A good practice guide for the introduction of Cross-Industry Remote Condition Monitoring

T1010-03

This document gives guidance and suggests good practice for the planning, implementation and operation of Cross-Industry Remote Condition Monitoring systems

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1 Introduction

1.1 Cross-Industry Remote Condition Monitoring

The benefits of Remote Condition Monitoring (RCM) as a tool to inform a condition based maintenance strategy are now widely recognised; its use can improve maintenance efficiency, increase asset availability and reduce safety risk.

RCM is now widely used on modern trains to monitor the condition of key components, such as: doors, brakes and traction systems, through the Train Management System (TMS). On the infrastructure Network Rail also use significant amounts of RCM systems to monitor the condition of points, signalling systems, track geometry and the power supply network*. Both the train and infrastructure maintainers have achieved significant benefits from their use of RCM.

However, it can be more efficient to monitor some aspects of train condition from the line-side and to monitor some aspects of the condition of the infrastructure from passing trains. A sensor placed on the line-side can monitor multiple passing trains over the course of a day, whilst a train borne sensor can monitor significant parts of the infrastructure as it travels around the network.

The infrastructure tends to be owned, operated and maintained by a separate organisation to that which owns or operates the trains. It is therefore necessary for an element of collaboration between different railway organisations in order to monitor trains from the infrastructure, or infrastructure from trains (and to use the information received).

Cross-Industry RCM systems are monitoring systems based on an asset owned by one railway organisation that monitors the assets of another railway organisation.

1.2 Background

This document gives guidance and suggests good practice for the planning, implementation and operation of 'Cross-Industry RCM' systems.

This guide has been produced as part of the RSSB T1010 research project 'Cross-Industry Remote Condition Monitoring, Phase 2'. T1010 included four work packages:

1. Data sharing architecture
2. Commercial considerations
3. Standards and good practice guide (which includes this guide)
4. A guide to business case assessment of cross-industry RCM projects.

Detailed reports for each of these work packages have been published on RSSB's web portal SPARK. This guide is intended as high level outline of how to plan, implement and operate a cross-industry RCM system and refers to the relevant detailed reports from the other work packages where necessary.

* See 'T1010-01 Recent Developments in RCM'[1] for more details

2 Project Lifecycle

Figure 1 shows an overview of the suggested project life cycle. Each step is explained further in Section 3, 4 & 5. A particular project may cover all or part of this lifecycle, some activities may be carried out in parallel or in a different order as appropriate.

