NordicWay Service Definitions

NordicWay 2

Deliverable D21:2

Version 1.0.0

Date: 28 February 2019

Document Information

Authors

The document is the result of collaborative work of the NordicWay2 partners. The list below includes people which have contributed to the document text.

NAME	ORGANISATION
Erlend Aakre	COWI (Norway)
Camilla Nordström	City of Gothenburg, Urban Transport Administration (Sweden)
Anders Fagerholt	Ericsson (Sweden)
Jørgen Flensholt (editor)	Danish Road Directorate (Denmark)
Magnus Hjälmdahl	Sweco Society AB (Sweden)
Fredrik Hoxell	Scania (Sweden)
Ulrik Janusson	Kapsch TrafficCom (Sweden)
Tomas Levin	Norwegian Public Roads Administration (Norway)
Hannes Lindkvist	Lindholmen Science Park AB (Sweden)
Edwin Mein	Technolution (Sweden)
Johan Scholliers	VTT (Finland)
Henrik Segesten	Connected Car, Volvo Car Corporation (Sweden)
Jonas Sundberg	Sweco Society AB (Sweden)
Torgeir Vaa	Norwegian Public Roads Administration (Norway)
Anette Westerlund	Volvo Cars Corporation (Sweden)
Johan Östling	RISE Viktoria (Sweden)

Document History

DATE	VERSION	UPDATES AND CHANGES	STATUS
2018-05-16	0.0.1	Initial distribution	Draft
2018-07-26	0.0.2	Draft proposal for service and use case definitions for discussion and comments	Draft
2018-11-26	0.0.3	Revised following NordicWay review comments and related discussions within C-Roads TF4.	Draft
2018-12-10	0.0.4	Updated following service and use case descriptions from pilot projects and discussions between the involved partners.	Draft
2019-01-15	0.0.5	Updated following further input from partners.	Draft
2019-01-29	0.0.6	Updated and prepared for review by PMB. Updates of a general nature includes: • Renaming NordicWay Interchange Server to ITS Interchange Server; • Updating C-Roads references to the latest version (Version 1.4).	Draft
2019-02-25	0.0.7	Updated following review comments from partners. Major updates include: • Model of NordicWay Communication Environment updated to make explicit that road operations and content provision systems may include backend modules for direct communication with non-backend systems; • Use cases for Time To Green and Dynamic Environmental Zone revised.	Draft
2019-02-28	1.0.0	Edited for official release.	D21:2

Nordic WAY 2

Content

1 Introduction

1.1 This report

The NordicWay2 Grant Agreement includes a set of tasks related to Activity 2 Technical Coordination. Relating to system design the most important tasks are:

- Improvement of the core architecture designed under the Action NordicWay 2014-EU-TA-0060-S by bringing in the additional services being piloted under Activities 5, 8 and 9. This work will include the development of detailed definitions of each chosen service, including the definition of data value chains, definition of service levels and quality requirements and the definition and agreement on partnership models within NordicWay2 for future full scale implementation.
- Expansion of the security functionality of the Interchange Network defined under the Action NordicWay 2014-EU-TA-0060-S by including confidential channels and improving the granularity of the geo-lookup functions to accommodate use also for applications with high requirements on geographical precision (e.g. intersection level). The security framework will fit with appropriate parts of the security framework developed by the C-ITS Platform working group and will contribute to the security development within C-Roads.

This work is to be reported in two deliverables which after adoption by the Project Management Board also constitute formal milestones of NordicWay2:

- M7: NordicWay architecture and service definitions design, approved by the Project Management Board.
- M8: Final report on the NordicWay architecture and services, approved by the Project Management Board.

The deliverable for milestone 7 is for practical reasons divided into two parts; This document (D21:2) including the Service Definitions, and a separate document developed for Architecture and Security the (D21:1).

The intention of this deliverable, and the work so far in NordicWay2, is to function as a guide for the continued work by reporting on the current status and positions taken. Considerable changes are to be expected for the Final Report, due in 2020, hence this document is not intended to provide detailed instructions on systems design or to report on final results from NordicWay2.

1.2 Relation to C-Roads

The results reported from NordicWay2 concerning Service Definition and Architecture (including this deliverable) are also developed as reports for C-Roads. As the documents are subject to continuous updates and are work in progress following not exactly the same time schedule, eventual differences between the two documents shall be understood as an effect of this rather than being intentional. The work objective is to have fully synchronized results from the projects.

1.3 Purpose of document

The purpose of this document is to provide specifications for the C-ITS services being deployed in the NordicWay Pilots. The specifications include:

- Description of the communication structure of the environment (the NordicWay Communication Environment) in which services are deployed;
- Service profiles defining the functional properties for communication and exchange of ITS messages in C-ITS service provision;
- Messages profiles for the ITS messages being communicated and exchanged during the service provision.

The specifications are developed with the aim of being compatible with the specifications which are developed in C-Roads. With this in view, service and message profiles are defined following the same structure and format which are used in the C-Roads specifications, and by reusing profiles from these specifications.

The communication environment and service profiles are described in terms UML diagrams. The diagrams include Class, Use Case, Communication and Sequence Diagrams.

The document is the first deliverable (D21) for WP 221 (Service Definitions) of Task 2: NordicWay Service Definition, of the NordicWay project. This deliverable provides initial design specifications for the Pilots. The second deliverable (D22) provides the final specifications with possible revisions and updates following from Pilot experiences [NW2-WP].

The document represents work in progress. It includes specifications which are tentative and subject to change and refinement as well specifications which are incomplete with elements to de defined (TBD). The specifications will be completed in the second deliverable (D22).

1.4 Scope

1.4.1 NordicWay Pilots

The NordicWay project includes 3 pilots which implement C-ITS services. These pilots are managed and operated by the Norwegian, Finnish and Swedish partner, respectively. Pilot execution is from June 2019 to May 2020.

Table 1 provides an overview of the Pilots.

Pilot	Description	Responsible Partner
Norwegian Pilot 1: C-ITS Services	The Pilot builds on the C-ITS Platform – with a focus on the rural road network. The benefits of C-ITS services and use cases to road users, freight transport operators and/or road authorities will be explored. Also, the feasibility of services under the prevailing conditions in the subarctic areas will be explored [NO-PILOT].	Norway
Finnish Pilot 2: C-ITS Services	In the Finnish pilot 3 consortia deliver Day 1 C-ITS services over cellular networks. Focus in the Finnish pilot is the collection of data from users and vehicles.	Finland
Swedish Pilot: C-ITS Services	The Swedish Pilot is based around four service clusters (Emergency vehicles warning, Traffic signals, Access control and Road Work Warnings). For each of these clusters one or several services will be developed, implemented, piloted and evaluated. The pilots will take place in real traffic in the cities of Stockholm, Uppsala and Gothenburg. Vehicles for the pilots are provided by industry partners, and there are also app-based services being implemented [SW-PILOT].	Sweden

Table 1 NordicWay2 Pilots implementing C-ITS Services

1.4.2 Types of Services

The Pilots target deployment of the Day-1 and Day-1.5 C-ITS services plus some additional C-ITS and CAD-related services [NW2-WP].

1.4.2.1 Day-1 and Day 1.5 Services

Table 2 and Table 3 summarize the Day-1 and Day-1.5 services to be deployed by the various NordicWay pilots according to current plans. With a few exceptions, services are named in the same way as the Day-1 and Day-1.5 services of the C-ITS Platform [C-ITS-16]. Exceptions are marked in italics.

Day-1 Service	Deployed by
Slow and stationary vehicle(s) *&Traffic ahead warning*	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
Road works warning	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
	Swedish Pilot: C-ITS Services
Weather *and road* condition	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
Emergency brake light	Norwegian Pilot 1: C-ITS Services
Emergency vehicle approaching	Finnish Pilot 2: C-ITS Services
	Swedish Pilot: C-ITS Services
Other hazardous location notifications (OHLN)	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
	Swedish Pilot: C-ITS Services
In-vehicle signage	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
	Swedish Pilot: C-ITS Services
In-vehicle speed limits	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
Probe vehicle data	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
Signal violation/Intersection safety	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
Traffic signal priority request by designated vehicles	Finnish Pilot 2: C-ITS Services
	Swedish Pilot: C-ITS Services
Green light Optimal Speed Advisory (GLOSA)	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
	Swedish Pilot: C-ITS Services
Time To Green	Swedish Pilot: C-ITS Services

Table 2 Day-1 Services in the NordicWay Pilots.

Day-1.5 Service	Deployed by
Information on AFV fueling & charging stations	Norwegian Pilot 1: C-ITS Services
On street parking information and management	Norwegian Pilot 1: C-ITS Services
Traffic information and smart routing	Norwegian Pilot 1: C-ITS Services
	Finnish Pilot 2: C-ITS Services
Cooperative collision risk warning	Norwegian Pilot 1: C-ITS Services
Connected & cooperative navigation into and out of the city	Swedish Pilot: C-ITS Services

Table 3 Day-1.5 Services in the NordicWay Pilots

1.4.2.2 Other Services

In addition to Day-1 and Day-1.5 services two other services will be deployed (Table 4).

Service	Deployed by
Collection of data for mapping of infrastructure readiness	Norwegian Pilot 1: C-ITS Services
Running of automated driving pilots	Finnish Pilot 2: C-ITS Services

Table 4 Other Services in the NordicWay Pilots

1.5 Document Overview

The document is structured as follows:

- Chapter 1 (Introduction) defines the purpose of the document and outlines the scope of the work.
- Chapter 2 (Abbreviations and Definitions) lists abbreviations and definitions which apply to the document.
- Chapter 3 (References) lists the references which apply to the document.
- Chapter 4 (The NordicWay Communication Environment) defines the different types of entities and communication links of the environment in which C-ITS services are piloted.
- Chapter 5 (Functional Service Specification) defines the service profiles for the C-ITS services which are piloted in this environment.
- Chapter 0 (Message Harmonization) defines message profiles for the messages being communicated and exchanged during service provision in the NordicWay pilots.
- Chapter 7 (Appendices) includes appendices of the document.

A separate document on the Finnish DATEX II profile [FI-DATEXII] shall be considered as annexed to the document.

2 Abbreviations and Definitions

2.1 Abbreviations

For the purpose of this document, the following abbreviations apply.

Term	Definition
AFV	Alternative Fuel Vehicle
CAD	Connected and Automated Driving
CAM	Cooperative Awareness Message
C-ITS	Cooperative Intelligent Transport Systems
CZ	Control Zone
DENM	Decentralized Environmental Notification Message
EBL	Emergency Brake Lights
Eco-AT	European Corridor – Austrian Testbed for Cooperative Systems
ETSI	European Telecommunications Standards Institute
EVA	Emergency Vehicle Approaching
GLOSA	Green Light Optimal Speed Advisory
HLN	Hazardous Location Notifications
I2V	Infrastructure-To-Vehicle
IVS	In Vehicle Signage
MAPEM	MAP (topology) Extended Message
MCS	Motorway Control Systems
N/A	Not applicable
OEM	Original Equipment Manufacturer
PDA	Personal Digital Assistant
PVD	Probe Vehicle Data
RSU	Road Side Unit
RTA	Road Traffic Authority
RWW	Road Works Warning
SI	Signalized Intersections
SPATEM	Signal Phase And Timing Extended Message
SRTI	Safety Related Traffic Information
SWD	Shockwave Damping
TBD	To be defined
TSP	Traffic Signal Priority request by designated vehicles
TTG	Time To Green
UML	Unified Modeling Language
V2I	Vehicle-To-Infrastructure
V2V	Vehicle-To-Vehicle

Term	Definition
VMS	Variable Message Sign

2.2 Definitions

For the purpose of this document, the following terms and definitions apply.

Term	Definition
Actor	An entity (human, system) which is involved in the provision of an ITS or C-ITS service.
C-ITS Message	ITS message being distributed and exchanged between actors during provision of a C-ITS service. In the C-ROADS platform C-ITS messages are ETSI standard messages.
C-ITS Service	An ITS service provided to ITS users by distributing and exchanging secured and trusted ITS messages. In the C-Roads platform security is implemented using the EU C-ITS Security Credential Management System.
ITS Message	Message being distributed and exchanged between actors during provision of an ITS Service.
ITS Service	Service provided to an ITS User.
Service Profile	A set of functional specifications for the provision of an ITS or C-ITS service.
Message Profile	A set of functional and technical specifications for messages which represent the information being exchanged during the provision of an ITS or C-ITS service.
Scenario	A sequence of messages, events and actions in the interaction between actors in a use case for provision of an ITS or C-ITS service.

3 References

C-ITS-16	C-ITS Platform Final Report January 2016
C-ITS-17	C-ITS Platform Final report Phase II September 2017
DEL-ACT	ANNEX to the Commission Delegated Regulation supplementing ITS Directive 2010/40/EU of the European Parliament and of the Council with regard to the provision of cooperative intelligent transport systems Ref. Ares(2019)153204 - 11/01/2019
DG-886/2013	Commission Delegated Regulation (EU) No 886/2013 Official Journal of the European Union 18.9.2013
ETSI-302 665	Intelligent Transport Systems (ITS) Communications Architecture ETSI V1.1.1 (2010-09)
FI-DATEXII	NordicWay Finnish DATEX II 3.0 profile Forthcoming
NO-PILOT	Pilot Plan for the Norwegian Pilot 1: Use cases of Day and Day 1.5 C-ITS services Version 1.0 29. October 2018
NW-ARC	NordicWay Architecture, Services and Interoperability Issue 1.0 25 October 2016
NW2-WP	NordicWay2 Work Plan Version 0.95 15. May 2018
SCOOP-MES	Specification of DATEX II v2.3 messages in conjunction with CAMs and DENMs in SCOOP Deliverable 2.4.1.4 Activity 2: Studies Version 2.00

SRTI	Safety related message sets – Selection of DATEX II, Codes, DENM Event Types, TPEG2-TEC Causes and TMC Events for EC high level Categories ITSTF17001 v1.0 2017-02-14
SW-PILOT	M35 Pilot Plan NordicWay2 16 November 2018
TF2-SD1.4	Common C-ITS Service Definitions C-Roads Platform Working Group 2 Technical Aspects Taskforce 2 Service Harmonisation
TF3-IFS1.3	C-ITS Infrastructure Functions and Specifications Release 1.3 C-Roads Platform Working Group 2 Technical Aspects Taskforce 3 Infrastructure Communication
TF3-IFS1.4D	C-ITS Infrastructure Functions and Specifications First draft for Release 1.4 C-Roads Platform Working Group 2 Technical Aspects Taskforce 3 Infrastructure Communication

4 The NordicWay Communication Environment

4.1 Introduction

This chapter describes the environment of interconnected entities which interact and exchange information to support C-ITS service provision in the NordicWay pilots. The entities (actors) include the major systems/components of the physical architecture (distributed backend systems, road user systems and road side systems).

4.2 Entities

The following identifies the different types of entities (systems and humans) of the NordicWay communication environment.

The communication architecture includes two types of systems, backend systems on one hand, and other (non-backend) systems of road users (personal and vehicle systems, road side unit systems) on the other. The latter type of systems are the in-device and in-vehicle parts of C-ITS service provision, and the backend systems provide the remaining communication infrastructure for ITS message distribution and exchange. The NordicWay backend may include multiple different interconnected systems (traffic management centres, OEM application clouds, interchange servers, etc.).

All types of systems are assumed to be service providing systems, i.e. they implement services (functionality) for distributing and exchanging ITS messages.

