Governance of digital data sharing in a cross-organisational railway maintenance context

Veronica Jägare
Luleå University of Technology
971 87 Luleå
Sweden
+46-0920 49 1629
veronica.jagare@ltu.se

Ulla Juntti
Omicold AB
Maskinvägen 22
972 54 Luleå
+46-705 26 5035
ulla.juntti@minus8.nu

Ramin Karim
Luleå University of Technology
971 87 Luleå
Sweden
+46-920 49 2344
ramin.karim@ltu.se

ABSTRACT

The purpose of this paper is to study and explore the essential aspects of data governance in eMaintenance that need to be considered such as data sharing and data ownership in a cross-organisational railway maintenance context. Furthermore, the paper develops and provides an approach to strategies and guidelines, which can be used to govern digital data sharing.

To fulfil this purpose, case studies of several projects where sharing of data between stakeholders in order to develop maintenance decision support, was selected as a research strategy and supported by a literature study. Empirical data were collected through interviews, workshops, document studies, and observations. An approach was developed and validated using a case study.

The proposed approach supports the understanding and establishing strategies and guidelines for data governance in a cross-organisational railway context. This can be considered as one of the enablers for information logistics for maintenance purposes where the approach can be used as a support tool in order to facilitate the development of maintenance decision support within the railway industry.

Keywords

Data governance, cross-organisation, maintenance, maintenance decision support, railway, eMaintenance.

1. INTRODUCTION

Organisations maintaining railway infrastructure require routine monitoring and inspection of track condition [1]. Existing sensor technology can replace manual measurements in many cases. The sensor data can be used for e.g detection, localisation and cause identification of anomalies. Coupled with advanced analytical capability based on Artificial Intelligence (AI), deep learning, machine learning, sensor systems can provide maintenance stakeholders with valuable insights into the health of the railway system, including infrastructure and the rolling stock.

In the railway industry, large amounts of condition monitoring data is being stored, but most of the information never finds its way to the maintenance decision process [2].

Useful information for prognostics is often never used and hence the development of the predictive capability has been on a more moderate level [3]. This allows for the increased possibilities of analysing big data sets and develop diagnostic and prognostic approach for the railway industry [4]-[7].

Various types of data is needed in order to enable context- and condition-based maintenance. The stakeholders have different requirements for collecting data for maintenance decision support. The infrastructure manager needs information about how the track is operated in terms of amount of trains and axles, train speed and actual axle load, vehicle characteristics, but also data about asset condition and the degradation rate. The traffic operator needs condition monitoring information, e.g. trend data for wheel degradation. The maintenance contractor need data on asset condition, amount of traffic, type of vehicles, amount of train kilometres and the supplier wants to know where the asset/component is installed, how it is used and what kind of failures that has occurred [8].

The ePilot is a development and implementation project aimed at improving railway maintenance [9]. The objective of the project is to test and implement eMaintenance solutions and support the development of decision support to enable context- and condition-based maintenance. eMaintenance is considered to be the integration of all necessary ICT-based tools for the optimisation of costs and improvement of productivity through utilisation of web services [10]. The project is based on industry collaboration between infrastructure managers, operators, maintenance entrepreneurs, maintenance workshops, suppliers, innovators and Luleå Railway Research Center (JVTC) at Luleå University of Technology. ePilot provides a collaboration platform for testing innovations and development of new solutions for maintenance decision support. The solutions are based on needs and requirements from various stakeholders in order to enable and transform the maintenance of the Swedish fragmented rail industry to an integrated digitalised system. Additional project objectives are to; create an industry-wide process-oriented approach and create an industry-wide service-oriented IT infrastructure that provides decision support based on condition data.

In the ePilot, a platform for decision making in maintenance has been developed which provides a cloud based, one-stop-shop for data collection and analysis, which aids research projects and maintenance practices.

The platform called Testbed Railway, includes: 1) A process for gathering information about remaining useful life, dynamic maintenance program, performance measurements, maintenance support and planning; 2) Services, such as, wheel query, force data analysis, context adaption and data fusion; 3) Data collected from mobile sensors and way-side monitoring equipment; 4) Measurement data of track quality, failure statistics and inspection data.

During the course of the project, a number of challenges related to data sharing between stakeholders have been identified, which led to uncertainty among the parties regarding data collection and ownership. It has also emerged that there is no common nomenclature to describe different types of data in the flow from data to decision to use in a cross-organisational project where data sharing is necessary.

This paper aims is to answer the research question; which essential aspects of governance need to be considered regarding data sharing between cross-organisational stakeholders in a railway maintenance context?

