF.42 application sends the request for the needed data to its LDM. The LDM executes the query and provides the results to the application.

SF.16_Query LDM-RSU info (from application functional description)

The SF.55 application sends the request for the needed data to the RSU-LDM. The LDM executes the query and send the results back to the application.

SF.17_Generate message for VANET roadside (from application functional description)

This functionality corresponds with the operations performed by the roadside Message Manager module. The Message Generation component contains the rule set determining when and what messages to send to the VANET (containing all the information needed by the in-vehicle application). These rules are defined at design phase by the applications. These rules define under what situations and conditions which messages are to be sent to other nodes via the VANET router.

SF.18_Generate message for VANET onboard (from application functional description)
This function includes the generation of the messages which then will be routed towards the VANET from the SAFESPOT vehicles (secondary actors). In the SP4 applications, this corresponds with the operations performed by the in-vehicle Message Manager module. The messages generated by this application contain the dynamics of the vehicles, the other information detected by the on board sensors or recorded by the in-vehicle system (heading, yaw rate, driver commands) and the static information about the vehicles (ID, vehicle type, dimensions, weight, dangerous goods transported).

**SF.20_Send message to VANET from roadside** *(from global architecture)*

This function includes the message routing towards the VANET from the RSU router. The messages are those generated by the SF.17.

**SF.21_Send message to VANET from veh** *(from global architecture)*

This function includes the message routing towards the VANET from the vehicle router. The message are those generated by the SF.18.

**SF.22_Update static map** *(added within the Organizational Architecture analysis)*

This function is referred to the periodic update of the LDM static layer. This update is performed following up changes in the road geometry, location of ITS devices or relevant permanent static objects, etc.).

**SF.23_Alert driver on board** *(from application functional description)*

Prioritizing the messages plus the final visualization of the warning on the vehicle HMI.

**SF.24_Display warning on VMS** *(from application functional description)*

Enabling the visualization of the warning on a roadside alert device.

**SF.25.Validate warning** *(added within the Organizational Architecture analysis)*

This function verifies that the SAFESPOT message coming from the SF.55 is compliant with the messages generated by the Infrastructure Manager’s own ITS system in terms of content and priority.

**SF.30_Detect visibility roadside** *(from platform / application functional description)*

Detect visibility info through roadside sensors.

**SF.31_Detect traffic roadside** *(from platform / application functional description)*

Detect traffic info (in case of the SLSD application: the traffic density) through roadside sensors.

**SF.55_Determine Speed and Distance for LONC_2.3** *(from application functional description)*

This functionality includes the operations in charge of the infrastructure RSU performed in order to transmit the suggested speed and suggested safety distance to the vehicle SF55 function; SF55 uses this information to generate the warning to be displayed on the vehicle.

**SF.42_Determine Safety Margin – LONC_2.3** *(from application functional description)*

This block represents the core of the SLSD application and includes the in-vehicle functionalities of the Driver Assistance Application, for the primary actors, and the
Cooperative Support Application, for the secondary actors, other than the Scenario Analysis performed by the Application Manager of the primary actors.

### 3.5.3. The Value Chain

After the simplification and "harmonization" process is performed on the logical functions of the applications, the detected sub-processes/activities are positioned on the value chain, to build what will be called "sub-processes diagram":

![Value Chain Diagram]

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Detection</th>
<th>Processing</th>
<th>Alert</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF.01_Update circulation rules</td>
<td>SF.13_Data fusion &amp; update LDM-RSU</td>
<td>SF.23_Alert driver on board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td>SF.14_Data fusion &amp; update LDM-VEH</td>
<td>SF.24_Display warning on VMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.02_Provide circulation rules</td>
<td>SF.15_Query LDM-VEH info</td>
<td>SF.25.Validate warning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.04_Provide vehicle dynamics from vehicle</td>
<td>SF.17_Generate msg for VANET roadside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.05_Provide vehicle other info from vehicle</td>
<td>SF.18_Generate message for VANET on board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.06_Provide static road geometry &amp; ITS devices</td>
<td>SF.21_Send msg to VANET from veh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.07_Provide events info</td>
<td>SF.20_Send msg to VANET from roadside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.08_Provide external safety-related info</td>
<td>SF.55_Determine Speed and Distance for LONC_2.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.11_Detect road status roadside</td>
<td>SF.42_Determine Safety Margin i LONC_2.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.12_Detect weather info roadside</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.30_Detect visibility roadside</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF.31_Detect traffic roadside</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The diagram depicts the value chain and all the activities or sub-activities positioned on the single rings of the chain.

As mentioned in paragraph 3.1.2, the Detection chain mail contain all the activities performed in order to introduce information to the system; this may come from sensors (dynamic information), but can also be "static" or "quasi static" information, as for example the updates on the circulation rules or the static map. The Processing element is associated to the functionalities involved with the platforms processing (data fusion), the interface with the LDM (query mechanisms), the Applications and the Message Generation; this last activity, involving the process of data coming from the Detection step of the "secondary actor" vehicle (or even the RSU), is considered as a processing activity; however, in principle, it could also be considered as a Detection activity, since it produces data for the main Driver Support Applications. The same can be said for the function of message routing to the VANET (SF.20).

The Alert chain mail contains two functions managing the warning provision to the driver on board and roadside through the Variable Message Sign.
3.5.4. The Organizational scheme

![Diagram](image)

Figure 21. Speed Alert SP4 SLSD (Speed Limitation and Safety Distance) organizational scheme
3.5.5. Roles analysis  

a. Public Authority  

Functionalities  

Within the SLSD SP4 application, the Public Authority is in charge of the activity:  

- SF.01 Updating circulation rules  

This functionality includes to provide and communicate to the Infrastructure Manager/Owner any update on the rules affecting the traffic circulation on the portion of road network covered by the SAFESPOT service. As anticipated in the functions description paragraph, the circulation rules involved in the Speed Alert field are essentially the speed limits, since the system application strongly relies on this information. The fulfilment of this functionality would likely require to establish an apposite form of agreement between the two entities, in order to guarantee that the Infrastructure manager promptly communicates any change to the Road Manager/Owner. The speed limit change may come from a high level Public Authority (as for example a change of the speed limits for a certain road category brought in the road code by the national competent legislative body), or from a local Public Authority (for example a change of speed limit for a particular stretch of road due to works or other safety related reasons). This kind of communication may be only theoretic in most cases, due to the fact that the body covering the role of Public Authority (e.g. the local government) may coincide to the body managing or owning the road; in other cases the change in the speed limits may be agreed between the Public Authority and the Road Manager before it is put in place.  

Responsibilities  

The responsibilities linked to the Public Authority activity within the application belong basically to the Institutional/Regulatory category and to the Delivery one. The first aspect, however, will be external to the SAFESPOT system (i.e. the Public Authority issues a new speed limit independently from the SAFESPOT system); what impacts more on the SAFESPOT service is the delivery responsibility; the data delivery needs to be well-timed and correctly defined in all its aspects (spatial, time - in case the new limit has a limited duration, vehicle categories involved, etc.).  

Levers  

The levers in service of the Public Authority delivery responsibility will be in most cases any form of contracts to guarantee the well-timed and complete update of speed limits. Also any automatic procedure for the update would reduce time, costs and improve the added value for this step.  

Criticalities  

The lack of an agreement regulating the correct communication of updated speed limits in the SAFESPOT area may jeopardize the correct functioning of the SLSD application.  

b. Infrastructure SF Service Provider  

Functionalities  

The functionalities in charge of the Infrastructure SF Service Provider include:
- SF.11_Detect road status roadside
- SF.12_Detect weather info roadside
- SF.30_Detect visibility roadside
- SF.31_Detect traffic roadside
- SF.13_Data fusion & update LDM-RSU
- SF.16_Query LDM-RSU info
- SF.55_Determine Speed and Distance for LONC_2.3
- SF.17_Generate message for VANET roadside
- SF.20_Send message to VANET from roadside

The first four functionalities are dedicated to the detection of the measures needed by the system from the road sensors: road status, weather, visibility, traffic. The next two functions are dedicated to the interaction with the RSU LDM (processing, upload and extraction). SF.55 includes processing the detected data in order to determine the dynamic speed limit and the safety distance; the last two functions are dedicated to the transmission of this information to the VANET.

