Milestone 2.6

Task 2.4.2 Interoperability demonstrator – making use of real-time safety related transport information cross border.

Status: [final]

Version: [1.00]

Date: [12. Feb. 2024]

Legal disclaimer

Document information

Project acronym	NAPCORE
Full project title	National Access Point Coordination Organisation for Europe
Grant Agreement No.	MOVE/B4/SUB/2020-123/SI2.852232
Activity no. and title	WG2, Task 2.4, Work item 2.4.2 - Interoperability demonstrator – making use of real-time safety related transport information cross border
Author(s)	Kenneth Sørensen, NPRA, Norway
Co-author(s)	Christian von Huth, DRD, Denmark and Björn Selander, STA, Sweden
Related to Milestone no.	2.6
External Milestone	yes

Document history

Version	Date	created/ modified by	Comments
0.75	27.10.2023	Kenneth Sørensen, N-NPRA	
0.80	31.10.2023	Kenneth Sørensen and Christian von Huth, DK-DRD	
0.92	03.11.2023	Kenneth Sørensen and Christian von Huth, DK-DRD	
0.93	04.11.2023	Björn Selander, STA	
0.94	11.12.2023	Kenneth Sørensen, Christian von Huth, DK-DRD and Björn Selander, STA	
0.99	25.01.2024	WG2	Review from WG 2. Changes suggested by WG 2 have been adopted.
1.0	12.02.2024	Christian von Huth, DK-DRD	Modified based on the CAT-review.
	14.03.2024	Hana Peters, Rupprech Consult	Finalized following Steering Committee approval

Document status:

☐	To be revised by partners involved in the preparation of the document
☐	For review/ approval by the Core Alignment Team and Peer Reviewers
☐	For approval by the NAPCORE Steering Committee
☒	Final
☐	Updated/revised final version (e.g. when a second version of Milestone is published)

Abstract

This report presents the idea and reasoning behind the interoperability demonstrator making use of real-time safety related transport information cross border. This report will describe why the use of the Improved Interface (II) and Basic Interface (BI) capabilities of the interchange, is a good way of making it easy for service provider to find and access transport related data using the NAPs, and afterwards describe the result of the demonstration carried out to "test" the idea with a real service provider. The report will also list implementation possibilities resulting in NAPs improvements and increased level of service.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

Abbreviations

Abbreviation	Meaning
API	Application Programming Interface
AMQP	Advanced Message Queueing Protocol
BI	Basic Interface – related to Interchange
CAT	Core Alignment Team
CEF	Connecting Europe Facility
C-ITS	Cooperative Intelligent Transport Systems
CKAN	Comprehensive Knowledge Archive Network
C-ROADS	EU project for harmonization of C-ITS related deployments
DCAT-AP	Data Catalogue Vocabulary-Application Profile
EC	European Commission
II	Improved Interface – related to Interchange
KPI	Key Performance Indicator
NAP	National Access Point
NAPCORE	National Access Point Coordination Organisation for Europe
NLKF	NAP Level of Service KPI Framework
PKI	Public Key Infrastructure
REST	Representational State Transfer
RTTI	Real Time Traffic Information (delegated Act B, under the ITS Directive)
SC, SCOM	Steering Committee
SRTI	Safety Related Traffic Information (delegated Act C, under the ITS Directive)
UI	User Interface
WG	Working Group

Definitions

Term	Meaning
End user	An end user is the driver using the traffic information service provided by a service provider – in some cases the end user can be a car or a self-driving vehicle.
GitHub	GitHub, Inc. is an AI-powered developer platform that allows developers to create, store, manage and share their code.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

REST API	An application programming interface (API or web API) that conforms to the constraints of REST architectural style and allows for interaction with RESTful web services
User	A user is to be seen as a service provider accessing the data in order to use it in a traffic information service used by end users.

Table of contents

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

List of tables

List of figures

1. Introduction

Throughout European nations, large amounts of transport-related data are generated and made available by multiple organizations and owners in multiple formats. These data can enable innovation, promote safer and more sustainable use of the road network, and enable drivers to make better informed decisions. By keeping a repository of metadata, the National Access Points (NAPs) enable service providers and other interested parties to browse these sources to find relevant data. The concept of these NAPs was introduced by the European Union's legislation outlined in ITS Directive 2010/40/EU. However, the anticipated benefits of this legislation regarding the NAPs have not been fully realized.

Although the NAPs make data sources easily searchable, the current implementation represents multiple data sources, and thus forces interested parties to join data from multiple data streams and organizations to build new services (Figure 1).

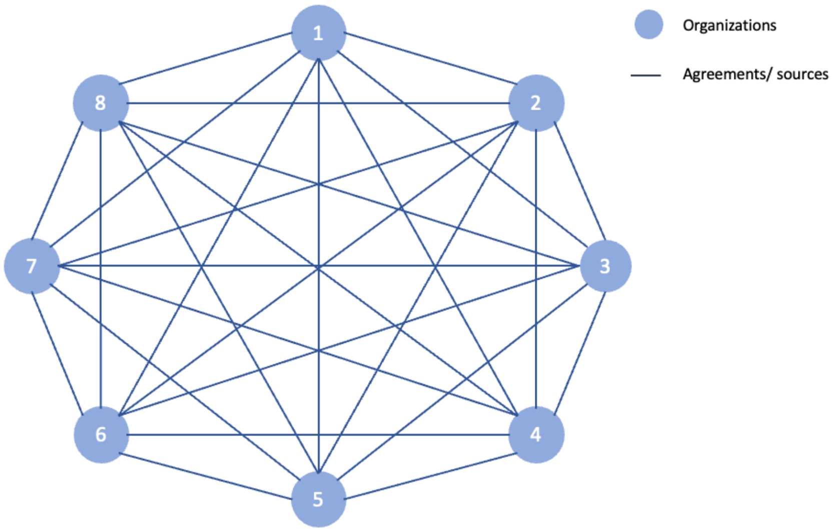

Figure 1 Complexity of sharing multiple data sources across multiple organizations.

