Enhanced collaboration models in eMaintenance projects

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ABSTRACT: The increased digitalisation has led to greater transparency in recent decades, even in the railway industry, as it is now has taken a more holistic approach, discussing the railways as one system and introduced eMaintenance as a concept. Today the railway system is divided in several subsystems managed by different stakeholders, all having their own business objectives. In order to enhance the collaboration in the Swedish railway, Trafikverket initiated a project called ePilot in 2013, where all the stakeholders were invited to participate with the objective to implement results from research and development within railway maintenance.

ePilot provides a collaboration platform for the development of solutions for maintenance decision support, based on the needs and requirements from various stakeholders, in order to enable and transform the Swedish fragmented rail industry to an integrated industry. A new collaboration model has been developed in the ePilot, providing tools and game rules for enhanced collaboration towards jointly agreed goals. The model is dependent on trust, credibility in order for all parties to feel safe, during the whole project.

This paper will describe factors enabling a successful collaboration, collaborative methodology and provide conditions for continued participation in the ePilot project.

1 INTRODUCTION

The Swedish railway industry is very complex and difficult to grasp, regardless from what perspective you are viewing, e.g. technology, organisation, operations, regulations or communication and involves several different parties. This has led to a non-holistic goal setting and strategies within the Swedish railway industry. The division of the railway management in silos has led to a waterfall related maintenance process (Eriksson & Dackewall, 2017) which has contributed to a large amount of corrective maintenance actions which causes downtime, train delays and dissatisfied customers and stakeholders. Maintenance regulations and outsourcing are other hindrances for implementing a more proactive strategy in order to convert corrective maintenance to preventive, but also to implement results from research and development. A strategy in the future is to work more proactively in order to transfer reactive maintenance to predictive maintenance. i.e. taking into consideration that the amount of corrective maintenance (in cost or man-hours) never should exceed 20% of the total maintenance (Espling, 2004, Salonen & Deleryd, 2011, Hägerby&Johansson, 2002, Dunn, 2003) and that corrective maintenances are at least more than three times more expensive than preventive maintenance (Ben-Daya & Duffua, 2010, Espling, 2004).

Rules and regulations also make it difficult to implement innovations. It is not uncommon that it takes more than 10 years to introduce or implement innovations (Eklund & Paulsson, 2010).

The current situation has led to efficiency improvements of maintenance are conducted by removing such maintenance activities that are considered unnecessary for the moment, such as e.g. drainage and removing vegetation from the track. i.e. not replacing oil in the engine. This can cause major problems in the future with increased degradation such as poor track position, settlements and washed-out embankments.

The deregulation and outsourcing of services has downsized the collaboration and communication efforts to being performed by contracts, often procured as lowest cost (Karrbom-Gustavsson et. al, 2018).

Above mentioned, in combination with the resent years increase in train delays, bad weather conditions and the increased level of digitalization, has triggered the Swedish railway industry to find new ways to implement research and development. A prerequisite for this is enhanced collaboration amongst the partners involved, creating a friendlier environment and working towards common goals that will improve the railway industry's performance.

1.1 *ePilot, an eMaintenance collaboration project*

Trafikverket (the Swedish Transport Administration) which is an important player in the Swedish railway industry, has taken the initiative to gather the industry's parties to jointly start the ePilot-project in order to implement results from research and development to improve the operation and maintenance of the Swedish railway system.

Trafikverket assigned Luleå Railway Research Center (JVTC) at Luleå University of Technology (LTU) as project leader for the project. This because JVTC is a strategic center for research and development of operation and maintenance with earlier experience from working jointly with its members in the TURSAM-project (Applied Maintenance in Collaboration) on the Iron Ore Line (Espling, 2006).

