Evaluation Outcome Report

NordicWay Evaluation in Danish Pilot
Best practices and lessons learned

NordicWay

Version: 1.1

Date: 7th November 2017

Document Information

Authors

Name	Organisation
Lone Dörge	Genua Consult
Jørgen Flensholt	Danish Road Directorate
Henrik Friis	Danish Road Directorate
Anders Bak Sørensen	Danish Road Directorate

Distribution

Date	Version	Dissemination
27-09-2017	0.8	Internal
29-09-2017	0.9	Draft for comments in DRD
05-10-2017	1.0	Final
09-11-2017	1.1	Revised following partner comments

Nordic
WAY

TABLE OF CONTENTS

1. Summary

The performance testing demonstrates the feasibility of the NordicWay approach to sharing and exchanging real-time Safety Related Traffic Information (SRTI) between various Nodes. This approach is based on representing traffic information using standard DATEX II data definitions and formats and exchanging this information using a queue-based message exchange system (NordicWay Interchange).

The focus of the performance testing has been on the integration of the Danish Node into the NordicWay Network and the exchange of SRTI messages in the form of DATEX II messages to and from the Danish TMC via a pre-production version of the NordicWay Interchange. The purpose of the assessment has been to assess performance behaviour - not to test performance requirements in terms of absolute numbers.

The observed performance as regards data volumes shows a small decrease in performance within the Danish Node in addition to the decrease which can be expected with increasing data volumes. But overall, the performance is within the required performance levels in which TMC's shall operate.

As regards performance over a longer period of time it is not possible to evaluate performance with respect to integrity and availability on the basis of the available log data.

Future work is necessary to develop the pre-production implementation of the Interchange mechanism into a stable and viable production system. In addition to better performance this will include provision of standardized services for operation, management and administration (access control, service catalogue, SLA management, charging and billing, partner onboarding, etc.). Requirements for this future development have already been discussed within the NordicWay project.

2. Description of the problem

The Danish Pilot is designed for the purpose of assessing technical Quality of Service (QoS) properties of exchange and distribution of DATEX II messages in the NordicWay C-ITS environment.

The Danish Pilot evaluation is solely a technical performance evaluation.

3. Description of the C-ITS implementation

This section outlines an overview of the design of the Danish Node (Danish TMC and Cloud) and its integration to the NordicWay Interchange.

The Danish Node is composed of two separate subsystems, the Danish Trafic Management Center (TMC) and the Danish Cloud. The two subsystems interact by exchanging DATEX II messages in the form of DATEX II SituationPublications. This interaction is internal to the Danish Node.

The Danish Cloud is responsible for interacting with the NordicWay Interchange in terms of exchange of AMQP messages which envelope DATEX II messages.

The figure below shows the overall flow of data in the data exchange between the three systems.

