

National Data Governance in the Transport Sector

An International Outlook
and Literature Review

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Kort sammanfattning

Denna rapport syftar till att ge bakgrundsinformation om nationella initiativ runt data kopplat till transportområdet. Syftet är att stödja arbetet med att etablera en nationell grunddatadomän för transportsektorn i Sverige.

Fokus i det pågående arbetet har legat på förvaltning av transportdata och särskilt nationella datamängder.

För att hitta information om nationella datainitiativ genomfördes två parallella informationsinsamlingar. För det första har vi letat efter vetenskapliga publikationer i bibliografiska databaser. För det andra skickades en förfrågan om information inom VTI:s befintliga nätverk, detta inkluderar både andra forskningsleverantörer och myndigheter över hela världen.

Den litteratur som hittades samt de svar som erhöles på utskickad förfrågan är entydiga när det gäller att uttrycka behov av datatillgänglighet som en grundsten för ett framtida transportsystem. De flesta aktörer beskriver behovet av att göra data tillgänglig på ett konsekvent sätt, både för att underlätta nya tillämpningar och för att vara mer effektiva i nuvarande praxis.

I den vetenskapliga litteraturen finns inga initiativ som direkt kan jämföras med den svenska strävan att etablera en transportdatadomän på nationell nivå (Grunddatadomän Transport). Det går också av omvärldsanalysens litteraturstudie konstatera att det verkar vara få som genomfört kostnads- och nyttoanalyser som kvantifierar värdet av en speciell tillämpning i monetära värden. En slutsats av detta är att nyttovärderingar i dagsläget endast kan göras baserat på kvalitativa resonemang snarare än exakta beräkningar.

Nyckelord

Transportdata, grunddata, förvaltning, ramverk.

Abstract

This report aims to provide background information on national efforts to establish and govern data within the transport area. The purpose is to support the work of establishing a national data domain for the transport sector in Sweden.

The focus of the current work has been on transport data, governance of transport data and in particular emphasizing national datasets and national data governance initiatives.

To find information about this a dual approach was used. Firstly, we have looked for scientific publications in bibliographic databases. Secondly, a request for information within the existing networks of VTI was sent out, this includes both other research providers and authorities across the world.

The literature found and the replies from the international outreach are very consistent in the need and potential of handling data more efficiently. Most actors describe the need for making data accessible in a consistent way, both to facilitate new applications and to be more efficient in current practices.

In the scientific literature there are very few if any initiatives that can be directly compared with the Swedish effort to establish a transport data domain on a national level (e.g., Grunddatadomän Transport). Furthermore, there is not much work that quantifies, in monetary values, the cost and benefits of establishing and maintaining data.

Keywords

Transport data, data governance, framework

Preface

This work has been carried out on commission by the Swedish Transport Administration (STA). It is a part of an investigative pre-study looking at possibilities to establish a national transport data domain. We would like to express our gratitude to the project group led by Britt-Marie Calles at the STA, and all the other working group participants from the other transport authorities.

Linköping, February 2022

Jonas Jansson
Project leader

Granskare/Examiner

Jeanette Andersson, VTI.

De slutsatser och rekommendationer som uttrycks är författarens/författarnas egna och speglar inte nödvändigtvis myndigheten VTI:s uppfattning./ The conclusions and recommendations in the report are those of the author(s) and do not necessarily reflect the views of VTI as a government agency.

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1. Introduction

This report aims to provide background information on national efforts to establish and govern data within the transport area. The purpose is to support the work of establishing a national data domain for the transport sector in Sweden.

The Swedish government has set ambitious targets to utilize the possibilities offered by digitalization in society. The goal is to make work within and between authorities more efficient, but also to provide a foundation for new digital services. Thus, providing increased value to citizens, business, and society.

On November 22nd, 2021, the government decided to adopt a national strategy¹ for data governance including six focus areas:

1. Increased access to data
2. Open and controlled data sharing
3. Cooperation and culture
4. Governance regulation and follow-up
5. Research innovation and competence
6. EU and international cooperation

Each focus area has also been assigned goals that are specific and measurable.

The Swedish Agency for Digital Government (DIGG) has been appointed the task to investigate the possibility to establish national data domains within several sectors (DIGG, 2021). This task directly addresses focus area 1 above. One sector that has been selected for further investigation is the transport area. Other areas that are being investigated are Person, Company, and Real estate- and geographic information.