The goal is to identify aspects to consider in guidelines for common rules for cross-organisational data sharing in collaboration projects. Consequences for deviations from agreed guidelines will be discussed. The proposed approach explains governance aspects for cross-organisational data sharing between stakeholders in a railway maintenance context, a prerequisite for enabling predictive and prescriptive maintenance.

This paper contributes to a more effective collaboration that enables the implementation of innovations that requires data from several stakeholders, by identifying aspects to consider agreed and common guidelines for digitalised railway maintenance in collaboration projects.

2. LITTERATURE REVIEW

Lotfi [11] defines information sharing as "distributing useful information for systems, people or organisational units" and states that organisations must answer four questions to get the desired value from information sharing; when to share, with whom, how to share and what to share. Data Governance means "the exercise of decision-making and authority for data-related matters." More specifically, Data Governance is "a system of decision rights and accountabilities for information-related processes, executed according to agreed-upon models which describe who can take what actions with what information, and when, under what circumstances, using what methods." [12] Organisations need to move from informal governance to formal data governance when certain situations e.g. the organisation gets so large that traditional management is not able to address data-related cross-functional activities and regulation, compliance, or contractual requirements call for formal data governance.

The EU 2011 white paper 'Roadmap to a single European transport area' [13] identifies a number of required initiatives that will depend on greater data exchange, such as smart ticketing and integrated management of freight corridors. The white paper also identifies integrated information systems and interoperability as key areas for future innovation. The effective exchange and integration of data is, however, a significant challenge. The Swedish government's strategy for a digital collaborative administration [14] from 2012 describes the government's objectives for efforts to strengthen the ability of government authorities to interact digitally with governance-common IT issues. The strategy is built around three goals - easier, more transparent and efficient - and nine sub-goals, for example, a more open management that supports innovation and participation, and makes it easier to find and use open data. The Swedish framework for digital collaboration [15] is based on the new version of the EIF (European Interoperability Framework). By developing, based on common principles, we can more easily exchange information with each other and reuse solutions and in the long run it becomes more cost-effective. The framework is developed by eSam in a broad collaboration to be able to be used by the entire public sector and concerns the entire organisation, i.e. architecture, law, security, activities etc. The framework consists of 13 principles and 41 recommendations. The recommendations provide guidance from different perspectives on digitisation (law, digital meeting, business, information and data, technology, security and integrity, governance and management). Data-driven innovation means that public authorities provides the right conditions for the business community to be able to carry out innovative and value-creating work, based on digital information and digital services from the public sector. Data-driven innovation requires that public actors make information and data available, open APIs for external parties, as well as regulations and algorithms. The increased access to information creates new opportunities to, with current and qualitative information as a basis, create new insights and make the right decisions. Analysis and decision support provides better conditions for organisations to understand their activities, and corporate actions and needs. Information is a basic building block in an organisation, in the same way as employees, premises and equipment.

Railway networks comprise a large number of information systems, many of which are implemented by different stakeholders according to different design requirements, and in different ways. Owing to the safety-critical nature of these systems, data is rarely shared across boundaries, and the potential for re-use of information is lost. Tutcher et.al. [16] examine the aspects of data re-use likely to benefit the industry, and describes a railway condition monitoring ontology that is being designed in conjunction with several industrial stakeholders to improve operational efficiency. In the rail industry, the exchange of data across system and organisational boundaries is an essential step in the delivery of advances such as intelligent infrastructure, real-time capacity management and greater interoperability between stakeholders. The industry, however, faces a serious challenge in the form of siloed, legacy ICT systems based around different technologies and data formats. Golightly et.al [17] presents an evidence-based top-down map of the diverse range of scenarios in which wider data exchange, facilitated by a common data framework, could provide value to the industry. Golightly describes in a scenario analysis barriers such as: 1) Commercial sensitivity and value: In the absence of knowing exactly what data was worth or whether it really was sensitive, an organisation is likely to adopt the most conservative case and restrict access; 2) Data ownership: clarification as to whom owned the data in certain circumstances. 3) IT competence: Getting data to the right people at the right time was only part of the solution. Whether people could understand that data and embrace it was another matter; 4) Data exchange is impeded (technically and in business case) by the structure of the industry; 5) Requires government direction; 6) Lack of flexibility on the part of stakeholders; 7) Requires contractual agreement; 8) Fragmentation within the rail industry; and 9) Data not available or in enough detail. The study by Backmyr et.al [18] explores the current barriers to effective information sharing within the rail freight industry and proposes strategies to mitigate the identified barriers. Five general categories of barriers are proposed. Nineteen barriers specific for the Swedish rail freight industry are identified, the most significant being; lack of capabilities; fragmented information; fear of losing business; antitrust regulations, intangible returns; misaligned incentives; and lack of customer pressure. Some identified barriers within ePilot for collaboration and implementation of eMaintenance is: data ownership, data access rights, unclear responsibility in the case of disperse conditions for ownership of rolling stock causing maintenance data to be lost and a lack of incentives in the contracts for the stimulation of innovation, implementation, collaboration and information sharing [19].