The Infrastructure Service Provider role will be covered by any entity taking in charge the management of the SAFESPOT road-based part of the system on a certain portion of road network. In most cases this entity would likely be the Infrastructure Manager, but there may also be the option it is a different organization, for example a company managing the ITS systems in a city area.

**Responsibilities**

This role shares with the SF Vehicle Service Provider the fundamental responsibility of Delivery of the service (safety alert) to the final user (driver); in fact a significant part of real-time information about the road environment, feeding the application, is detected via the roadside sensors, processed by the Road Side Unit, and sent to the VANET from the RSU router. Moreover the SLSD application includes extra focus on this role because it makes use of the result of a "support" application running on the RSU (SF.55_Determine Speed and Distance for LONC_2.3), dedicated to the calculation of the dynamic speed limit and safety distance. The responsibility of alert Delivery to the driver can be seen as decomposed into the single steps of information delivery from one single ring of the system chain to the following one: the detection system to the RSU, the RSU to the router and to the VMS, the router to the vehicles. In general the Delivery responsibility is a delicate issue, since timing plays a fundamental role in the safety related alert provision. An average and maximum delay will need to be defined from the moment the safety related event happens to the moment the driver is alerted. Also, the Infrastructure Service Provider shall be able to quantify the delivery timing of the critical information provided to the following steps within the system information flow sequence, in order to monitor its compliance to the limit delays. Two particular critical steps under the timing point of view are the query mechanism to extract the needed data from the RSU and the process of dispatching-validating-displaying the alerts on the VMSs. In this latest case the role of Infrastructure Manager/Owner is involved as well (see OA diagram).

Since input data may come not only from the SAFESPOT sensors but also be communicated by external organizations, the way this exchange of information is ruled
is also very important. The RSU receives information (that may also be real-time) from the VASP role, therefore proper agreements will be needed for this data transfer; a periodic update needs to be provided also by the Map Provider, from which the Infrastructure Service Provider will need prompt update in case of static road geometry changes. More information may come from the Infrastructure Manager as well; this would imply extra agreements on this information exchange.

Another important aspect to be taken into account for the Delivery responsibility is data reliability; the information should comply defined limits of precision and accuracy when delivered from detection systems to the RSU, from the RSU to the SF.55 function and to the VANET.

The Infrastructure Service Provider, finally, is charged of a major Management responsibility of the system, since some of the main physical devices and external organizations upon which the system relies are under its control.

**Levers**

The main levers for the Delivery responsibility are technical-related. The timing and reliability of data will strongly depend upon the technological supports, the processing techniques, the communication devices.

The other important lever for the Delivery responsibility, both in terms of timing and data reliability, are the contracts set up between this role and those acting as information suppliers (VASP, Map Provider, Infrastructure Manager, Vehicle Service Provider) and information clients (Vehicle Service Provider through the VANET and Infrastructure Manager for the alert visualization via the roadside alert equipment).

**Criticalities**

The critical aspects for this role are those involving the supply well-timed and reliable alerts to the driver. The Infrastructure Service Provider, together with the Vehicle Service Provider, is the interface between the system and the user; moreover, the SAFESPOT system will be successful inasmuch as the driver will modify its behaviour according to the alert messages. Since this will happen proportionally to the confidence that the he will have in the reliability of the messages he will receive, it is easy to understand that a major focus has to be given at all levels, included the organizational one, in order to reach the highest possible level of trust of the driver towards the system. Several aspects will be involved in this goal other than the timing and the reliability of the alerts: the homogeneity of the warning in time and space, the information on the current functioning status of the system; on the other hand, the risk of over compliance of the driver towards the system may have dangerous effects as well.

c. **Vehicle SF Service Provider**

**Functionalities**

The functionalities in charge of the Vehicle SF Service Provider include:

- SF.04_Provide vehicle dynamics from vehicle
- SF.05_Provide vehicle other info from vehicle
- SF.14_Data fusion & update LDM-VEH

---

9 excluding the probe vehicles
- SF.15_Query LDM-VEH info
- SF.42_Determine Safety Margin i LONC_2.3
- SF.18_Generate message for VANET onboard
- SF.21_Send message to VANET from veh
- SF.23_Alert driver on board

The first two functions are dedicated to the detection of data needed for the application from the vehicle. Functions SF.14 and SF.15 are in charge of the input data processing and interaction with the LDM, in parallel to the roadside platform. Two functions are then dedicated to the generation and sending of the messages from the probe vehicles to the VANET, with the information grabbed by SF.04 and SF.05 and processed by SF.14. Finally SF.42 is the core function of the application, producing the alert.

**Responsibilities**

This role (see paragraph 3.1.1) is charged of a Delivery responsibility, similarly as the SF Infrastructure Service Provider, both from a global service point of view and as for the single steps of information delivery within the system, down to the driver alert via the on board HMI. For the data coming from the external sources, the vehicle SAFESPOT system is able to receive data exclusively from the VANET, therefore all data would pass through the RSU. The only exception are the static map updates, that may come from the Map Provider directly to the Vehicle Service Provider. This periodic update shall be ruled by a proper commercial agreement.

The Management responsibility in charge of this role, shared with all the different Infrastructure SF Service Providers, includes ensuring that the in-vehicle SAFESPOT system is compliant with different SAFESPOT-equipped infrastructures.

**Levers**

As for the SF Vehicle Service provider, the main levers are represented by the technological capabilities of the system. In terms of events detection, data processing and alert visualization.

Moreover, being the in-vehicle Application strongly dependent upon the data coming from the SAFESPOT infrastructure platform, the agreements with the entities managing various SAFESPOT-infrastructured portion of roads will be fundamental for a successful provision of the service.

**Criticalities**

The major organizational challenge in cooperative systems is represented by the need to manage the interaction between the two platforms (vehicle and infrastructure). Considering that, as mentioned (see par 3.1.1), so far it is not completely clear how the role of Vehicle SF Service provider will be covered, it results rather difficult to envisage all possible organizational implications. In any case, being in the future the SAFESPOT service distributed over the whole European road network, a strong standardization level among the technologies and communication procedures will be needed on behalf of all possible different Infrastructure and Vehicle SAFESPOT Service Providers.
d. Infrastructure Manager/Owner

Functionalities

Functional blocks in charge of the Infrastructure Manager:
- SF.02_Provide circulation rules
- SF.06_Provide static road geometry & ITS devices
- SF.07_Provide events info
- SF.24_Display warning on VMS
- SF.25_Verify warning

The role of Infrastructure Manager includes a series of functions for the data supply, either quasi-static (updates on speed limits from the Public Authority, updates on road geometry) or dynamic (events or measures detected by safety systems installed on the infrastructure other than the SAFESPOT system).

The other group of functions is related to the warning display on the road based devices (VMS).

Responsibilities

As the supplier of part of the data needed to run the application (SF.06, SF.07), the Infrastructure Manager holds the responsibility to deliver data in the required time and with the required reliability (Delivery responsibility). The same responsibility is assigned to this role when the warning message to reduce speed or increase the safety distance is delivered to the driver through the VMSs. In fact, in case these are shared with other ITS services operating on the same portion of network, the Infrastructure Manager will make use of automated procedures in order to verify if the SAFESPOT warning is compliant with possible other warnings presented to the drivers, and, if needed, will set the proper priorities.

Moreover, as pointed out in D6.4.2 (Legal Aspects of SAFESPOT Systems), the Road Manager may be, within the boundaries set by the national legislator (and international treaties) responsible for setting speed limits for the roads within its jurisdiction (Speed Alert Consortium, 2004). In this case this role will detain as well a Normative responsibility.

Levers

As for the information detection side (first three functions), the main lever at disposal of the Infrastructure Manager in order to fulfill its Delivery responsibility is the ownership of the original data, allowing the control on the information timing and reliability. As for the warning displaying on the VMSs, the Infrastructure manager role holds the last filter before the message is published to the driver (SF.25_Verify warning function), therefore he can adjust the level of impact of the SAFESPOT system according to the situations.