JVTC has also built up an infrastructure containing a research station (part of Testbed Railway) and an Information and communication (ICT) platform in eMaintenance LAB, which enables tests and gathers data from the railway system. ePilot started in 2013, using track section 119 between Luleå and Boden, nearby JVTC, eMaintenance LAB and the research station as the laboratory.

ePilot is operated by a support group, acting as facilitator and assisting the project with project- and process management, finance, supervision, game rules and legal. Initially ePilot chose partnering as a collaboration model, adjusted according to the framework for partnering in maintenance developed by Olsson and Espling (2004), with the factors "asset condition knowledge in measurable terms, " "a clear description of client/contractor primary objectives" and "a action plan for reaching planned objectives". The chosen collaboration model was not quite appropriate for projects implementing results from research and development since the aim for the collaboration was innovation not construction. It needed to be improved and adjusted for the specific purpose. A sub-project was started with the aim to be a "framework project" for ePilot, which meant that the sub-project is both supportive, consulting and demanding in relation to the other ePilot 2.0 other sub-projects. The project will retrieve relevant observations and results within a set of identified key areas. One key area is collaboration models.

1.2 *Goal and aim*

This paper will describe factors enabling a successful collaboration, collaborative methodology and provide conditions for continued participation in the ePilot project.

1.3 *Method*

The following methods have been used:
- Active observations retrieving relevant results
- State of the art based on literature studies
- Comparison of different collaboration models and a gap-analys of ePilot versus other models

RESULTS

2.1 *Collated Observation*

The observations have continuously been gathered from meeting notes, results from surveys, from active participations in sub-projects, workshops and seminars, since the start of ePilot in 2013,.

The project started with a kick-off that presented the current condition of the railway system on track section 119 and also the desired condition. All the railway parties on the section were invited, bringing knowledge about their business goals, which were not always aligned with the transport policy goals.

A workshop was carried out where common targets for the ePilot were agreed. It was also agreed that subprojects should be started focusing on developing solutions for problems considered to be low hanging fruits, with a short start-up period and a potential to demonstrate results.

The requirement for starting a subproject was that at least three parties should be involved, common objectives was agreed on, a clear picture of benefits and who the recipient of the solution was. It was also stated that each part should contribute with a certain amount of their own time, e.g. while forming the common objectives and writing specifications.

Quite soon, it became clear that all the parties of the ePilot had not understood the requirement regarding collaboration i.e. some consultancy parties did not stick to the agreed budget resulting in additional invoices sent to the project. Others thought that collaboration only meant that they had to fulfil the demand that at least three different parties was engaged in the sub-project and that it was a cooperation i.e. common behaviour and coordination rather than collaborating, i.e. working together to achieve common goals. In order to enhance the knowledge regarding collaboration, several process meetings were arranged, to which all partners were invited. The aim was to explain, educate and train the partners in enhanced collaboration, using the partnering model as a tool. Not all the parties attended these meetings.

Some smaller disagreement regarding project deliverables and data sharing occurred during the continued work and it was decided that ePilot would apply a step-wise conflict resolution method, implying that if a conflict arises between the parties, the conflicting partners themselves should try to resolve the conflict. If this fails, the next level is to bring the conflict to the sub-project leader, who sits down with the conflicting parties, who may begin by presenting their view of the conflict without being interrupted. The subproject leader summarises the problem giving a number of suggestions for solutions that are then discussed in order to find a solution for the conflict. If the conflict is still unresolved, the next level is to bring the issue to the ePilot's steering group and then JVTC's board. The last step is a public court. This method has been used twice resulting in the disagreements being solved at the first level.

In two of the subprojects, questions arose regarding how to interpret what had actually been agreed upon in the project specification. In one of these sub-projects, no consideration was made regarding how the technical demonstrated solution should be validated with regard to access to expert competence from the end-user i.e. due to lack of time and lean organisations. This lead to difficulties to evaluate the tests results. Many of the participants in the subproject were very technology oriented and tended to draw hasty conclusions regarding the results discarding their proficiency to give correct information as basis for decision support, when in fact, partial results were presented still in the development stage.