Entity	Definition
Application Backend System	Backend system for communicating with personal devices, vehicles and road side units. Includes application backend systems of equipment manufacturers (OEM's) as well as of other (public, private) service providers. Subtype of Backend System.
Backend System	Central system with service for communicating ITS messages. Subtype of Service Provider System.
Content Provisioning System	System providing ITS message content. Examples of this type of type of system are 3rd party service provider and integrator systems. Subtype of Backend System.
Designated Vehicle	Public transport vehicle, emergency vehicle, heavy goods vehicle, etc. Subtype of Vehicle.
Driver	Driver of a vehicle. Subtype of Road User.
ITS Interchange System	System with public standard service for communicating ITS messages between backend systems. Also referred to as Interchange Server or System. Subtype of Backend System.
Application Backend System	Backend system for communicating with personal devices, vehicles and road side units. Includes application backend systems of equipment manufacturers (OEM's) as well as of other (public, private) service providers. Subtype of Backend System. Maybe be module of Road Operations System and Content Provisioning System.
Personal Device	Personal device (smartphone, navigator, etc.) with service for communicating ITS messages. Subtype of Road User System.
Road Operator	Operator of a road network and traffic on that network. Includes traffic mangers, traffic controllers, etc. User of Road Operations System and Content Provisioning System.
Road Operations System	System for operating and managing a road network and the traffic on that network. Includes service for communicating ITS messages. Examples of this type of system are Traffic Operations and Traffic Management Systems. Subtype of Backend System.
Road Side System	System of devices located at the roadside with service for communicating ITS messages. Examples of this type of devices are variable message signs (VMS), traffic light systems, cameras and detectors. May provide connectivity support to passing vehicles. Subtype of Service Provider System.
Road User	User of the road network. User of Road User System and Road Side System.
Road User System	Personal or vehicle system with service for communicating ITS messages. Subtype of Service Provider System.
Service Provider System	System with service for distributing ITS messages. Includes central, local, personal and vehicle ITS subsystems [ETSI-302 665].
Vehicle	Car, truck, bus, emergency vehicle, maintenance vehicle, etc. Includes service for communicating ITS messages. Subtype of Road User System.
Vulnerable Road User	Cyclist, pedestrian, etc. Subtype of Road User.

Table 5 Types of Entities (systems and humans)

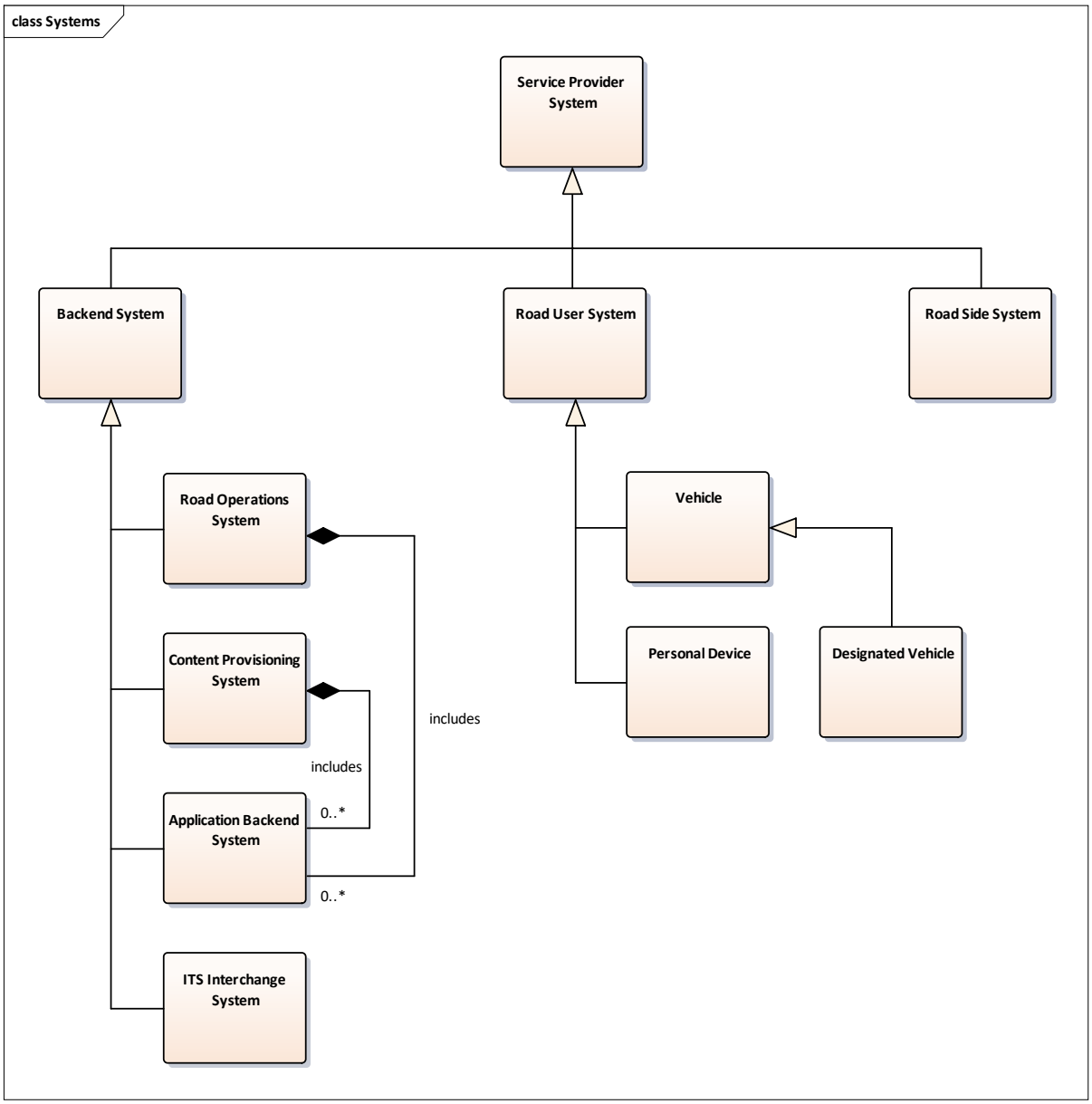

Figure 1 Systems and Their Type-Subtype Relationships

Compared to the C-Roads service and use case definitions, C-ITS service provision in NordicWay involves two additional types of systems, ITS Interchange System and Application Backend System. These systems perform the role of intermediaries for communication between road operations systems and other service provider systems and between these systems and road user systems and road side systems. The role may be played by multiple different systems corresponding to different and alternative communication services and technologies.

The model covers the case where application backend facilities are included as parts/submodules of road operator and content provision systems for direct communication with non-backend systems.

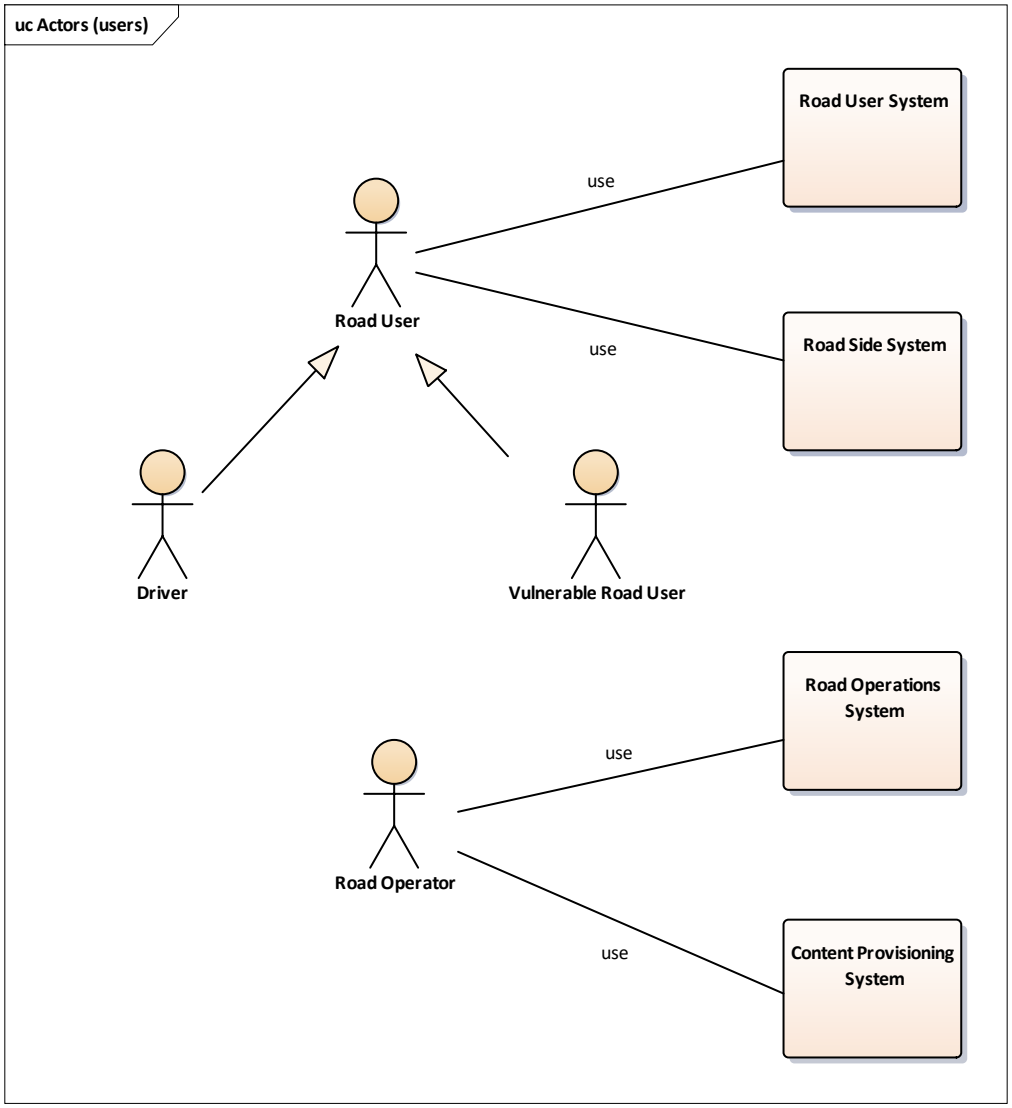

Figure 2 Human Entities (Actors) and Their Relationships to Systems

4.3 Communication Links between Systems

The following identifies the communication links between the different types of systems in the Nordic-Way communication environment.

These links include communication links between backend systems (backend communication) and between backend systems and other (non-backend) systems (vehicles, personal devices, road side systems).

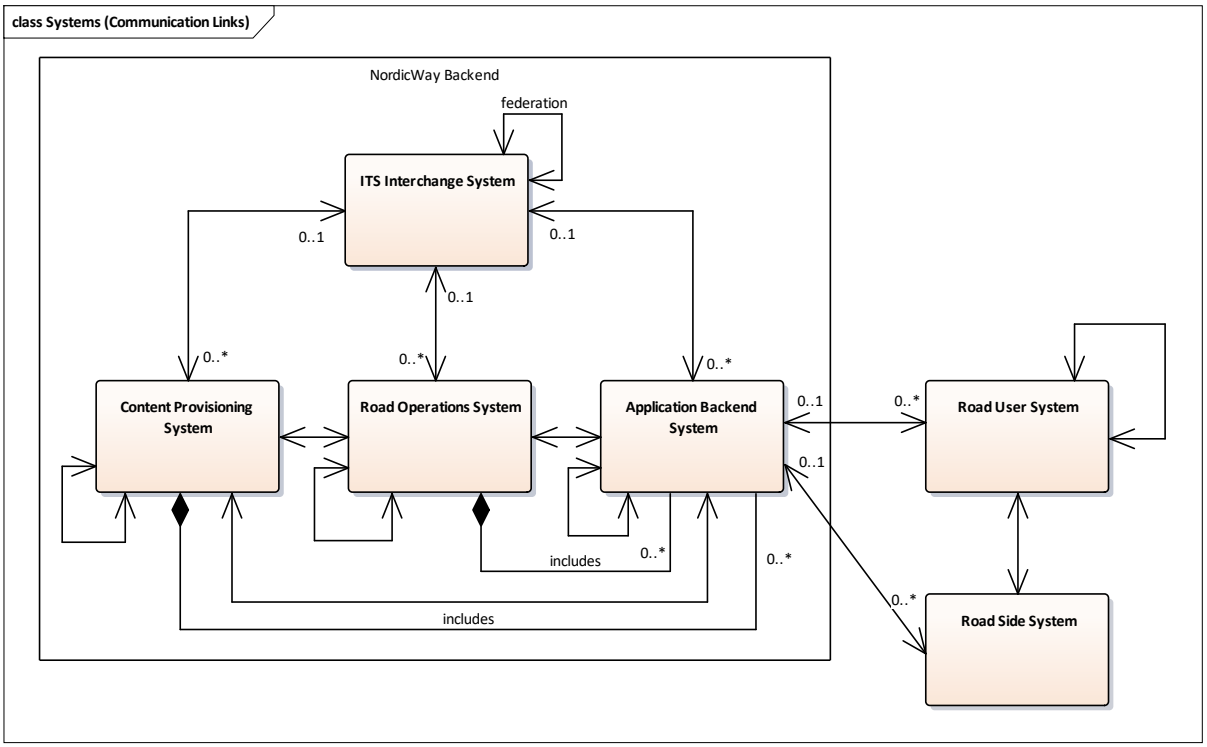

Figure 3 Communication Links between Systems

4.3.1 Backend Communication

Backend systems are organized in a connected structure, where individual systems can communicate via a common interchange system, which supports message distribution and exchange following a Publish-Subscribe pattern. This model supports loose and flexible coupling between publishing and subscribing systems which can communicate via a common interface without the need to know each other and the underlying system and network architecture. Another advantage of the model is that it supports scalability.

The interchange system may be a single entity or a federation of individual interchange systems operating in a collective fashion (the Interchange Network). This aspect of backend system communication is not considered in the service and use case descriptions, and communication with interchange systems is described as if communication is with a single entity.

The model of communication supports many-to-many communication between the different types of backend systems (road operations systems, content provisioning systems and application backend systems), allowing road, content provisioning and application operators to coordinate their activities by exchanging and sharing information via the common interchange facility. Direct communication between road operations and content provisioning systems and non-backend systems will be via application backend modules of the backend systems.

The model allows direct communication in the backend between road operations systems, content provisioning systems and application backend systems. This type of communication is applied but is not in the focus area of the NordicWay Pilot Projects.

4.3.2 Communication with Road User Systems and Road Side Systems

The primary form of communication with non-backend systems (vehicles, personal devices, road side systems) in the NordicWay environment is via application-specific backend systems which are available for this communication.

The communication may be one-way and two-way supporting service provision where communication is from backend to road users and service provision where services provided to road users are based on information from devices and vehicles.

5 Functional Service Specification

5.1 Introduction

This chapter identifies service profiles for the C-ITS services being deployed by the NordicWay Pilots. Services are defined in terms of use cases with scenarios showing how the different types of entities interact in the NordicWay Communication Environment to realize prescribed objectives. The services are described following the structure and format of the C-Roads specifications [TF2-SD1.4].

The specifications are developed using the following main guidelines:

- The grouping of services and use cases into service groups should be the same as the grouping used in the C-Roads specifications.
- Services and use cases are based on the list of Day-1 and Day-1.5 services of the NordicWay2 workplan [NW2-WP]. Every use case description includes an entry describing how the use case relates to C-Roads use cases.
- Services and use cases should be described from a functional perspective without making assumptions about technology and implementation. The use cases are intended to be abstract and high-level and not biased towards specific use case realizations.
- Service and use case definitions should be designed to provide a common basis for defining the realizations to be deployed by the various Pilots.

The NordicWay service and use case definitions are related to the C-Roads specifications as follows:

- The entity (actor model) is extended with systems and communication links of the NordicWay Communication Environment;
- Services and use cases of the C-Roads specifications are reused;
- New use cases are added. These use cases include composite use cases defined by combining and extending existing and new (elementary) use cases;
- Existing use cases are complemented with use case realizations for service provision in the NordicWay Communication Environment.

The specifications focus on system-to-system communication. Interaction with human entities (such as road users, drivers, road operators and road traffic operators) is only covered to show how it relates to the system-to-system communication.

References to C-Roads services and use case definitions refer to the latest version of the definitions which has been approved by the C-Roads Steering Committee. At the time of writing this version is version 1.4 [TF2-SD1.4].

The specifications may include references to C-Roads proposals for services and use cases which have not yet been approved by the C-Roads Steering Committee. These references are for informative purposes only.

Annex 1 of the draft Delegated Act [DEL-ACT] includes descriptions of use cases and scenarios for a list of priority services – primarily from a V2V perspective. Use cases and scenarios for these services have not considered in this version of the document.

5.2 Use Case Structure

Use cases may be structured in terms of the following types of relationships:

- Generalization relationships defining a use case as a specific use case of a more general one;
- Extension relationships extending the behaviour of one use case (the base use case) with behaviour of another use case (the extension);
- Inclusion relationships where a use case includes the behaviour of another use case.

Use case structures are described in terms of UML use case diagrams. The current version of the specifications includes only use case structures defined in term of generalization and extension relationships.