*DIGG describes its overarching goal as follows *To reach Sweden's goal of being the best in the world at leveraging the potential of digitalization an efficient, innovative and data driven public sector is of great importance. DIGG develops building blocks, principles and services that helps the public sector with their digitalization. Through analyses and assignments we assists the Government with proposals for digital policy development. Digitalization is a team sport which means that collaboration is a key word for us at DIGG - collaborating with others to drive developments.*(Translated from Swedish by the authors).*

While DIGG provides the basic framework, the pre-study for a transport data domain is led by the Swedish Transport Administration. The work is performed as a joint co-operation between the Swedish transport authorities including the Swedish Transport Administration, the Swedish Transport Agency, the Civil Aviation Administration (LFV), The Swedish Maritime Administration, Transport Analysis and the Swedish National Road and Transport Research Institute (VTI).

The work presented in this report aims at providing an international outlook on national data initiatives outside of Sweden. The task assigned to VTI is part of the above mentioned pre-study exploring the possibility of establishing a national transport data domain. The assignment to VTI is described as:

...The aim of this external analysis, including a literature study, is to provide guidance on how these issues have been handled in other countries and in particular reviewing applications linked to the transport system. The purpose is also to increase understanding on how other nations view the need for standardized data sets linked to the development of the transport system. How can we, with the

¹ [Ny nationell strategi ska göra Sverige ledande i delning av data - Regeringen.se](https://www.regeringen.se/pressmeddelanden/2021/11/ny-nationell-strategi-ska-gora-sverige-ledande-i-delning-av-data/)

help of national control, and coordination of information, enable future transport systems and secure / efficient information exchanges? (Translated from Swedish by the authors)

The work consists of two main activities:

- 1) Literature review of scientific publications – This activity aims to capture research on data governance within the transport area. The goal is to provide scientific references that support decision making relating to a Swedish transport data domain.
- 2) Outreach to transport actors outside of Sweden, within VTI's network – This activity aims at finding on-going initiatives that has not been documented in scientific publications and to provide advice from other actors.

A benefit analysis is also carried out as a part of the pre-study. Interim results e.g. scientific references has been provided to the consultants carrying out the benefit analysis.

2. Scope

The area of data governance and dealing with data sets is a huge topic and is not a new issue. Certainly, there are a lot of datasets and databases which have been in use for a long time within the transport sector. Therefore, the work presented here, carried out in a limited timeframe and with a fixed budget, cannot claim to be exhaustive or provide a full overview even within the selected scope.

The scope is limited to deal mainly with transport data. Furthermore, data governance on a macro level, i.e. national data governance, is of main interest.

Geographically the aim is to cover the whole world. i.e., we are interested in looking at national attempts to harmonize data in any given country. However, with the used tools and networks the investigation may result in a bias towards Europe, the US and Australia.

The search is mainly oriented to find references in scientific publications. However, a separate effort has also been made to capture on-going work, i.e., national efforts of importance that has not yet been published.

Already from the start the possibility to provide input to the benefit analysis (that was carried out in parallel with this literature review task) was identified. Therefore, a special consideration was finding research that could be used as input to the benefit analysis.

3. Method

The focus of the current work has been on transport data relating to transports data governance and in particular emphasizing national data sets and national data governance initiatives.

To find information about this a dual approach was used. Firstly, we have searched for scientific publications in bibliographic databases. Secondly, we have made an outreach within the existing networks of VTI, including both research providers and authorities across the world

The literature review and the outreach served to give a general overview of initiatives that have been scientifically documented. However, it was also used as an input to the benefit analysis and therefore emphasis was put on work that could be used in this context.

Searches were made in the databases TRID²³.and Scopus. In TRID, the world's largest database on transport research covering both publications and ongoing research, the search was made on "data governance" and "data framework" as well as only "governance" in connection with the subject area "Data and information technology". In Scopus, the world's largest literature database covering all research areas the search was also made on "data governance" and "data framework". Since Scopus covers all topics and not only transport the search was limited to the title and keyword field and also combined with words describing the transport topic. Some of the replies of the outreach also included literature searches, for example in the French HAL science ouverte.