3. METHODOLOGY

To investigate the stakeholders' perceived needs and issues regarding data sharing in a collaboration project, a case study of projects was selected as an appropriate research strategy. In the selected projects, stakeholders were sharing data, in order to develop maintenance decision support, Empirical data were collected through interviews, workshops, document studies, and observations. The case study activities have been performed within the ePilot collaborative platform for railway stakeholders.

Four ePilot sub-projects where data was shared between stakeholders, were selected and used as examples during the interviews. For each of these projects, a data flow model has been constructed. These models have been discussed with all interviewees. Fifteen questions were constructed based on Golightly´s and Backmyr´s identified barriers and referred to the parties before the interviews. The interviewees answered the same questions regarding data sharing. The two interviewers asked the same questions to all the interviewees without affecting the answers and recorded the answers. The responses from the interviews have been compiled, analysed and presented in a summarised form without organisational affiliation for the interviewee.

Thirteen people were interviewed from various parties in the railway industry, according to Table 1. The interviewees were selected based on participation in the ePilot subprojects where data sharing has occurred.

Table 1. Distribution of represented parties during the interviews.

Part	Quantity
Infrastructure manager	3
Traffic operator	3
Maintenance entrepreneur	1
Academy incl. legal advisor	3
Supplier of measuring system	2
Analytic company	1

The next step was to interview parties from other industries e.g airplane manufacturer etc., where data sharing occurred outside the organisation. The procedure was the same as for the interviews from the railway industry where the same data flow models were introduced and a new set of questions were answered. The purpose of these interviews was to investigate if other industries were experiencing the same issues, with regards to cross-organisational data sharing, and if benchmarking for the railway industry would be possible.

Then an analysis of ePilot governing documents, laws and regulations with respect to barriers for data sharing was performed. Then guidelines for data sharing in collaboration projects, were proposed.

4. CASE STUDY RESULTS

Results from the analysis of completed interviews for both railway and other industries, analysis of governing documents in ePilot and other laws and regulations with regards to data sharing are presented in this chapter.

4.1 Terms for asset management of cyber assets

During the interviews, we have seen the importance of clarifying commonly used terms, e.g. data and information, to avoid misunderstandings. The ePilot chose to use definitions according to table 2. These definitions are partially based on ISO 55000.

Table 2. Terms for asset management of cyber assets.

Term	Definition
Cyber Asset	In our definition, Cyber Asset refers to digital fixed assets. Cyber Assets (e.g. data and information) should be considered as part of a business facility.
Physical Asset	In our definition, Physical Asset refers to physical fixed assets. Physical Asset is normally regarded as the main part of a business facility.
Data	Data in this context refers to unprocessed content between two processing points. Data is generated by a data provider (such as a sensor). Data is considered a Cyber Asset.
Processing point	Processing point means a step in which processing of data takes place, for example, converting analogue signals to digital, filtering, quality assuring, extracting, transforming, analysing and visualising. A refining process can consist of several processing points.
Algorithm	Algorithm in this context refers to a series of instructions intended for data processing.
eMaintenance	eMaintenance refers to the area of maintenance technology that aims to provide decision support for operations and maintenance, through the application of advanced information technology.
Information	Information in this context refers to processed content (data). That is, results from a so-called processing point / refining process. It is important to point out that information (ie output) from a processing point can be regarded as data (ie input) to another processing point. Information is to be considered a Cyber Asset.
Asset	An asset is an item, thing or entity that has potential or actual value to an organization. The value will vary between different organisations and their stakeholders, and can be tangible or intangible, financial or non-financial. (ISO 55000)
Asset Management	Asset management involves the balancing of costs, opportunities and risks against the desired performance of assets, to achieve the organisational

	objectives. The balancing might need to be considered over different timeframes. Asset management enables an organisation to examine the need for, and performance of, assets and asset systems at different levels. Additionally, it enables the application of analytical approaches towards managing an asset over the different stages of its lifecycle. (ISO 55000)
Asset owner (Cyber Asset and Physical Asset)	Asset owner refers to the organisation / party that has the right of decision over the management of an asset throughout its life cycle.
Asset User (Cyber Asset and Physical Asset)	Asset user refers to the organisation / party that has the right to use an asset (cyber or physical) during the entire contract period and according to agreed terms.

