



Milestone 2.10

Interoperability demonstrators with real-world use of data and different Levels of Service – 2nd round

Status: final
Version: 1.0
Date: 09 January 2024

Legal disclaimer

The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the European Union. The European Commission is not responsible for any use that may be made of the information contained therein. All images are provided by the respective partners (unless otherwise noted) and are approved for reproduction in this publication.

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 items 2.4.3 – Interoperable NAP demonstrator of a marketplace or clearing house NAP, 2.4.4 - Interoperable NAP demonstrator with Metadata, and 2.4.6 – Alternative Fuels Demonstrator
Author(s)	João Montenegro, PT-Armis; Sara Linhas, PT-Armis; Petr Bureš, CZ-RSD CR; Christian Von Huth, DK-DRD; Kenneth Sørensen, NO-NPRA; Ed Ooms, NL-NTM/NDW; Arthur Kessen, NL-NM/NDW.
Co-author(s)	Peter Lubrich, DE-Federal Highway Research Institute (BAST), Lígia Conceição, PT-Armis
Related to Milestone no.	2.10
External Milestone	yes

Document history

Version	Date	created/ modified by	Comments
0.1	25.06.2024	João Montenegro, Armis	First draft
0.2	09.12.2024	João Montenegro, Armis; Petr Bures, Tamtam Research	Second draft
0.2	13.12.2024	Hannah Walther	For review/ approval by the Core Alignment Team and Peer Reviewers
1.0	09.01.2024	João Montenegro	Final draft
1.0	11.03.2025	Hannah Walther	Final version after SCOM approval by written procedure

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 document presents four interoperability demonstrators aimed at improving cross-border mobility data exchange and ITS service continuity. The demonstrators include (meta)data solutions for topics of common interest, such as interchanges, marketplaces, metadata and alternative fuels. The document summarises the demonstrators' scopes, architectures, and key outcomes. Organized into four sections, the report highlights findings and lessons learnt, with further technical details provided in the Annexes.



Abbreviations

Abbreviation	Meaning
AFIR	Alternative Fuels Infrastructure Regulation
API	Application Programming Interface
AMQP	Advanced Message Queuing Protocol
BI	Basic Interface
EC	European Commission
EU	European Union
C-ITS	Cooperative Intelligent Transport Systems
CKAN	Comprehensive Knowledge Archive Network
DCAT-AP	Data Catalogue Vocabulary-Application Profile
DR	Delegated Regulation
II	Improved Interface
ITS	Intelligent Transport Systems
KPI	Key Performance Indicator
LoS	Level of Service
M	Milestone
MS	Member States
NAP	National Access Point
NAPCORE	National Access Point Coordination Organisation for Europe
NLKF	NAP Level of Service KPI Framework
NRA	NAP Reference Architecture
POC	Proof of Concept
REST API	Representational State Transfer API
RTTI	Real Time Traffic Information
SRTI	Safety Related Traffic Information
SWG	Sub-working Group
T	Task
UI	User Interface
WG	Working Group
WP	Working Programme

Table of contents

1. Introduction.....	1
2. Context and background	2
2.1. National Access Points (NAPs).....	2
2.2. NAP Levels of Service (LoS).....	2
2.3. NAP Reference Architecture	2
3. Summary description of the demonstrators	4
3.1. Interchange demonstrator	4
3.2. Marketplace demonstrator	7
3.3. Metadata demonstrator.....	10
3.4. Alternative Fuels demonstrator	12
4. Conclusions.....	16
4.1. Common lessons learnt and challenges faced	16
4.2. Combined feedback to NLKF	16
4.3. Combined feedback to the NAP Reference Architecture.....	18
4.4. Future work/next steps	19
List of Annexes	20
A. Interoperable NAP demonstrator of a marketplace or clearing house NAP	20
B. Interoperable NAP demonstrator with Metadata.....	20
C. Alternative Fuels Demonstrator	20
D. Scoping of demonstrators expectations.....	20
E. Demonstrator feedback to the NRA.....	20

List of tables

Table 1 - NAP typology definition (according to Milestone 2.9)	2
Table 2 - NLKF features associated with the different demonstrators	17

List of figures

Figure 1 – Interchange Demonstrator - High Level Architecture	5
Figure 2 – Interchange demonstrator: The purpose-optimized architecture for the demonstration	6
Figure 3 - Overview of the MarketPlace Demonstrator’s architecture.....	9
Figure 4 – Functional architecture of the Metadata Demonstrator	11
Figure 5 - Alternative Fuels Demonstrator - use cases' description.....	14



1. Introduction

The second working group of the NAPCORE project (WG2 “Interoperability and level of service of NAPs”) aims to define minimum conditions and coordinate the development of European National Access Points (NAPs) by enhancing their compatibility and interoperability. Task 2.4 focuses on enabling better cross-border interoperability and ensuring the continuity of ITS Services. Task 2.4 supports those goals by developing NAP interoperability demonstrators.

An interoperability demonstrator is a digital solution that showcases and validates how different systems, services or organizations can interact and exchange data. In the context of NAPs, these demonstrations assess solutions for leveraging NAP data to facilitate mobility data exchange, considering real-world scenarios from the data consumer’s perspective.

Task 2.4 involves two milestones, each corresponding to a round of interoperability demonstrators. The first milestone (M2.6) describes an Interchange demonstrator for real-time, cross-border, Safety-Related Traffic Information (SRTI). This document pertains to the second milestone (M2.10), which includes the following demonstrators:

1. Interchange demonstrator (already covered in the first round)
2. Interoperable NAP demonstrator of a marketplace or clearing house NAP
3. Interoperable NAP demonstrator with Metadata
4. Alternative Fuels Demonstrator

These demonstrators were developed throughout the NAPCORE project and presented at the 2023 and 2024 Mobility Data Days in Budapest and Turin, respectively.

This document summarizes the scopes, architectures, main outcomes and lessons learnt from the demonstrators. Detailed documentation for each demonstrator is provided separately and referenced in the Annexes (see List of Annexes)¹. The Annex **Fehler! Verweisquelle konnte nicht gefunden werden.** includes scoping demonstrator expectations, defining what a demonstrator is, identifying key elements to be delivered/reported, determining goals, and determining challenges. A template to suggest changes to the NRA is provided in Annex E.

