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SEMANTICS FOR PERFORMANT AND SCALABLE INTEROPERABILITY OF MULTIMODAL TRANSPORT

D2.2 Requirements for an IF architectural design (C-REL)

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EXECUTIVE SUMMARY

This deliverable presents the requirements that emerge from an analysis of the projects and initiatives that have been identified in Deliverable D2.1 – "Initial analysis of requirements of S2R IP4 projects and other EU initiatives". First, for each of the projects and initiatives, it summarizes and labels their main features and requirements. Then, it identifies the elements that are most common across projects and initiatives, to highlight which are the most widely felt needs, but also which needs are important enough to be considered for the design of the Shift2Rail Interoperability Framework.

ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
API	Application Programming Interface
DCAT	Data Catalogue vocabulary
DCAT-AP	DCAT Application Profile for data portals in Europe
DMA	Data Market Austria
EU	European Union
GA	Grant Agreement
GTFS	General Transit Feed Specification
H2020	Horizon 2020 framework programme
IDSCP	International Data Spaces Connector Protocol
IF	Interoperability Framework
IP	Innovation Programme
IT	Information Technology
ITS	Intelligent Transportation System
JU	Shift2Rail Joint Undertaking
MaaS	Mobility as a Service
NAP	National Access Point
OWL	Web Ontology Language
RDF	Resource Description Framework
RDFS	RDF Schema
S2R	Shift2Rail
W3C	World Wide Web Consortium

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1. INTRODUCTION

This deliverable is the first output of Task 2.2 – "Requirements for an IF architectural design aligned with S2R IP4 and other initiatives" of WP2. It follows – and is based on – the output of Task 2.1 "Task 2.1: Analysis of requirements of S2R IP4 projects and other EU initiatives" – i.e., Deliverable D.2.1 - "Initial analysis of requirements of S2R IP4 projects and other EU initiatives" – in which we have identified and studied the most relevant Shift2Rail (S2R) IP4 projects and related EU initiatives (see Table 1), and in which a preliminary requirement analysis was reported. This report is a continuation to our previous study and has been devoted to a more detailed elicitation of functional and non-functional requirements for the construction and management of the S2R Interoperability Framework (IF).

List of studied initiatives and projects		
	1	The New EIF [1]
	2	ERTICO [1]
	3	EU ITS PLATFORM [2]
	4	NAP [3]
	5	STA [4]
	6	MAAS ALLIANCE [5]
	7	ITXPT [6]
	8	MASAI [7]
	9	IDSA [8]
	10	STRIA [9]
	11	TRANSMODEL [10]
	12	OASIS [11]
	13	MyCorridor [12]
	14	Data Market Austria [13]

Table 1 List of initiatives and projects studied in Deliverable D2.1

[1] https://ertico.com/
[2] https://www.its-platform.eu/
[3] https://www.its-platform.eu/filedepot_download/1971/6491
[4] https://www.smart-ticketing.org/
[5] https://maas-alliance.eu/the-alliance/
[6] https://itxpt.org/
[7] http://masai.solutions/
[8] https://www.internationaldataspaces.org
[9] https://trimis.ec.europa.eu/roadmaps
[10] http://www.TRANSMODEL-cen.eu/
[11] https://oasis.team/
[12] http://www.mycorridor.eu/
[13] https://datamarket.at/

It is important to highlight the fact that the target users of the S2R IF include stakeholders of the aforementioned projects – and in some cases the project itself as well. Accordingly, the main challenges that have been posed to them and the requirements that drove them to design their solutions are in good part overlapping with the potential requirements that must be addressed by the IF. Hence, our procedure for the identification of the main requirements for the IF includes an analysis of the main concerns, challenges and contributions of these projects. The studied initiatives range from applications for smartphones to comprehensive academic/industrial project. Therefore, the extracted set of requirements covers various aspects and challenges of mobility and transportation systems. We have categorized these aspects using three viewpoints as follows:

- **Data Management Viewpoint:**
  The Data Management Viewpoint highlights the main challenges, concerns and/or contributions of each project with respect to various aspects concerning data, including the management, sharing, access and distribution of any types of data within and across the transportation ecosystem. With reference to the architecture of IF introduced in the SPRINT Deliverable D3.1 – "Analysis of the state-of-the-art and best practices in architecting systems processing semantic data", data abstraction is among the primary functions of the IF. Hence, the analysis of requirements for dealing with data can greatly help in the design of the data-abstraction layer and other relevant features and functionalities of the IF.

- **Service Management Viewpoint:**
  The Service Management Viewpoint studies the challenges concerning the design, implementation and cooperation of different types of IT services in the transportation domain, as well as the consumer expectations and needs for interacting with such services. This study leads us to the identification of the key requirements for the design and development of Interoperability Services of the IF, which are the central components of the IF to facilitate interoperability among involved parties.

- **System Management Viewpoint:**
  Finally, the System Management Viewpoint focuses on the analysis of the requirements for the design and development of the IF itself. The identification of the main challenges that similar systems are facing can help create a better architecture design from the early stages of the development of the IF.

Deliverable D2.1 includes also an initial analysis of requirements gathered from companion S2R projects, in particular CONNECTIVE and ATTRACkTIVE. We do not repeat the analysis here, and refer the interested reader to Deliverable D2.1 for further information.

In the rest of this document, we first study the non-S2R projects and initiatives considered in Deliverable D2.1 (and listed in Table 1), and for each of them we highlight the main high-level requirements that emerge from the analysis (Section 2). Then, Section 3 summarizes the findings of the study of Section 2 and highlights the requirements that are most common.

2. REQUIREMENT DESCRIPTION PER PROJECT

This section analyzes one by one the projects and initiatives listed in Table 1 and, for each of them, extracts the high-level requirements and the main features and concerns (which are themselves manifestations of requirements) according to the viewpoints introduced in Section 1 (Data, Service, and System Management).

For each project, first a table is introduced that briefly lists the requirements according to the aforementioned viewpoints; then, a brief description is provided for each requirement. Each requirement is also associated with a short name that is illustrative of the type of the requirement (for example, *Data standardization and portability*, or *"SeR6.Service Efficiency"*). These names are re-used as much as possible across projects and initiatives, to facilitate the analysis carried out in Section 3.

2.1 THE NEW EIF

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data accessibility and openness	User-centricity of service design and implementation	Subsidiarity and proportionality
Data standardization and portability	Inclusion and accessibility for all types of users	Transparency
Security and privacy	Multilingualism	Reusability
Preservation of information		Administrative simplification
		System monitoring and assessment

Table 2 Summary of The New EIF's concerns and/or contributions

Data accessibility and openness: Free data availability for use and reuse by others, unless restrictions apply (e.g., for protection of personal data, confidentiality, or intellectual property rights).

Data standardization and portability: Data are easily transferable among different systems to avoid lock-in, support the free movement of data – i.e. the ability to move and reuse data easily among different applications and systems.

Security and privacy: Data have to be in full compliance with relevant regulations – e.g., the Regulation and Directive on data protection.[14]

[14] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

Preservation of information: Data have to be stored and accessed for a specified time. The goal is to ensure that records and other forms of information keep their legibility, reliability and integrity and can be accessed as long as needed subject to security and privacy provisions. The formats should be chosen to ensure long-term accessibility.

User-centricity of service design and implementation: A multi-channel service delivery approach (alternative channels). A single point of contact should be made available to users to facilitate access. Users' feedback should be systematically collected, assessed and used to design new services and to further improve existing ones.

Inclusion and accessibility for all types of users: Inclusion means the full use of the opportunities offered by new technologies. Accessibility ensures that people with disabilities, the elderly and other disadvantaged groups can use services at service levels comparable to those provided to other people. Inclusion and accessibility must be part of the whole development lifecycle of a service in terms of design, information content and delivery.

Multilingualism: Multilingualism is important within the user interface, but also the multilingual aspect of interoperability becomes relevant when a service requires exchanges between information systems across language boundaries, as the meaning of the information exchanged must be preserved.

Subsidiarity and proportionality: The interoperability policy of the lower layer should be developed with respect to the higher layer but, if needed, it should tailor and extend the latter to address particular contexts and needs.

Transparency: Ensuring the availability of interfaces with internal information systems. Facilitate the reuse of systems and data, and enable their integration into larger systems.

Reusability: To be open to sharing its interoperability solutions, concepts, frameworks, specifications, tools and components with others.

Administrative simplification: Administrative simplification can help to reduce the administrative burden of complying with EU legislation or national obligations.

System monitoring and assessment: the effectiveness and efficiency of the system should be evaluated – e.g., its level of flexibility and adaptability, reduced risk, transparency.

2.2 ERTICO

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data standardization and portability	Service efficiency	System efficiency
	User-centricity of service design and implementation	Technological neutrality and system/infrastructure harmonization

Table 3 Summary of ETRICO's concerns and/or contributions

Data standardization and portability: Overcoming the provision of data in various formats and the use of incompatible communication interfaces.

Efficiency (both Service and System Management Viewpoint): Achieving efficiency through greater interoperability and better information that helps transport users and providers make smarter decisions.

User-centricity of service design and implementation: This manifests itself in terms of attractiveness and user convenience. The service design and functions must be attractive and facilitate the engagement process for potential consumers, by employing innovative technologies, connectivity and automation.

Technological neutrality and system/infrastructure harmonization: Interconnection and integration of transport systems, mobility data and related services.

2.3 EU ITS PLATFORM

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data standardization and portability	Service efficiency	System monitoring and assessment
	Quality of service	Interoperable and flexible laws and regulations
		Integration of complementary services
		Technological neutrality and system/infrastructure harmonization

Table 4 Summary of EU ITS Platform's concerns and/or contributions

Data standardization and portability: Deploying traffic data in a harmonized way using uniform technical standards. EU ITS Platform favors the DATEX II format and encourages transport authorities to implement an infrastructure for data exchange based on this standard.

Service efficiency: Improvement strategies with the objective of implementing an efficient, multimodal transportation network and cooperative ITS service deployments (see, e.g., the Arc Atlantique project[15]).

Quality of service: Development of an integrated network improving the use of the infrastructure through the use of intelligent transport systems.

System monitoring and assessment: Provides and maintains a comprehensive suite of tools and guidance required to nurture a consistent approach based on best practices, which will in turn generate a more harmonized evaluation.

Technological neutrality and system/infrastructure harmonization: Each transport authority implements an infrastructure for data exchange.

Interoperable and flexible laws and regulations: EU Member States and neighboring countries cooperate promoting the actual take-up of EU specifications, guidelines, best practices and/or methodologies in order to foster, accelerate and optimize current and future ITS deployments in Europe in a harmonized way.