To give an overview of results and make the pursuit of further references a categorization was done. This categorization was based on the initial scan of findings and the ongoing pre-study ("utforskande förstudie Grunddatadomän transport")

The international outreach was carried out by the VTI Library. The library is part of international networks of transport libraries, via Transportation Research Board in USA and also through VTI membership in OECD/ITF. Request for information was sent out to both of these networks and to other contacts like CEDR, BAST, FEHRL and PIARC. Information was also gathered through the European Conference of Transport Research Institutes (ECTRI) network. The e-mail requests for information were sent out in early October 2021. Answers was received during October, November and early December.

² <https://trid.trb.org/>

³ www.scopus.com

4. Results

The literature found and the reply from the international outreach is very consistent in the need and potential of handling data more efficient. Most actors advocate the importance and need for making data accessible in a consistent way both to facilitate new applications and to be more efficient in current practices.

In the scientific literature there are very few, if any, initiatives that can be directly compared with the Swedish effort to establish a transport data domain on a national level (e.g., Grunddatadomän Transport). Furthermore, there is not much work that quantifies, in monetary values, the costs and benefits of establishing and maintaining data.

Based on the selected scope and search dictated by criteria described in the methods part (chapter 3) roughly 100 scientific publications were selected for inclusion and further scrutiny. Responses were received from approximately 10 international organizations (see section 4.2). Below reference to many of these publications divided into the four categories that was chosen.

4.1. Literature review

The selected publications were categorized according to topic in four different groups: costs and benefits; data governance; future transport applications; current applications.

4.1.1. Cost-benefit

The benefit of establishing access to and harmonization of important data is generally believed to be of great value. Quantifying the benefits in monetary values seem to be very difficult though. Potentially the evaluation of costs and benefits for establishing and maintaining open data is both expensive and time consuming. Publications that discuss the value and costs and benefits of transport data are:

(Buddhavarapu et al., 2014; Harrison & Duke, 2021; LAIRD, 2006; Ogle et al., 2019; Vandervalk, Almario, et al., 2017; Vandervalk, Snyder, Almario, et al., 2017a, 2017b; Vandervalk, Snyder, Hajek, et al., 2017; Wilmsmeier & Martinez-Zarzoso, 2010)

4.1.2. Data governance

Effective data governance is in many cases considered a key component to ensure data quality. Open and transparent publishing of data increases utility and also makes data management more efficient at authorities and between different actors.

Methods and standards for data governance is not only an issue within the transport sector and potentially much knowledge could be found in other domains. This search was however restricted to transport and some publications that discusses data governance are:

(Administration, 2015b, 2015a, 2017, 2018; Andraško et al., 2021; Basukie et al., 2020; Bejleri et al., 2006; Bodó, 2021; Butler et al., 2019; Chandler et al., 2016; DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES & GROUP, 2004; Draheim, 2021; Gan et al., 2010; Golightly et al., 2013; Green et al., 2018; Hall et al., 2016; KARL & AUSTRoads, 2006; Landshoff & Polak, 2008; Linåker & Runeson, 2021; Office, 2017, 2020; Rothenberg et al., 2005; Runeson et al., 2021; Salanova Grau et al., 2018; Stickel & Vandervalk, 2014; Vandervalk & Snyder, 2017; Veeneman et al., 2018; Zhou & Golledge, 2007)

4.1.3. Future transport applications

Future applications of emerging technologies may drive the need to provide new data and databases. Such applications include connected and automated vehicles, the use of AI algorithms for a data driven approach to planning, design and controllability on demand (MoD), Mobility as a service

(MaaS), Advanced air mobility, geofencing applications etc. The access to open high-quality data is often mentioned as a foundation for these new services and applications. Scientific papers discussing these applications and issues on data governance are:

Automated vehicles:

(Alonso Raposo et al., 2019; Andraško et al., 2021; Deng, 2021; Fagnant & Kockelman, 2015)

AI:

(Draheim, 2021; Ferrario et al., 2020; Office, 2021)

Connected vehicle and other applications:

(Ferrario et al., 2020; Forum & Forum, 2020; Liu et al., 2016; Office, 2021; Yigitcanlar & Kamruzzaman, 2019)

4.1.4. Current applications

A lot of databases and collection of data has been in operation for several decades. Establishing a national data domain should start with considering which existing datasets and databases that should be included. Scientific publications describing work with existing applications in conjunction with data storing issues are:

(Administration, 2017; Buddhavarapu et al., 2014; Chandler et al., 2016; Polzin et al., 2011; Rajbhandari & Aldrete, 2009; Stewart et al., 2015; TISATO, 2005; Zhou & Golledge, 2007)

