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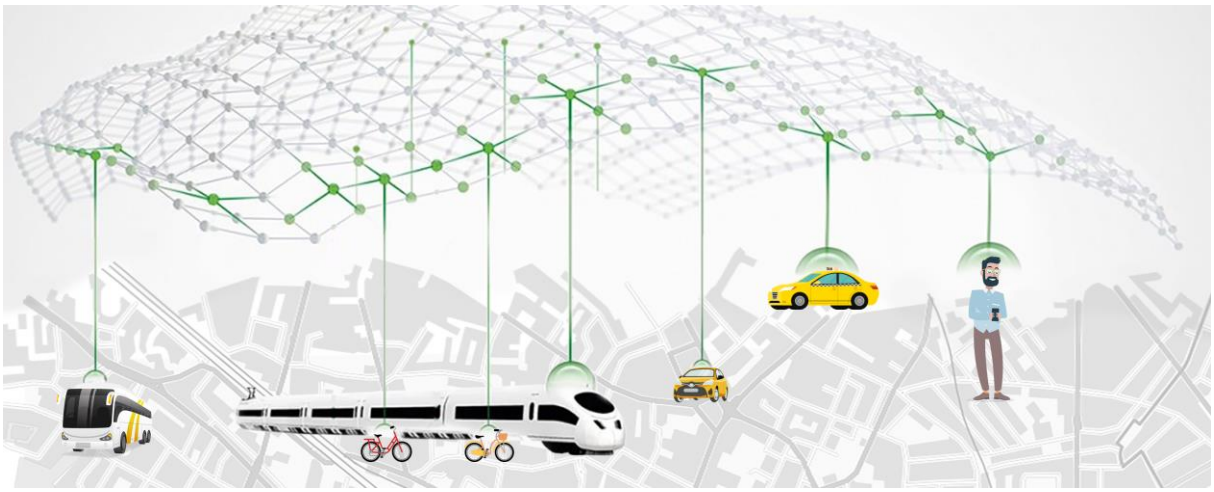
Federal Department of
the Environment, Transport, Energy and Communications (DETEC)

Swiss Federal Office of Transport (FOT)

Discussion basis
for a NADIM standardisation concept



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Contents

1. Management summary

The ability to easily access and exchange mobility data is indispensable to the efficient, sustainable and interlinked operation of road and rail infrastructures and the public and private transport running on them. The National Mobility Data Networking Infrastructure (NADIM) is to contribute to this in future as part of a state-owned mobility data infrastructure (MODI). Standardising data formats and interfaces will support investment protection and data quality, facilitate the reuse of IT solutions and promote the scalability, sustainability and interoperability of the NADIM.

Acceptance of the NADIM and the various actors' willingness to use it will largely depend on whether the NADIM can meet the requirements of the potential users. This document is to form the basis for discussions with and between the future NADIM users and is primarily aimed at experts and developers. It is a basis for the standardisation of mobility data in the interim period until the NADIM is commissioned and also for the standardisation by the NADIM operator.

Initial work is underway to prepare the NADIM in parallel to the ongoing legislative process (Federal Act on Mobility Data Infrastructure, MODIG). To ensure a smooth migration of the current systems into the future system landscape, the necessary developments will be designed to be as upwardly compatible as possible and with medium-to-longterm planning security. In the context of these developments, a decision must be taken on the standards that are to be supported. This applies in particular to those areas where there are no established standards yet (e.g. on-demand services and parking facilities).

This version 1.0 contains an overview of the existing standards in the field of mobility data and classifies them according to their areas of application. It presents the standards, describes their respective advantages and disadvantages, makes recommendations for their use and identifies gaps.

The standards were evaluated and selected based on eight principles which are elaborated and substantiated.

The Transmodel CEN standard is recommended as the basis of a conceptual model. If possible, interface standards based on Transmodel or similar should be used: NeTEx for timetables and services, SIRI for real-time and disruption information, OJP for journey planning, DATEX II for road transport. The use of the conceptual model will be explained in a detailed document on transportdatamanagement.ch by the end of 2022.

In areas where standardised solutions are already in use, these should be adopted, e.g. OICP for charging stations and GBFS for sharing schemes.

For sales, the following standards and extensions are recommended: an extension of OJP with availability and price information, OSDM and TOMP.

2. Introduction

This version 1.0 forms a discussion basis for a NADIM standardisation concept. It was created on behalf of the Federal Office of Transport (FOT) and is continuously being further developed in consultation with the stakeholders. It is a basis for the standardisation of mobility data in the interim period until the NADIM is commissioned and also for the standardisation by the NADIM operator.

2.1 Purpose of the document

This version contains an overview of the existing mobility data standards and classifies them according to their areas of application. It introduces the standards, describes their respective advantages and disadvantages, makes recommendations for their use and identifies gaps. This document is to serve as a basis for discussions with and between future users of the NADIM and is aimed primarily at experts and developers.

2.2 Status

This document was developed on behalf of FOT together with the SBB Infrastructure' Customer Information System Office (GS SKI) and coordinated with the Federal Office of Topography (swisstopo), the Federal Roads Office (FEDRO) and the Federal Office of Energy (SFOE). Any feedback on the further development of this document is welcome.

2.3 Scope

This document is limited to the technological aspects of the data exchange standardisation, and specifically to interface standards and structural standards. See also section 3.2. The standardisation of business processes, data management, contracts and organisational structure was not included.

2.4 Integration into the "Programme for use of data for an efficient mobility system" and the planned Mobility Data Infrastructure (MODI)

In July 2020, the Federal Council instructed DETEC to establish a national mobility data infrastructure step-by-step as part of the programme for the use of data for an efficient mobility system and to develop the legal basis for this in parallel. Within the contract for system leadership in customer information in 2021-2024, the FOT instructed SBB Infrastructure to tackle the development of some initial elements to improve the exchange of mobility data as an extended Customer Information System Task (SKI+). These elements will be transferred to the NADIM at a later stage. The standardisation already has a key role in the transition phase until the NADIM is commissioned. This document was therefore prepared as part of the action plan for the "Programme for the use of data for an efficient mobility system"[1].

Standardisation is a key task of the future NADIM operator organisation as set out in the draft of the new Federal Mobility Data Infrastructure Act (MODIG)[2]. In future, it will be the NADIM operator's task to define standards and specifications for data, interfaces and processes while consulting with the stakeholders and observing international developments, and to ensure that they are enforced.

The mobility industry is also calling for expedited standardisation. The Transition Council, an advisory body for SKI+ implementations, places high priority on the standardisation and the use of internationally recognised standard interfaces. In a broad assessment of requirements, Trafiko identified standardisation as one of the main concerns in the mobility sector with regard to the NADIM (see Report NADIM Requirements Assessment).

[1] Originally, the programme was entitled "Multimodal mobility" as per the Federal Council decision of December 2018 and was then extended until the end of 2025 under the new title "Programme for the use of data for an efficient mobility system" with the Federal Council decision of 2.2.2022.

[2] Draft as per Federal Council decision of 2.2.2022 to open the consultation process.

Transportation Network CH under the leadership of swisstopo will form the spatial reference system for the digital mapping of Switzerland's transport system as a further part of the planned Mobility Data Infrastructure (MODI). On the one hand, the federal government will centrally synchronise, extend and optimise a wide range of network data relating to the transportation infrastructure and, on the other hand, it will provide tools for their use. In this way, Transportation Network CH will provide an up-to-date, reliable and interlinked basis on which mobility data can be linked to an exact spatial and topological reference as well as the services needed to use it. As far as possible and reasonable, Transportation Network CH will use existing (geodata) standards. A set of rules to define the use of Transportation Network CH is in development.

2.5 Document structure

This document is structured as follows:

Section 3: Clarification of the terms "standard" and ''standardisation'' and their significance to the NADIM, recommendation for the SKI+ standardisation tasks (transitional period) and the NADIM operator (expected from 2025).

Section 4: Classification of standards by mode, data type and from the perspective of the customer process.

Section 5: Definition of principles for the selection of appropriate standards.

Section 6: Overview of CEN and other standards relevant to the NADIM.

Section 0: Evaluation of the standards based on the principles from Section 5.

Section 8: Recommendations for standards by mode, data type and customer process perspective, and identification of gaps.

Anhang A): Glossary.

Anhang B): Literature and references.

Anhang C): Outlines of the standards.

Anhang D): Standardisation organisations for mobility data.

3. Standardisation: definition and processes

Standards enable technical and organisational systems to interact. By adhering to standards, systems that are different can interact and exchange information and data.

This section defines some terms and explains the importance of standardisation to the NADIM operator and the stakeholders involved. Furthermore, recommendations will be made for the NADIM operator's standardisation tasks.

3.1 Definitions

The following definitions[3] are used in this document:

Term	Definition
Standard	A uniform or unified, widely accepted and most commonly used way of describing, producing or doing something which has prevailed over other ways or is regarded as a yardstick.
Standardisation	In technology and business, the standardisation of components, production methods, units of measurement, processes, structures, types or goods and services; the development, maintenance and dissemination of standards.
Data standard	Documented agreements on the representation, format, semantics, definition, structuring, labelling, transmission, modification, use and management of shared data.

Synonyms or related terms are also often used. The following compilation provides a brief overview.

Term	Description
Best practice / common practice	A procedure or approach that is used in many places because it is known and proven; a precursor of the quasi standard.
Harmonisation	Standardisation with the aim of bringing together different or conflicting standards.
Norm	Standardisation by high-level institutions gives rise to norms that describe generally accepted fundamental standards. Such norms can be prescribed by law for certain areas of application.
Open standard	A standard that is freely usable, free of charge and documented on the WWW; sometimes also open with regard to cooperation in its development.
Profile	A subset, refinement or specific application of a standard. A profile defines, for example, which part of a standard is to be used and substantiates the specification of the standard, e.g. with regard to the specific application or the use of attributes. This will reduce the scope of interpretation as much as possible. In some circumstances, different profiles may not be compatible with each other.
Proprietary standard	A standard that is under the control of a company or institution and is not open or free to use.
Quasi standard, de-facto standard	A procedure that has unintentionally or unofficially become a de-facto standard.
Sector standard, industry standard	A standard developed by companies or associations for a specific sector, industry or economic activity.

Table 1: Synonyms and related terms of standardisation.

[3] Adapted from Wikipedia, the quasi standard for terminology definitions.

Figure 1 provides an overview of the chronological sequence of the standardisation process using the terms introduced in Table 1.

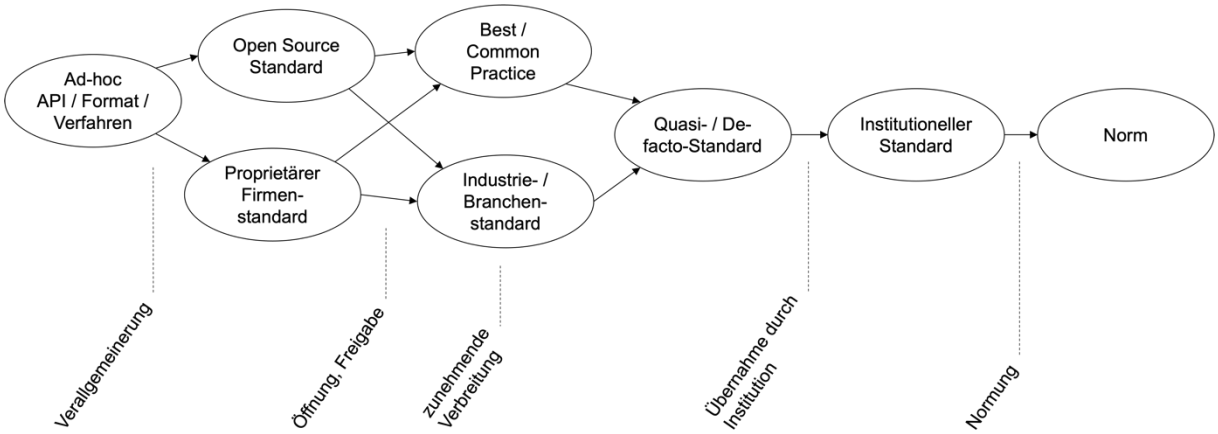


Figure 1: Schematic representation of possible standardisation sequences.

3.2 Standardisation levels

In the context of the NADIM, standards will in future be developed, selected and followed at multiple levels. These levels are shown in Figure 2. In this document, only the levels of the structural and interface standards will be discussed.

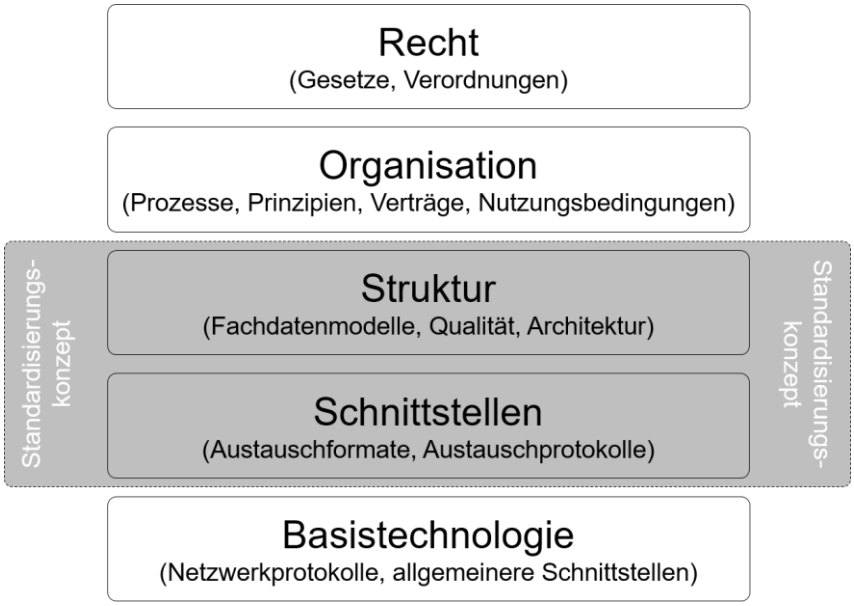


Figure 2: Levels of standardisation. This document discusses the "Structure" and "Interfaces" levels.

3.3 Significance of standards to the NADIM

In the context of the NADIM, standards are required for all data exchange formats, but also for interfaces, APIs, processes, data models, identifiers and metadata, as well as for other topics such as quality assurance or contracts.

The following two tables show the significance of standards to the tasks and objectives of the NADIM and its operator, as well as the benefits of standards to various actors and stakeholders.