Integration of complementary services: The activities performed to implement Europe-wide Traveler Information Services, Traffic Management Services and Logistic Services.

2.4 NAP

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data standardization and portability	Dataset publication and subscription services	Authorization and Authentication mechanisms
Preservation of information	Discoverability	System monitoring and assessment
Dataset lifecycle management	Service standardization	Scalability
	Quality of Service	Integration of complementary services

[15] https://arcatlantique.its-platform.eu/?_ga=2.159371324.723247978.1563198802-681999141.1561445653

	User activity monitoring	Fault tolerance and backup / Recovery mechanisms
		Technological neutrality and system/infrastructure harmonization

Table 5 Summary of NAP's concerns and/or contributions

National Access Points (NAPs) are established under Delegated EU regulations 2017/1926[16], 2015/962[17], 886/2013[18] and 885/2013[19] supplementing Directive 2010/40/EU[20] to constitute "single points of access for users" of certain datasets also described in the Delegated EU regulations. The emphasis of the regulation is on establishing rights and obligations on the producers and consumers of the data sets, and in the management of access to datasets. The bulk of the NAP requirements concern therefore the service and system management views, which are fundamentally the same for all contents – i.e. datasets – described in the regulation.

Data standardization and portability: In terms of the actual NAP contents – i.e. the datasets themselves – the NAP regulation provides guidelines and recommendations on the dataset's structure or format. However, dataset providers falling within an EU Member State's jurisdiction normally create data using a local or proprietary different format. Accordingly, to achieve data standardization and foster interoperability, automated dataset conversion between the local and recommended format is a requirement of the Data Management View.

Preservation of information: Data stored in – and made available through – the single NAP needs to be persistent for a long period of time and across possible system updates or migration, and its integrity must be guaranteed. Multiple versions of the same dataset will be stored in the NAP as successive updates, and all versions need to be maintained and/or archived.

Dataset publication and subscription services: The NAP must provide a service allowing dataset producers to store datasets on the NAP and make it available (publication service). The service may be available to human users through a portal-like service, and/or to machines through a web service interface. On publication of a dataset, its machine-readable

[16] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32017R1926&from=EN
[17] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32015R0962&from=EN
[18] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32013R0886&from=NL
[19] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32013R0885&from=NL
[20] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:207:0001:0013:EN:PDF

metadata description must be persistently associated with the data set. Subscription services to the dataset must also be provided (to humans through a portal-like service, and/or to machines through a web service interface), to consumers of the dataset, so that on publication of the dataset consumers are notified of its availability on the NAP.

Dataset lifecycle management: Datasets are digital resources that go through a lifecycle of creation, validation, publication, updating and possibly archiving. At a point in time multiple versions of the same dataset may exist in the NAP repository in different stages of the process. Lifecycle management services should be provided to the different roles responsible for the different phases of the cycle in order to support the fulfillment of the principal data access management functions of the NAP.

Discoverability: A NAP provides a single access point to all datasets managed by that access point. However, discovery services are needed to identify specific datasets, or items within a dataset, that may be needed by a consumer for a specific application. Dataset discovery is also a service that may be needed by the NAP administrators for validation and quality control.

Service standardization: The standardization of NAP service interfaces is needed to allow producers and consumers to write specialized applications that integrate access to the NAP in local technical or business processes.

User activity monitoring: As a NAP is essentially concerned with managing rights, obligations and access to datasets, it must be equipped with services that create persistent records of user activity on the NAP (where users can be producers, consumers and NAP administrators). These services additionally help in the management of the system itself, for example by identifying performance indicators, failures, attacks to the security and integrity of the system.

Authorization and Authentication mechanisms: An essential part of NAPs is the managing of user rights and obligations to NAP contents, so authorization and authentication mechanisms must be provided to enforce them across all users of the system.

Fault tolerance and backup / Recovery mechanisms: As NAPs are considered by design as a Member State-level centralized system of record for all its users, backup and recovery mechanisms must be introduced to avoid outages or loss of contents, to provide contents integrity, and to guarantee continued operations nationwide.

Technological neutrality and system/infrastructure harmonization: The EU regulation does not include the specification of a mandated technological platform for the implementation of NAPs, leaving its choice to Member States. Technological neutrality and the ability to deploy on different infrastructures is therefore an important system management view requirement.

Integration of complementary services: NAPs are established to facilitate the creation of interoperable Traffic Management Systems in Member States, but they can only be considered as a component of these systems. Therefore, a NAP must be integrated in an environment providing specialized additional resources.

System monitoring and assessment: Complementary to user activity monitoring, system activity monitoring such as networking, I/O operations, processor loads, and others must be provided to guarantee continued system availability and performance.

Scalability: As a centralized system at the Member State-level, a NAP is required to allow for practically arbitrary scalability.

2.5 STA

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Depth of data	Service efficiency	Guidelines
Security and privacy	User-centricity of service design and implementation	Technological neutrality and system/infrastructure harmonization
Data standardization and portability	Quality of service	Integration of complementary services
		Profit vs Cost ratio

Table 6 Summary of STA's concerns and/or contributions

Depth of data: Depth of data allows for the implementation of an important statistical function that permits an operator to better know the transport network usage by tracking the users: improving knowledge of customers' behavior/choices/preferences.

Security and privacy: The project highlights the need and importance of having a secure identity.

Data standardization and portability: STA makes use of standards and specifications published by Organizations for Standards, bodies such as CEN and ISO; and other membership bodies such as GSMA, the NFC Forum, etc.

User-centricity of service design and implementation: The project aimed to improve the relationship between users and system, especially by facilitating the process of buying, managing and using tickets.

Service efficiency: The project highlights the requirements for increasing public transport efficiency.

Quality of service: To ensure the quality of contactless communication between contactless readers and fare media.

Profit vs Cost ratio: STA aimed at reducing the operational costs of ticketing, improving the efficiency of fare collection.

Technological neutrality and system/infrastructure harmonization: Global ticketing interoperability for the public transport sector.

Integration of complementary services: Integration of services not directly linked to the basic functions related to tickets, providing complementary services related to users' mobility.

Guidelines: guidelines for potential implementation of smart ticketing.

2.6 MaaS Alliance

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data accessibility and openness	Service standardization	Interoperable and flexible laws and regulations
Security and privacy	User-centricity of service design and implementation	Technological neutrality and system/infrastructure harmonization

Table 7 Summary of MaaS Alliance concerns and/or contributions

Data accessibility and openness: Access and openness of data, open APIs for the creation of a united MaaS network.

Security and privacy: To deliver personalized offerings, service providers have to recognize, save and safeguard the individual preferences of every user of MaaS. Users should have the possibility to manage their own data and minimize the data collected, processed and stored by the providers.

Service standardization: Standardized sub-element features, such as payment, ticketing, authentication and security are required to maximize the development of the MaaS market by building safe payment channels (in compliance with the Payment Card Industry Data Security Standard PCI DSS).

User-centricity of service design and implementation: In this project, convenience is highly important to users, as it is required to clearly inform them of the ranking policy by the MaaS providers, to compensate them in case of inconveniences during service, to provide personalized transfer information, to plan journeys depending on the user's needs, and to provide users with a ranking of the services based on their preferences.

Interoperable and flexible laws and regulations: More flexible transport and mobility regulations are necessary for the market uptake.

Technological neutrality and system/infrastructure harmonization: To integrate various forms of transport services into a single mobility service accessible on demand.

2.7 ITxPT

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data standardization and portability	Service standardization	Guidelines
		Interoperable and flexible laws and regulations
		Technological neutrality and system/infrastructure harmonization

Table 8 Summary of ITxPT Alliance concerns and/or contributions

Data standardization and portability: Even if ITxPT created their own specifications, they have started to deal also with legacy data models. The TRANSMODEL family of standards are taken into account as a single reference data model.

Service standardization: Suppliers use the provided specifications to design ITxPT-compliant equipment and services; an agreement between many public transport stakeholders enables the digitalization and integration of mobility services.

Guidelines: Recommendations and requirements to support the purchase and integration of interoperable IT architecture.

Interoperable and flexible laws and regulations: Framework for how to design hardware and software so that modules can be integrated into a coherent architecture.

Technological neutrality and system/infrastructure harmonization: Transition from proprietary systems to an open integrated architecture based on established standards.

2.8 MASAI

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data standardization and portability	Service standardization (Resolver)	Integration of complementary services
	Dataset publication and subscription services	Technological neutrality and system/infrastructure harmonization

Table 9 Summary of MASAI concerns and/or contributions

Masai is a platform managed by a community already including a centralized publication (directory) system and exposing standardized APIs (interfaces) and discovery services for these tools. With respect to the Masai platform, the S2R IF can be considered as an extension that adds specialized features to it, particularly automated dataset conversion and resolvers. In the following we list features and possible interactions between the two frameworks that highlight important requirements for the S2R IF.

Data standardization and portability: In Masai, this is achieved through dataset conversion across data structure specifications**.** Automated dataset conversion across data structure specifications provides Masai with the ability to extend the range of data structure specifications it can work with. The particular S2R IF ontology dataset can also extend the Masai domain modeling function. Semantic Converters are additional artifacts available in the Masai SDK for the creation of applications and modules.

Services standardization (Resolver): The Masai platform includes a Service Provider platform exposing APIs (service interface descriptors). S2R IF resolver services can be deployed in the Masai platform's API marketplace as standardized extensions.

Dataset publication and subscription services: The Masai platform's publication subsystem offers primitives to publish artifacts. S2R IF publication and subscription services could extend such primitives, and published IF artifacts could become available to the Masai's SDK.

Integration of complementary services: The S2R IF and the Masai platform can be in fact considered as 'complementary services' of one another. The ability to integrate across the two is an essential requirement in the design of the IF reference architecture.

Technological neutrality and system/infrastructure harmonization: The Masai platform can be considered as one of many different existing environments or infrastructures on which IF artifacts can be deployed, or with which they can be integrated. Technological neutrality and infrastructure 'harmonization' are ground requirements of the system.

2.9 IDSA

We separate the analysis of the features and requirements of the IDSA in two parts: the applications and connectors store, and the connectors themselves.

2.9.1 Applications and Connectors Store

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Security and privacy	Standardization	Guidelines
Data accessibility and openness		
Machine readable data (semantic mapping, ontologies)		

Table 10 Summary IDSA concerns and/or contributions in Applications and Connectors Store

Security and privacy: Publishing assets on the Store is performed using a secure connection as required by IDSCP (International Data Spaces Connector Protocol).

Data accessibility and openness: Data are strictly hosted on the providers' side. The Store only contains metadata about the various Connectors and Data Apps.