The document is organised into four sections: “1. Introduction”; “2. Context and background”, which includes information about NAPs and NAPCORE activities; “3. Summary description of the demonstrators”, covering the scope, architecture and main findings of each demonstrator; and **“Fehler! Verweisquelle konnte nicht gefunden werden.. Fehler! Verweisquelle konnte nicht gefunden werden.”**, which gathers the main outcomes of the individual reports and provides feedback to other NAPCORE tasks.

¹ The Interchange Demonstrator has been available since the publication of M2.6 on the NAPCORE Website and is not included as an Annex. The Annexes here only refer to the remaining demonstrators developed under M2.10.



2. Context and background

2.1. National Access Points (NAPs)

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. Currently, there are over 30 operational National Access Points, spanning across nearly all EU Member States and beyond, wherein mobility-related data is disseminated and made accessible for purposes such as travel information services.

While defining how NAPs can be set up, NAPCORE T2.3 proposed a differentiation of two NAP types, which are described in **Fehler! Verweisquelle konnte nicht gefunden werden..** These are relevant for the conceptualization of the demonstrators and have been included in this report for reference.

Table 1 - NAP typology definition (according to Milestone 2.9)

NAP type	Definition	Key features
Metadata Directory	Contains descriptions of the data and services important for their identification, assessment and subscription by consumer, i.e. metadata. It provides facilities to authenticate data provider and functionality to insert a metadata records. The NAP provides search and discovery services of the hosted records to end user and via machine readable to other portals. The NAP is not involved in the data exchange process between data providers and data consumers	Storage & provision of metadata records of data, services and providers; search/discovery functionality; data provider authentication
Data platform	Contains descriptions of the data and services important for their identification, assessment and subscription by consumer, i.e. metadata, together with the data and/or services themselves. It provides facilities to authenticate data provider and data consumer and functionality to insert a data and metadata records to NAP internal database. The NAP provides search and discovery services of the hosted records to end user and via machine readable to other portals and distribution interface for the data dissemination. The NAP is an intermediary between data provider and consumer, the data however remain in the ownership of the data provider	Storage & provision of metadata records of data, services and providers, storage & provision of data and services; search/discovery functionality; data provider and data user authentication

2.2. NAP Levels of Service (LoS)

While WG2 focuses on enhancing interoperability between NAPs as a whole, Task 2.1 (T2.1) aims to harmonize and improve the Level of Service (LoS) of NAPs. To achieve this, T2.1 developed the NAP LoS KPI Framework (NLKF), which evaluates the LoS of NAPs based on their features. Some of these features are critical for the development of demonstrators, and additional features may be required for their successful implementation. Moreover, the outcomes of the demonstrators may highlight the need for further features to be incorporated into NAPs to foster interoperability and enhance mobility data exchange through this platform. Consequently, during the development of the demonstrators, task leads were asked to review the NLKF features and propose potential adaptations.

2.3. NAP Reference Architecture

The NAP Reference Architecture (NRA) defines the structure, behaviour, and various aspects of a system through several views: motivational, functional, physical, communications, organizational, and security. Each view offers a different perspective, from the reasons behind the system's creation to the interactions between its components and the relationships between actors. Based on the European ITS Framework Architecture (FRAME) methodology, the NRA aims to harmonize the functionalities and procedures of National Access Points (NAPs) across Europe.

The NRA ensures the compatibility of NAPs at the European level, complementing the NAP LoS KPI Framework (NLKF). It is crucial for the development of demonstrators, providing a structured framework for their implementation and evaluation. Practical experience from demonstrator



deployment, requirements creation, and gap identification will be leveraged in the NRA. This approach ensures that the demonstrators effectively contribute to the interoperability and efficiency of European NAPs.



3. Summary description of the demonstrators

3.1. Interchange demonstrator

Scope and objectives

The primary goal of this demonstrator is to show how service providers 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 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 (BI) and the Improved interface (II), also called the federation layer. This demonstrator describes why the use of the II and 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.

The overarching goal can be summarized as 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 specific use cases:

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 expected outcome of the first use case is:

- 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 second use case 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 service provider gets access and starts receiving data that can be published to their customers within a short time.

Description of the system's architecture

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 provides a standardized and structured mode of creating, searching, filtering, and accessing metadata (and actual data) in each NAP.

The high-level architecture can be seen in Figure 1. 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 access data.

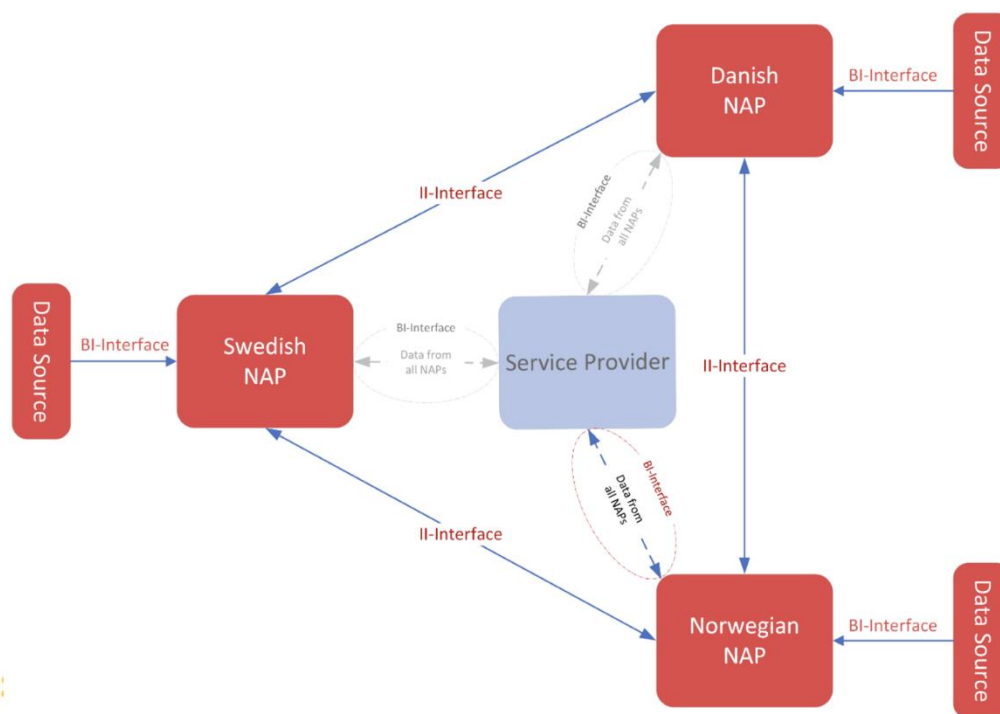


Figure 1 – Interchange Demonstrator - High Level Architecture

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.

