BE OPEN

European forum and oBsErvatory for OPEN science in transport

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D5.2 KPIs for Open Science in transport evaluation

[Final Version]

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Author name(s):	Kristel Palts (DLR), Attila Akac (CERTH), Afroditi Anagnostopoulou (CERTH), Jakob Michelmann (VDI/VDE)
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Abbreviations and Terminology

CAT	Connected and Automated Transport
COAR	Confederation of Open Access Repositories
CORDIS	Community Research and Development Information Service
CPU	Central Processing Unit
CSA	Coordination and Support Action
DOAJ	Directory of Open Access Journals
DORA	Declaration On Research Assessment
EC	European Commission
EOCS	European Open Science Cloud
EPATS	European Personal Air Transportation System
EREA	Association of European Research Establishments in Aeronautics
ERTICO	European Road Transport Telematics Implementation Coordination
EU ODP	EU Open Data Portal:
FAIR	Findable, Accessible, Interoperable, Re-usable
H2020	Horizon 2020
IETF	Internet Engineering Task Force
IoT	Internet of Things
IP	Intellectual Property
KPI	Key Performance Indicator
OSPP	Open Science Policy Platform
OSTR	Open Science Transport Research
PID	Persistent IDentifiers
RDA	Research Data Alliance
RI	Research Infrastructures
STRIA	Strategic Transport Research Agenda
TOPOS	Transport fOrum/Observatory for Promoting Open Science
TRC	Transport Research Cloud
TRIMIS	Transport Research and Innovation Monitoring and Information System

Executive summary

The **objective** of Task 5.2 is to present the main KPIs for **evaluating the Open Science services in transport research**. More detailed, task 5.2 aims at developing proper Key Performance Indicators (**KPIs**) for **assessing Open Science in transport in terms of validity or not**. The main objective is to determine **proper criteria and measures that will be used to evaluate the performance of Open Science in transport research**. The proper assessment of the Open Science in transport will embed an on-going analysis which will help to assess the proper **critical success factors** such as transport research policies, transport research projects per mode of transport, transport research infrastructures and software per mode of transport or per EU country member state, transport research publications per mode of transport or per transport research policy.

This Deliverable is the second step in the strategic development carried out in BE OPEN WP5 – "Guidelines for promoting Open Science". With the elaboration of an initial list of KPIs for monitoring the system, this report contributes to measure effective implementation of Open Science in transport research data. The work carried out has been based on literature review and using information gathered in BE OPEN project, including input from Deliverables D5.1 "Identifying barriers, challenges and opportunities for Open Science" and D3.2 "TOPOS development".

This deliverable builds up on two main sections. The first chapter is dedicated to mapping the situation and paving the way for KPIs in Open Science research data in general and for international guidelines by highlighting the most important areas that should be considered for successful monitoring and evaluation of Open Science implementation in the research sector. In order to focus on transport and transport research data, information mainly deriving from BE OPEN Project activities has been considered to highlight the challenges and opportunities of Open Science in such a sector together with key stakeholders identified. The successful selection of KPIs, by analyzing the challenges and opportunities of Open Science in transport sector, recognize the critical success factors, which need to be monitored for successful implementation of Open Science. In that framework, stakeholders play a key role and are an important factor as they create, use and share the data. The other key point is TOPOS – the Transport fOrum / Observatory for Promoting Open Science – an important tool for transport research data, developed within the BE OPEN project and which aims to create a solid knowledge base on the implementation of Open Science approaches and therefore a key factor for successful KPIs development. With this regards, guidelines and recommendation from European Open Science Cloud SRIA have been used. The second chapter introduces a methodology for the initial set of KPIs. This includes the identification of key stakeholders to establish the essential user groups. The developed KPIs have been then clustered into operational and strategical ones. Operational KPIs including the identified opportunities and European Open Science Cloud KPI recommendations are focused on TOPOS. The strategical KPIs are based on the main challenges identified and are aiming to measure the overall success of Open Science implementation in the transport sector. In addition, a possible measuring criterion for the operational and strategic KPIs has been proposed to create extra value for the deliverable. A comprehensive list of initial KPIs is being proposed. Further actions to successfully consolidate and implement the set of indicators encompass the involvement of all stakeholders, for instance by organizing thematic needed, and workshops, to enter into the discussion.

1 INTRODUCTION

1.1 Purpose of the document

The BE OPEN project is a coordination and support action funded by the European Commission in the Horizon 2020 research and innovation programme under the grant agreement No 824323. BE OPEN aims to promote Open Science in transport research and assist in regulating Open Science aspects and standardising them. The overarching vision of BE OPEN is to create a common understanding on the practical impact of Open Science and to identify and put in place the mechanisms to make it a reality in transport research. The main objectives of the BE OPEN project are:

- To develop a framework in order to establish a common understanding of operationalizing Open Science in Transport;
- To map existing Open Science resources and see how transport research fits in.
- To facilitate an evidence-based dialogue to promote and establish Open Science in Transport;
- To provide the policy framework and guidance for Open Science implementation in transport;
- To engage a broad range of stakeholders in a participatory process for Open Science uptake.

Deliverable 5.2 – "KPIs for Open Science in transport evaluation" is contributing to WP5 by defining key performance indicators by using Challenges and barriers in Open Science. These were identified in D5.1 "Main challenges and opportunities, constraints and bottlenecks of Open Science in transport research" and providing input to the D5.4 "Roadmap and guidelines to promote Open Science in transport research (OSTR)".
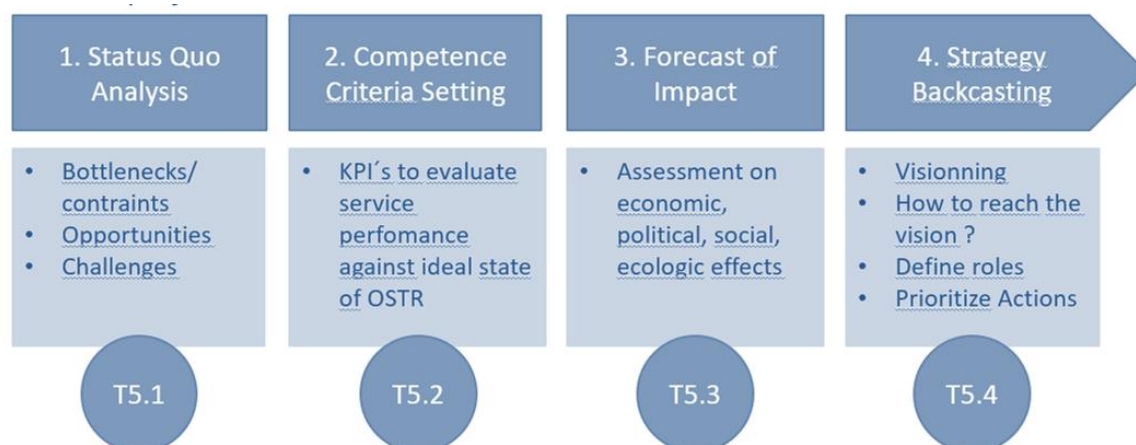
Figure 1 Introduction BE OPEN WP 5

The main purpose of the deliverable is to provide necessary criteria for Key Performance Indicators to evaluate of OSTR. This is needed to evaluate efficiency of the system (Open Science implementation), to monitor the progress as well as to ensure/ create reliability among stakeholders/users on the system sustainability. For an efficient implementation of Open Science, a roadmap will display the strategies to promote OSTR.

1.2 **Objectives and Scope**

The **objective** of Task 5.2 is to present the main KPIs for **evaluating the Open Science services in transport research**. This translates into the determination of the proper KPIs for evaluating the Open Science services in transport research. More detailed, task 5.2 aims at developing proper Key Performance Indicators (**KPIs**) for **assessing Open Science in transport in terms of validity or not**. The main objective is to determine **proper criteria and measures that will be used to evaluate the performance of OSTR**. The proper assessment of the Open Science in transport will embed an on-going analysis which will help to assess the proper critical success factors covering transport research policies, transport research projects, transport research infrastructures and software per mode of transport or per EU country members, transport research publications per mode of transport or per transport research policy.

KPIs are a set of performance measurements that demonstrate how effectively key objectives are being achieved. Concerning the transport research data, the project has developed the so-called TOPOS – Transport fOrum/Observatory for Promoting Open Science – an online platform that will contribute to create a solid knowledge base on the implementation of Open Science approaches in transport research, and in particular on current constraints and bottlenecks in this field. Therefore, to develop KPIs for **evaluating the Open Science services in transport research**, TOPOS Objectives through identified challenges and opportunities, as well as the relevant stakeholders, are setting the scene for achieving the key goals in transport research data. The analysis has also been substantiated by including the international point of view – in particular by assuring a coherency with TRIMIS and EOSC SRIA – to create synergies in between different platforms.

The outcome of the deliverable 5.2 include - mapping the current situation, identification of the initial list of possible KPIs for transport research data, considering EOSC SRIA recommendations and the analysis of the TOPOS Observatory and Forum suitability for implementing the identified KPI-s. The methodology for KPI development includes two stages - Operational - KPIs for TOPOS and Strategic - KPIs for Open Science as overall in the transport research data. A short overview of the methodology steps is listed in Figure 2.

1. Analyses of Open Science Objectives in transport research
- Literature review
- BE OPEN Challenges and opportunities (D5.1)
- BE OPEN TOPOS Observatory and Forum (D3.6)

2. Development of Open Science KPI-s for Transport Research Data
- Stakeholder categorisation
- Challenges and opportunity oriented KPI-s
- Reccomendations for KPI

3. Conclusion
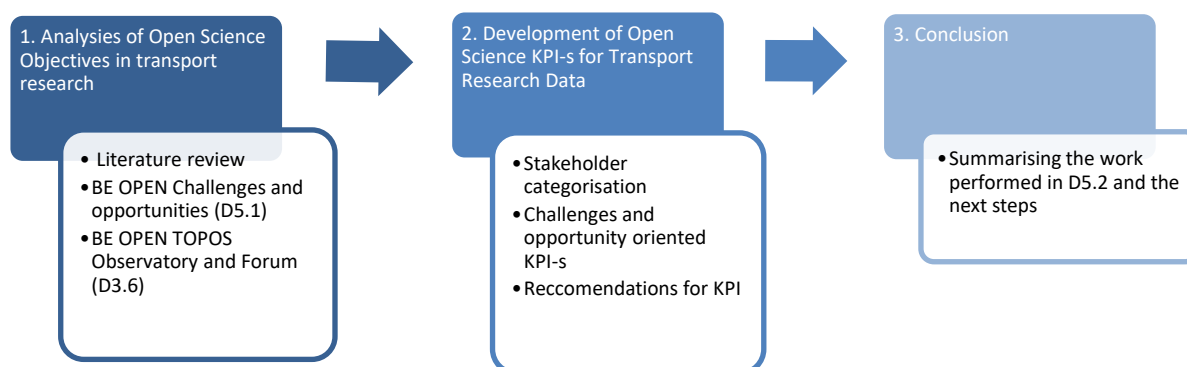- Summarising the work performed in D5.2 and the next steps

Figure 2 Indicators development and implementation methodological steps

2 Analyses of Open Science Objectives in transport research

2.1 Mapping the situation

KPIs are important measure to evaluate the success of a process as well as implementation of a change. The Open Science and the European Open Science Cloud initiative are paving the way by proposing guidelines for successful implementation, as well as for the Open Science, proposing a unanimous set of KPI-s are required in order to allow knowledgeable decisions. In European level for Open Science, the development of detailed list of KPI-s is still work in progress. One of the main challenges is to harmonies the Open Science related activities in various sectors and to create synergies. In order to answer the challenge – European Open Science Cloud was initiated to better regulate and to provide guidelines and recommendation. Nevertheless, each sector is addressing unique issues, related to implementation of Open Science. Therefore, for successful execution of the task – development KPI-s in the transport sector, analyses are needed, based on the secularities of the sector and considering available regulations to develop the custom set of KPIs.