Criticalities

An important critical point has to be considered for this role. Introducing a new system for road safety on a certain portion of network may be regarded with some distrust by a road manager correspondingly to the responsibility that would be imputed to him in case of malfunctioning of the system, possibly causing any damage to drivers. Although this issue is deeply dealt within the legal aspects analysis, it shall be
considered as a major concern also for its implications on some organizational aspects, in particular on the contracts regulating the exchange of information between this role and the other actors.

e. Map Provider

Functionalities

The Map Provider has in charge the functionality

- SF.22_Update static map

The Map Provider periodically collects the possible changes in the static information contained in the Local Dynamic Map (road geometry, speed limits, objects position) based on the inputs from the Infrastructure Manager and, possibly, from in-house surveys. The update is then communicated to the Infrastructure Service Provider for its own RSU-LDM update, and to the Vehicle SF Service Provider, that in its turn, will take care of updating the equipped vehicles systems. The contracts that will define this periodic exchange of information will include the time mode (e.g. one update every change or one update every fixed period) and the physical procedure for the data exchange.

Responsibilities

This role will have exclusively a responsibility on the data delivery; static maps represent an essential part of the whole mechanism.

Levers

In order to supply well-timed information the Map Provider can rely on the contracts setup with the Infrastructure Manager for the data supply, as well as on its internal availability of resources to collect more information and/or validate the data received. Depending on the way the updates are distributed to the RSU and vehicles LDMs (e.g. making use of a wireless connection), another important lever may be represented by the technological communication means used.

Criticalities

Timing will be a major issue due to the fact that safety related information may not be reliable in the period of time between the change and the update. For planned interventions on the road geometry by the Infrastructure Manager, optimized procedures may be introduced in order to minimize this time (e.g. the communication may be given in advance to the Map Provider), or at least to put the system in “down state” in order to avoid misleading warnings.

f. VASP

Functionalities

The Value Added Service Provider is assigned the following function:

- SF.08_Provide external safety-related info

This role may or may not be present in the application scenario according to the single sites. Typical actors for this role are traffic coordination centers, fleet monitoring systems, roadside assistance services, first aid or emergency operative centers, and, in general, all organizations external to SAFESPOT that may have at their disposal
useful safety-related information. The only link of this source towards the SAFESPOT environment is the Infrastructure SAFESPOT Service Provider; proper dedicated standard operating procedures have to be established to rule this exchange of information and make it continuous and reliable over time.

Responsibilities

Once a VASP agrees on a standard procedure for the information exchange, it will be charged with the responsibility of providing the committed information according to a defined timing and level of accuracy. Also, the management of the possible different sources of information will be under the VASP responsibility.

Levers

The added value brought by this role to the SAFESPOT service will lever on the technical means to deliver the information and the resources dedicated to the collection, verification and communication of real time information to the SAFESPOT system.
4. Organizational Architecture of the Global System

This section reports the description of the results obtained from the application of the methodology to the Global System, made of the four selected applications. The steps performed for the single applications are retraced for the ideal SAFESPOT system containing these four services; the Organizational scheme is obtained as the overlap of the single applications diagrams and the roles are described considering that all the functionalities used in the single applications would now be part of the global system.

In paragraph 4.2 a step forward was done, by trying to envisage the legal implications possibly brought by the system Actors interactions (contracts, agreements) that are needed, according to the Organizational analysis, in order to run the SAFESPOT system.

4.1. The Global System

The term “Global System” as explained in the following sections, is referred to as the system including the four applications under analysis (SP5 IRIS - Intelligent coopeRative Intersection Safety, SP4 RIS i Road Intersection Safety, SP5 Speed Alert, SP4 SLSD i Speed Limitation and Safety Distance). In this paragraph the Organizational Architecture of such system is described. For convenience, the same paragraphs structure is used as for the single applications (par 4.1).

4.1.1. Background

SAFESPOT is a road safety system relying on the cooperation of roadside and on-board devices, which includes a set of applications to help the driver in potentially dangerous situations. These applications are developed to provide support in different conditions of location, driving environment (Motorway, Urban areas, Rural areas), morphology, and are run under a common system architecture including inter-communicating components from the two platforms (road and vehicle).

Figure 22. SAFESPOT global system (from D7.3.1 Global System Reference Architecture Specification)
The "Global System" architecture developed at the IP level system design phase is depicted in the following scheme; it contains all the elements forming the structure, and their interrelations leading from the safety relevant information detected on the site to the alert provided to the driver in order to avoid or minimize the consequence of incidents.

![Diagram of SAFESPOT Infrastructure component architecture](image)

Figure 23. SAFESPOT Infrastructure component architecture (Guyenacourt diagram)

Being SAFESPOT a modular system made of several applications, there may be different combinations, according to those that, from the whole available set, are implemented on a single site (as for the applications including the support of the infrastructure platform) or on a single vehicle (as for the mere V2V applications) because of the inner risk potentially included in a particular situation. Therefore every single implementation of the SAFESPOT system is the result of the combination of a subgroup of the whole applications set, both roadside and vehicle side.

It is then clear that the term "Global System" should not be used to refer to an ideal system where all the developed SAFESPOT applications are implemented, which would be unrealistic, but rather to the structure obtained from the overlap of the single applications that are put in place in a particular situation. With this premise, in the present document the Global System is referred to as the system including the four applications under analysis (SP5 IRIS - Intelligent coopeRative Intersection Safety, SP4 RIS i Road Intersection Safety, SP5 Speed Alert, SP4 SLSD i Speed Limitation and Safety Distance).

The comparison between the single Applications Organizational schemes clearly shows that the functionalities that are in common among the different applications are the majority. This implies that the representation of a Global System made of a certain
A group of applications actually does not differ radically from a theoretical global system including all the developed SAFESPOT V2V and V2I applications or, which is more interesting, from a different SAFESPOT system including a different subset of applications. In fact, in order to put in place even a small number of functionalities, the basic logical functions block would be required, and this represents a relevant part of the total available system functions.

This aspect, which is true to a certain extent also under a functional and physical point of view, is very evident looking at the result of the overlapping operation of the single organizational structures of the applications under analysis, that was worked out in order to obtain the global one. Considering the depicted SAFESPOT site supporting the two analyzed V2I applications and hosting vehicles equipped with the two V2V applications, it can be clearly seen that in the Global System the same roles are foreseen compared to every single application system. The responsibilities, on the other hand, will vary inasmuch different functional blocks are activated in the different applications, with the related levers and functionalities.

### 4.1.2. The Logical Functions

The Global Architecture scheme, that was worked out from the overlap of the single Applications, shows two predominant roles, the **Infrastructure Service Provider** and the **Vehicle Service Provider**, charged with a significant part of the system functionalities. Within each of these two roles, the first group of functions in the chain of operations includes the functionalities providing information to the system. In both platforms, this information feeds the LDM after having been processed by the respective Data Fusion blocks.

Extra information is sent to the two platforms Local Dynamic Maps (again through the Data Fusion blocks) by external sources: the Map Provider, supplying the updates of the map static layer, The Value Added Service Provider, sending more safety-related information, the Infrastructure manager, that may have at disposal extra information through extra-SAFESPOT systems or channels, other than providing the information coming from the roadside devices under its control (e.g. traffic lights) as well as the needed updates in terms of road geometry and circulation rules.

As for the processing part of the system, the Global Organizational Architecture shows the same mechanism for the two platforms, made of the main applications functionality (here grouped for convenience and named respectively SF.60 and SF.61) generating the alerts on the basis of the data coming from the field, and the message generation, producing the messages to be sent to the VANET.

As for this second mechanism, it is important, also under an organizational point of view, to highlight the path of the messages sent to the VANET by the two different types of applications (Infrastructure based or Vehicle based). For the Infrastructure based applications, two situations should be distinguished:

1) the messages are measures (coming from the roadside sensors or from sources external to the SAFESPOT environment) that are put on the VANET in order to be used by the passing vehicles through their Driving Support Applications (e.g. the road status or the weather info that may serve the two SP4 applications)
2) The messages are alerts generated by the Infrastructure based Applications. In this second case, even if at the moment this document is published this aspect is not yet consolidated, it seems that the vehicles shall be equipped with a special application taking in charge this message and managing the visualization of the warning to the driver on board (SF.19).