Building cross-border services compounds this challenge, since the interested parties will have to search multiple NAPs to find the desired data sources. Earlier EU projects have proposed solutions to this challenge. By utilizing some of these solutions, metadata and actual data from different countries could be made available on all the NAPs, strengthening the NAPs "one stop shop" ability. This is especially relevant for real-time data and safety-related transport data, distributed over the DATEX-nodes. The purpose of this demonstrator is to showcase how using the best of the NAP functionality together with the best of the C-ROADS/NordicWay Interchange functionality, can facilitate sharing and use of for example SRTI-data (Safety Related Traffic Information), and introduce new innovative services for road users.

1.1. Objectives and scope

The primary purpose of this initiative is to explore solutions to overcome the challenges associated with Europe-wide metadata and data sharing, by promoting collaborative metadata and data sharing practices among different nations and their NAPs, making relevant metadata and real-time data accessible to all interested parties through any NAP. This will be achieved by using results from earlier EU-projects like C-Roads and NordicWay.

The aim is to propose a potential solution leveraging existing technology and facilitate sharing of metadata and data among NAPs, without a multitude of bilateral agreements, using the Swedish, Norwegian, and Danish NAPs as examples (Figure 2).

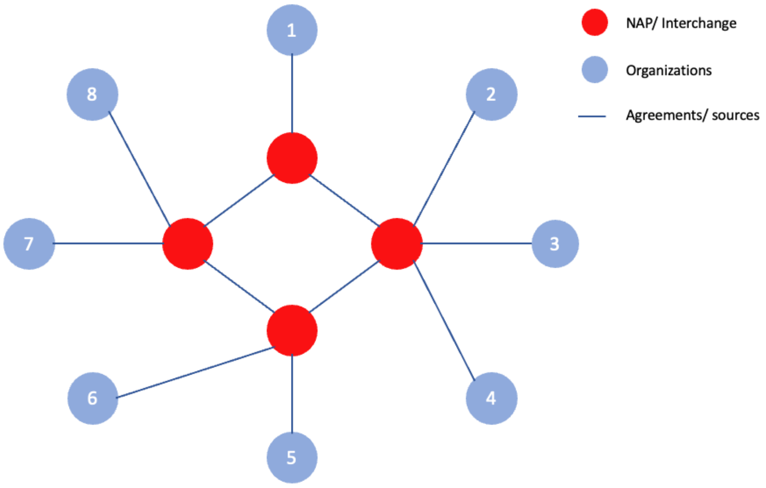

Figure 2 Less complexity through a federated system for data and metadata

This demonstrator will provide a conceptual and technical solution to how this type of interoperability can be achieved, both in terms of suggested minimum requirements for the reference architecture, and by providing the implementation as an open-source code repository that can be used for any nation or organization. The demonstration will showcase that the concepts developed can be utilized by all NAPs, even if they are technically and conceptually quite different.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

2. Context and background

2.1. NAP

The Directive 2010/40/EU on Intelligent Transport Systems (ITS) and its Delegated Regulations mandate the establishment of a National Access Point (NAP) for mobility data within each European Member State. Presently, there are over 30 operational NAPs, spanning across nearly all EU Member States and extending beyond, wherein mobility-related data is disseminated and made accessible for purposes such as travel information services.

It has been observed that the existing NAPs exhibit significant disparities in their structural configurations and data access interfaces. Additionally, there exists considerable diversity in data formats and standards employed across Europe. In pursuit of achieving better alignment and cohesion, the National Access Point Coordination Organisation for Europe (NAPCORE) initiative was undertaken.

NAPCORE receives co-financing through a Programme Support Action under the European Commission's Connecting Europe Facility (CEF). NAPCORE has been established as a coordinating mechanism aimed at enhancing the interoperability of NAPs, which serve as the foundation for the exchange of mobility data across Europe. NAPCORE seeks to enhance interoperability by standardizing and aligning mobility data, thereby increasing accessibility, and expanding the availability of mobility-related data through coordinated data access and improved harmonization of European NAPs. Furthermore, NAPCORE empowers National Access Points and National Bodies by defining and implementing common procedures and strategies, reinforcing the position and role of NAPs, and facilitating steps towards the development of pan-European solutions that enhance the utilization of EU-wide data.

NAPCORE has been conceived in the spirit of collaboration and consultation and encompasses 36 participants, including 33 Beneficiaries representing 26 EU Member States and 3 associated partners. Additionally, there are 37 Implementing Bodies involved in this endeavour. While the initial duration of the Programme Support Action extends until the conclusion of 2024, the overarching objective is to establish a sustainable and forward-looking organizational platform.

3. Solution design

3.1. Purpose and goals

The primary goal of this demonstrator is to show how a service provider can search and access safety related traffic data from different countries in an easy way through a single arbitrary NAP. In addition, the demonstrator aims at providing input for the NAP reference architecture and KPIs regarding level of service. The overarching goal can be summarized in a use case:

As a Service Provider, I wish to provide real-time safety related traffic information, cross-border, to my end users, so that they can receive relevant and updated information in a timely fashion and plan their journey accordingly.

This has been broken down into two more precise use cases:

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

Use case 1: As a service provider I would like to have access to up-to-date meta-data from one source, and the tools and mechanism for setting up necessary endpoints on the fly, so that the data I provide is always updated and available for the end-users of my services.

The demonstrator aims to show:

- An enhanced NAP model with an added Improved Interface (II) demonstrating an effective way to distribute metadata amongst the NAPs.
- A near production-ready tool/interface for exploring the metadata in the NAP Network, available as an open-source repository.
- By using the enhanced NAP model, the service providers can find a list of relevant metadata and filtering criteria available.
- The NAPs operate in common federated network, so querying one NAP for its metadata will return all metadata for all data sources made available by any country or organization that is connected to the network, granted that the NAP has the control interface, defined as the II-interface.