The EC regulation recommendation on access to and preservation of scientific information, published on 2018 supports the cooperation in between academia and researchers. Together with the national regulation implementation, fostering **measuring and rewarding** system is foreseen.[1] This highlights the importance of the rewarding system and should be included as a main factor while developing KPIs for transport research data. Further analysis is needed to see how measuring a rewarding system could be successfully implemented and monitored in Transport research sector. For general Open Science Metric "new generation metrics" are being developed. To support the activity, at European level, a working group has been established, the so-called Open Science Policy Platform (OSPP) whereas topics such as Altmetrics, including bibliometrics for measuring publication in social media are continuously being discussed.[2]

In 2019, an expert group by European Commission put in place: "**Indicator Frameworks for Fostering Open Knowledge Practices in Science and Scholarship**" [3] . The group elaborated a set of recommendations dealing with the following dimensions:

- Monitoring (implementation of Open Science practices)
- Learning (knowledge about Open Science publications)
- Resource allocation and career assessment

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[1] eur-lex.europa.eu (2018). COMMISSION RECOMMENDATION (EU) 2018/790 of 25 April 2018 on access to and preservation of scientific information. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0790&from=EN Last access: 7th April 2021.

[2] op.europa.eu (2017). Next-generation metrics. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/b858d952-0a19-11e7-8a35-01aa75ed71a1 Last access: 7th April 2021.

[3] op.europa.eu (2019). Indicator frameworks for fostering open knowledge practices in science and scholarship. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/b69944d4-01f3-11ea-8c1f-01aa75ed71a1/language-en Last access: 7th April 2021.

In particular, the OSPP identified the following recommendations:

Recommendation 1	*"Evaluations of individual researchers or of research groups should not use journal brand or Impact Factor as a proxy for research quality. Those responsible for hiring, promotion, funding and/or the evaluation of researchers must use a broader, tailored range of quantitative and qualitative indicators of research activity, progression and impact that incentivises and rewards open research practice. All publication venues must prominently display a broad range of indicators for all research outputs."*
Recommendation 2	***"Quantitative and qualitative indicators need to be identified and developed for research assessment that captures the full range of contributions to the knowledge system.*** *These should reflect the complexity and varied context of the research environment, the specific characteristics of the research being undertaken, as well as the new kinds of questions and results that might emerge in an open system. Experiments, pilots and case studies assessing the validity of such indicators need to be undertaken urgently, and included as part of FP9 with appropriate funding allocated to support them. The results and data of these pilots must be made publicly available as exemplars for further implementation."*
Recommendation 3	*"All researchers need to be identified through an ORCID ID. Best practice for CV/biosketch evaluation should be developed and publicly showcased to encourage a broader recognition of the range of verifiable (and especially open) contributions individuals make to the knowledge system, including teaching and peer review, and the production of a broad range of output types. The career narrative should be central to the evaluation of individual researchers as it provides the crucial context in which indicators can be interpreted."*
Recommendation 4	*"The data, metadata and methods that are relevant to research evaluation, including but not limited to citations, downloads and other potential indicators of academic re-use, should be publicly available for independent scrutiny and analysis by researchers, institutions, funders and other stakeholders."*

Table 1 OSPP Recommendations[4]

For effective KPIs development it is important to understand the overall system. For Open Science implementation, the steps listed in Figure 3 should be considered.

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[4] OSPP-REC (2018) Open Science Policy Platform Recommendations https://op.europa.eu/en/publication-detail/-/publication/5b05b687-907e-11e8-8bc1-01aa75ed71a1 Last access: 19th April 2021.

<div align="center">**Figure 3 Roadmap for Open Science implementation[5]**</div>

For a criterion for effective evaluation of the system should be developed for every step. For effective implementation, an overall system of Open Science deployment needs to be understood. To this end, **4 Important categories** for Open Science in the transport research have been identified (see figure 4):

1) Research trends,
2) **Opportunities and challenges**,
3) impact for competence areas and
4) **Policies.**

Figure 4 illustrates the homogenous system and the factors related to Open Science implementation. This is important for related KPIs development to assess the overall system.

<div align="center">**Figure 4 Categories for OSTR[6]**</div>

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[5] OSPP-REC (2018) Open Science Policy Platform Recommendations https://op.europa.eu/en/publication-detail/-/publication/5b05b687-907e-11e8-8bc1-01aa75ed71a1 Last access: 19th April 2021.
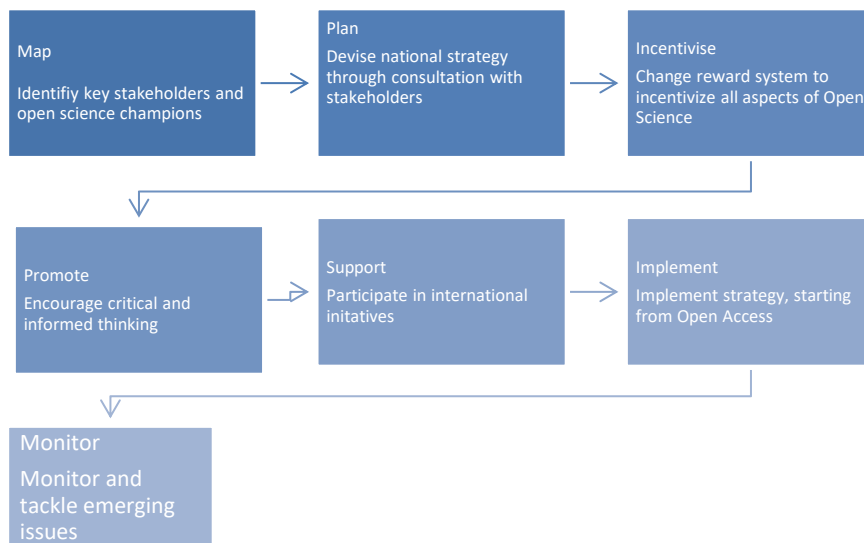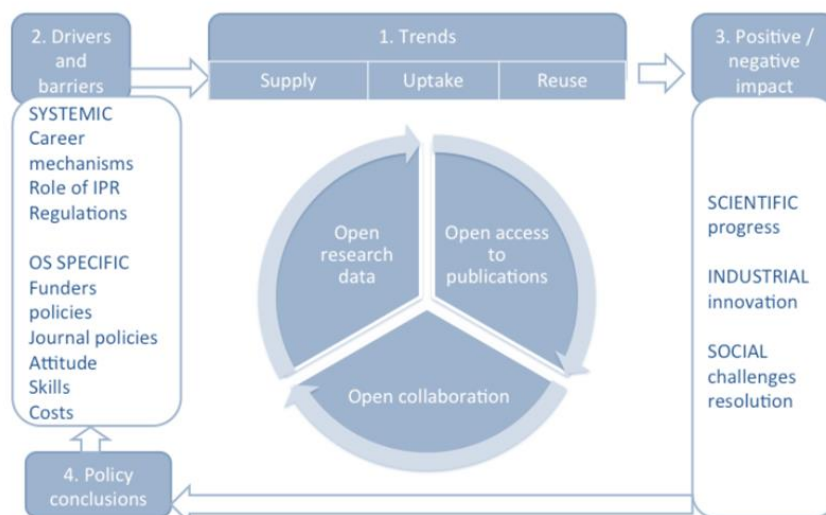
[6]
https://ec.europa.eu/info/sites/info/files/research_and_innovation/knowledge_publications_tools_and_data/documents/ec_rtd_open_science_monitor_final-report.pdf

Open Science metrics

The report of the European Commission Expert Group on "Next-generation metrics", highlights that metrics in Open Science have an important role of monitoring the development of the scientific system towards openness at all levels. This includes measuring performance in order to reward improved ways of working at group and individual level. There is a need for development of new indicators, as well as prompting the use of existing metrics in a more responsible fashion.[7]

In addition to traditional metrics, there are so called altmetrics, which are aimed to measure societal impact research results have on the public in general. In general the information is gathered from social media platforms as the main data source. [8]

In order to develop appropriate strategy for deployment of Open Science in transport Research and to reach the set goals, an efficient monitoring process has to be put in place. The identification of key indicators to monitor the current situation of reaching the goals is the basis of efficient strategy and mission deployment.
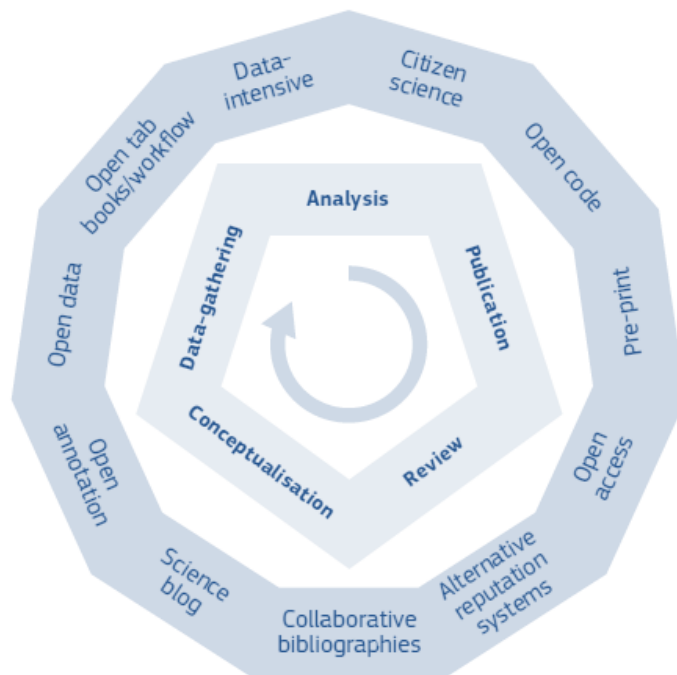
Figure 5 Open Science opens up the entire research enterprise (inner circle) by using a variety of means and digital tools[9]

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[7] op.europa.eu (2017). Next-generation metrics. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/b858d952-0a19-11e7-8a35-01aa75ed71a1 Last access: 7th April 2021.