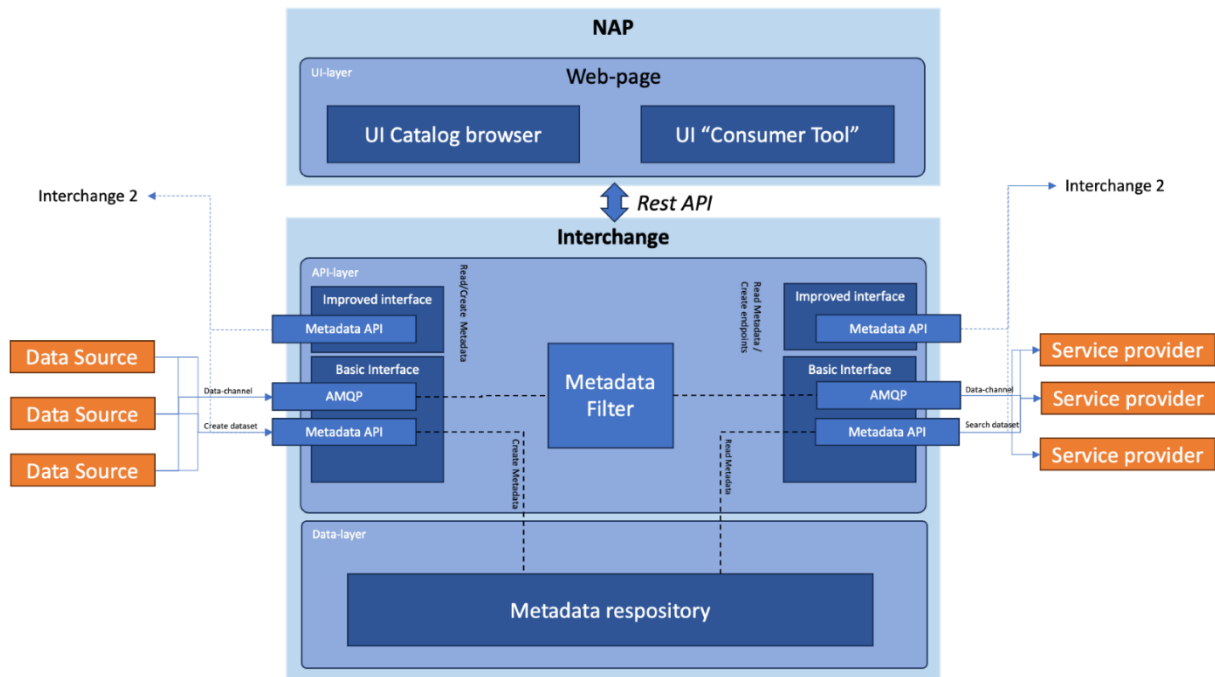


Figure 2 – Interchange demonstrator: The purpose-optimized architecture for the demonstration

Overview of findings

The demonstration elicited a highly favourable 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 they 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.

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. To achieve tight integration, the NAP requires an AMQP message broker or a publish/subscribe mechanism, both Basic and Improved Interfaces, the demonstrator's REST-API, and the implementation of the created webpage. In contrast, loose integration only requires access to an Interchange, hosting for the REST-API and webpage, and a link to the webpage from the NAP. 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.

Future work

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 (this could be done by using AMQP) and thus provide new data sources. The mechanism for this functionality was not implemented in the current iteration of the demonstrator software.

It is also worth exploring mechanisms for generating MobilityDCAT-AP from the metadata available on the Improved Interface, for certain key data sets, so that they are automatically added and maintained on the NAPs.

Feedback to NLKF

Adding the BI and II to a NAP may affect the 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

3.2. Marketplace demonstrator

Scope and objectives

The Marketplace Demonstrator project represents an initiative to enhance the interoperability of National Access Points (NAPs) across Member States. At its core, the project focuses on establishing seamless cross-border data exchange between the Netherlands and Germany, using planned roadworks data as a pilot case study to demonstrate the potential for broader European integration of mobility data.

This demonstrator addresses a fundamental challenge in modern cross-border logistics and traffic management. Currently, while data is available through various National Access Points, data consumers face the cumbersome task of accessing multiple NAPs to gather similar datasets from different countries. This fragmentation creates significant inefficiencies and poses substantial barriers to effective cross-border operations, for example affecting logistics service providers who need to plan efficient routes across European borders.

The demonstrator's primary objective is to showcase a marketplace that enables secure and efficient data exchange between Dutch data consumers and German data providers. By implementing a central



catalogue for dataset discovery, the system allows data consumers to find cross-border data through their preferred NAP, eliminating the need to navigate multiple systems. Furthermore, the project aims to reduce the complexity of point-to-point arrangements for data access by establishing a unified framework for authentication, authorization, and data exchange. Through this streamlined approach, the demonstrator seeks to improve route planning and logistics efficiency by making German roadworks data readily available to Dutch logistics service providers through a marketplace.

Description of the system's architecture

The demonstrator's architecture builds upon proven components from the Catena-X automotive data space, specifically leveraging the Eclipse Tractus-X open-source project, which has demonstrated success in connecting over 180 participants. This architectural approach combines robust security with scalable performance through a multi-layered design that ensures both data protection and efficient access.

At the foundation of the system lies the Eclipse Data Space Connector (EDC), which is divided into two main components: the Control Plane for managing access control, policy enforcement, and contract negotiations, and the Data Plane for handling the actual secure data transfer between participants. This core component works in concert with a comprehensive Identity and Access Management system through Keycloak, while a Managed Identity Wallet handles credential management. A central catalogue, hosted outside the dataspace, facilitates dataset discovery, while a sophisticated data transformation pipeline converts German DATEX II data to the Dutch OTM format every 12 hours, ensuring regular updates and compatibility across different national standards.