Use case 2: As a service provider I would like to collect traffic-related messages on behalf of users from one official source, relevant to his or her location and route, even when crossing national borders, which enables the end-user to make decision regarding his and her route in ample time to reduce travel time and avoid incidents.

The demonstrator aims to show:

- That an enhance NAP model with an added BI-interface is a good solution for a standardized and structured mode of creating, filtering, and accessing metadata and actual data.
- Functionality for generating publish/subscribe endpoints on the NAPs to receive data based on needs and available data.
- Filtering mechanisms based on geographical position, message type or other criteria, to ensure that the data is updated and relevant.
- A servicer provider gets access and starts receiving data that can be published to their customers within a short time.

3.2. Relation to other CEF supported projects

The demonstrator builds upon both specification and implementation work done in earlier CEF-financed projects. The Interchanges and the accompanying specifications for the Improved and Basic Interfaces have been specified in the C-ROADS project.

The practical implementation of the interchange has been done through the CEF-financed NordicWay projects.

3.3. The idea of demonstrating already existing technologies

The idea of the solution came through the learnings and 10+ years of development in other European-financed CEF-projects (C-ROADS and NordicWay). Sweden, Norway, and Denmark have in cooperation with other European countries created an entity called the interchange that had needed capabilities.

The Interchange is an implementation of the European C-ITS hybrid specification which is essentially the definition of two APIs that enable both metadata sharing and distribution of actual data. The two APIs are the Basic interface and the Improved interface.

The idea of this project was to implement the basic interface and the improved interface developed in each participating country's NAP to demonstrate how to make use of existing technologies to solve some of the fundamental core issues with current European NAP implementations.

C-roads hybrid specifications

Basic Interface – BI

The basic interface is part of the hybrid C-ITS specifications from C-ROADS. The interface consists of an API (to create and/or search for metadata) and several AMQP endpoints to produce and/or consume the data related to the different datasets.

Improved Interface – II

The improved interface is part of the hybrid C-ITS specifications from C-ROADS and is also called the Interchange control layer or federation layer. This is both a protocol and a set of metadata that needs to be set when a dataset is made available on the message broker. An important function of this layer is the automatic discovery of other nodes with an Improved Interface in the network.

Why add II and BI to the NAPs?

The addition of the C-ROADS II- and BI to the NAPs is an approach that offers several advantages. First and foremost, the II would enhance data accessibility and interoperability cross-border NAPs by providing access to dynamic and real-time data from any NAP, regardless of organization or nationality. The BI-interface provide a standardized and structured mode of creating, searching, filtering, and accessing metadata (and actual data) in each NAP.

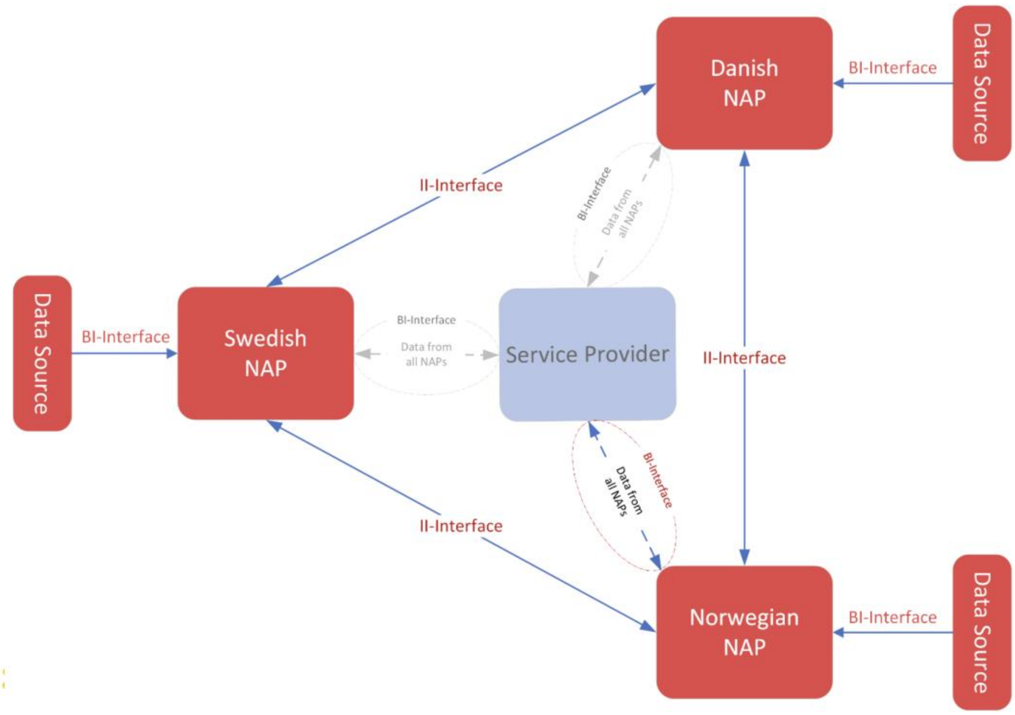

Figure 3 High level architecture

The high-level architecture can be seen in Figure 3**Error! Reference source not found.**. The figure illustrates a Service Provider getting access to Swedish, Danish, and Norwegian metadata and data by accessing the Norwegian NAP and using the Interchange to find and accessing data.

3.4. Extended NAP reference architecture

The existing Swedish, Norwegian and Danish NAPS already consist of a user interface to add and search for datasets and a database with dataset records (metadata). The concept described in this demonstration introduces a few new components for the extended NAP reference architecture.