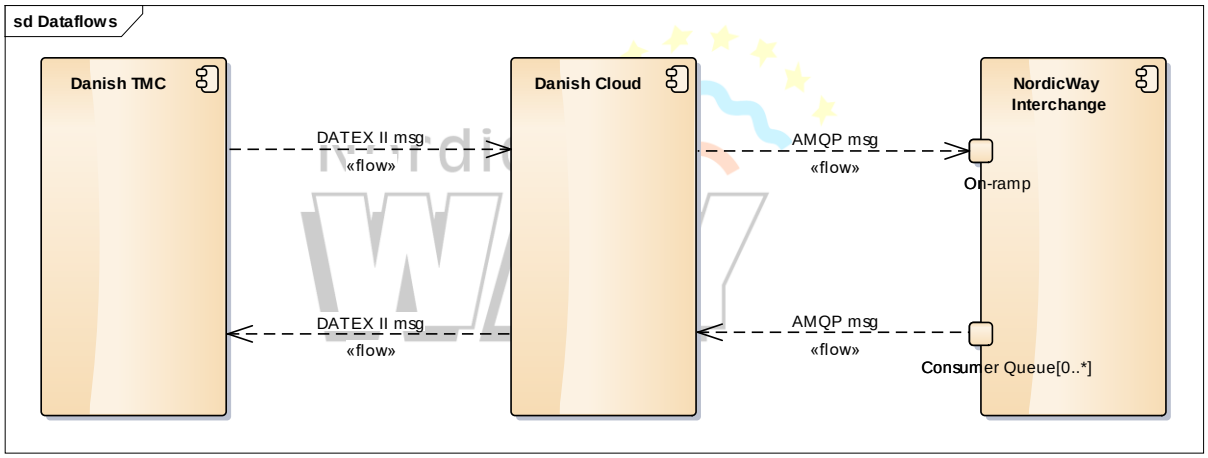

Figure 1 Dataflow between the Danish Node (TMC and Cloud) and the NordicWay Interchange

Structural Model

The Danish TMC and the Danish Cloud implement interfaces for exchanging DATEX II messages. The implementation profile for the data exchange has been the existing SOAP-based web services used by the Danish Road Directorate (DRD).

The Danish Cloud implements interfaces for exchanging AMQP messages with the NordicWay Interchange. The implementation profile is an AMQOP client implementation.

The interfaces are summarized in the figure below.

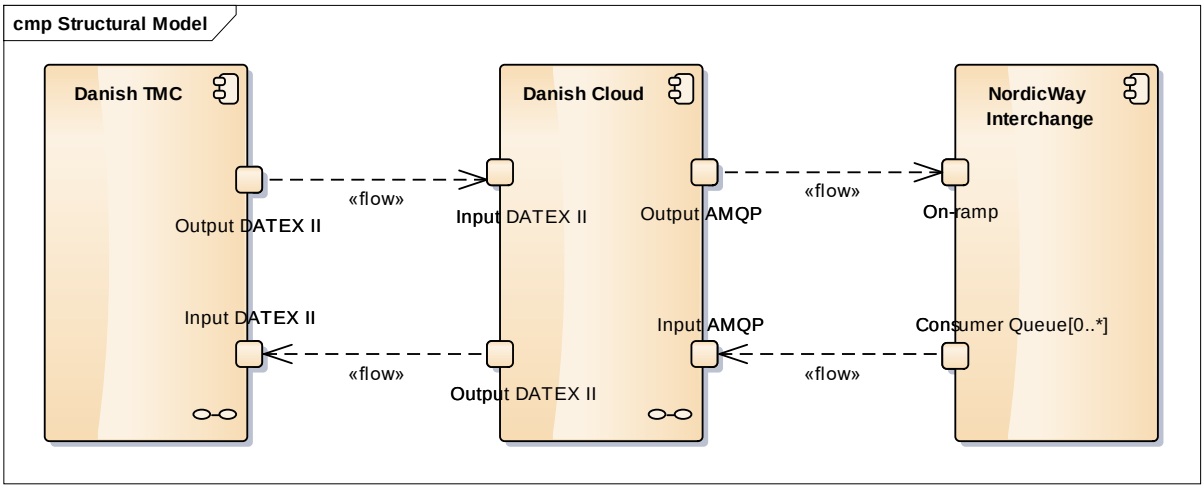

Figure 2 Interfaces for data exchange between the Danish Node (TMC and Cloud) and the NordicWay Interchange

Behavioural Model

The data exchange between the Danish Cloud and the NordicWay Interchange is queue-based message exchange. Each node in the NordicWay pilot has two default queues, one for receiving messages and one for sending AMQP messages. The default queue for sending messages is called **onramp**.

Design of the Danish Node

Setting up the Danish Node involves two separate development efforts, design and implementation in the Danish Trafic Management Center (TMC) and design and implementation of the Danish Cloud.

The implementation of the Danish Node is described in further detail in the Document « NordicWay – Design of the Danish Node », Jørgen Flensholt, 20th September 2016.

4. Program theory

The program theory of the Danish Pilot C-ITS services is shown in Appendix A.