The regulations in the railway system is also hindering changes, which causes a hesitant attitude towards changes due to the complex process of implementing an innovation.

Another challenge is intellectual property rights, i.e. what do you bring into the project, how should it be protected and who will own the results after the project has ended? ePilot used the same game rules as for JVTC. In the start of the project these paragraphs were formulated in the project agreement template and therefore came in too late in the process, causing a surprise for some of the smaller company partners that were involved. In the following discussion, it was noted that there were uncertainties regarding who owned data and got to use data in the different process steps from measurement, conversion to information, analysis and results presented in the form of a recommended decision. This resulted in the ePilot reviewing the governing documents used within the project and suggests improvement measures.

Competing parties also participated in the same sub-projects without incentives how to share the profit and risks.

It has also been difficult to visualise cost benefits due to many involved parties and abstract social and environmental benefits.

Finally, Jägare (et. al. 2015) discovered three collaboration influencing factors in a case study. These factors are grouped in the topics Legal, Organisation and Financing and considers the factors immaterial properties, rules and regulations, data ownership, data access rights, commitment/communication, methodology readiness, money/in kind, return on investments strategies and benefit models.

2.1 *State of the Art – collaborations models*

Seven different collaboration models have been studied:

- Partnering used in the construction industry
- Extended collaboration used in Swedish construction industry
- Client collaboration model for demonstration projects and testbeds” used in the construction industry and in the field of research and development
- Strategic alliances used for gaining advantages market, technology development
- Digital collaboration used by public authorities to share information
- Collaboration on a basic level or a high level used by Trafikverket, used in construction and maintenance contracts
- The ePilot collaboration model, used by the railway industry, trying to implement results.

“Partnering” was developed and is being used in the construction and civil engineering industry with the aim of reducing conflicts, costs, keeping schedules and improving quality. Partnering can be used by two or more organisations to achieve specific business goals by maximising the effectiveness of each participant's resources. The system is based on common goals, an agreed method for problem solving and an active search for continuous measurable improvements. A special collaboration group consisting of key persons representing the parties is formed and works for goal fulfillment. These key people are consciously working on building respect and trust in the respective roles. The collaboration group often includes a moderator, facilitator who with various process methods helps to develop a common goal image, and common measurement parameters that are used to check that the goals are achieved. The goals can be both economic and qualitative. An agreed conflict resolution model is used in cases where disagreements arise (Barlow, 1997, Olsson 2012).

"Extended collaboration" was developed in the Swedish construction industry, with adaptation to the regulations that apply there. The purpose is that it can be combined with all existing procurement, contracting and remuneration forms. The model has three levels, where level one consists of six compulsory elements that assume that the parties work for an open and continuous dialogue between each other to achieve common goals. The six compulsory elements are 1) joint organisation and process management, 2) target management, 3) risk management, 4) a conflict resolution method, 5) continuous follow-up and 6) improvement and openness in issues of a common nature. Level two has optional steps and level three is so-called strategic collaboration. The collaboration process begins with a mandatory opening seminar where key persons from the parties initiate a structured collaboration by getting to know each other, discussing common values, clarifying and defining roles and areas of responsibility, designing an integrated organisation in collaboration issues, formulating common goals during the contract period, and initiating a common risk and opportunity analysis (Olsson, 2012, FIA, 2006).

"Client collaboration model for demonstration projects and testbeds" is another model developed by the Swedish civil engineering industry. The model is used by an organisation in a systematic manner and under organised forms and develops tests, evaluates innovations in practical solution. The purpose of the model is to highlight the client's crucial role in leading and motivating development and innovation with the help of an implementation guide (Femenías and Edén, 2009).

Recently, testbeds have also become a concept for collaboration to conduct joint development and testing. A testbed is a physical or virtual environment where companies, academia and other organisations can collaborate in the development, testing and introduction of new products, services, processes or organisational solutions (Vinnova, 2017).