Tasks and objectives of NADIM operation	Significance of standards
Efficient and scalable implementation	Without standardisation, the NADIM could not be implemented cost-effectively and data suppliers would have to be connected individually via proprietary formats. Standards and profiles allow for more efficient implementation and ensure the scalability of the NADIM.
Standardised integration and provision of data, functions and processes	Thanks to standards, data suppliers and recipients know how data integration and provision as well as the interfaces and processes work and can design their systems accordingly. This raises the quality of the data and helps to ensure predictability and investment security.
Coverage of the NAP (National Access Point) functions	The Delegated Regulation (EU) 2017/1926 specifies standards for the NAP data formats.
NADIM as a task of the state	A widely used public service requires rules (standards).
NADIM as a guarantor of openness and non-discrimination	Open, freely usable standards are necessary so that all companies can participate in the system for the benefit of the end customers.
NADIM as an enabler for national and international interoperability and for networking actors	The automated interaction of many mobility intermediaries, providers and suppliers requires precisely defined and rigorously followed standards. Internationally recognised standards are a prerequisite for interoperability in an international context.

Table 2: Importance of standards to tasks and objectives of NADIM operation.

Stakeholder	Benefits of standards to this stakeholder
Mobility intermediaries, providers and suppliers	Procuring IT systems that function company-wide (in terms of compatibility, interoperability, investment protection) is more affordable for the following reasons: – economies of scale – innovative business models are built – automation of data exchange, bookings and sales.
IT service provider	The following benefits arise during the operation of these IT systems: – the quality of service can be increased – development risks can be reduced – economies of scale can be exploited – investment protection is ensured
End customers	Attractive, seamlessly integrated apps with personalised information and MaaS – "all in one app".
Public sector	Contribution to the optimisation of the mobility system and thus to higher-level goals such as environmental protection and welfare. This is due to positive effects on services purchased and across all federal levels, including more efficient planning, traffic management, incident management, blue-light traffic organisation.
Research	Improved access to mobility data for research purposes.

Table 3: Benefits of standards to various stakeholders.

3.4 Standardisation tasks in the operation of a data infrastructure

The draft Federal Mobility Data Infrastructure Act (MODIG) specifies that the operator of the NADIM will define and review the requirements for mobility data and services with the stakeholders concerned and in consideration of international developments to ensure interoperability.

These requirements relate in particular to the standards to be used for data models, identifiers, interfaces, the level of quality and the delivery process, as well as the anonymisation, tracking and documentation of the data, services or interfaces.

Table 4 below describes the main standardisation tasks in the operation of a mobility data infrastructure and makes recommendations for their implementation.

Standardisation task[4]	**Recommendation**
Develop, implement and review standardisation strategy	Develop standardisation governance. Continuously review, prioritise and adapt tasks and tools.
Market monitoring: monitor standards in the mobility market	Identify and assess trends and innovations. Follow professional publications, conferences and congresses. Tools: trend radars, wikis, links, who-is-who, assessments, activity logs, etc.
Suggestion scheme: accept suggestions from stakeholders	Accept suggestions for new standards or optimisations and process them proactively. Document suggestions, comments and measures transparently in the web forum.
Requirements management with all stakeholders	Record and coordinate requirements; resolve any conflicts.
International committee work, working groups	Cooperate with working groups and national / international bodies.
Design, development, profiling and optimisation of standards	Develop specifications, standards, profiles (partial standards), implementation specifications.
Test standards and profiles	Test and validate standards in concepts, prototypes and proofs of concept (PoCs) and check their quality.
Dossier management and documentation of the standardisation and committee work	Document participation in national and international bodies appropriately for transparency. Tools: wikis, filing systems. Foundation: uniform requirements for documentation.
Adopt, implement and replace standards	Introduce new standards or new versions in an orderly way. These may be binding requirements or recommendations. Decommission expiring standards in an orderly way and replace them with suitable alternative standards. The introduction process may also include the use of profiles as suitability or award criteria in tenders. This can be a promising strategy to disseminate standards.
Communicate documentation and requirements of the standards and provide advisory support	Communicate documentation and requirements of the standards to all stakeholders through various channels and provide advice on implementation. Tools: web forum, newsletter, conferences, helpdesk.

[4] To the extent that they are relevant to this document. There will also be other standards, e.g. for processes and terms of use, which are not considered in this document (see also section 3.2).

Standardisation task[4]	Recommendation
Conduct systematic surveys on the use of the standards	Analyse usage data of the NADIM datasets and APIs to ascertain the significance of the individual standards. Tools: server log files, statistics, data science.
Life cycle management: systematically maintain a range of NADIM standards	Continuously monitor and prioritise standards in order to optimise the use of specific resources. Tools: trend/technology radar, roadmaps, cost-benefit analyses. Keep the lifecycles of the standards in a table and publish them together with the roadmap.

Table 4: Standardisation tasks for which the future NADIM operator will be responsible.

4. Classification

This section introduces a classification by mode and data type as well as the customer process perspective for the classification and evaluation of the standards. In section 8 the standards are classified and recommended according to this classification.

4.1 Classification by mode and data type

Figure 3 below illustrates the classification by mode and data type, with data examples. The following sections explain the subdivision into modes and data types.

		Individualverkehr MIV (Auto, Motorrad) LV (zu Fuss, eigenes Velo)	**Geteilte Mobilität** Sharing / Miete	**Abrufverkehr** Taxi, Ridehailing, ODV, Ridepooling	**Fahrplanbasierter Verkehr** öV, Fernbusse, Luftfahrt	**Angebote ohne Beförderungsleistung** Parking, Tankstellen, Ladestationen
Kerndaten	**Geodaten**	Strassen-, Veloweg-, Fusswegnetz (inkl. Lift), Signalstandorte	Stationen, Bediengebiete	Bediengebiete, Stationen Einsatzgebiet	Schienennetz, öV-Netz, Haltestellen, BehiG	Standorte
	Betriebsdaten - Statisch - Echtzeit - Prognose - historisch	Strassenklasse, Kapazität, Verbote, Abbiegebeziehungen	Fahrzeugdaten, Kapazität	Fahrzeugdaten, Kapazität	Linienplan, Soll-Fahrpläne, Formationen, Fahrzeuge	Öffnungszeiten
		Signalstatus, Baustellen, Sperrungen, Verkehrszähler	Verfügbarkeiten, Fahrzeugstandorte	Verfügbarkeiten, angebotene Fahrten, Störungen, Ankünfte	Störungen, Verspätungen, Ausfälle, Unterbrüche, Baustellen, Belegungsdaten	Verfügbarkeit, Belegung
		Stauprognose, Ganglinien	Verfügbarkeitsprognose	Verfügbarkeitsprognose	Auslastungs-Prognose	Verfügbarkeitsprognose, Ganglinien
	Vertriebsdaten	Strassengebühr, Tunnelzoll	Angebote, Tarife	Angebote, Tarife	Angebote, Tarife	Angebote, Tarife, Zahlungsmöglichkeiten

Interaktionsdaten	**Personendaten**	Personenstammdaten, Verträge, Abos, Nutzungen, Präferenzen
	Transaktionsdaten	**Einzeldatensätze**: Verkäufe, Reservationen, Anfragen **Anonymisiert / aggregiert**: Abrechnungsdaten
	Bewegungsdaten	**Einzeldatensätze**: Durchgeführte Fahrten, Standorte **Anonymisiert / aggregiert**: statistische Nutzungen / Frequenzen, Verkehrsflüsse, regulatorische Daten (z.B: QMS)

Figure 3: Classification of the core data by data type and mode as well as classification of the interaction data with data examples.

4.1.1 Mode

Many standards emerged from use cases for a particular mode. By mode we mean here the forms of mobility services as per the following breakdown:

- **Individual transport**: "travelling independently with your own vehicle": human-powered mobility (HPM) and motorised individual transport (MIT) with own vehicle.
- **Shared mobility**: "travelling independently with a rented vehicle": sharing and rental services.
- **On-demand services**: "one is transported, alone or pooled, arranged as needed": e.g. taxi, on-demand services, ride-sharing services (ridehailing, ridepooling)
- **Timetable-based**: "one is transported by mass transport, according to a timetable": public transport, long-distance coaches, aviation.
- **Services not providing transportation**: e.g. parking, petrol stations, charging stations.

4.1.2 Data type

Classification by data type is based on the following categorisation:

- **Core data**: a minimum inventory of the mobility data necessary for the NADIM to function. The core data includes:
  - **Geodata**: spatial data relating to the transport infrastructure.
  - **Operating data**: data on the operational status of a transport infrastructure or mobility service.
    Operational data forms the bulk of all data, and can be further subdivided according to the following characteristics as needed for analyses and descriptions:
    - static: a foundation of data that remains stable over an extended period of time
    - dynamic/real-time: current operations data

        - prognostic: calculated data for future models.
    - **Sales data**: data required for the sale of mobility services, i.e. description of the services, tariffs, costs and conditions. *(Please note: sales data does not include personalised bookings or similar; these are part of the interaction data).*
- **Interaction data:**
    - **Personal data**: data relating to a customer (e.g. master data, preferences)
    - **Transaction data**: e.g. routing requests, reservations, ticket purchases, payments, after-sales service, promotions
    - **Movement data**: georeferenced data generated through the use of a mobility service.

4.2 Classification from perspective of customer process

To arrange and take a trip, customers go through the process steps "search, book, use". In the "search" process step, generally valid information about the mobility service is exchanged and interactive route planning is done in the background systems. The following division into functional areas is therefore proposed from the perspective of the customer process.

Functional area	Process step	Description
Information exchange	searching	In this process step, the customer receives an overview of the available mobility services and intermodal travel chains based on generally available data (timetables, service plans, services, price information, availability).
Booking	booking	This step describes a personalised or at least individualised action for an end customer. This process step may include a reservation, the actual booking including payment, or a cancellation.
Use	using	This process step comes into play once the customer has completed the booking and is interacting directly with the mobility provider. This may include e.g. unlocking / locking, access to the vehicle, arrival information for on-demand services.

Table 5: Classification into functional areas from the perspective of the customer process.

Figure 4 below shows the functional areas as a process chain:

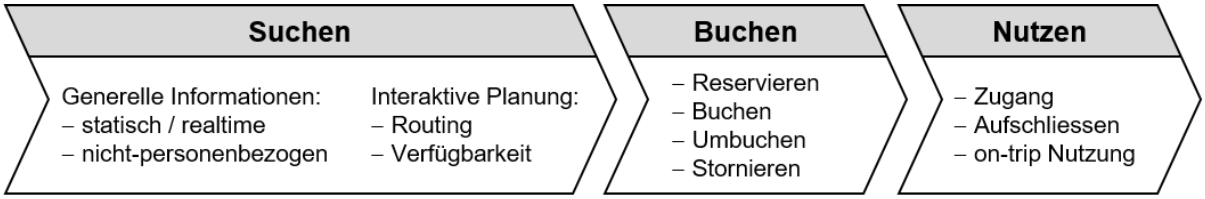


Figure 4: Process chain for arranging and taking a trip.

5. Principles for the selection of appropriate standards

Principles are overarching policies and rules that help to define a consistent strategy for standardisation and to make the correct decisions.

Eight principles for standardisation are proposed:

1. international
2. open
3. simple
4. established
5. evolving
6. high quality
7. compliant
8. unambiguous.

The principles will be elaborated and explained in this section. The evaluation of the standards in section 0 builds on these principles.

5.1 Principle 1: international

Standards are to be developed in international cooperation to enable international data exchange and interoperability.

International data exchange and interoperability	International standards are necessary for seamlessly integrated international travel. They enable the exchange of data and the interaction of processes across national borders. International interoperability and MaaS roaming are only possible with international standards.
Reuse of solutions	Competition and markets with proven solutions and systems are much more likely to develop if the standards are international.
Avoidance of isolated solutions and additional costs	Separate standards for Switzerland would lead to isolation of the Swiss market, require expensive custom-made products and inhibit progress and innovation.
Attractiveness to international providers	The NADIM is only attractive to international providers if international standards are applied.
Attractiveness to Swiss providers	Swiss providers can benefit from international standards as they can offer their solutions both at home and abroad.
Benefits to travellers	Both Swiss travellers abroad and foreign travellers in Switzerland benefit from cross-border travel information.

5.2 Principle 2: open

The principle of openness is one of the NADIM's fundamental goals. Non-discrimination, open data, voluntariness and transparency are all facets of this principle that should apply to both the NADIM and its standards.

Open ownership	The standard belongs to an open, broad-based organisation. New members are welcome and the members are known. This results in transparency and trust. If necessary, cooperation and influence is possible.
Use free of charge	There are no costs for the use of an open standard. This facilitates experimentation and innovation and reduces costs.
Free licence	The standard has liberal, non-restrictive licensing conditions. This provides protection from legal problems and restrictions (e.g. restrictions on use, compulsion to upgrade, changing GTCs). It also avoids dependencies on the vendor ("vendor lock-in").

Non-discriminatory access	Anyone who follows the rules gets access. All actors are treated according to the same principles. A climate of fair competition is created.
Open specification, documentation	All specifications and documentation are freely accessible on the web. This promotes confidence in the standard and facilitates detailed clarifications.
Open source	The technical details and implementations, including program code, are freely available. This promotes trust, acceptance and system security.
Developer-friendly and production-ready	Developers are given easy access without time-consuming registration.
Open community	There is a freely accessible network of specialists.
Transparent financing	There is transparency concerning who is financially involved in the standardisation and how the funds are used.

5.3 Principle 3: simple

Simplicity makes a standard attractive and cost-effective for developers. This promotes acceptance and broad use of the standard.

Applicability to the complexity of the problem	A standard should not be more complicated than the problem it is intended to solve. Simple tasks should be easy to solve.
Simple documentation	There are comprehensible, clearly structured webpages with many application examples, allowing visitors to find their way around quickly.
Simple structures	Simple, clear, elegant, orderly data structures, process logic, rules and processes are implemented.
Easy entry	There is plenty of support, e.g. with quick start guides, hello world programs, sample applications, sandboxes for quick, initial successes. Developers quickly find their way around and are motivated to use the standard. Experimentation and innovation are encouraged.
Simple structure, modularity	The standard supports concepts such as profiles, editions, components and modules, allowing any parts not needed to be omitted.

5.4 Principle 4: established

Broad dissemination and use of a standard yields many benefits: acceptance, planning security, lower risks, widespread know-how and implemented application examples.

Dissemination is more important than perfection	Dissemination and multiple years of application practice are more important and valuable than the level of perfection.
Future-proof	High dissemination ensures stability and planning security.
Communities	Powerful communities and ecosystems are forming around the standard.
Experience, know-how and practice	Experience, know-how and practice is cumulative. There are many specialists and illustrative examples.
Known strengths	The properties, potentials and strengths of the standard are known.
Known weaknesses	Any problems and errors are known and can be factored in. There are solutions and workarounds for them.
Proven solutions	Software solutions, frameworks and libraries based on the standard are forming, making them easier and cheaper to use.
Acceptance	The level of acceptance of the standard is known and calculable.