5. Evaluation design

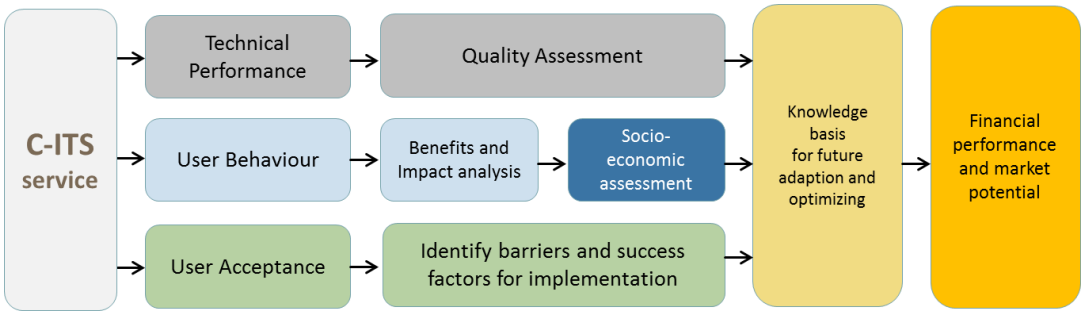

Figure 3 The NordicWay structural evaluation approach

The Danish Pilot evaluation is designed to cover the performance testing of the technical Quality of Service (QoS) properties of data exchange and distribution in the NordicWay C-ITS environment.

The overall NordicWay archictecture is shown in Figure 4. The purpose the Danish performance testing is to measure the performance of the transfer of SRTI (Safety-related Traffic Information) messages from the Danish TMC and back again via the NordicWay Interchange Node. The measurements are used for assessing the quality of the End-to-End exchange of SRTI messages in the NordicWay Network.

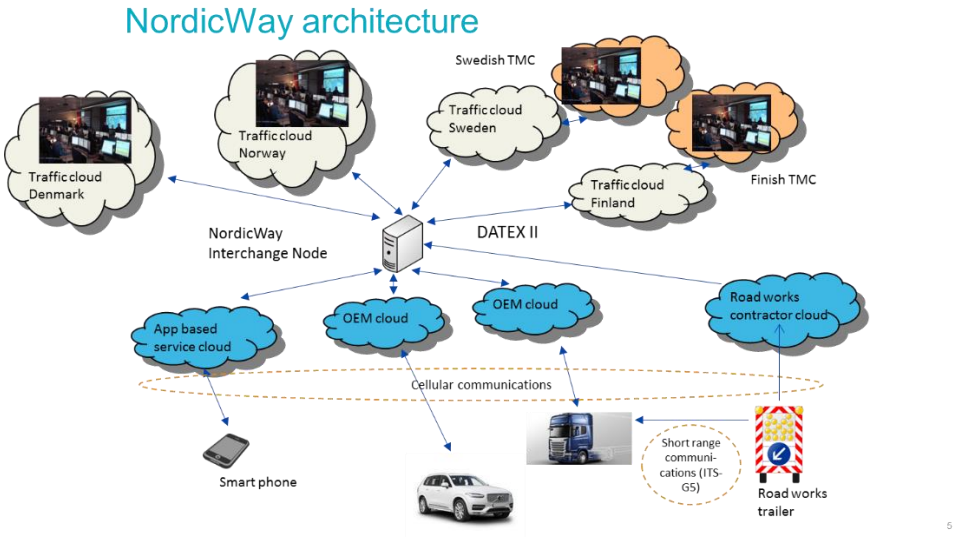

Figure 4 The NordicWay architecture

Types of tests

- Functional Tests
    - From Danish Node to Danish Node (17 SRTI messages)
    - From Danish node to Finnish Node (InfoTripla) (16 SRTI messages)
    - From Danish Node to Swedish Node (2 SRTI messages)
- Performance Tests
    - Message exchange for Publications of different size
        - *From Danish Node to Danish Node*
    - Message exchange over a longer period of time
        - *From Danish Node to Danish Node*
        - *From other Nodes to Danish Node*

The performance test covers two tests, one for measuring the performance of the message transfer for different data volumes, and one for measuring the performance of the message transfer over a longer period of time.