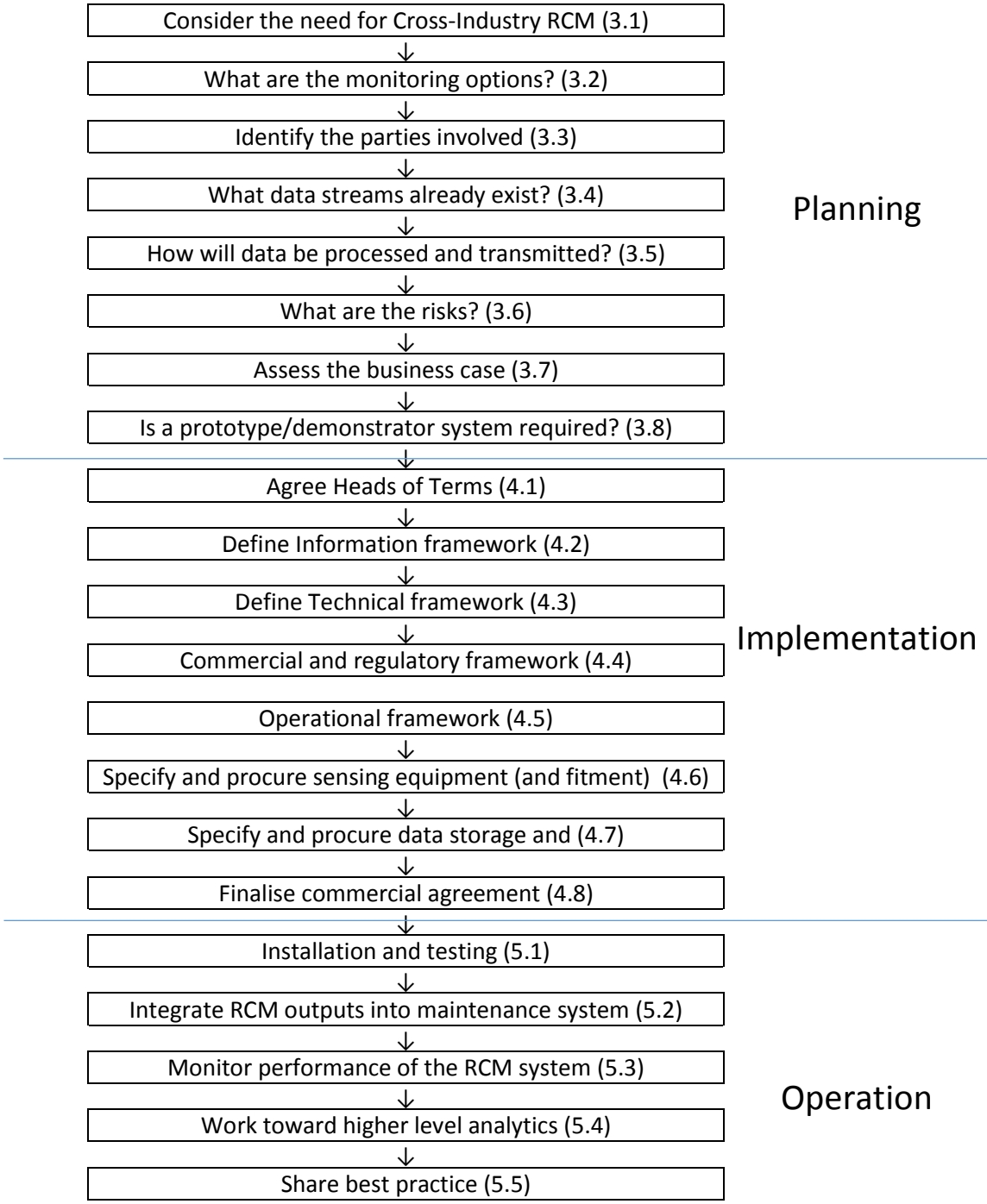

Figure 1 - Framework of Project Lifecycle

3 Planning

3.1 Consider the need for Cross-Industry RCM

A proposal to introduce a new form of cross-industry RCM may stem from a number of sources, including:

- Difficulty obtaining enough asset condition data about a specific asset that is leading to reliability and availability issues;
- Introduction of a new asset that will require monitoring;
- Introduction of a new asset that gives the opportunity to include monitoring systems in that asset that can be used to monitor the assets it will interact with;
- Identification of an existing data stream that could be more effectively used to contribute to the understanding of the condition of a given asset;
- The need to replace existing cross-industry RCM (or existing single asset RCM systems) due to obsolescence; or
- Implementation of a cross-industry RCM enabler (such as a train location system or Automatic Vehicle Identification {AVI}) that would ease the introduction of that RCM system or increase the benefits that it could achieve.

When considering the need for a new cross-industry RCM system, decision makers should take into account how the outputs of that system will be used and how those outputs will help to inform a better maintenance strategy in order to improve reliability, availability, maintenance efficiency (including efficiency of the monitoring activity) or safety.

How the condition data will be communicated to the maintenance processes or planning systems should also be considered, as should the real needs for the data (how accurate does it need to be; how precise; how often it needs to be provided; how reliable does the monitoring equipment need to be; how reliable does the monitoring system need to be; and what is the necessary range of coverage of assets to be monitored in order to achieve the desired outcomes).

It is often most effective to install RCM equipment when either the asset it is going to be monitored is being introduced, or the asset where the RCM equipment will be based is being introduced.

3.2 What are the monitoring options?

Early in the planning stage, the variety of condition monitoring options that can achieve the aims of the project should be considered. These options should include manual monitoring techniques, single asset RCM systems as well as the various cross-industry RCM systems that could provide the required asset condition information. Cross-industry RCM will not be the best option for the provision of asset condition data in all circumstances.

Options can be ruled out or in based on a high level assessment, and the more realistic options can then be considered in a business case assessment.

3.3 Identify the parties involved

It is important to identify all parties who may be involved in the possible data sharing architecture project. Those parties may be: providers of data, recipients of data, suppliers of monitoring equipment, owners of other assets affected, owners of other relevant data, maintenance contractors for the assets involved (both the monitored asset and monitoring system hosting asset).

Consideration should be given to when these affected parties are consulted, how they might be affected by the project and whether any contractual arrangements need to be set up between them.

Appendix C1 of 'Cross-industry remote condition monitoring and data sharing – a template approach to commercial implementation'[2] shows a diagram of the industry parties likely to be involved in a Cross-Industry RCM project. It may also be beneficial to consider Appendix B of the same report which shows a summary of the industry consultation exercise carried out as part of T1010-02 (in July 2013); this may be a useful background to consider as it highlights the priorities of the other parties involved.