5.5 Principle 5: evolving

Standards should be able to constantly evolve, grow and adapt to meet changing requirements. Incremental, controlled development reduces risks.

Continuous development	A standard should be in a state of constant and well-considered development so that deficiencies and errors can be eliminated and new goals and requirements can be incorporated.
Backward compatibility, version concept	Backwards compatibility should be ensured as far as possible to increase stability and avoid breaking changes. A traceable concept (e.g. semantic versioning) is available.
Transparency, visibility	The standardisation process should be transparent and open to the public. The history is documented in detail and is public.
Roadmap	The development plans must be communicated and followed.
Change requests	It must be possible to submit proposals for changes through an orderly process, including from outside.
Visible activity	New versions of the standard have been published in recent years / months and forums, Q&As, etc., are maintained. An active, lively community can be identified.
Scalability	The standard must permit the systems built on it to be scalable.

5.6 Principle 6: high quality

The quality of the standards affects the quality of the services offered and supports the other principles too. The following quality criteria are relevant for standards.

Complete functional coverage	The standard covers as many of the functional requirements as possible and is missing as few parts as possible that have to be solved by workarounds and proprietary extensions.
Good documentation	The documentation is complete, up-to-date and multilingual, target-group-appropriate and comprehensible. It is the users' perspective that is decisive, not that of the authors.
Solid processes	Strategy and planning processes, requirements management, development and maintenance of the standard, but also ancillary processes such as new member admissions and meeting management are arranged expediently and fairly.
Craftsmanship and technical quality	The standard has a defined procedure, follows best practices and uses appropriate tools. The underlying basic standards and technologies (e.g. XML, JSON) are used correctly and appropriately.

5.7 Principle 7: compliant

The applications that use the NADIM as a foundation often use several standards simultaneously. Standardisation by the NADIM operator must therefore ensure that the set of standards that emerges fits together and facilitates smooth interoperability.

Compatibility with existing standards	It must be possible to integrate and combine the transmitted data and the interacting processes of existing standards in specialised applications. Any new standard should therefore fit the framework of the NADIM standards that already exist.
Compatible business data model	A shared business data model, or at least compatible business data models, is/are essential for a standard to work with the other standards. For example, NeTEx and SIRI use the same business data model

	(Transmodel); GTFS and HRDF use different models; mapping processes were therefore developed.
Common understanding of semantics	There must be a common understanding of the semantics (meaning of individual technical terms and designations).
Transformations	Conversions or output-input relationships between a new standard and the existing standards should be easy to achieve. Example: SIRI data (output) can be archived smoothly with OpRa data (input) because both are based on Transmodel.

5.8 Principle 8: unambiguous

Standards should be precise and clear so that there is as little room for interpretation and misunderstanding as possible. Profiles must therefore be used.

Technical level	All technological aspects (protocols, security, etc.) are clearly and unambiguously defined.
Semantic level	The meaning of all data / information is clearly and unambiguously defined (example: a specified time refers to the UTC time zone).
Syntax level	Data formats and notations are clearly defined (example: time is specified with the syntax hh:mm:ss).
Process level	Procedural or transactional procedures are clarified (example: bookings are confirmed with "commit" and then marked with the status "confirmed" if successful).
Refining and simplifying the standard through a profile	Standards are usually not open to interpretation. For this reason, profiles (also referred to as "realisation guides") which are decisive to the evaluation of the standards (for example VDV 736 instead of SIRI SX) are developed. Profiles are a suitable way for the NADIM to leave no room for interpretation of standards and also to simplify their use (in Switzerland). Please note that profiles only refine a standard (limit it, define it more accurately), and do not result in an incompatible variation that deviates from the standard.

6. Overview of standards

This section provides an overview of the standards that are relevant from today's perspective. The standards under discussion were selected based on the authors' assessments of their relevance to mobility data. Because developments are highly dynamic, it may be assumed that further standards will still be added.

As illustrated in section 3.2 Figure 2, only the following standards are discussed in this document:

- **Structural standards**: e.g. business data models**,** architecture
- **Interface standards**: e.g. exchange formats**,** protocols

Sections 6.1 to 6.3 below describe the standards evaluated in this document. Anhang C) contains detailed outlines of these standards.

6.1 Structural standards

The "Public Transport Reference Data Model" (Transmodel), the European reference data model for public transport, is relevant in the area of structural standards. All of the CEN standards described in section 6.2 are based on Transmodel or borrow heavily from it.

Standard	Description
Transmodel	A CEN standard with a reference data model for public transport information. The model covers both conventional public transport and flexible transport models. Sharing, pooling, rentals and taxis are also covered with the "alternative modes" extension. The reference model represents timetables, service plans, pricing models, operational management, real-time information and journey planning, among other things. The model is abstract and is used, among other things, to describe aspects of effective interface standards and to improve interoperability. The model is very difficult to read and understand. Building on one of the more implementation-oriented models (NeTEx, SIRI, OJP) is therefore recommended if the relevant aspects are mapped there. – https://www.transmodel-cen.eu/

6.2 CEN standards

Standard	Description
DATEX II	Exchange format for traffic information and data such as road closures, accidents and diversions. – https://www.datex2.eu
NeTEx	A CEN standard for the exchange of timetables and related data. Timetables can be used both in operations (data exchange for operators, operational aspects) as well as for passengers. The standard includes not only classic public and on-demand services, but all modes of transport where the vehicle is not owned by the passenger. The transmission of tariff information is also included. The "New Modes" extension also includes parking, taxis, sharing and pooling schemes. Accessibility stops, staffing and vehicle dispatch data and connections can be mapped. – http://www.transmodel-cen.eu/standards/netex – https://transportdatamanagement.ch/de/standards – https://github.com/NeTEx-CEN/NeTEx
OJP API	The "Open API for Distributed Journey Planning" (OJP) provides an endpoint through which various services can be accessed. The underlying idea is distributed trip planning. Information on locations / POI (points of interest) can be retrieved, trips can be planned, information can be delivered to stations (arrival and departure times) and

Standard	Description
	availability requests can be made (from version 2.0 onwards). Price enquiries can also be made. Information on relevant vehicles and trips can be obtained while travelling. – http://www.transmodel-cen.eu/standards/ojp/ – https://opentransportdata.swiss/en/cookbook/open-journey-planner-ojp/ – https://github.com/VDVde/OJP
SIRI	SIRI defines various services in the area of real-time data. SIRI comes primarily from the world of conventional public transport. The standard can also be used for faults, vehicle information (e.g. its position), securing onward connections and facility monitoring. However, it does not provide individualised information to individual customers. – http://www.transmodel-cen.eu/standards/siri – https://github.com/SIRI-CEN/SIRI
OpRa	OpRa is a CEN initiative for the exchange of raw data in public transport. It is specifically aimed at the aspect of "study and control", i.e. analysis and statistics by the authorities. The standard is not yet very developed. – https://www.opra-cen.eu/overview

6.3 Other standards

Standard	Description
APDS	APDS is a data standard that allows car park owners, operators and service providers to exchange data. APDS offers extensive support (data objects, formats, etc.) including for: – the mapping of information/data such as car parks (hierarchically structured) with spaces, levels / floors, street parking spaces – opening hours, prices, availability – permissions – "sessions" (period of use of a parking space) APDS has been adopted as an ISO standard and is to be embedded into DATEX II. – https://www.allianceforparkingdatastandards.org – https://www.allianceforparkingdatastandards.org/iso-formal-adoption – https://www.datex2.eu/news/datex-ii-has-chosen-apds-core-its-parkingdata-standard
GBFS	GBFS is an open data standard for bike sharing and shared micromobility. GBFS is used by over 600 sharing providers worldwide (as of April 2021). With GBFS, providers can display the locations and availabilities of vehicles, and also provide booking links. The data of the vehicles currently in use and those of their users is not distributed via GBFS. – https://mobilitydata.org/gbfs-and-shared-mobility-data-policy
GTFS	GTFS defines a digital exchange format for public transport timetables and associated geographic information, such as stop locations. In addition to the original, static variant "GTFS Static", there is a "GTFS Realtime" extension for real-time data. GTFS was developed in the Google context from 2005 onwards and is under the control of Google and mobilitydata.org. – https://developers.google.com/transit – https://gtfs.mobilitydata.org

Standard	Description
GOFS	GOFS (General On-Demand Feed Specification) is managed by mobilitydata.org. GOFS was announced as a "specification family supporting plan-book-pay and including GTFS-flex" that "integrates on-demand services more deeply (e.g. live availability, booking)". This is not a new standard but a toolbox that recommends different standards for on-demand services. In the coming months, the GOFS working group intends to define the design of the standardisation. The GTFS-Flex and TOMP (official announcement still pending) standards will be used as the underlying basis. – https://mobilitydata.org/mobilitydata-is-accelerating-the-standardization-of-on-demand-transportation-with-the-gofs-project
OICP	OICP is one of several roaming standards for electric vehicle charging stations. The standard enables the interplay of different charging station operators, so that the customers of one provider can charge up at the charging stations of another provider. The SFOE currently uses OICP for the data infrastructure for electromobility (DIEMO). – https://github.com/hubject/oicp
OSDM	OSDM is a specification for ticketing / sales in international rail transport and public transport. OSDM defines APIs and data models for this purpose. OSDM has two goals: – simplify the booking process for rail customers. – reduce complexity and costs for rail operators and intermediaries. To this end, OSDM is to enable the simple combination of tickets and fares. In addition, the distribution (purchase, sale) of rail travel is to be simplified, both from the customer's perspective and also for the rail sector (rail companies, intermediaries). – https://unioninternationalcheminsdefer.github.io/OSDM
OSM	OpenStreetMap is an international quasi standard service for web map services with worldwide coverage. Similar to Wikipedia, OSM is maintained collaboratively and can be freely used and integrated into apps and websites as a "slippy map" (movable and zoomable) and with route planners. OSM also offers an API through which, for example, points of interest (POIs) can be retrieved. – https://www.openstreetmap.org
TOMP	TOMP-API stands for "Transport Operator to MaaS Provider Application Programming Interface". From the beginning, TOMP-API was primarily developed for the MaaS deep link integration, i.e. the "look-book-use-pay" customer process chain. TOMP-API includes: – Planning: planning a journey from A to B by querying transport companies or route planners. – Booking: booking individual travel segments (legs) with the respective transport companies, involves entering a small amount of personal information. – Trip execution: the implementation of the trip with all the required travel information e.g. tickets, QR codes, unlock codes. The "billing" and "payment" processes between MaaS providers and transport companies still need to be further standardised. – https://github.com/TOMP-WG/TOMP-API/wiki – https://tomp-wg.org

7. Evaluation of the standards

Table 6 below evaluates the standards that are known and relevant today against the principles set out in section 5. The evaluation is based on the assessment by the team of authors with the help of experts as well as a literature study. It is described in detail in Anhang C).

Standard	Modality	international	open	simple	established	evolving	high quality	compliant	unambiguous
Structural standard									
Transmodel	Multimodal	+++	++	+	++	+	++	++	++
CEN standards									
DATEX II	Road	+++	++	+	+++	++	++	++	++
NeTEx	Multimodal	+++	++	+	++	+++	+++	+++	++
OJP	Multimodal	+++	++	++	+	+++	++	+++	+++
SIRI	Public transport (multimodal)	+++	++	++	+++	+++	++	+++	+++
OpRa	PT	+++	++	+	+	++	?	+++	?
Other standards									
APDS	Parking	+++	++	?	+	++	?	?	?
GBFS	Sharing	+++	+++	+++	+++	+++	++	++	++
GTFS	PT	+++	+++	+++	+++	++	++	++	++
GOFS	On-demand	++	+++	?	?	?	?	?	?
OICP	Charging stations	++	++	++	++	++	++	+	?
OSDM	Public transport (multimodal)	+++	+++	++	+	++	+++	+++	+++
OSM	All	+++	+++	++	+++	++(+)	?	?	?
TOMP	Multimodal	+++	+++	++	+	++	++	++	+

Table 6: Evaluation against the eight principles from section 5. + / ++ / +++: principle is fulfilled to a low, medium, high degree. A question mark indicates: not assessed or not assessable.

8. Recommendations

This section makes recommendations for standards and profiles based on the assessments in section 0 and Anhang C) . Where required, profiles and possible restrictions are mentioned. The recommendations are classified as follows:

- **recommended** = introduction of the standard is recommended.
- **optional** = the standard can be used for data deliveries if use of the corresponding recommended standard is unreasonable. For receiving systems, however, the standard is not provided through the NADIM.
- **decided** = The standard is already in use or its introduction has already been decided.

In some areas it may be useful to apply multiple standards. Often, several standards are worth considering due to their distribution and areas of application, for example in the case of timetable standards (HRDF, GTFS, NeTEx). Broad support of standards potentially leads to more participants, while a reduction to one or a few supported standards allows for cost savings in the long term. Generally speaking, more standards and profiles should be accepted for data deliveries than for data provision by the NADIM (a maximum 3 will be supported).

8.1 Recommendation for a structural standard

The Transmodel CEN standard is recommended for use as a conceptual model (see Table 7). If possible, interface standards should therefore be used that are based on Transmodel, borrow from it or can be mapped to it. It is often easier to refer to NeTEx, SIRI or OJP directly, as these are implementations of elements of Transmodel. As a conceptual model, Transmodel has some gaps. Transmodel is not always easy to interpret because it was designed as a purely conceptual model with a high degree of abstraction and normalisation.

Standard	Recommendation	Reason	Introduction
Transmodel	Optional	Conceptually, SKI+ and in future the NADIM operator as well will work with Transmodel (https://www.transmodel-cen.eu) where appropriate. SKI is in the process of deriving a Swiss business data model from it. Often the implementation-oriented models of NeTEx, SIRI and OJP are used directly, as they are closer to actual practice. Transmodel and SKI's Swiss business data model are supplemented with an additional document that presents the SKI+ profile and explains how to interpret Transmodel, NeTEx, SIRI and OJP. Mapping tables are also provided.	introduced

Table 7: Recommendation for a structural standard.

8.2 Recommendations for standards by mode

This section makes recommendations for interface standards. Figure 6 below shows the degree to which the standards cover each area of application and how well they are established.

In the following subsections, the recommendations are listed according to the classification from section 4, and grouped by mode. The recommendations will be the basis for discussions with the various stakeholders.