"Strategic Alliances" is an agreement between companies to do business together to achieve strategically important goals that are mutually beneficial and go beyond the normal co-operation between companies, but which cannot be considered a merger or full partnership. The working method means that the customer and the client together with the important suppliers create a unified view of how the projects should be run. Common project goals are developed and the parties take joint responsibility for risks and project economics. Furthermore, open cost accounting is applied. The result is time and cost savings. The objectives can vary depending on the type of collaboration and can, be to gain greater market shares through partnerships, pursue development together, increase flexibility or, for example, push the costs. (Elmuti and Kathawala, 2001).

"Digital Collaboration". The increasing digitisation has led to the authorities, companies, academia having a need for an expanded exchange of information in digital form. eSam (a member-driven program for collaboration within the public sector) has developed a Swedish framework for digital collaboration. The aim is to exploit the possibilities of digitisation. The public authorities need to collaborate across organisational boundaries for development of digital services and the exchange of digital information to make it simple, qualitative and legally secure and effective. One prerequisite is that there is a common understanding, target image and an identified need for information exchange, another requirement is that there are agreed game rules (Legal for data sharing).

"Collaboration on basic or high level" has been developed by Trafikverket as a strategy for collaboration in investment and maintenance contracts. The aim is to increase productivity, innovation grade and competition. There are two levels; basic and high level. The activities for basic level are to create: 1) an organisation with the parties' representatives (with co-location as far as possible), 2) common goal management, 3) joint risk management, 4) conflict resolution methods, 5) continuous monitoring, improvement and benchmarking and 6) transparency in issues of a common nature.

In addition to listed activities, a person must be appointed to lead the collaboration, a collaborative leader. It can be an external person but can also be a suitable person in the project organisation or someone in the parties' other organisations.

Collaboration at high level means that the work is carried out in close collaboration between the client and the supplier in order to ensure an efficient working method, the right quality, improvements and goal fulfillment. Mandatory activities are: 1) The early stage is a complexity assessment (uncertainty), decisions are made on the level of collaboration and an internal organisation is appointed, 2) The procurement phase is chosen as a form of business and procurement parameters 3) Production stage (with a designated collaboration leader):

- Co-location with structure adapted to contract / assignment
- Common goal management
- Joint risk management
- Conflict Resolution Methods
- Continuous monitoring, improvement and benchmarking
- Transparency in issues of a common nature
- Object-adapted activities, e.g. team building
- Project-adapted communication

"ePilot collaboration model"; ePilot's goal is to implement relevant research and development results in the railway system in collaboration with the industry. The strategy has been to create an industry-wide process-oriented approach that has a service-oriented IT infrastructure that provides decision support based on condition data and provision of information material and disseminate the results in the industry.

The general strategies applied in ePilot:

- To involve relevant stakeholders for the purpose of finding development and improvement opportunities
- Use of eMaintenance LAB at LTU

- –Use international standards such as EN 50126 (RAMS) and EN 13306 (Maintenance)
- –Utilisation of technologies and results from research projects
- –An organisational neutrality for collaboration
- –An organisational neutral platform for information and education
- –A common project model, XLPM (Excellent Project Management)
- –Active participation in conferences and exhibitions

To succeed with industry collaboration, the project has designed a concept that has been based on common goals, an agreed method for problem solving and an active search for continuous measurable improvements.

The concept is based on the following cornerstones:

- – Neutral game plan and common rules
- – Enabling support organization
- – Collaboration between parties
- – Active participation
- – Responsibility
- – Transparency around one's own business
- – Control and quality assurance
- – Economic, legal and administrative conditions
- – Data Bank, data storage, analysis, report generation
- – eMaintenanceLAB
- – That the stakeholders help each other to get the right decision support
- – Testbed Railway, enables test in operated track

All parties have had the same status and ability to communicate openly with a fair balance of power.