3.4 What data streams already exist (are they the main condition data source or supplementary)

For any given asset, there may already be a number of sources of information about the condition of that asset, its usage, the range of locations it is used at, the environmental conditions it has been subject to and the maintenance interventions that have been carried out on it. These are all potential sources of information that can be used to develop a more efficient and effective maintenance strategy. When considering the introduction of a new cross-

industry RCM system, the existing sources of information about the asset to be monitored should be identified. Analysis of these existing sources may show that there is already enough asset information available to achieve the objectives of the project (without the need for additional monitoring systems), or that the existing information could be more effectively combined and processed to provide the necessary information without the need for any new monitoring equipment.

3.5 How will data be processed and transmitted

A key decision to be made early in the planning phase is how the asset condition data measured by the monitoring system will be transmitted to the maintenance engineers who will ultimately be using it.

Data may be transmitted automatically at a predefined periodicity (or in response to a certain event or cumulative usage of the asset being monitored) via the General Packet Radio Service (GPRS) network for either train based or infrastructure based monitoring systems, or may be downloaded from a train as it passes a certain base station. Alternatively data may be downloaded manually by an operator visiting the monitoring equipment on the trackside or from a train at the depot.

It may be possible for the company, which owns the assets being monitored, to also own and operate the sensing equipment that monitors them and only require the other party to host that monitoring equipment.[†] This makes the data transmission easier to arrange and simplifies the contractual details. This may be the most appropriate option for assets which degrade slowly over time (or usage); the downside is the need for manual intervention to collect the data and

[†] This is currently the arrangement for the Unattended Geometry Monitoring Systems (UGMS) used on the West Coast, where Virgin Trains host the UGMS system which is owned by Network Rail. Virgin Trains' responsibility is to keep the system attached to the train at the necessary location, Network Rail own the monitoring equipment and visit the depot to download measured data.

the risk of not being able to physically access the monitoring system on a given day.

The monitored parameters will be measured at the 'State Detection' level‡; it may be useful to store and transmit all of the detail included in these measurement for downstream analysis of the data and to allow possible alternative uses for the same data in a different application. Alternatively, the amount of data can be reduced by 'on-sensor' processing to create higher order asset condition information. This reduces the amount of data that needs to be stored or transmitted and turns the collected data into useable information. However, this does reduce the level of detailed data that can be reviewed later for other uses or for in-depth incident investigation.

Asset condition data can be stored, transmitted, processed and integrated with other data streams using the RCM Data Sharing Architecture defined in 'T1010-01 Architecture Principles and Requirements'[4].

3.6 What are the risks?

The commercial and technology risks affecting the project should be considered. Specific consideration should be given to the likelihood of obtaining funding and the various sources of funding.

A realistic assessment should be made of how mature the RCM technology is and how suitable the formats of the existing outputs are to communicate with the necessary maintenance management system (either directly or through the RCM data sharing architecture). The maturity of the measurement system, decision making algorithms and communication system should all be taken into account, along with the reliability of the monitoring system. It will be beneficial to identify examples of the system's use for other applications and find any lessons learnt from those examples.

‡ As defined in ISO 13374 [3]

The level of engagement from all of the parties who will be affected by the introduction of the system should also be considered.

A risk register for the project should be created along with a record of the necessary actions to address those risks. At this stage if the necessary risk mitigation measures are not realistically achievable or the RCM system is not at the appropriate Technology Readiness Level (TRL) it may not be the best time to pursue the project.

These identified risks and mitigations will inform how best to proceed at future stages of the project, including any necessary technology developments, the need for prototyping or testing and may identify necessary commercial arrangements.

3.7 Develop a business case

In order to select the most appropriate option for obtaining asset condition data and to inform any necessary funding application, a business case analysis for the cross-industry RCM project should be carried out.

The business case should show how the costs and benefits are expected to be allocated.

'RCM Business Case Guidance' [5] provides advice on how to approach the business case analysis. A business case template spreadsheet is also available to help set up the analysis[6].

3.8 Is a prototype/demonstrator system required?

Depending on the TRL of the monitoring system being introduced it may be beneficial to carry out a feasibility study or development activity through the use of a demonstrator system operating on a limited number of assets or within a limited geographical scope. This will help reduce the risk of attempting to introduce an unproven system on a large scale and will also aid any funding application. The asset condition data collected during the trial can be used to

inform the development of any necessary data processing system and the setting of suitable intervention values. The trial data can also be used to help develop a link (if necessary) to an RCM data sharing architecture.