5.1. Test Set-up for Performance for Different Data Volumes

5.1.1. Test Execution

The test cases cover SRTI messages from all of the SRTI event/condition categories which are supported by the Danish TMC. This means that the setting for the “what” parameter of the enclosing AMQP messages includes all three possible parameter values: “Obstruction”, “Works” and “Conditions”.

The test is executed manually as follows:

- For each test case, files with XML file representations of the test case input (DATEX II Publications) are created. One file is created for every DATEX II Publication.
- The Publications are input to the TMC by copying the files to the input folder of the TMC.

The TMC reads the files and outputs the messages to the NordicWay Interchange via the Danish Cloud. The messages are then returned to the TMC from the Interchange via the Cloud.

5.1.2. Test Environment

The test cases are executed using two instances of the Danish TMC (Trafikman2), one for outputting SRTI messages and one receiving SRTI messages.

The communication with the NordicWay Interchange is via the production-endpoint (of the pre-production version of the Interchange). The Interchange is configured such that the

Danish Node receives all messages published by the Danish TMC (as well as messages published by other Nodes connected to the Interchange).

No restrictions have been applied to the use of the NordicWay Interchange by other Nodes of the NordicWay network during testing.

5.2. Test Set-up for Performance over a Longer Period of Time

5.2.1. TEST EXECUTION

The test input includes all DATEX II Messages which are generated by the Danish TMC Production System in a one-month period (from 2017-07-07 to 2017-08-07). It should be noted that these messages include not only SRTI Messages, but also other types of DATEX II Messages generated by the Danish TMC.

5.2.2. TEST ENVIRONMENT

The test is executed using two instances of the Danish TMC (Trafikman2); the DATEX II messages are generated and output from the Danish TMC Production System, and messages are received by a separate test version of that System.

The communication with the NordicWay Interchange is via the production-endpoint (of the pre-production version of the Interchange). The Interchange is configured such that the Danish Node receives all messages published by the Danish TMC (as well as messages published by other Nodes connected to the Interchange).

No restrictions have been applied to the use of the NordicWay Interchange by other Nodes of the NordicWay network during the testing period.

6. Evaluation results

6.1. Quality Of Service Parameters

The parameters/KPIs used for the Quality of Service (QoS) assessment are defined below.

Parameter/KPI	Definition
Integrity	Correctness and completeness of data are preserved
Availability	Continuity/operational availability of transfer service
Volume/Load/Capacity/Throughput	Amount/volume of data that is/can be transferred.
Response Time/Latency	The time between data are sent and received

Table 1: Definition of KPIs

6.2. Functional Test

These test serves to assess integrity of end-to-end message transfer.

The tests gave the following test results:

Test	Test Cases	Results
From Danish TMC to Danish TMC	17	2 tests failed All other tests passed
From Danish TMC to Finnish Node (InfoTripla)	16	All tests passed
From Danish TMC to Swedish Node	2	Both passed

Table 2: Functional test results

The first functional test (from Danish TMC to Danish TMC) revealed an error in the Danish Cloud implementation which was then corrected. After that all the functional tests could be executed.

6.3. Technical performance and quality assessment

The results of the performance tests are described in the next sections.

Performance for different Data Volumes

The performance test with DATEX II Publications of different size gave the results in the table below. The response times are computed based on log files from the Danish TMC and the Danish Cloud.

No. of DATEX II Situation Records (per DATEX II Publication)	Size (kb)	Response Time (ms) (first Publication received by TMC)
10	43	200
50	207	230
450	1.851	1.455
950	3.905	3.806

Table 3: Test results of Performance for different data volumes

The results indicate that the total response time (From TMC to TMC) increases when the size of the DATEX II messages increases. The relationship is not linear, and for large messages there seems to be a small performance penalty (increase in response time) in addition to the increase which can be expected by the increase in message size.

This increase is most likely due to the work required by the Danish Cloud to package DATEX II messages from the TMC into AMQP messages. This involves, among others, scanning the DATEX II Publications to extract information for the AMQP parameter settings. However, the available log data are not sufficient for futher analysing the reasons for the increase in response time.