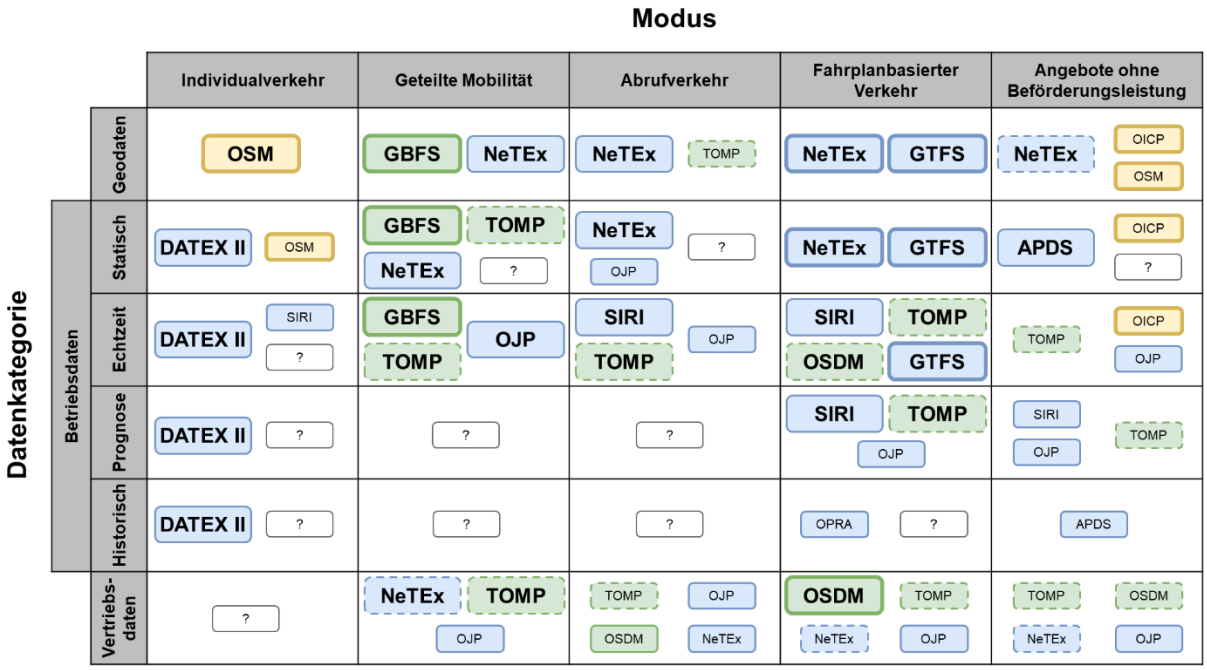


Figure 5: Classification of standards by data category and mode.

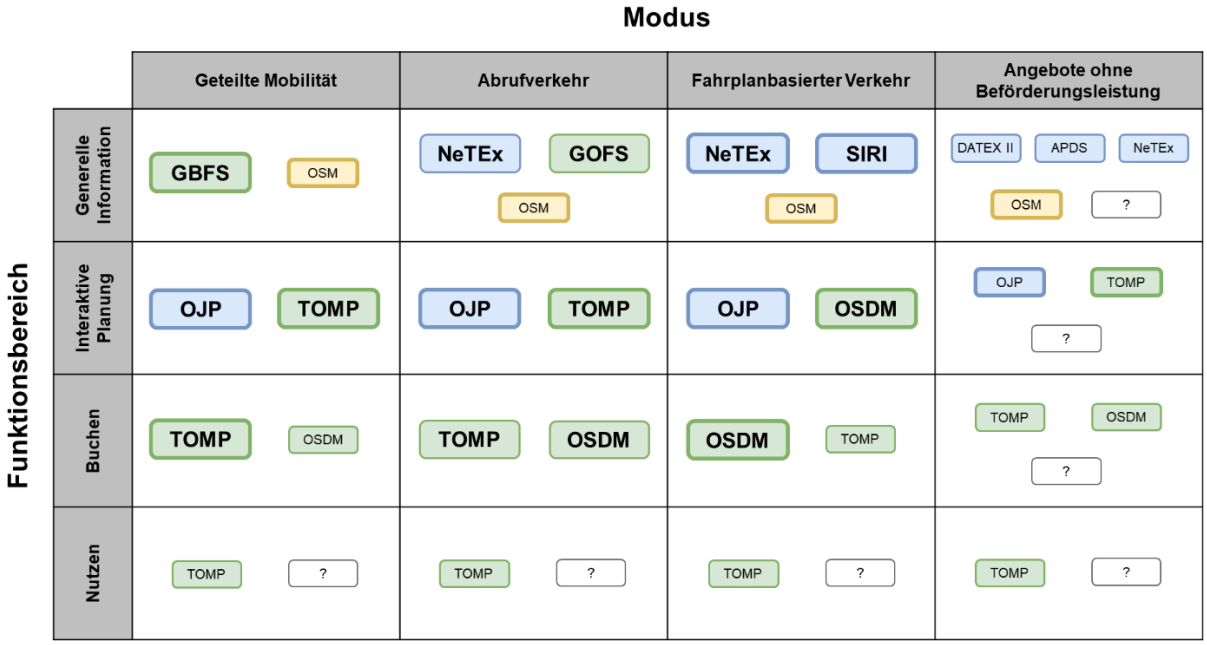
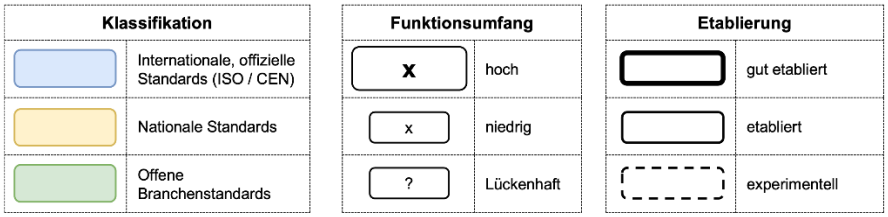


Figure 6: Classification of standards by mode and functional area in the customer process.



8.2.1 Individual transport

Standard	Recommendation	Reason	Introduction
OSM	decided	OSM is the quasi standard for free, open map services and has worldwide coverage. A profile is being developed for POIs and stops. In the case of OSM, this is a guide on how to model stops and POIs and which fields are to be completed. For POIs, this is done per category (e.g. electric charging station, car parks).	introduced next release 2022
DATEX II	optional	DATEX II should be used whenever possible. With an additional profile that is still to be developed, DATEX II is also to be applied for: – closures (by Swiss transport network) – traffic counter – real-time data road	introduced next release 2023
NeTEx	decided	A Swiss EPIAP profile is currently being developed to address accessibility issues at stops and will be introduced from 2025. It will probably be based on VDV 462. As there is an overlap with SKI here, acceptance by KIDS Target Data working group and the Management Board is relevant.	2025

Table 8: Recommendations for standards in individual transport.

8.2.2 Shared mobility

Lack of standards: There is currently a lack of suitable standards for operational shared mobility data. SKI+ is investigating possibilities on behalf of the FOT to close this gap by approx. 2023+.

Standard	Recommendation	Reason	Introduction
GBFS	decided	A SFOE profile is currently being used. We recommend that the SFOE recreates the change in the official GBFS.	introduced
NeTEx	optional	NeTEx is creating a uniform, comprehensive European standard for bulk data exchange (e.g. timetables) across all modes (public transport, shared mobility, on-demand services). NeTEx is used for static geodata and operational data as well as for the exchange of service data and price information. NeTEx for Fares is to be defined as a profile by SKI+.	2023+
OJP	decided	OJP is the leading open standard in Europe for public transport and multimodal journey planning. OJP offers comprehensive options to represent customer requirements. The current version in use is 1.0 with the LinkingAlps profile as per the Cookbook with sharing workaround (the sharing modes are defined via an extension). OJP 2.0 will introduce an extended profile from 2023, including availability requests and price information.	introduced next release 2023

Standard	Recommendation	Reason	Introduction
TOMP-API	optional	TOMP is currently the leading MaaS standard for planning and operations. However, it has not yet caught on, with many providers preferring their own API. TOMP is to be used with a corresponding profile for availability, reservation and sales. TOMP can be used for planning, to submit requests to a mobility provider. However, TOMP is limited in its ability to capture and transmit customer requests.	2022+
TOMP-API / OJP	optional	TOMP can also be applied in the area of use (ticketing, codes, information en route, etc.). OJP, too, can be used for information en route, but there is still a lot of uncertainty about which functions should (or could) optimally be covered by which standard.	open

Table 9: Recommendations for standards in shared mobility.

8.2.3 On-demand transport

Standard	Recommendation	Reason	Introduction
NeTEx	optional	NeTEx is developing a uniform, comprehensive European standard for bulk data exchange (e.g. timetables) across all modes (public transport, shared mobility, on-demand services). NeTEx can also be used in part for geodata (e.g. routes, stops, geofences) and static operational data. For tariffs, SKI+ is to define a NeTEx profile.	2023+
OJP	decided	OJP is the leading open standard in Europe for public transport and multimodal journey planning. OJP offers comprehensive possibilities for capturing and transferring customer requirements. Version 1.0 has been selected. OJP 2.0 will introduce an extended profile from 2023, including availability requests and price information.	introduced
SIRI	decided	Similar to NeTEx, SIRI is a universal standard for real-time data pertaining to public transport, on-demand schemes and other mobility services.	2023+
SIRI SX	decided	The use of SIRI SX for on-demand services with a corresponding profile has been decided. SKI is developing the prerequisites so that the European SIRI profile can be used unchanged for Switzerland as well.	2022
SIRI ET SIRI PT	decided	The use of SIRI ET and PT with the corresponding profile is decided for public transport-related, scheduled services.	2022
SIRI VM SIRI FM	optional	Currently there is no system that uses SIRI VM or SIRI FM; and the standardisation of the European profile has not yet been completed.	2023+
TOMP-API	optional	TOMP is currently the leading MaaS standard for planning and operations. However, it has not yet caught on, with many providers preferring their own API. TOMP is to	2022+

Standard	Recommendation	Reason	Introduction
		be used with a corresponding profile for availability, reservation and sales. TOMP can also be used for planning, to submit requests to a mobility provider. However, TOMP is limited in its ability to capture and transmit customer requests.	
OSDM	optional	OSDM can be used for availability, reservation and booking until it is clear whether and how the public transport industry will support the standard.	2023+
TOMP-API / OSDM / OJP	optional	In the area of use (ticketing, codes, information en route, etc.), TOMP and / or OSDM can also be used, depending on the sub-area. OJP can also be used for information en route. However, there are still many uncertainties about which functions could best be covered with which standard.	open

Table 10: Recommendations for standards in on-demand services.

8.2.4 Timetable-based transport

Standard	Recommendation	Reason	Introduction
NeTEx	optional	NeTEx is creating a uniform, comprehensive European standard for bulk data exchange (e.g. timetables) across all modes (public transport, shared mobility, on-demand services). The recommendations for NeTEx in public transport are primarily made by the SKI Management Board.	2023+
GTFS GTFS-RT	decided	GTFS is the dominant standard worldwide but it has a smaller range of functions compared to NeTEx. GTFS can be used for data deliveries. The use of GTFS and GTFS-RT for data provision by the SKI has been decided. However, they are not recommended for data deliveries because, among other things, the range of functions is insufficient.	introduced
SIRI **SIRI PT** **SIRI ET** **SIRI SX** **SIRI VM** **SIRI FM**	decided	Similar to NeTEx, SIRI is a universal standard for public transport, on-demand schemes and other mobility services. The use of the various SIRI services (PT, ET, SX, VM, FM) with a corresponding profile has been decided. The recommendations regarding SIRI in public transport are primarily issued by the SKI Management Board.	introduced
OJP	decided	OJP is the leading open standard in Europe for public transport and multimodal journey planning. OJP offers comprehensive possibilities for capturing and transferring customer requirements. Version 1.0 with the LinkingAlps profile as per Cookbook has been decided. OJP 2.0 will introduce an extended profile from 2023, including availability requests and price information.	introduced
TOMP-API	optional	TOMP can be used for public transport sales. The relevant profile must cover this. SKI+ is working to clarify the	2022+

Standard	Recommendation	Reason	Introduction
		relationship between TOMP and Transmodel. This is also being done specifically for the interaction between TOMP and NeTEx, SIRI, OJP.	
OSDM	decided	The use of OSDM for international public transport sales has been decided. SKI+ is working to ensure that OSDM is aligned with NeTEx. OSDM can also be used for public transport planning.	2023+
TOMP-API / OSDM / OJP	optional	In the area of use (ticketing, codes, information en route, etc.), TOMP and / or OSDM can also be used. OJP is also a contender for information en route. However, there are still many uncertainties about which functions could best be covered with which standard.	open

Table 11: Recommendations for standards in timetable-based transport.

8.2.5 Services not providing transportation

Lack of standards: The gaps shown in Figure 6 are to be detailed and the potential standards / profiles evaluated. On behalf of FOT, SKI+ is examining, until approx. 2023+, options to close this gap.

This section is about non-transport mobility services (see Figure 3). The standardisation defined in this area can be less binding, because very different services are involved and many of the functions provided by these standards are also covered by the previous standards. The following is a selection of possible areas of application.

Standard	Recommendation	Reason	Introduction
APDS	optional	If APDS is coordinated with NeTEx, APDS will be used for parking management, otherwise NeTEx should be used. If APDS is chosen as the ISO standard, this will be reconsidered.	2023
NeTEx	optional	NeTEx can be used for parking information (see previous recommendation).	2023+
OSM	optional	OSM is to be used for POIs of all kinds, e.g. parking spaces and lifts. The required profiles are being adapted on an ongoing basis. An initial version will be required in 2022.	2022
OICP	optional	The international standard for charging station roaming has not yet been settled. This will be monitored further. For the time being, the SFOE profile will be used for OICP.	introduced
SIRI	optional	SIRI FM is to be applied for real-time data of facilities / equipment (e.g. lifts, escalators) where accessibility is a factor, otherwise, SIRI can be used. SIRI FM will be introduced when the DDA (BehiG) comes into force.	2024
OJP	decided	OJP can represent POIs and parking spaces, for example, at the time a trip is planned. This is already done currently and should always be considered in	2022

Standard	Recommendation	Reason	Introduction
		the POI profile (see 8.2.1 recommendations for individual transport).	
TOMP-API	optional	The standard is being monitored and the general TOMP profile is being completed. SKI+ is working to align TOMP more closely aligned with CEN standards. OSDM could be used for sales, e.g. of parking spaces.	2022+
OSDM	optional	The standard is being monitored and additions will be made to the profile. OSDM could be used for sales, e.g. of parking spaces.	2023+

Table 12: Recommendations for standards for services not providing transportation.