In both cases the message should be generated by the same function (SF.17), on the basis of a query mechanism from the LDM.

For the vehicle based applications, in parallel, the messages are generated by the dedicated function called, in the SP4 environment, Cooperative Support Application, and represented in the Organizational charts by the SF.18 functionality. In this case, however, the messages contain only information at the service to the in-vehicle Driving Support Applications and to the Infrastructure based applications (point 1 of previous list), while it is not planned, at least as for the analyzed applications, to repeat roadside the alerts generated by the on-board applications.

In the following, the complete list of logical functions is reported for the Global System.

**SF.01_Update circulation rules**
This function consists of communicating to the Road Manager any change in the traffic regulation with effects on the road safety of an administrative area (municipality, region, state). The change can be either a long-term/final one (e.g. a change in the highway code), or a temporary one (e.g. traffic restrictions in an urban area)

**SF.02_Provide circulation rules**
Passing the information on (updated) circulation rules to the SAFESPOT system, once they have been received from the Public Authority.

**SF.03_Provide vehicle dynamics from infrastructure**
Detecting the vehicle dynamics (position, speed, acceleration) via the roadside sensors

**SF.04_Provide vehicle dynamics from vehicle**
Detecting the vehicle dynamics (position, speed, acceleration) via the on-board sensors (GPS, speedometer, etc.)

**SF.05_Provide vehicle other info from**
Detecting via the on-board sensors or recording by the in-vehicle system other (than dynamics) vehicle information needed for the application (heading, yaw rate, driver commands).

**SF.06_Provide static road geometry & ITS devices**
Passing the information on (updated) road geometry and position/ dimensions/ characteristics of static ITS devices or relevant permanent static objects.

**SF.07_Provide events info**
Passing the information of events detected or acquired by systems that are installed on the infrastructure (sensors, communication media) but do not belong to the SAFESPOT system

**SF.08_Provide external safety-related info**
Sending the information produced by services external to SAFESPOT to the system, in order to improve the robustness of the available information (e.g. VASP, other safety systems like CVIS, etc.).

**SF.11 _Detect road status roadside**
Detect road status through roadside sensors

**SF.12_Detect weather info roadside**
Detect environmental info through roadside sensors

**SF.13_Data fusion & update LDM-RSU**
The data coming from the sensors and from other possible sources (messages from the VANET, external applications, static information providers, data about non-SAFESPOT ITS devices, etc.) are fused in order to obtain ready-to-use information for applications, and loaded on the RSU LDM. According to the specific applications, different functionalities are activated.

**SF.14_Data fusion & update LDM-VEH**
This is the Data Fusion taking place in the vehicle unit. The purpose is the same than the "Data fusion & update LDM-RSU" functional block. In the IRIS case, this block is in charge of producing and storing on the LDM the information on the vehicle dynamics derived from possible different sensors.

**SF.15_Query LDM-VEH info**
The in-vehicle application sends the request for the needed data to its LDM. The LDM executes the query and provides the results to the application.

**SF.16_Query LDM-RSU info**
The SP5 application sends the request for the needed data to the LDM (vehicle dynamics and TLC planning). The LDM executes the query and send the results back to the application.

**SF.17_Generate msg for VANET roadside**
The Message Generation component contains the rule set determining when and what messages to send to the VANET. These rules are defined at design phase by the applications. These rules define under what situations and conditions which messages are to be sent to other nodes via the VANET router. The messages generated by the road-based system within this application are essentially the alerts generated by the application and sent via the VANET to the applications in order to be processed and finally displayed on the HMI.

**SF.18_Generate msg for VANET onboard**
This function includes the generation of messages to be routed towards the VANET from the SAFESPOT vehicles. In the SP5 IRIS application, the messages generated by this function contain the dynamics of the vehicles.

**SF.19_In-vehicle SP5 application client**
This application was not planned in the SP5 application functional description. However, since it is unlikely that the alert message from the SP5 IRIS application to the vehicles is sent straight to the HMI, it is assumed, until clarifications from the SP5
specifications are published, that the following path is likely to happen (see also the SP5 Speed Alert chapter):

- the alert message from the IRIS application is sent to the VANET
- the vehicles collect the message and put it into the LDM via the vehicle Data Fusion module
- a dedicated application (or the SP4 Road Safety Intersection application?) process this information and possibly sends it to the HMI through the Alert driver on board functionality (see below)

The other option is that the alert message from the IRIS application is managed directly by the Alert driver on board functionality. In this case this extra vehicle application does not exist and the message generated by the Generate message for VANET onboard is directly linked to the Alert driver on board functionality. (this is the configuration that may be put in place on the Application test site).

**SF.20_Send msg to VANET from roadside**

This function includes the message routing towards the VANET from the RSU router. The messages are those generated by the SF.17.

**SF.21_Send msg to VANET from veh**

This function includes the message routing towards the VANET from the vehicle router. The messages are those generated by the SF.18.

**SF.22_Update static map**

This function is referred to the periodic update of the LDM static layer. This update is performed following up changes in the road geometry, location of ITS devices or relevant permanent static objects, etc.)

**SF.23_Alert driver on board**

Prioritizing the messages plus the final visualization of the warning on the vehicle HMI.

**SF.24_Display warning on VMS**

Enabling the visualization of the warning on a roadside alert device.

**SF.25_Validate warning**

This function verifies that the SAFESPOT message coming from the SF.55 is compliant with the messages generated by the Infrastructure Manager’s own ITS system in terms of content and priority.

**SF.26_Provide TLC planning info**

Passing the traffic light planning info from the traffic lights control system manager to the SAFESPOT system.

**SF.27_Validate SF TLC actuation**

This function verifies that the SAFESPOT request for red prolongation is compliant with the Infrastructure Manager’s own ITS systems in terms of conflicts and priority

**SF.28_Actuate TLC**

Activates the red traffic light prolongation.

**SF.30_Detect visibility roadside**
Detect visibility info through roadside sensors.

**SF.31_Detect traffic roadside**

Detect traffic info (in case of the SLSD application: the traffic density) through roadside sensors.

**SF.60_Determine Safety Margin – I2V**

Generic Infrastructure based application

**SF.61_Determine Safety Margin – V2V**

Generic vehicle based application

### 4.1.3. The Value Chain

The diagram depicts the value chain and all the activities or sub-activities positioned on the single rings of the chain.

As mentioned in paragraph 3.1.2, the Detection chain mail contain all the activities performed in order to introduce information to the system; this may come from sensors (dynamic information), but can also be static or quasi static information, as for example the updates on the circulation rules or the static map. The Processing element is associated to the functionalities involved with the platforms processing (data fusion), the interface with the LDM (query mechanisms), the Applications and the Message Generation; this last activity, involving the process of data coming from the Detection step of the secondary actor vehicle (or even the RSU), is considered as a processing activity; however, in principle, it could also be considered as a Detection activity, since it produces data for the main Driver Support Applications. The same can be said for the function of message routing to the VANET (SF.20).