The main type of use case extensions in the specifications define data provision and data collection from different sources required for service provision. For example, the focus in the Finnish Pilot is on the collection of data from service providers, vehicles and users on the road network.

To identify use cases with this type extensions the following extension to the C-Roads syntax for naming use cases is used:

<*C-Roads service name*>-<*C-Roads use case name*>[-<*data source*>]

where a possible use case extension is indicated by an optional <*data-source*> element. The <*data source*> is one of the following:

- "-v" indicates vehicle generated data, from vehicle sensors;
- "-u": indicates data generated manually by a road user;
- "-t": indicates data generated by road side systems (e.g. traffic lights).

A use case name with no <*data source*> indicates a C-Roads use case, as in the C-Roads specifications.

5.3 In Vehicle Signage (IVS)

5.3.1 Service Introduction

Service Introduction: In Vehicle Signage	
Summary	The service is to inform drivers about actual, static and dynamic road signs via in-vehicle systems. Road signs can be mandatory or advisory.
Background	Physical road signs are used to inform drivers of passing vehicles about speed limits, expected travel times, etc. The same information is provided to all drivers irrespective of vehicle type. Access to physical road sign information can be impeded in different ways due to reduced visibility, lack of driver attention, etc. Providing road sign information to drivers via in-vehicle equipment is an alternative way to inform drivers about road signs. It can be used to complement physical road signs and improve accessibility to road sign information. Furthermore, it provides for targeting road sign information to specific types of vehicles and drivers.
Objective	The objectives of the service are to: • Increase awareness of drivers to road signage; • Reduce drivers' problems with observing and interpreting physical signs, e.g. due to reduced visibility, obstructions of different kinds, and limited attention to signs.
Expected benefits	Expected benefits include: • Improved driver awareness to road sign information; • Improved quality of road sign information (information can be provided in a timely and continuous manner); • Improved accessibility of road sign information irrespective of reduced visibility and other environmental conditions; • Increased usability (information can be targeted to specific vehicles and users).
NordicWay Use Cases	The use cases for the service include: • In Vehicle Speed Limits
C-Roads Services	In Vehicle Signage (IVS) [TF2-SD1.4].

Table 6 Service Introduction to In Vehicle Signage

5.3.2 Use Cases

5.3.2.1 In Vehicle Speed Limits

Use Case Description	
Summary	Drivers receive notifications via in-vehicle systems about the dynamic speed limits displayed on road side VMS systems.
C-Roads Use Cases	Dynamic Speed Limit Information (IVS-DSLI) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Side System (displays and sends speed limit information) • Road Operations System, Content Provisioning System (receives and distributes speed limit information); • Interchange System, Application Backend System (distributes speed limit information) • Vehicle (receives speed limit information and displays it to driver);
Logic of transmission	Two-way communication (I2V, V2I)
Triggers	TBD
Constraints/dependencies	The road operator has defined speed limits which are displayed on the VMS systems.

Table 7 Description of In Vehicle Speed Limits

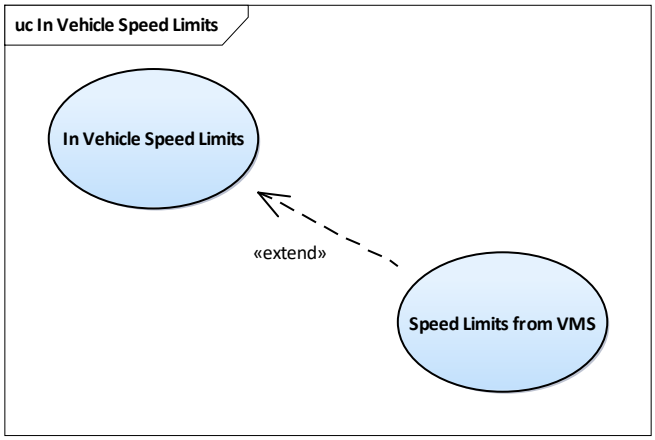

Figure 4 Use Case Structure for In Vehicle Speed Limits

Scenario for use case with extension: Speed Limits from VMS (IVS-DSLI-t) (Figure 5)
The road operator (N) gets the speed limit displayed on a VMS-based road side system (VMS1) via its application backend system (VMS) and publishes this information to the interchange system. The information is received by an application backend system (V) subscribing to messages from the operator. The backend system forwards the information to vehicles (V1, V2), which are on the section of the road network to which the speed limit applies.

Table 8 Scenario for In Vehicle Speed Limits

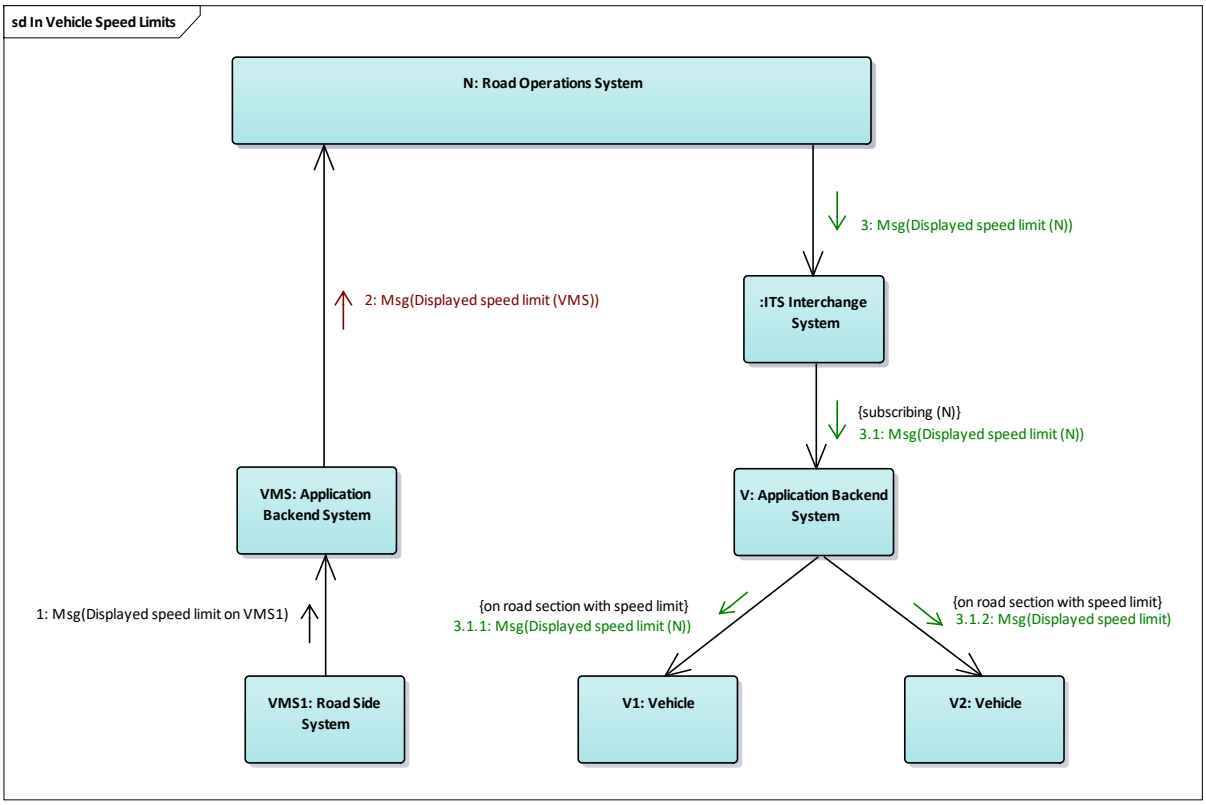

Figure 5 Scenario for In-Vehicle Speed Limits (Speed Limits from VMS)

5.4 Hazardous Location Notifications (HLN)

5.4.1 Service Introduction

Service Introduction: Hazardous Location Notifications	
Summary	The service is to warn road users about potentially hazardous situations or events on the road. Warnings include information about the location and type of a hazard, distance to the hazard, its expected duration, etc.
Background	Hazardous locations represent a risk for road users since they may cause (more) accidents resulting in injuries/fatalities. Warning road users about nearby hazardous locations should increase their alertness and allow them to adapt their behaviour accordingly.
Objective	The objective is to inform road users about nearby hazardous locations.
Expected benefits	Expected benefits include: • More attentive and cautious driving while approaching and passing hazardous locations. • Reduced risks for collisions and accidents and hence fewer incidents/injuries/fatalities among road users.
NordicWay Use Cases	The use cases for the service include: • Accident Zone Description • Weather and Road Conditions • Slow and Stationary Vehicles • Traffic Ahead Warning • Emergency Brake Lights • Emergency Vehicle Approaching • Animal or Person on the Road • Obstacle on the Road • Cooperative Collision Warning
C-Roads Services	Hazardous Location Notifications (HLN) [TF2-SD14].

Table 9 Service Introduction to Hazardous Location Notifications

5.4.2 Use Cases

5.4.2.1 Weather and Road Conditions

Use Case Description	
Summary	Drivers receive warnings about dangerous and changing weather and road conditions.
C-Roads Use Cases	Weather Condition Warning (HLN-WCW) and Temporarily slippery road (HLN-TSR) [TF2-SD1.4].
Actors and relations	The main actors are: • Interchange System, Application Backend System (distributes warnings); • Road Operations System, Content Provisioning System (receives and distributes warnings) • Vehicle, Personal Device (may detect and report dangerous and changing conditions, receives warnings and displays them to the driver);
Logic of transmission	One-way and two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	Warnings shall include information about the location and type of the conditions, and driving behaviour advice, where appropriate. Warnings shall be withdrawn if the conditions cease to exist, or they shall be updated if the conditions change.

Table 10 Description of Weather and Road Conditions

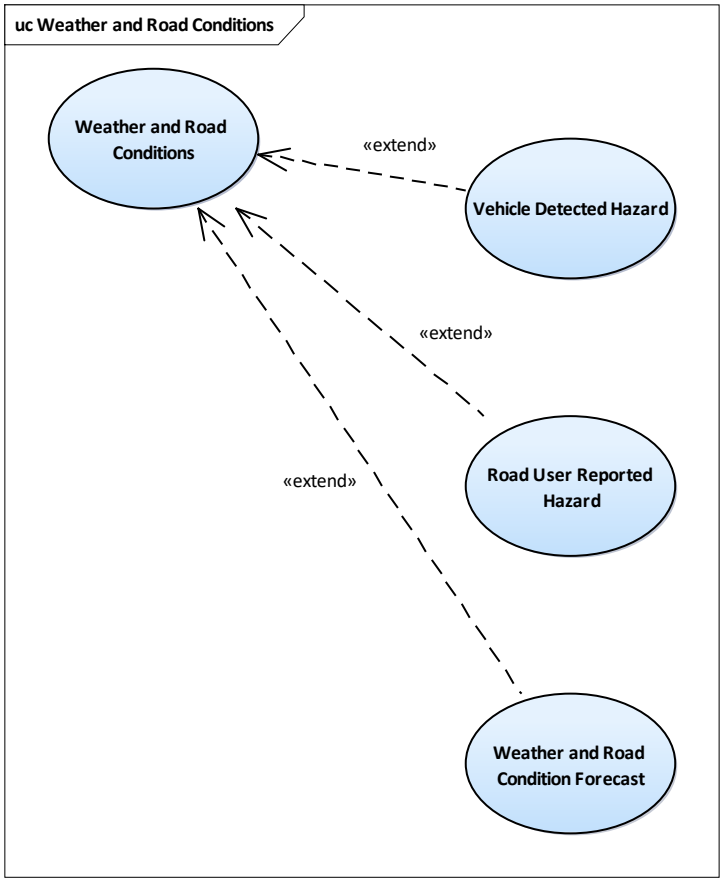

Figure 6 Use Case Structure for Weather and Road Conditions

Scenario for use case with extension: Vehicle Detected Hazard (HLN-WCW-v) (Figure 7)
A vehicle (V1) detects a hazard (slippery road condition) by means of its sensors. Information about the hazard goes to the application backend system (V) of that vehicle which distributes the information via the interchange system to service the road operator (N) and other service providers subscribing to messages from that backend system. A hazard warning is then distributed via the interchange system and application backend systems (V, P) to road user systems (vehicles, devices) approaching the hazard.
Scenario for use case with extension: Weather and Road Condition Forecast (HLN-WCW)
A content provisioning system (meteorological service) predicts a hazard (slippery road condition, fog, or storm) and distributes a hazard warning as described above.
Scenario for use case with extension: Road User Reported Hazard (HLN-WCW-u)
A road user reports a hazard (e.g. reduced visibility) through a personal device (phone app). Information about the hazard goes to the application backend system of the app which distributes the information via the interchange system to service providers (road operator, content provider) subscribing to messages from that backend system. A hazard warning is then published and distributed as described above.

Table 11 Scenarios for Weather and Road Conditions

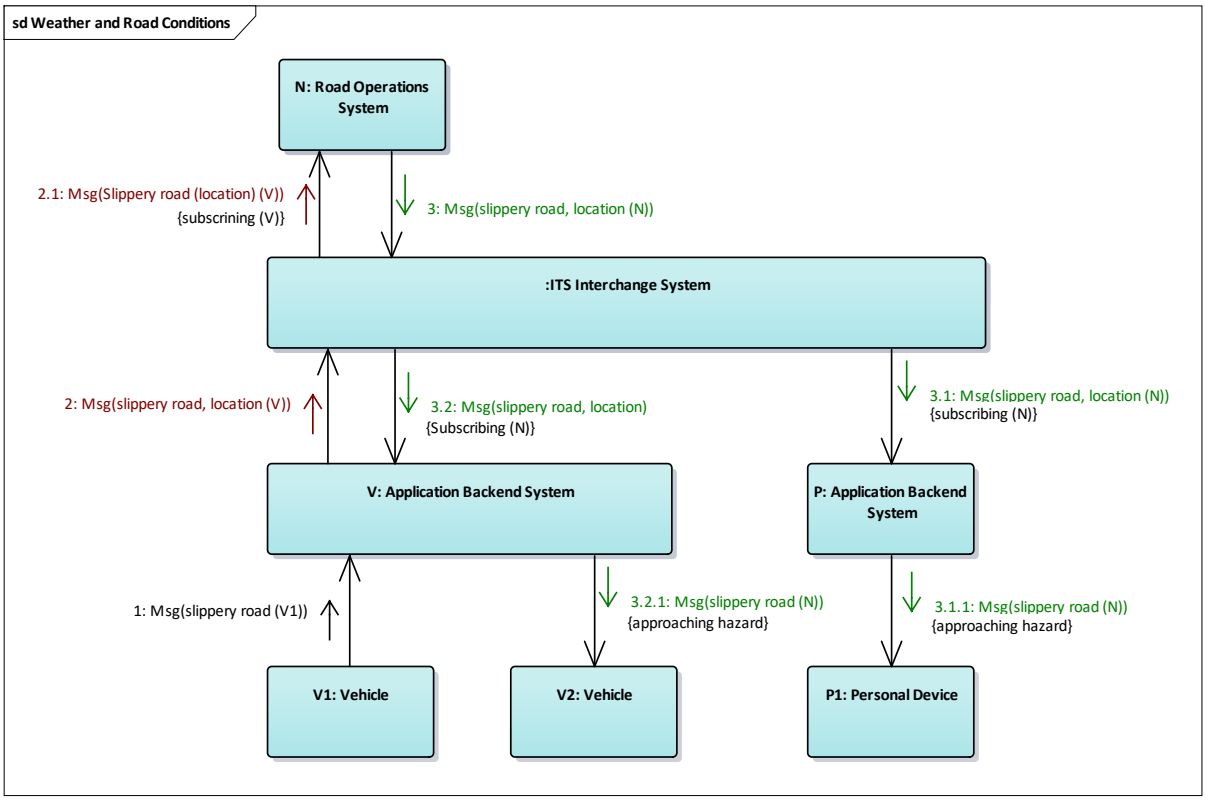

Figure 7 Scenario for Weather and Road Conditions (Vehicle Detected Hazard)

5.4.2.2 Slow and Stationary Vehicles

Use Case Description	
Summary	Drivers receive information about nearby slow or stationary vehicles.
C-Roads Use Cases	Stationary Vehicle (HLN-SV) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System (receives and distributes information); • Interchange System, Application Backend System (distributes information); • Vehicle, Personal Device (may detect and report slow moving and stationary vehicle, receives warnings and displays them to the driver);
Logic of transmission	Two-way communication (I2V, V2I)
Triggers	TBD
Constraints/dependencies	TBD