The architecture implements distinct functional layers to ensure smooth operation. The Application Layer manages metadata, data storage, and transformation processes, while the Data Exchange Layer oversees secure data transfer between participants. A dedicated Security Layer provides comprehensive identity and access management, all built upon an Infrastructure Layer using Kubernetes, an open-source container orchestration platform that automates the deployment, scaling, and management of container-based applications. This layered approach ensures that each component can be maintained and upgraded independently, while maintaining the overall system's integrity.

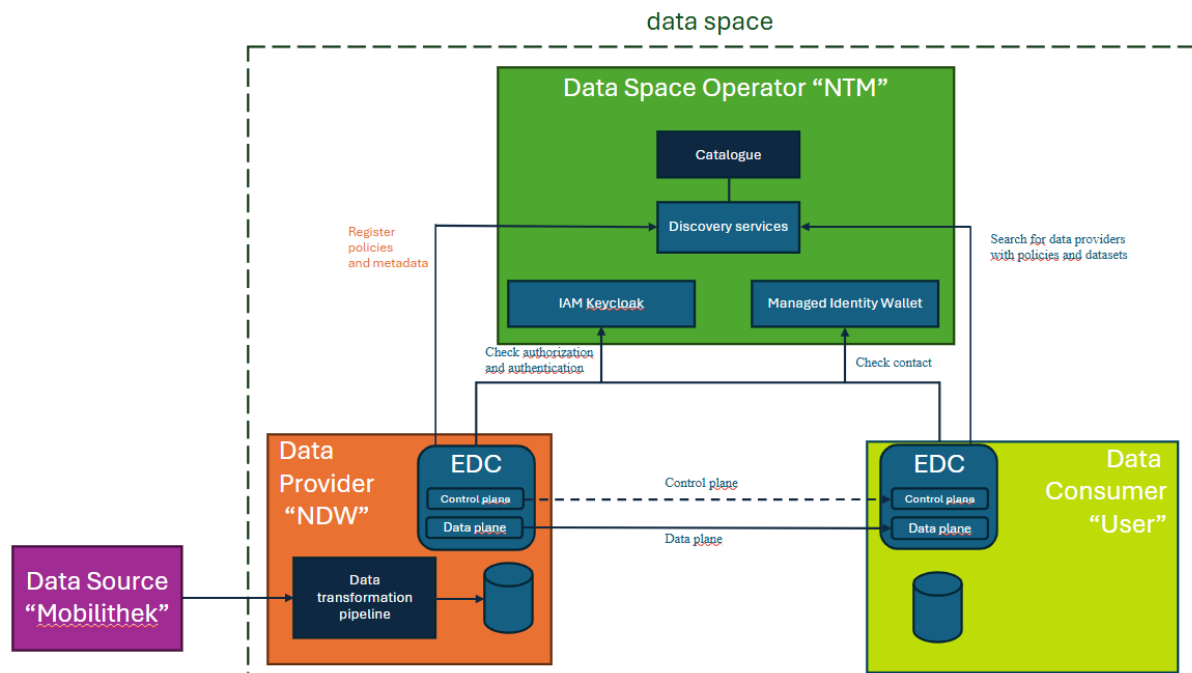


Figure 3 - Overview of the MarketPlace Demonstrator's architecture

In this ecosystem, the National Access Point for Mobility Data (NTM) serves as the data space operator, managing the authorization and trust of users in the data space through policy enforcement and user identification. The Dutch Data Portal for Road Traffic (NDW) acts as a data publisher, retrieving data from the German Mobilithek, converting it to the OTM standard, and making it available through an Eclipse Data Space Connector. A key aspect of this arrangement is the implementation of policy management and contract negotiations, ensuring that data providers maintain complete control over access to their data through their dedicated connectors.

Overview of findings

The implementation of the demonstrator has yielded valuable insights across multiple dimensions of cross-border data sharing. From a technical implementation perspective, the use of established open-source tools like Catena-X and Tractus-X significantly accelerated the development process. The solution demonstrated a strong potential for scalability and flexibility, with an architecture designed to accommodate future additions of participants and services while maintaining robust security protocols throughout the system.

However, the project also revealed significant standardization challenges that need to be addressed for future implementations. Notable differences exist in how Germany and the Netherlands implement DATEX II, which complicated the direct conversion of data between systems. The absence of an established standard for OTM5 necessitated making certain assumptions about the correct data structure. These differences underscore the pressing need for further standardization efforts in cross-border data exchange, particularly as more countries join similar initiatives.

Several key factors emerged as critical to the project's success. The use of standardized components like EDC proved instrumental in supporting interoperability between different sectors and regions. The modular architecture demonstrated its value by allowing for organic growth and adaptation to emerging needs. Additionally, the implementation of strong security measures and clear governance structures proved essential for maintaining trust within the data space.

The demonstrator successfully established the technical feasibility of creating a cross-border marketplace for mobility data. While challenges remain, particularly in standardization and governance, the project provides valuable insights for future implementations of cross-border data spaces and lays a solid foundation for more extensive data sharing initiatives within the European mobility sector. The lessons learnt from this implementation will be invaluable for similar projects across other European countries and domains.

3.3. Metadata demonstrator

Scope and objectives

Metadata, a detailed and standardized data set description, facilitates access by enabling discoverability of data sets within a NAP. Metadata describes the administration, organisation, and content of a dataset and of a data service. Metadata datasets are therefore crucial elements to make NAPs accessible and searchable. The primary aim of this demonstrator was to demonstrate the feasibility of metadata consolidation from multiple National Access Points (NAPs) into a unified metadata portal.

Similar to the Interchange demonstrator, this work was based in an overall use case, where a service provider wishes to view metadata of all NAPs to get a grasp of the available traffic data characteristics. This was broken down into two more specific use cases:

Use case 1: OVERVIEW OF NAP DATASETS – “As a Service Provider I would like to grasp which countries have an easily available metadata description of the dataset, organized by geographical area, so that I can design a product that is capable of extracting data across borders.”

Use case 2: FILTER THE AVAILABLE DATA BY CATEGORY – “As a Service Provider I would like to have access to up-to-date metadata that is organized according to a certain category, for example Heavy Vehicle Parking, so that I can observe what are the characteristics of that dataset (format of the data, updated timeframe).”

The Demonstrator aimed to show how heterogeneous metadata from individual NAPs can be harvested, processed and displayed in an integrated IT solution. The main functionality is the accessibility of metadata from multiple NAPs, i.e., a data consumer would be able to discover NAP data offerings from multiple NAPs via one online platform. This way, the solution is somewhat similar to the EU Open Data portal, which also harvests several other data portals.