Machine readable data (semantic mapping, ontologies): Metadata published on a DMA Catalogue node are described in RDF according to the Industrial Data Space information model. It is an ontology which lets users describe services used to provide data, and the data access policies which must be accepted by the clients.

Standardization: the IDSA Information Model[21] allows defining metadata to convey information about Connectors, their related Services, Data Applications and Brokers. The Information Model uses the W3C Semantic Web stack, therefore it is expressed as a set of ontologies and vocabularies in RDFS and OWL.

Guidelines: IDSA defines how Connectors and Data Apps must communicate their metadata and availability to the Broker. In particular, the specification mandates a self-registration to the Broker, so that in each moment the catalogue contains all and only the Connectors and Data Apps which are live and running.

2.9.2 Connectors

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Security and privacy	Service standardization	Reusability
Data accessibility and openness		

Table 11 Summary IDSA concerns and/or contributions in Connectors

Security and privacy: communications between Connectors is achieved using IDSCP. The protocol requires using certificates issued by a trusted entity.

Data accessibility and openness: in the IDSA architecture, a Connector is the way to expose a data service in a trusted way. Instead of exposing the service itself, the data provider exposes the Connector, which is able to ensure a trusted and secure communication with other Connectors.

Service standardization: The IDSA specification mandates the usage of WebSockets for Connector-to-Connector communication. In case of secure communication via the IDSCP protocol, TLS with mutual authentication is used.

Reusability: The Connector principle is a highly reusable concept, which introduces a secure communication middleware to ensure data sovereignty. The usage of WebSockets makes Connectors usable both in case of request/response and publish/subscribe interactions.

[21] https://github.com/IndustrialDataSpace/InformationModel

2.10 STRIA

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data analytics	Service efficiency	Fault tolerance and backup / Recovery mechanisms
Data accessibility and openness		Interoperable and flexible laws and regulations
Preservation of information		
Data standardization and portability		
Machine readable data (semantic mapping, ontologies)		
Quality of data		

Table 12 Summary of STRIA concerns and/or contributions

Data standardization and portability: This project deals with data coming from different sources and it highlighted the need to create one data model or standard and bring all data in one format.

Machine readable data (semantic mapping, ontologies): Performing semantic mapping on data to make it machine-understandable.

Data accessibility and openness: Data must be gathered and stored in a certain (shared) location, which is accessible to intended users for processing and developing as per their access rights follow privacy rules by the data provider. Data can be gathered from different sources and stored in some storage/commodity hardware.

Preservation of information: To keep the integrity and reliability of data and information, as long as needed, and following security and privacy provisions.

Quality of data: There has to be a method to preprocess data to ensure that data is free of noise, duplication and missing information.

Service efficiency: The system should be able to process large amounts of data fast using cheap resources to achieve the goal of building smart transport systems.

Fault tolerance and backup / Recovery mechanisms: The project uses a distributed architecture. There might be situations where a node (a processing/storage unit) fails. In case of a storage unit failure a backup of data should be available. In case of failure of a processing unit the system should not halt, but there should be a mechanism to keep the system up and running by assigning the task of the failing node to some other working node.

Interoperable and flexible laws and regulations: This project aimed at enhancing the interoperability among transportation systems by favoring autonomous vehicles and the electrification of transportation systems. To this end, new transport laws and regulations should be introduced.

2.11 TRANSMODEL

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data standardization and portability	Processing	Guidelines

Table 13 Summary of Transmodel concerns and/or contributions

Data standardization and portability: Given the heterogeneity of data models and formats, the Transmodel ontology highlights the need for and contributes to envision easy mapping processes (mappings between ontologies) and the easy examination of semantic equivalence of semantic models.

Processing: A (partial) automation of the process for mapping a data format to Transmodel would be useful.

Guidelines: Guidelines are provided for the process of usage of different profiles, other APIs, and for the qualification of mappings.

2.12 OASIS

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Data accessibility and openness	Discoverability	Guidelines
Data standardization and portability		
Machine readable data		

Table 14 Summary of OASIS concerns and/or contributions

Data accessibility and openness: The project fosters openness and reuse of linked open data in the field of public services offered by local entities and in the public transport sector and it allows for their use through open data portals. In addition, it defines how to publish the data so that they are always available and achieve interoperability.

Data standardization and portability: It generates open data following the paradigm of linked data that allows users to see the dataset as one.

Machine readable data: It works with data formats and vocabularies such as GTFS, Linked GTFS, Linked Connections, which allow expressing relationships between the data in a comprehensive and self-describing way, allowing large amounts of data to be processed and machines to recover information based on logical relationships.

Discoverability: It promotes an increase interoperability by making data more "discoverable". To achieve this, they establish a common semantics that allows users to unambiguously model and represent specific domain concepts, elements and properties.

Guidelines: It provides guidelines to good practices in its publication and use of open data following the paradigm of linked data – e.g., it proposes a new DCAT profile for transport, the TransportDCAT-AP[22], for enhancing the search of transport data in open data portals across Europe.

2.13 MyCorridor

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Quality of data	Service efficiency	System monitoring and assessment
Data accessibility and openness		
Data standardization and portability	User-centricity of service design and implementation	
Security and privacy		

Table 15 Summary of MyCorridor concerns and/or contributions

Quality of data: In this project "quality of data" mostly refers to frequency of data gathering. Data is gathered by different sources in different time spans, and it should be updated after every time span (which can be measured in months). Accuracy of data is another concern, since, as mentioned above, the project relies on getting data from different sources. Data should be validated to make sure that it is accurate in terms of the information it provides (availability of transport, time tables, sources and destinations).

[22] https://oasis.team/storage/app/media/O1.2%20TransportDCAT-AP%20and%20Controlled%20Vocs.pdf

Data accessibility and openness: Data has to be stored at certain locations and it must be accessible to intended users for processing and developing as per requirements. Access rights to data must follow the rules set by the data provider.

Data standardization and portability: In case of different producers of data, it should be considered to produce or bring all data in one format.

Security and privacy: Precautionary steps should be taken to secure the data to avoid misuse and protect it from illegal use. In addition, it should be made sure that data is accessible to the right users in the right time frame.

Service efficiency: The service response time is important in case of linked/multimodal transport systems. The system should quickly provide responses to user queries. In a real-time scenario the response time can range between 0.5 to 2 seconds.

User-centricity of service design and implementation: In this project user-centricity is mostly related to providing users with information about problems: there has to be a function that informs users about any problem (accident, strike, earthquake) that occurs; also, the system should suggest to users possible alternative solutions in the given time of travel.

System monitoring and assessment: Since the services provided by this project exploit multiple transport means for a single trip, special focus must be put on examining and ensuring the availability (for a given time and location) of particular transport means in correspondence to other related transport means. The system should provide solutions to users for a given time frame, and provided solutions should be validated in terms of time, origin, destination and information about the availability of particular transport means, and the traffic along the routes.

2.14 Data Market Austria

Data Management Viewpoint	Service Management Viewpoint	System Management Viewpoint
Machine readable data (semantic mapping, ontologies)		Transparency
Data accessibility and openness		Reusability
Data standardization and portability		
Efficiency		

Table 16 Summary of Data Market Austria concerns and/or contributions

Machine readable data (semantic mapping, ontologies): Metadata published on a DMA Catalogue node are described in RDF according to an extension of the DCAT-AP vocabulary.

Data accessibility and openness: Data is not stored centrally in the Catalogue node. The central node only hosts metadata and pointers to the actual data.

Data standardization and portability: Even though DMA does not force users into using any specific data format or specification, metadata which are hosted on the Catalogue node are standardized using an extended version of DCAT-AP.

Efficiency: Data is never shared on the Catalogue. The Catalogue only holds the metadata repository in order to provide users with asset search capabilities.

Transparency: Accountability is guaranteed by using blockchain technologies.

Reusability: DMA is a generic marketplace to let users advertise their data and services, and to let users access them in a controlled way.

3. DISCUSSION

This section summarizes the requirements analysis of the projects discussed in Section 2 (Table 17 lists all the requirements), which in turn enlightens the main design strategy, goal and target challenges of the S2R IF. We first categorize requirements according to their importance. Then, we define four additional dimensions to further analyze and categorize the requirements for the development of the IF; first, we explore their blocking behavior; second, their functional and non-functional characteristics; third, their non-functional implications; and fourth, the feasibility and relevance of addressing such requirements within the scope of the IF.

Data Management Requirement	
DR1	Data standardization and portability
DR2	Data accessibility and openness
DR3	Dataset lifecycle management
DR4	Depth of data
DR5	Efficiency
DR6	Machine readable data
DR7	Preservation of information
DR8	Quality of data
DR9	Security and Privacy
Service Management Requirement	
SeR1	Dataset publication and subscription services
SeR2	Discoverability
SeR3	Inclusion and accessibility for all types of users
SeR4	Multilingualism
SeR5	Quality of Service
SeR6	Service Efficiency
SeR7	Service Standardization
SeR8	User activity monitoring
SeR9	User-centricity of service design and implementation
System Management Requirement	
SyR1	Administrative simplification
SyR2	Authorization and Authentication mechanisms
SyR3	Fault tolerance and backup / Recovery mechanisms
SyR4	Guidelines
SyR5	Integration of complementary services
SyR6	Interoperable and flexible laws and regulations
SyR7	Profit vs Cost ratio
SyR8	Reusability

SyR9	Scalability
SyR10	Subsidiarity and proportionality
SyR11	System Efficiency
SyR12	System monitoring and assessment
SyR13	Technological neutrality and system/infrastructure harmonization
SyR14	Transparency

Table 17 Index of Data, Service and System Management Requirements

3.1 Requirements Importance Dimension

With respect to the results of our study, we deem the identified requirements that occur in more than 70% of the cases as *Essential* requirements, those that occur between 30% and 70% of the cases as *Primary* requirements, and those that occur less than 30% of the cases as *Secondary* requirements.

3.1.1 Data Management Viewpoint

Figure 1 summarizes the requirements for the Data Management Viewpoint identified for each project in Section 2.

Essential Requirements

The only **Essential** Requirement here is "**DR1.Data Standardization and Portability**", which is a concern of 78% of the studied projects. Indeed, "DR1" is one of the main motivations for the development of the S2R IF itself. We can summarize the requirement as follows:

- **DR1.Data Standardization and Portability**. In general, it aims at the harmonization of data specifications and representation formats, the unification of data communication protocols/interfaces and the convergence of database models and systems. This, in in turn, makes data coming from various systems portable and compatible with other systems, and leads to an interoperable ecosystem.