4.2. International outreach

The international outreach provided a solid foundation and clearly shows that initiatives to harmonize and make transport data available is ongoing in many countries. Several of the contacts referred to different platforms and websites where data or collection of links to data sites can be found. These links are presented in detail in section below. The picture provided by the e-mail answers is that while many initiatives are taken, and have started, there is much work to be done when it comes to harmonization nationally and internationally. Questions of data ownership, governance, which data to include etc. is still to be resolved in many countries. There are few established, if any, initiatives that can be compared with the Swedish national consideration of a transport data domain “Grunddatadomän Transport”.

In the replies the following organizations are represented

- Conference of European Directors of Roads (CEDR)
- Bundesanstalt für Strassenwesen (BASt)
- Forum of European National Highway Research Laboratories (FEHRL)
- The Australian Road Research Board (ARRB)
- European Conference of Transport Research Institutes (ECTRI)
- The Centre for Research & Technology, Hellas (CERTH)
- Deutsches Zentrum für Luft- und Raumfahrt (DLR)
- World Road Association (PIARC)

Many replies referred to sites where data or links to data are collected. These links, along with some quotes from answers received, are provided below, per region that they referred to.

4.2.1. EU

<https://www.its-platform.eu/>

<https://ec.europa.eu/eurostat/web/main/data/database>

<https://data.europa.eu/>

<https://www.cedr.eu/docs/view/6063289f6eb55-en>

<https://www.cedr.eu/news-data/1656/CEDR-updates-its-TEN-T-Roads-Performance-GIS-Web-Map>

4.2.2. Sweden

<https://www.trafficdata.se/>

4.2.3. Australia

National infrastructure data collection and dissemination plan, Federal Department of Infrastructure, Regional Development and Cities:

https://www.bitre.gov.au/data_dissemination

National Freight Data Hub

<https://www.infrastructure.gov.au/infrastructure-transport-vehicles/transport-strategy-policy/freight-supply-chains/national-freight-data-hub>

iMOVE Australia 2020, *Multimodal Freight Data Exchange - Pilot Projects Summary Report*

https://imoveaustralia.com/wp-content/uploads/2021/08/Freight-Data-Exchange-Pilot-Report_Final.pdf

Transport Network Strategic Investment Tool (TraNSIT)

<https://www.csiro.au/en/research/technology-space/it/Transport-logistics-TRANSIT>

CSIRO 2019. *TraNSIT Web*;

<https://doi.org/10.25919/5ea337397313f>

NSW Open Data Hub The Open Data Hub is the central location for all Transport for NSW open data. TfNSW offers a number of datasets and APIs for all public transport modes and roads. These include static timetable information, as well as live and real time information (feed data).

<https://opendata.transport.nsw.gov.au/>

Austroroads 2019, Opportunities in Mobility as a Service (MaaS),

<https://austroroads.com.au/publications/network/ap-r601-19>

ITS Australia – Future Mobility

<https://its-australia.com.au/future-mobility>

IMove Australia

<https://imoveaustralia.com/>

The Sydney mobility as a service (MaaS) trial: design, implementation, lessons and the future, iMOVE Cooperative Research Centre Sydney, NSW, <<https://imoveaustralia.com/wp-content/uploads/2021/04/iMOVE-Sydney-MaaS-Trial-Final-Report-March-2021.pdf>>.

Future Transport and Mobility Environment, ARRB, <https://f.hubspotusercontent20.net/hubfs/3003125/iMOVE%20FTME%20Final%20Discussion%20Paper%2029Jun2020.pdf>

4.2.4. Greece

in Greece, a National Access Point (NAP) was designed and developed within the European co-financed (CEF 2014-2020) project CROCODILE

<https://nap.imet.gr/>

NAP is a requirement of the European Union, as stated in the Delegated Regulations 885/2013, 886/2013 and 962/2015 that supplement the ITS Directive 2010/40/EU. A new European co-financed (CEF 2014-2020) project NAPCORE is about to begin.

4.2.5. Germany

Where are we coming from? The MDM was based on a joint initiative by the Federal Ministry of Transport and Digital Infrastructure and the Federal Highway Research Institute (BASt). The “Mobility Data Marketplace”. The MDM was based on a joint initiative by the Federal Ministry of Transport and Digital Infrastructure and the Federal Highway Research Institute (BASt). The first idea was born in 2007 as part of the umbrella project ‘Meta data platform for traffic information of private transport’. As part of the Federal Government’s innovation program the MDM was realized and is operated by the Federal Highway Research Institute (BASt).

