

Guidance Document

G0213 Condition Monitoring

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MAYOR OF LONDON



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1 Purpose

- 1.1 The purpose of this guidance is to outline a consistent and integrated approach to CM systems in London Underground.
- 1.2 This Guidance Document provides guidance for work to implement new or expand existing Condition Monitoring (CM systems). It covers:
 - a) A process and guidelines for determining CM strategy and requirements, CM system selection and embedding the system into business-as-usual use,
 - b) Explanation of the reasoning for the technical content of the Category 1 Standard (S1213).

2 Scope

- 2.1 This Guidance applies to all work to implement new Condition Monitoring systems or to develop & expand existing Condition Monitoring systems.
- 2.2 This guidance document explains the reasoning behind the requirements mandated by the Category 1 Condition Monitoring Standard (S1213) and offers guidance on the best practice approach for achieving compliance with this Standard
- 2.3 The guidance document also, where relevant, explains the current strategic approach to Condition Monitoring in London Underground (as at the date of issue of this document). Note this document is planned for review two years after the issue date in recognition of the rapid pace of development of CM and associated technologies as well as an accelerating adoption of CM in the railway industry.
- 2.4 Sections of the CM Category 1 Standard (S1213) are quoted in appropriate sections within this guidance document. Clauses from the Standard are shown as text in italic within a box, for example:

3.5.2 *TfL shall be able to access and interpret all input and output data in a documented readable format*

3 Guidance

The guidance section is divided into two parts as follows:

- A process and guidelines for CM strategy definition, determination of the drivers for performing CM, system selection, research & development and embedding the system into business-as-usual use,
- Explanation of the reasoning for the technical content of the Category 1 Standard (S1213).

3.1 System Development & Delivery Process

The process outlined within this section is applicable at many levels of detail. It can be applied to perform a high level analysis of CM prioritisation across asset areas, through to development and delivery of discrete CM solutions.

This guide is intended to be followed within existing best practice project delivery process. So, for London Underground this is (currently) the Project Management Framework (PMF), but for non-LU areas different project frameworks may apply. A core principle of this Guidance Document and the CM Standard is that Condition Monitoring assets should not be treated differently to other assets; projects are required to follow all governance steps for delivery of CM including asset documentation, training, handover and entry onto Ellipse (or equivalent Maintenance Management System) as a maintainable asset.

Figure 1 below based upon the process in ISO 17359:2011 outlines the best practice process to follow:

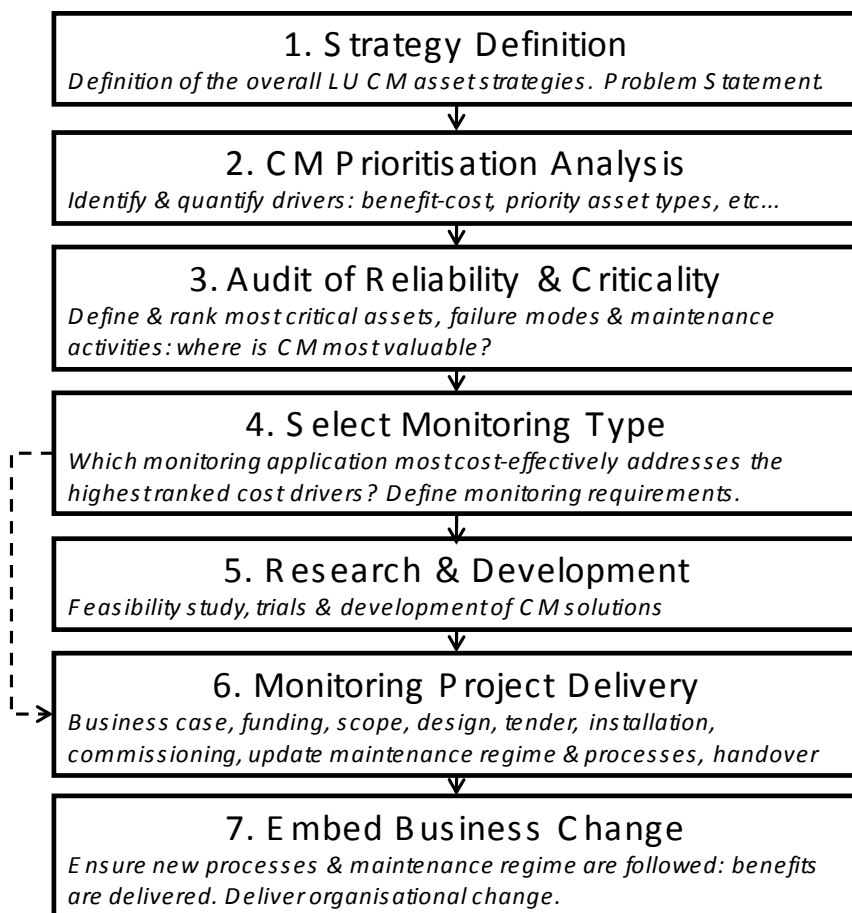


Figure 1 - Best Practice Process for delivery of Condition Monitoring

Applying this process ensures consistency to the way in which CM systems are developed, that the optimum CM system configuration is selected, that only CM which is demonstrably cost-effective is progressed and that the potential benefits of the CM are actually delivered.