The Alert chain mail contains two functions managing the traffic light control actuation and the warning provision to the driver on board and roadside through the Variable Message Sign.
Service Provider

Detection 

Processing 

Alert

Driver

<table>
<thead>
<tr>
<th>Service Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF.01_Update circulation rules</td>
<td>SF.22_Update static map</td>
</tr>
<tr>
<td>SF.02_Provide circulation rules</td>
<td>SF.15_Query LDM-VEH info</td>
</tr>
<tr>
<td>SF.03_Provide vehicle dynamics from infrastructure</td>
<td>SF.13_Data fusion &amp; update LDM-RSU</td>
</tr>
<tr>
<td>SF.11_Detect road status roadside</td>
<td>SF.16_Query LDM-RSU info</td>
</tr>
<tr>
<td>SF.12_Detect weather info roadside</td>
<td>SF.27_Valdiate SF TLC actuation</td>
</tr>
<tr>
<td>SF.13_Data fusion &amp; update LDM-RSU</td>
<td>SF.28_Acuate TLC</td>
</tr>
<tr>
<td>SF.14_Data fusion &amp; update LDM-VEH</td>
<td>SF.20_Send msg to VANET from roadside</td>
</tr>
<tr>
<td>SF.17_Generate msg for VANET roadside</td>
<td>SF.23_Alert driver on board</td>
</tr>
<tr>
<td>SF.18_Generate message for VANET on board</td>
<td>SF.25_Validate warning</td>
</tr>
<tr>
<td>SF.19_In-vehicle SP5 application client</td>
<td>SF.26_Provide TLC planning info</td>
</tr>
<tr>
<td>SF.20_Send msg to VANET from roadside</td>
<td>SF.24_Display warning on VMS</td>
</tr>
<tr>
<td>SF.21_Send msg to VANET from veh</td>
<td>SF.27_Valdiate SF TLC actuation</td>
</tr>
<tr>
<td>SF.22_Update static map</td>
<td>SF.28_Acuate TLC</td>
</tr>
<tr>
<td>SF.23_Alert driver on board</td>
<td>SF.25_Validate warning</td>
</tr>
<tr>
<td>SF.24_Display warning on VMS</td>
<td>SF.27_Valdiate SF TLC actuation</td>
</tr>
<tr>
<td>SF.25_Validate warning</td>
<td>SF.28_Acuate TLC</td>
</tr>
<tr>
<td>SF.26_Provide TLC planning info</td>
<td>SF.27_Valdiate SF TLC actuation</td>
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<tr>
<td>SF.27_Valdiate SF TLC actuation</td>
<td>SF.28_Acuate TLC</td>
</tr>
<tr>
<td>SF.28_Acuate TLC</td>
<td>SF.27_Valdiate SF TLC actuation</td>
</tr>
<tr>
<td>SF.29_Provide TLC status</td>
<td>SF.27_Valdiate SF TLC actuation</td>
</tr>
<tr>
<td>SF.30_Detect visibility roadside</td>
<td>SF.60_Determine Safety Margin I2V</td>
</tr>
<tr>
<td>SF.31_Detect traffic roadside</td>
<td>SF.61_Determine Safety Margin V2V</td>
</tr>
<tr>
<td>SF.04_Provide vehicle dynamics from vehicle</td>
<td>SF.62_Determine Safety Margin V2V</td>
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<tr>
<td>SF.05 Provide vehicle other info from vehicle</td>
<td>SF.63_Determine Safety Margin V2V</td>
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<tr>
<td>SF.06_Provide static road geometry &amp; ITS devices</td>
<td>SF.64_Determine Safety Margin V2V</td>
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<tr>
<td>SF.07_Provide events info</td>
<td>SF.65_Determine Safety Margin V2V</td>
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<tr>
<td>SF.26_Provide TLC planning info</td>
<td>SF.66_Determine Safety Margin V2V</td>
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<tr>
<td>SF.29_Provide TLC status</td>
<td>SF.67_Determine Safety Margin V2V</td>
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<tr>
<td>SF.30_Detect visibility roadside</td>
<td>SF.68_Determine Safety Margin V2V</td>
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<td>SF.31_Detect traffic roadside</td>
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<td>SF.04_Provide vehicle dynamics from vehicle</td>
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<td>SF.30_Detect visibility roadside</td>
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<td>SF.04_Provide vehicle dynamics from vehicle</td>
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<td>SF.05 Provide vehicle other info from vehicle</td>
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<td>SF.81_Determine Safety Margin V2V</td>
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<tr>
<td>SF.26_Provide TLC planning info</td>
<td>SF.82_Determine Safety Margin V2V</td>
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<td>SF.29_Provide TLC status</td>
<td>SF.83_Determine Safety Margin V2V</td>
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<tr>
<td>SF.30_Detect visibility roadside</td>
<td>SF.84_Determine Safety Margin V2V</td>
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<td>SF.31_Detect traffic roadside</td>
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<td>SF.05 Provide vehicle other info from vehicle</td>
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<tr>
<td>SF.26_Provide TLC planning info</td>
<td>SF.114_Determine Safety Margin V2V</td>
</tr>
</tbody>
</table>
4.1.4. The Organizational Scheme

Figure 24. The Global System Organizational scheme
4.1.5. Roles analysis

With the same “overlapping” approach, the analysis of the roles made for the four analyzed applications is now fused, with the aim to obtain a complete and more general description for the Responsibilities and Levers assigned to each one of them.

a. Public Authority

Functionality

Globally, the Public Authority is in charge of the activity:

- SF.01 Updating circulation rules

This functionality includes to provide and communicate to the Infrastructure Manager/Owner any update on the rules affecting the traffic circulation on the portion of road network covered by the SAFESPOT service. For the Safe Intersection applications area, this kind of updates may regard traffic restrictions (in time or for certain vehicles categories for example) in the SAFESPOT area, provided by the local government. For the Speed Alert field the updates would regard essentially the speed limits, since the system applications of this family strongly rely on this information.

The fulfilment of this functionality would likely require to establish an apposite form of agreement between the two entities, in order to guarantee that the Infrastructure manager promptly communicates any change to the Road Manager/Owner. The rules change may come from a high level Public Authority (as for example a change of the speed limits for a certain road category brought in the road code by the national competent legislative body), or from a local Public Authority (for example a change of speed limit for a particular stretch of road due to works or other safety related reasons).

This kind of communication may be only theoretic in most cases, due to the fact that the body covering the role of Public Authority (e.g. the local government) may coincide to the body managing or owning the road; in other cases the change in the circulation rules may be agreed between the Public Authority and the Road Manager before it is put in place.

Responsibilities

The responsibilities linked to the Public Authority activity within the application belong basically to the Institutional/Regulatory category and to the Delivery one. The first aspect, however, will be external to the SAFESPOT system (i.e. the Public Authority issues a new circulation rule independently from the SAFESPOT system); what impacts more on the SAFESPOT service is the delivery responsibility; the data delivery needs to be well-timed and correctly defined in all its aspects (spatial, time - in case the new circulation rule has a limited duration, limited vehicle categories involved, etc.).

Levers

The levers in service of the Public Authority delivery responsibility will be in most cases any form of contracts to guarantee the well-timed and complete update of the circulation rules. Also any automatic procedure for the update would reduce time, costs and improve the added value for this step.
Criticalities

The lack of an agreement regulating the correct communication of updated circulation rules in the SAFESPOT area may jeopardize the correct functioning of the system applications.

b. Infrastructure SF Service Provider

Functionalities

The functionalities in charge of the Infrastructure SF Service Provider include:

- SF.03_Provide vehicle dynamics from infrastructure
- SF.11_Detect road status roadside
- SF.12_Detect weather info roadside
- SF.30_Detect visibility roadside
- SF.31_Detect traffic roadside
- SF.13_Data fusion & update LDM-RSU
- SF.16_Query LDM-RSU info
- SF.60_Determine Safety Margin ı I2V
- SF.17_Generate message for VANET roadside
- SF.20_Send message to VANET from roadside

The first functionalities are dedicated to the detection of the measures needed by the system from the road sensors (road status and weather, vehicle dynamics from the Laserscanner system or the camera-based object detection module). The next functions are dedicated to the interaction with the RSU LDM (processing, upload and extraction). The last two functional blocks regard the transmission of the information about the danger to the VANET, as to send the message to the single vehicles on-board HMI.

The Infrastructure Service Provider role will be covered by any entity taking in charge the management of the SAFESPOT road-based part of the system on a certain portion of road network. In most cases this entity would likely be the Infrastructure Manager, but there may also be the option it is a different organization, for example a company managing the ITS systems in a city area.

Responsibilities

This role shares with the SF Vehicle Service Provider the fundamental responsibility of Delivery of the service (red prolongation, safety alert on board) to the final user (driver); in fact a significant part of real-time information feeding the application (the vehicle dynamics, the road status, the weather information), is detected via the roadside sensors, processed by the Road Side Unit, and sent to the VANET from the RSU router. The responsibility Delivery of safety information to the driver can be seen as decomposed into the single steps from one single ring of the system chain to the following one: the detection system to the RSU, the RSU to the router or to the respective platform alert system or actuators, the router to the vehicles. In general the Delivery responsibility is a delicate issue, since timing plays a fundamental role in the safety related alert provision. An average and maximum delay will need to be defined
from the moment the safety related event happens to the moment the driver is alerted. Also, the Infrastructure Service Provider shall be able to quantify the delivery timing of the critical information provided to the following steps within the system information flow sequence, in order to monitor its compliance to the limit delays. Two particular critical steps under the timing point of view are the query mechanism to extract the needed data from the RSU and the process of dispatching-validating-displaying the alerts on the VMSs for the applications where this is required. In this latest case the role of Infrastructure Manager/Owner is involved as well (see OA diagram).