[8] edoc.hu-berlin.de. Altmetrics and Open Access Comparison of Altmetric Scores of open and closed access articles published by German research institutions in the field of natural sciences (2019) Retrieved from: https://edoc.hu-berlin.de/bitstream/handle/18452/21498/BHR-444-Satzinger.pdf?sequence=1&isAllowed=y Last access: 29.04.2021

[9] Wilsdon, James & Bar-Ilan, Judit & Frodeman, Robert & Lex, Elisabeth & Peters, Isabella & Wouters, Paul. (2017). Next-generation metrics: responsible metrics and evaluation for open science.

The two main roles of metrics in Open Science are:[10]

a) Monitoring the development of the scientific system towards openness at all levels;
b) Measuring performance in order to reward improved ways of working at group and individual level.

This needs a development of appropriate indicators to match the roles. Metrics are also included in the framework of Open Science in transport sector, as the metrics and altmetrics were briefly addressed in the related BE OPEN deliverable, D1.2 "Open Science framework, terminology and instruments". [11]

To develop successful KPIs, a two-step approach has been implemented:

1) Identification of stakeholders by considering that:

- A transport research cloud operates in an environment defined by key stakeholders.
- Considering TOPOSTOPOSs key stakeholders are associations of transport research infrastructures, universities in the sector of transport, transport researchers, public service providers for transport research, associations of transport industry and transport research scientists. TOPOS will be successful if it has strong relationships with the mentioned stakeholders.
- Measuring performance by proper KPIs means measuring relationships with the stakeholders.
- KPIs should reflect how effectively TOPOS is supporting relationships with its stakeholders.

2) Development of initial list of appropriate KPIs:
   I. Operational KPIs for TOPOS, based on the defined objectives, opportunities of Open Science in transport research
   II. Strategic KPIs based on the defined challenges, to monitor the overall implementation of Open Science among the stakeholders

For effective implementation, an overall system of Open Science deployment needs to be understood. For transport research, an important tool is the Transport Research and Innovation Monitoring and Information System (TRIMIS).

Transport Research and Innovation Monitoring and Information System – TRIMIS

The European Commission has launched an online tool to help analyse the effectiveness of transport innovation in delivering the EU's energy and transport strategy. The Transport Research and Innovation Monitoring and Information System (TRIMIS) monitors the implementation and effectiveness of the roadmaps developed by the Strategic Transport Research and Innovation Agenda

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[10] Wilsdon, James & Bar-Ilan, Judit & Frodeman, Robert & Lex, Elisabeth & Peters, Isabella & Wouters, Paul. (2017). Next-generation metrics: responsible metrics and evaluation for open science.

[11] beopen-project.eu (2019). Open Science framework, terminology and instruments. Retrieved from: https://beopen-project.eu/storage/files/beopen-d12-open-science-framework-terminology-and-instruments.pdf Last access: 7th April 2021.

(STRIA). TRIMIS analyses technology trends, research and innovation capacities and developments in the European transport sector, providing open-access information.

TRIMIS tool[12] is an operational tool and supports the implementation and monitoring of the Strategic **Transport Research and Innovation Agenda (STRIA) that outlines future transport**. TRIMIS is an analytical support tool that provides a complete assessment of technology trends and research and innovation capacities in the European transport system.

2.2 **European Open Science Cloud - EOSC**

EOSC SRIA lists an **open metrics framework**, which sets the rules (usage, performance, value for money) for the assessment of EOSC elements, highlighting **policies, access framework, services, data, business, funding and usage models.**

As a first step, the identification of key stakeholders plays a significant role. Furthermore, KPIs support and ensure efficient processes for the stakeholders, enabling to create a trustworthy environment and generate an attractive system for them. In addition, KPIs are implemented as a mean of communication within stakeholders to inform them about improvement of endeavors. KPIs development, especially for Open Science should follow the principles dealing with non-financial, as the cost and money are critical actors for Open Science, and timescale, so long-term and short-term indicators. [13]

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[12] ec.europa.eu (2017). Launch of TRIMIS, new tool to analyse transport innovation. Retrieved from: https://ec.europa.eu/transport/themes/research/news/2017-09-19-trimis_en Last access: 7th April 2021.
[13] growingscience.com (2014). Key indicators for organizational performance measurement. Retrieved from:http://growingscience.com/beta/msl/1701-key-indicators-for-organizational-performance-measurement.html Last access: 7th April 2021. http://growingscience.com/beta/msl/1701-key-indicators-for-organizational-performance-measurement.html
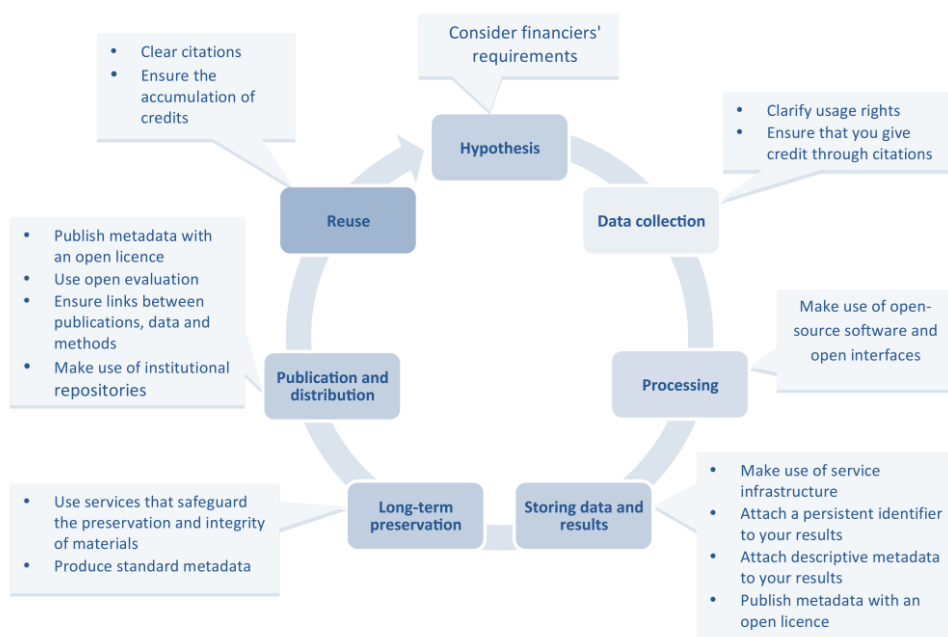
Figure 6 Input from Deliverable 5.1

The Open Science Roadmap points out three main categories for enabling Open that need to be fostered[14]:

1. Transparency: the whole research cycle has to be transparent, including the cost, open peer review, open metrics. Libraries should share licensing information, promote next generation metrics, disseminate Open Access requirements and mandates as well as Open Access publishing opportunities to researchers.

2. Sustainability: research production, together with infrastructures and funding have to be sustainable. Metadata should be standardized including persistent identifiers and long-term preservation solutions.

3. Collaboration: sharing best practices and case studies at international level by taking advantage of common standards and services should be fostered.

The following list of KPIs suggested by the EC does not display actual indicators. The list shall rather provoke a discussion taken on from here in the context of OSTR:

Identifier	Description
KPI1	Researchers performing publicly funded research make relevant results available, as openly as possible
KPI2	Professional data stewards available in research-performing organizations in Europe to support Open Science.
KPI3	Researchers are incentivized to perform Open Science
KPI4	The scope of EOSC is widened to serve the public and private sectors.
KPI5	Research data produced by publicly funded research in Europe is FAIR by design.

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[14] digital.csic.es (2018). LIBER Open Science Roadmap. Retrieved from: https://digital.csic.es/handle/10261/167474 Last access: 7th April 2021.

KPI6	The EOSC Interoperability Framework supports a wide range of FAIR digital objects including data, software and other research artefacts.
KPI7	European research is increasingly discovered and reused across disciplines as a result of EOSC.
KPI8	EOSC is operational and provides a stable infrastructure, supporting researchers addressing societal challenges.
KPI9	EOSC is populated with a valuable corpus of interoperable data.
KPI10	EOSC is a valuable resource to a wide range of users from the public and private sectors

Table 2 EOSC list of selected KPIs[15]

KPIs in Transport Research data are needed to monitor the effectiveness of Open Science Implementation and identify the activities or areas which need to be fostered to simplify the process. Researchers performing publicly funded research should make relevant results available, as openly as possible.

EOSC Strategic objectives are highlighting following main issues, which should be considered as an important topic to monitor:

- Efficient rewarding system for researchers to foster (open) science
- Interoperability of publication by machine readable data and interoperable data formats
- Ensuring infrastructures for enabling open data sharing among scientist across the borders and across disciplines

As in the Table 3 EOSC priorities EOSC SRIA identified 14 Action Areas (AA) - the gaps that need to be addressed and priorities where action is needed, should be considered as important areas for further development of KPIs. EOSC SRIA points out following categories[16]:

Category		Description
AA1	Identifiers (PID)	Implement the EOSC Persistent Identifier (PID) Policy and develop additional infrastructure required to support the publication, curation and tracking of research outputs.
AA2	Metadata and Ontologies	Offer a common dataset search to enhance discovery via EOSC
		Support communities to develop metadata standards and controlled vocabularies to enable all stakeholders to engage equally in EOSC.
AA3	FAIR Metrics and Certification	Implement metrics to assess FAIR digital objects and iterate based on testing.

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[15] EOSC Secretary (2020). Open Consultationfor theS trategic Research and Innovation Agenda (SRIA) of the European Open Science Cloud (EOSC). Retrieved from: https://www.eoscsecretariat.eu/sites/default/files/open_consultation_booklet_sria-eosc_20-july-2020.pdf. Last accessed 28th April 2021.

[16] eoscsecretariat.eu (2020). Open Consultation for the Strategic Research and Innovation Agenda. Retrieved from: https://www.eoscsecretariat.eu/sites/default/files/open_consultation_booklet_sria-eosc_20-july-2020.pdf Last access: 7th April 2021.