Mobilitäts Daten Markplatz

<https://www.mdm-portal.de/>

mCLOUD. Das offene Datenportal des BMVI

<https://www.mcloud.de/>

Geoportal

<https://www.geoportal.de/>

Bundesministerium für Verkehr und digitale Infrastruktur, BMVI. Open data

<https://www.bmvi.de/SharedDocs/DE/Artikel/DG/open-data.html>

[Catena-X](#) German Alliance for secure and standardized data exchange in the automotive sector

Catena-X derives from [Gaia-X](#), the European project for an open, transparent and secure digital ecosystem.

<https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/map/maps.html>

Traffic volumes Germany

https://www.bast.de/BASt_2017/DE/Verkehrstechnik/Fachthemen/v2-verkehrszaehlung/zaehl_node.html

https://www.bast.de/BASt_2017/DE/Statistik/Verkehrsdaten/Manuelle-Zaehlung.html

4.2.6. USA

Transit Statistics. American Public Transportation Association

<https://www.apta.com/research-technical-resources/transit-statistics/>

Bureau of Transportation Statistics (bts.gov)

[Bureau of Transportation Statistics \(bts.gov\)](https://www.bts.gov/)

4.2.7. France

PIARC Databook of Roads and Road Transport (2014-2018)

[https://www.piarc.org/en/order-library/29489-en-PIARC%20Databook%20of%20Roads%20and%20Road%20Transport%20\(2014-2018\)](https://www.piarc.org/en/order-library/29489-en-PIARC%20Databook%20of%20Roads%20and%20Road%20Transport%20(2014-2018))

References

- Administration, F. H. (2015a). *Michigan Department of Transportation Safety Data Processes and Governance Practices: Case Study*. <https://rosap.ntl.bts.gov/view/dot/49548>
- Administration, F. H. (2015b). *Utah Department of Transportation Safety Data Processes and Governance Practices: Case Study*. <https://rosap.ntl.bts.gov/view/dot/49549>
- Administration, F. H. (2017). *Connecticut Crash and Roadway Safety Data Management Peer Exchange*. <https://rosap.ntl.bts.gov/view/dot/49574>
- Administration, F. H. (2018). *GIS and Data Governance Peer Exchange Summary Report*. https://www.gis.fhwa.dot.gov/reports/GIS_and_Data_Governance_Peer_Exchange_ARDOT.pdf
- Andraško, J., Hamulák, O., Mesarčík, M., Kerikmäe, T., & Kajander, A. (2021). Sustainable data governance for cooperative, connected and automated mobility in the European Union. *Sustainability (Switzerland)*, 13(19). <https://doi.org/10.3390/SU131910610>
- Basukie, J., Wang, Y., & Li, S. (2020). Big data governance and algorithmic management in sharing economy platforms: A case of ridesharing in emerging markets. *Technological Forecasting and Social Change*, 161. <https://doi.org/https://doi.org/10.1016/j.techfore.2020.120310>
- Bejleri, I., Kim, D., Yang, X., University of Florida, G., & Transportation, F. D. of. (2006). *A New Database Framework for Florida's Transportation Planning: Integrating Work Program, Multimodal Transportation Networks, Planning and Environmental Databases* (Final Report). [http://ftp.fdot.gov/file/d/FTP/FDOT LTS/CO/research/Completed_Proj/Summary_PL/FDOT_BD545_11_rpt.pdf](http://ftp.fdot.gov/file/d/FTP/FDOT_LTS/CO/research/Completed_Proj/Summary_PL/FDOT_BD545_11_rpt.pdf)
- Bodó, B. (2021). Mediated trust: A theoretical framework to address the trustworthiness of technological trust mediators. *New Media and Society*, 23(9). <https://doi.org/10.1177/1461444820939922>
- Buddhavarapu, P., Smit, A. F., Prozzi, J. A., Fan, W., Gurmu, Z., University of Texas, A., University of Texas, T., Transportation, T. D. of, & Administration, F. H. (2014). *Revised Pay Adjustment Factors for HMA and Concrete Pavements* (Technical Report). <http://library.ctr.utexas.edu/ctr-publications/0-6675-1.pdf>
- Butler, J. (AI), Scopatz, R., Anderson, S., Hausman, J., Administration, F. H., & Administration, F. H. (2019). *Applications of Enterprise GIS for Transportation: Guidance for a National Transportation Framework (AEGIST Guidebook)* (Final Report). https://www.gis.fhwa.dot.gov/documents/AEGIST_Guidebook.pdf
- Chandler, B., Smadi, O., Cheema, A., Leidos, I., & Administration, F. H. (2016). *Roadway Data Improvement Program Technical Assistance: Final Project Report* (Final Report). <https://rosap.ntl.bts.gov/view/dot/50493>
- DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES, A., & GROUP, A. T. COUNCIL. N. T. D. W. (2004). *National transport data framework*. <https://trid.trb.org/view/783794>
- DIGG. (2021). *Ramverk för nationella grunddata inom den offentliga förvaltningen*. <https://www.digg.se/globalassets/dokument/publicerat/publikationer/slutrapport-uppdrag-om-saker-och-effektiv->
- Draheim, D. (2021). Data Exchange for Digital Government: Where Are We Heading? ADBIS2021 Keynote. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 12843 LNCS, 7–12. https://doi.org/10.1007/978-3-030-82472-3_2

- Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, 77, 167–181. <https://doi.org/10.1016/J.TRA.2015.04.003>
- Ferrario, A., Loi, M., & Viganò, E. (2020). In AI We Trust Incrementally: a Multi-layer Model of Trust to Analyze Human-Artificial Intelligence Interactions. *Philosophy and Technology*, 33(3). <https://doi.org/10.1007/s13347-019-00378-3>
- Forum, I. T., & Forum, I. T. (2020). *Leveraging digital technology and data for human-centric smart cities: the case of smart mobility*. <https://www.itf-oecd.org/data-human-centric-cities-mobility-g20>
- Gan, A., Liu, K., Wang, T., Research, L. C. for T., & Transportation, F. D. of. (2010). *Development of a Data Framework for the Florida Standard Urban Transportation Modeling Structure (FSUTMS) (Final Report)*. http://ftp.fdot.gov/file/d/FTP/FDOT_LTS/CO/research/Completed_Proj/Summary_PL/FDOT_BDK80_977-04_rpt.pdf
- Golightly, D., Easton, J. M., Roberts, C., & Sharples, S. (2013). Applications, value and barriers of common data frameworks in the rail industry of Great Britain. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, 227(6), pp 693-703. <https://doi.org/https://doi.org/10.1177/0954409713499148>
- Green, M., Lucivero, A., Center, V. N. T. S., & Administration, F. H. (2018). *Data Governance & Data Management Case Study: Case Studies of Select Transportation Agencies (Final Report)*. <https://rosap.nhtl.bts.gov/view/dot/53783>
- Deng, Z. (2021). *Guidance on Risks Related to Emerging and Disruptive Transportation Technologies*.
- Hall, J., Vanasse Hangen Brustlin, I., & Administration, F. H. (2016). *Roadway Safety Data Governance in Illinois: Roadway Safety Data and Analysis Case Study (Final Report)*. <https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa16108.pdf>
- KARL, C., & AUSTROADS. (2006). *A review of road use data integration and management models (Issue AP-R292/06)*. <https://trid.trb.org/view/810407>
- LAIRD, P. (2006). Freight transport cost recovery in Australia. *AUSTRALASIAN TRANSPORT RESEARCH FORUM (ATRF), 29TH, 2006, GOLD COAST, QUEENSLAND, AUSTRALIA, VOL 29*, 13P-13P. <https://trid.trb.org/view/809789>
- Landshoff, P., & Polak, J. (2008). *The National Transport Data Framework Final Report*.
- Linåker, J., & Runeson, P. (2021). How to enable collaboration in open government data ecosystems: A public platform provider's perspective. *EJournal of EDemocracy and Open Government*, 13(1), 1–30. <https://doi.org/10.29379/jedem.v13i1.634>
- Liu, P., Liao, F., Huang, H.-J., & Timmermans, H. (2016). Dynamic activity-travel assignment in multi-state supernetworks under transport and location capacity constraints. *Transportmetrica A: Transport Science*, 12(7), pp 572-590. <https://doi.org/https://doi.org/10.1080/23249935.2016.1189739>
- Harrison, F., & Duke, W. (2021). *NCHRP Implementation Support Program. Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs*.
- Office, U. S. G. A. (2017). *DATA Act: As Reporting Deadline Nears, Challenges Remain That Will Affect Data Quality*. <http://www.gao.gov/assets/690/684382.pdf>
- Office, U. S. G. A. (2020). *Data Governance: Agencies Made Progress in Establishing Governance, but Need to Address Key Milestones*. <https://www.gao.gov/assets/720/711325.pdf>