Since input data may come not only from the SAFESPOT sensors but also be communicated by external organizations, the way this exchange of information is ruled is also very important. The RSU receives information (that may also be real-time) from the VASP role, therefore proper agreements will be needed for this data transfer; a periodic update needs to be provided also by the Map Provider, from which the Infrastructure Service Provider will need prompt update in case of static road geometry changes. More information may come from the Infrastructure Manager as well; this would imply extra agreements on this information exchange.

Another important aspect to be taken into account for the Delivery responsibility is data reliability; the information should comply defined limits of precision and accuracy when delivered from detection systems to the RSU, from the RSU to the VANET.

The Infrastructure Service Provider, finally, is charged of a major Management responsibility of the system, since some of the physical devices and external organizations upon which the system relies are under its control.

Levers

The main levers for the Delivery responsibility are technical-related. The timing and reliability of data will strongly depend upon the efficiency of the technological supports, the processing techniques, the communication devices.

The other important lever for the Delivery responsibility, both in terms of timing and data reliability, are the contracts set up between this role and those acting as information suppliers (VASP, Map Provider, Infrastructure Manager, Vehicle Service Provider) and information clients (Vehicle Service Provider through the VANET and Infrastructure Manager for the alert visualization via the roadside alert equipment or actuation). Any synergies with other safety systems installed on the same platform (e.g. CVIS) would significantly decrease the costs and therefore improve the value.

Criticalities

The critical aspects for this role are those involving the supply well-timed and reliable information to the driver. The Infrastructure Service Provider, together with the Vehicle Service Provider, is the interface between the system and the user; moreover, the SAFESPOT system will be successful inasmuch as the driver will modify its behaviour according to the alert messages. Since this will happen proportionally to the confidence that the he will have in the reliability of the messages he will receive, it is easy to understand that a major focus has to be given at all levels, included the organizational one, in order to reach the highest possible level of trust of the driver towards the system. Several aspects will be involved in this goal other than the timing and the reliability of the alerts: the homogeneity of the warning in time and space, the

10 excluding the probe vehicles
information on the current functioning status of the system; on the other hand, the risk of over compliance of the driver towards the system may have dangerous effects as well.

c. Vehicle SF Service Provider

Functionalities

The functionalities in charge of the Vehicle SF Service Provider include:

- SF.04_Provide vehicle dynamics from vehicle
- SF.05_Provide vehicle other info from vehicle
- SF.14_Data fusion & update LDM-VEH
- SF.15_Query LDM-VEH info
- SF.61_Determine Safety Margin V2V
- SF.18_Generate message for VANET onboard
- SF.19_In-vehicle SP5 application client
- SF.21_Send message to VANET from veh
- SF.23_Alert driver on board

The first functions are dedicated to the detection of data needed for the application from the vehicle (vehicle dynamics). Functions SF.14 and SF.15 are in charge of the input data processing and interaction with the LDM, in parallel to the roadside platform. Two functions are then dedicated to the generation and sending of the messages from the probe vehicles to the VANET, with the information grabbed by SF.04 and SF.05 and processed by SF.14. This information can be either the messages from the secondary actors (vehicle dynamics and vehicle controls status) that the primary actor will use for the Driving Assistance Application, or possibly the controls status messages that will be used by the Infrastructure SAFESPOT Service Provider to infer the road status or the weather.

The last two functions are dedicated to process vehicle-side the data coming from the VANET and to display it on the on board HMI.

Responsibilities

This role (see paragraph 3.1.1) is charged of a Delivery responsibility, similarly to the SF Infrastructure Service Provider, both from a global service point of view and as for the single steps of information delivery within the system, down to the driver alert via the on board HMI. For the data coming from the external sources, the vehicle SAFESPOT system is able to receive data exclusively from the VANET, therefore all data would pass through the RSU. The only exception are the static map updates, that may come from the Map Provider directly to the Vehicle Service Provider. This periodic update shall be ruled by a proper commercial agreement.

The Management responsibility in charge of this role, shared with all the different Infrastructure SF Service Providers, includes ensuring that the in-vehicle SAFESPOT system is compliant with different SAFESPOT-equipped infrastructures.
Levers

As for the SF Vehicle Service provider, the main levers are represented by the technological capabilities of the system. In terms of data acquisition and processing, and alert visualization.

Moreover, being the communication with the infrastructure fundamental for this Application, the agreements with the entities managing various SAFESPOT-infrastructured portion of roads will be fundamental for a successful provision of the service. As for the Infrastructure SAFESPOT Service provider, an extra value would be brought to the system supply in case the data and the technologies provided to the system would be shared with other safety systems installed on the same platform (e.g. CVIS).

Criticalities

The major organizational challenge in cooperative systems is represented by the need to manage the interaction between the two platforms (vehicle and infrastructure). Considering that, as mentioned (see par 3.1.1), so far it is not completely clear how the role of Vehicle SF Service provider will be covered, it results rather difficult to envisage all possible organizational implications. In any case, being in the future the SAFESPOT service distributed over the whole European road network, a strong standardization level among the technologies and communication procedures will be needed on behalf of all possible different Infrastructure and Vehicle SAFESPOT Service Providers.

d. Infrastructure Manager/Owner

Functionalities

Functional blocks in charge of the Infrastructure Manager:
- SF.02_Provide circulation rules
- SF.06_Provide static road geometry & ITS devices
- SF.07_Provide events info
- SF.24_Display warning on VMS
- SF.25_Visualize warning
- SF.26_Provide TLC planning info
- SF.27_Visualize SF TLC actuation
- SF.28_Actuate TLC
- SF.29_Provide TLC status

The role of Infrastructure Manager includes a series of functions for the data supply, either quasi-static (updates on circulation rules from the Public Authority, updates on road geometry) or dynamic (traffic lights status, events or measures detected by safety systems installed on the infrastructure other than the SAFESPOT system).

The other group of functions is related to the warning display on the road based devices (VMS) and the management of the red prolongation at the TLC system level.
Responsibilities

As the supplier of part of the data needed to run the application (SF.06, SF.07, SF.26), the Infrastructure Manager holds the responsibility to deliver data in the required time and with the required reliability (Delivery responsibility). The same responsibility is assigned to this role when the warning message to reduce speed is delivered to the driver through the VMSs or the red prolongation is implemented. In fact, in case other TLC control or warning systems are operating on the same portion of network, the Infrastructure Manager will use automated procedures in order to verify if the SAFESPOT alerts or traffic lights controls are compliant with possible other actions on the same area, and, if needed, set the proper priorities. However, for the "pure" V2V applications (i.e. where no roadside alert or actuation is planned) the Infrastructure Manager has no responsibility on the delivery of the alert to the driver.

Moreover, as pointed out in D6.4.2 (Legal Aspects of SAFESPOT Systems), the Road Manager may be, within the boundaries set by the national legislator (and international treaties) responsible for setting speed limits for the roads within its jurisdiction (Speed Alert Consortium, 2004). In this case this role will detain as well a Normative responsibility.

Levers

As for the information detection side (first three functions), the main lever at disposal of the Infrastructure Manager in order to fulfill its Delivery responsibility is the ownership of the original data, allowing the control on the information timing and reliability. As for the red-phase prolongation and the warning displaying on the VMSs, the Infrastructure manager role holds the last "filter" before the control or warning is put in place, therefore he can adjust the level of "impact" of the SAFESPOT system according to the situations.