AA4	Authentication and Authorisation Infrastructure	Establish and implement a common framework for managing user identity and access in a highly distributed ecosystem.
AA5	User environment	Ensure a feedback mechanism to engage with users and further develop the EOSC environment to meet their needs.
AA6	Resource Provider Environments	Implement procedures to ensure services that meet requirements can be federated into EOSC easily and efficiently.
AA7	EOSC Interoperability Framework	Promote the use of open specifications where available, to ensure technical interoperability when establishing EOSC services.
		Agree and implement a common set of rules to ensure data and services within EOSC support interoperability.
AA8	Rules of participation	Define the cooperation framework enabling RDIs to work together more fully and effectively
		Evolve EOSC by recognizing enhanced standards for policy, processes and procedures to provide increasing levels of assurance of quality and trust in the services offered through EOSC.
AA9	Landscape Monitoring	Ensure continuous monitoring of the existing readiness of countries to contribute to EOSC
		Suggest priorities for action based on the monitoring.
AA10	Business Model	Perform cost assessments
		Ensure sustainable financing for EOSC
AA11	Skills and Training	Develop Open Science training and professionalize associated roles.
AA12	Rewards and Recognition	Create Europe-wide framework for rewards and recognition that includes Open Science
AA13	Communication	Inform stakeholders about the developments of EOSC.
AA14	Widening to the Public and Private Sectors	Widen EOSC stakeholder engagement in a strategic and timely manner

Table 3 EOSC priorities

Based on the EOSC objectives and recommendations the main categories involve establishing sufficient rewarding system to foster Open Science implementation, supporting regulation and policy to provide guidelines and recommendation for different groups of stakeholders, handling research data, FAIR data requirements and certification, and enabling infrastructures for data publishing.

2.3 FAIR Data

As it was one of the important category recommended for KPIs development in EOSC: **"5. Research data produced by publicly funded research in Europe is FAIR by design"**[17] KPIs should refer to the

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[17] EOSC SRIA. V0.9(2020). EOSC. Retrieved from: https://www.eoscsecretariat.eu/sites/default/files/eosc-sria-v09.pdf Last Access: 15th April 2021.

FAIR principle. The following list is taken from the EOSC roadmap to see the goals for each category (findable, accessible, interoperable, re-usable):

Findable (F)	Accessible (A)	Interoperable (I)	Re-usable (R)
F1. (meta)data are assigned a globally unique and eternally persistent identifier.	A1 (meta)data are retrievable by their identifier using a standardised communications protocol.	I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.	R1.1. (meta)data are released with a clear and accessible data usage license
	A1.1 the protocol is open, free, and universally implementable		
	A1.2 the protocol allows for an authentication and authorization procedure, where necessary.		
F2. data are described with rich metadata.	A2 metadata are accessible, even when the data are no longer available.	I2. (meta)data use vocabularies that follow FAIR principles.	R1.2. (meta)data are associated with their provenance.
F3. (meta)data are registered or indexed in a searchable resource.		I3. (meta)data include qualified references to other (meta)data	R1.3. (meta)data meet domain-relevant community standards.
F4. metadata specify the data identifier.			

Table 4 FAIR Data Principle characteristization

There are currently many factors missing or inadequately implemented, and also many institutional barriers that limit the deployment of research data. This situation can be improved using a systematic approach in applying these principles in order to maximise the FAIRness of data management. [18]

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[18] go-fair.org (2021).Go Fair. Retrieved from: https://www.go-fair.org Last access: 7th April 2021

EOSC latest update lists that the FAIR principles are a recent concept so metrics are still under definition. The implementation of FAIR can only be achieved in an ecosystem. The Metrics and Certification Task Force of the EOSC FAIR Working Group recommends that the definition of metrics should be a continuous process, regularly tested and iterated to minimize these risks.[19]

For FAIR Data, the RDA FAIR Data Maturity Model Working Group has published a model with 41 criteria, which allows to compare data with the FAIR principles and to be assessed. It addresses a degree of priority: essential, important, useful. The H2020 Project FAIRs FAIR is displaying metrics and certification. The projects recommendations necessitate investment in the development of data standards, crosswalks and registries to support a FAIR ecosystem.

2.4 TOPOS as transport research data forum – information exchange (D3.2)

TOPOS has a goal to Promote, Regulate and standardize Open Science in transport. The core objectives of TOPOS Observatory and Forum are focused on limiting existing barriers in Open Science in Transport Research and aligning transport research with EOSC by following FAIR principles. By identifying applied development strategies, operation and services offered from existing Transport RIs (Research Infrastructures) and EOSC, TOPOS schemes and services aim to offer a stakeholder-driven governance with the active involvement of transport research organizations/institutions, transport infrastructures and e-infrastructures, transport research funding bodies and other relevant players(relent research communities, authorities and any other body dealing with transport-related data).[20]

TOPOS includes[21, 22]:

a. the TOPOS Forum for national and European stakeholders – public and private - to exchange ideas and share best practices for operationalizing Open Science principles in transport research. This Forum will capture and present the common culture and practices of data stewardship in transport research.

b. the TOPOS Observatory which aim is to showcase the status and progress of open science uptake in transport research. This will be a collaborative effort with OpenAIRE which is currently developing a European Open Science Observatory, and will be based on existing efforts, i.e., the Open Science Monitor Framework developed in the EOSC pilot project, the DG-RTD Open Science Monitor, FAIR tools, TRIMIS. The TOPOS observatory will follow the specifications of the Open Science Monitor Framework with the proper modifications to the difficulties and the complexity of promoting Open Science in transport. To this end, new

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[19] eoscsecretariat.eu (2020). EOSC Strategic Research and Innovation Agenda Version 0.9. Retrieved from: https://eosc.eu/sites/default/files/EOSC-SRIA-V1.0_15Feb2021.pdf. Last Access: 7th April 2021.

[20] Be Open (2021). D3.2 TOPOS Development. Retrieved from:https://beopen-project.eu/storage/files/beopen-d32-topos-development.pdf. Last Access: 7th April 2021.

[21]topos-observatory.eu (2021).Home. Retrieved from: https://www.topos-observatory.eu/ Last access: 7th April 2021

[22]   beopen-project.eu (2021). TOPOS development. Retrieved from: https://beopen-project.eu/storage/files/beopen-d32-topos-development.pdf Last access: 7th April 2021.

schemes for membership and governance will be utilized and a portal area will be included to gather all research results.

Figure 7 The structure of TPO TOPOS

TOPOS include various transport related publication. Some of the categories are shown at the Word cloud, in Figure 8.

Figure 8 Word cloud Categories for TOPOS[19]

To support the adoption of the guidelines, OpenAIRE provides technical support (help desk and tutorials) and a validator service for the automatic verification of the compliance of the exported records with the guidelines. If applicable, the content provider can give the consent to OpenAIRE to also collect the full-texts of Open Access publications: OpenAIRE will run its full-text mining algorithms to further enrich metadata records with links to projects, publications, datasets, software, organisations, research infrastructures and terms from standard classification schemes.[23]

TOPOS is an important environment for statistics and OSTR data. Therefore, it plays a vital role for measuring the success and implementation of Open Science in the transport sector, e.g. in terms of its adoption through the community. There are some altmetrics – alternative metrics, used in TOPOS for measuring societal impact and to foster Open Science. The list of available altmetrics in TOPOS is listed at Figure 9.

Organisations
- Publication
- Research data
- Software
- Other research

Individuals
- Publication
- Views
- Reputation score

Forum
- Road
- Air
- Rail
- Water
- Multimodal
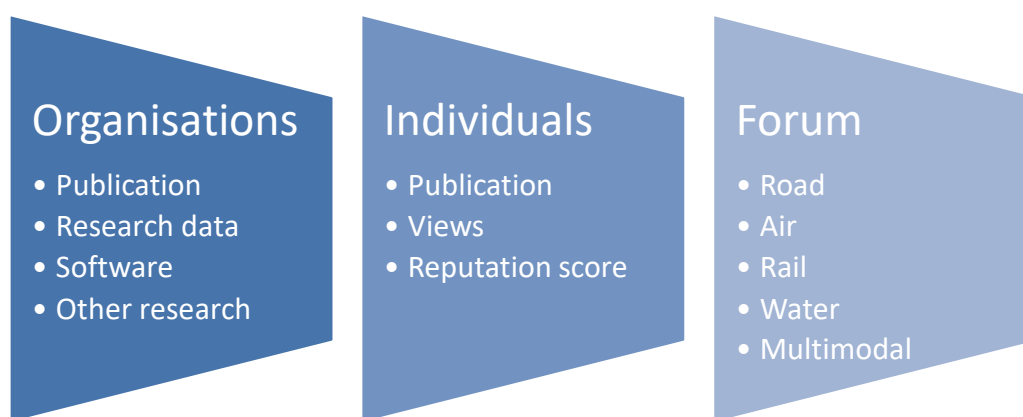
Figure 9 TOPOS Categories for Altmetric

The TOPOS altmetrics are being managed by OpenAIRE EXPLORE portal and the gateway, which monitors their content in terms of access (via the OpenAIRE UsageCounts service4) and statistical indicators, as follows:

- Usage Counts: usage statistics about the research products aggregated from the providers. The example in figure 11 only shows counters for the "OpenAIRE views", that is the number of accesses to the research products of the provider in the OpenAIRE portals (EXPLORE or any of the gateways).
- Statistics (See Figure 11, 12, 13): graphs and charts about the results aggregated from the content provider (Research results per year, per type, per funder, per projects).