Table 12 Description of Slow and Stationary Vehicles

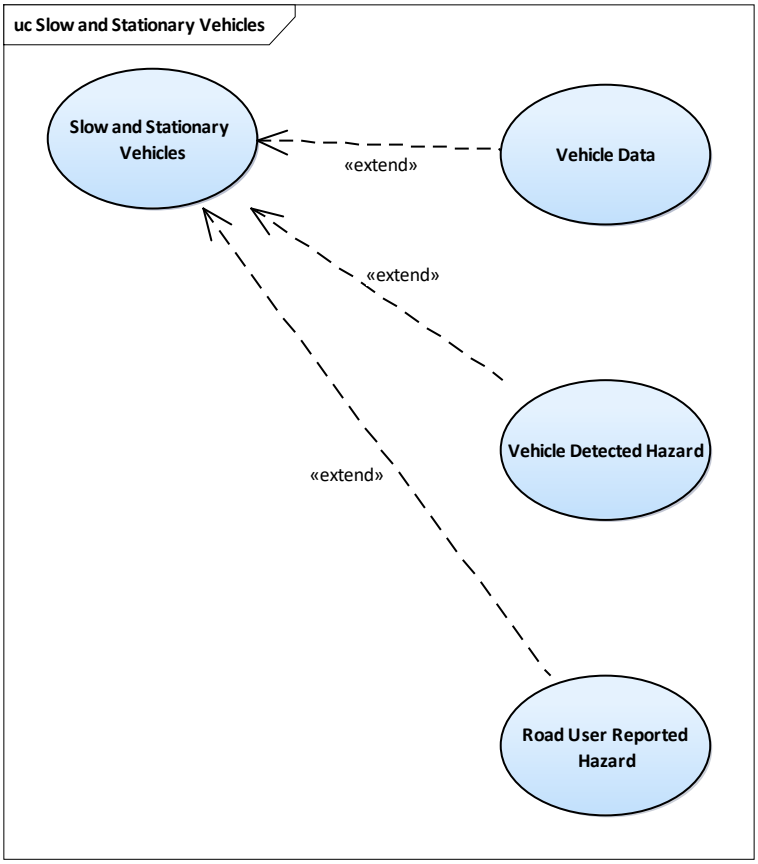

Figure 8 Use Case Structure for Slow and Stationary Vehicles

Scenario for use case with extension: Vehicle Data (Figure 9)
The application backend system (M) of a slow-moving vehicle (e.g. heavy goods vehicle) (M1) receives location and status information from the vehicle. The information is published to the interchange system and is received by a subscribing road operator (S) responsible for the road network where the vehicle is located. The road operator issues a general warning (SSV) with the status and location information. The warning is published on the interchange system and received by subscribing application backend systems (V, P) and by the road operator (DK) of a neighbouring road network which is now informed about the vehicle. The application backend systems forward the warning to vehicles (V1, V2) and personal devices (P) which are close to the vehicle.
Scenario for use case with extension: Road User Reported Hazard (HLN-SV-u)
A road user reports a stationary vehicle via a personal device (phone app). Information about the hazard goes to the application backend system of the app which forwards the information via the interchange system to service providers subscribing to messages from that backend system. A hazard warning is distributed to road users via the interchange system as described above.

Table 13 Scenarios for Slow and Stationary Vehicles

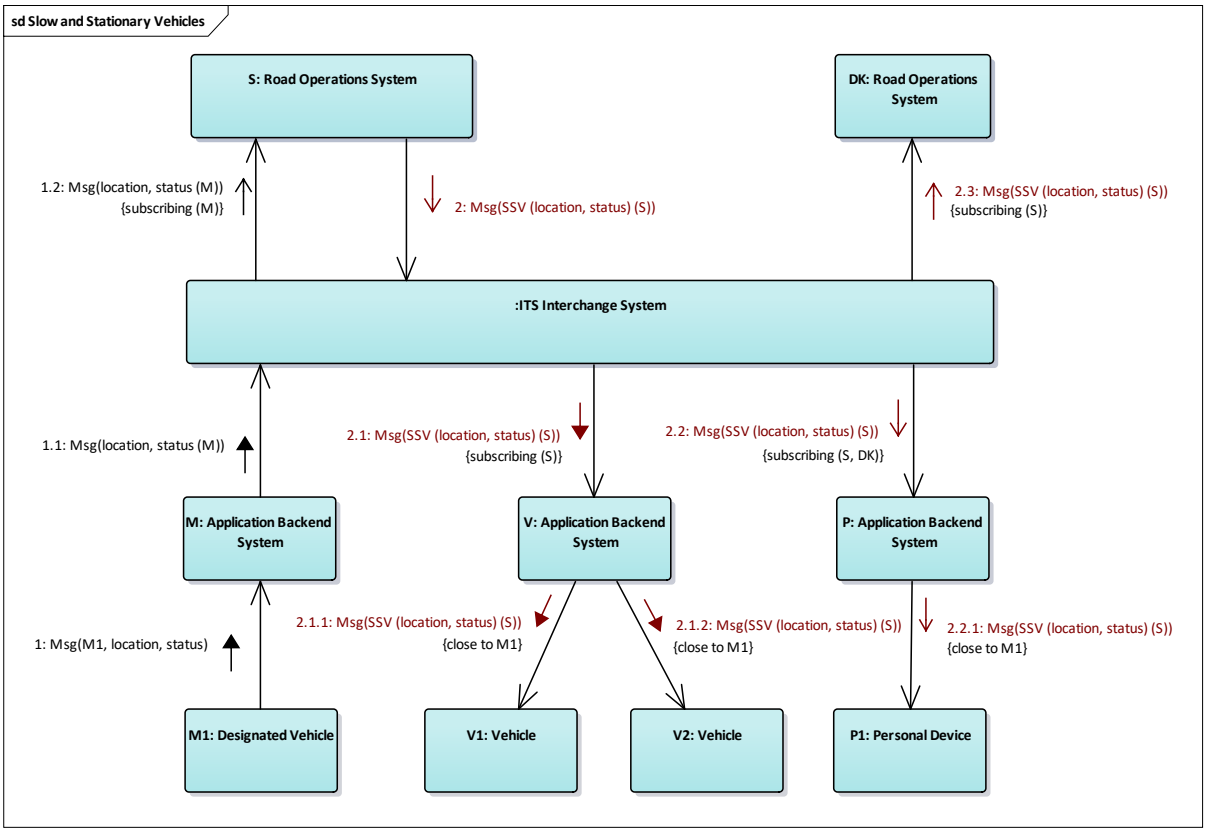

Figure 9 Scenario for Slow and Stationary Vehicles (Vehicle Data)

5.4.2.3 Emergency Vehicle Approaching

Use Case Description	
Summary	Drivers receive warnings about approaching emergency vehicles.
C-Roads Use Cases	Use cases for Emergency Vehicle Approaching (HLN-EVAP) are being developed.
Actors and relations	The main actors are: • Emergency Vehicle (reports current position and speed); • Content Provisioning System (distributes emergency vehicle data); • Application Backend System, Interchange System (distributes emergency vehicle data and warnings); • Road Operations System (distributes warnings) • Vehicle (receives warnings and displays them to the driver).
Logic of transmission	Two-way communication (V2I, I2V).
Triggers	Emergency vehicle starts mission.
Constraints/dependencies	Communication channel from Emergency Vehicle must exist with information about position and heading if vehicle is on mission.

Table 14 Description of Emergency Vehicle Approaching

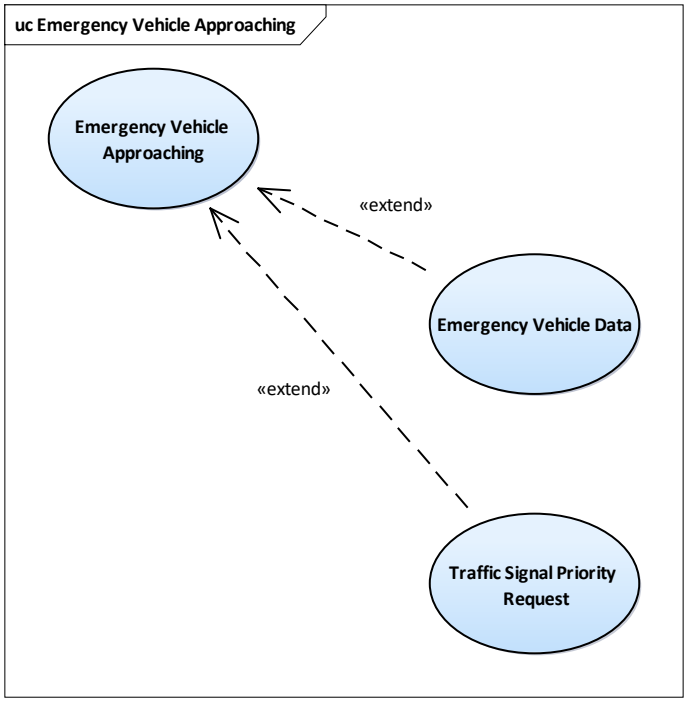

Figure 10 Use Case Structure for Emergency Vehicle Approaching

Scenario for use case with extension: Emergency Vehicle Data (HLN-EVAP-v) (Figure 11)
The current position and speed of an emergency vehicle (D1) travelling on the road network are received by the content provisioning system (D) managing the vehicle. The system distributes the information to the interchange system. The information (EVA) is distributed in three formats, DATEX II, DENM and CAM. The DATEX II messages are received by the road operator (S) and by an application backend system (V) subscribing to this type of messages. The application backend system forwards the messages to connected vehicles (V1, V2) which are near the emergency vehicle. DENM and CAM messages are received by an application backend system (W) subscribing to messages in these formats. The messages are forwarded to vehicles (W1) close to the emergency vehicle.
Scenario for use case with extension: Traffic Signal Priority Request (HLN-EVAP-t)
An emergency vehicle requests priority to a traffic light system which forwards the request to its application backend system. The backend system publishes an EVA message to the interchange system. The warnings are forwarded to nearby vehicles via subscribing application backend systems.

Table 15 Scenarios for Emergency Vehicle Approaching

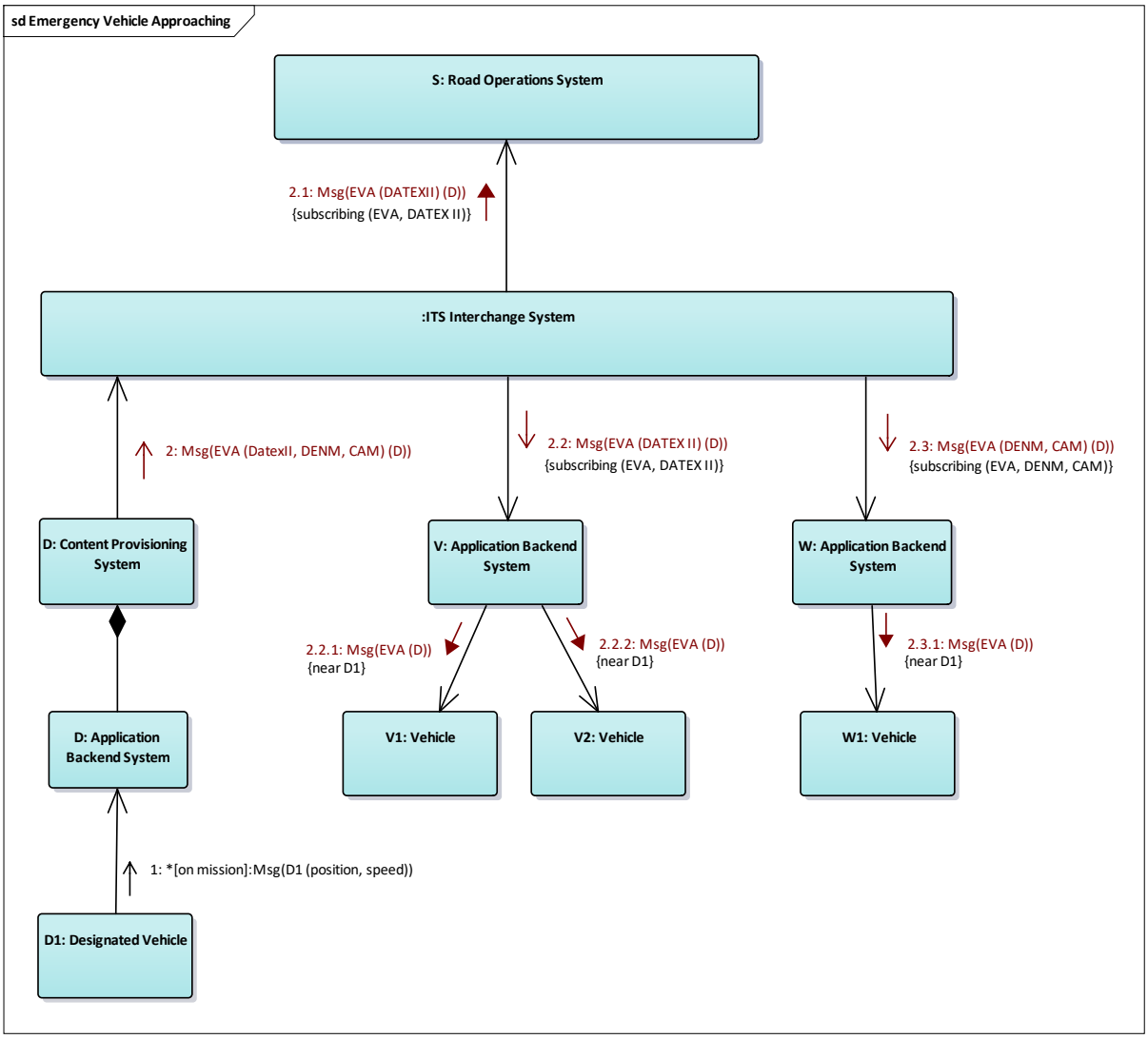

Figure 11 Scenario for Emergency Vehicle Approaching (Emergency Vehicle Data)

5.4.2.4 Traffic Ahead Warning

Use Case Description	
Summary	Drivers receive warnings about traffic jams ahead.
C-Roads Use Cases	Traffic Jam Ahead (HLN – TJA) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System (receives information about traffic ahead, distributes traffic ahead warning); • Interchange System, Application Backend System (distributes warnings); • Vehicle, Personal Device (detects and reports traffic ahead, receives warning and displays them to the driver).
Logic of transmission	Two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 16 Description of Traffic Ahead Warning

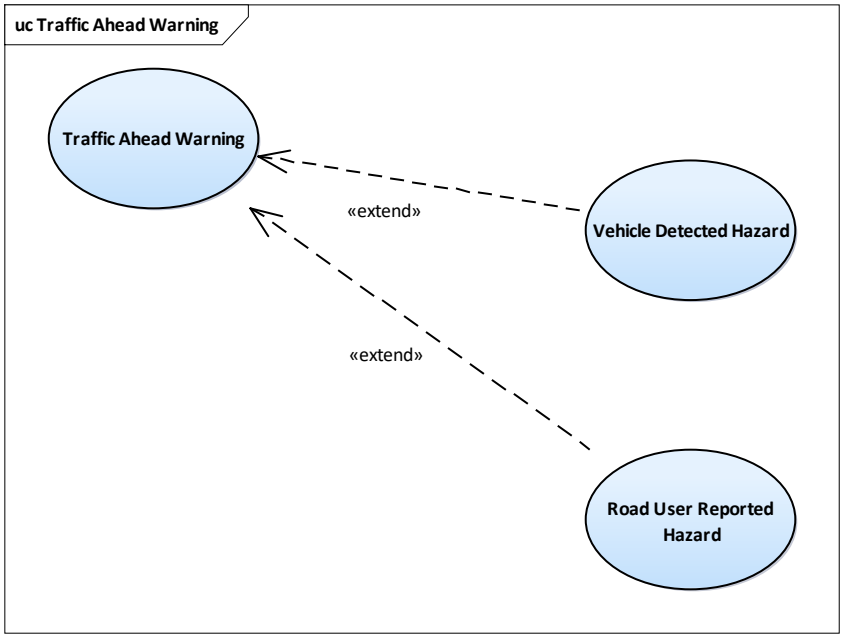

Figure 12 Use Case Structure for Traffic Ahead Warning

Scenario for use case with no extension (HLN-TJA)
The road operator is informed about a traffic jam on the road network and decides to issue a hazard warning. The warning is distributed to road users approaching the hazard via the interchange system and subscribing application backend systems.
Scenario for use case with extension: Vehicle Detected Hazard (HLN-TJA-v)
A vehicle detects a traffic jam by means of its sensors. Information about the hazard goes to the application backend system of that vehicle and is then forwarded to subscribing road operators (and other service providers) via the interchange system. A hazard waring is then distributed to road users as described above.
Scenario with extension: Road User Reported Hazard (HLN-TJA-u)
A road user reports a traffic jam through a device (phone app). Information about the hazard goes to the application backend system of that vehicle and is then forwarded to subscribing road operators (and other service providers) via the interchange system. A hazard waring is then distributed to road users as described above.