4 Implementation

4.1 Heads of Terms

Assuming there appears to be a viable project to introduce a new cross-industry RCM monitoring system (or to use data from existing monitoring systems more effectively), the first step will be a high level agreement to proceed between the parties involved. This agreement is known as the 'Heads of Terms' (HoT); topics to consider are shown in the Business Process maps in Appendix C2 of 'Cross-industry remote condition monitoring and data sharing – a template approach to commercial implementation'[2]. The topics are:

- Agree overall aims
- Agree who does what
- Agree who gains what outputs
- Agree who pays what
- Agree target timescales
- Agree other key commercial terms

These Heads of Terms will later form the basis of the full commercial agreement.

4.2 Define information framework

The information framework should include:

- Metadata for data that would be gathered
- Information lifecycle (taking into account the ISO 13374[3] RCM maturity levels)
- Processing requirements
- Meta-information for information that would be generated
- Warranty of information
- Data & information storage / retrieval requirements

This list is also shown in the business process maps in Appendix C2 of 'Cross-industry remote condition monitoring and data sharing – a template approach to commercial implementation'[1].

This framework will inform the development of the RCM system; help to define how the outputs will be used; and also inform the development of the full commercial agreement.

4.3 Define Technical framework

The technical framework will build on the information framework to include:

- An output specification for the monitoring equipment (including number and location of monitoring sites);
- An acceptable failure rate of the monitoring equipment
- An acceptable accuracy of the system (in terms of false failures)
- The communication system;
- Any links to other systems, such as the data sharing architecture or directly to a maintenance management tool;
- A description of how the outputs of the system will be used to inform maintenance plans.

Any lessons learned from a feasibility study (if one has been carried out) can be included in the technical framework.

4.4 Commercial and regulatory framework

At this stage the necessary commercial agreement between the parties involved should be drafted and agreed. Template contracts that can be used to help this process are included in Appendix E of 'Cross-industry remote condition monitoring and data sharing – a template approach to commercial implementation' [2], along with a guide of how to use the template agreement in Appendix F of the same report.

The template contract defines the structure of the commercial principles of the agreement, covering:

1. Organisation and Parties
2. Objectives
3. Governance
4. Business Case
5. Initial Investment, Renewals
6. System Operation, Maintenance
7. Data Collection, Processing, Hosting, Transmission
8. Data Ownership (IPR), Sharing, Usage and Confidentiality (NDAs)
9. Service Level Agreements (SLAs)
10. Warranties, [Insurances], [Liability Caps]

Along with eight schedules, covering:

- Contract Specific Provisions
- Specification
- Programme
- Data Ownership and Intellectual Property
- Payments
- Service Level Agreement
- Insurance
- Joint Management Group

The templates are a starting point for the drafting of the necessary contracts and are not necessarily intended to be used with the exact wording in the draft documents. They provide *'a legal framework for the parties to arrive at an agreement, as well as pointers and aide memoires of the sorts of issues that will need to be resolved. It is noted that the parties are not required to use this document and may choose, for example, not to use the format where a party is collecting data as part of its usual course of business. Nonetheless, the template agreement can be versatile and used, potentially, multiple times in any one project – if appropriate, for example, by acceding new parties seeking to join an existing RCM scheme'*[2].

4.5 Operational framework

The operational framework should include details of how the monitoring system will work during the live phase: what has to be done to operate, maintain and upgrade the system; what are the roles and responsibilities involved; and how will costs be allocated between the parties involved.

4.6 Specify and procure sensing equipment (and fitment)

Building on the details of the technical framework, a full specification for the monitoring system should be defined, taking into account any lessons learned from any testing that has been carried out and checking that the specification matches up with any relevant requirements in the commercial agreements. Based on this specification the monitoring system can be procured and installed.

4.7 Specify and procure data storage and transmission

Building on the outputs of activities 3.5, 4.2, 4.3 the necessary data storage and transmission equipment should be fully specified and procured. It is recommended to consider the use of the RCM data sharing architecture specified in 'T1010-01 Architecture Principles and Requirements' [2]. Where a range of cross-industry RCM systems are being used in the same area, if those systems can all communicate through a common data sharing architecture, there will be significant saving to each of the projects that implement the different cross-industry RCM systems. Any new data sharing architecture should be specified so that it is modular in nature and can be extended in future (as recommended by T1010-01[4]).

The commercial sensitivity of the condition data being shared should be considered, and this can be taken into account in the commercial agreement. Data may be shared directly between two specific parties, i.e. the party collecting the asset condition data and the party that owns the asset being monitored.