To pursue this requirement, however, different approaches could be followed. For instance, in many of cases, including some of the projects we have analyzed such as the EU ITS PLATFORM in Section 2.3, data standardization is assumed to be achieved in a top-down manner by opting for and favoring a single format/specification and encouraging other parties to follow the same format. Such approach may indeed lead to the adoption of a unified standard in the long term, but at the risk of locking in the standard that has been selected in the first step, and at the cost of setting and enforcing many rules and regulations on a large scale and in a broad geographical area, which in turn needs huge managerial and political enforcement.

The other solution to achieve interoperability is through the creation of tools and technology that make different standards compatible with one another, such as in the NAP approach (Section 2.4). Similarly, the IF aims to develop components such as converters, which allow different actors to keep data in their native formats and standards, while letting them communicate and interact with other systems with different specifications.

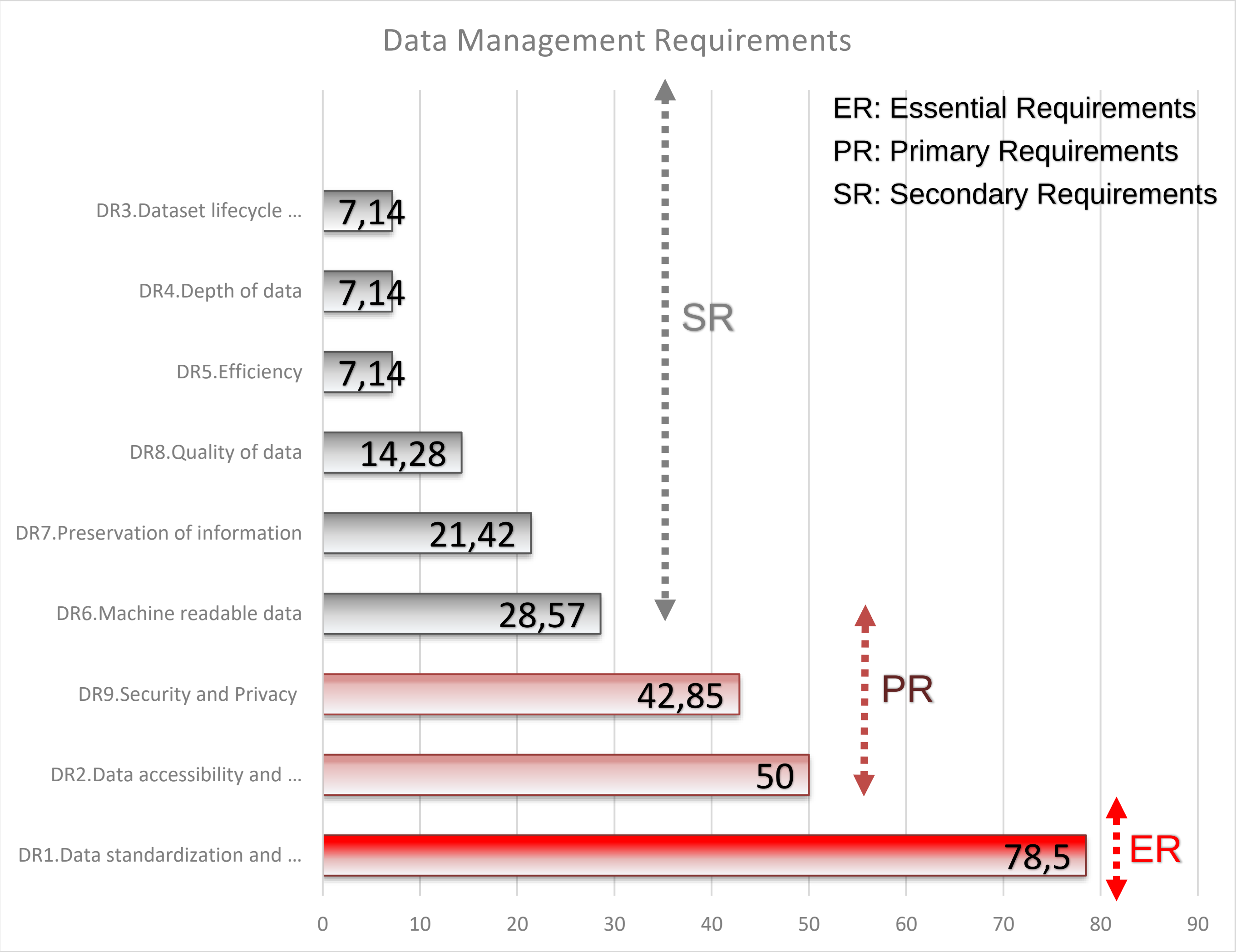

Figure 1 Distribution of the identified Data Management Requirements in the studied projects

Primary Requirements

As depicted in

Figure 1, there are two Primary requirements for Data Management, "*DR2.Data Accessibility and Openness*" and *"DR9.Security and Privacy"*, which have been targeted by 50% and 42% of the projects, respectively. Interestingly, they are relatively close issues which are centered around concepts such as data ownership and the rules for accessing and sharing the data.

- **DR2.Data Accessibility and Openness**. It highlights the importance of encouraging and practicing free access to data. In general, Data Accessibility and Openness include two concepts, namely Legally and Technically open data. The former refers to increasing the accessibility of data by placing them in the public domain with minimal restriction, while the latter means that data should be openly discoverable, assessable, processable, and re-usable.

- **DR9.Security and Privacy.** In general, it refers to the requirement of keeping data safe and secure, and to make each piece of information only available for authorized entities.

Evidently, "**DR2.Data Accessibility and Openness**" is a broad concept which covers other requirements discussed throughout this report. For instance "**DR6.Machine Readable Data**" (see Section 2.9 and Section 2.10) and **"DR8.Quality of Data"** (see Section 2.10 and Section 2.13) are among the necessary factors to make data discoverable and processable, while "**DR7.Preservation of information**" (e.g., Section 2.4) fosters the reusability and accessibility of data.

"DR9.Security and Privacy", is a highly important issue, especially in a domain such as transportation, where the involved parties include organizations competing with one another to achieve a higher market share, companies that might have many conflicts of interests, and private sector entities that have invested considerable assets to create, collect and process data. In these circumstances, data owners are not willing to endanger their systems, for instance through insecure communication channels or by making their data freely available to everyone.

3.1.2 Service Management Viewpoint

Figure 2 summarizes the requirements concerning the Service Management Viewpoint identified for each project in Section 2. As the figure shows, none of the requirements has been targeted by the vast majority (i.e., more than 70%) of the studied projects. This is not necessarily unexpected, as the selected projects are developing a wide range of functions, with different business goals, which naturally leads to a divergence in the requirements and characteristics of the developed services.

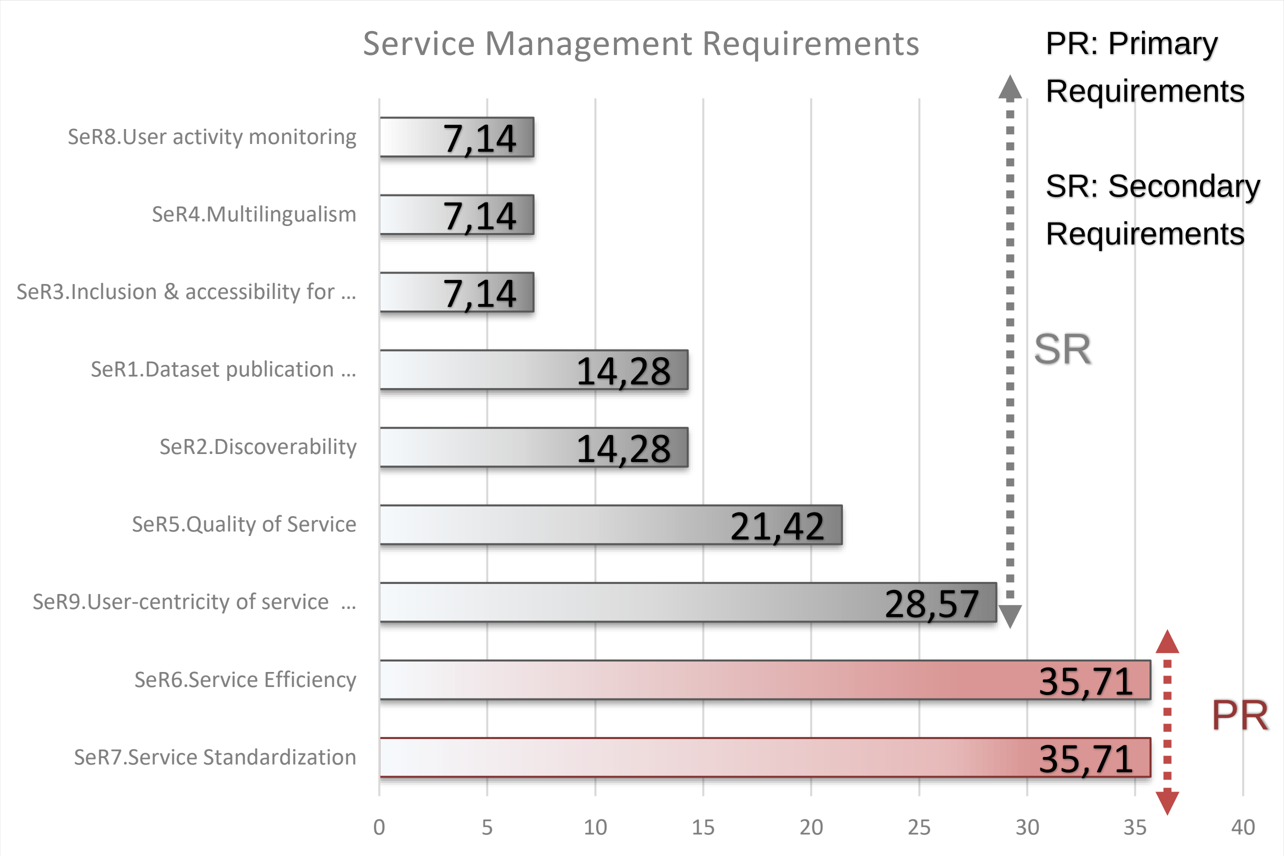

Figure 2 Distribution of the identified Service Management Requirements in the studied projects

Primary Requirements:

According to the result of our study, 35% of the projects have been concerned with the standardization and with the efficiency of their provided services, which suggests that they are among the primary requirements to be addressed by the IF.

- **SeR1.Service Efficiency**: How well a service utilizes available resources.

- **SeR7.Service Standardization**: It refers to the need to develop and publish services that adhere to some standard to ease their invocation.