Table 17 Scenarios for Traffic Ahead Warning

5.4.2.5 Emergency Brake Lights

Use Case Description	
Summary	Drivers receive information about nearby vehicles with emergency brake lights switched-on.
C-Roads Use Cases	No use case is defined.
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System (receives and distributes warning) • Interchange System, Application Backend System (distributes warning); • Vehicle (distributes emergency brake lights warning, receives warning and displays it to the driver).
Logic of transmission	Two-way communication (V2I, I2V)
Triggers	Emergency brake lights of vehicle are turned on.
Constraints/dependencies	TBD

Table 18 Description of Emergency Brake Lights

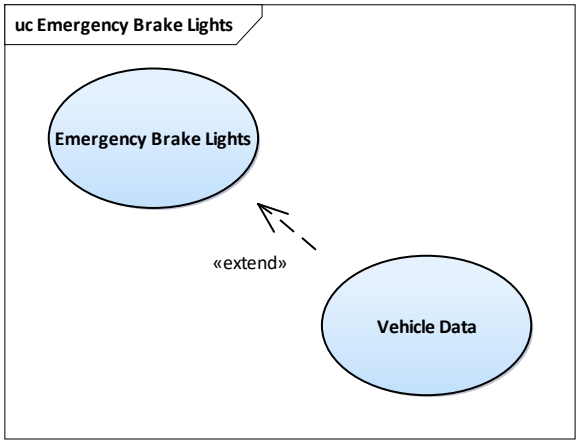

Figure 13 Use Case Structure for Emergency Brake Lights

Scenario for use case with extension: Vehicle Data (Figure 14)
The emergency braking system of vehicle (VA1) is activated. The application backend system (VA) for the vehicle publishes a warning (EBL) to other connected vehicles (VA2) approaching the vehicle as well as to the interchange system. The warning published to the interchange system is received by subscribing road operations system (DK). The road operator publishes a general warning to the interchange system. The warning goes to subscribing application backend systems (VB, VC) which distribute the warning to vehicles (VB1, VC1, VC2) approaching VA1.

Table 19 Scenario for Emergency Brake Lights

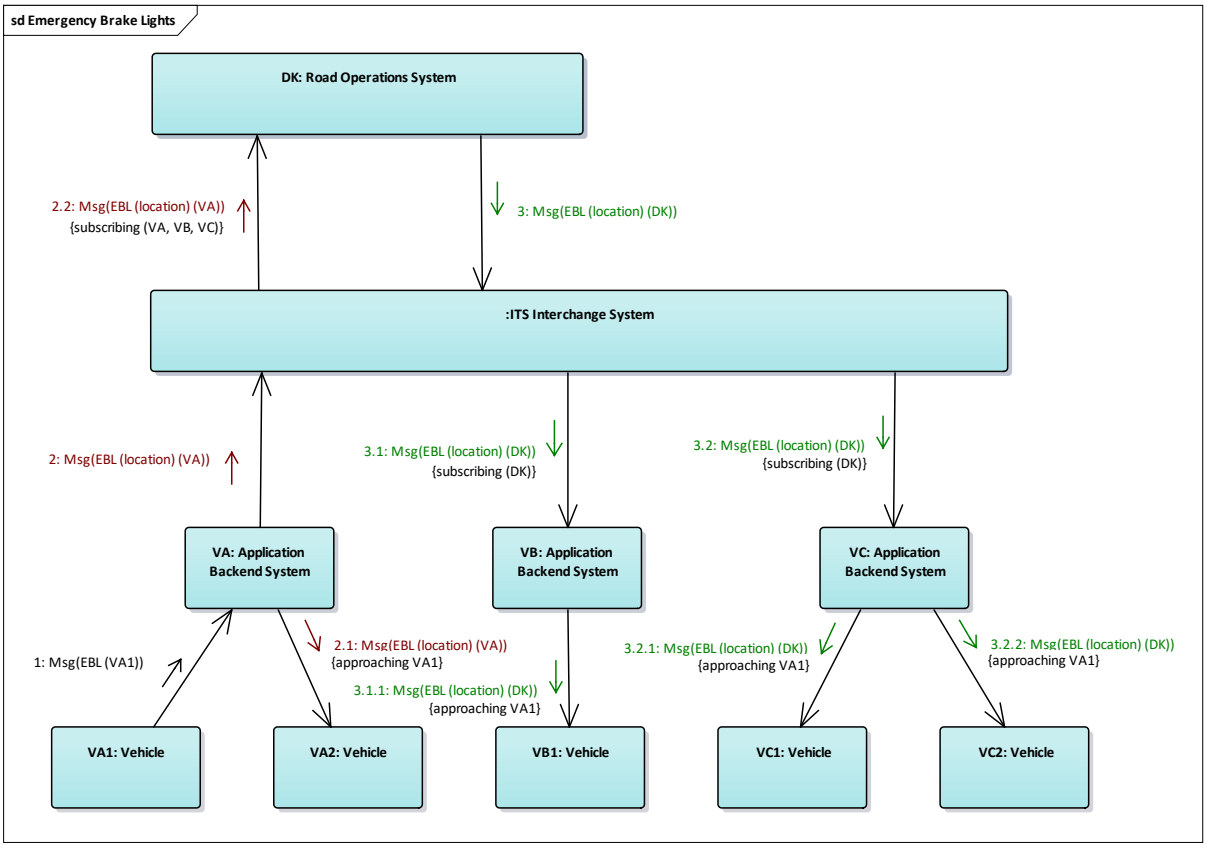

Figure 14 Scenario for Emergency Brake Lights (Vehicle Data)

5.4.2.6 Animal or person on the road

Use Case Description	
Summary	Drivers are warned about animals or persons on the road.
C-Roads Use Cases	Animal or Person on the Road (HLN-APR) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System (receives information about hazards and distributes warnings) • Interchange System, Application Backend System (distributes information and warnings) • Vehicle, Personal Device (may detect and report hazards, receives warnings and display them to the driver) • Road Side System (may detect hazards)
Logic of transmission	Two-way communication (I2V, V2I)
Triggers	TBD
Constraints/dependencies	TBD

Table 20 Description of Animal or Person on the Road

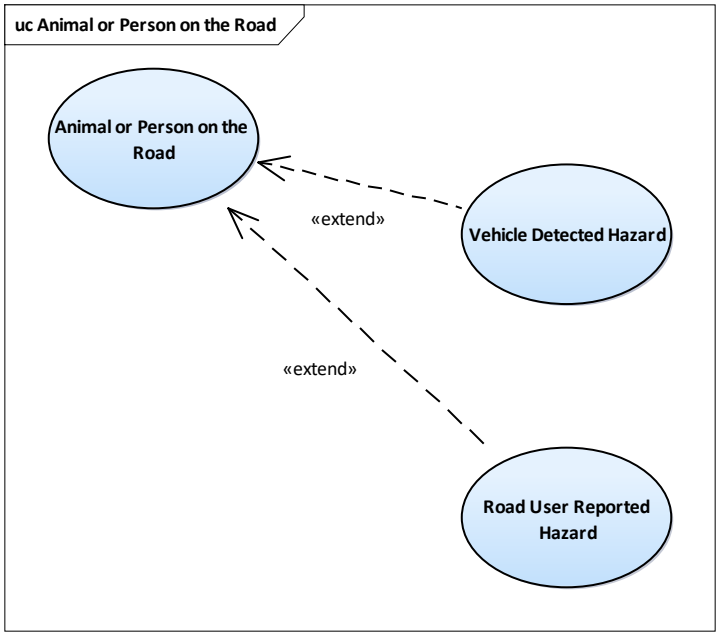

Figure 15 Use Case Structure for Animal or Person on the Road

Scenario for use case with extension: Road User Reported Hazard (HLN-APR-u)
A user reports an animal or person on the road through a personal device (phone app). Information about the hazard goes to the application backend system of the device which forwards the information to subscribing road operators (and service operators) via the interchange system. The operators then distribute warnings to road users which are close to the hazard which are close to the hazard.
Scenario for use case with extension: Vehicle Detected Hazard (HLN-APR-v)
A vehicle detects an animal or person on the road by means of its sensors (e.g. camera). Information about the hazard goes to the application backend system of the vehicle which forwards the information to subscribing road operators (and other service operators) via the interchange system. The operators then distribute warnings to road users which are close to the hazard.

Table 21 Scenarios for Animal or Person on the Road

5.4.2.7 Obstacle on the Road

Use Case Description	
Summary	Road users receive information about nearby non-blocking obstacles on the road.
C-Roads Use Cases	Obstacle on the road (HLN-OR) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System (receives information about obstacles and distributes warnings); • Road Side System (may detect obstacles and distribute information about obstacles); • Interchange System, Application Backend System (distributes information and warnings); • Vehicle, Personal Device (may detect and report obstacles, receives warnings and displays them to the driver).
Logic of transmission	Two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 22 Description of Obstacle on the Road

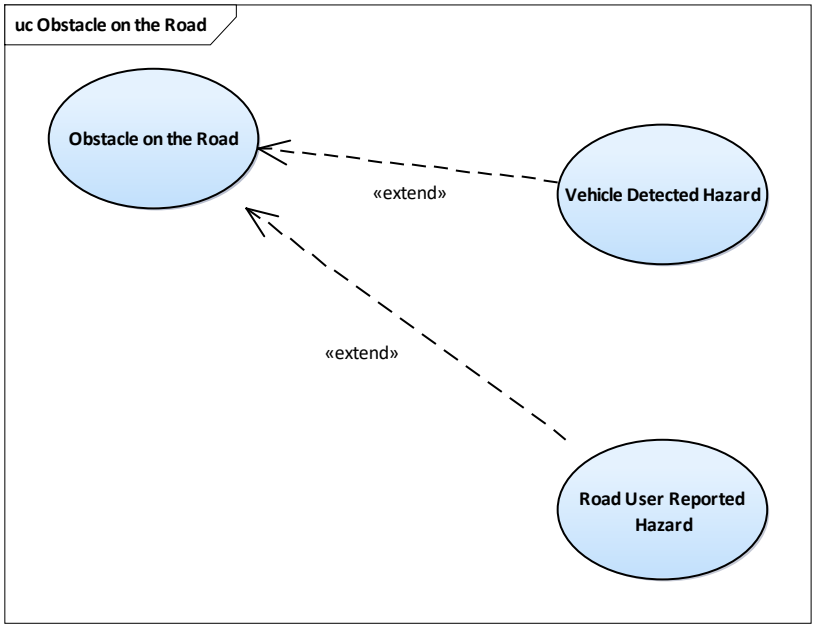

Figure 16 Use Case Structure for Obstacle on the Road

Scenario for use case with extension: Vehicle Detected Hazard (HLN-OR-v)
A vehicle detects an obstacle on the road by means of its sensors (e.g. camera), and the information about the hazard goes to the application backend system of that vehicle. The application backend system forwards the information via the interchange system to the road operator and other service providers subscribing to messages from that backend system, which distribute it to the road users.
Scenario for use case with extension: Road User Reported Hazard (HLN-OR-u)
A road user reports an obstacle on the road through a personal device (phone app), and the information about the hazard goes to the application backend system of the device. The application backend system forwards the information via the interchange system to road operators and other service providers subscribing to messages from that backend system, which distribute it to the road users.

Table 23 Scenarios for Obstacle on the Road

5.4.2.8 Accident Zone Description

Use Case Description	
Summary	Drivers receive information about accidents in the vicinity.
C-Roads Use Cases	Accident Zone (HLN-AZ) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System (receives information about accident zones and distributes warnings); • Road Side System (may detect accidents and distribute information about accidents); • Interchange System, Application Backend System (distributes information and warnings); • Vehicle, Personal Device (may detect and report accidents, receives warnings and displays them to the driver).
Logic of transmission	Two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 24 Accident Zone Description

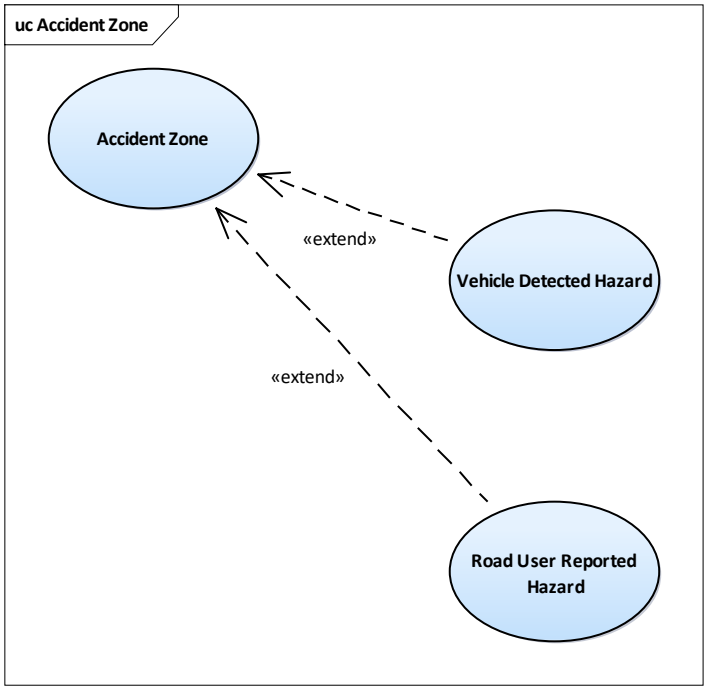

Figure 17 Use Case Structure for Accident Zone

Scenario for use case with extension: Vehicle Detected Hazard (HLN-AZ-v)
A vehicle detects an accident on the road by means of its sensors (e.g. camera), and the information about the hazard goes to the application backend system of that vehicle. The application backend system forwards the information via the interchange system to a road operator and other service operators subscribing to messages from that backend system. The operators then distribute a warning to the road users.
Scenario for use case with extension: Road User Reported Hazard (HLN-AZ-u)
A user reports an obstacle on the road through a phone app, and the information about the hazard goes to the application backend system of the app. The application backend system forwards the information via the interchange system to other service operators subscribing to messages from that backend system, which distribute it to the application backend systems subscribing to these messages, which distribute it to the road users. A warning is then distributed to the road users as described above.

Table 25 Scenarios for Accident Zone Description

5.4.2.9 Cooperative Collision Warning

Use Case Description	
Summary	Drivers receive information about turning, crossing or merging collision risks in the vicinity.
C-Roads Use Cases	No use case is defined.
Actors and relations	TBD
Logic of transmission	TBD
Triggers	TBD
Constraints/dependencies	TBD

Table 26 Description of Cooperative Collision Warning

5.5 Road Works Warning (RWW)

5.5.1 Service Introduction

Service Introduction: Road Works Warning	
Summary	The service is to warn road users about nearby road works (mobile, static, short-term, long-term).
Background	Road works usually lead to changes of road layout and driving regulations. This may give rise driver anxiety possibly leading to unsafe traffic situations and accidents. Warning road users about road works in advance should increase their alertness and allow them to adapt their driving behaviour.
Objective	The objective of the service is to inform road users of road works providing for more attentive and adjusted driving when approaching and passing road works zones.
Expected benefits	Expected benefits include: • Increased alertness; • Better traffic flow; • Improved traffic safety (reduced number of collisions and other accidents).
NordicWay Use Cases	The use cases for the service include: • Road and Lane Closure; • Mobile Road Works.
C-Roads Services	Road Works Warning (RWW) [TF2-SD1.4].