The concepts for data and information has been illustrated in ePilot according to figure 1. Data is defined as unprocessed content between two processing points and with information meant processed content (data) i.e. results from a so-called processing point / process.

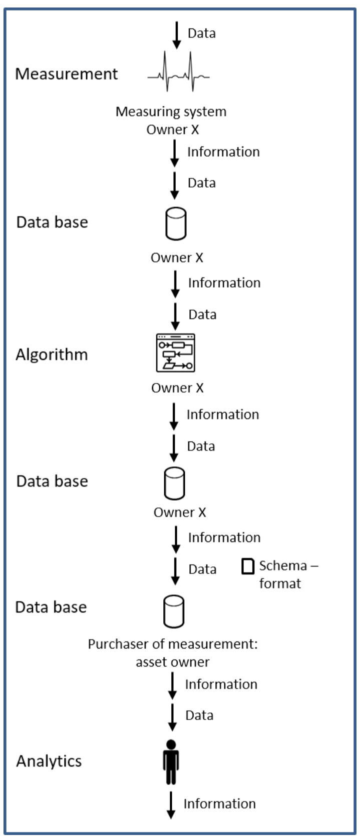

Figure 1. Illustration of data and information.

4.2 Data governance in the railway industry

The purpose of the interviews were to investigate the laymen´s view of data sharing in order to identify needs for clarification. After analysing the interviews, answers from similar questions have been summarised in eight aspects influencing data sharing in a cross-organisational collaboration project: 1) Data ownership, 2) Agreements regarding data and information, 3) The rights to share information with third party, 4) Archiving data, 5) Classification of data, 6) Incentives or barriers to data sharing, 7) An industry-wide data base, 8) The ideal situation for data sharing in the railway industry.

4.2.1 Data ownership

Regarding the question of whether the asset generating data always owns data, three examples were given of situations that may occur: A) A train runs over a sensor that measures the train, B) A train carries a sensor and measures on the infrastructure, and C) A satellite measures the position of the track.

The majority of the interviewees (62%) generally believe that it is the asset, i.e. the infrastructure or the train, which generates data that also owns data. It is also believed that it is the organisation who owns the asset that is to agree with the company who measures. The general feeling is that contracts are often missing. Other interviewees replied that it is the sensor owner who owns data or is uncertain how it works.

For example A, the following may be considered valid, unless otherwise agreed: a) The infrastructure owner is an authority, the measurement data is a public record, b) If the infrastructure owner is a private company, the infrastructure owner has the power of disposal for the information. Ownership of data from Hotbox and Wheel Impact Detectors is regulated in the traffic agreement and Trafikverket (TRV) owns this data. If a sensor is installed in the track, the infrastructure owner has power of disposal of the information.

For example B, the following may be considered valid. The trains that operate on the facility for which TRV is responsible do so within the framework of a Traffic Agreement (TRAV). Maintenance entrepreneurs operate on the facility with special measurement trains within the framework of national contracts in order to inspect the facility. Maintenance entrepreneurs within the framework of base contracts can also operate on the track with vehicles to perform maintenance. If the sensor is part of the rolling stock, then the rolling stock owner owns the information. The rolling stock owner who carries the sensor owns the information, unless otherwise agreed (e.g. the rolling stock owner grants space to the infrastructure owner or other party, and then the parties should agree on this). The owner of the asset should be able to control the company who performs the measurements.

Regarding example C, most have argued that there is no physical connection to where the sensor is located and then it is not possible to claim the right to ownership of data. It is not possible to regulate the collection of satellite data, nor the collection of e.g. data from travellers on board trains. It might be possible to regulate via the establishment of object of protection.

When asked whether there are exceptions to the hypothesis that the asset who generates data always owns data, all respondents replied that it can be agreed differently in different specific projects and assignments.

There is a desire for a uniform approach with contract models that clarify who owns what, who has the right to use data, how data is to be stored, sorted, deleted and how third parties may use data.

4.2.2 Agreements regarding data and information

To write data and information agreements is today perceived as a neglected area where no clear guidelines regarding who owns what, exists e.g. when applying new sensors. An agreement has to be made regarding what to measure, how data is to be extracted, during what time and power of disposal after the project ends. Data and information must also be defined, and degree of detail for delivered data. The interviewees experience that regulations do not keep up with the rapid development.