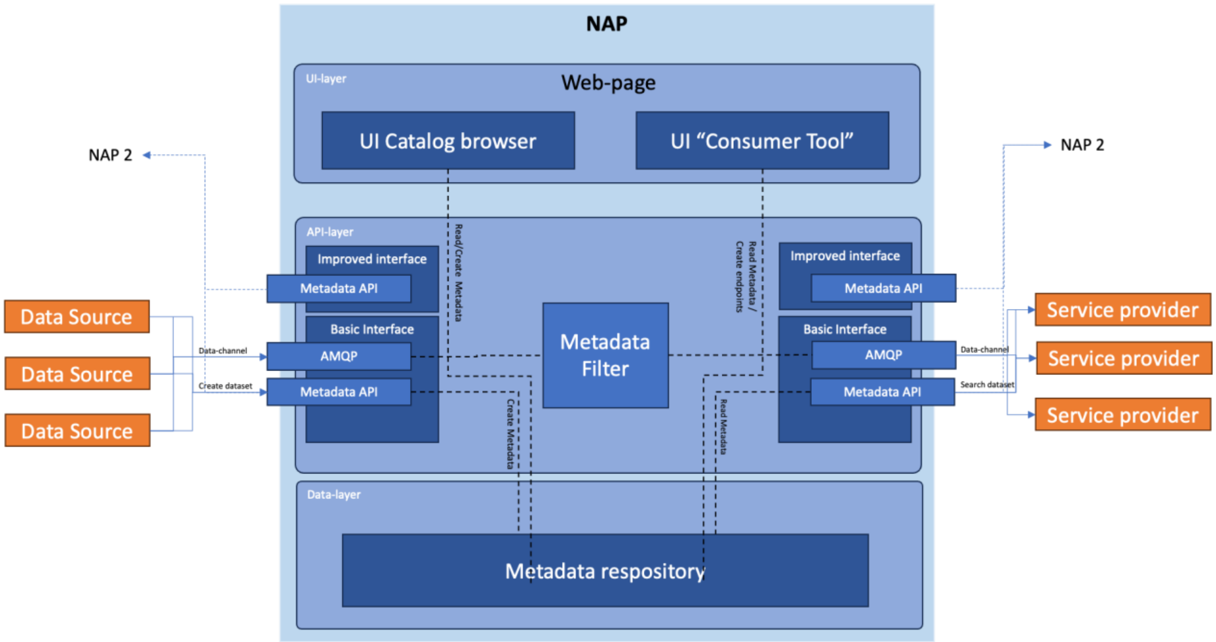

Figure 4 Functional view of a fully implemented NAP

The new components in the fully extended NAP are:

- AMQP- message broker and metadata filters
- Basic Interface
- Improved Interface
- UI "Consumer tool"

AMQP - Message broker and Geo filter

The system is built around publish/subscribe architecture to enable messages to be pushed to the service providers on set intervals or when new messages arrive. From the C-ROADS specification this message broker is AMQP (Advanced Message Queuing Protocol) version 1.0. This is a standard protocol used by for example Google, NASA and IBM. Some NAPs, for example the Danish, has this as part of the services portfolio already, while most others do not. This serves as the foundation upon which the two essential interfaces, II and BI, are constructed.

Basic Interface

See chapter **Error! Reference source not found.** for more information.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

Improved Interface

See chapter **Error! Reference source not found.** for more information.

UI Consumer tool

This is the user interface providing the interaction necessary for the service providers to create unique subscriptions (endpoints) from DATEX based traffic data sourced, using ad hoc filtering mechanisms independent of when the source was created, or in which NAP the data resides. The tool also provides the service providers with the necessary PKI certificates to deploy their services. This layer is the main outcome of the demonstrator.

4. Demonstrator architecture design decisions

With a short timeframe and a limited budget for this demonstrator, the team made two significant deviations from the original reference architecture:

1. Using the existing and operational interchanges in each county.
2. No DCAT-AP in the BI and II.

Using the existing and operational interchanges in each country

There were already fully functioning interchanges running in Sweden and Norway which could be extended with a user interface that at a later stage can be integrated into any NAPs. Using this approach, the development of this demonstrator became significantly cheaper and faster, without any lack of functionality.

At an early stage of NAPCORE, there was a proposal to provide an API for generating *mobilityDCAT-AP* from the metadata available over the Improved Interface (II) (called *capabilities* in the C-ROADS specification) that would be automatically uploaded to the participating NAPs. However, subsequent discussions revealed that this approach was deemed overly time-consuming and potentially suboptimal for mainly two reasons:

Firstly, the capabilities available over II are quite dynamic, and datasets can be added (and removed) by data providers continuously. The NAPs would therefore have to be updated relatively often, potentially encountering challenges such as ensuring uniform updates of metadata across all platforms.

Secondly, one of the strengths of the capabilities in the II is the ability to filter in a highly flexible manner, giving the service providers access to exactly the data they want, based on for example type of data, location, organization providing the data, etc.

It is, however, a possibility to align mobilityDCAT-AP and Basic Interface (BI) so that you can automatically update NAP with new data sources. This potentially involves alignment between C-ROADS and NAPCORE and involves adding more metadata fields in the BI. It also means adding functionality to the User Interface (UI) consumer tool and the Interchange specifications. This was not done for this demonstration, but should be explored further, as it might bring big benefits. Using mobilityDCAT-AP could be a good solution for Interchanges running without the improved interface as a common metadata repository, but it would not provide the federation.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

4.1. The proposed solution for the demonstrator

The demonstrator team landed on a looser coupling by adding a REST-API between and existing interchange and NAPs. The Interchanges can be seen as a tool in the NAP toolbox. The tool is accessed through a separate webpage available on the NAP where the service providers can see the available data sources, build their own custom metadata queries, and provision an endpoint where they will connect their service or application.

Through this tool, service providers can also generate the necessary PKI-keys so that their service can access the data securely. For the demonstration, a regular PKI-scheme was used, consisting of a public key identifying the message broker the service will connect to, and a public and a private key identifying the service provider. Once these are added to the service, the service provider can start accessing the data. The keys are obtained after the user is granted access to the tool upon request to the project team.

The design consideration and architecture concept introduced one new key component (specific to this demonstration).