Description of the system's architecture

The Demonstrator, as an application, is divided into three modules: Extractor, Processor, and Display. The Figure 4 shows how the functional architecture outlines data flow through these modules to achieve the application's objectives. The Extractor module retrieves data from a source, the Processor module manipulates and processes the extracted data according to predefined rules or algorithms, and the Display module presents the processed data to users in a comprehensible format. This architecture ensures a clear separation of concerns, with each module handling distinct responsibilities in the overall functioning of the application.

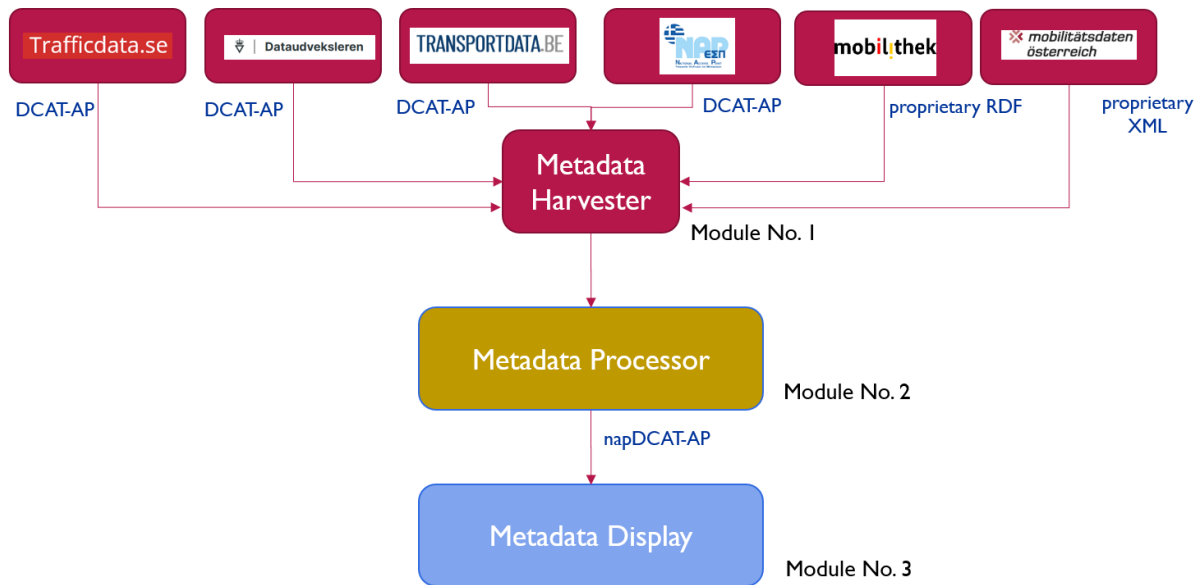


Figure 4 – Functional architecture of the Metadata Demonstrator

The **metadata harvester** module is a crucial component designed to fulfil the specific objective of retrieving Metadata records from individual National Access Points (NAPs), whether on a periodic basis or based on triggers. Its primary functions encompass extracting metadata records in their original format, conducting validity checks, and attaching "Meta-Metadata" to enhance the overall metadata management process.

The metadata mapping and **processing module** of the Demonstrator serves a critical role in harmonizing metadata records sourced from different portals while adhering to the mobilityDCAT-AP standard. Its primary objective is to analyse and transform metadata records to ensure consistency and compliance with the designated metadata scheme.

The core purpose of the **visualization module** is to make metadata from various NAPs visible and easily searchable. Users can access metadata records from different sources through a unified interface, simplifying the discovery process. To enhance user experience and streamline data discovery, the module incorporated aligned search and filter functions. This means that users can apply consistent search criteria and filters across metadata records from different NAPs, regardless of the original source. The module also implemented a standardized structure for result pages, irrespective of the original NAP source. This ensures a consistent and user-friendly presentation of metadata records, making it easier for users to interpret and compare information. A noteworthy feature of this module is the ability to offer geographical visualization. It allows users to visualize metadata records on maps, providing a spatial context to the data. This feature can be particularly valuable for geospatial datasets, facilitating location-based exploration.

Overview of findings

The implementation of the first use case successfully returned over 300 datasets. However, several challenges were faced, such as the existence of missing fields, difficulties during the extraction process, and extensive time consumption during the extraction and processing phases. The second use case, on the other hand, was focused on filtering abilities granted by NAPs. The test search query – applied to Alternative Fuels-related datasets – was based on a full-text search tailored to a specific term within the Title and Description fields and was able to return 10 datasets. Although the primary purpose was achieved, some limitations are worth mentioning, both on the side of the demonstration and on the side of the NAPs.

Limitations of the demonstrator

One notable limitation of the Demonstrator stems from the time latency observed during the extracting and processing phases. This latency hinders real-time updates of metadata datasets, creating a lag between the availability of new data and its incorporation into the Demonstrator. Addressing this delay is crucial to ensure that the Demonstrator reflects the most current and relevant information.

The Demonstrator focused on two modules for metadata extraction. While effective for extracting metadata from a single file encompassing all NAP datasets and using CKAN API to obtain and process datasets, this limited scope may overlook other potential sources. Expanding the range of extraction modules would enhance the Demonstrator's adaptability to diverse data structures.

Additionally, the ease of scaling the Demonstrator, particularly beyond the proof-of-concept (POC) stage, is contingent upon well-documented and readily available metadata extraction APIs. A robust extraction API ensures scalability, allowing the Demonstrator to adapt to an expanding ecosystem of NAPs seamlessly.

The registration process introduces additional steps when extracting metadata, an aspect not utilized in this POC. Moreover, the difference in the extraction processes between data and metadata from the same datasets raises considerations for streamlining these operations to enhance efficiency.

Limitations of the NAPs involved

The lack of harmonized metadata across NAPs introduces challenges during the integration process. Field-by-field validation becomes a necessity, especially when dealing with disparate formats. The adoption of the DCAT-AP format has proven advantageous, simplifying the identification of gaps and facilitating a more standardized approach to metadata integration.