Conversely in other cases condition data could be made publically available for software developers to use and develop processing algorithms to help inform maintenance decisions.

4.8 Finalise commercial agreement

Based on the commercial and regulatory framework already agreed, the commercial agreement should be finalised for the installation, operation and maintenance of the system including the agreed usage of condition data collected. In defining the operational framework and fully specifying the monitoring equipment and data sharing architecture, more information may have been collected that will help to better inform the development of the commercial agreement; this final check of the agreement gives the opportunity to do this.

5 Operation

5.1 Installation and testing

An installation and testing plan should be created that allows for the most efficient and effective implementation of the system. Results of any testing carried out as part of activity 3.8 should be considered along with any relevant risks (and mitigations) identified in activity 3.6. Depending on the Technology Readiness Levels, availability of funding and the operational model, a phased approach to installation and operation may be beneficial. The testing plan should consider likely failure modes and include a thorough fault finding and snagging process.

5.2 Integrate data stream into maintenance management system

Once the new RCM system 'goes live' this may result in significant increases in the volume of asset condition data. Plans detailing how to store, process and

transmit that data along with how to use that data to inform maintenance decisions should already have been made during activities 3.5, 4.3 and 4.5. As more experience is gained of how to use that data, these plans can be revised.

As more data is collected, a better understanding of the condition of the assets will be developed. If the spread of existing asset condition falls outside the expected or target asset condition, a programme of targeted maintenance and renewals activity to take out the worst condition assets first may be beneficial. Intervention limits can then be slowly adjusted as the asset condition moves towards the targeted distribution.

Initially, as assets are identified to be renewed, those assets can be manually inspected in order to make sure they really are in need of renewal or maintenance. As this knowledge develops it can be used to help calibrate the monitoring system. Inspecting the assets in need of intervention will also help to understand the failure modes and help plan more efficient maintenance in future.

As experience of using the system is gained, the operational framework can be revisited and updated as required.

5.3 Monitor performance of the RCM system

The performance of the RCM system will ultimately be measured against how well its use has helped improve reliability, availability, cost of maintenance and safety. Collecting data on these parameters, over time will allow them to be trended in order to carry out an assessment of the system. Any improvements can then be compared against the figures suggested in the business case analysis carried out in activity 3.7 and used to help calculate realistic cost/benefit analyses in future. If the expected outcomes are not being achieved, this evidence may allow the system to be adjusted in order to work towards the desired outcomes.

Successfully achieving performance targets will help justify wider role out of the existing system or for further use of other cross-industry RCM systems.

The reliability of the sensing equipment itself should also be monitored along with the levels of 'false faults' it has highlighted (i.e. alarms or maintenance interventions that were not necessary). Trending this data should allow the problems to be targeted in order to improve the system.

5.4 Trend data and use for higher level analytics

Once the system is established and successfully achieving the desired outcomes there is an opportunity to evaluate other potential uses for the condition data or how other data streams may be integrated into a maintenance decision model. This will allow 'higher level analytics' to be used in order to gain more benefits from the system.

Detailed understanding of asset degradation rates and failure modes can also be used to inform the design of future versions of those assets.

5.5 Share best practice

Sharing lessons learnt and best practices developed by the cross-industry RCM projects with other industry parties will help the whole industry work towards the goals of improved reliability, availability, maintenance efficiency and safety.

Best practice might include: how the RCM data was used and integrated with maintenance planning systems; technical details of how sensors where mounted and communications achieved; problems found during implementation; the commercial arrangements; and a record of the real benefits achieved. All of which are likely to benefit other industry partners. Lessons learnt and best practice can be shared through the RSSB facilitated Cross Industry RCM Strategy Group[§].

[§] Further detail of the Cross Industry RCM Strategy Group can be found at www.rssb.co.uk or by contacting enquirydesk@rssb.co.uk.

6 References

[1] T1010- 01 Review of RCM Developments, T1010-01 Cross-Industry Remote Condition Monitoring Programme, Phase 2, April 2015

[2] Cross-industry remote condition monitoring and data sharing – a template approach to commercial implementation, T1010-02 Cross-Industry Remote Condition Monitoring Programme, Phase 2, April 2015

[3] ISO 13374, Condition monitoring and diagnostics of machines – Data processing, communication and presentation, Part 2: Data Processing, 2007

[4] Johnson, P., T1010-01 Architecture Principles and Requirements, April 2015

[5] RCM Business Case Guidance, Project T1010-04, AMCL, April 2015

[6] RCM Tool 3.0, April 2015