Anhang A) Glossary

Term	Definition
API	Application Programming Interface. Refers to a connection option (interface) through which computer systems (programs) can exchange data and functionalities. These days, APIs are almost always implemented as web services (REST or SOAP).
Best practice / common practice	A procedure or approach that is used in many places because it is known and proven; a precursor of the quasi standard.
Bikesharing	See →Sharing.
Bulk data exchange	Exchange of complete, sometimes extensive data sets (files), e.g. all of Switzerland's public transport timetables.
Car sharing	See →Sharing.
Common practice	See →Best practice.
Core data	The minimum amount of mobility data that is required in order for →NADIM to function, such as location, availability and tariffs of mobility services.
Data exchange format	Data formats specifically designed for exchanging data between different computer systems and between different companies. In particular, data exchange formats should be platform-independent (suitable for all operating systems), open (free of licensing charges), processable without special software, machine-readable and easily verifiable by humans (legible, displayable in text editor).
Deep integration	Also sales integration: "deep" cooperation between transport companies and mobility service providers (MaaS providers), i.e. encompassing the entire chain beyond →Information exchange: service / connection request A to B - booking - use - payment - supplementary services (cancellation, support, complaints, etc.). In contrast to pure information exchange (service data, timetable data, etc.), deep integration requires participants' B2B business processes to be linked and viable contractual relationships to be established. Sensitive, personal data and financial flows (payment, clearing) must be secure.
De-facto standard	See →Quasi standard
DIEMO	Data Infrastructure for Electromobility. A system that provides information about the public electric vehicle charging stations in Switzerland as well as their availability and other information in real time (e.g. charging capacity, providers) (ich-tanke-strom.ch). The data is provided uniformly and free of charge in the form of open data via an interface.
FOT	The Swiss Federal Office of Transport.
Functional / non-functional requirements	"Functional / non-functional" is a distinction commonly used for the requirements of an IT system: Functional requirements refer to the functionality of a system, e.g. the area of application, use cases and business processes. Non-functional requirements refer to the remaining characteristics of a system which are often collectively referred to as "quality" or "quality features". Examples include: response time, availability, reliability, stability, scalability, resilience of a system.
Geofence	"Geographical fence"; a virtual, spatial boundary or zone, e.g. of service areas. Geofences can be monitored with GPS receivers.

Term	Definition
Geoinformation	Information that refers to a position (point, line, area) on the earth's surface. This includes position and location information (points, coordinates), lines, polygons, areas (zones →Geofence), but also names and other location-linked information.
Harmonisation	Standardisation with the aim of bringing together different or conflicting standards.
Identifier	An identifier (ID) is a characteristic that is assigned to an object for its unique identification.
Industry standard	See →Sector standard.
Information exchange (of mobility data)	Exchange / transfer of mobility data from transport companies or →MaaS providers, such as services, fares, timetables, in some cases also real-time data (delays, disruptions, short-term offers). Information can be exchanged in the form of a bulk load (to load large amounts of data in one go) or by online query for real-time data. In contrast to →Deep integration, the information exchange consists only of a simple, one-way request for information. There does not have to be a close contractual relationship between the provider and the requester of the information. The information exchange is the core mission of →NAP and →NADIM.
Intermodal mobility	Intermodal transport is a special form of →Multimodal mobility. It describes a multi-link transport chain and refers to both passenger and freight transport. In passenger transport, different means of transport are linked within a single travel chain.
Interoperability	Interoperability is the ability of independent, heterogeneous systems to work together seamlessly to exchange data in an efficient and usable way or to make it available to the user without the need for special adaptations.
JSON	Abbreviation for JavaScript Object Notation. JSON is a method or standard for defining data formats. JSON-formatted data has a simple structure that is easily legible by humans and is widely used today. Compare with →XML. Example: { "departure": "10:30", "from": "Olten", "to": "Aarau" }
MaaS	Mobility-as-a-service. Comprehensive mobility solutions in which physical mobility services in combination with digital services form a high-quality, seamless mobility service that can be accessed via a uniform customer interface, so that multimodal journeys can be planned and carried out without owning a vehicle. The central idea is to integrate mobility services from different providers (public transport, sharing, micromobility, etc.) via an app and make them easily accessible.
MaaS provider	A company that offers →MaaS through a smartphone app or web application.
Micromobility	Forms of mobility with small, agile vehicles such as bicycles or scooters. New technologies and digitalisation have given rise to new types of vehicles and business models, e.g. e-scooter sharing.
MIT	Motorised individual transport. Transport by a personally owned motorised vehicle for individual use.
Mode, modality	Characteristics of mobility services as per the following breakdown: – Individual transport: human-powered mobility (HPM) and motorised individual transport (MIT) with own vehicle. – Shared mobility: sharing and rental services. – On-demand services: e.g. taxi, on-demand services, ride-sharing services (ridehailing, ridepooling). – Timetable-based: public transport, long-distance coaches, aviation.

Term	Definition
	– Services not providing transportation: parking, petrol stations, charging stations.
MODI	Mobility data infrastructure. Infrastructure planned by the federal government for mobility data. The mobility data itself is also part of MODI →NADIM and → VnCH in particular are elements of it.
MODIG	Draft for the new federal law on the mobility data infrastructure which legally regulates →NADIM and the →VnCH.
Multimodal mobility	Multimodal mobility refers to the use of a variety of transport modes within a certain period of time. The persons or goods are transported by two or more different modes of transport within a certain period of time.
NADIM	National Data Networking Infrastructure Mobility →NADIM comprises mobility data and IT systems that use the data in a standardised way and connect the users.
NAP	National Access Point. Technical and organisational interface through which mobility data and the corresponding metadata can be exchanged. The implementation of a NAP by the EU member states is required by various EU regulations and should, among other things, ensure that mobility data can be exchanged in the European context.
Non-functional requirements	See →Functional / non-functional requirements.
On-demand services	Services where the passenger can book a trip via a booking process, often without a timetable. There are various types: regular service, corridor service, area service; with physical or virtual stops or door-to-door.
Open standard	Standard with a publicly documented and freely accessible and usable specification. This is the opposite of closed or proprietary standards which are considered business secrets.
Profile	A subset, refinement or specific application of a standard. A profile defines, for example, which part of a standard is to be used and substantiates the specification of the standard, e.g. with regard to the specific application or the use of attributes. This will reduce the scope of interpretation as much as possible.
Proprietary standard	A standard that is under the control of a company or institution and is not open or free to use.
PT	Public transport. Mobility services that are usually provided by railways, rapid transit/metro systems, buses, trams, ships and cableways/funiculars using specific timetables, routes and stops. The services can be used by all persons on the basis of specified transport regulations in accordance with the Passenger Transport Act (PBA) Art. 6 or 8.
Quality	See →Functional / non-functional requirements.
Quasi / de-facto standard	A procedure that has unintentionally or unofficially become a de-facto standard.
REST, REST API	Abbreviation for Representational State Transfer. With REST →APIs are realised with simple standard internet technologies: HTTP, HTTP methods, URLs, JSON and OpenAPI. REST APIs are widely used today.
Roaming (MaaS roaming)	Roaming is known in mobile telephony as the ability to make calls and use mobile data (internet) with your mobile phone abroad on the mobile telephony networks of other providers.

Term	Definition
	Analogously, MaaS roaming enables people to search for, book and use mobility services nationwide and also abroad with a single MaaS app.
Route planner (journey planner)	A computer application that can be used to plan journeys from location A to location B. Route planners make suggestions for appropriate routes from A to B. Route planners are well known and widely used in road traffic (navigation devices, websites). Special route planners, on the other hand, are used in public transport to find suitable timetable connections from A to B. The current and future challenges lie in providing →Multimodal route suggestions, adapted to personal preferences, and →Deep integration (i.e. the subsequent booking, use and payment of a route).
Sales integration	See →Deep integration.
Scooter	Kick scooter; light, two-wheeled vehicle for one person standing on a footboard. The vehicle is propelled either by kicking / pushing off or electrically ("e-scooter"). In many urban areas, kick scooters are also offered in →Sharing schemes (GPS localisation; rental, unlocking through smartphone apps).
Sector standard / industry standard	A standard developed by companies or associations for a specific sector, industry or economic activity.
SFOE	The Swiss Federal Office of Energy.
Sharing	Organised, communal use of transport modes. Similar to rentals, but often linked to a membership or subscription. Well-known forms are car sharing, bike sharing, scooter sharing, and also carpooling.
Standard	A uniform or unified, widely accepted and most commonly used way of describing, producing or doing something which has prevailed over other ways or is regarded as a yardstick.
Standard, standardisation	Standardisation by high-level institutions gives rise to norms that describe generally accepted fundamental standards. Such norms can be prescribed by law for certain areas of application.
Standardisation	In technology and business, the standardisation of components, production methods, units of measurement, processes, structures, types or goods and services; the development, maintenance and dissemination of standards.
Taxi	Transportation service, usually operated by private providers with cars. Regulated at state, canton or municipality level. Taxis usually drive exclusively for individual clients.
VnCH	A spatial reference system for mapping, exchanging and linking mobility data. It comprises geodata of Switzerland's transport infrastructure and systems that provide, exchange, link and obtain the geodata in a standardised manner, in particular via →NADIM.
XML	Abbreviation for Extensible Markup Language. XML is a procedure or standard for defining complex data formats. Compared to →JSON, XML is somewhat more complex and bulky. Example: <?xml version="1.0" encoding="UTF-8" standalone="yes"?> <connection> <departure>10:30</departure> <from>Olten</from> <to>Aarau</to> </connection>

Anhang B) Literature and references

FOT, "General topics" page (Data for an efficient mobility system), has been continuously updated since 2020: https://www.bav.admin.ch/bav/de/home/allgemeine-themen/mmm.html. *Introductory text and collection of the key documents on MODIG, MODI and NADIM*

EU, Delegated Regulation (EU) 2017/1926 of the Commission of 31 May 2017, EU Delegated Regulation (EU) 2017/1926. *EU mandate to its members to establish National Access Points (NAPs).*

Open Data Platform Mobility Switzerland, https://openmobilitydata.swiss.

Transport Data Management, standards: Customer Information (SKI) system tasks, information, specifications and explanations on structural standards and interface standards. https://transportdatamanagement.ch/de/standards/

NADIM Requirements Assessment, https://www.bav.admin.ch/dam/bav/de/dokumente/uebergeordnete-themen/mmm/bericht-beduerfniserhebung-nadim.pdf.download.pdf/Bericht%20Bed%C3%BCrfniserhebung%20NADIM.pdf

Anhang C) Outlines of the standards

This appendix contains outlines of the standards that have been discussed in the previous sections and were positioned as important for the NADIM. The standards are presented in alphabetical order.

C 1. APDS (Alliance for Parking Data Standards)

<table>
<tr><td>Description</td><td>APDS is a data standard for the exchange of data between car park owners, car park operators and parking service providers. APDS offers extensive support such as data objects and formats for:
– the interaction between different actors such as owners, operators, intermediaries (apps)
– the registration of objects such as multi-storey car parks with floors, sectors, street parking spaces
– opening hours, prices, availability
– permissions
– sessions (use of parking space from-until).
APDS has been adopted as an ISO standard and is to be embedded into DATEX II.</td></tr>
<tr><td>Responsible</td><td>Alliance for Parking Data Standards, a non-profit organisation.</td></tr>
<tr><td>Links</td><td>https://www.allianceforparkingdatastandards.org</td></tr>
<tr><td>Technology</td><td>UML-based data modelling, REST APIs, OpenAPI specifications.</td></tr>
<tr><td>Application</td><td>The focus is on data exchange around car parks and street parking. APDS defines complex data models for parking spaces (hierarchical), usage rights (e.g. parking, pick-up/drop-off), actual sessions (usage), tariffs and tariff models, as well as occupancies.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>British-dominated but internationally oriented.</td></tr>
<tr><td>P2 open</td><td>++</td><td>Open organisation, but the specification is only available after registration.</td></tr>
<tr><td>P3 simple</td><td>?</td><td>Rather complex, top-down modelling, no quick start guides to be found.</td></tr>
<tr><td>P4 established</td><td>+</td><td>Young standard; adoption by ISO and DATEX II is strengthening APDS.</td></tr>
<tr><td>P5 evolving</td><td>++</td><td>Follows common procedures; open feedback process.</td></tr>
<tr><td>P6 high quality</td><td>?</td><td>Detailed, systematic documentation.</td></tr>
<tr><td>P7 compliant</td><td>?</td><td>Compliant with DATEX II; not coordinated with Transmodel.</td></tr>
<tr><td>P8 unambiguous</td><td>?</td><td>Currently still difficult to assess, a lack of practical examples/showcases.</td></tr>
</table>
</td></tr>
<tr><td>Assessment</td><td>A parking standard that was established quite recently. There are no standards yet for deep integration of parking. The future international significance of APDS is uncertain but a declaration of cooperation with DATEX II is in place.</td></tr>
<tr><td>Recommendation</td><td>If APDS is aligned with NeTEx/Transmodel and DATEX II, the standard should be examined in more detail on a case-by-case basis and, if it proves advantageous, it should be given preference; otherwise NeTEx should be used.</td></tr>
</table>

C 2. DATEX II

<table>
<tr><td>Description</td><td>DATEX II is a European industry standard for the exchange of traffic information and traffic data.
DATEX II was developed in the 2000s as a non-compatible successor of DATEX I. The latest release of DATEX II is version 3.3.
DATEX II consists of 12 parts. The most important functionally relevant parts are: Location Data (2), Situation (3), Variable Traffic Signs (4), Measurement Data (5), Parking (6), Traffic Management (8) and Traffic Signal Management (9). Parts of it have been recognised and adopted by CEN since 2018.
DATEX II can be used to record traffic measurements, road traffic events and construction sites, among other things.</td></tr>
<tr><td>Responsible</td><td>DATEX II Organisation, i.e. CEN (European Committee for Standardization) Intelligent Transport Systems (CEN/TC 278).</td></tr>
<tr><td>Links</td><td>– https://www.datex2.eu
– https://opentransportdata.swiss/de/rt-road-traffic-counters
– Swiss profile for DATEX II, i.e. FEDRO Traffic Data Platform (TDP) DATEX II Profile, undated (approx. 2020), 50 pages.</td></tr>
<tr><td>Technology</td><td>UML models, XML, XML Schema, SOAP web services.</td></tr>
<tr><td>Application</td><td>DATEX II has been widely used throughout Europe for many years.
In Switzerland, the Federal Roads Office FEDRO publishes two data feeds (SOAP operations) on openmobilitydata.swiss:
– pullMeasurementSiteTable: static data of the traffic counting network, approx. 2,300 measuring points, 20 MB
– pullMeasuredData: current data from the traffic counters, counts/measurements from the measuring points updated every minute.
The data feeds are provided via a SOAP interface.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>EU or European standard.</td></tr>
<tr><td>P2 open</td><td>++</td><td>Open organisation; specifications and instructions are freely accessible.</td></tr>
<tr><td>P3 simple</td><td>+</td><td>More complex XML structures; on openmobilitydata.swiss they are also packaged in SOAP.</td></tr>
<tr><td>P4 established</td><td>+++</td><td>Widespread and established in Europe.</td></tr>
<tr><td>P5 evolving</td><td>++</td><td>The standard is being actively developed according to the usual process.</td></tr>
<tr><td>P6 high quality</td><td>++</td><td>Good rating, extensive materials available.</td></tr>
<tr><td>P7 compliant</td><td>++</td><td>Harmonisation with CEN, APDS etc.</td></tr>
<tr><td>P8 unambiguous</td><td>++</td><td>Good rating thanks to detailed materials and Swiss profile.</td></tr>
</table>
</td></tr>
<tr><td>Assessment</td><td>DATEX II is the CEN standard for road traffic. The distinction from APDS needs to be further monitored and investigated.</td></tr>
<tr><td>Recommendation</td><td>Use for the road transport sector.</td></tr>
</table>