Table 27 Service Introduction to Road Works Warning

5.5.2 Use Cases

5.5.2.1 Road and Lane Closure

Use Case Description	
Summary	Drivers receive information about nearby road and lane closures. The information may include advice on adaptive behaviour such as alternative routes.
C-Roads Use Cases	Road Closure (RWW-RC) and Lane Closure (and other restrictions) (RW-LC) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Operations System, Content Provisioning System • (distributes information); • Interchange System, Application Backend System (distributes information); • Vehicle, Personal Device (may detect and report road and lane closure, receives information and displays it to the driver).
Logic of transmission	One-way communication (I2V) and two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 28 Description of Road and Lane Closure

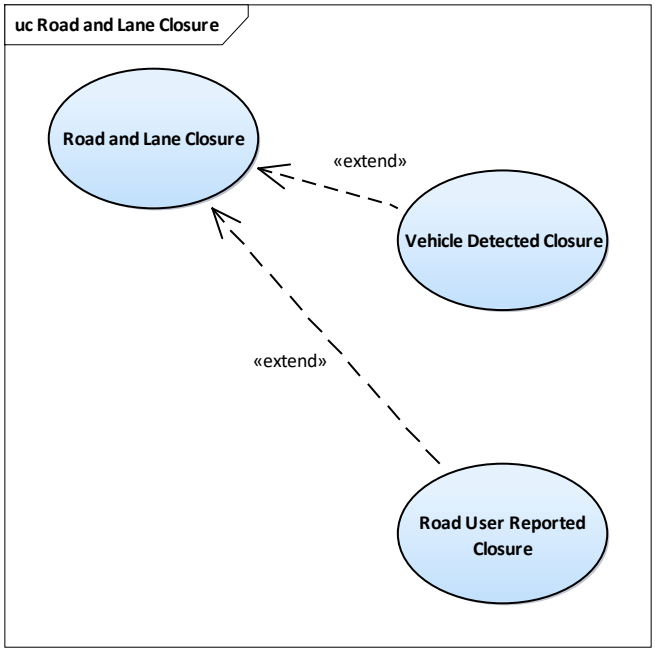

Figure 18 Road and Lane Closure

Scenario for use case (RWW-RC) (Figure 19)
A road operator (F) distributes a road closure warning to vehicles via the interchange system. The warning is received by application backend systems (VA and VB) subscribing to messages from the road operator and then distributed to connected vehicles (VA1, VA2, VB1) approaching the road closure. The warning is also received by another road operator (N) operating a neighbouring road network close to the road closure, and the operator decides to forward the warning via the interchange system for distribution to nearby vehicles and devices (P1). This is done via application backend systems (P) subscribing to messages from that road operator.
Scenario for use case with extension: Vehicle Detected Closure (RWW-RC-v)
A vehicle detects a road closure (e.g. through recognition of a traffic sign) on the road by means of its sensors (e.g. camera), and the information about the hazard goes to the application backend system of the vehicle. The backend system forwards the information via the interchange system to the road operator and other service providers subscribing to messages from that backend system. A warning is then distributed to the road users as described above.
Scenario for use case with extension: Road User Reported Closure (RWW-RC-u)
A road user reports a road closure through a personal device (phone app), and the information about the closure goes to the application backend system of the device. The application backend system forwards the information via the interchange system to road operators and other service providers subscribing to messages from that backend system. A warning is then distributed to the road users as described above.

Table 29 Scenarios for Road and Lane Closure

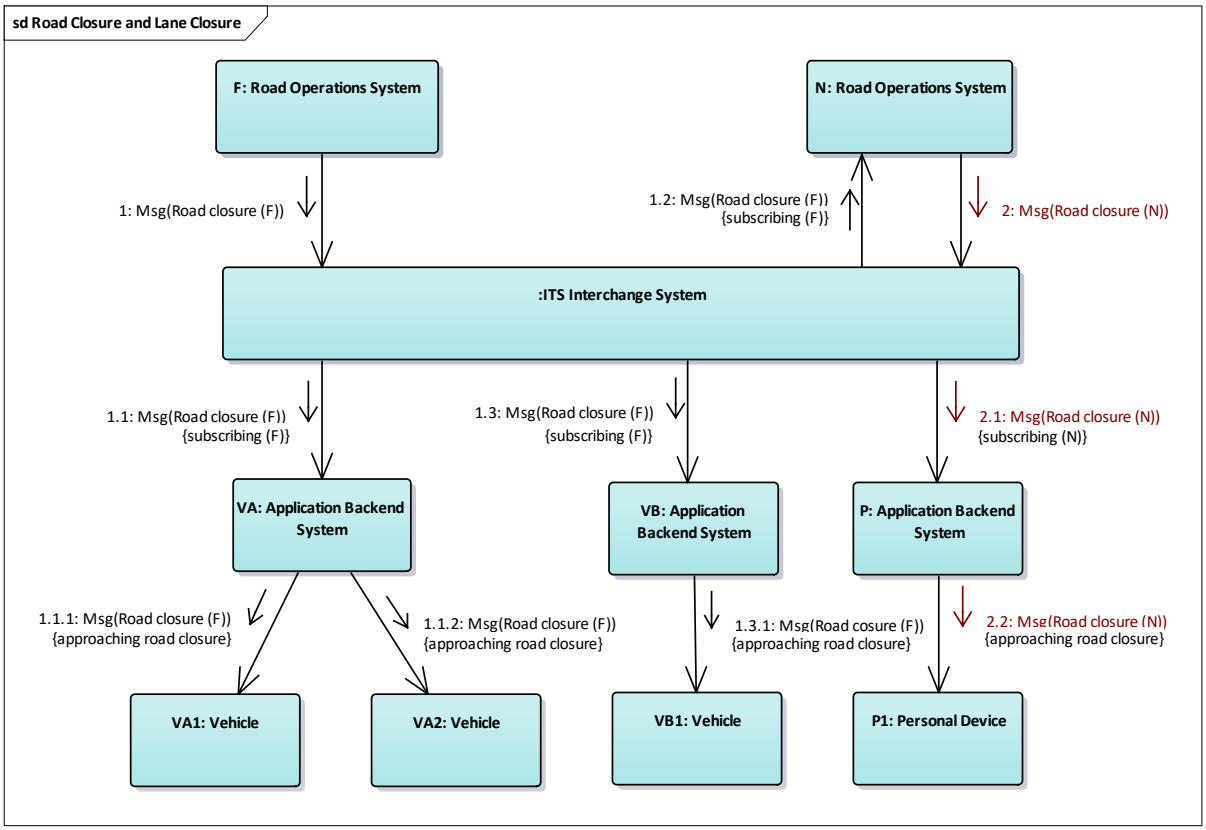

Figure 19 Scenario for Road and Lane Closure (Cooperating road operators)

5.5.2.2 Mobile Road Works

Use Case Description	
Summary	Drivers receive information about nearby mobile road works such as slow-moving maintenance vehicles.
C-Roads Use Cases	Road Works – Mobile (RWW-RM) [TF2-SD1.4]. Use case for Winter Operation (RWW-WO) is being developed.
Actors and relations	The main actors are: • Designated Vehicle (reports its location) • Road Operations System, Content Provisioning System (distributes information); • Interchange System, Application Backend System (distributes information); • Vehicle, Personal Device (receives information and displays it to the driver).
Logic of transmission	Two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 30 Description of Mobile Road Works

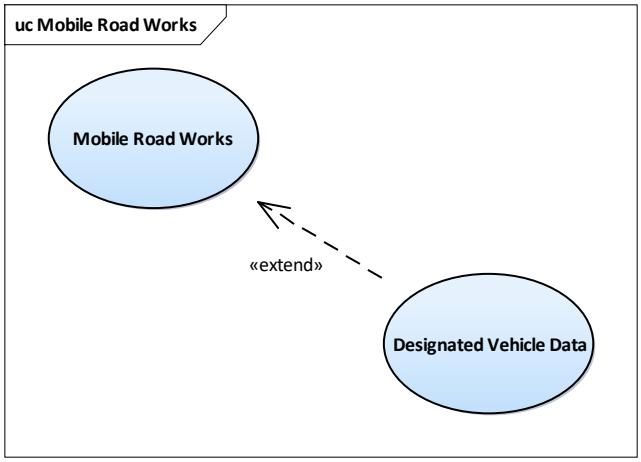

Figure 20 Use Case Structure for Mobile Road Works

Scenario for use case with extension: Designated Vehicle Data (RWW-RM-v) (Figure 21)
The application backend system (M) receives location and status information for two maintenance vehicles (M1, M2) and publishes this information to the interchange system. The information is received by a subscribing road operator (DK) (or content provider) responsible for planning and monitoring mobile work zones of a road network. The road operator issues warnings (MRV) about the vehicles when they enter a mobile work zone. The warnings are published on the interchange system and received by subscribing application backend systems (V, W) which forward the warnings to vehicles (V1, W1) within the mobile work zone.
Scenario for use case with extension (Snowplow in operation) (RWW-WO)
TBD

Table 31 Scenario for Mobile Road Works

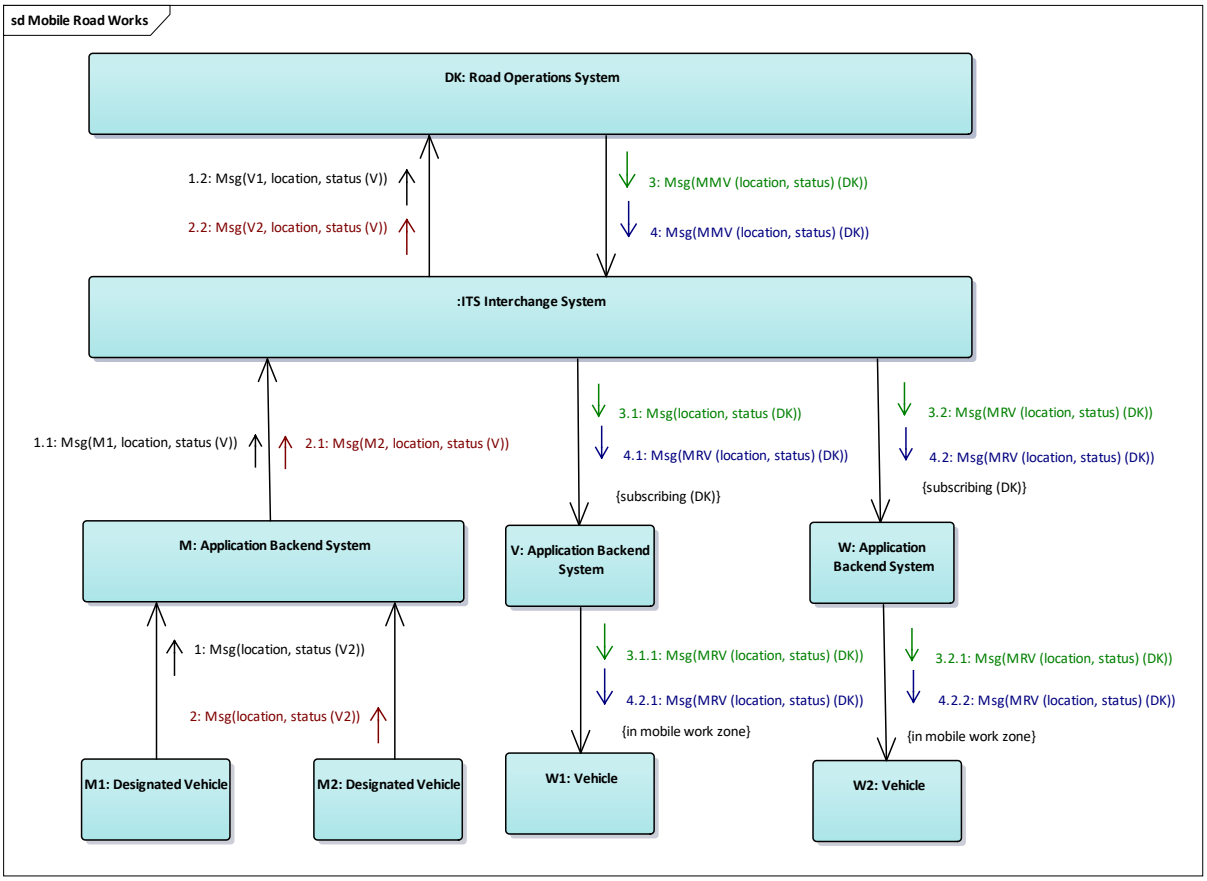

Figure 21 Scenario for Mobile Road Works (Designated Vehicle Data)

5.6 Signalized Intersections (SI)

5.6.1 Service Introduction

Service Introduction: Signalized Intersections	
Summary	The service is to provide information to road users to support safe and efficient crossing of signalised intersections. The implementation of the use cases should increase safety and traffic flow efficiency and reduce adverse environmental effects following from erratic and stop-and-go driving.
Background	Road intersections represent complex traffic environments where traffic flows may be impeded in different ways, where risks for accidents are higher, and where fuel consumption and adverse environmental effects are high due to stop-and-go driving. Providing road users with information for passing intersections should allow them to adapt their driving behaviour for safe and smooth passing of intersections.
Objective	The objective is more attentive driving
Expected benefits	Expected benefits include: • More attentive and cautious driving; • More energy efficient driving (reduced fuel consumption); • More efficient traffic flow; • Reduced travel time for designated vehicles; • Improved traffic safety (reduced number of collisions and other accidents).
NordicWay Use Cases	The use cases for the service include: • Signal Violation; • Time To Green; • Green Light Optimal Speed Advisory (GLOSA); • Traffic Signal Priority Request.
C-Roads Services	Signalized Intersections (SI) [TF2-SD1.4].

Table 32 Service Introduction to Signalized Intersections

5.6.2 Use Cases

5.6.2.1 Signal Violation

Use case Introduction	
Summary	Drivers receive warnings about potential signal violations at nearby signalized intersections. Drivers are warned when they are in danger of violating a red light, or when it is possible that another vehicle is going to make a red-light violation.
C-Roads Use Cases	Imminent Signal Violation Warning (SI-ISVW) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Side System (distributes information about the current phase state and predicted timing of the traffic lights): • Interchange System, Application Backend System (distributes warnings); • Vehicle (receives read light warnings and display them to the driver).
Logic of transmission	Two-way communication (V2I, I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 33 Description of Signal Violation

5.6.2.2 Scenario

Scenario for use case (SI-ISVM)
TBD

Table 34 Scenario for Signal Violation

5.6.2.3 Time To Green

Use case Introduction	
Summary	Drivers receive information about time-to-green when approaching signalized intersections.
C-Roads Use Cases	Signal Phase and Timing Information (SI-SPTI) [TF2-SD1.4].
Actors and relations	The main actors are: • Road Side System (distributes signal phase and timing data): • Interchange System, Application Backend System (distributes data and time advice); • Road Operations System, Content Provisioning System (defines policy and traffic light infrastructure, process signal phase and timing data); • Vehicle (receives phase and timing data and displays the information to the driver).
Logic of transmission	One-Way communication (I2V)
Triggers	TBD
Constraints/dependencies	Constraints and dependencies include: • Phase state and timing information available must be sufficiently accurate and reliable to ensure the required quality of the speed advice; • The actual signal state displayed by the physical traffic lights takes over any advice. MAP description available to describe actual lane/Signals connection (left-or right-hand signals etc.)

Table 35 Description of Time To Green

Scenario for use case
A Road Traffic Operator's signal system distributes Signal Phase and Time and MAP-information to vehicles via the interchange system when vehicles are approaching the signalised Intersections. The information is received by application backend systems subscribing to messages from the Road Traffic Operator and then distributed to connected vehicles approaching the signalised intersection(s).

Table 36 Scenario for Time to Green

5.6.2.4 Green Light Optimal Speed Advisory (GLOSA)

Use case Introduction	
Summary	Drivers receive speed advice when approaching and passing traffic light-controlled intersections.
C-Roads Use Cases	Green Light Optimal Speed Advisory (GLOSA) [TF2-SD1.4].
Actors and relations	The main actors are: • Traffic Light System (distributes traffic light information) • Application Backend System (distribute traffic light information); • Road Operations System, Content Provisioning System (may compute and distribute TTG and MAP information); • Interchange System (distributes traffic light information); • Vehicle (calculates speed advice and displays it to the driver).
Logic of transmission	Two-way communication (I2I, I2V)
Triggers	TBD
Constraints/dependencies	Constraints and dependencies include: • Phase state and timing information available to the traffic manager must be sufficiently accurate and reliable to ensure the required quality of the speed advice. • The actual signal state displayed by the physical traffic lights takes over speed advice.