Today, measurements are performed according to maintenance instructions, traffic agreements, rental contracts, and utilisation agreements. But if you want to use a new sensor, the uncertainty becomes greater. Generally, you do not make an agreement regarding data, only information. The information can sometimes be delivered as pdf-files, and can be difficult to refine. The maintenance entrepreneur has more data from the measuring train than what is delivered according to agreement, and the remaining data is considered to be owned by the maintenance entrepreneur.

Interviewees expressed a desire for better quality from detectors with clearer organisation and management especially with regard to maintenance and calibration. Regulations for retrieving data from the infrastructure owner or rolling stock owner should be regulated in the railway network description, according to one interviewee. Then other agreements can control the details. The exception is when detectors are on private tracks. Then you have to agree directly with the owner of the track to gain access to the data.

For the question if an agreement is needed in order to record data about the rolling stock who run over sensors, the answers were disperse, where eight respondents answered yes, three responded no and two do not know.

Seven interviewees believe that for future measurement test sites, a general agreement, guidelines and policy should be established. For measuring equipment of a more operative nature, such as measuring stations, extra agreements may be needed.

4.2.3 Rights to share information with third party

The majority of the interviewees respond that the information owner can pass the information on to a third party for analysis unless otherwise agreed. An example of this is the measuring train that delivers data to TRV according to agreements, which can then sell / share without asking the maintenance entrepreneur for permission. The relationship between supplier and customer should be based on a transaction and transfer of right of disposal or right to ownership.

4.2.4 Archiving data

Research data must be stored for a long time so that other researchers can follow in the first researcher's track. Responsibility for the readability of the format is not with the researcher but with the authority. Otherwise, reference is made to the Archives Act, the Product Liability Act, the Public Procurement Act and the Secrecy Act, but also that this should be regulated in agreements.

One interviewee believes that data could be classified with a sustainability date. One point of view is that there should be no time limit since you can build analyses and see trends for a long time afterwards. However, there is a risk of reusing and interpreting secondary data in order to look at something with a different purpose.

Regarding maintenance contracts, it is important that data is stored for at least eight years in order to be able to assess how the condition has changed, but also to be able to describe conditions as a function of time in future procurements.

4.2.5 Classification of data

Configuration of the facility, the daily graph and water supply are examples of classified data. Security classified data are things that endanger the security of the nation. There are also data that are considered confidential, e.g. competitive information. Data could be classified as open, competitive, or classified by security, and be protected by information security agreements. One interviewee replied that condition data should be used for the railway system's best in mind and has difficulty seeing how it can be used from a competitive point of view.

4.2.6 Incentives or barriers to data sharing

Incentives that could stimulate data sharing are; sharing data to get better analysis services, better quality of the railways, extensive decision-making data, data for continued research, less operational disturbances, knowledge to build better systems and better condition control.

Barriers can be commercial i.e. regulations and competition, measuring in a process that is exposed to competition; immaturity i.e. uncertainty causes fear of sharing data, security issues are not clear; and the quality of data is insufficient.

4.2.7 An industry-wide data base

Organisations should internally produce a goal and a regulatory framework for sharing data. The owner of the asset decides on the data series. The mechanism for sharing can be industry-wide (protocol, technology). One suggestion from interviewees is that the industry could form a separate company that manages a common data base. Some believe that TRV should own this data base, while others say that there is a risk that TRV has a special interest in track. Such a future data base must also be compatible with other railway administrations. The governing authority for the data base should be a non-commercial party. The various proposals for governing authorities were 1) Infrastructure owner (TRV) 2) The Association of Swedish Train Operating Companies (ASTOC) 3) The Swedish Transport Agency 4) the European Railway Agency (ERA).

4.2.8 The ideal situation for data sharing in the railway industry

The interviewees represented a wide spectrum from those who believe this is a matter between the parties that make agreements, to those who see a sector-wide data base where an authority sets up rules for data sharing and that work across national borders. Some interviewees commented that transparency for condition data should increase since trains are crossing borders and a European detector network with common concepts, systems and standards could be considered. One interviewee suggested a combination of cloud and edge infrastructure. Everything should be in a cloud, but data should be downloadable near the user. A data sharing authority is needed that sets regulations for how to share, how to connect, who can provide and retrieve data. The cloud should be outside any of the organisations that have special interest in the industry. The Swedish Transport Agency has been proposed by many interviewees as a suitable authority to set up and govern the regulations for Swedish data sharing. Service Level Agreements (SLAs) for detectors should be established since decision support systems built upon detector data and depends on continuity of deliveries and quality assurance of data.