3.3.1 *The CM solution shall be designed and optimised using the methodology in section 4 of BS ISO 13379:2003 to:*

- a) Decide if CM is the right solution*
- b) Measure the correct variables*
- c) Optimise the CM system*

The subsections below offer explanation and guidance for each process step.

3.1.1 Strategy Definition

The strategy for CM should be defined at several levels:

- The High-Level Condition Monitoring Strategy
- The CM Strategy captured in Asset Group Strategies (AGSs) and Asset Maintenance Plans (AMPs)
- Application/Project Specific CM Strategy covering the strategy, aims and objectives for a specific project or existing monitoring solution

As relevant to the work being carried out, the relevant parent documents should be reviewed to ensure the CM Solution delivered is consistent with these strategies and plans.

3.1.2 CM Benefit-Cost Prioritisation Analysis

Performing a prioritisation analysis establishes the key business drivers for applying CM to a particular asset type or application or problem, thereby setting out what the success criteria for an effective solution are.

Factors worth considering when performing the analysis are:

- Cost of failures: Lost Customer Hours, replacement & repair cost, consequential damage, equipment life degradation, reputational cost.
- Life cycle cost: Life extension, replacement & refurbishment timings optimisation,
- Asset population & variability: more assets → sharing of core costs, more variable assets → cost of customisation, benefit of full asset base CM coverage
- Cost of maintenance: potential gain through maintenance based upon condition (note: at this stage a possible monitoring solution may not yet have been identified).

3.1.3 Audit of Reliability & Criticality

A reliability and criticality audit is to determine where to implement CM. There may only be value in performing condition monitoring on a subset of assets of a particular type.

For some asset types all of them are considered equally critical (e.g. a given fleet of identical trains) whereas for other assets types some are more critical than others (e.g. criticality of point sets will vary by location). Thus, criticality analysis can be quite simple, or when the asset base is highly variable more factors may need to be taken in to consideration. In many instances certain subsystems of assets may be more critical than others.

Whilst reliability is invariably a key factor to derive criticality due to the potential for customer-affecting disruption, it is not necessarily the sole driver.

Factors which can be considered when defining a particular individual asset's criticality & reliability are:

- Cost of failure in terms of Lost Customer Hours, Service Points, Materials and Labour costs (This was covered in 3.1.2 at a macro/strategic level, but here the consideration is for individual assets and ideally individual subsystems of assets).
- Cost of maintenance (including inspection) in terms of:
 - Time taken to carry out maintenance tasks
 - Level of skill required to carry out maintenance tasks
 - Cost of consumable items
 - Accessibility of the asset – is it difficult or impossible to access the asset to maintain it without significant cost
- Failures by location
- Historical failure rates (MTBF/MDBF)
- Mean time to repair (MTTR)
- Time to site (TTS) and time to fix (TTF)
- System and Asset Redundancy (e.g. multiple escalators running in the same direction versus just a single escalator)
- Whole life costs (cost of maintenance, inspection, refurbishment, replacement)
- Safety and environmental impact
- Items whose failure would have significant impact on the operation of the railway

The factors above, and others as considered relevant, can be weighted, scored and a formula applied to produce a ranked criticality list of assets or sub-assets.

3.1.4 Select Monitoring Type

3.1.4.1 Failure Modes Effects and Criticality Analysis

Performing a Failure Modes Effects and Criticality Analysis (FMECA) is a useful structured approach to follow when selecting the type of CM to use and indeed to also evaluate if CM is the correct solution or if another is best (e.g. redesign or process improvement). An assessment should be performed of the appropriate level of granularity at which to perform an FMECA:

- If performed at too high a level (e.g. at a per-asset level) the output in most cases would be quite meaningless as the underlying cause of failure will most likely not be revealed and it will not be possible to see clearly what the best CM or non-CM mitigation is
- If performed at a level which is too detailed (e.g. component/sub-component) the process might take too long and cost too much to complete. In some instances it may well be relevant to go to a deep level of detail only for certain subsystems on an asset so a good approach is to perform the FMECA at a higher level (e.g. subsystem) to identify those systems which it is worthwhile drilling-down then focusing on those a more detailed FMECA.