C 3. GBFS (General Bikeshare Feed Specification)

Description	GBFS is an open data standard for real-time data in the area of bike sharing and shared micromobility. GBFS was launched in 2014 and introduced by the North

<table>
<tr><td></td><td>American Bikeshare & Scootershare Association (NABSA) in 2015. GBFS is currently at version 2.2; a new version 3.0 is being drafted.
GBFS enables real-time data feeds from providers of sharing services for planning trips. Similar to GTFS for public transport providers, the aim of GBFS is to create the MaaS basis for sharing schemes.
With GBFS, providers can display their current vehicle locations and availabilities, and also provide booking links. The data of the vehicles currently being used and their users are not displayed.
The GBFS specification defines "feeds" (JSON files) that a provider offers via REST services (HTTP endpoints). The "gbfs" feed (or the gbfs.json file) is the start page with links (URLs) to the other feeds. The remaining 12 feeds are: gbfs_versions, system_information, vehicle_types, station_information, station_status, free_bike_status, system_hours, system_alerts, system_calendar, system_regions, system_pricing_plans, geofencing_zones.
Depending on the use case, some feeds are mandatory, e.g. station_information for dock-based systems and free_bike_status for free-floating systems.</td></tr>
<tr><td>Responsible</td><td>NABSA and the mobilitydata.org organisation which is dominated by Google and Apple.</td></tr>
<tr><td>Links</td><td>– https://nabsa.net/resources/gbfs
– https://www.bfe.admin.ch/shared-mobility-angebote
– https://www.sharedmobility.ch</td></tr>
<tr><td>Technology</td><td>REST services (HTTP endpoints), JSON, JSON schema.</td></tr>
<tr><td>Application</td><td>GBFS is used by over 600 sharing providers worldwide (as of the beginning of 2022).
In Switzerland, the Swiss Federal Office of Energy (SFOE) provides data feeds of the (known) bike, scooter and car sharing providers in version 2.0, with the following feeds:
– gbfs: Start page with all URLs.
– providers: master data and app URLs of all providers.
– system_information: master data of these SFOE-GBFS feeds.
– station_information: static data of the fixed parking spaces (stations).
– free_bike_status: position and status of free-floating vehicles.
– station_status: real-time data (availabilities) per station.
– system_hours: operating times; currently not used.
– system_regions: served regions with providers; used only rudimentarily.
– system_pricing_plans: pricing models; used only rudimentarily.
– geofencing_zones: permitted zones of a few providers.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>In use in approx. 50 countries worldwide.</td></tr>
<tr><td>P2 open</td><td>+++</td><td>Specification and instructions freely and openly available on the web.</td></tr>
<tr><td>P3 simple</td><td>+++</td><td>Very simply constructed, easy-to-use standard. Data structures are self-explanatory.</td></tr>
<tr><td>P4 established</td><td>+++</td><td>Widespread since the late 2010s.</td></tr>
<tr><td>P5 evolving</td><td>+++</td><td>GBFS is still very much in development. A solid, considered strategy and implementation are evident.</td></tr>
<tr><td>P6 high quality</td><td>++</td><td>Solid documentation and specifications on github.</td></tr>
<tr><td>P7 compliant</td><td>++</td><td>GBFS was started as an independent standard but actively seeks coordination with GTFS, TOMP, NeTEx, and other standards.</td></tr>
</table>
</td></tr>
</table>

	P8 unambiguous	++	Good rating due to years of use and alignment/mapping tables with CEN.
Assessment	In recent years, GBFS has become the only undisputed standard in shared micromobility.		
Recommendation	Continue to use for shared mobility. The SFOE should incorporate its changes into GBFS.		

C 4. GOFS (General On-demand Feed Specification)

Description	GOFS is not an independent standard but a toolbox for mapping on-demand services. Currently, the two standards GTFS-Flex (as an extension of GTFS) and TOMP for deep integration are available for mapping on-demand services.
Responsible	The mobilitydata.org organisation which is dominated by Google and Apple.
Links	https://mobilitydata.org/mobilitydata-is-accelerating-the-standardization-of-on-demand-transportation-with-the-gofs-project
Technology	Probably CSV or JSON files, same as GTFS and TOMP.
Application	Due to the reach of mobilitydata.org, it is to be expected that on-demand standardisation using GOFS will quickly gain in importance.
Assessment (principles)	Please refer to the GTFS and TOMP standards for this.
Assessment	According to mobilitydata, the foundations for standardisation were laid in 2021 with around 30 partners. However, details and specifications have not yet been published.
Recommendation	Monitor.

C 5. GTFS (General Transit Feed Specification - Static, Realtime, Flex)

Description	GTFS (Static) was introduced by Google in 2006 to allow transport companies to make their public transport timetables available to Google and other web portals. GTFS Static quickly became the quasi standard for this use case. GTFS defines a digital exchange format for public transport timetables and the corresponding geographic details, such as stop locations. Currently there are 15 entities or tables (agency, stops, routes, trips, stop_times, calendar, calendar_dates, fare_attributes, fare_rules, shapes, frequencies, transfers, pathways, levels, feed_info, translations, attributions). Often they are implemented only partly. GTFS Realtime is a GTFS extension for real-time information and deviations. It was first released in 2011 and contains the entities trip updates (delays, outages, changes), service alerts (special incidents) and vehicle positions. GTFS Flex is a proposal to extend the standard for "Demand-Responsive Transportation (DRT)" (e.g. on-demand services, call buses). For this purpose, three new files (booking_rules.txt, location_groups.txt and locations.geojson) are to be added and the stop_times.txt file is to be extended.
Responsible	The Google/Alphabet Group and the mobilitydata.org organisation which is dominated by Google and Apple.
Links	– https://developers.google.com/transit/gtfs/ – https://mobilitydata.org/ – https://opentransportdata.swiss/de/cookbook/ – https://github.com/MobilityData/gtfs-flex

<table>
<tr><td>Technology</td><td>GTFS Static: ZIP archive with CSV files (one per entity or table).
GTFS Realtime: protocol buffers (format).</td></tr>
<tr><td>Application</td><td>GTFS Static and Realtime are widely used worldwide.
The timetable of the entire Swiss public transport system is currently mapped on the ODMCH (Open Data Platform Mobility Switzerland) in the following 9 tables:
– agency (the transport company),
– calendar (the normal operating days/weekdays),
– calendar_dates (exceptions to the normal operating days),
– routes (one line, e.g. S6),
– trip (a specific trip, e.g. the S6 Bern departing 14:36),
– stop_times (stop times at a stop location on a specific journey),
– stop (a stopping place, e.g. "Bern, track 1"),
– as well as feed_info and transfers with further information.
ODMCH also offers a GTFS Realtime feed with all the known changes in the Swiss public transport system within the entire preview window (three hours).</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>In use worldwide.</td></tr>
<tr><td>P2 open</td><td>+++</td><td>Specification and instructions freely available, public on the web.</td></tr>
<tr><td>P3 simple</td><td>+++</td><td>Simply constructed, easy-to-use standard.</td></tr>
<tr><td>P4 established</td><td>+++</td><td>Very widely used for over 15 years.</td></tr>
<tr><td>P5 evolving</td><td>++</td><td>Under the control of Google.</td></tr>
<tr><td>P6 high quality</td><td>++</td><td>Developer-friendly documentation and specifications.</td></tr>
<tr><td>P7 compliant</td><td>++</td><td>Good rating thanks to alignment and mapping tables with CEN. However, GTFS cannot map all the required features of the Swiss public transport system.</td></tr>
<tr><td>P8 unambiguous</td><td>++</td><td>Good rating due to years of use and alignment/mapping tables with CEN.</td></tr>
</table>
</td></tr>
<tr><td>Assessment</td><td>GTFS will certainly be the dominant standard for years to come. However, since GTFS does not have the full functionality required by the Swiss public transport system, it only has the role of a secondary standard.</td></tr>
<tr><td>Recommendation</td><td>Continue to support as a second standard (besides NeTEx).</td></tr>
</table>

C 6. NeTEx (Network Timetable Exchange)

Description	NeTEx is the official CEN standard for exchanging timetable data and related public transport data. NeTEx can be used to exchange data of detailed timetables, complex routes, operating days, train compositions, transport companies, service trips, access for people with mobility impairments as well as price information. However, NeTEx is not intended as a format or protocol for querying individual connections for journey planning. NeTEx resulted from the harmonisation of various national standards (including Bison in the Netherlands, NEPTUNE in France, TransXchange in the UK, VDV 452 in Germany). Version 1.0 was published in 2014. The NeTEx specifications consist of these parts: – Part 1 for describing public transport network topologies (2014).

<table>
<tr><td></td><td>
– Part 2 for describing timetables (scheduled timetables, 2014).
– Part 3 for describing tariffs and prices (fare information, 2015).
– Part 4 defines a European profile for customer information (2017).
– Part 5 defines exchange formats for alternative modes (2021).
– Part 6 European Passenger Information Accessibility Profile - EPIAP (still in progress).
Another part called "Liaison" examines linkages and harmonisations with other standards, including OJP, SIRI, GTFS, GBFS, MDS, NAP/MaaS Alliance, DATEXII, IXSI.
NeTEx is regarded as a replacement or successor for older standards, e.g. for HRDF or the German VDV 452 standard.
</td></tr>
<tr><td>Responsible</td><td>CEN (European Committee for Standardization), Technical Committee 278, Work Group 3, Sub Group 9.</td></tr>
<tr><td>Links</td><td>
– https://www.transmodel-cen.eu/netex-standard
– https://netex-cen.eu
– https://www.vdv.de/netex
– https://opentransportdata.swiss/search?q=NeTEx
– https://transportdatamanagement.ch/de/standards
– NeTEx realisation directive for public transport in Switzerland, 26.11.2019, 360 pages, status: Draft.
</td></tr>
<tr><td>Technology</td><td>XML, XML Schema.</td></tr>
<tr><td>Application</td><td>
NeTEx, for example, is described by VDV as "the future European standard". Its implementation is still sluggish but NeTEx is likely to be the dominant standard in a few years.
In Switzerland, NeTEx is already used in the data exchange between SKI (Mentz) and SNCF.
SKI already developed a profile for Switzerland in 2019 (see Links, realisation directive). In it, the application for Switzerland is specified in detail and explained with many examples.
NeTEx test data as an alpha test is also provided here: openmobilitydata.swiss .
</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>Specified for Europe thanks to CEN.</td></tr>
<tr><td>P2 open</td><td>++</td><td>Free use (GPL licence); however, the specifications are unfortunately not freely available.</td></tr>
<tr><td>P3 simple</td><td>+</td><td>High complexity, extensive specifications. This can be mitigated somewhat by profiles.</td></tr>
<tr><td>P4 established</td><td>+</td><td>Still not very widespread but defined by CEN.</td></tr>
<tr><td>P5 evolving</td><td>+++</td><td>Boad-based work over years as is typical for CEN.</td></tr>
<tr><td>P6 high quality</td><td>+++</td><td>High quality, very rigorous, detailed specifications.</td></tr>
<tr><td>P7 compliant</td><td>+++</td><td>High compliance with the other Transmodel standards. Also detailed mappings to other standards.</td></tr>
<tr><td>P8 unambiguous</td><td>++</td><td>See P6 and P7. In practice, however, many details raise questions of interpretation.</td></tr>
</table>
</td></tr>
<tr><td>Assessment</td><td>NeTEx has great potential as a comprehensive standard harmonised within Europe that can be validated with XML Schema and extended for new modes.</td></tr>
<tr><td>Recommendation</td><td>
Use NeTEx as the leading standard for timetables / service plans (together with secondary standard GTFS).
Replace the obsolete and insufficiently upgradeable HRDF standard.
</td></tr>
</table>

	Support the implementation with rapid introduction on openmobilitydata.swiss, with up-to-date profiles (realisation directives), with quick start guides, instructions and templates for individual user groups (e.g. taxi companies, mountain railways, lake-steamer companies).

C 7. OICP (charging station information exchange and roaming)

There are two challenges in the field of electromobility today:

1. Exchange of information: where can you find suitable charging stations? (e.g. locations, availabilities, tariffs, payment options)
2. Charging station roaming: how can you charge there even if the station is owned by a third-party provider?

1. Exchange of charging station information

In Switzerland, the Federal Office of Energy (SFOE) plays the leading role with its Data Infrastructure for Electromobility (DIEMO). DIEMO offers static and real-time data of over 5,000 charging stations in Switzerland as a web application (http://ich-tanke-strom.ch) and as open data (bulk load and queries, JSON formatted).

However, charging stations can also be found via search engines (Google, Bing), websites (especially https://lemnet.org for Europe) and apps. A random sample shows that not all data from lemnet is also available on DIEMO.

Standardisation recommendation: DIEMO is based on OICP (or extracts thereof). Deliveries must also be made in OICP format. This can continue for the time being.

2. Charging station roaming (sales integration)

Direct payment at the charging station (e.g. with cash, credit card) is often only possible to a limited extent. Instead, smartphone apps are often used for activation, billing and payment.

Charging station roaming means that, similar to mobile phone roaming, a contract is concluded with a provider, making it possible to charge at the charging stations of other providers.

In Europe, roaming for charging stations has been developed and available for about 10 years. The problems are as follows:

- market fragmentation, lack of standardisation: there are at least 4 widely used standards across Europe (OCHP, OICP, eMIP, OCPI) and other proprietary company standards as well as roaming service providers.
- practical problems for clients: due to incompatibilities of end user apps, some charging stations cannot be found or activated.
- tariffs can vary greatly.

This situation and the four standards eMIP, OCHP, OCPI and OICP were investigated in detail by van der Kam, Bekkers et al. (2020). Their main findings:

- The four standards are functionally quite similar and comparable.
- They differ on some functional details and on some non-functional aspects.
- The standards each have national roots: OCHP has German-Dutch, OICP German, eMIP French and OCPI Dutch roots.
- They are all essentially open and freely available.
- OICP and eMIP envisage a centralised roaming service (Hubject and GRIEVE respectively).