4.3 Data governance in other industries

The interviewees described a daily exchange of data outside the organisation where a partnership exists with end customers and distributors. One interviewee replied that there is a long tradition of sharing data with a maintenance provider where design data, maintenance data and operating data are available. Data is a commodity of great value. It should not only be operational data, but also, for example, discrete events.

Comments to be highlighted from the interview:

- By linking meaningful information and reliability to how the system feels, you see a causal connection if everything is clearly documented in e.g. maintenance system. In order for time series data to be relevant, interpretation how things are done, by whom and according to which instructions must be possible.
- There must be a structure and hierarchy, according to standard. If one cannot derive information from a component, the information is useless.
- Data is considered valid as long as it is quality assured. As long as the product exists, it should be relevant to maintain data, i.e. throughout the whole life cycle.
- Everything must be regulated in agreements. Agreements with customers, subcontractors, suppliers who deliver services. Moving and managing data is governed by agreements. Agreements have three dimensions: process (temporal, business, operation), structure (local, computer system) and content (information flow, value flow).
- There are more standards for cyber security. Large multinational customers come with their own requirements that one must meet. The area is in constant development. One respondent replies that there are regulations when the authorities require this. Validity is important i.e. no one can enter and change data.

4.4 ePilot governing documents

Collaboration in the ePilot is regulated in a number of governing documents, which has been analysed concerning data sharing between stakeholders.

The JVTC membership agreement is the foundation for the collaboration within ePilot that regulates e.g. Foreground, Right to background and Confidentiality. Project partners can enter information or material of a confidential nature within the framework of a project. Each project partner therefore undertakes necessary measures in the processing of confidential information, which can reasonably be required in order to maintain the confidentiality during the time the project is in progress, and a maximum of three years thereafter. A project party who considers information or material submitted to be considered confidential shall mark this with "Confidential information". The members are aware that JVTC is a Center of Excellence at LTU, which means that the public access applies to public documents, unless the information can be classified as confidential according to the rules of the secrecy law.

The ePilot project specification is a governing document stating the common agreed goal, collaboration and deliverables for each project within the ePilot. This document is used as a basis for negotiation between the parties during the initiation of the project. Information regarding regulation of data sharing between parties in the template was missing, resulting in some disagreements later during the course of the project. Therefore information regarding ownership of data, rights of disposal, distribution to third part, archiving and deletion has been added.

The ePilot project agreement establishes the arrangement between the parties during the contract period. The project specification is an appendix to the agreement. This document does not contain any regulations for data sharing.

eMaintenanceLAB (eMLAB) store and deliver data for research within eMaintenance. Data is collected from sources from various parties in the maintenance industry. Data is only intended for use in education and research. Internal and external agreements regulate the use of data from eMLAB. Contracts and regulations must contain things such as: ownership and use rights, data security, storage, deletion, confidentiality, etc.

4.5 Other laws and regulations

Other laws and regulations containing information regarding data sharing in the railway industry have been identified and analysed.

Laws that affect whether data may be disclosed are: the Public Access and Secrecy Act (in principle only commercial agreements that can be invoked with regard to the confidentiality of data omission) and the Security Protection Act (constitution relating to socially critical activities, the nation's security and terrorism).

A public record is any document, printed or electronic, that is stored by an authority, and has been submitted to it from outside or has been drawn up within the authority. Documents that are so-called work material does not generally become official.

The Railway Act contains the basis for Swedish rail traffic legislation. In the Railways Ordinance (2004: 526) and the Ordinance (1990: 1165) on safety at the subway and tramway, the Government has further developed the rules from the laws and granted the Swedish Transport Agency the right to issue regulations to detail the area. The Swedish Transport Agency's regulations are published in the Swedish Railway Agency's statutory collection (JvSFS). The Railway Act does not include any text related to definition or ownership of digital assets such as data or information.

TRV measures, via detectors, to achieve traffic safety and avoid damage to the facility, as described in the Railway Network description (JNB) (with reference to regulations, e.g. TDOK 2014: 0689 BVF 592.11 - Detectors. Management of alarms from in stationary detectors and measures after detected damage during manual inspection").

4.6 A generalised data sharing model

A generalised data sharing model that can describe data sharing for a sub-project in the ePilot is shown in Figure 2. The asset owner writes an agreement with a measurement company about performing measurements on the asset. Measurements are performed which are placed in the measurement company database after being processed in an algorithm. The information is transferred to the asset owner who has ordered the measurement. Data can then be forwarded to a company that analyses data. An agreement for data transfer is written together with a permit given to the analysis company to retrieve the asset owner's data.