Still, even a DCAT-AP-compliant representation of metadata in a NAP does not resolve all challenges. The main reason is the heterogeneous provision of metadata information across individual NAPs, in particular, the population and usage of individual metadata fields. For example, some NAPs describe the data contents by a free-text description; other NAPs use a (sometimes complex) set of keywords, and others use a predefined list of content categories. The mobilityDCAT-AP specification is resolving such issues by clear stipulations on the population and usage of metadata fields. Thus, it is recommended that any future deployment of new NAP systems or revisions of existing NAP systems consider a native implementation of the mobilityDCAT-AP specification within their internal information models, so a post-mapping (as proposed in the Demonstrator architecture) becomes reluctant.

To overcome these NAP limitations, the outcomes of this demonstrator were used to provide feedback to the other NAPCORE tasks mentioned in the section 2. Concerning the NLKF, different KPIs were deemed crucial for the implementation of the demonstrator. NAPs participating in this demonstration were required to meet a specific Level of Service for features within three key categories: 1 (Access), 3 (Data Discovery), and 7 (Operation Policy). Additionally, aspects of the NAP Reference Architecture—encompassing the functional, physical, and organizational layers—were identified as critical to the activities carried out by the demonstrators. These aspects are described in detail in Annex B.

3.4. Alternative Fuels demonstrator

Scope and objectives

The Alternative Fuels (AF) Demonstrator was developed considering the ongoing efforts by the European Commission (EC) to accelerate the adoption of alternative fuel infrastructures across EU member states. A key initiative, which served as the main motivation behind this report, is the



Delegated Regulation Implementing Act (2023/1804). The document was introduced to support the EU's goals under the Alternative Fuels Infrastructure Regulation (AFIR). It begins with a preamble that justifies the need for consistent EU-wide targets for recharging and refuelling infrastructures, addressing growing transportation demands and environmental goals. This framework ensures the development of accessible, harmonized infrastructure for electric and hydrogen-powered vehicles, underscoring the European commitment to energy transition and sustainable mobility.

To this end, we established a set of specific objectives for the AF demonstrator:

- Explore how both static and dynamic could be made available and accessible at European level, without creating storing duplicities with Member States' NAPs repositories, considering NAP format and need for harmonisation (linked to other WG activities)
- How a Mobility Data Space (e.g. European Alternative Fuel Observatory EAFO) can use the information from the NAP
- Explore processes of harvesting AF data from NAPs (link, how to find, how to extract –if possible)
- Establish a set of recommendations for NAPs to make alternative fuels data available

Description of the system's architecture

The solution design leverages results from the NAPCORE project to create a harmonized interaction with the European Alternative Fuels Observatory (EAFO)², aligning the Alternative Fuels Infrastructure Regulation/Directive (AFIR/AFID) and NAPCORE activities. Therefore, it is important to introduce how these two concepts, EAFO and AFIR provider, were incorporated within the methodology. The first gathers, harmonises and disseminates AF information, working as a centralized data space. The second, on the other hand, includes the alignment needed between the AF data providers and the AFIR regulation.

Based on this understanding, two use cases have derived from an overall need of the service providers, described as follows: *"As a Service Provider I wish to view which NAPs have available metadata that Refers Alternative Fuels data and how the data could be extracted"*. These use cases are described in Figure 5.

² European Alternative Fuels Observatory - <https://alternative-fuels-observatory.ec.europa.eu/general-information/alternative-fuels>

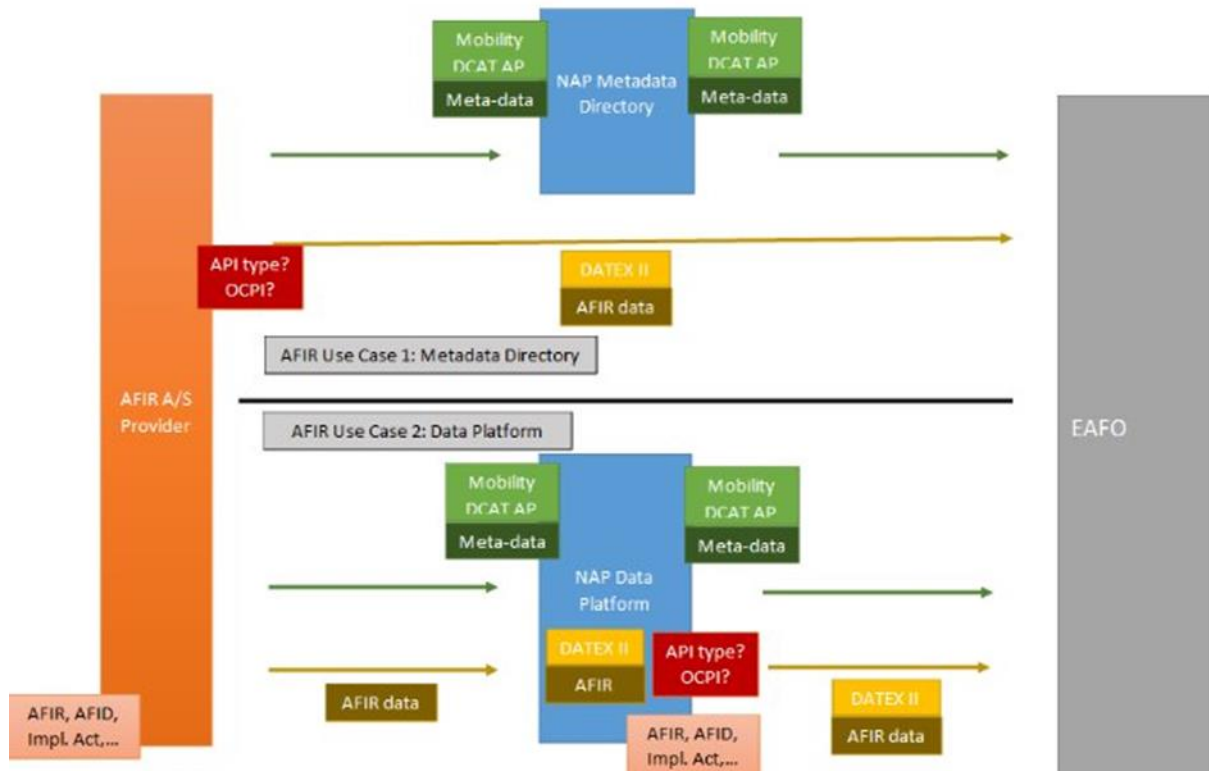


Figure 5 - Alternative Fuels Demonstrator - use cases' description

The first is defined as “enabling data discoverability through nap metadata” and deals only with the metadata directory’s functionalities. It allows streamlined metadata exchanges with EAFO. In this scenario, EAFO would maintain a registry of Metadata directory NAPs, where national stakeholders submit AFIR-related data descriptions using standardized categories and keywords. The second use case is defined as “filter the available data by category and evaluate data harvesting”, which also comprises the data platform’s functionalities by dealing with actual data. In this case, the NAP directly supplies AFIR data to EAFO through a cost-free API connection. EAFO, in turn, integrates data directly from the NAPs, facilitating consistent data sharing and adherence to EU requirements.