The principles of standardisation (see section 5) tend to favour OCPI (open, simple) and OICP (established). For an evaluation and selection, however, a precise requirements assessment would have to be carried out.

The following is the **OICP profile**:

Description	Open InterCharge Protocol (OICP) was developed for charging station roaming from 2013. Hubject developed the OICP standard but, in parallel, it also offers

<table>
<tr><td></td><td>the roaming service as well as a contractual framework for roaming between participants. OICP has been free (open source) since 2019.
With OICP, roaming can be obtained from Hubject as a service; theoretically, however, the service could also be offered by another service provider.</td></tr>
<tr><td>Responsible</td><td>Hubject, founded in 2012 (shareholders: BMW Group, Bosch, EnBW, enelx, e-on, Mercedes, Siemens, Volkswagen).</td></tr>
<tr><td>Links</td><td>– https://de.hubject.com/
– https://github.com/hubject/oicp</td></tr>
<tr><td>Technology</td><td>SOAP web services; JSON-based data structures; also REST from OICP 2.1 onwards.</td></tr>
<tr><td>Application</td><td>Clear focus on charging station roaming. The current version 2.3 offers the following services: eRoamingAuthorization, eRoamingChargeDetailRecord, eRoamingReservation, eRoamingEVSEData, eRoamingEVSEStatus, eRoamingDynamicPricing, eRoamingChargingNotifications.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>++</td><td>Used internationally; dominated by German companies.</td></tr>
<tr><td>P2 open</td><td>++</td><td>Open, rather sparsely spread on github.</td></tr>
<tr><td>P3 simple</td><td>++</td><td>Relatively simple structure, JSON-based.</td></tr>
<tr><td>P4 established</td><td>++</td><td>Widely used in Europe among other standards.</td></tr>
<tr><td>P5 evolving</td><td>++</td><td>Semantic versioning, documented history, open feedback process.</td></tr>
<tr><td>P6 high quality</td><td>++</td><td>The documentation is in an orderly state.</td></tr>
<tr><td>P7 compliant</td><td>+</td><td>Compliant with DATEX II; not coordinated with Transmodel.</td></tr>
<tr><td>P8 unambiguous</td><td>?</td><td>Not examined in detail.</td></tr>
</table>
</td></tr>
<tr><td>Assessment</td><td>See explanations above. The international, European standardisation of charging station roaming has not yet been completed. OICP can be regarded as a temporary interim solution.</td></tr>
<tr><td>Recommendation</td><td>Use OICP for the time being. Coordinate with SFOE. Review based on future development and strategy. Monitor developments in the EU. If necessary, drive standardisation forward as part of a roaming strategy.</td></tr>
</table>

C 8. OJP (open API for distributed journey planning)

Description	OJP is a standard of the European CEN family for journey planning in public transport as well as complementary multimodal journey segments. OJP is used to retrieve and exchange service information (routes or trips consisting of individual sections or legs) in public and multimodal transport. OJP was developed based on national preliminary work in the 2010s (EU-Spirit, JourneyWeb, DELFI) and on VDV TRIAS, and published as a specification in November 2017. Tasks/requests for versions 1.1 and 2.0 are currently being processed. The basic process of planning a trip with OJP is as follows: 1. The client sends a request to the OJP home system (e.g. origin and destination, travel options). 2. If required, the home system gets assistance from other OJP systems (see "distributed routing" below).

<table>
<tr><td></td><td>3. The home system responds with route suggestions, detailed information and real-time information (e.g. delays).
OJP offers support for distributed route planning for international travel. Several OJP route planners, each responsible for a country or region, work together on this. A request (TripRequest) is received by the enquirer's home system and forwarded to a distributing system which splits the request into partial requests (MultipointTripRequest) to the respective regional/national route planners and orchestrates the route planning process.
The following OJP services are currently defined in the specification:
– Location information: place names, stops, POI, addresses.
– Exchange points: query border points (border or node stations) where it is possible to change from one OJP region to another.
– Intermodal trip information: support for interception using TripRequest and for DJP (distributed journey planning) by linking multiple responding systems 1..n) using MultiPointTripRequest.
– Stop events: arrivals and departures from a station or stop.
– Trip information: additional travel information, including real-time information.
– Tickets and fare calculation: information on the fare.</td></tr>
<tr><td>Responsible</td><td>CEN (European Committee for Standardization)</td></tr>
<tr><td>Links</td><td>– https://opentransportdata.swiss/en/cookbook/open-journey-planner-ojp/
– https://www.transmodel-cen.eu/ojp-standard/
– Specification CEN/TS 17118, (DIN SPEC 4627):2018-02, November 2017 or February 2018, ICS 35.240.60, intelligent transport systems - public transport - open API for distributed journey planning - version 1.0 specification, "all rights reserved", not freely available.</td></tr>
<tr><td>Technology</td><td>HTTP(S) Web Services, XML, XML Schema, XML Namespaces.</td></tr>
<tr><td>Application</td><td>Several European countries have implemented journey planners with OJP, usually with public transport routes and financed by the public sector.
In Switzerland, the FOT ordered the implementation of an OJP-based journey planner called Open Journey Planner (also abbreviated to OJP) by SKI+ and the service provider Mentz. It went live in 2021 and currently covers public transport in Switzerland and some multimodal extensions.
Currently, the following services ("requests") are provided and can be used freely (after registration):
1. Location information: query of locations (esp. stops)
2. Stop event: departures from one stop
3. Trip: travel planning, the main function of the OJP.
4. Trip information: target and actual times of a specific journey section.
Distributed travel planning is not yet comprehensively supported.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>Specified and widespread in Europe thanks to CEN.</td></tr>
<tr><td>P2 open</td><td>++</td><td>Specification not freely available.</td></tr>
<tr><td>P3 simple</td><td>++</td><td>Complex, wordy, elaborate in use.</td></tr>
<tr><td>P4 established</td><td>+</td><td>Initial applications in Europe since late 2010s.</td></tr>
<tr><td>P5 evolving</td><td>+++</td><td>Broadly supported at CEN; rather cumbersome processes, slow progress.</td></tr>
<tr><td>P6 high quality</td><td>++</td><td>Thorough, detailed, elaborate standardisation work.</td></tr>
<tr><td>P7 compliant</td><td>+++</td><td>Compliance with the CEN Transmodel family of standards is an important principle.</td></tr>
</table>
</td></tr>
</table>

	P8 unambiguous	+++	Very good rating, see P6 and P7.
Assessment	Multimodal, international journey planners are an important building block for efficient and environment-friendly mobility of the future. The OJP standard could play an important role in this in Europe. The complexity of the OJP standard and the slowness of its development are problematic. Private competitors, such as Google with its simple Directions API, could overtake OJP. In this context OpenTripPlanner is interesting; this is an open, freely available open source travel planner system that is already used in Norway, for example, and could be combined with OJP.		
Recommendation	Continue to use and promote the OJP standard. Pursue the simplification (e.g. JSON-based sub-profiles?) and acceleration of development.		

C 9. OpRa (Operating Raw Data and Statistics Exchange)

Description	OpRa is a standard of the CEN Transmodel family. Its focus is on the exchange, collection and preservation of historical, measured or collected raw public transport data after the journey for analysis and study purposes. OpRa was introduced in 2019. It is under development by Technical Committee 278 (TC278, "Intelligent Transport Systems") in Working Group 3 (WG3), Sub Group 10 (SG10) of CEN/Transmodel.		
Responsible	CEN (European Committee for Standardization).		
Links	– http://www.transmodel-cen.eu/standards – https://www.opra-cen.eu		
Technology	XML, XML Schema		
Application	OpRa is likely to play a role in the future as an exchange format for transport companies, the public sector, academia and research. Its dissemination currently still seems to be slow. There are hardly any references to the standard on the web. At SKI, on https://openmobilitydata.swiss and at SBB, OpRa is not yet in use because it is still being developed.		
Assessment (principles)	**P1 international**	+++	Specified for Europe thanks to CEN.
	P2 open	++	Specification not freely available.
	P3 simple	+	Probably comparable to the other Transmodel standards.
	P4 established	+	Still not very widespread but defined by CEN.
	P5 evolving	++	Likely to be typical for CEN: broadly supported and at a slow pace.
	P6 high quality	?	This cannot be assessed at present.
	P7 compliant	+++	Compliance with Transmodel standards is basically OpRa's unique selling point.
	P8 unambiguous	?	Probably analogous to compliance and quality.
Assessment	OpRa will likely only be useful if NeTEx and SIRI are widely used.		
Recommendation	Use opportunistically for appropriate use cases in the future.		

C 10. OSDM (Open Sales and Distribution Model)

<table>
<tr><td>Description</td><td>OSDM has two goals:
1. improve the booking process for public transport customers,
2. reduce the complexity and cost of distribution processes for intermediaries and carriers.
However, OSDM should also be applicable to distribution/sales of non-public transport providers.
OSDM was developed by a small, international team led by Andreas Schlapbach (SBB) and version 1.0 was published in November 2020. Version 1.3 followed in November 2021.
OSDM distinguishes between two parts:
– offline sales: standardised exchange of tariff data.
– online sales: standardised online API for tickets and reservations.
OSDM refers to the standards of UIC and ERA and other railway and ISO standards. In version 1.3 it was aligned with OJP. An integration into the CEN family is being considered but has not yet been implemented.
All details of the standard are contained in online guides ("Getting Started" etc.) as well as the 200+ page specification. All documentations are freely and openly available without registration.</td></tr>
<tr><td>Responsible</td><td>International Union of Railways (UIC).</td></tr>
<tr><td>Links</td><td>https://unioninternationalcheminsdefer.github.io/OSDM</td></tr>
<tr><td>Technology</td><td>OSDM offline: data exchange structures modelled in UML and JSON.
OSDM online: REST services, OAuth2, JSON, JSON schema, OpenAPI.</td></tr>
<tr><td>Application</td><td>OSDM is a very young standard and not yet widely used. However, it could play a dominant role as a sales standard in the public transport sector in the future, especially if a connection to CEN/NeTEx and to the corresponding funding is successful.
OSDM is intended to standardise deep integration in public transport and beyond (sharing, on-demand services). For this, all participants (transport companies and intermediaries) must implement OSDM (online).
In Switzerland, the existing public transport sales system NOVA in particular would have to be extended into an "OSDM provider".
The basic procedure follows the usual pattern (search-book-use-pay) as described in the "Getting Started" guide:
1. Request location codes.
2. Request offers with POST /trips-offers-collection - the easiest way is with the IDs of the starting point, the destination and the time. The response returns 0..n trips (trip suggestions) with 1..m trip legs.
3. Booking of an offer (trip) with POST /bookings.
4. Pick up tickets with GET /bookings/{booking_id}/fulfillments. The response includes download links, QR codes or similar elements.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>As a UIC standard, it is international, with a European orientation.</td></tr>
<tr><td>P2 open</td><td>+++</td><td>Specification and instructions freely available, public on the web. Open working group structure and processes.</td></tr>
<tr><td>P3 simple</td><td>++</td><td>Contemporary standards (REST APIs). Online API on SwaggerHub. Relatively complex, extensive specification (200+ pages).</td></tr>
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</td></tr>
</table>

	P4 established	+	Very young, hardly established.
	P5 evolving	++	Has followed standard procedures so far, maintains open feedback processes.
	P6 high quality	+++	Solid, detailed documentation and specifications.
	P7 compliant	+++	Good rating thanks to proximity to European rail/public transport operations. Connection to Transmodel still open.
	P8 unambiguous	+++	See P7, good rating, however it is still little proven in practice.
Assessment	OSDM could play a central role in the opening and harmonisation of European public transport and multimodal sales and gain importance as a standard for MaaS.		
Recommendation	Support and promote OSDM: depending on the future strategies regarding the opening of public transport sales and MaaS, OSDM could play an important role.		

C 11. OSM (OpenStreetMap)

Description	OpenStreetMap (OSM) is a free-to-use online map service with worldwide coverage. OpenStreetMap, like Wikipedia, is maintained worldwide by volunteer authors who collect and update the map data. OSM can essentially be freely integrated into other web applications. The Open Database Licence (ODC-ODbL) applies, which allows use free of charge with reference to the originator and subject to the same licence. OSM is a quasi standard for this area of application.		
Responsible	OpenStreetMap Foundation		
Links	https://www.openstreetmap.org		
Technology	Web, tiles, REST APIs		
Application	OSM and various extensions open up numerous uses today, including: – embedding in web pages as "slippy maps" (movable, zoomable map sections), – enrichment with points, lines, texts, etc. using JavaScript frameworks such as Leaflet, – route planning (for car, bicycle, pedestrians). Possible uses of OSM in the area of mobility and MaaS are, for example: – visualisations of mobility requests A to B, – visualisations of mobility services in the vicinity of A, for example lessors, taxi ranks, public transport stops, available scooters/e-bikes, etc, – representation of travel routes, footpaths, zones, service areas (geofences), etc, – representation of indoor navigation, e.g. in airports, railway stations, mobility hubs. In Switzerland, all the populated areas have been captured down to street and house number level.		
Assessment (principles)	**P1 international**	+++	Global project
	P2 open	+++	Free and open source
	P3 simple	++	Somewhat confusing documentation (wiki)
	P4 established	+++	Widespread.

	P5 evolving	++	See P3.
	P6 high quality	++	Good quality.
	P7 compliant	?	Not examined in detail.
	P8 unambiguous	?	Not examined in detail.
Assessment	Virtually a public service for maps, POIs and other geodata.		
Recommendation	Use.		

C 12. SIRI (Standard Interface for Real-time Information)

Description	SIRI is a European standard of the Transmodel family for the exchange of planned ("target"), current ("actual") or forecast operational information in public transport, in particular timetables, departure boards, interchange connections, as well as vehicle and asset status information. SIRI is already an older standard with origins going back about 20 years. The current version 2.0 was published between 2011 and 2016. Its focus is on the exchange of real-time data ("actual data"). SIRI defines all the necessary data formats and two main communication protocols for this (synchronous and asynchronous). SIRI consists of five parts: – Part 1 Context and framework. Basic topics. – Part 2 Communications infrastructure, defines 2 models: request-response and publish-subscribe (asynchronous messages). – Part 3 Functional service interfaces, containing the following elements: o Production Timetable (PT): daily timetables; planned journeys (target) in public transport operations (vehicles, stops, departure times, etc.) o Estimated Timetable (ET): e.g. the current course (actual) of journeys in public transport operations and forecast data, delays, cancellations o Stop Timetable (ST): planned departures (target) from a stop. o Stop Monitoring (SM): actual departures, departure board for a particular stop. o Vehicle Monitoring (VM): current vehicle position and status. o Connection Timetable (CT): planned arrival times at a stop (target), as a basis for connections. o Connection Monitoring (CM): forecast actual arrival time at a stop as a basis for connections. o General Message (GM): general messages (free text). – Part 4 Functional service interfaces: Facility Monitoring (FM): exchange of status data of installations (ticket machines, lifts, etc.). – Part 5 Functional service interfaces: Situation Exchange (SX): exchange of structured messages for travel information systems.
Responsible	CEN (European Committee for Standardization)
Links	– https://www.transmodel-cen.eu/siri-standard – https://transportdatamanagement.ch/de/standards – SIRI - realisation directive for public transport in Switzerland, 15.04.2020, 219 pages, status: draft.