REST-API (NAP Federation REST-API)

The purpose of the NAP Federation REST-API is to make the necessary features of the BI and II layers available as a webpage on the NAP. Through this API, the system can authenticate users for login, create queries for data filters, provision endpoints, and store queries and endpoints that the user has created. This API, and the accompanying webpage, available on GitHub upon request to the author, are main technical outcomes from this demonstrator.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

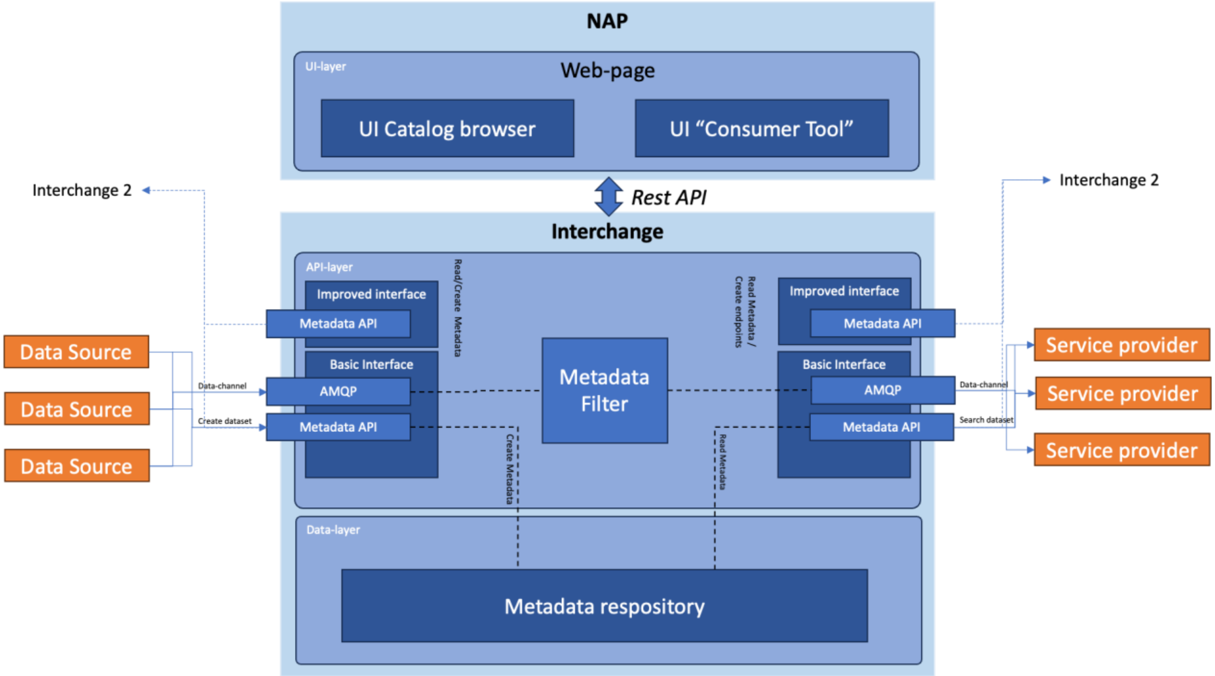

Figure 5 The purpose-optimized architecture for this specific demonstration

4.2. Dataflow through the system

The data-producer creates a dataset (metadata) by making use of the BI API. Metadata for the sources are made available over a REST-API that translates these II (Improved Interface) metadata to HTTP that can be used by the webpage. No data is transmitted over the REST-API, just metadata, it is a facilitation layer.

The data-producer then publishes data into a message broker using DATEX II and a reference to the created dataset (metadata). The broker publishes these data on several topics, based on the metadata (Basic Interface) of the sources. Service providers can then browse available datasets in the NAP browser catalog.

Based on the service provider's needs (what they request/query via the tool), a query is generated in the webpage, that is sent to the REST-API which then again requests a new topic from the message broker. Results matching the query will be published on a provisioned endpoint. These endpoints are also called a subscription. The necessary information is then stored in REST-API on a service provider level. Examples of the user interface can be seen in Figure 6 and Figure 7.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

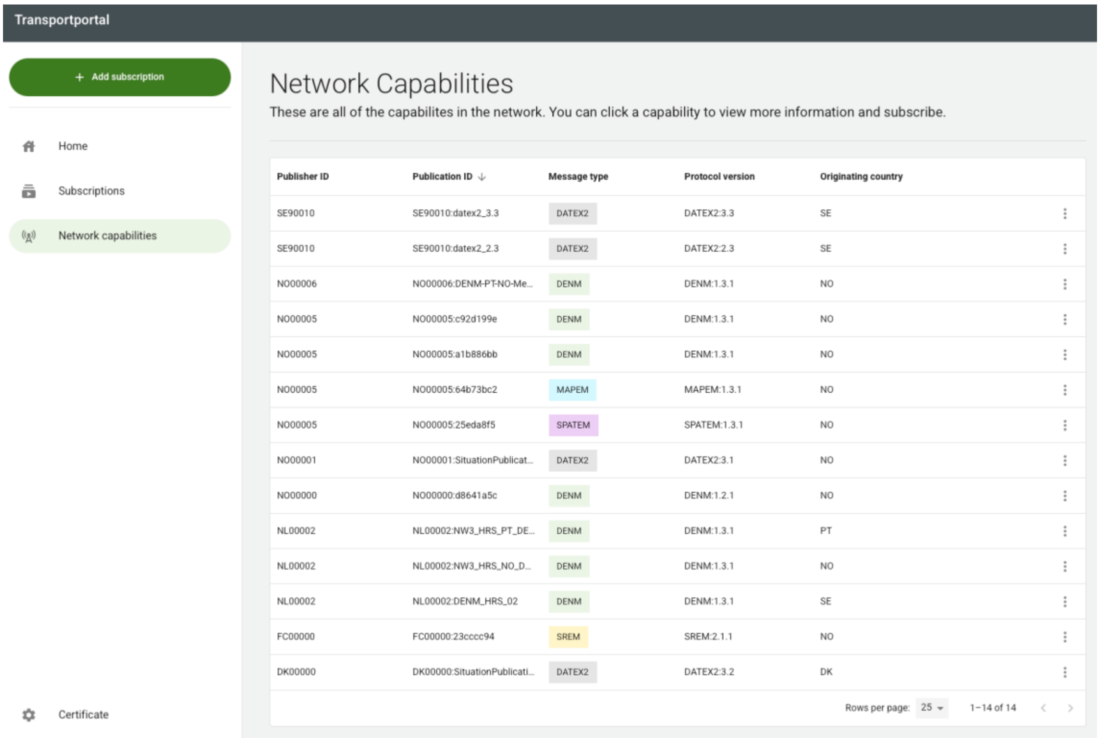

Figure 6 Available sources and their metadata available on the federated message brokers