Table 37 Description of GLOSA

Scenario for use case (Figure 22)
Vehicle, application backend system and road operations system compute speed advice for a signalized intersection based on data from the signal systems of the intersection. The speed advice is displayed to the drivers of vehicles approaching the intersection. Data are distributed in terms of SPATEM and MAPEM.

Table 38 Scenario for GLOSA

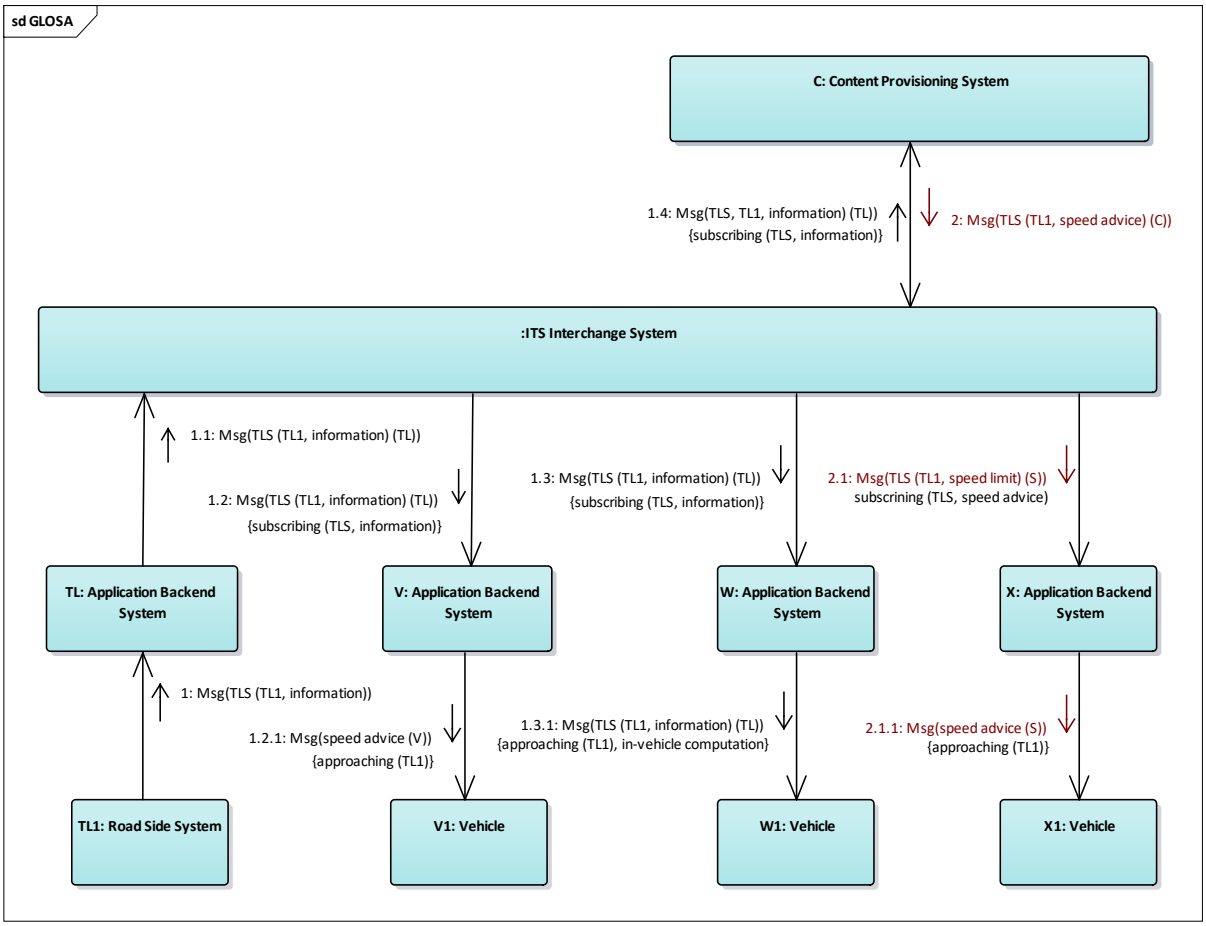

Figure 22 Scenario for GLOSA

5.6.2.5 Traffic Signal Priority Request

Use case Introduction	
Summary	Designated vehicles request priority over other vehicles when passing signalized intersections.
C-Roads Use Cases	Public Transport Prioritization (SI-PTP) [TF2-SD1.4].
Actors and relations	The main actors are: • Designated Vehicle (issues priority request); • Road Operations System, Content Provisioning System (receives priority request, computes and distributes signal settings); • Interchange System, Application Backend System (distributes priority requests and signal setting commands); • Road Side System (receives and executes signal settings);
Logic of transmission	Two-way communication (V2I, I2I)
Triggers	Designated vehicle issues priority request.
Constraints/dependencies	The Designated Vehicle operations system asks for priority for execution by the Road Traffic Operator's Signals system executes

Table 39 Description of Traffic Signal Priority Request

Scenario for use case
TBD

Table 40 Scenario for Traffic Signal Priority Request

5.7 Probe Vehicle Data (PVD)

5.7.1 Service Introduction

Service Introduction: Probe Vehicle Data	
Summary	The service is to provide vehicle-generated data about vehicles, road conditions and traffic situations to road users, and to road operators and other types of service providers.
Background	Vehicles are increasingly becoming sources for data on driver actions (e.g. steering and braking), vehicle status (e.g. position, motion, flat tyre, windscreen wiper status and air bag status) and environmental conditions (e.g. weather and road conditions). These data constitute an additional source of information for use in managing traffic flows, for alerting road users on hot spots where the risk of accidents is high and for maintaining the road network.
Objective	The objective is to collect data from vehicles for use by road users, road operators and service providers.
Expected benefits	The expected benefit of the service is to provide a more comprehensive and up-to-date picture of the state of the road network and of the traffic situation. This information can be used as a basis for: • Improved traffic information to road users (e.g. location-specific warnings and alerts to drivers). • Improved traffic flow management • Improved road maintenance (e.g. maintenance on-demand).
NordicWay Use Cases	The use cases for the service include: • Single Vehicle Data
C-Roads Services	Service is considered for future release.

Table 41 Service Introduction for Probe Vehicle Data

5.7.2 Use Cases

5.7.2.1 Single Vehicle Data

Use case Introduction	
Summary	Collects data from individual vehicles.
C-Roads Use Cases	Use cases for Awareness Data Collection (PVD-ADC) and Event Data Collection (PVD-EDC) are being developed.
Actors and relations	The main actors include: • Vehicle (collects and distributes data); • Interchange System, Application Backend System (distributes data); • Road Operations System, Content Provisioning System (receives data).
Logic of transmission	One-way communication (V2I).
Triggers	TBD
Constraints/dependencies	TBD

Table 42 Description of Single Vehicle Data

Scenario for use case (PVD-EDC) (Figure 23)
A vehicle (V1) reports the occurrence of an event (slippery road condition) to its application backend system (V) which publishes a report to the interchange system. The report is received by a road operations system (DK) and a content provisioning system (C) subscribing to messages on hazards.

Table 43 Scenario for Single Vehicle Data

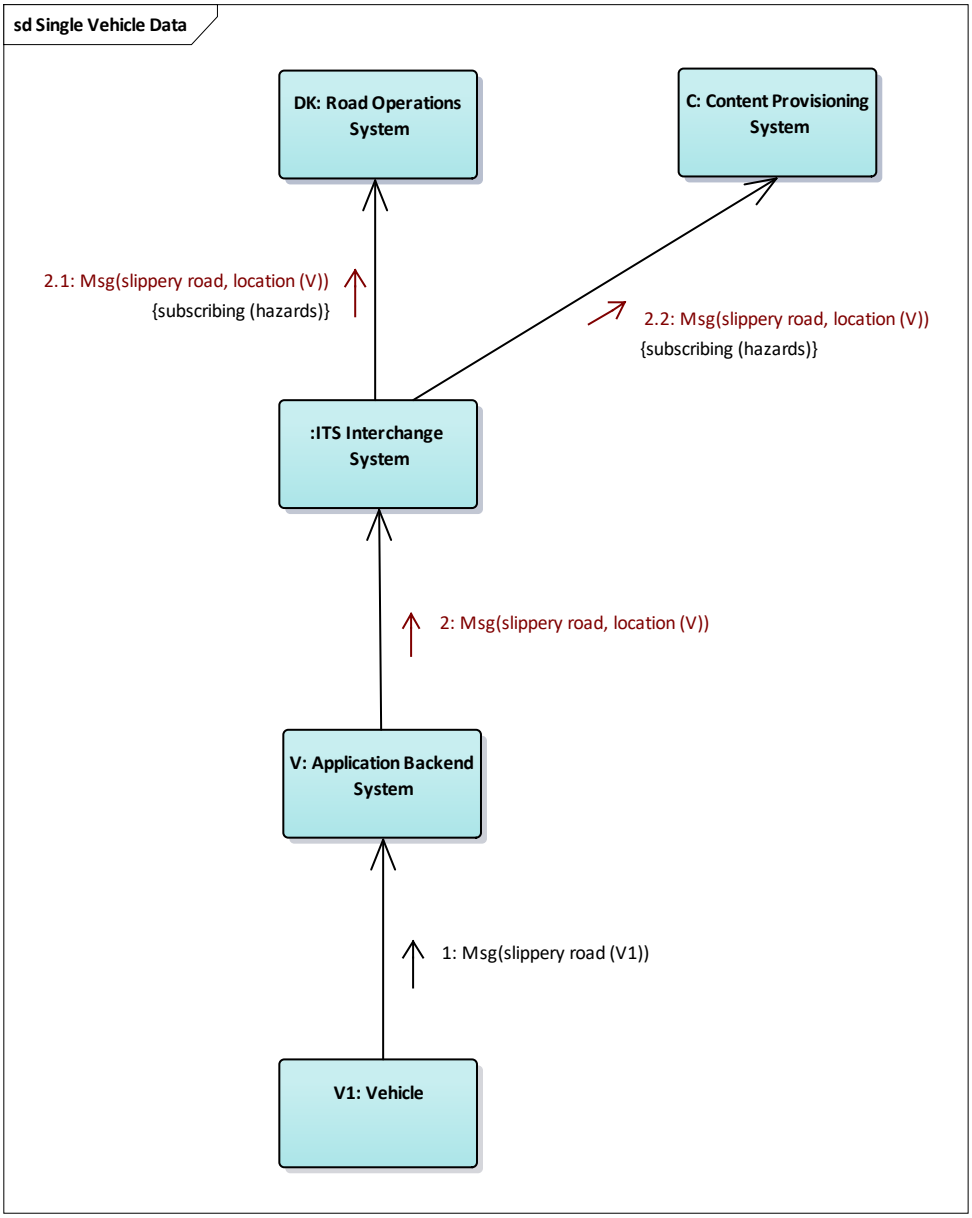

Figure 23 Scenario for Single Vehicle Data

5.8 Traffic Management

5.8.1 Service Introduction

Service Introduction: Traffic Management	
Summary	The service is to improve traffic flow management by optimizing traffic light settings and speed limits and by offering re-routing suggestions in response to real-time traffic jam alerts.
Background	TBD
Objective	TBD
Expected benefits	TBD
NordicWay Use Cases	TBD
C-Roads Service	No service is defined.

Table 44 Service Introduction for Traffic Management

5.8.2 Use Cases

5.8.2.1 Traffic Information and Smart Routing

Use Case Description	
Summary	Optimizes traffic flows by coordinating traffic light settings and speed limits and by providing re-routing advice in response to real-time traffic jam alerts.
C-Roads Use Cases	No use case is defined.
Actors and relations	TBD
Logic of transmission	TBD
Triggers	TBD
Constraints/dependencies	TBD

Table 45 Description of Traffic Information and Smart Routing

5.9 Connected Autonomous Driving (CAD)

5.9.1 Service Introduction

Service Introduction: Connected Autonomous Driving	
Summary	TBD
Background	TBD
Objective	TBD
Expected benefits	TBD
NordicWay Use Cases	The use cases for the service include: • Collection of data for mapping of infrastructure readiness.
C-Roads Service	No service is defined.

Table 46 Service Introduction for Connected Autonomous Driving

5.9.2 Use Cases

5.9.2.1 Collection of data for mapping of infrastructure readiness

Use Case Description	
Summary	TBD
C-Roads Use Cases	No use case is defined.
Actors and relations	TBD
Logic of transmission	TBD
Triggers	TBD
Constraints/dependencies	TBD

Table 47 Description of Collection of data for mapping of infrastructure readiness

5.10 Connected and Cooperative Navigation in and out of the city

Service Introduction: Connected and Cooperative Navigation in and out of the city	
Summary	TBD
Background	TBD
Objective	TBD
Expected benefits	TBD
NordicWay Use Cases	The use cases for the service include: • Dynamic Access Control of Designated Infrastructure.
C-Roads Service	No service is defined.

Table 48 Service Introduction for Connected and Cooperative Navigation in and out of the city

5.10.1 Use Cases

5.10.1.1 Dynamic Access Control of Designated Infrastructure

Use Case Description	
Summary	Road users are granted access to infrastructure with free capacity in highly congested traffic environments.
Background	Motorways and ring roads are getting more congested in highly populated urban areas which decrease accessibility for several road users. Still there are many areas where infrastructure is not used to its full potential. With the help of connected and cooperative traffic management it will be possible to steer traffic into infrastructure with free capacity in real-time which increase the usage of infrastructure capacity and may reduce congestion.
C-Roads Use Cases	No use case is defined.
Actors and Relations	The main actors are: • Road Operations System, Content Provisioning System (computes accessibility in designated lane and distributes approval to specific vehicles); • Interchange System, Application Backend System (distributes access to designated lane); • Vehicle (receives approval to use designated lane and displays it to the driver);
Logic of Transmission	One-way communication (I2V)
Triggers	TBD
Constraints/dependencies	TBD

Table 49 Description of Dynamic Access Control of Designated Infrastructure

5.11 Dynamically Controlled Zones

5.11.1 Service Introduction

Service Introduction: Dynamically Controlled Zones	
Summary	The service is to distribute traffic policy protocols to road users in real-time which enable dynamically controlled zones and vehicles to adjust characteristics accordingly.
Background	Many European cities implement regulated zones in urban areas, e.g. environmental zones, restrictions on physical parameters such as length and weight and usage characteristics (public transport, private car etc.). The regulations in these zones and the zones themselves may sometimes need real-time adjustment due to current traffic or weather conditions or due to events affecting desired vehicle characteristics in defined zones.
Objective	The objective of the service is to enable road authorities to adjust geo- and policy data in real-time and distribute data to service-subscribing vehicles which can adjust characteristics according to current zones and policy.
Expected benefits	Expected benefits include: • Support introduction of control zones (CZ); • Improve traffic safety (e.g. through speed compliance); • Improve environment and air quality in urban areas.
NordicWay Use Cases	The use cases for the service include: • Dynamic Environmental Zone.
C-Roads Service	No service is defined.

Table 50 Service Introduction for Dynamically Controlled Zones

5.11.2 Use Cases

5.11.2.1 Dynamic Environmental Zone

Use Case Description	
Summary	Enable road authorities to create and distribute zone description of an environmental zone in an urban area to vehicles which can adjust vehicle characteristics accordingly, e.g. shift from hybrid mode to electric mode when accessing a designated environmental zone.
Background	More and more European cities implement environmental zones in urban areas which aim to protect the inhabitants of the cities and municipalities against emissions, e.g. noise and air pollutants. If the requirements of a zone are known it is possible for a vehicle to adjust the characteristics accordingly, i.e. shift from hybrid mode to electric mode when accessing a designated environmental zone, reducing emissions in desired zone. In addition, a dynamic environmental zone could change due to occurring air quality and noise emissions, or other events in particular areas, creating dynamic zones when and where they are needed for better environment and air quality. Furthermore, dynamic environmental zones can be used to encourage transition to more environmentally friendly vehicles with effective incentives, e.g. if the service is used the road user will be offered lower road tolls or free parking.
Objective	To enable cities to create and distribute dynamic environmental zone descriptions to road users. The purpose is to reduce local emissions (air pollutants and noise) in urban dense areas. This will improve health and lower the risk for heart problems or other vascular diseases.