- Office, U. S. G. A. (2021). *Artificial Intelligence: An Accountability Framework for Federal Agencies and Other Entities*. <https://www.gao.gov/assets/gao-21-519sp.pdf>
- Ogle, J. H., Sarasua, W., Chowdhury, M. (Ronnie), Putman, B., Davis, J., Huyhan, N., Ziehl, P., University, C., Transportation, S. C. D. of, & Administration, F. H. (2019). *SCDOT Asset Data Collection Assessment (Final Report)*. <https://www.scdot.sc/tap.org/wp-content/uploads/2019/10/SPR-716-Final-Report.pdf>
- Polzin, S., Chu, X., Bunner, R., Pinjari, A., Catala, M., Research, N. C. for T., Transportation, F. D. of, & Administration, R. and I. T. (2011). *TBEST Model Enhancements - Parcel Level Demographic Data Capabilities and Exploration of Enhanced Trip Attraction Capabilities (Final Report)*. <https://doi.org/https://doi.org/10.5038/CUTR-NCTR-RR-2008-09>
- Rajbhandari, R., & Aldrete, R. M. (2009). Paso Del Norte Regional Mobility Information System: Creating Archived Transportation Data User Services and an Advanced Traveler Information System. *Transportation Research Record: Journal of the Transportation Research Board*, 2121, pp 110-120. <https://doi.org/https://doi.org/10.3141/2121-12>
- Rothenberg, H. A., Riessman, R., & Flatten, D. (2005). Development of a Statewide Highway Safety Data Warehouse: Massachusetts Data Warehouse and Web-Based Access. *Journal of Safety Research*, 36(5), pp 465-467. <https://trid.trb.org/view/778057>
- Runeson, P., Olsson, T., & Linåker, J. (2021). Open Data Ecosystems — An empirical investigation into an emerging industry collaboration concept. *Journal of Systems and Software*, 182. <https://doi.org/10.1016/j.jss.2021.111088>
- Salanova Grau, J. M., Mitsakis, E., Tzenos, P., Stamos, I., Selmi, L., & Aifadopoulou, G. (2018). Multisource Data Framework for Road Traffic State Estimation. *Journal of Advanced Transportation*, 2018(Article ID 9078547), 9p–9p. <https://doi.org/https://doi.org/10.1155/2018/9078547>
- Stewart, A. F., Attanucci, J., & Wilson, N. H. M. (2015). Ridership Response to Incremental Bus Rapid Transit Upgrades in North America: Demographic and Network Effects. *Transportation Research Record: Journal of the Transportation Research Board*, 2538, pp 37-43. <https://doi.org/https://doi.org/10.3141/2538-05>
- Stickel, J., & Vandervalk, A. (2014). Data Business Plans and Governance Programs: Aligning Transportation Data to Agency Strategic Objectives. *Transportation Research Record: Journal of the Transportation Research Board*, 2460, pp 154-163. <https://doi.org/https://doi.org/10.3141/2460-17>
- Alonso Raposo, M., Ciuffo, B., Alves Dias, P., Ardente, F., Aurambout, J., Baldini, G., Baranzelli, C., Blagoeva, D., Bobba, S., Braun, R., Cassio, L., Chawdhry, P., Christidis, P., Christodoulou, A., Corrado, S., Duboz, A., Duch Brown, N., Felici, S., Fernandez Macias, E., ... Vandecasteele, I. (2019). *The future of road transport : implications of automated, connected, low-carbon and shared mobility: study*. <https://doi.org/https://doi.org/10.2760/9247>
- TISATO, P. (2005). Recent developments in transport planning and project appraisal in Australia. *ADELAIDE INTERNATIONAL PUBLIC WORKS CONFERENCE, 2005, ADELAIDE, SOUTH AUSTRALIA, AUSTRALIA*, 7P-7P. <https://trid.trb.org/view/788667>
- Vandervalk, A., Almario, R., Pasumarthy, P., Snyder, D., Cambridge Systematics, I., Office, I. T. S. J. P., & Administration, M. S. H. (2017). *Maryland State Highway Administration Pilot of the Data Business Plan Guide for State and Local Departments of Transportation: Data Business Plan (Final Report)*. <https://ops.fhwa.dot.gov/publications/fhwahop18010/fhwahop18010.pdf>
- Vandervalk, A., Snyder, D., Almario, R., Pasumarthy, P., Cambridge Systematics, I., Office, I. T. S. J. P., Administration, F. H., & Council, M.-A. R. (2017a). *Mid-America Regional Council Pilot of*