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[23] beopen-project.eu (2021). TOPOS development. Retrieved from: https://beopen-project.eu/storage/files/beopen-d32-topos-development.pdf Last access: 7th April 2021.
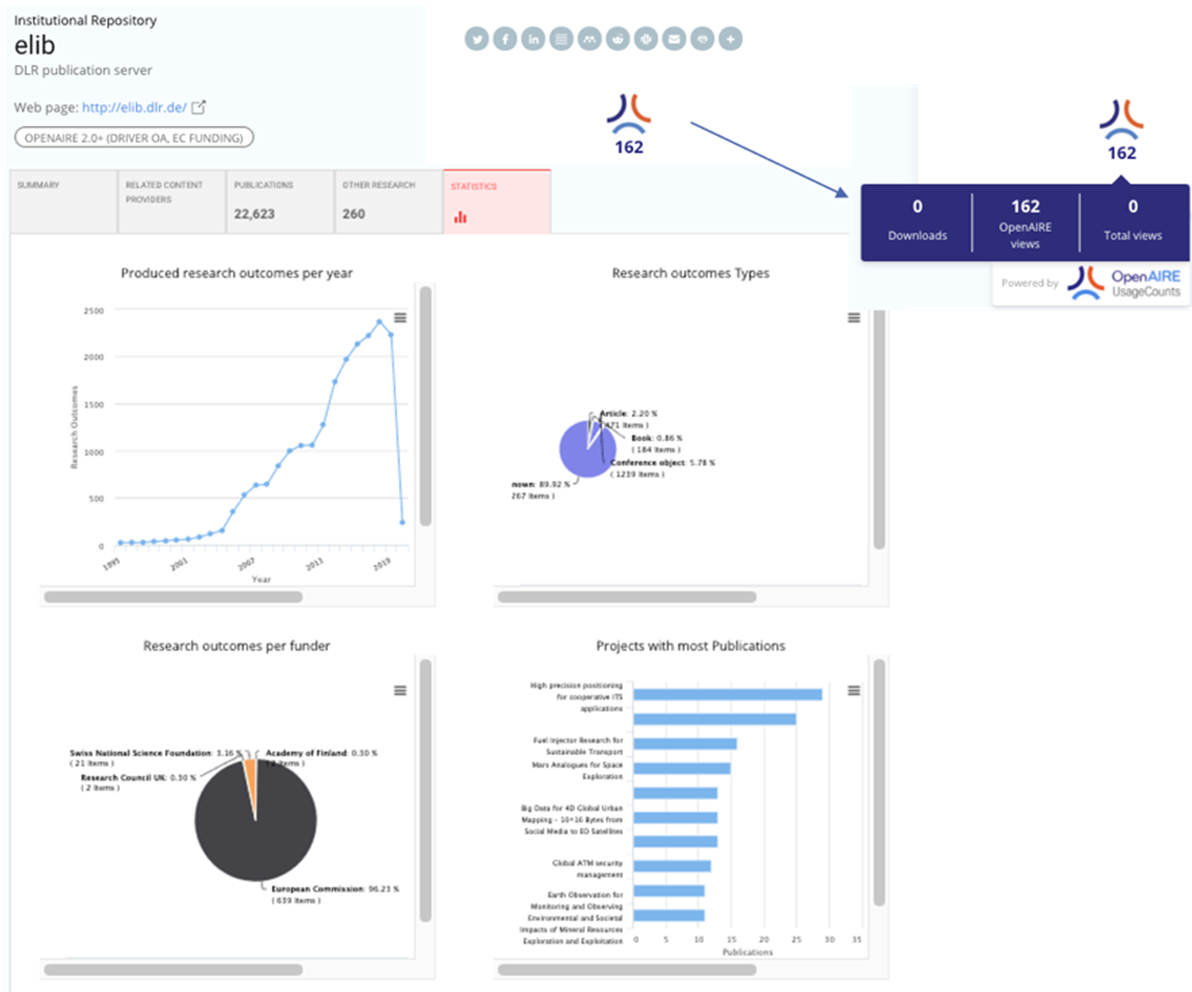
Figure 10 Example Dashboard of a repository of DLR [24]

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[24] Be Open (2021). D3.2 TOPOS Development. Retrieved from: https://beopen-project.eu/storage/files/beopen-d32-topos-development.pdf. Last Access: 7th April 2021.
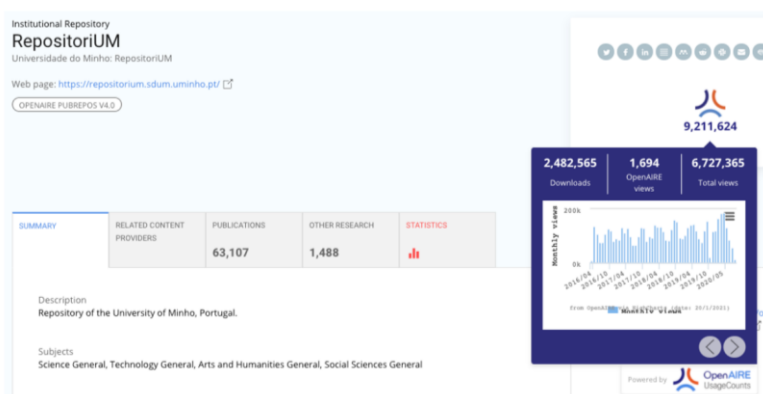
Figure 11 Repositorium of Universidade do Minho[25]
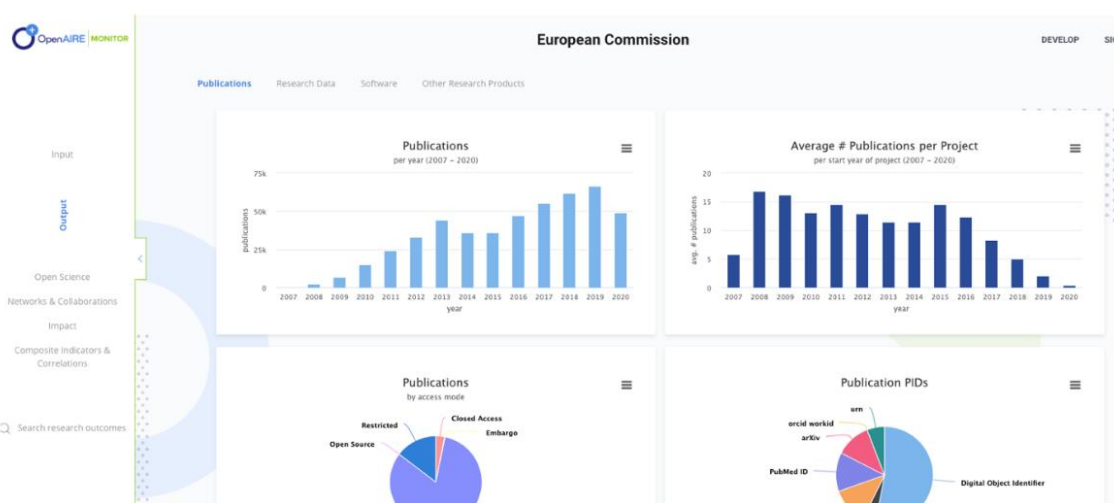
Figure 12 Dashboard of publications of EC[26]

The TOPOS Observatory for Individuals has analytical information about views of the contents of transport research, number of total publications and total citations to the TOPOS Observatory publications (the total citations are obtained from Web of Science Core Collection). Analytical information about views of the contents is show in different formats giving an overview of the impact of the publications:

- Views by country
- Views by month
- Data evolution
- Total reputation score of members
- Total publications
- Total views of members publications
- Total citations to the members publications

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[25] ibid.
[26] ibid.

Figure 24: Views by country
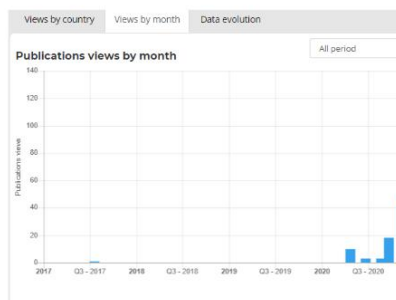
Figure 25: Views by month
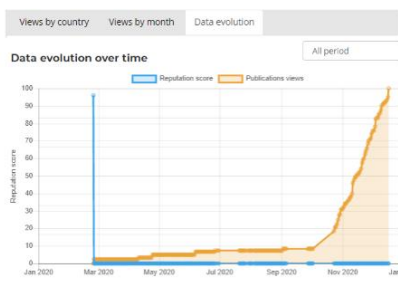
Figure 26: Data evolution
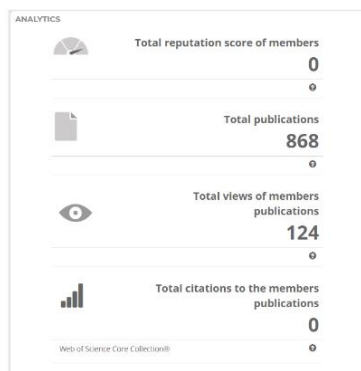
Figure 27: Publications analytics

Figure 13 Analysis of views (year, month,…)[27]

The information gathered in TOPOS includes mainly altmetrics and the statistics should be used to monitor the overall attractivity of TOPOS for Organisations and Individuals as well as the usage of Forum, based on the started discussions, on mode of transport. Regulatory monitoring system should put in place to analyse the collected data and establish the trend.

Beside altmetrics which give information on the usage of TOPOS Observatory and Forum, overall Key Performance Indicators need to be developed and proposed to measure Open Science integration into transport research data. Therefore, EOSC plays a vital role as the goals is to create synergies and harmonisation of available data. For successful development of Key Performance Indicators in the sector, the matching could be done by objectives of TOPOS together with opportunities of Open Science research data and analysing the recommendations for Key Performance indicators from EOSC SRIA.

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[27] ibid.

2.5 Open Science Barriers, Opportunities and Challenges (D5.1)

For effective implementation of transport research data in an Open Science environment, there are several challenges and barriers to overcome, but it also offers many opportunities. The list of Open Science Research data barriers, challenges and opportunities were identified in the BE OPEN D 5.1. The main challenges identified are shown on the figure 14[28]:

Open Science in transport companies and organisations

Barriers	Challenges	Opportunities
-Time consuming - Sensitive information of data - Ethical concerns - Data misuse - Missing publication - Marketizasition Competition	- Resources and organisational issues; - data quality and timeliness issues - Standards and formatting issues; - marketing issues related to making the open data known and addressing the branding issues - technical issues - cost	- Data sharing - Models and methods sharing and improvement - Exchange knowledge - Validation of data - Good practices - Collaboration of researchers - Visibility of results -Enhance the reputation of researchers

Figure 14 Open Science barriers, challenges and Opportunities

For the KPIs development Open Science in transport research data opportunities and challenges have been analysed in a way to categorise the KPIs by "field of purpose" and propose measurable criteria.

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3 KPI for Open Science in transport research

3.1 KPIs for performance measurement of OS initiatives in transport research

Measuring the performance of the current actions and policies using proper KPIs evaluates their impact assessment supporting decision making regarding OS in transport research. The KPIs evaluate comprehensively the performance of the applied actions and policies, and quantify the criteria of end users for promoting OS in transport research. The proposed KPIs are defined to assess the different criteria of both private and public stakeholders.