"SeR6.Service Efficiency", or Efficiency in general, is one of the facets of "Performance Requirements" which themselves itself are a type of non-functional requirements [2]. According to the above definition, a performance requirement measures how efficiently a service consumes a resource to complete the required function. Most often, "resource" refers to a computational or memory resource; however, response time – i.e., how fast a service accomplishes its task – could also be categorized as a type of service efficiency. In any case, measurement of the service efficiency and usage of the corresponding resources are highly depending on the nature of the service and its application domain. We refer the

interested reader to Deliverable D3.2 – "Performance and Scalability Requirements for the IF" for a thorough analysis of the issue with respect to the services offered by the IF.

Concerning the *Service Standardization* requirement, there is no common agreement for the standards to be used to make services available to the community; however, various project and initiatives highlight the need to provide standardized interfaces to their services, at various levels. In particular, initiatives and projects that aim at creating and managing ecosystems of services highlight the need that created services have common APIs to facilitate their invocation by clients.

3.1.3 System Management Viewpoint

Figure 3 summarizes the requirements identified in Section 2 for the System Management Viewpoint. Unlike data and service management requirements that help us to understand the features of the assets with which the IF must deal (i.e., the data), and the functions that must be offered by the IF (i.e., interoperability services), system management requirements help us understand the necessary characteristics of the architecture of the IF, as well as the strategic decisions, common development practices and the process to establish the IF. However, the variety of desired characteristics from the system management viewpoint that emerges from the analysis of Section 2 is higher than for the data and service management viewpoints. Indeed, as depicted in Figure 3, fourteen different aspects have been identified in our study, where each of them has been targeted by only a few projects/initiatives.

Primary Requirements

There are only two aspects that are of concern for almost half of the projects studied: *Guidelines* (42,85%) and *Technological neutrality and system/infrastructure harmonization* (50%).

- **SyR13.Technological neutrality and system/infrastructure harmonization:** As the name suggests, this requirement highlights the lack of standardization in the lower layer of the technology stack and the need to decoupling the services/functions provided by a system from the underlying enabling technologies.

- **SyR4.Guidelines:** This requirement covers two different categories of audiences: firstly, end-users, through the provision of comprehensive instructions for them to engage with the system; secondly, business partners, potential followers and any interested party who might enhance the system in future, through the provision of generic rules and recommendations to facilitate and direct them.

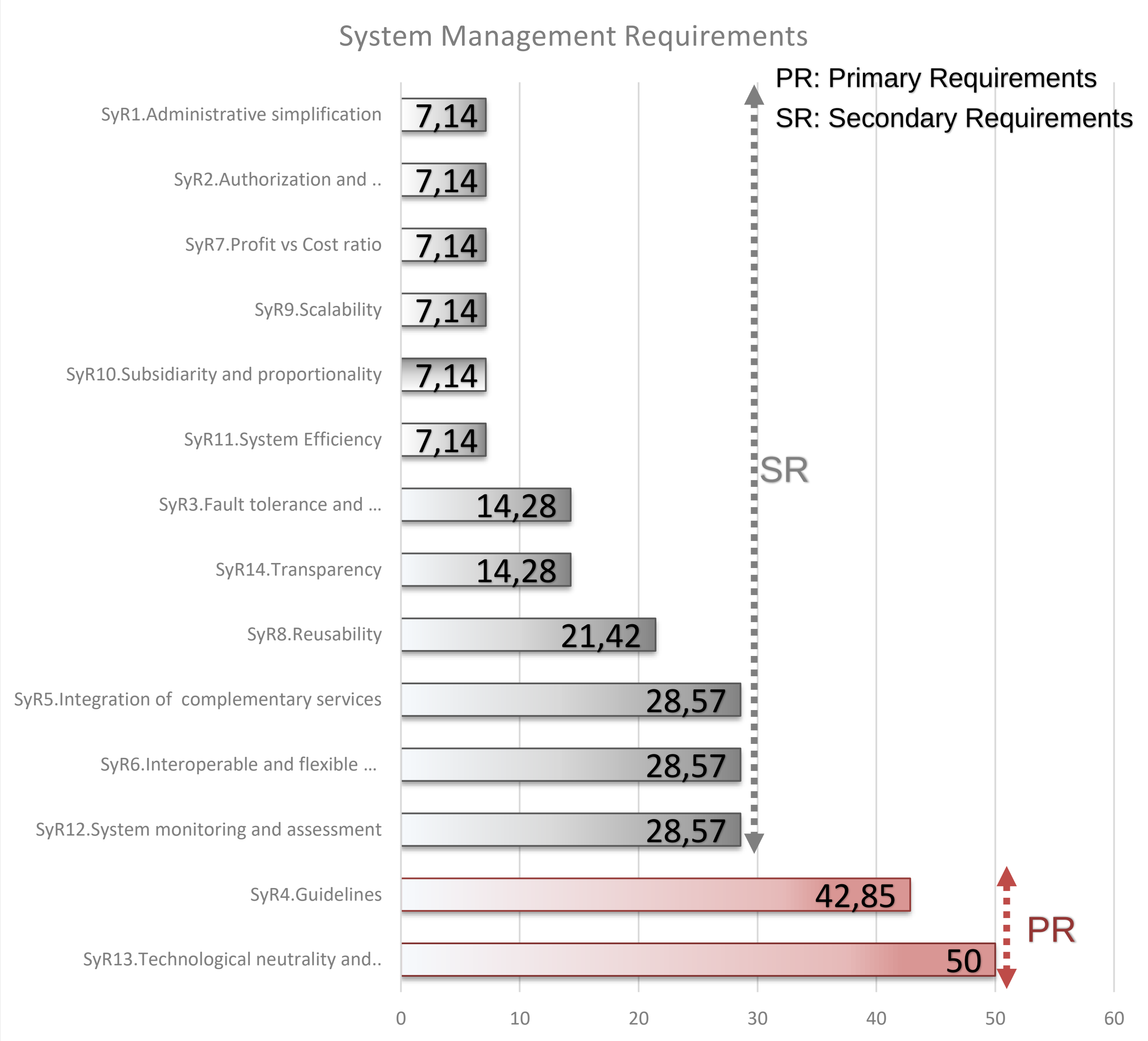

Figure 3 Distribution of the identified System Management Requirements in the studied projects

While the second requirement highlights a strategic and administrative viewpoint, the first one emphasizes two fundamental aspects of the architecture and system design of the IF. More precisely, it highlights the usefulness and supports the main idea behind an approach based on a service-oriented architecture and on semantic web technologies. Indeed, a service-oriented architecture suggests focusing on what must be provided, rather than how; semantic web technologies, on the other hand, foster the use of structured formats (e.g., structured and machine-readable service descriptions) which in turn help overcome technological heterogeneity and leads to “a common framework that allows data to be shared and reused across application, enterprise, and community boundaries” [3]. Both of these aspects have already been considered as the main elements for the architecture and the development of the IF. However, this study proves the importance of this approach and provides further motivation to continue in this direction.

3.2 Interoperability bottleneck Dimension

Though the elicited requirements are all necessary aspects to enhance interoperability, some of them might have greater weight or they might be a prerequisite for solving another one. Accordingly, addressing such requirements must take precedence over other requirements, since they can potentially block achieving interoperability more than others.

To identify these basic interoperability requirements, we explore interoperability issues at a larger scale than the transportation eco-system. More precisely, given that the transportation domain could be categorized as an extended enterprise system, it is relevant to understand the interoperability requirements and challenges in a generic enterprise system. In this direction, we refer to the interoperability barriers introduced by David et al in [4]. In specific, the authors define three main barriers that hamper cooperation and collaboration among enterprise systems as follows:

- *Conceptual barriers:* They are concerned with the syntactic and semantic differences of information to be exchanged. These problems concern the modeling at the high level of abstraction (such as for example the enterprise models of a company) as well as the level of the programming (for example XML models).

The conceptual barrier hence covers the obstacles generated from the heterogeneity of data formats and data models. In this regard, the relevant requirements are the first part of DR1, i.e., "**DR1.Data Standardization**" and "**DR6.Machine Readable Data**". Standardization is a unification approach to harmonize utilization of data formats and modes which significantly enhances syntactic interoperability, while machine readability opens the door to the possibilities of semantic interoperability.

- *Technological barriers*: These barriers refer to the incompatibility of information technologies (architecture and platforms, infrastructure, etc.). These problems concern the standards to present, store, exchange, process and communicate data through the use of computers.

While conceptual barriers mainly occur at data representation level, technological barriers cover the interoperability issues when it comes to persisting and integrating data as well as data-models in communication channels and service interfaces. We have identified five requirements as the technological barriers for interoperability, namely "**SyR5.Integration of complementary service**", "**SyR13.Technological neutrality**...", "**SyR8.Reusability", "SeR7.Service Standardization"**, and the second part of DR1, i.e., "**DR1.Data portability**". The first two requirements are indeed the most generic ones and target the same concerns specified under the technological barrier. As explained in section 3.3.1, Technology neutrality refers to the loosely-coupled provision of services and processes so that they could be deployed in various platforms and underlying enabling technologies. Such design and development practice can significantly help to overcome technology barriers and the presence of complementary services can foster this process. In this context, reusability is another good practice since it fosters the modularization development approach, which in turn improves the loosely-coupled feature of a system. Service Standardization – at the interface, communication protocol and data model level – and data portability are the next steps toward removing the technological incompatibility and to facilitate the interaction and cooperation among different systems.

- *Organizational barriers*: They relate to the definition of responsibility (who is responsible for what?) and authority (who is authorized to do what?) as well as the incompatibility of organization structures (matrix vs. hierarchical ones, for example).

Finally, we have the organizational barrier, which can be divided into three types. First, the barriers that prevent smooth cooperation among organizations because of the heterogeneity of organizations' structures, internal business models, legal limitations, etc. Second, the obstacles toward overall orchestration of a work to be done by multiple systems in a cooperative manner. For instance, how a work should be divided fairly, how partners can monitor the activity of other members, how to manage the rights and roles in a process, how decisions are taken, etc. The third concerns all security issues of the cooperative and shared working process. There are several requirements in our study which can address organizational barriers, including "**DR3.Dataset Lifecycle Management**", that lets organizations define the various steps that must be taken to manage a piece of data according to their internal work method and structure. "**SyR4.Guidelines**" and "**SyR1.Administrative Simplification**" are effective practices toward overcoming the complex bureaucracy and legislation obstructions. Finally, although "**DR2.Data accessibility and openness**" can play an important role to ease communication among various organizations, since such openness is not part of the common practice, provision of distributed and semantic-based **"DR9.Security and Privacy"**, as well as, simple but proficient "**SyR2.Authentication and Authorization**" systems are other relevant requirements to overcome the third category of organizational barriers.