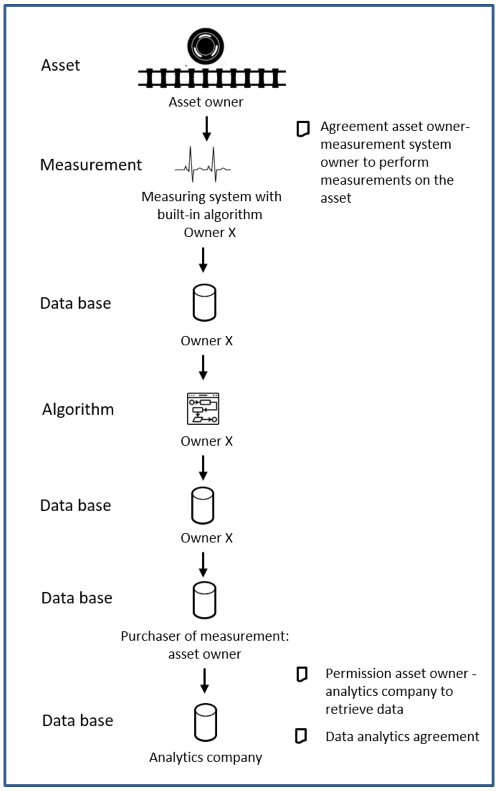

Figure 2. Generalised data model.

4.7 An approach to strategies and guidelines

This section proposes some basic approaches that can be used for, among other things, contract writing.

- A Cyber Asset should be considered and managed as a Physical Asset
- Cyber assets (eg data and information) shall be covered by the company's comprehensive asset management strategy
- Data for (which describes properties of) a physical fixed asset is part of that asset.
- Data and information are considered cyber assets.
- Ownership of data for (which describes properties of) a physical asset belongs to the owner of the physical asset. This means that the business that is regarded as an asset owner and thus has the administrative responsibility for the asset during its lifetime is also the asset owner of the digital asset.
- Use of rights to cyber asset (such as data and information) is regulated according to agreements between asset owners and asset users. The recommendation for contract writing is to consider and regulate, among other things, the following aspects:
    - Purpose
    - Period
    - Dissemination
    - Sorting and deletion (after contract period)
    - Commercial conditions
    - Security (before, during and after the project)

5. DISCUSSION

In order to enable and transform the maintenance of the Swedish fragmented rail industry to an integrated digitalised system with possibilities of optimised maintenance activities, a greater degree of sharing asset, operational and condition data is needed. The study by Golightly et.al in Great Britain shows similar barriers as in Sweden, preventing a wider data exchange in the railway industry.

This case study focuses on issues regarding data sharing in the ePilot projects but can also be related to the whole industry. Consequences for deviations from agreed guidelines can be that parties disagree on what has been promised in projects, stagnation in the industry if nobody dares to share data and quality assurance need to be guaranteed if decisions are to be made based on information.

Figure 1 and 2 describe a generalised model of data sharing in a collaboration project. It is more common that there are many parallel measuring systems in a non-linear model, but we have found this generalisation to be effective in order to initiate discussions regarding data sharing.

In order to avoid barriers surrounding data sharing that might hinder the development of methods to support condition-based maintenance, it is important to establish guidelines for the industry. A common ground could be to consider the asset owner as the data owner unless other is agreed upon in a contract. Data should be considered relevant for the whole lifecycle as long as it has been quality assured and clearly documented e.g. in a maintenance system. During the starting phase of a collaboration project, it is important to discuss how data and information should be handled after the project end.

Guidelines for data sharing should be developed for future test sites where data and information can be made available to the industry in order to increase the development of new solutions. These test sites should be added to the JNB.

Organisations need to move from informal governance to formal data governance to be able to address data-related cross-functional activities and regulation, compliance, or contractual requirements call for formal data governance. The four questions, according to Lotfi, that need to be answered to get the desired value from information sharing is; when to share, with whom, how to share and what to share.

6. CONCLUSIONS

Some of the essential aspects of governance that need to be considered regarding data sharing between stakeholders in a cross-organisational collaboration project in a railway context are:

- Common terms for cyber assets
- Data ownership/ rights for disposal

- Agreements/contracts/tendering
- Classification of data

The uncertainties regarding data sharing in the railway industry leads to slower development since cross-organisational maintenance data is needed for development. ePilot is a useful platform and toolbox where the industry can test and verify solutions and clarify issues that might occur when sharing data. The interviews show the need for clarification and agreements that are needed.