The architecture framework used in this demonstrator is very similar to the one presented in section 3.3. However, for the AF demonstrator, additional requirements and modules were needed to retrieve and process AF data, since the metadata demonstrator only worked with metadata.

Overview of findings

The first use case results allowed us to obtain interesting insights on how easily EAFO could retrieve API links considering the availability of automatic metadata extraction. As for the second use case, several challenges were faced, which avoided more concrete results. Some of the challenges raised were:

- Lack of AF data availability
- Datasets often described in the local language
- Issues with permissions to access data
- Lack of data standardisation

To address these barriers, harmonizing metadata standards and adopting multilingual frameworks are essential steps for improving data discoverability and integration. Additionally, leveraging technologies like RESTful APIs compatible with OCPI and DATEX II standards can facilitate seamless real-time data



sharing. Moreover, implementing robust validation and mapping processes, such as mobilityDCAT-AP, is crucial to align metadata with uniform specifications, enhancing interoperability.

Concerning feedback to the LoS Framework and NAP reference architecture, this was very similar to the metadata demonstrator. Still, since the AF demonstrator also dealt with actual data, additional features of the NLKF were considered essential, such as the API usage for data transfer. Moreover, specific modules of the NAP reference Architecture were outlined, such as the “Metadata Management” and the “Metadata Quality Checks”.

Furthermore, key insights and challenges were outlined in the conclusions. In addition to the ones already pointed out in this document, a need for stronger collaboration between the stakeholders, such as Charging Point Operators (CPOs), policy-makers and NAP operators. Another important challenge raised was related to issues regarding bilateral agreements and licensing for data reuse.

Finally, the AF demonstrator, building upon the Metadata Demonstrator, successfully highlighted both the potential and the challenges of leveraging metadata specifications, such as mobilityDCAT-AP, to improve data discoverability for Alternative Fuels (AF). It showcased how standardized metadata can enhance access to AF data and align with European guidelines while also revealing significant gaps that must be addressed to establish a European Access Point for AF data by 2027, as envisioned by the EC under the AFIR. Key challenges include the inconsistent availability and standardization of AF data across National Access Points (NAPs), a lack of metadata harmonization, and the need for improved stakeholder collaboration to resolve issues around bilateral agreements and licenses for data reuse. The demonstrator also highlighted the need to expand metadata frameworks, such as Mobility Theme Controlled Vocabulary, to better classify diverse fuel sources and to integrate standards like DATEXII for better data uniformity. Addressing these issues is crucial for ensuring meaningful interoperability and supporting the transition to sustainable fuels in the EU.

4. Conclusions

Looking at the demonstrators' individual reports (Annexes A, B, and C), as well as the highlights added to this document, it was possible to extract some common lessons from the different solutions adopted. Those refer primarily to the importance of specific features and common challenges faced and are included in the subchapter 4.1. The individual reports also contained specific sections or mentions of features and functionalities included in the NLKF and NRA; those were analysed, and a summary of the feedback already provided by the demonstrators to these NAPCORE tools has been added to subchapters 4.2 and 4.3. Finally, subchapter 0 indicates elaborates on how the results shall be used in the future, indicating future work.

4.1. Common lessons learnt and challenges faced

The adoption of the MobilityDCAT-AP, the NAPCORE-recommended metadata specification, has been identified as a key value-add by three out of four demonstrators. The Interchange demonstrator highlights that incorporating this specification into future iterations of the interchange solution could bring significant improvements. Meanwhile, the Metadata and AF demonstrators underscore that adopting a common catalogue standard significantly enhances data discoverability, streamlining the locating and sharing of NAP information.

Standardization issues emerged as a critical challenge during development. In the MarketPlace demonstrator, one of the most time-consuming tasks was establishing the "marketplace" between the German and Dutch NAPs. The difficulty lay in translating the German DATEX II into the Dutch DATEX II format, underscoring interoperability hurdles. Similarly, processing AF data within the AF demonstrator also presented substantial challenges due to standardization gaps. Most data was either in proprietary formats or adhered to the OCPI standard, making it difficult to process or convert into DATEX II, the recommended standard for AF data types.

Open-source tools played a pivotal role in the design of various solutions. In the MarketPlace implementation, tools such as Catena-X and Tractus-X significantly accelerated the development of the data space. Likewise, the Metadata and AF demonstrators relied on the CKAN framework to efficiently find and process datasets from multiple NAPs, demonstrating its utility in handling different information sources.

Some limitations of the current NAPs' setup were also observed. For instance, the current features offered by most NAPs are insufficient to support the tight integration suggested by the Interchange demonstrator, meaning that implementing an interchange solution would require additional functionalities within the NAP framework. The Metadata demonstrator further illustrated that issue, observing that several NAPs lack crucial features such as the harmonised description of datasets and the difficulty of extracting metadata in a machine-to-machine readable format.

Scalability remains a mixed prospect across demonstrators. Both the MarketPlace and Metadata solutions showcased strong scalability potential, reflecting their robust design. However, the AF demonstrator raised concerns regarding scalability, particularly in data management. It emphasized that handling large volumes of data could introduce significant challenges, potentially limiting the solution's effectiveness in larger-scale applications.

4.2. Combined feedback to NLKF

To help analyse how the demonstrators endorsed the features encompassed by the NLKF (described in 2.2), Table 2 provides an overview of the NLKF features associated with the different NAP interoperability demonstrators: Interchange, MarketPlace, Metadata, and AF. It highlights the key



existing features that were either utilized or identified as necessary during the implementation of these demonstrators. For the Interchange, Metadata, and AF demonstrators, specific features were explicitly outlined, focusing on their importance to the requirement analysis and their impact on the corresponding KPIs. Although the MarketPlace demonstrator did not explicitly document these features, they were inferred based on the individual report (Annex A). An "X" is assigned to a specific demonstrator for a given feature when that feature is impacted by or interferes with the solution implemented in that demonstrator. The purpose of this analysis is to verify which features were most relevant and to observe which categories (to which these features belong) were more requested or deemed important during the implementations. The demonstrators reflect real-world scenarios, making their implementation and the features they used valuable parameters for assessing the practical importance of various functionalities.