Technology	XML, XML Schema for data formats; HTTP (as communication protocol).
Application	SIRI is increasingly being used in Europe and worldwide. In Switzerland, SIRI is used by some transport companies. Some new data feeds from transport companies to SKI are being implemented with SIRI, including those in areas abroad that are close to the Swiss border. SKI has drafted an implementation guideline to clarify and simplify the application in Switzerland (see links).
Assessment (principles)	**P1 international** +++ Specified for Europe thanks to CEN. **P2 open** ++ Specification not freely available. **P3 simple** ++ Comparable to the other Transmodel standards. **P4 established** +++ Already widespread in Europe. **P5 evolving** +++ Broadly supported and at a slow pace, as is typical for CEN. No update since 2016. **P6 high quality** ++ High quality as is typical for CEN. **P7 compliant** +++ In all CEN Transmodel standards, compliance is one of the most important principles. **P8 unambiguous** +++ Good rating thanks to compliance and years of practice.
Assessment	For the intended areas of application (including real-time timetables, departure boards in public transport), SIRI is unparalleled. The use of this international standard is already proving to be an advantage in several respects: data deliveries involve less effort even from abroad and the systems of IT service providers are already set up for SIRI.
Recommendation	Continue to use and expand. Support simplification efforts (subprofiles, JSON variants, instructions and templates for key use cases).

C 13. TOMP-API (Transport Operator to Mobility-as-a-service Provider API)

Description	TOMP-API is the quasi standard in the field of MaaS. TOMP-API was developed from 2018 by a small Dutch team led by Edwin van den Belt with the aim of enabling an open, interoperable ecosystem for MaaS. TOMP-API is completely freely available and open source. The vision of the TOMP Working Group is "Effortless mobility for everyone". In future, every mobility customer should be able to call up, book, pay for and use mobility services (travel suggestions) with an app from a MaaS provider. For this purpose, TOMP-API (so far) mainly defines the API interfaces along the MaaS process chain "search-book-pay-use" (plus after-sales services). The following parts are defined in version 1.3: – operator information: basic information from the provider (e.g. operating times, price models, stops, vehicles) – planning: journey planning: inquiries (non-binding queries) and offers (binding, bookable services). – booking: booking a trip. – trip execution and support: information during the trip, on individual sections (legs), additional services, events, trip progress, etc. – payment: payment information. These parts are to be implemented by the transport operator (TO), the MaaS provider (MP) or both, as appropriate.

<table>
<tr><td></td><td>A complete, interoperable, "roaming-enabled" MaaS ecosystem would also require further foundations that are still missing today, in particular:
– a directory service (registry) of TO and MP.
– a legal or contractual framework.
– billing, clearing and payment.</td></tr>
<tr><td>Responsible</td><td>TOMP Working Group.</td></tr>
<tr><td>Links</td><td>– https://tomp-wg.org
– https://github.com/TOMP-WG/TOMP-API
– https://github.com/TOMP-WG/TOMP-API/blob/master/TOMP-API.yaml</td></tr>
<tr><td>Technology</td><td>REST services with OpenAPI 3.0 YAML specification, JSON, JSON schema.</td></tr>
<tr><td>Application</td><td>TOMP-API is receiving worldwide attention and being applied increasingly. The TOMP Working Group lists around 60 users. However, exact figures and details are not known. Often these are likely to be only partial implementations.
A complete, interoperable MaaS system has not yet been realised.
In Switzerland, individual companies have implemented parts of it, including ZüriMobil or YOURTAXI. SKI+ conducted its first PoCs with it in 2021.</td></tr>
<tr><td>Assessment (principles)</td><td>
<table>
<tr><td>P1 international</td><td>+++</td><td>Originally from the Netherlands but internationally supported.</td></tr>
<tr><td>P2 open</td><td>+++</td><td>Completely open project, open source, free licence, open documentation, blueprints available. Open Working Group.</td></tr>
<tr><td>P3 simple</td><td>++</td><td>Relatively compact, simple formats, intuitive processes.</td></tr>
<tr><td>P4 established</td><td>++</td><td>Young standard but rapidly increasing distribution.</td></tr>
<tr><td>P5 evolving</td><td>++</td><td>The TOMP WG applies common conventions and best practices (e.g. deprecation).</td></tr>
<tr><td>P6 quality</td><td>++</td><td>Parts of the documentation could be improved.</td></tr>
<tr><td>P7 compliant</td><td>++</td><td>TOMP WG is seeking compliance with CEN and G*FS.</td></tr>
<tr><td>P8 unambiguous</td><td>+</td><td>Experience to date shows that various points still need to be specified and missing parts (such as a registry, see above) need to be specified.</td></tr>
</table>
</td></tr>
<tr><td>Assessment</td><td>TOMP-API is currently the most advanced open standard for MaaS applications. Only OSDM can be considered a competitor, but it has hardly been tested in MaaS scenarios yet.</td></tr>
<tr><td>Recommendation</td><td>Actively test and promote.</td></tr>
</table>

Anhang D) Standardisation organisations for mobility data

This section contains a compilation of organisations that are important in the field of mobility data standards today.

The compilation also includes organisations that are currently not primarily responsible for any of the standards relevant to the NADIM and are only of marginal importance. However, as the developments are very dynamic, these organisations should be monitored continuously.

The sub-sections are arranged in a sequence that progresses from global to local: global, European, supranational/national and Swiss organisations. A selection of companies with proprietary standards will follow at the end of the section.

D 1. Global organisations

Organisation	Description
Alliance for Parking Data Standards (APDS)	International non-profit organisation with the mission to develop, promote and manage the global standard of the same name that enables the exchange of parking data between IT platforms worldwide. Founded in 2018.
IEC (International Electrotechnical Commission)	International association for standards in electrical engineering and electronics based in Geneva, over 100 years old, has defined over 10,000 standards. The Swiss Electrotechnical Committee is the Swiss member. The IEC is active in the area of charging stations.
ITF (International Transport Forum at the OECD)	International, intergovernmental organisation with 63 member nations, including Switzerland. The ITF is a think tank for transport policy and claims to be the only global organisation with an interest in all modes of transport. In particular, it organises the annual summit of transport ministers, conducts trend analyses and publishes studies.
ISO (International Organization for Standardization)	Independent non-governmental organisation (NGO) based in Geneva. Association of 165 national standardisation organisations, including the Swiss SNV, and thus the umbrella organisation of all standardisation organisations. ISO standardisation can be a goal of international standardisation. However, ISO is in competition with CEN. For the NADIM, CEN takes priority over ISO.
MobilityData	A US-dominated international non-profit organisation for multimodal mobility data standards, formally established in Canada and France in 2019. MobilityData is dominated by Google and Apple. MobilityData plays a leading role in the G*FS standards and collaborates with CEN, TOMP-WG and others.
Open Mobility Foundation	A foundation for open source software and standards in the field of urban mobility (sharing, micro mobility), mainly supported by North American cities. The OMF developed the MDS (Mobility Data Specification) standard.
International Union of Railways, UIC	Worldwide association of railways, founded in 1922. Its main task is the standardisation in the railway sector. Members include SBB, BLS, Alliance Swiss Pass. The UIC is responsible for the OSDM standard relevant to the NADIM.
https://www.uitp.org	Worldwide advocacy organisation for public transport, founded in 1885. Over 20 Swiss companies and authorities are represented in it.
World Trade Organization (WTO)	UN global trade organisation based in Geneva. Its tasks include technical standards in international trade. The WTO defines six principles for standards in 2000: transparency, openness, consensus decisions, relevance, coherence, benefits to developing countries.

D 2. European organisations

Organisation	Description
CEN (European Committee for Standardization)	Non-profit organisation for standardisation in Europe. CEN is responsible (together with CENELEC and ETSI) for the EN standards (European Norm). In the mobility data area, CEN is responsible for the public transport standards (Transmodel, NeTEx, SIRI, OpRa) and the road traffic data standard DATEX II. SNV, FOT and SBB, among others, are Swiss members of or contributors to CEN. The CEN standards play a very important role in the context of the NADIM. We expect that in the medium term the standardisation authority CEN will make some standards (and also profiles) binding for the EU.
EU Commission	The EU Commission is the executive body of the EU. The EU Commission funds and promotes the standardisation of mobility data at multiple levels, including NAP legislation (including the EU Delegated Regulation (EU) 2017/1926), the Initiative for Multimodal Digital Mobility Services and the financing of various EU projects including Eltis, ERTICO, IMOVE, ITXPT, MaaS4EU, MyCorridor.
MaaS Alliance	Public-private partnership for the promotion and standardisation of MaaS. Numerous mainly European companies and organisations are represented, including FOT. The aim is to facilitate an open market with MaaS services.

D 3. Supranational and national organisations

Organisation	Description
BCS (Bundesverband Car-Sharing)	Umbrella association and lobby organisation of German carsharing providers, founded in 1998. Responsible for the IXSI 5.0 standard (interface for x-sharing information).
FabMob (La Fabrique des Mobilités)	French association and think-tank for multimodal, climate-friendly mobility and MaaS. FabMob writes studies and publications, and is responsible for Mon Compte Mobilité (MOB), a system with personal, virtual credits.
NOMAD (Nordic Open Mobility and Digitalization)	A Scandinavian project for multimodal mobility and MaaS (roaming, interoperability) in Scandinavia. NOMAD is aiming for the corresponding international standards for the whole of Scandinavia. NOMAD cooperates with ODIN and the OpenTripPlanner standard for travel planning.

D 4. Swiss organisations

Organisation	Description
Alliance SwissPass (ASP)	Organisation of the public transport sector and alliance of 250 transport companies and 18 associations. The ASP is committed to harmonised, comprehensible and economical tariff regulations, sales solutions, product ranges and information systems throughout Switzerland. ASP is also responsible for the Swiss Association of Public Transport's standardised sales system NOVA.
CH Open	"The CH Open association has been promoting open systems (open source software) and standards (open standards) in the Swiss ICT landscape since 1982" (quote from website).
eCH (Association)	The eCH association "promotes, develops and adopts e-government standards for efficient electronic cooperation between public authorities, businesses and private individuals" (translated quote from website).

Organisation	Description
innolab smart mobility	Swiss association and non-profit organisation with the aim of developing an ecosystem of innovation for mobility in Switzerland. No specific standardisation activities are known.
openmobility	A cooperative that was formed to "build an open, collaborative mobility ecosystem for Switzerland to establish sustainable mobility." (translated quote from website). No specific standardisation activities are known.
Swiss Confederation (federal government)	On the part of the federal government, DETEC (FOT, FEDRO and SFOE) and DDPS (swisstopo) in particular are working on the standardisation of mobility data for the future MODI.
SNV (Swiss Association for Standardization)	Switzerland's standardisation association. Member of CEN and ISO. Currently, however, there are only isolated points of contact with the NADIM topics (e.g. intelligent transport systems).
Transport Data Management / Customer Information System Tasks (SKI)	FOT commissioned SBB Infrastructure with the customer information system tasks (SKI). SKI collects, consolidates and publishes Swiss public transport passenger information data. SKI is currently responsible for structural standards (including Swiss Location ID) and interface standards: Timetable data: HRDF, NeTEx, real-time data: VDV453, VDV454, SIRI, fault data: VDV736.
VöV (Swiss Association of Public Transport)	VöV is an industry association of public transport companies in Switzerland. It is committed to the interests of public transport, public transport companies, ASP and NOVA.
VSS	Swiss Association of Road and Transport Professionals, founded in 1913, is regarded as the leading standardisation organisation in the road and transport sector in Switzerland. The association is the Swiss link to CEN and ISO in the field of mobility.

D 5. Sector and industry organisations

Organisation	Description
railML.org	International trade organisation of railway companies. Is developing the railML standard for railway infrastructure, rolling stock, timetables and dispatching. railML could be relevant to the NADIM in the area of timetables.
TOMP-WG	An international working group established by industry and IT representatives for the TOMP-API and CDS-M (City Data Standard for Mobility) standards.
VDV	Association of around 600 German public transport companies, founded in 1991 (current form). VDV acts as an association of public transport interests and in particular as a standardisation organisation in the (German) public transport system. Switzerland is actively involved with VDV. Various VDV standards have been integrated by European standards (CEN, Transmodel).

D 6. Companies

Private companies are also trying to establish their proprietary standards (technologies, data formats, APIs). The following selection is incomplete and represents a snapshot of trends and developments.

Organisation	Description
Fluidtime	Austrian provider of MaaS solutions, including UbiGo in Sweden. FluidTime offers its own APIs for mobility platforms.

Organisation	Description
Google	Google developed GTFS and, together with Apple, dominates mobility data. Furthermore, Google Maps (platform) offers a Directions API for REST-based travel planning requests.
Hacon	Subsidiary of Siemens. In particular, Hacon has developed the widely used HRDF format for timetable data. Hacon also offers MaaS apps and market-place solutions with its own APIs.
HERE	HERE grew out of various mapping and navigation services, including Nokia Maps; today it is primarily a supplier of geodata, map data and route planners. HERE offers its own APIs, e.g. for route planning, some of which are also mul-timodal.
Lyko	Lyko offers a proprietary, fee-based API for route planning, booking and pay-ment of trips mainly in France.
MaaS Global	MaaS Global offers MaaS in some European cities with its Whim app for which it operates MaaS platforms with its own API.
Mentz	Mentz develops and operates IT and mobility solutions, especially for public transport. Mentz has also introduced its own proprietary standards for this, e.g. DINO for timetable data.
Ioki	A provider of complete solutions (including whitelabel apps) for call bus opera-tions. ioki uses a private, proprietary API for this.
iomob	A provider of MaaS solutions and call bus systems. iomob uses its own propri-etary APIs for this.
skedgo	Travel planning services available worldwide (TripGo). Skedgo has a proprie-tary API.
routerank	A Swiss company for local and international travel planning services. Offers IT solutions with its own proprietary APIs.
shotl	A provider of complete solutions (including whitelabel apps) for urban call-bus systems. Has its own proprietary, openly documented API.
Trafi	A provider of MaaS solutions with backends (platforms), (whitelabel) apps, e.g. for yumuv in Switzerland. Own proprietary API.