The proposed approach supports the understanding and establishing strategies and guidelines for governance in a cross-organisational railway maintenance context. This can be considered as one of the enablers for information logistics for maintenance purposes where the approach can be used as a support tool in order to facilitate the development of maintenance decision support within the railway industry.

7. RECOMMENDATIONS

To further test the usefulness of the proposed approach, a larger scale case study should be performed. This can involve additional stakeholders or a study of data governance in other countries in a railway context.

8. ACKNOWLEDGMENTS

Our thanks to sponsors of eMaintenance2019 for their intellectual and financial support. We would like to also thank Trafikverket (the Swedish Transportation Administration) for their financial support of this project, as well as all the participating railway organisations and companies.

9. REFERENCES

[1] Kumar, S., Espling, U., & Kumar, U. (2008). ”*Holistic procedure for rail maintenance in Sweden”.* Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit, 222(4), 331–344.

[2] Asplund, M., Lin, J., & Rantatalo, M. (2016). “*Assessment of the data quality of wayside wheel profile measurements”.* International Journal of COMADEM, Vol.19, nr 3, sid 19–25.

[3] Galar, D., Palo, M., Van Horenbeek, A. & Pintelon, L. (2012). “*Integration of disparate data sources to perform maintenance prognosis and optimal decision making”.* Insight - Non-Destructive Testing and Condition Monitoring, Volume 54, Number 8, August 2012, pp. 440-445(6).

[4] Bergquist, B., & Söderholm, P. (2015). “*Data analysis for conditionbased railway infrastructure maintenance”.* Quality and Reliability Engineering International, 31(5), 773-781.

[5] Bergquist, B., & Söderholm, P. (2016a). ”*Measurement System Analysis of Railway Track Geometry Data using Secondary Data”.* In eMaintenance 2016: 15/06/2016-16/06/2016.

[6] Bergquist, B., & Söderholm, P. (2016b). ”*Measurement Systems Analysis of Railway Measurement Cars”.* In International Conference on the Interface between Statistics and Engineering: 20/06/2016-23/06/2016.

[7] Bergquist, B., & Söderholm, P. (2017). “*Improved Condition Assessment through Statistical Analyses: Case Study of Railway Track”.* Luleå University of Technology.

[8] Juntti, U., Karim, R., Larsson, L. (2014). ”*Implementation of eMaintenance concept within the Swedish railway*.” Presented at the International Congress on Condition Monitoring and Diagnostic Engineering Management : Implications of life cycle analysis in asset and maintenance 16/09/2014 - 18/09/2014.

[9] Karim, R. & Jägare, V. (2017). ePilot : Slutrapport : ett samverkansprojekt inom järnväg. Luleå.

[10] Kajko-Mattsson, M., Karim, R. and Mirjamsdotter, A. (2011). “*Essential Components of e-Maintenance”,* International Journal of Performability Engineering, Vol. 7, No. 6, November 2011, pp. 515-517K.

[11] Lotfi, Z., Mukhtar, M., Sahran, S. and Zadeh, A. T. (2013) *“Information Sharing in Supply Chain Management”*, Procedia Technology. Elsevier B.V., 11(Iceei), pp. 298–304.

[12] The Data Governance Institute. www.datagovernance.com

[13] European Commission. (2011). *“Roadmap to a single European transport area—towards a competitive and resource-efficient transport system”.* White paper on transport, Luxembourg: Publications Office of the European Union.

[14] *”Med medborgaren i centrum – regeringens strategi för en digital samverkande statsförvaltning”*, dnr N2012/06402/ITP.

[15] *”Svenskt ramverk för digital samverkan 1.2.”* www.esamverka.se.

[16] Tutcher, J., Roberts, C., & Easton, J. M. (2011). *“Integrating railway maintenance data: Development of a semantic data model to support condition monitoring data from multiple sources.”* Paper presented at the KEOD 2011 - Proceedings of the International Conference on Knowledge Engineering and Ontology Development, 442-444.

[17] 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), 693-703.

[18] Backmyr, H. and Gjörup, N. (2017). *“Information Sharing in the Swedish Rail Freight Industry - Barriers and Mitigation Strategies”.* Masters Thesis. Lund University.

[19] Jägare, V., Juntti, U., & Karim, R. (2015). *”Implementation of eMaintenance concept on the Iron Ore Line in Sweden.”* Presented at the International Heavy Haul Association: The 11th International Heavy Haul Association Conference will be held 21 - 24 June 2015 in Perth 21/06/2015 - 24/06/2015.