Table 2 - NLKF features associated with the different demonstrators

KPI Information		NAP Interoperability Demonstrators			
No.	Description	Interchange	MarketPlace	Metadata	AF
1.1	Online availability	X	X	X	X
1.9	Security – technical (certificates)		X		
1.10	Security – provider verification		X		
1.12	Procedure for metadata publication			X	X
1.13	Metadata output and access restrictions			X	X
1.14	Security – access restrictions for data uploading		X		
1.15	Security – access restrictions for data downloading		X		
1.18	API usage for data transfer		X		
2.1	Support to register/add metadata	X	X		
3.1	Search functionalities	X	X	X	X
3.2	Search results	X	X	X	X
3.3	Machine-readable metadata	X		X	X
4.2	Content and metadata	X			
4.3	Monitoring and evaluation		X		
6.1	Metadata Specification	X			X
6.2	Harvesting functionalities	X			
7.1	Data reuse – NAP		X		
7.2	Data reuse – data provider		X		
7.3	Operational procedure information		X	X	X

The analysis of the table provides important insights for updating the NLKF framework. The category related to discovery services stands out, with all its features being relevant to most use cases. Notably, all demonstrators outlined two features – search functionalities and search results – indicating their universal importance. Additionally, features impacted by at least three demonstrators, such as operational procedure information, should receive particular attention. These observations could



inform a potential revision of the NLKF's weighting system, where the relative importance of each feature is adjusted to reflect its relevance across different implementation scenarios.

The differences between the demonstrators also highlight distinct priorities. The MarketPlace demonstrator emphasized features associated with data platforms, such as KPIs 1.14, 1.15, and 1.18, whereas the other demonstrators focused more on metadata directories. MarketPlace placed significant attention on security aspects and data reuse policies, particularly regarding access restrictions and contractual arrangements. In contrast, the Interchange, Metadata, and AF demonstrators concentrated more on metadata exchange, highlighting the availability of machine-to-machine (M2M) readable metadata and the use of harmonized specifications. Additionally, features related to support, such as the ability to register or add metadata, were not addressed by the Metadata and AF demonstrators but were noted as important by the Interchange and MarketPlace demonstrators, reflecting varying use-case requirements.

Beyond the table, the demonstrators provided suggestions for improving the NLKF. The Interchange demonstrator proposed changes to existing KPIs to better evaluate key components of the interchange solution. It also identified additional functionalities required for its implementation, which are detailed in the individual report. Similarly, the Metadata and Alternative Fuels demonstrators made relevant recommendations for the framework. [Placeholder for specific suggestions derived from the Metadata and Alternative Fuels demonstrators]. These inputs offer valuable perspectives for aligning the NLKF with the realities and challenges of implementation scenarios.

4.3. Combined feedback to the NAP Reference Architecture

All demonstrators incorporated an architectural approach in their design, as evidenced by their detailed reports. These reports reference overall concepts, requirements, functional views, and methodological approaches. The NAP Reference Architecture (NRA), presented in milestone M2.9, included a fully developed functional view and partially developed physical and organizational views, while communications and security views were not addressed. These views provide perspective when setting up the minimum NAP, particularly leveraged by the metadata and AFIR demonstrators, which built on the metadata directory functionality.

The metadata and AFIR demonstrators provided feedback on key components in the functional, physical, and organizational views used during their development, highlighting the need for further clarification on "metadata quality checks." The NAP reference architecture is crucial for building NAPs, as demonstrated by these two projects.

Although no direct feedback was provided via the NRA commenting template, useful insights were inferred from the demonstrators' reports, leading to a better-structured NAP reference architecture.

The architecture also serves as a blueprint for interfaces and specifications, allowing for the description of best practices. Even though as no direct feedback identifying specific standards (apart from mobilityDCAT-AP), profiles, or best practices was provided, demonstrators made numerous architectural decisions regarding software use, security levels, protocols, data standards, and interface definitions. Key experiences include:

- Using mobilityDCAT-AP for describing and harvesting data.
- Prescribing a harmonized API across NAPs with guidelines.
- Exploring C-ROADS interfaces with pub-sub mechanisms.
- Recognizing that using the same standard does not guarantee interoperability; guidelines and profiles should be referenced if they exist.

The NRA development team will analyse these reports along with additional feedback from demonstrators via a specialized form focused on experiences and lessons learnt. These experiences will be incorporated into the final version of the NAP reference architecture once feedback from demonstrator leaders is received.

4.4. Future work/next steps

The next steps will involve analysing feedback collected from demonstrator leaders to identify actionable insights and lessons learnt. This feedback will inform not only improvements to the NRA and NLKF but also guide other NAPCORE tasks. Collaboration among partners will be key to ensuring that these insights are applied effectively, enabling updates and maintenance across multiple areas of work.

In particular, the feedback forms distributed in October 2024 (see Annex E) will be essential for proposing updates to the NRA. These forms allow demonstrator leaders to highlight specific changes needed to address gaps or improve functionality based on their implementation experiences. Additionally, the reports produced by the demonstrators will provide key findings that will be incorporated into the NRA and NLKF. This includes addressing issues such as metadata management, interoperability, and scalability, ensuring that these frameworks evolve to meet real-world needs.

Finally, the outputs of the demonstrators, such as the interchange system already in use in Nordic countries, will serve as valuable references for future development. Ongoing tests and additional implementations will also contribute insights that NAPCORE can use to refine existing tools and frameworks. By leveraging these outcomes, NAPCORE can ensure that the lessons learnt are applied effectively, fostering improvements that address both current challenges and future opportunities.

List of Annexes

- A. Interoperable NAP demonstrator of a marketplace or clearing house NAP**
- B. Interoperable NAP demonstrator with Metadata**
- C. Alternative Fuels Demonstrator**
- D. Scoping of demonstrators expectations**
- E. Demonstrator feedback to the NRA**



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