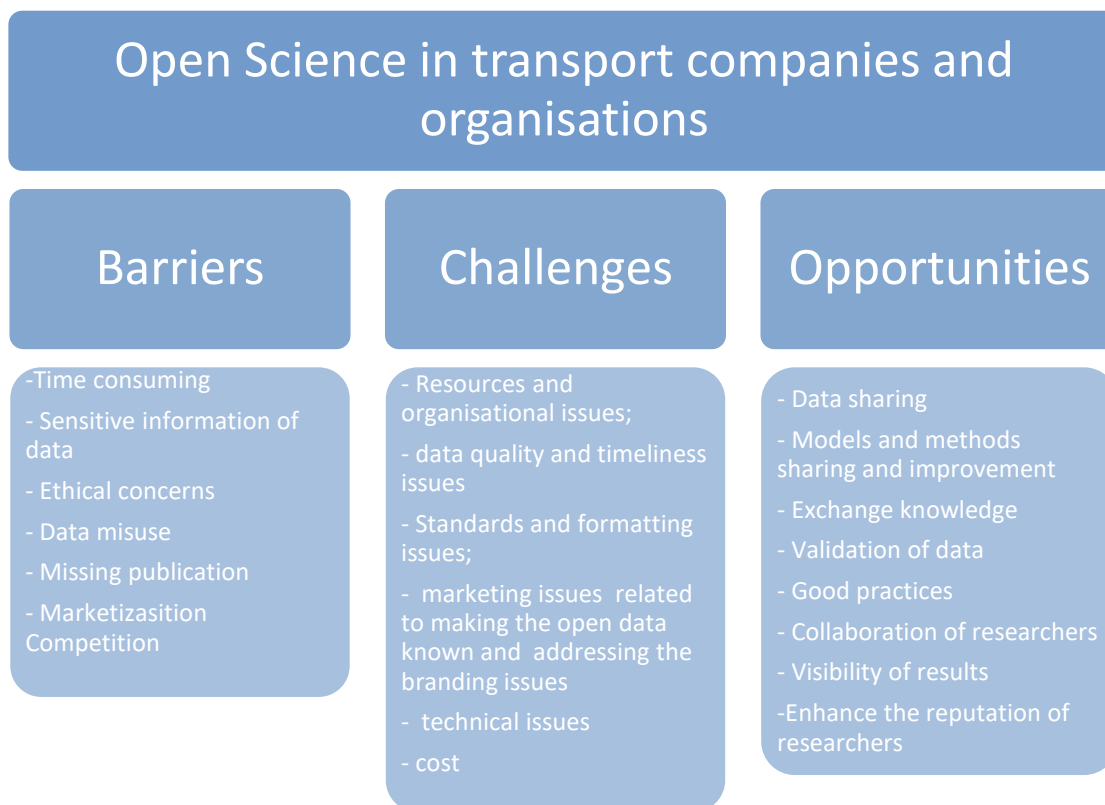Open Science data Monitoring (OSM) – standing for provision of data and insights to support the implementation process – should also be considered in Transport research Data. We need to develop indicators, general as well as area specific, to monitor the implementation of the policies. This is not an easy task due to fragmentation and quantity of available data.[29]
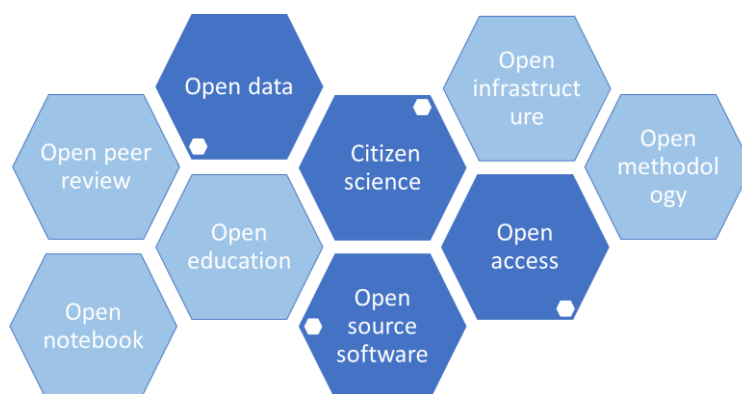
Figure 15 Open Science consist of openness in several different areas[30]

TOPOS Observatory and Forum provide valuable resources and **collaboration** to a wide range of users (individuals and organizations) in transport research from the public and private sector. They enhance **visibility of results** as well as the **reputation of individual researchers** presenting their citations, defining a reputation score and presenting the total number of their views. In addition to the TOPOS tool developed within BE OPEN project, the TRIMIS tool is another **good practice** of Open Science in transport research even though it covers only research outcomes of the Strategic Transport Research and Innovation Agenda (STRIA).

The **models and methods sharing and improvement** are determined by the TOPOS interoperability which supports a wide range of sources in transport research such as publications, research data, software and other as well as by the TOPOS Forum which supports collaborative ways of working and

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[29] ec.europa.eu (2019). OPEN SCIENCE MONITORUPDATEDMETHODOLOGICAL NOTE. Retrieved from: https://ec.europa.eu/info/sites/info/files/research_and_innovation/knowledge_publications_tools_and_data/documents/open_science_monitor_methodological_note_april_2019.pdf Last access: 7th April 2021.
[30] Be Open (2021). D5.3 Impact assessment of Open Science in transport. In print.

exchange information among transport researchers in Europe. **Exchange knowledge** specifies the total number of researchers who are incentivized to perform Open Science in transport sector and how TOPOS tool makes European transport research increasingly discovered and reused. The **validation of data** of TOPOS tool is ensured as the available research data were produced by publicly funded research in Europe which are officially approved by the funding agencies.

The identified opportunities and barriers, BE OPEN Task 5.1 are reallyespecially important as they give valuable input to policy makers to provide/ develop/ publish/ support the community by supplying recommendations: the so- (policy drivers). To foster Open Science, it is important to tackle the issues with emphasis on market exploitation of research which could be an de-accelerator to the establishment of OS.

Thus, the proposed KPIs have been built upon BE OPEN D5.2 where the challenges, opportunities and barriers were identified and analysed. The goal of KPIs is to develop a set of metrics which are aimed to measure and monitor Open Science implementation in the transport (research data) sector. Based on that, a short summary of the most important barriers, challenges and opportunities is concluded on the following picture.

3.2 Key stakeholders

Criteria of stakeholders

In an attempt to monitor and assess the performance and the validity of implementing initiatives (i.e. actions and policies) of OS in a systematic way, a two-step methodology is defined to ensure the relevance to as well as the commitment of the relevant stakeholders. Criteria that could be quantified by proper KPIs are developed in order to support monitoring and evaluation. Within the evaluation stage, performance measurements will be utilized to revise properly actions and policies based on the results derived from the KPIs supporting decision making regarding OS in transport research.
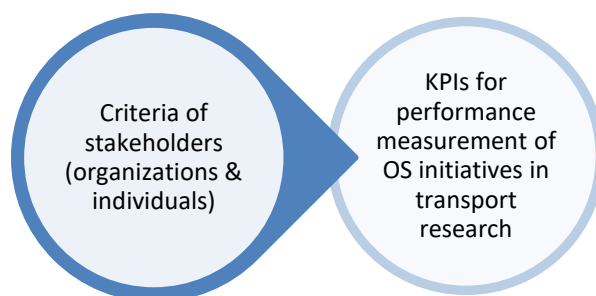
Figure 16 Methodology for assessing OS initiatives in transport research

The end users in transport research involve both individuals and organizations. The priorities of transport stakeholders address the needs and objectives of end users in transport research sector. In more detail, organizations could be either private or public and there are 3 main different categories

which represent industry, research community and society by summarizing the criteria for promoting OS in transport research linked to the mentioned categories of end users. The proposed criteria are based on the opportunities of OS at national and institutional level in Europe as they are presented in the deliverable 5.1 of the BE OPEN Project[31.]
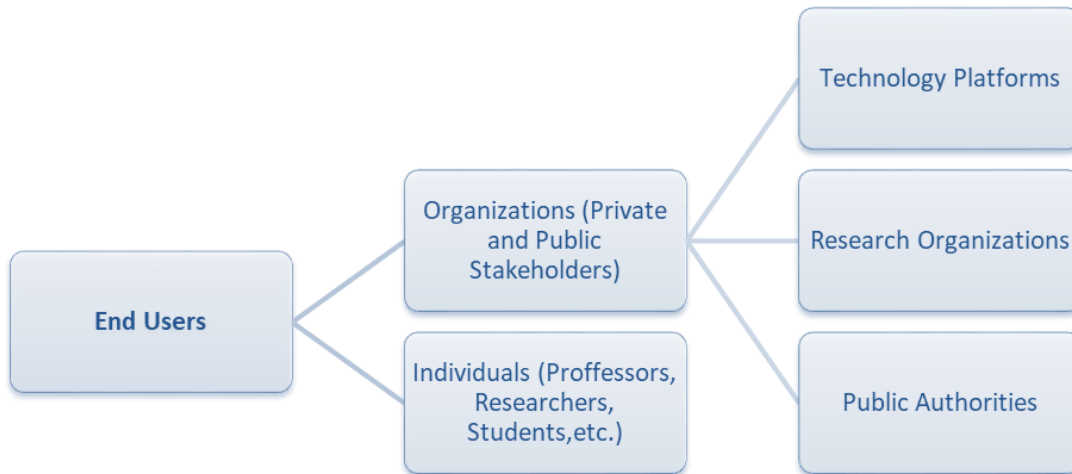
Figure 17 Different categories of end users

Individual users are displayed at figure 18.[32]
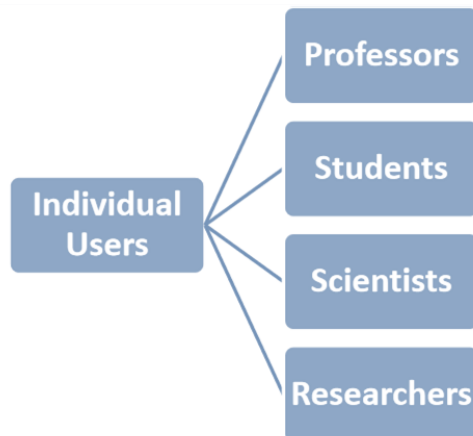
Figure 18 Individual users

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[31] beopen-project.eu (2020). Main challenges and opportunities, constraints and bottlenecks of Open Science in transport research. Retrieved from: https://beopen-project.eu/storage/files/beopen-d51-main-challenges-and-opportunities-constraints-and-bottlenecks-of-open-science-in-transport-research.pdf Last access: 7th April 2021.

[32] beopen-project.eu (2020). TOPOS Declaration. Retrieved from: https://beopen-project.eu/storage/files/beopen-d31-topos-declaration.pdf Last access: 7th April 2021.