Criticalities

An important critical point has to be considered for this role. Introducing a new system for road safety on a certain portion of network may be regarded with some distrust by a road manager correspondingly to the responsibility that would be imputed to him in case of malfunctioning of the system, possibly causing any damage to drivers. Although this issue is deeply dealt within the legal aspects analysis, it shall be considered as a major concern also for its implications on some organizational aspects, in particular on the contracts regulating the exchange of information between this role and the other actors.

e. Map Provider

Functionalities

This role has in charge the functionality

- SF.22_Update static map

The Map Provider periodically collects the possible changes in the static information contained in the Local Dynamic Map (road geometry, speed limits, objects position) based on the inputs from the Infrastructure Manager and, possibly, from in-house surveys. The update is then communicated to the Infrastructure Service Provider for
its own RSU-LDM update, and to the Vehicle SF Service Provider, that in its turn, will take care of updating the equipped vehicles systems. The contracts that will define this periodic exchange of information will include the time mode (e.g. one update every change or one update every fixed period) and the physical procedure for the data exchange.

Responsibilities

This role will have exclusively a responsibility on the data delivery; static maps represent an essential part of the whole mechanism.

Levers / Criticalities

In order to supply well-timed information, the Map Provider can rely on the contracts setup with the Infrastructure Manager/Owner for the data supply, as well as on its internal availability of resources to collect extra information and/or validate the received data. Depending on the way the updates are distributed to the RSU and vehicles LDMs (e.g. making use of a wireless connection), another important lever may be represented by the technological communication means used.

Timing will be a major issue, but also an important value contribution, due to the fact that safety related information may not be reliable in the period of time between the change and the update. For planned interventions on the road geometry by the Infrastructure Manager, optimized procedures may be introduced in order to minimize this time (e.g. the communication may be given in advance to the Map Provider), or at least to put the system in "down state" in order to avoid misleading warnings.

f. VASP

Functionalities

The Value Added Service Provider is assigned the following function:

- SF.08_Provide external safety-related info

This role may or may not be present in the application scenario according to the single sites. Typical actors for this role are traffic coordination centers, fleet monitoring systems, roadside assistance services, first aid or emergency operative centers, and, in general, all organizations external to SAFESPOT that may have at their disposal useful safety-related information. The only link of this source towards the SAFESPOT environment is the Infrastructure SAFESPOT Service Provider; proper dedicated standard operating procedures have to be established to rule this exchange of information and make it continuous and reliable over time.

Responsibilities

Once a VASP agrees on a standard procedure for the information exchange, it will be charged with the responsibility of providing the committed information according to a defined timing and level of accuracy. Also, the management of the possible different sources of information will be under the VASP responsibility.

Levers

The added value brought by this role to the SAFESPOT service will lever on the technical means to deliver the information and the resources dedicated to the collection, verification and communication of real time information to the SAFESPOT system.
4.2. Legal Aspects concerning the contracts between Actors

As emerged in the previous sections, the organizational structure of the SAFESPOT service, either considering the single applications or the entire global system, is made of the interaction of different Actors, each of which, in general, covers one of the identified roles and takes charge of the related responsibilities. This interaction, that was described and decomposed in terms of input-output of the system functions in charge of different roles, can be seen as the underlying meto ruling the activities needed for the system operation. In the following section a further effort was performed in order to envisage how the single interactions would be formalised, and what legal implications these would possibly bring once such a system would be put in practice.

This attempt, being developed by the British BLADE partner taking care of the Legal Aspects, mainly refers to the English law, and therefore does not aim to be exhaustive for the whole European environment. However, it represents a valuable reference to help the analysis within any other legislative system.

4.2.1. The Contractual Matrix

In order to analyse the single contractual interactions between the SAFESPOT actors, the analysis of the roles played by the various Actors, as set out in Chapter 3, sections 3.2, 3.3, 3.4 and 3.5 dealing with the four chosen applications, Chapter 4 dealing with the Global System, and the paragraph on Roles Analysis contained within each of those sections, were represented in a tabular form, entitled the Contractual Matrix. Each contract in the Matrix refers to an arrow line in the diagrams at Sections 3.2.4, 3.3.4, 3.4.4, 3.5.4 and 4.1.4 which links a party in one column to a party in another.

<table>
<thead>
<tr>
<th>Contract Party 1</th>
<th>Contract Party 2</th>
<th>Nature of Contract</th>
<th>Relevant Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Authority</td>
<td>Infrastructure Manager/Owner</td>
<td>Contract provides standards for up-dates sent by Party 1 to Party 2 on rules</td>
<td>SP5 - IRIS_01 (Intelligent cooperative Intersection Safety)</td>
<td>1. In some cases there will be no contract, as the Public Authority may also be the Infrastructure Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td>affecting traffic circulation on the part of the road network covered by the SF service</td>
<td>SP4 – 1.1 (Road Intersection Safety)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SP5 – 4.2 (Speed Alert)</td>
<td>2. As regards safe intersections applications, the updates may relate to traffic restrictions (in time, or for certain categories of vehicles)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SP4 – 2.3 (Speed Limitation and Safety Distance)</td>
<td></td>
</tr>
<tr>
<td>Contract No. 2</td>
<td></td>
<td></td>
<td>All applications, as for Contract No. 1</td>
<td></td>
</tr>
<tr>
<td>Infrastructure Service Provider</td>
<td>Value Added Service Provider</td>
<td>Contract regulates transfer from Party 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract No. 3</td>
<td>Contract No. 4</td>
<td>Contract No. 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Infrastructure Service Provider</strong></td>
<td><strong>Infrastructure Service Provider</strong></td>
<td><strong>Infrastructure Service Provider</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Map Provider</strong></td>
<td><strong>Infrastructure Manager/Owner</strong></td>
<td><strong>Vehicle Service Provider</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Contract regulates transfer from Party 2 to Party 1 of updates on static road geometry changes** | **Contract regulates transfer**  
1. from Party 2 to Party 1 of  
a) safety-related events information  
b) traffic light control planning information*  
2. from Party 1 to Party 2 of Traffic Light Control actuation data **  
3. from Party 1 to Party 2 of warning message for VMS *** | **1. Contract regulates the exchange of messages via the VANET to the data fusion and update functions in the respective LDMs*  
2. Contract defines limits of precision and accuracy of data transferred** |
| **All applications, as for Contract No. 1** | ***applicable only in SP5 – IRIS_01 (Intelligent cooperative Intersection Safety) and SP4 – 1.1 (Road Intersection Safety)**  
** applicable only in SP5 – IRIS_01 (Intelligent cooperative Intersection Safety)**  
*** applicable only in  SP5 – 4.2 (Speed Alert) and SP4 – 2.3 (Speed Limitation and Safety Distance)** | *** includes in IRIS_01, data sent by Party 1 from SF51_Determine Safety Margin in IRIS_01; in SP4 – 1.1, data sent by Party 2 from SF41_Determine Safety Margin in LATC_1.1; in SP5 – 4.2 (Speed Alert), data sent by Party 1**  
**Note that the main physical devices, such as the RSUs, are under the control and responsibility of Party 1** |
4.2.2. Check-List of Contents for the Contracts between the Actors

If these contracts were to be governed by English law, they would all contain, in addition to commercial information such as Service Levels and Tariff/ Pricing, some standard terms to the following effect.
1. They would define the agreed services (outputs) to be provided and the Service Levels/standards. The obligation would, we anticipate, be to provide those services to those standards, not on an absolute or guaranteed basis but on the basis of *best endeavours*. The agreed Service Levels would address issues of security.

2. They would include some *force majeure* exceptions.

3.1 They would exclude or [more likely] limit liability to a pre-determined amount, perhaps equivalent to or a multiple of the revenue related to the transaction concerned. In particular, they might include terms excluding responsibility for pure financial loss claims, that is, claims not related to physical loss or damage or personal injury. This might be expressed as an exclusion of claims for consequential damages or indirect loss, such as loss of revenue or loss of profits.

3.2 Freedom of contract in regard to exclusion and limitation clauses is likely to be subject to statutory provisions, such as (in England) the Unfair Contract Terms Act 1977, which imposes a test of reasonableness in commercial contracts.

3.3 This is the more so in the case of Contract No. 9 where, as the table shows, the terms of the contract would be subject to Consumer Protection legislation, which would certainly curtail the contractual freedom of the service provider to exclude or limit its liability, and its choice of the method of dispute resolution.