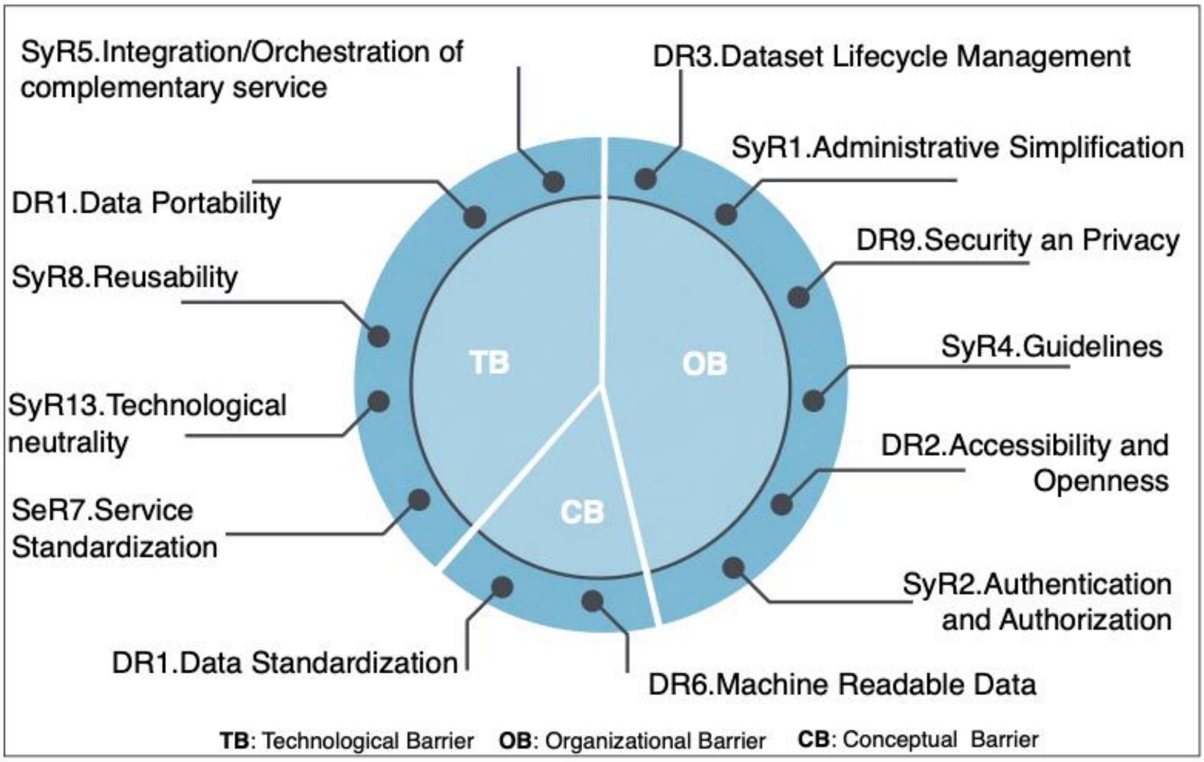

Figure 4 Requirements to address three categories of interoperability barriers

In summary, as depicted in Figure 4, most of the elicited requirements belong to organization and technology barriers. It suggests the main interoperability bottleneck arises, firstly, from managerial and strategic concerns at organizations' level and, secondly, from technological deficiencies and shortcomings. This is indeed a very important hint for steering the development of the IF towards addressing those requirements that would have greater impacts on enhancing interoperability. In this direction, we include the technological and organizational requirements to the list of "primary" requirements of the IF.

3.3 Functional and non-functional Dimension

It is customary to refer to "functional requirements" as those concerning the outcomes of the computations of the system, whereas "non-functional requirements" are all other constraints that instead concern aspects such as timing, performance, scalability, security, user-friendliness, etc. In our research, functional requirements simply refer to specific functions that must be implemented by a component/organization, while non-functional requirements correspond to certain qualities and features of a data set, function, procedure and/or the organization itself. Figure 5-Figure 7 show a rough[23] functional and non-functional categorization of the requirements from the data, service and system viewpoints.

[23] Notice that many of the requirements are borderline cases between being functional or non-functional depending on the interpretation of the definition of the categories of requirements. Hence, the provided categorization is not sharp.

For example, in the case of "**DR1.Data Standardization and Portability**", if one defines the standardization as a feature of data such as its efficiency and depth, then this requirement should be categorized as non-functional. On the other hand, one may define standardization as a procedure that must be fulfilled by a data provider, which would make it a functional requirement. In this document we stick to the second definition and hence it is represented as functional requirement.

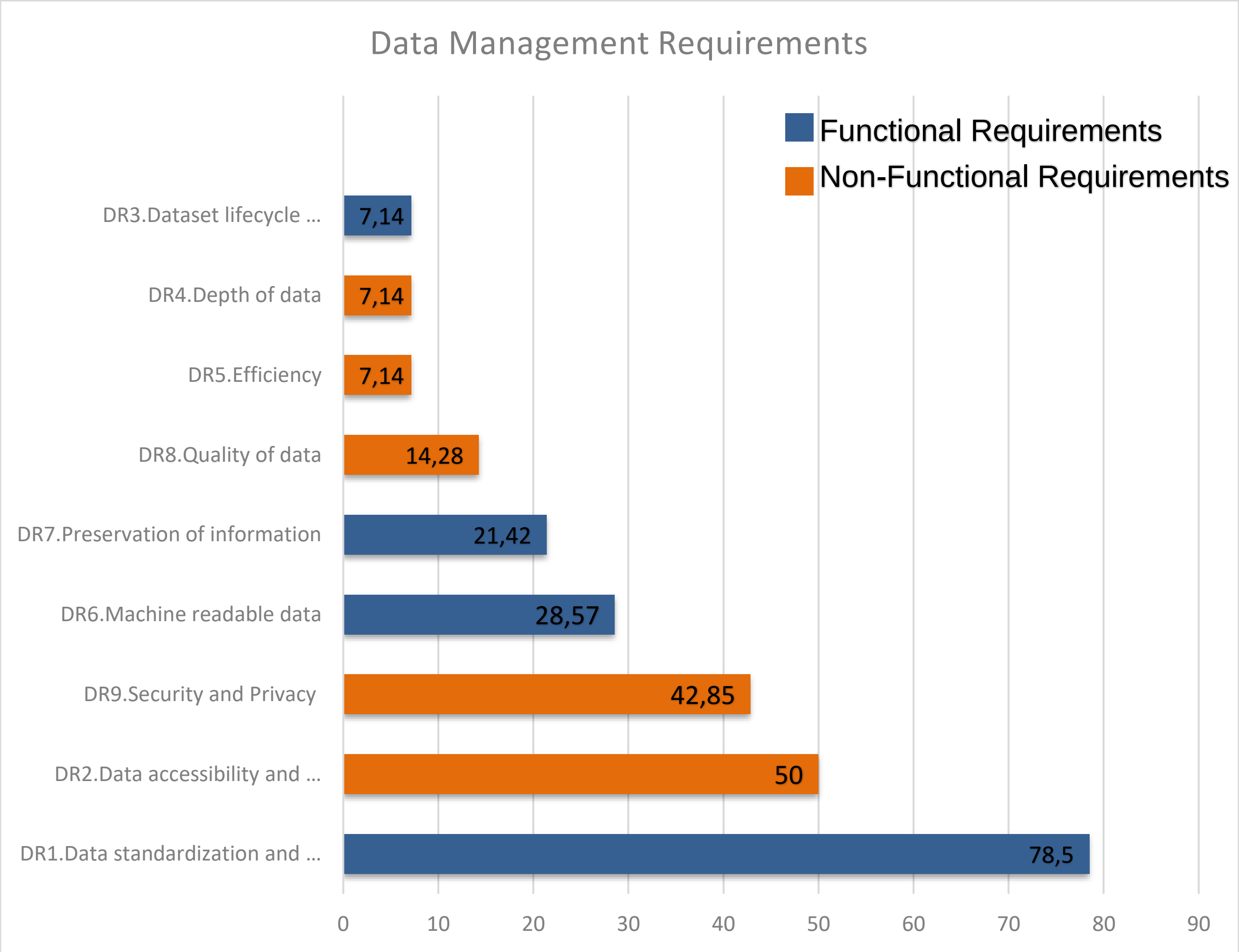

Figure 5 Functional and Non-functional categorization of requirements in Data Management Viewpoint

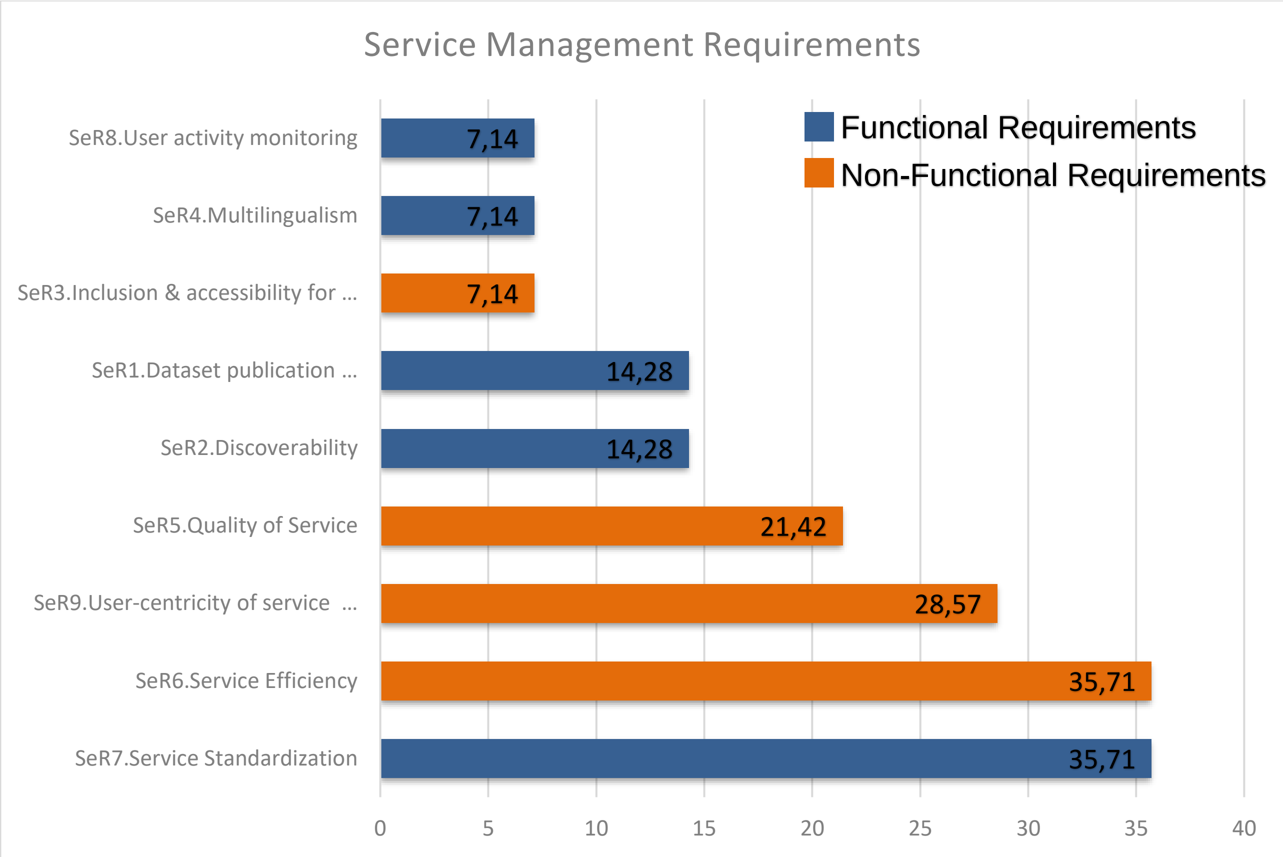

Figure 6 Functional and Non-functional categorization of requirements in Service Management Viewpoint

Similarly, in System Management Requirements, we have considered the "**SyR13.Technological Neutrality and system/infrastructure harmonization**" as a procedure that must be taken by the organization as well as the middlewares and frameworks such as the IF, hence in the figure it is categorized as a functional requirement. Yet, it is a valid and sound argument if we consider it as a characteristic of functions and components of a system and accordingly named it as a non-functional characteristic.