2.2 *Comparison of the models*

When comparing the collaboration models, an analysis was made to see if there are more emphasised areas, any parameters that were commonly used and if there were parameters in some of the models that has been not used in ePilot. The method for the analysis was: 1) Collection of all key parameters mentioned for each collaboration model and comparing them with ePilot, 2) Grouping them in the perspective MOTE, i.e. Human (H) (origin from Man Machine, but here associated to Human Factors), organisation (O), technology (T) and economics (E). 3) Comparing and matching these factors toward the factors identified by Jägare (et. Al, 2015) as collaboration influencing factors sorted in the topics Legal, Organisation and Financing.

2.3 *Collection of key-parameters*

In total there were 104 key factors expressed, that was essential for achieving good collaboration in the models studied. Many of these factors had almost the same meaning, but were expressed in different words. In this study we kept the original parameter description to avoid subjective interpretation. A gap analysis revealed, key factors not expressed in the ePilot model were; economic factors such as economically gains for parties involved when implementing an innovation, gaining market shares, incentives, work actively with law, communication with the outside world during the project and risk management.

2.4.1 *Perspective Human, Organisation, Technology, Economic*

The factors were grouped towards the triggers, Human (H), Organisation (O), Technology (T) or Economic (E).

The following assumptions were made concerning categorising the parameters belonging into HOTE: "H" includes factors such as implementation, competence development, networking, conflicts and conflict solving, commitment of the management, methods for collaboration, openness, cooperating organisations, roles, teambuilding and a learning process. "O" includes targeting, measuring and feedback, quality assurance and steering documentation. "T" includes technology development, increased productivity, flexibility and data sharing and "E" includes profit, decreased cost, gain market share, minimize economical risks and target price with incentives.

The result of this shows that the factors mentioned as important for good cooperation can be classified as organizational (39 % of all factors collected), and human aspects 32 %), see Figure 1.

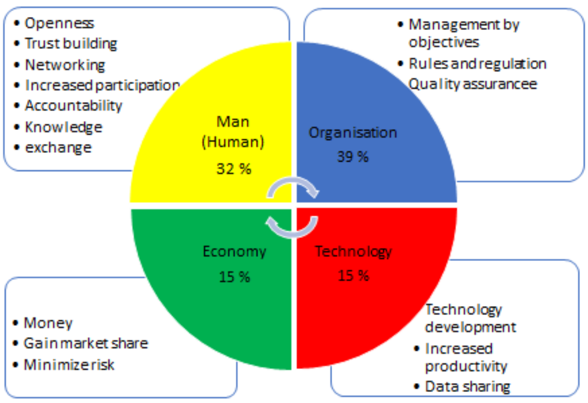

Figure 1. Factors grouped according to HOTE

The gap between the ePilot collaboration model and the other models are the factors, "Gain market share" and "Minimize risk".

2.5 *Collaborating influencing factors in ePilot*

The three influencing topics according to Jägare (et. al, 2015) are legal, organisation and finance. Legal consists of the factors: 1) Intellectual properties (IP) i.e. how to handle the background, progress and solutions of the subprojects, 2) Rules and regulation (R&R), 3) Data ownership (DOS) i.e. who owns the data, and 4) Data access rights (DAS) i.e. who is allowed to use the data and for what purpose. Organisation (Org) consists of the factors: 1) Commitment/communication (C/C) and 2) Methodology readiness (MR) i.e. are all parties ready and willingly to participate. Financing (Fi) has the factors: 1) Money in Kind (MiK) i.e. risk for sudden budget changes, 2) Return on Investment (ROI) strategies i.e. unclearness how to get a commercial advantage from participating in the project and 3) Benefit models (BM) where the benefits from participating in the project are unclear.