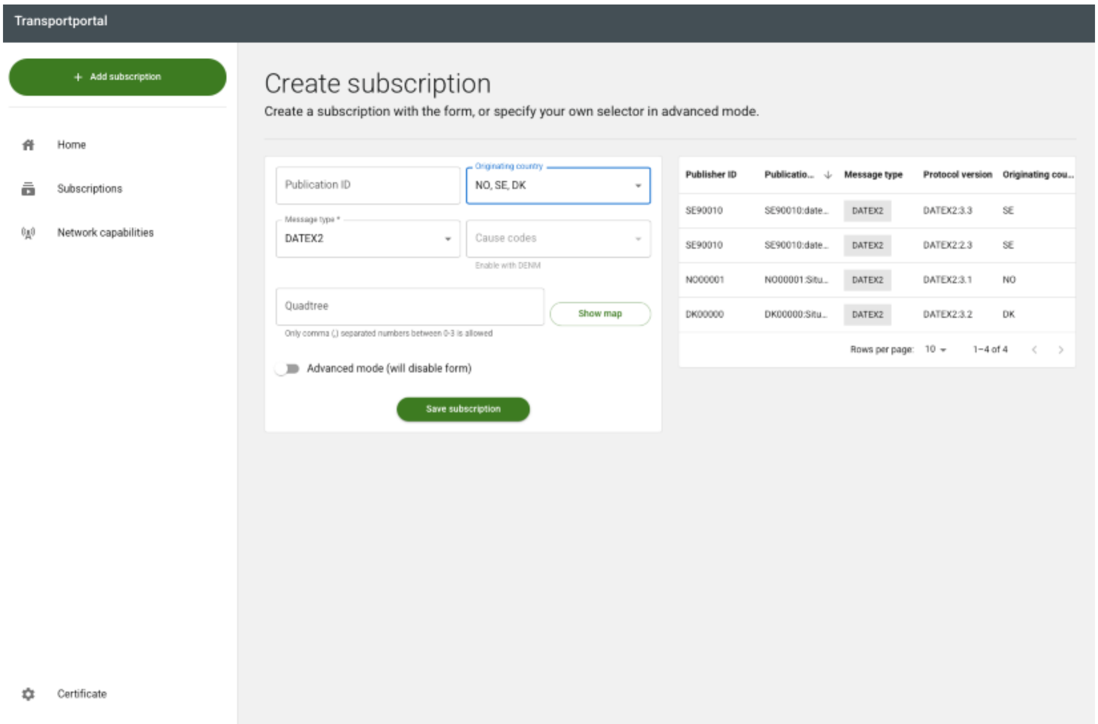

Figure 7 Example for building a DATEX II in Norway, Sweden and Denmark query

Once the subscription has been provisioned, the service providers can connect directly to the message broker end point providing the data using PKI keys, initiating the flow of data.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

In the example above there are two NAPs involved. Data from Sweden is published using the Swedish NAP, supplied by Monotch, and data from Norway and Denmark is supplied by the Norwegian NAP, hosted by the NPRA, and developed by Bouvet. The data is available on different versions of DATEX II depending on the source. This is clearly stated in the metadata, so this can be accounted for by the service providers. If another country or organization decides to connect/add an Interchange or a NAP implementing the two above mentioned interfaces (II and BI) to the network, the new metadata and data will become available to all.

4.3. Implementation guideline

Implementation is too broad a scope for this document. The implementation requires deep knowledge of the C-ROADS specifications for the Interchange and the improved and basic interfaces. There are also several paths for implementation.

The implementation and the associated costs will depend on several factors:

- Whether the NAP has message broker
- Whether or not the NAP is a meta data repository or a data warehouse
- Service level:
  - Message throughput
  - Uptime
- Implementation path:
  - Add BI and II to a current NAP.
  - Buy an Interchange as a service and integrate it with a NAP.
- If a tight or a loose integration is chosen by the NAP operator.

A tight integration means adding BI and II to a current NAP, while a loose integration means linking to a separately hosted Interchange. The source code with short implementation guideline and information about the tool created in this demonstrator is available on GitHub, currently on request but it will be made opensource in the future.

Implementation also requires that the necessary agreements are set up with different sources that provides the data that is to be published. If all could agree on using Creative Commons by 4.0, will ease the sharing of data.

5. The demonstration

To demonstrate how easily service providers can find and connect to real life data using the concepts in the demonstrator, participation from a service provider interested in getting access to data from Denmark, Sweden and Norway was needed.

The demonstrator team approached Be-Mobile at the ITS congress in Lisbon, where they visited the NordicWay project demonstrating the use of the interchange for passing information from mobile road works into an application running on the infotainment system in a Polestar. Be-Mobile agreed to participate in the demonstration. After being presented the purpose and the use case, they could immediately see the benefits of participating in the demonstration.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

Preparation

Before the date of the demonstration, the team made sure that Be-Mobile had the necessary login credentials and that they had access to the demonstrator webpage for a few days to prepare for the demonstration.

The online demonstration

The demonstration took place at an online meeting on the 25. October 2023, from 09:00 to 10:30, of which the actual demonstration lasted a little less than 30 minutes (The full video can be found at the NAPCORE SharePoint in the WG2 folder).

One of Be-Mobiles backend developers demonstrated to the participating representatives from WG2 from NO, DK, and SE what they had done in order to get access to the dataset they needed via the Norwegian NAP. This could also have been achieved using any of the other NAPs.