Overall, the observed response times fulfil the requirements to response times for SRTI messages from a TMC point of view.

Performance over time

The test was performed in a one-month period from 2017-07-07 to 2017-07-08 both days inclusive.

Table 4 summarizes the transfer of DATEX II messages to and from the Danish TMC via the NordicWay Interchange in the one-month testing period. The numbers are computed based on log files from the Danish TMC and the Danish Cloud.

DATEX II Message Transfer	No of DATEX II Messages
Messages generated by Danish TMC	8.925
Messages received (from the Danish Cloud)	37.949
Messages received from Danish TMC	6.682
Messages received from other Nodes	31.267

Table 4 Transfer of DATEX II Messages to and from the Danish TMC

The results show that DATEX II messages from other active Nodes (in the NordicWay Network) make up the majority of the valid DATEX II messages received by the Danish TMC. About 80 percent of these messages (31.267) are received and recognized as valid and unique DATEX II messages by the Danish TMC (A unique DATEX II message is a Situation record where the combination of Id, Version and SituationVersionTime is unique). The remaining 20 percent of messages are missing for different reasons: They are received by the Danish Node but not recognized as valid and unique DATEX II messages by the Danish TMC, or the TMC receive multiple copies of the same DATEX II message, in which case the messages are recorded as one single message by the TMC.

Apart from that, it is not possible to evaluate the quality of service of the message transfer from other Nodes because of lack of information about which messages have been generated and output by these Nodes.

As regards messages from the Danish TMC and back again about 75 percent of the messages generated by the TMC are returned to the TMC. The deficit lies within the Danish Node. The TMC did not receive messages in a 15-hour period due to a server breakdown at the Danish Node. This may explain some of the deficit, but the available log data does not provide a sufficient basis for analysing the reasons for the deficit and for assessing quality of service.

7. The impact of the service

Summary of findings

The performance testing demonstrates the feasibility of the NordicWay approach to sharing and exchanging safety related and real-time traffic information between various Nodes (National TMCs, OEM Clouds). This approach is based on representing traffic information using standard DATEX II data definitions and formats and exchanging this information using a queue-based message exchange system.

The observed performance as regards data volumes shows no substantial performance penalty in addition to the decrease in performance which can be expected with increasing data volumes. The performance is within the required performance levels in which TMC's shall operate.

As regards performance over a longer period of time problems with missing messages in the Danish Node (TMC, Cloud) have been observed, but it is not possible to evaluate performance with respect to integrity and availability in a thorough manner on the basis of the available log data.

8. Transferability of the results

8.1. Lessons learned

Future work is necessary to develop the proof-of-concept implementation of the Interchange mechanism into a stable and viable production system.

In addition to better performance this will include provision of standardized services for operation, monitoring, management and administration (access control, service catalogue, SLA management, charging and billing, partner onboarding, etc.). Requirements for this future development have already been discussed within the NordicWay project.

In particular, the service catalogue should be implemented in terms of a standard metadata catalogue. This will provide the basis for a standard way of searching for and discovering, which types of data are available via the Interchange.

The use of a standard metadata catalogue would also provide a basis for a standard way to defining subscriptions to data - subscriptions are currently defined in terms of application-specific property settings for the AMQP messages - following a project-specific standard. This should also help removing current application-specific restrictions (for example, that location specifications allow only point-based locations).

Finally, attention should be paid to ensuring that payload implementations are consistent and compliant with respect to the applied data exchange standards (in this case DATEX II). In general, clients with standard DATEX II implementations should be able to connect to the NordicWay network for queue-based message exchange without having to modify their DATEX II implementations.

8.2. Definition of next phase deployment

The NordicWay project has demonstrated the viability of queue-based message exchange for many-to-many data communication in a networked C-ITS environment. Furthermore, the use of payload-agnostic type of message exchange provides for a flexible data exchange involving different types of data in different formats and with different types of data definitions (with the proviso that the number of data standards be kept at a minimum).

In addition to preserving these properties, next phase deployment should accommodate the lessons learned which are described above.