- the Data Business Plan for State and Local Departments of Transportation: Data Business Plan* (Final Report). <https://ops.fhwa.dot.gov/publications/fhwahop18012/fhwahop18012.pdf>
- Vandervalk, A., Snyder, D., Almario, R., Pasumathy, P., Cambridge Systematics, I., & Transportation, D. of. (2017b). *Hillsborough Metropolitan Planning Organization Pilot of the Data Business Plan for State and Local Departments of Transportation: Data Business Plan* (Final Report). <https://ops.fhwa.dot.gov/publications/fhwahop17018/fhwahop17018.pdf>
- Vandervalk, A., & Snyder, D. (2017). *U.S. Department of Transportation Roadway Transportation Data Business Plan (Phase 3): Data Business Plan Development for State and Local Departments of Transportation* (Final Report). <https://ops.fhwa.dot.gov/publications/fhwahop18009/fhwahop18009.pdf>
- Vandervalk, A., Snyder, D., Hajek, J. K., Cambridge Systematics, I., & Administration, F. H. (2017). *Guide for State Department of Transportation Safety Data Business Planning*. <https://rosap.nhtl.bts.gov/view/dot/49567>
- Veeneman, W., van der Voort, H., Hirschhorn, F., Steenhuisen, B., & Klievink, B. (2018). PETRA: Governance as a key success factor for big data solutions in mobility. *Research in Transportation Economics*, 69, pp 420-429. <https://doi.org/https://doi.org/10.1016/j.retrec.2018.07.003>
- Wilmsmeier, G., & Martinez-Zarzoso, I. (2010). Determinants of maritime transport costs – a panel data analysis for Latin American trade. *Transportation Planning and Technology*, 33(1), pp 105-121. <http://www.informaworld.com/10.1080/03081060903429447>
- Yigitcanlar, T., & Kamruzzaman, Md. (2019). Smart Cities and Mobility: Does the Smartness of Australian Cities Lead to Sustainable Commuting Patterns? *Journal of Urban Technology*, 26(2), pp 21-46. <https://doi.org/https://doi.org/10.1080/10630732.2018.1476794>
- Zhou, J. J., & Golledge, R. (2007). Real-Time Tracking of Activity Scheduling/Schedule Execution Within a Unified Data Collection Framework. *Transportation Research Part A: Policy and Practice*, 41(5), pp 444-463. <https://trid.trb.org/view/805752>

ABOUT VTI

The Swedish National Road and Transport Research Institute (VTI), is an independent and internationally prominent research institute in the transport sector. Our principal task is to conduct research and development related to infrastructure, traffic and transport. We are dedicated to the continuous development of knowledge pertaining to the transport sector, and in this way contribute actively to the attainment of the goals of Swedish transport policy.

Our operations cover all modes of transport, and the subjects of pavement technology, infrastructure maintenance, vehicle technology, traffic safety, traffic analysis, users of the transport system, the environment, the planning and decision making processes, transport economics and transport systems. Knowledge that the institute develops provides a basis for decisions made by stakeholders in the transport sector. In many cases our findings lead to direct applications in both national and international transport policies.

VTI conducts commissioned research in an interdisciplinary organisation. Employees also conduct investigations, provide counseling and perform various services in measurement and testing. The institute has a wide range of advanced research equipment and world-class driving simulators. There are also laboratories for road material testing and crash safety testing.

In Sweden VTI cooperates with universities engaged in related research and education. We also participate continuously in international research projects, networks and alliances.

The Institute is an assignment-based authority under the Ministry of Infrastructure. The Institute holds the quality management systems certificate ISO 9001 and the environmental management systems certificate ISO 14001. Certain test methods used in our labs for crash safety testing and road materials testing are also certified by Swedac.



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