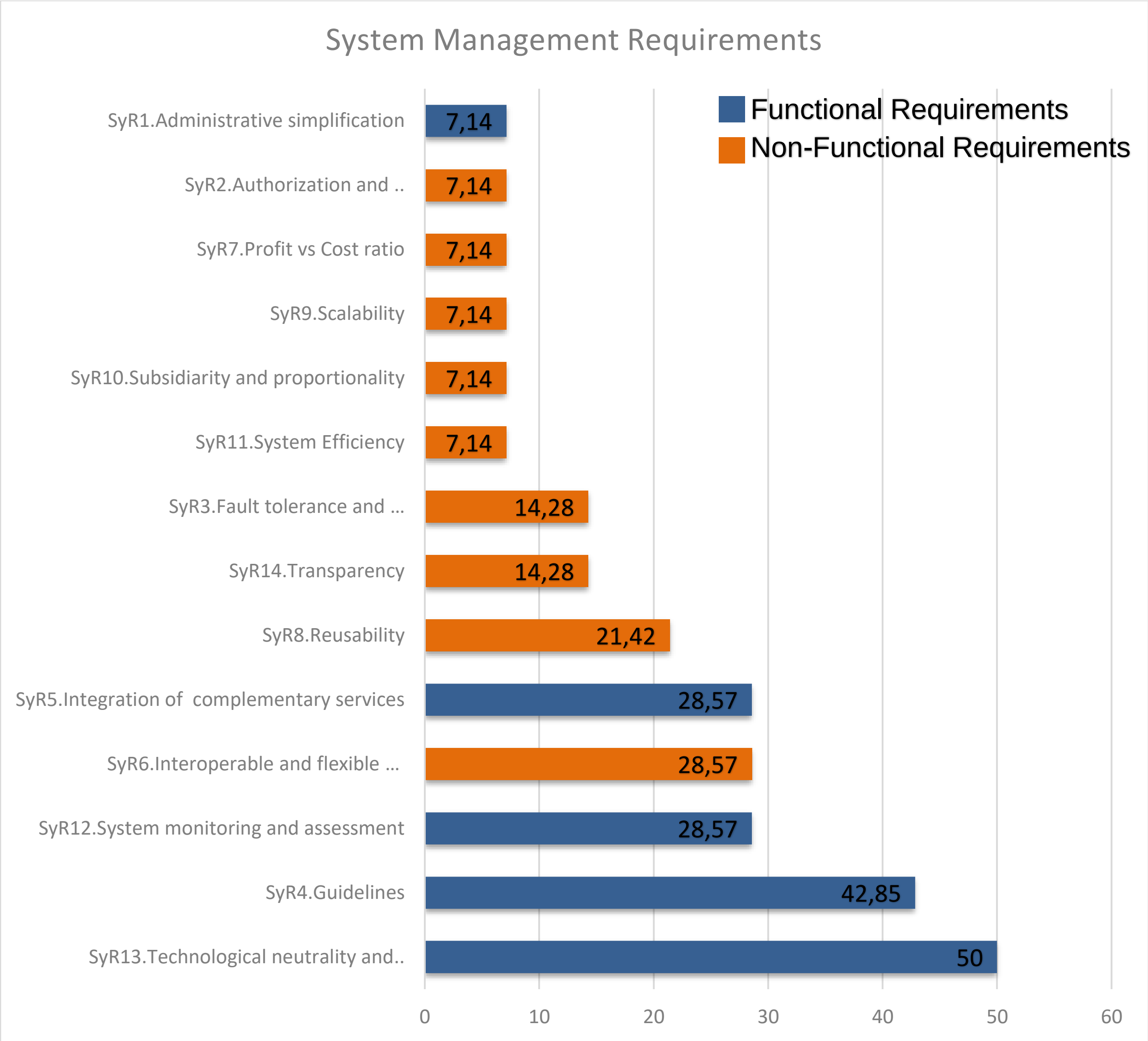

Figure 7 Functional and Non-functional categorization of requirements in System Management Viewpoint

3.4 NON-FUNCTIONAL IMPLICATIONS DIMENSION

Furthermore, given that functional requirements are usually sets of functions/services that must be delivered by a system, we can define various non-functional requirements that must be satisfied by each. Table 18 Non-functional implications of some of functional requirements in each viewpoint

shows the non-functional implications of all the identified functional requirements. For example, **"DR7.Preservation of information"** is a functional requirement since it is a function that must be performed by a system. However, to be able to perform its tasks and successfully achieve its goals, it needs to meet a certain qualification. For instance, the process of storing information must be available to the users all the time, the whole procedure must be reliable and, finally, it must be immune to any data loss by having some backup strategy or by being fault-tolerant.

	Elicited Functional Requirement	Non-Functional Implication		
Data Viewpoint	DR3.Data Life Cycle Management	User friendliness	Reliability	Manageability
	DR7.Preservation of information	Reliability	Availability	Fault tolerance Back up
	DR6.Machine readable data	Durability	Efficiency	Robustness
	DR1.Data Standardization	Efficiency	Effectiveness	Maintainability
Service Viewpoint	SeR8.User Activity Monitoring	Reliability	Availability	Scalability
	SeR2.Dataset publication and subscription services	Availability	Scalability	Accessibility
	SeR7.Service Standardization	Effectiveness	Maintainability	Documentation
Service Viewpoint	SyR5.Integration of complementary services	Efficiency	Scalability	Quality
	SyR12.System monitoring and assessment	Maintainability	Reliability	Effectiveness
	SyR4.Guidelines	User friendliness	Supportability	Usability
	SyR13.Technological neutrality and system/infrastructure harmonization	Efficiency	Scalability	Quality

Table 18 Non-functional implications of some of functional requirements in each viewpoint

As another example, "**SeR7.Service Standardization**" and "**SyR13.Technological neutrality and system/infrastructure harmonization**" are mentioned in the table for **Service** and **System Management**, respectively. Non-functional features are crucial in service standardization processes. They concern the effectiveness of a standard, which could be measured in terms of its abstraction level, expressiveness and completeness. A good level of documentation (especially when it comes to interface standardization) is another important non-functional feature that a standard should have, because the first step to adopt a standard is to thoroughly and comprehensively understand how it works. Finally, the maintainability of a standard refers to the ability of continuously updating and enhancing it, which has a direct impact on the effectiveness of the standard.

3.5 Feasibility and Relevance for the IF Dimension

The last dimension to analyze the requirements extracted in Chapter 2 concerns the feasibility of addressing them within the scope of the IF. In other words, not all requirements are relevant to achieve the goal of the IF to enhance interoperability.