Appendix A. Program Theory

C-ITS Service: Cooperative hazardous location warning (Traffic Management Centre to Vehicles)			
Program theory Denmark 			
Description of C-ITS service and Context	**What mechanism forms the basis for the expected results?**	**Expected results**	**Expected impact (outcome)**
The objective of hazardous location warning is to detect potentially dangerous locations on the road network and to warn drivers approaching the dangerous location, so that they can react by reducing vehicle speed and/or increase alertness. The hazardous event is detected and validated by: - The Road Directorate, in the TMC - detection is done automatically through a range of systems or could be done manually by a driver or the Police via e.g. phoning to the TMC	When the vehicle/driver receives a cooperative warning of a hazardous location ahead, it/he/she is aware of the situation earlier than without the warning. Due to this the vehicle can inform the driver and the driver can be better prepared for the hazard. Further, the vehicle might be able to inform other vehicles about the hazard.	Drivers: Increased alertness and lower speeds when vehicles/drivers are approaching a hazardous site, Network management: More efficient traffic and incident management. Technical performance: Technical parameters will be logged in the TMC and the vehicles (/mobile app) e.g. data latency, location accuracy, data volume, uptime etc. (Only the technical performance is included in the Danish pilot test).	• Better informed road users • Less accidents/incidents • Less congestion due to fewer incidents • Less emissions • Increased road network performance/efficiency

The objective of the Danish Pilot test is to test the technical performance of one part of the data chain: From the TMC to the NordicWay Interchange server/node.			

Relate to national objectives (described in NordicWay application form part D) and the NordicWay project objectives, which are as follows;

- *Improving road network performance through deployment of cooperative services, in terms of efficiency, environmental impact, safety and security*
- *Improving the quality and coverage of key safety services (road weather warning and hazardous location warning)*
- *Demonstration of benefits of C-ITS to users*
- *Establishment of the C-ITS market*
- *Assessing the benefits of C-ITS, including user acceptance and feasibility for wider deployment*

C-ITS Service: Cooperative weather and slippery road warning (Traffic Management Centre to Vehicles)

Program theory Denmark

Description of C-ITS service and Context	What mechanism forms the basis for the expected results?	Expected results	Expected impact (outcome)
The objective of weather and slippery road warning is to detect potentially dangerous or slippery weather conditions on the road network and to warn drivers of the potentially hazardous conditions, so that	When the vehicle/driver receives a cooperative warning of a hazardous weather or slippery road surface ahead, it/he/she is aware of the situation earlier than without the warning (before detecting/seeing it). Due to	Drivers: Increased alertness and lower speeds when vehicles/drivers are approaching a hazardous site, Network management: More efficient	• Better informed road users • Less accidents/incidents • Less congestion due to fewer incidents • Less emissions • Increased road network

they can react by reducing vehicle speed and/or increase alertness. The hazardous weather is detected and validated by: - The Road Directorate, in the TMC - detection is primarily done automatically through a range of systems, but could be done manually by a driver or the Police via e.g. phoning to the TMC The hazard classes are: a) temporary slippery road b) exceptional weather conditions (e.g. heavy rain, heavy wind). The objective of the Danish Pilot is to test the technical performance.	this the vehicle can inform the driver and the driver can be better prepared for the hazard. Further, the vehicle might be able to inform other vehicles about the hazard.	traffic management and winter road management. Technical performance: Technical parameters will be logged in the TMC and the vehicles (/mobile app) e.g. data latency, location accuracy, data volume, uptime etc. (Only the technical performance is included in the Danish pilot test).	performance/efficiency • Better winter road management

Relate to national objectives (described in NordicWay application form part D) and the NordicWay project objectives, which are as follows;

- *Improving road network performance through deployment of cooperative services, in terms of efficiency, environmental impact, safety and security*
- *Improving the quality and coverage of key safety services (road weather warning and hazardous location warning)*
- *Demonstration of benefits of C-ITS to users*
- *Establishment of the C-ITS market*
- *Assessing the benefits of C-ITS, including user acceptance and feasibility for wider deployment*