3.3 Challenges and opportunities oriented KPIs

3.3.1 Opportunities/Operational (oriented) KPIs

Concerning KPIs for TOPOS, criteria for Stakeholders were defined, based on the Open Science in transport research opportunities, defined in D5.1[33]. KPIs are then conceived as a set of performance measurements demonstrating how effectively TOPOS is achieving key objectives per year. The definition of KPIs will focus on the challenges and opportunities. The barriers do not contain aspects that could be turned into defined indicators.

Open Science in transport companies and organisations

Barriers	Challenges	Opportunities
-Time consuming - Sensitive information of data - Ethical concerns - Data misuse - Missing publication - Marketizasition Competition	- Resources and organisational issues; - data quality and timeliness issues - Standards and formatting issues; - marketing issues related to making the open data known and addressing the branding issues - technical issues	- Data sharing - Models and methods sharing and improvement - Exchange knowledge - Validation of data - Good practices - Collaboration of researchers - Visibility of results -Enhance the reputation of researchers

Figure 19 Barriers, Challenges and opportunities of OS at national and institutional level

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[33] beopen-project.eu (2020). D4.2 TransportOpen Data: Properties and Specifications for Open Science. Retrieved from: https://beopen-project.eu/storage/files/beopen-d42-transport-open-data-properties-and-specifications-for-open-science.pdf Last access: 7th April 2021.

	End Users			
		Organizations		
	Individuals	*Technology Platforms*	*Research Organizations*	*Public Authorities*
Criteria	Data sharing	Data sharing		
	Models and methods sharing and improvement	Models and methods sharing and improvement		
	Exchange knowledge	Exchange knowledge		
	Validation of data/sources	Validation of data/sources		
	Good practices	Good practices		
	Collaboration of researchers	Collaboration of research organizations		
	Visibility of results	Visibility of results		
	Enhance reputation of researchers	Enhance reputation of research organizations		

Table 5 KPI examples based on assumed stakeholder relevance

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of action	**KPI**	**Motivation (What & Why)**
Data sharing	Transport researchers performing publicly funded research make relevant results available, as openly as possible.	• Number of authors in TOPOS • Number of projects being published	Number of authors in transport research, who make data openly available, by monitoring the increase per year.
	Associations of transport research sector performing publicly funded research make relevant results available, as openly as possible.	• Number Associations • Number of projects by associations	Number of Associations in Transport research, who make data openly available, monitoring by increase per year.
	Research organizations of transport research sector with	• % of data FAIR compliant	For measuring the % of FAIR data, the recommendations for FAIR data principles need to

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of action	**KPI**	**Motivation (What & Why)**
	formal standards for data sharing and reuse.		(Chapter 2.3) the following criteria should be met[34]: F- assigned PID A – metadata available I – compatible data format (pdf or other R – data format can be reused
		• Number of FAIR standards approved by year	
Models and methods sharing and improvement	a) TOPOS Observatory supports the interoperability of a wide range of sources in transport research such as publications, research data, software and other. b) TOPOS Forum supports collaborative ways of working and exchange information among transport researchers in Europe.	• Number of various publications in The TOPOS Observatory • Number of users for TOPOS Forum and number of contributions	Measuring (yearly) different publications, for example research data, software and other. Measuring (yearly) the number of registered users and contributions in the TOPOS Forum

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[34] go-fair.org (2016). Fair Principles. Retrieved from: https://www.go-fair.org/fair-principles/ Last access: 7th April 2021.

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of action	**KPI**	**Motivation (What & Why)**
Exchange knowledge	Researchers are **incentivized** to perform Open Science in transport sector	• Existence of a contribution rating system • Number of Credentials (ECTS, EOSC specified credentials) delivered through OS training activities.	Creating a possibility to rate the contributions How often the TOPOS publication/ from a user was cited Number of ECTS/ credentials
	Strengthen the exchange within the community of European transport research in line with the objective of Horizon Europe to foster Open Science	• Number of uploads in the context of projects granted by the EC (e.g. Horizon Europe) & views by EU-projects participants	Number of uploads of projects granted by EC each year
	European transport research is increasingly discovered and reused as a result of TOPOS tool.	• Number of views and citations of TOPOS content	Yearly increase of number of views and citations of TOPOS content
Validation of data	Transport Research data produced by publicly funded research in Europe are valid by default and TOPOS includes this information.	• Number of publicly funded projects listed/ published in TOPOS • Number of publicly funded openly available datasets	Establishing central source (TOPOS) for validated data from publicly funded research per year

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of action	**KPI**	**Motivation (What & Why)**
Good practices (guidelines)	TOPOS follows **Transport Research and Innovation Agenda (STRIA) that outlines future transport** research and innovation (R&I) priorities to decarbonize the European transport sector.	- Number of publication uploads in the areas of the STRIA - Number of access for a publication - Number of transport-based publication (air, road, rail, maritime, multimodal)	TOPOS - effectiveness for research - Researchers can upload – central "database" - Central "database" for information research
	TOPOS tool is operational and provides relevant services, information and data to support transport researchers.	Survey among community	TOPOS provides services to support transport research activities.
Collaboration of researchers	**TOPOS Observatory** is a valuable resource to a wide range of users (individuals and organizations) in transport research from the public and private sector.	- Overall number of users - number of PPPs created through the Forum (projects, MoUs, agreements) - number of citations of TOPOS publications % of publication from open PPP results	Monitoring the increase of number of TOPOS users and the number of citations of TOPOS publications. Indicator that defines the analogy of open source datasets/results coming from completed or ongoing PPP projects
	TOPOS Forum is a valuable collaboration tool to a wide range of users (individuals and organizations) in transport	Number of registered individuals and number of	Monitoring number of different users in TOPOS Forum for

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of action	**KPI**	**Motivation (What & Why)**
	research from the public and private sector.	registered organisation	supporting researchers finding new collaboration partners
Visibility of results	TOPOS is populated with valuable interoperable information and data about transport research.	• Number of TOPOS publications with readership activity • Number of citations	Monitoring user activity and the number of citations to evaluate TOPOS visibility per year
Enhance reputation of researchers	TOPOS supports researchers to enhance reputation.	• Number of citations	Measuring the citation and analyzing the score and number of views we can value the TOPOS attractivity to enhance reputation of researchers.
		• Reputation score	A score can be invented through the community

Table 6 KPIs for performance measurement of OS in transport research

3.3.2 Strategic (oriented) KPI-s to react to challenges

Furthermore, for Operational KPIs, such as identifying proper KPIs for TOPOS, there are also strategic KPIs needed to be listed, to measure the Open Science implementation in transport Research. This could be done by monitoring the challenges/ developing KPIs to monitor the Challenges/ How successful originations are by overcoming the challenges for Open Science in transport research.

There is a need for an integrated approach of Open Science Monitoring. Therefore, Transport Research Data KPIs have been developed in coherence with EOSC.

Open Science in transport companies and organisations

Barriers	Challenges	Opportunities
-Time consuming - Sensitive information of data - Ethical concerns - Data misuse - Missing publication - Marketizasition Competition	- Resources and organisational issues; - data quality and timeliness issues - Standards and formatting issues; - marketing issues related to making the open data known and addressing the branding issues - technical issues	- Data sharing - Models and methods sharing and improvement - Exchange knowledge - Validation of data - Good practices - Collaboration of researchers - Visibility of results -Enhance the reputation of researchers

Figure 20 Barriers, Challenges and opportunities of OS at national and institutional level

In order to monitor Open Science implementation in transport research data and to propose proper KPIs to measure the success, the identified challenges were used for categorization and for main focus, as to overcome the challenges is the most important part. This has been pursued by identifying and monitoring the process for finding solution for challenges.

For assessment of the successful implementation of the Open Science in the transport research, the TOPOS Observatory and TOPOS Forum are good tools to measure the proposed KPIs. In addition, the stakeholders – as main users – are also playing a vital role whereas the resources and organizational issues are one of the main challenges to consider. Monitoring the implementation of Open Science in organizations ensures the successful OS implementation in the transport sector. Due to complex nature of transport research data, not all the challenges are being analysed and included in the list of developed KPI-s. The Task 5.2 team concluded that the main challenges is related to resources and

organizational issues, as well as this is one of the main influencers for the TOPOS Observatory and Forum and should be monitored. **Main challenges** are described in the following table (see table 7):

Categories	Challenges
1. Resources and organizational issues	Qualified staff, available software, reputation of researchers, exchange knowledge, cooperation, recognition, Co-authorship to other researchers' publications using their data, cost
2. Marketing for making the open data known and addressing branding issues	Models and methods for information sharing, format of publication, database design, DOI, IPR

Table 7 Challenges for Open Science implementation

The following KPIs are addressing the challenges just illustrated (see table 8):

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of Action	KPIs[35]	Measuring/Motivation
Resources and organizational issues	Open Science implementation in organization: available Process and qualified staff	• Number of organisation with a process in place for integrating Open Science activities.	Training researchers in Open Science principles and methods; Developing curricula and programs in Open Science methods, including Open Science data management; Raising awareness and understanding in Open Science in undergraduate and "Does your organization have a process in place for integrating Open Science activities?" (y/n) masters programs.
		• Number of organisations of continuous training process for Open Science experts	"Do you have continuous training process for Open Science experts?" (y/n)
		• Number of organisations with a process in place to support	Mentoring and encouraging others in developing their open science

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[35] eoscsecretariat.eu (2020). Open Consultationfor the Strategic Research and Innovation Agenda. Retrieved from: https://www.eoscsecretariat.eu/sites/default/files/open_consultation_booklet_sria-eosc_20-july-2020.pdf . Last access: 7th April 2021.