Use Case Description	
Desired behaviour	TBD
Expected benefits	Expected benefits include: • Support the future implementation of dynamic environmental zones in environmentally sensitive urban areas; • Enable road authorities to encourage transition to more environmentally friendly vehicles with effective incentives; • For plug-in hybrid electric vehicles having the ability to operate both as conventional and as electric vehicles, this introduces a new control strategy for vehicles before and within the zone; • Improved environment and air quality in urban areas
C-Roads Use Cases	No use case is defined.
Actors and relations	The main actors are: • Road Operations System (defines zone descriptions); • Content Provisioning System (distributes zone descriptions); • Interchange System, Application Backend System (distributes zone descriptions); • Vehicle (subscribing vehicle receives zone descriptions and adjust vehicle characteristics accordingly, if necessary).
Logic of transmission	Two-way communication (I2V, V2I)
Triggers	TBD
Constraints/descriptions	TBD

Table 51 Description of Dynamic Environmental Zone

Scenario for use case (Figure 24)
A road operator (S) issues a message defining the characteristics of a dynamic environmental zone. The message is published to the interchange system and received by application backend systems (A, B) subscribing to messages from the operator. The application backend systems distribute the message to vehicles (A1, A2, B1) within or approaching the environmental zone. If the road user accepts the conditions for the zone, the vehicle characteristics, if necessary, are adjusted according to the environmental zone description. It would be possible to send a conditional zone report to road operations systems via the interchange system showing that the vehicle has fulfilled the requirements set in the defined zone.
Deployment: Swedish Pilot

Table 52 Scenario for Dynamic Environmental Zone

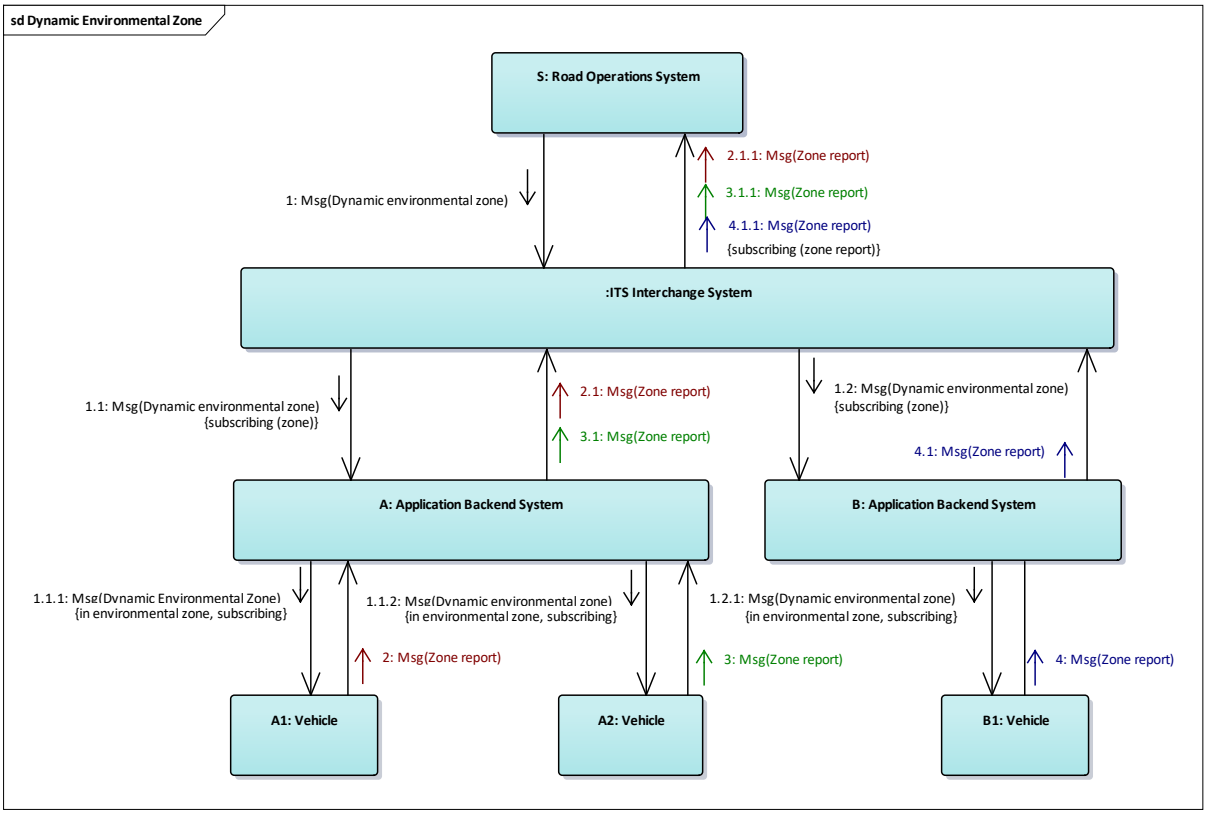

Figure 24 Scenario for Dynamic Environmental Zone

6 Message Harmonization

6.1 Introduction

This chapter identifies standard message profiles for ITS messages being exchanged during C-ITS service provision in the NordicWay communication environment. This includes describing:

- Rules for encoding ITS messages of the various use cases in terms of standard data models (DATEX II, ETSI message standards);
- Rules for mapping between different standard message representations.

The specifications apply to ITS messages being exchanged in backend communication of service provision whether this communication is direct or via the interchange system.

Regarding communication via the Interchange System, the proposed implementation model is AMQP (Advanced Messaging Queuing Protocol). With this model ITS messages are communicated between publishing and subscribing systems as payloads of AMQP messages. This communication is payload-agnostic in the sense that data of any type and format (standard and non-standard) may be transferred as payloads. Payload handling is the responsibility of the communicating systems and in the scope of the specifications.

In addition to recommendations for standard message representation, the specifications should address the following issues of ITS message representation:

- Unique persistent identification of message content (road and traffic conditions, traffic situations and events, etc.) across ITS message flows;
- Representation of validity information for the message content;
- Representation of location information for the message content.

Message profiles should be described at a logical level independent of platforms and technologies (communication protocols, serialization formats, etc.).

6.2 Standard Message Representations

The following general requirements apply to standard message representation in backend communication of ITS service provision.

- Messages should be represented following accepted and commonly used standard data definitions (data models) for ITS messages. These standards include DATEX II and ETSI standard data models.
- Data models should be machine-readable, and it should be possible to automatically validate message representations against these models.

These issues are not covered in this version of the document.

6.2.1 DATEX II Standard Representation of ITS Messages

The general requirements to DATEX II standard representation of ITS messages are as follows.

- Messages shall be represented according to the DATEX II standard data model Level A. Possible extensions shall be Level B extensions. Level C extensions are not allowed.
- Messages should be represented according to version 2.3 and version 3.0 of the DATEX II standard data model.

It should be possible to check that message representations are compliant with the selected version of the DATEX II standard data model by validating the representations against standard schemas for Level A of that model.

It is recommended that possible Level B extensions defined in the NordicWay Pilots be published in the DATEX II Extension Directory (https://www.datex2.eu/implementations/extension_directory).

Appendix 7.1.2 provides a summary of the proposed DATEX II standard representations for ITS messages of the services and use cases which are deployed in the NordicWay pilots.

6.2.2 ETSI Standard Representation of ITS messages

In general message representation should be in accordance with the C-Roads specifications for ETSI message representation for C-ITS services [TF3-IFS1.3], [TF3-IFS1.4D].

Messages should be represented according to the versions of the ETSI standards prescribed in these specifications.

6.3 Mappings between Standard Message Profiles

The following identifies requirements to rules for mapping/conversion between different standard message representations (DATEX II and ETSI standard representations). The rules should serve as a basis for converting between standard message representations such that information content is preserved.

The general requirement to mapping rules is that the rules should be accepted and commonly used standard rules. This should enable mapping of messages across actors in a consistent way.

The rules should be compliant to the mapping rules defined for DATEX II and DENM in [SRTI]. Appendix 7.2 provides a summary of these mapping rules. These rules apply to SRTI messages only and does not cover other types of ITS messages.

Different proposals for additional mapping rules are being investigated. These proposals include, among others, the proposal from SCOOP project [SCOOP-MES] and from the ECO-AT project.

7 Appendices

7.1 DATEX II

7.1.1 DATEX II in the NordicWay Pilots

The following table gives an overview of the DATEX II versions and possible extensions which are proposed for use in the NordicWay Pilots.

The Danish partner (which does not provide a separate NordicWay Pilot) will use DATEX II Version 2.3 for possible communication with the Pilots.

Pilot	Version and Extensions
Finnish Pilot	DATEX II Version 3.0 with OpenLR for Location Referencing. Refer [FI-DATEXII] for definition and discussion of the profile.
Norwegian Pilot	TBD
Swedish Pilot	TBD

Table 53 DATEX II versions and extensions in the NordicWay Pilots

7.1.2 DATEX II Representation

The following table shows proposals for standard representation of ITS messages in terms of DATEX II payload publications.

Service	Use Case	DATEX II PayloadPublication
In Vehicle Signage (IVS)	In Vehicle Speed Limits	VmsPublication
Hazardous Locations Notifications (HLN)	Weather and Road Conditions	SituationPublication
	Slow and Stationary Vehicles	SituationPublication
	Emergency Vehicle Approaching	SituationPublication
	Traffic Ahead Warning	SituationPublication
	Emergency Brake Lights	SituationPublication
	Cooperative Collision Warning	TBD
Road Works Warning (RWW)	Road and Lane Closure	SituationPublication
	Mobile Roadworks	SituationPublication
Signalized Intersections (SI)	Signal Violation	TBD
	Time To Green	TBD
	Traffic Signal Priority Request	TBD
Probe Vehicle Data (PVD)	Single Vehicle Data	MesuredDataPublication
		ElaboratedDataPublication
Traffic Management	Traffic Information and Smart Routing	TBD
Connected Autonomous Driving	Collection of data for mapping of infrastructure readiness	TBD
Connected and Cooperative Navigation in and out of the city	Dynamic Access Control of Designated Infrastructure	TBD
Dynamically Controlled Zones	Dynamic Environmental Zone	TBD

Table 54 ITS Message Representation: Types of DATEX II PayloadPublication

Comments:

- DATEX II Measured and Elaborated Data Publications target representation of direct measurement data from equipment or outstations, e.g. traffic and weather measurements, and data derived and computed from measurement data. The measurements sites may be static but can be mobile, e.g.

vehicles (DATEX II does constrain the Publications to representation of data from static measurements sites only).

The possible problems of using these Publications for probe vehicle data are primarily related to the problems inherent in using XML which is the standard serialization format for DATEXII. These problems include size of payloads and complexity of parsing.

Refer [FI-DATEXII] for further comments to the content of Table 54.

7.1.3 DATEX II Situation Publication Representation

The following table shows proposed standard representation for ITS messages in terms of records of type SituationRecord in publications of type SituationPublication.

Service	Use Case	DATEX II SituationRecord
Hazardous Locations Notifications (HLN)	Weather and Road Conditions	WeatherRelatedRoadConditions
		NonWeatherRelatedRoadConditions
		PoorEnvironmentConditions
	Slow and Stationary Vehicles	VehicleObstruction (brokenDownVehicle, vehicleOnWrongCarriageWay, slowMovingMaintenanceVehicle)
	Emergency Vehicle Approaching	VehicleObstruction (emergencyVehicle, highSpeedEmergencyVehicle)
		GeneralInstructionOrMessageToRoadUsers (allowEmergencyVehiclesToPass)
	Traffic Ahead Warning	AbnormalTraffic (stationaryTraffic, queuingTraffic, slowTraffic, heavyTraffic, unspecifiedAbnormalTraffic, other)
	Emergency Brake Lights	VehicleObstruction
Road Works Warning (RWW)	Road and Lane Closure	ConstructionWorks
		MaintenanceWorks
		With Impact:trafficConstrictionType (roadblocked)
	Mobile Road Works	ConstructionWorks
		MaintenanceWorks
		With Impact:trafficConstrictionType (roadblocked)
		VehicleObstruction (slowMovingMaintenanceVehicle)
Signalized Intersections (SI)	Signal Violation	TBD
	Time To Green	TBD
	Green Light Optimal Speed Advisory (GLOSA)	TBD
	Traffic Signal Priority Request	TBD
Traffic Management	Traffic Information and Smart Routing	TBD
Connected Autonomous Driving	Collection of data for mapping of infrastructure readiness	TBD
Connected and Cooperative Navigation in and out of the city	Dynamic Access Control of Designated Infrastructure	TBD
Dynamically Controlled Zones	Dynamic Environmental Zone	TBD

Table 55 ITS Message Representation: DATEX II Records of type SituationRecord

7.2 Mapping between DATEX II and DENM Standard Representations

7.2.1 Safety Related Traffic Information Messages

The following table lists proposals for standard mappings between DATEX II SituationPublication (version 2.3) and DENM standard representations for ITS messages.

The mappings are equal to the mappings defined for safety related messages in [SRTI].

DATEX II SituationPublicatopn	DENM		
Type of SituationRecord	Cause Code	Sub Cause Code	Description
ConstructionWorks	TBD	TBD	TBD
MaintenanceWorks (RoadMarkingWork)	3	2(0)	road marking work
MaintenanceWorks (maintenanceWork)	3	4(0)	short-term stationary roadworks
With Impact:trafficConstrictionType (road-blocked)	N/A	N/A	N/A
VehicleObstruction (vehicleOnWrongCarriage-way)	14	0	wrong way driving
VehicleObstruction (slowMovingMaintenance-Vehicle)	3	3(0)	slow moving road maintenance
VehicleObstruction (brokenDownVehicle)	94	2	vehicle breakdown
GeneralObstruction (UnprotectedAccidentArea)	2	7	unsecured accident
GeneralObstruction (objectOnTheRoad)	10	0	hazardous location - obstacle on the road
GeneralObstruction (shedLoad)	10	1	shed load
GeneralObstruction (obstructionOnTheRoad) EnvironmentalObstruction (avalanches, land-slips)	10	4	large objects
GeneralObstruction (peopleOnTheRoadway)	12	0	human presence on the road
GeneralObstruction (childrenOnRoadway)	12	1	children on roadway
GeneralObstruction (cyclistsOnRoadway)	12	2	cyclists on roadway
GeneralObstruction (rescueAndRecoveryWork)	15	0	rescue and recovery work in progress
EnvironmentalObstruction (rockfalls)	9	1	rockfalls
EnvironmentalObstruction (fallenTrees)	10	5	fallen trees
AnimalsPresenceObstruction (animalsOn-TheRoad)	11	0	hazardous location - animal on the road
AnimalsPresenceObstruction (herdOfAni-malsOnTheRoad)	11	2	herd of animals
AnimalsPresenceObstruction (largeAnimalsOn-TheRoad)	11	4	large animals
PoorEnvironmentConditions (stormForceWinds, strongWinds, crossWinds)	17	1	strong winds
PoorEnvironmentConditions (visibilityReduced)	18	0	adverse weather con-dition - visibility
PoorEnvironmentConditions (denseFog, patchyFog)	18	1	visibility reduced due to fog
PoorEnvironmentConditions (smokeHazard)	18	2	visibility reduced due to smoke
PoorEnvironmentConditions (heavySnowfall)	18	3	visibility reduced due to heavy snowfall
PoorEnvironmentConditions (lowSunGlare)	18	6	visibility reduced due to low sun glare
PoorEnvironmentConditions (heavyRain)	19	1	heavy rain
PoorEnvironmentConditions (heavySnowfall)	19	2	heavy snowfall
DisturbanceActivity (attackOnVehicle)	20	3	stone throwing per-sons
WeatherRelatedRoadCondition (surfaceWater, slipperyRoad)	6	0	adverse weather con-dition -adhesion
WeatherRelatedRoadCondition (ice, icyPatch-es)	6	5	ice on road
WeatherRelatedRoadCondition (blackice)	6	6	black ice on road
WeatherRelatedRoadCondition (snowDrifts)	9	5	snowdrifts

DATEX II SituationPublicatopn	DENM		
Type of SituationRecord	Cause Code	Sub Cause Code	Description
NonWeatherRelatedRoadCondition (petrolOnRoad)	6	2	fuel on road
NonWeatherRelatedRoadCondition (mudOnRoad)	6	3	mud on road
NonWeatherRelatedRoadCondition (oilOnRoad)	6	7	oil on road
NonWeatherRelatedRoadCondition (looseChippings)	6	8	loose chippings

Table 56 Mapping between DATEX II SituationPublication and DENM message representation