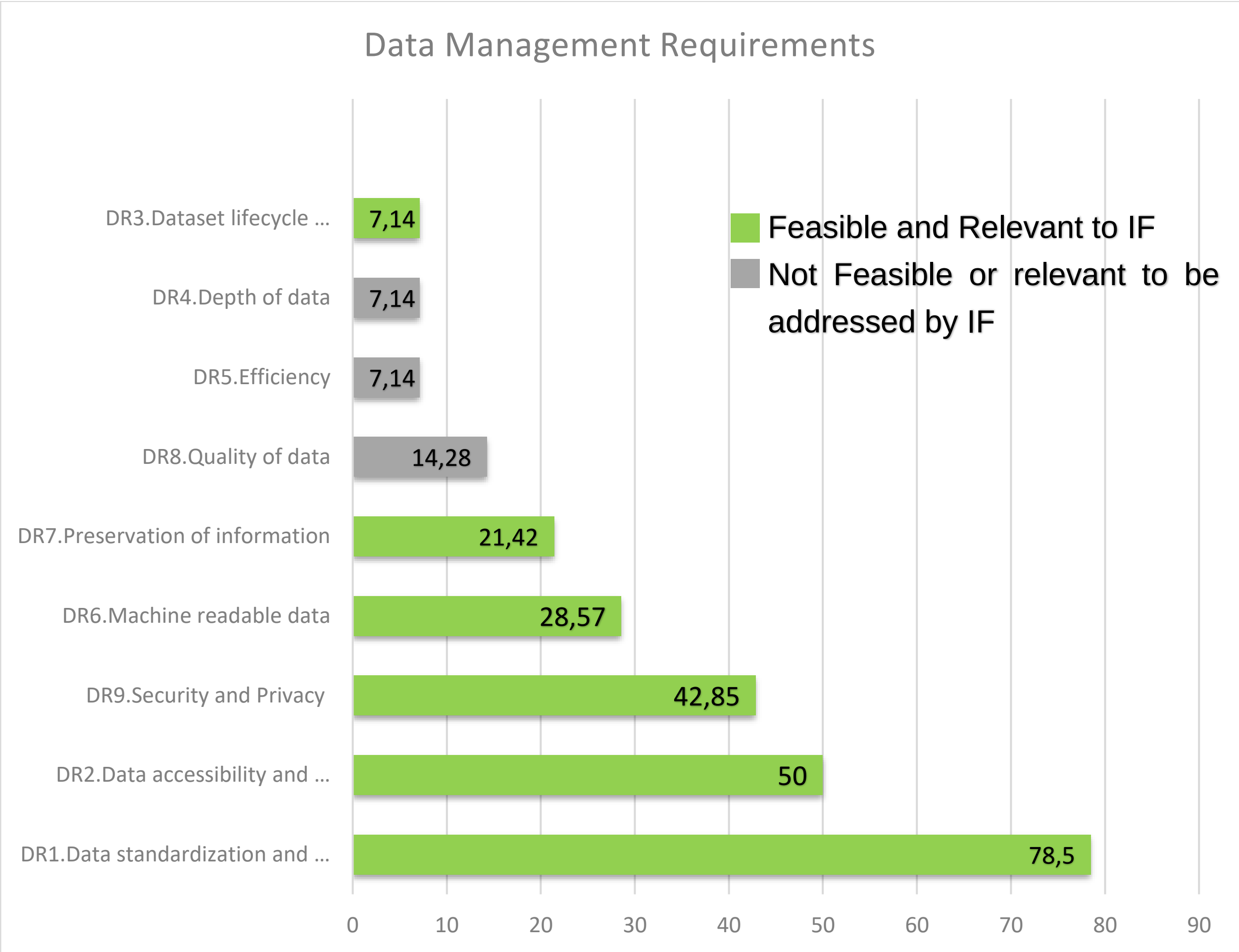

Figure 8 Feasibility and Relevance of Data Management Viewpoint in scope of IF

For example, the IF is not in charge of data generation, but it is only a platform to make data produced by various actors be shared, discovered and accessed by others. In this direction, though requirements such as "**DR8.Quality of Data**" and "**DR4.Depth of Data**" are very criticals aspect of data management, portability, reliability, and interoperability from the **Data Management Viewpoint**, it is up to data providers to guarantee such features. However, for some requirements the IF can play a more effective role, though some responsibility remains in the purview of data providers. For instance, the IF can enhance "**DR2.Data accessibility and openness**", for example by making data discoverable, but only if data are originally open by the data owners. Another example is "**DR1.Data Standardization and Portability**". The IF itself does not have in its scope to produce any standard, but the presence of a platform that lets standard providers announce and promote their standards, or of subsidiary functions that foster the use and interoperability of different standards – such as the Converter component of the IF – can greatly assist in overcoming the lack of standardization. Hence, the last two cases could be considered as the requirements which are feasible to be addressed (at least partially) by the IF. Figure 8 highlights all the requirements in the data viewpoint which are feasible in the scope of IF.

The feasibility study of **Service** and **System Management Viewpoint** requirements is slightly different from the data viewpoint, since the IF itself offers various services in addition to making services of external parties accessible to others (Interoperability Services vs. Auxiliary Services). Hence, the IF is responsible for achieving various requirements for such services and functions, including "**SeR5.Quality of Service"**, "**SeR7.Service Standardization**", "**SeR9.User Centricity of Services**", in the **Service Management Viewpoint**, and "**SyR2.Authorization and Authentication"**, "**SyR8.Reusability"**, "**SyR4.Guideline"** in the **System Management Viewpoint**. Accordingly, almost all of the identified requirements are feasible for, and relevant to the IF for the services/functions provided by it. Hence, Figure 9 and Figure 10, indicate that the IF is considering such requirements for its own services, but addressing those requirements for the services provided by external parties is the providers' responsibility.

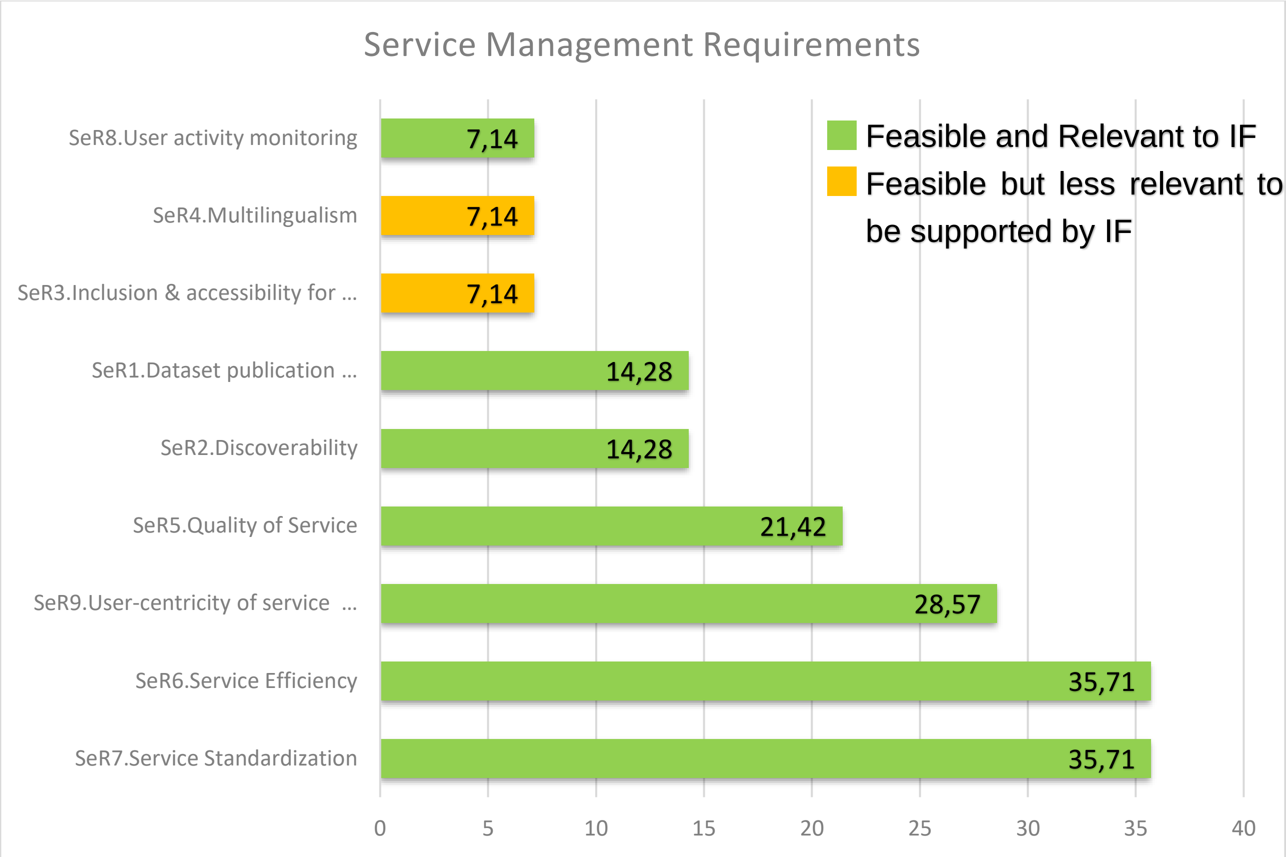

Figure 9 Feasibility and Relevance of Service Viewpoint in scope of IF for services provided by IF

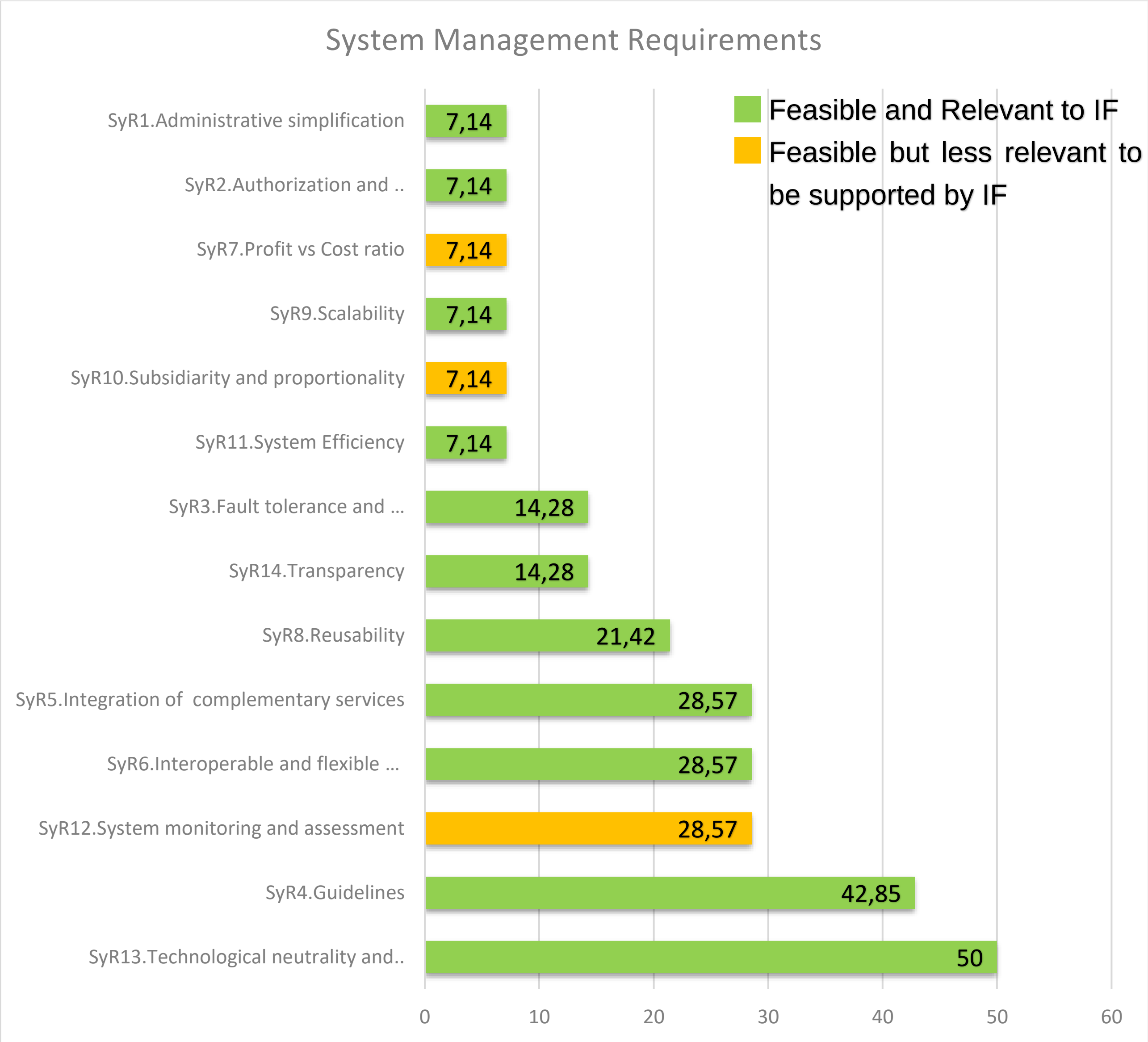

Figure 10 Feasibility and Relevance of System Viewpoint in scope of IF for services/functions provided by IF

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