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of Action	KPIs[35]	Measuring/Motivation
		Mentoring and Supervision in Open Science • Number of researchers taking part in a mentoring/supervisor program for Open Science (How many participants in mentoring/ supervision program/per year	capabilities/ Supporting early stage researchers to adopt an open science approach. "Do you have a process in place to support Mentoring and Supervision for Open Science" (y/n)
	FAIR metrics & certification	• Commonly agreed stamp/certification for repositories containing above X % of OS tools and open/FAIR data • % of transport research organizations/associations have policies which require FAIR principles to be implemented via a defined Data Management Plan • % of transport research organizations/associations have FAIR datasets deposited in their repositories (or ones they use) • % of transport research organizations/associations have FAIR datasets deposited in their repositories (or ones they use)	FAIR standards approval by transport research organizations Establishing open and fair in organisational repositories
	Promotion	• Number of dissemination channels (website, portals, blogs, social media channels, open repositories, etc.) used to promote organization's open transport research activities	Communication tools used for open dataset/publications/software promotion

Category	Performance Measurement of OS in Transport Research	Indicator	Description
	Field of Action	**KPIs[35]**	**Measuring/Motivation**
		• Number of mentions of TOPOS in social media • Number of transport research publications mentioned in social media	
		Number of overall events promoting OS in transport research initiatives	Thematic OS workshops for a specific transport mode/competence area could be organized.
Marketing for making open data initiative known and addressing branding issues	**Ensure Data Ownership and IPR[36]**	Number of TOPOS datasets which are compatible with EOSC licensing model	To ensure data ownership and IPR for Transport Research Data following aspects need to be measured to ensure compatibility with EOSC Licensing model Increase/yearly
	Opening up commercial information in the public interest.	% of data related articles yearly published by transport organizations	To monitor the development of open innovation and foster applied science transparency in Europe, it would be possible to measure the articles and data sets that contains commercially relevant information of public interest
		Number of organisations making data sets publicly available	

Table 8 KPIs addressing challenges of Open Science in transport research

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[36]   publications.jrc.ec.europa.eu.   (2017).   IPR,   Technology   Transfer   &   Open   Science.   Retrieved from:https://publications.jrc.ec.europa.eu/repository/bitstream/JRC106998/kj1a28661enn.pdf Last access: 7th April 2021

3.4 Recommendations for operational and strategical KPIs

Transport sector deals with complex, large amount of data whereas the challenge is to harmonise and create synergies among different transport sectors and platforms to enable successful implementation of Open Science. International initiatives like the Open Science Policy Platform (OSSP) and the European Open Science Cloud (EOSC) SRIA are working on guidelines for efficient implementation of Open Science as well as developing examples and recommendations for possible KPIs. The OSPP stresses the need of developing qualitative and quantitative indicators and highlights the importance of monitoring, learning and resource allocation. The EOSC objectives are to create transparency in the overall system and guarantee sustainability by establishing a common set of standards and fostering the collaboration through best practices sharing. International initiatives and the role of Open Science metrics to monitor the development of scientific system at all levels and measuring the performance for rewarding purposes have constituted the basis for the current deliverable that should be considered as a starting point for developing an effective monitoring system for Open Science monitoring in transport sector.

In the transport sector, the main objectives are to engage stakeholders and to create synergies among them. TOPOS is a practical tool which aims to create a solid knowledge base on the implementation of Open Science approaches and therefore a key factor for accommodating Open Science monitoring process. Different altmetrics, based on the stakeholders are included in the TOPOS. For example, view of publication, reputation score etc. In addition, usage counts based on country and by date are being included as well as total views and citations. By regular monitoring mentioned altmetrics, it is possible to monitor the popularity of the tool and in case of change of numbers, act to ensure the continuity and popularity of the tool. In addition to altmetrics, initial list of operational KPIs for TOPOS and overall, strategic KPIs were developed to further monitor the Open Science implementation and to ensure the continuity in the sector. To ensure the synergies with the European Open Science Cloud activities, the recommended KPIs in EOSC SRIA were followed. Based on that the contributors of the D5.2 agreed on following initial list, Table 9, of operational KPIs for TOPOS:[37]

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[37]eoscsecretariat.eu (2020). Strategic Research and Innovation Agenda (SRIA) of the European Open Science Cloud (EOSC). Retrieved from: https://www.eoscsecretariat.eu/sites/default/files/eosc-sria-v09.pdf Last access: 7th April 2021

Name	Description	KPI	Measuring
KPI1	1. Number of transport researchers performing publicly funded research make relevant results available, as openly as possible.	1.1 Number of authors in TOPOS 1.2 Number of projects being published	Number of authors/projects in transport research, who make data openly available, by monitoring the increase per year.
KPI2	2. Number of associations of transport research sector performing publicly funded research make relevant results available, as openly as possible.	2.1 Number Associations 2.2 Number of projects by associations	Number of Associations in Transport research, who make data openly available, monitoring by increase per year.
KPI3	3. Number of research organizations of transport research sector with formal standards for data sharing and reuse.	3.1 % of data FAIR compliant	For measuring the % of FAIR data, the recommendations for FAIR data principles the criteria of table 4 should be met[38] Increase/yearly
KPI4	4. TOPOS Observatory supports the interoperability of a wide range of sources in transport research such as publications, research data, software and other.	4.1 Number of various publications in The TOPOS Observatory 4.2 Number of users for TOPOS Forum and number of contributions	Measuring (yearly) different publications, for example research data, software and other. Measuring (yearly) the number of registered users and contributions in the TOPOS Forum
KPI5	5. Researchers are **incentivized** to perform Open Science in transport sector	5.1 Existence of a contribution rating system 5.2 Number of Credentials (ECTS,	Creating a possibility to rate the contributions

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[38] go-fair.org (2016). Fair Principles. Retrieved from: https://www.go-fair.org/fair-principles/ Last access: 7th April 2021.

		EOSC specified credentials) delivered through OS training activities.	How often the TOPOS publication/ from a user was cited Increase/yearly
KPI6	6. Transport research data produced by publicly funded research in Europe are valid by default and TOPOS includes this information.	6.1 Number of publicly funded projects listed/ published in TOPOS 6.2 Number of publicly funded openly available datasets	Increase/yearly
KPI7	7. TOPOS contributes to the implementation of **Transport Research and Innovation Agenda (STRIA) that outlines future transport** research and innovation (R&I) priorities to decarbonise the European transport sector.	7.1 Number of publication uploads in the areas of the STRIA 7.2 Number of access for a publication 7.3 Number of transport-based publication (air, road, rail, maritime, multimodal)	In order to find out how much TOPOS contributes to the decarbonisation of the transport sector, the number of publications that cover topic of STRIA, the number of their accesses as well as the coverage of publications per mode is measured Increase/ yearly
KPI8	8. TOPOS is populated with valuable interoperable information and data about transport research.	8.1 Number of TOPOS publications with readership activity 8.2 Number of citations	Monitoring user activity and the number of citations to evaluate TOPOS visibility per year

Table 9 List of Operational KPI's

In addition to operational KPIs, strategic KPIs were developed, based on the recommendation of OSSP and EOSC, which were considered as an important area in the Open Science. Furthermore, the specific challenges, listed in the transport sector were included in the analyses. Following two main categories were considered in the analysis: Resources and organizational issues and Marketing for making open data initiative known and addressing branding issues, as they are an important factor for transport sector. Based on that, a comprehensive list of KPIs was developed but in order to enable to monitor the Open Science implementation. The recommended strategical KPIs are listed in the table 10.

No.	Description	KPI	Measuring
KPI9	9. Open Science implementation in organization: available Process and qualified staff	9.1 Number of organisation with a process in place for integrating Open Science activities. 9.2 Number of organisations of continuous training process for Open Science experts 9.3 Number of organisations with a process in place to support mentoring and supervision in Open Science 9.4 Number of researchers taking part in a mentoring/supervisor program for Open Science	Increase/yearly No. Organisation process implemented (y/n) participants in mentoring/ supervision program/per year
KPI10	10. FAIR metrics & certification - FAIR standards approval by transport research organizations	10.1 Commonly agreed stamp/certification for repositories containing above X % of OS tools and open/FAIR data 10.2 % of transport research organizations/associations (on general) have policies which require FAIR principles to be implemented via a defined Data Management Plan 10.3 % of transport research organizations/associations have FAIR datasets deposited in their repositories (or ones they use) 10.4 % of transport research organizations/associations have FAIR datasets deposited in their repositories (or ones they use)	Increase/yearly
KPI11	11. Ensure Data Ownership and IPR[39]	11.1 Number of TOPOS datasets which are compatible with EOSC licensing model	Increase of number / yearly

Table 10 List of Strategical KPI's

Stakeholders are playing a central role for implementation of the Key Performance Indicators as they are the data providers and users. Therefore, before establishing final list of KPI-s, workshops are recommended to initiate the discussion among the interest groups to ensure the synergies and to establish functional list of KPI-s. For monitoring the KPI-s, the TOPOS tool could be used.

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[39] publications.jrc.ec.europa.eu. (2017). IPR, Technology Transfer & Open Science. Retrieved from:https://publications.jrc.ec.europa.eu/repository/bitstream/JRC106998/kj1a28661enn.pdf Last access: 7th April 2021

4 Conclusions

Open Science is becoming more important and the amount and complexity of data is creating a challenge for the transport sector. To find solutions and to use the opportunities of Open Science in the sector, a set of Key Performance Indicators is needed to be agreed on through the stakeholder community to monitor the overall OSTR development in Europe. The list of KPIs proposed in this deliverable can be a base for the OSTR community to discuss the topic further. Above that, the international initiatives, such as the European Open Science Cloud (EOSC), TRIMIS and the Open Science Policy Platform (OSPP), need to be involved to ensure synergies among national and international levels in the sector.

It can be concluded, that the critical areas for Open Science, which needs to be monitored are: Rewarding system and establishing standards, furthermore the tools and services, which allows researchers to find, access, reuse and combine results. In addition, the availability of infrastructures to store and exchange large amount of data.   To monitor the overall success of Open Science implementation in the transport research data, the deliverable focused on defining an initial list of Key Performance Indicators (KPIs) - a set of performance measurements that demonstrate how effectively key objectives are being achieved. Successful development of the KPIs for the transport sector starts with the main objectives and by listing challenges and opportunities of Open Science in the sector. This makes it possible to realise the critical success factors, which need to be monitored. In the transport sector, the main objectives are to engage various stakeholders – individuals, organisations and research establishments, from transport sector and to create synergies among the transport modes, open science society as well as international and national initiatives. TOPOS is a practical tool which aims to create a solid knowledge base on the implementation of Open Science approaches and therefore a key factor for accommodating Open Science KPI monitoring process in transport sector. Different altmetrics, based on the stakeholders are included in the TOPOS. For example, view of publication, reputation score etc. In addition, usage counts based on country and by date are being included as well as total views and citations. In addition to altmetrics, such as usage counts, number of publications, KPIs for TOPOS had to be developed to measure open science implementation in the transport sector. These KPI-s are covering the functionality and usage of TOPOS. This was done, based on the EOSC SRIA and categorized as operational KPIs. Furthermore, due to identified important challenges in Transport research, strategical KPIs were developed. They are aiming to measure the overall success of Open Science implementation in the transport sector. In order to create extra value for the deliverable, the task 5.2 team was identifying and proposing possible measuring criteria for the operational and strategic KPIs. A comprehensive list of KPIs were developed and the 11 most important KPIs were highlighted, covering the key areas of Open Science. For the successful development and implementation of Key Performance indicators, involvement of all key stakeholders is needed and workshops should be considered to initiate the discussion among stakeholders.