Be-Mobile skipped demonstrating the signing in process, since they were already signed into the tool, and demonstrated how the necessary certificates to authenticate their backend were created, how the data feeds were found and how data was accessed by integrating the source endpoint directly into their Traffic Event Manger. As can be seen from the screen below they were successful in this operation.

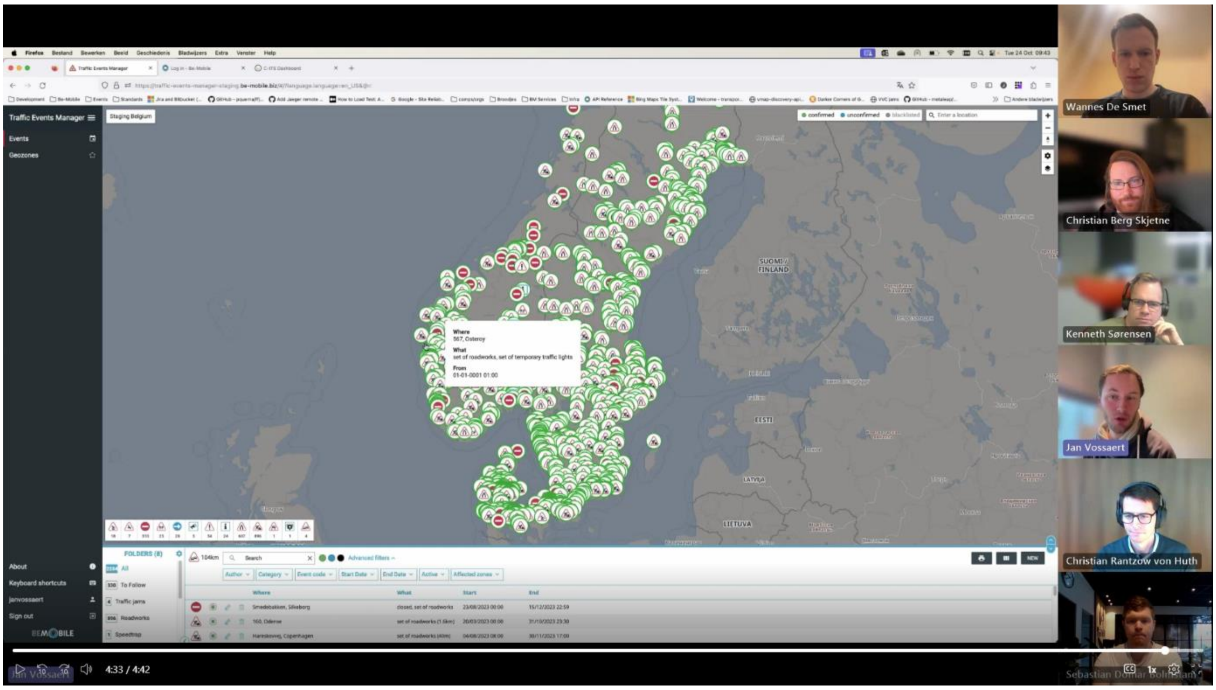

Figure 8 Screenshot from the end of the demonstration

Here is a link to a short version of the demonstration video that will be presented at Mobility Data Days in Budapest, the 9th of November 2023.

6. Results

The demonstration elicited a highly favorable response from Be-Mobile, who assumed the role as outlined in the overarching use case:

As a Service Provider I wish to provide real time safety related traffic information, cross border, to my end users, so that they can receive relevant and updated information in a timely fashion and plan their journey accordingly.

Be-Mobile found it easy to find the data needed. Especially after retrieving data from one country, it was very easy to add data from another country. There was no need to search elsewhere; rather, they simply repeated the steps they had already completed.

"So, we can see that it was very easy. We have one platform where can receive all traffic information from different countries. The integration for the different countries is actually identical, so when you integrate one country, you can very easily add additional countries.", Jan Vossaert, Backend Developer, Be-Mobile.

"If all countries or a group of countries had set up such a system, then that would make our technical work a lot easier. That is certainly fair to say. ", Wannes De Smet, Offering Manager Traffic Information, Be-Mobile

To take a deeper look at the results, it is necessary to examine the two more specific use cases into which the overall use case was divided. The following two chapters give an overview of the objectives aimed to be demonstrated in each use case and the outcomes achieved.

6.1. Use case 1.

As a service provider I would like to have access to up-to-date meta-data from one source, and the tools and mechanism for setting up necessary endpoints on the fly, so that the data I provide is always updated and available for the end-users of my services.

Table 1 - Summary of the outcomes of the first use case

The demonstrator aimed to show …	The result of the demo
An enhanced NAP model with an added II (Improved Interface) demonstrating an effective way to distribute metadata amongst the participating NAPs.	Proven – when Be-Mobile easily found the list of the different data sources.
A near production ready tool/interface for exploring the metadata in the NAP Network, available as an open-source repository.	Proven - even though, due to time limitation, the "loose connection" to the NAPs was used
By using the enhanced NAP model, the service providers can find a list of relevant publications and filtering criteria available.	Partly proven since the service provider didn't find the available filtering criteria.
The NAPs operate in common federated network, so querying one NAP for its metadata will return all metadata for all data sources in any country that is connected to the network, granted that the NAP has the control interface, defined as the II-interface.	Proven. The interface (see picture 1) shows the different.

6.2. Use case 2.

As a service provider I would like to collect traffic related messages on behalf of users from one official source, relevant to his or her location and route, even when crossing national borders, which enables the end-user to make decision regarding his and hers route in ample time to reduce travel time and avoid incidents.

Table 2 - Summary of the outcomes of the second use case

The demonstrator aimed to show …	The result of the demo
Functionality for generating publish/subscribe endpoints on the NAPs to receive data based on needs and available data.	The demonstrator showed a functioning basic implementation of achieving this.
Filtering mechanisms based on geographical position, severity, time before resolved or other criteria, to ensure that the data is updated and relevant.	Be-Mobile did not use this feature in their demonstration, this was however displayed by the development team.
A service provider gets access and starts receiving data that can be published to their customers within a short time.	Be-Mobile was able to receive and use data and do a demo just a few days after having access to the webpage.