Table 1. Collaboration influencing factors related to HOTE

Topic	Factor	H	O	T	E
Legal	IP			x	
	R&R	x		x	
	DOS				
	DAS				
Org	C/C		x		
	MR		x		
Fi	MiK				x
	ROI				x
	BM				

It was difficult to unambiguously derive the parameters collected from the collaboration models and HOTE. Some assumptions were made and a preliminary assessment is that approximately 10-15 key factors belonged to the legal topic, 60 to 80 % was organisation topics. Only the economic topic was possible to match and 13 key factors (12 %) were found, see Table 1.

The topics and factors, not possible to compare or match towards key factors mentioned in the collaborations model for ePilot were: data ownership, data access rights and benefit models.

3 DISCUSSION

The goals of the ePilot are to implement results from research and development within operation and maintenance in the Swedish railway industry in order to increase efficiency and improve the quality of railway services. The situation today is that the majority of the system's parties agrees that the railway is to be considered as one system, which is depending on all parties working together to achieve the overall goals, which in this case is to improve the quality of the operation and maintenance of the railway.

Implementing research and development into a complex system governed by rules and regulation , including several partiers which has previously worked in silos where the communication has taken place via contracts is a challenge. A paradox arise where the parties involved should suddenly break a behaviour pattern from working within a the safe box by going outside the box, bringing new things and perhaps change the ways of working.

In order to do this, collaboration is required. Various models developed by the construction industry, the business world or in public authorities, already exist based on methods like partnering, strategic alliances or digital collaboration.

For the construction industry, the purpose of cooperation is to achieve common goals delivering the right quality, at the right time and at the right cost without getting into a conflict. In maintenance contracts it becomes more complicated because difficulties to describe the goals with respect to maintenance being a process and that quality will fall with age and use. (Olsson & Espling, 2004).

In innovation projects where collaboration is required, the complexity is increasing, causing a difficulty to identify which factors to take into account in order to ensure that the collaboration leads to the goals being achieved. In ePilot, the first collaboration model applied was partnering with adaptation to maintenance (Olsson & Espling, 2004). From active observation it has been discovered that: 1) economic factors concerning benefits and business opportunities is poorly described and regulated i.e. using incentive models how to share profit and loss, 2) how to work actively with legal issues, 3) how to communicate with the outside world during the project, 4) risk management and 5 that the achievement of the goals must be possible to be visualized and measured

From HOTE it can be concluded that gained benefits efforts will be found in key factors belonging to organisation and human factors, and that “Gain market shares” and “Minimize risk” are factors that needs to be considered .

Concluding remarks are that before starting the collaboration, the purpose must be described in a very clear way, e.g. what is the aim and goal, can all parties agree on working towards them, what is in it for the parties and is it accepted by the other partners. Is there an agreement of sharing the benefits and the loss. Furthermore, one should be clear about whom, besides of the parties involved, that will be effected and who are the end users. It is of great importance that the benefit and what will change can be described before the project start. During the collaboration project, there is a need to continuously review the rules of the collaboration in order for all the parties feel safe. The project should also include a railway system expertise group for evaluation and validation of the results. Agreed risk assessment and conflict resolution model are also necessary.

Finally, in order to succeed in having a good collaboration, the message of why you work together must be repeated throughout the whole duration of the project.

4 CONCLUSION

The purpose of this paper is to describe factors enabling a successful collaboration, collaborative methodology and provide conditions for continued participation in the ePilot-project. In this work collated observations has continuously been gathered from the project concerning collaboration activities. Seven collaboration models has been studied and a comparison and gap-analysis has been conducted.

Concluding remarks are that the ePilot collaboration model needs a clearer and agreed definition of the aim for all parties involved, how the results will affect the whole railway system, who is the end user and how will it benefit the end users. It is crucial that all parties can feel safe during the project e.g. minimize the risks for the participants, and create a win-win situation.

RECOMMENDATION

As innovation projects means implementation of new technology, new methods, organisational changes etc. collaboration models to support the change are needed.

In order to keep up with the development, the collaborative models must also be constantly reviewed and developed so that they create a reliable and safe atmosphere for continued collaboration.

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