4 They would provide that no contracting party had the right to sue the other’s servants, agents or sub-contractors; the only party that a contracting party could sue in relation to a breach of contract would be the other contracting party itself. The objective here is to avoid a party circumventing the defences and limitations of the contract by suing a person who was not a party to that contract. The general principle, under English law, is *subject to what is said in 5. below, that only the parties to a contract can take its benefit or be subject to its burdens. That is known as the doctrine of *Privity of Contract*.*

5 They would seek to provide the same level of protection for its servants, agents and sub-contractors as the contracting party itself has, in the event that they find themselves, despite 4. above, sued by the other contracting party. This might be achieved through a specific term in the contract, which *by virtue of the Contracts (Rights of Third Parties) Act of 1999 - would now be enforceable at the suit of the beneficiary.*

6. If, contrary to 4. and 5. above, a contracting party (A) is successful in suing a servant, agent or independent contractor of the other contracting party (B), they would require A to indemnify B against any liability that B might incur to its servant, agent or subcontractor, to the extent that such liability exceeded the liability that B had under its contract with A *a circular indemnity clause*. A clause of this type effectively deprives A of any advantage that he might gain by suing the servant, agent or sub-contractor of B, in breach of the contract between him and B.

7. They would provide that neither contracting party could sue the other in tort and that all claims between the parties in relation to the particular service were to be brought under and pursuant to the contract. This would ensure that neither of the contracting parties could circumvent the terms and conditions of the contract.

8. They would provide that English law is the proper law of the contract.
9. They would provide for a dispute resolution procedure that might contain the following elements:
   a) agreement in advance to the use of a designated neutral body for the determination of the facts in dispute;
   b) agreement to mediate any dispute that cannot be settled in negotiation, in accordance with a pre-agreed mediation procedure of sufficient particularity to be legally enforceable under the principles of Cable & Wireless Plc v. IBM (UK) Ltd [2002] 2 All ER (Comm) 1041; and
   c) agreement to arbitrate in England any dispute that cannot be settled in mediation, including agreement to allow the arbitration proceedings to be consolidated with any other proceedings arising out of the same occurrence\(^\text{12}\).

10. They would require that, in the event of a breakdown in or serious impairment of the service provided, the defaulting party would:
   a) immediately notify all its contracting parties of the breakdown (so that users of the SAFESPOT service could become aware immediately of the service malfunction);
   b) restore the service within a pre-agreed time-scale; or
   c) if this were not possible, withdraw the service entirely and agree to its substitution by another (equivalent) service provider.

5. Conclusions

The first aim of this stage of the work was to outline the methodology to be adopted for the SAFESPOT service organizational analysis and to adapt the chosen case-tool to the SAFESPOT needs (task 6.3.1). The second goal was then to select a set of applications being developed in the technical subprojects and define for each of them a preliminary Organizational Architecture where the main roles of the actors involved in the operational level of the SAFESPOT system are identified together with their responsibilities, and the major relationships among the main functionalities are highlighted in an organizational view (task 6.3.2). From the single applications Organizational Architecture, the Global System organizational scheme was then obtained, as the union, or "overlap" of the previous schemes.

The preliminary step of the methodology, represented by the Value Chain definition, was the starting point of the research and can be considered as the first important result of the work. Following the general Value Chain concept, the business unit (that in this case is the SAFESPOT service) is broken down into its main strategic activities, making it possible to distinguish the behavior of costs and the associated generated value. The chain is made of the main functional steps of the system, including the acquisition of the data needed to observe the road, the processing of these data in order to recognize any safety related event, and the production of the alert to be provided to the driver. This represents the way the safety related information undergoes from its lowest level stage (rough information from the sensors, static information) to its finite form (safety alert presented to the driver).

\(^{12}\) A specific agreement to this effect is needed since, under section 35 of the Arbitration Act 1996, the tribunal has no power either to consolidate arbitrations or to order concurrent hearings, unless the parties agree to give it this power.
The second important result was the deep characterization of the roles involved in the service supply. As a cooperative system, SAFESPOT is significantly different if compared to the traditional driving assistance services; the environment where the system operates is, in fact, an enlarged field where the actors are, or may be, very numerous and where the information comes from different entities and points. A large number of roles is then involved in the provision of the service, not only as for the so called "horizontal activities" (administration, maintenance, etc.) but even to carry out the basic functional operations. The roles analysis, worked out starting from the single applications needs, and integrated into the global system view, provided a preliminary view of the responsibilities and criticalities for each of them.

The Global Architecture scheme, which was worked out from the overlap of the single Applications, shows two predominant roles, the Infrastructure Service Provider and the Vehicle Service Provider, in charge of a significant part of the system functionalities. The introduction of two separated units providing the SAFESPOT service was needed in order to take into consideration different possible scenarios; in fact the information needed by the cooperative system comes from the infrastructure sensors and from the probe vehicles and, in the real implementation of the system, the two parts may be managed by different entities. For example, the same entity covering the Infrastructure Manager role may act as the Infrastructure Service Provider, and in this case it will take in charge the responsibility on the data managed at the Infrastructure level (roadside sensors, roadside alert system, etc); on the other hand, another body (for example the car maker, or a dedicated service provide) may take in charge the data and the systems on the vehicle side.

The "bottom-up" approach (from the single Applications to the Global System), moreover, lead to other significant findings: the comparison between the single Applications Organizational schemes clearly shows that the functionalities that are in common among the different applications are the majority. This implies that the representation of a Global System made of a certain group of applications actually does not differ radically from a theoretical global system including all the developed SAFESPOT V2V and V2I applications or, which is more interesting, from a different SAFESPOT system including a different subset of applications. In fact, in order to put in place even a small number of functionalities, the basic logical functions block would be required, and this represents a relevant part of the total available system functions. This leads to conclude that the Global System worked out in the present research, may be considered as sufficiently representative of any different "multi-application" SAFESPOT system.

The Organizational Architecture schemes obtained as one of the final stages of the research, and compliant to the global "Guyancourt" architecture, show the way these two main roles interact with the other roles during the system operations: the Public Authority, with its main institutional/regulatory responsibility, the Infrastructure Manager/Owner, with the significant responsibilities deriving from the ownership of the roadside devices, the Map Provider, in charge of the LDM static layer, and possible Value Added Service Providers. The interactions between the different actors are mainly represented by data flows from an entity to the next one along the value chain; in general, these will be ruled by dedicated contracts or agreements formalized under the needed guidelines of the local contract law.

Through the relations highlighted by the work, the criticalities involving this aspect of the system were raised; these shall be considered by the other sub-projects in the
following development stages of SAFESPOT as well as by the future activities of BLADE (Business Model, Deployment Program).

The next step of this work package (task 6.3.3), which will be carried out in the last part of the project, will be to define the consolidated Organizational Architecture on the basis of these preliminary results, other than the findings from the other work packages and the feedbacks from the other technical subprojects.

It remains to be seen whether the chosen methodology is flexible enough in practice to deal with the fact that there are many motivations for stakeholders to invest (or not) in cooperative systems such as SAFESPOT and the assumption that the possible benefits of the system are largely macroscopic in nature. The latter implies that the tangible benefits could be lower and this could influence investment decisions.
6. References


SAFESPOT deliverables and working documents:
[4] SP2 - D2.2.2 Needs and Requirements
[5] SP2 - D.2.3.2 Part A - Specifications for Components of Infrastructure Platform
[6] SP3 - D3.3.4 Vehicular Ad Hoc Networks Specifications
[7] SP4 - D4.3.2 SP4 Applications Functional Specifications
[8] SP4 - Safety Margin Application Parameters Analysis and Characterisation
[9] SP5 - D5.2.2 Common Architecture & Communications v2.0
[10] SP5 - D5.2.3 Application Scenarios and Requirements_v2.0-1.doc
[11] SP5 - D5.3.2 Specification of SP5 Hazard and Incident Warning (H&IW) Applications
[12] SP5 - D5.3.3 Specifications for IRIS_v0.7.doc
[13] SP5 - D5.3.1 - Specification of SP5 Speed Alert (SpA) Applications
[14] SP6 - D6.2.1 - Report on preliminary analysis and initial deployment program
[15] SP6 - D6.4.2 - Legal aspects of SAFESPOT systems
[16] SP7 - D7.3.1 Global System Reference Architecture Specification