6.3. Lessons learned.

Be-Mobile gave good feedback during the demonstration. Some of their improvement points were directed more toward the technical implementation than toward the process of accessing the data. The main two points for improvement were:

- The certificates used are self-signed and didn't follow the standards used in Be-Mobiles implementation. The issue was overcome by turning off certain security features.
- Data from the data sources are being distributed in regular burst (on five- or ten-minute intervals). This is suboptimal with regards to load handling on the receiver end.

None of the improvements are related to the concept itself, but rather how it was implemented for the demonstration. The certificate issue would be fixed by using an official certificate authority, which most likely would be the case for an operational implementation. The data bursts can be solved through specifications and best practices.

Using the more advanced functionalities of the BI-interface such as the filtering mechanisms based on geographical position, severity, time before resolved or other criteria, may need introduction. Be-Mobile didn't utilize these functionalities in the demonstration. Most likely Be-Mobile simply did not anticipate encountering such functionalities, and as a result, did not actively seek them out. Alternatively, they may have deemed them unnecessary.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223

7. Conclusions

The main takeaway from this demonstrator is that using concepts developed around the Interchange in the C-ROADS and NordicWay projects, like the Improved and Basic interfaces, could provide several benefits for the NAPs. This includes facilitating the discovery and utilization of transport-related data. Furthermore, the federation removes the need for a complex web of bilateral agreements and credentials across multiple organization and facilitate data sharing across organizations and borders. By providing flexible filtering options, the concepts enable service providers to get exactly the data their users need.

The demonstrator has provided the building blocks and concepts for creating both a tight and loose coupling between the NAPs and the Interchange concept. Due to time and cost constraints, the demonstrator could not build a tightly coupled solution, but through a loosely coupled solution the project demonstrated that a commercial service provider can quickly start receiving and using data.

Adding the BI and II to other NAPs would be beneficial for achieving increased interoperability of data between the NAPs across Europe. It would also enable the NAPs to have both centralized and decentralized message distribution, enabling accessibility of / the flow of important data even if one or more NAPs are down.

It is also important to note that the BI and II functionalities are suited for real time data sharing. For example, SRTI and RTTI data that is time critical.

Additional functionality

In this demonstrator, the focus has been mainly on receiving data, but the concept can also be adapted so that data providers can push data, and thus provide new data sources. The mechanism for this functionality was not implemented in the current iteration of the demonstrator software.

7.1. Outcomes and future relations to other projects from this demonstrator

NAPCORE WG2 Task 2.1 Level of service of NAPs

Adding the BI and II to a NAP may affect the NAP Levels of service KPI Framework (NLKF). Some changes to the NLKF might be necessary to reflect this. The project has identified that the following KPIs might be affected, and therefore should be handled by the NLKF revision process:

- Communication feature 2.1 “Provision of support to user to register and add data/metadata” will be impacted by adding this functionality, since the user interface developed for the demonstration can also be adapted to provision endpoints for publishing data and therefore would impact this KPI.
- All three features under category 3 “data discovery” will be impacted by the concept. The user interface enables service providers to browse and filter multiple data sources at once, increasing search functionality and display of results. It also enhances the provisioning of machine-readable meta data for the different sources since this is a key requirement for the discoverability of sources across the federated II/BI nodes.
- Feature 4.2 “NAP content and metadata” will also be impacted. Metadata and data will be updated by the data provider in real-time (if implementing the BI/II). This is related to feature 3.3 “Provision of machine-readable metadata”.
- Features under category 6 “interoperability” will need an additional KPI-feature, or multiple KPI-features, in order to evaluate the impact of federation or cross-border functionality.
- Feature 7.2 “Data license” will be affected. By publishing data using the concepts described here, the data provider agrees to a certain set of terms and conditions, these should be easily accessible on the NAP

The scoring under the above mentioned KPIs might also depend on how tightly the concept described in the demonstrator is integrated into the NAP. In essence there are three levels of integration:

1. No implementation of cross-border data sharing solution.
2. Loose integration to an existing Interchange.
3. Tight integration into your NAP by making the key components of the architecture part of the NAP.

In order to achieve a **tight** integration, the NAP would need:

- An AMQP message broker or some mechanism for publish/subscribe architecture.
- Some mechanism to provide both the Basic and Improved Interface.
- The REST-API created in this demonstrator.
- An implementation of the webpage created in this demonstrator.

The only requirements for a **loose** integration are:

- Access to an Interchange, either public or private.
- Hosting for the REST-API and Webpage created in this demonstrator.
- A link to the webpage from the NAP.

The revision process for the NLKF is beyond the scope of this report.

NAPCORE WG2 Task 2.2 definition of requirements concerning data standards, reference profiles, metadata and support tools.

There is a need to investigate/map how the metadata schema mobilityDCAT-AP fits with metadata requirements of the basic and improved interfaces, and how they can co-exist and enrich each other. One way of achieving this could be extending the "attributes" described in the BI-interface creating (and reading) capabilities with the mobilityDCAT-AP attributes.

NAPCORE WG2 Task 2.3 NAP Reference Architecture

This is described in more detail in Chapter **Error! Reference source not found.**.

NAPCORE sWG4.4 - MobilityDCAT-AP

As discussed in Chapter 4 it would be beneficial to investigate how *mobiltyDCAT-AP* can be aligned with the metadata requirements for the Interchange concept, and how this could increase the availability and ease of access of SRTI and RTTI sources. Using mobilityDCAT-AP could also be a good solution for Interchanges running without the improved interface, as a common metadata repository. To have federated sources available all over Europe, it would be worth exploring how the NAPs and basic and improved interface (BI and II) specifications can be updated so that these concepts can co-exist and enrich each other.

This project has received funding from the European Commission's Directorate General for Transport and Mobility under Grant Agreement no. MOVE/B4/SUB/2020-123/SI2.85223