

Aging managements for railway infrastructure

an overview and ideas for discussion

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Sep, 2021

Some points

- 1 Traditional research objectives
- 2 Current Application area
- 3 Typical research questions
- 4 Some current research models/approaches

Discuss with **current problems** and **possible solutions**.

1 Traditional research objectives

The current studies are focusing on those components/systems, which are close to their designed lifetime.

- **Problem:**

The designed lifetime could be changed (shorter) due to abnormal “aging” caused by operation context, new technical/standards/other requirements (economy, safety, risk, environment, and climate), etc. Some “aging” problem could be delayed for being detected and even lead to accident or economic loss.

- **Research suggestion:**

- 1) Redefine the “aging” components/systems, not only according to designed lifetime but also the real aging process and changed context (for instance, China Railway speed up for 6 times (average speed from 48 k/h to 250 k/h) since 2000s with some “old” systems);
- 2) Start from the critical components/system, separate the monitoring/inspection approaches for different levels (time based, condition based, and context based).

2 Current Application area

Studies are more popular for infrastructure of: Nuclear power station, oil & gas platform, water supply/ wastewater system, transportation system (bridge, etc.)

- **Problem:**

So far, there is no systematic (only very limited) approaches focusing on railway infrastructure (either components or systems; with normal maintenance program (like PHM)); in particular, it seems less when they are compared with studies on other infrastructures.

This may lead to the risk on related knowledge development and human assets (one possible case is “American’s road infrastructure”).

- **Research suggestion:**

Lead and develop systematic research/education on aging management for railway infrastructures.

3 Typical research questions

The typical research questions include:

- How about their current operation status – inspection and assessment;
 - If those components/systems could be continued in use when they are close to / after their design lifetime – assessment and prediction;
 - If the lifetimes of those components/systems could be extended after the design lifetime and how to extend them – maintenance decisions and implementation;
 - How to digitalized the aging management – implementation.
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- **Problem:** The current research are studied more independently/locally. This may lead to a neglect of “Bullwhip effect” which could reduce the feasibility and competition strengthens.
 - **Research suggestion:** Raise new question to consider the research questions in a more collaborative way; for which a possible solution is to develop context driven dynamic decision tree for aging infrastructure.

4 Current research models/approaches (1/3)

Some current research models/approaches include:

- **Regarding inspection:**
 - tools and approaches
 - Detection for different aging modes
- **Regarding assessment:**
 - Framework on assessment (or according to some standards)
 - Structural integrity assessment (incl., function, safety, risk.)
 - Extreme conditions reassessment (incl. earthquake, etc.)
 - Economy assessment (incl. life cycle management)
- **Regarding prediction**
 - On Remaining Useful lifetime (incl. physical model based with tests and simulation or data driven approaches by sampling signals/data from critical components)
- **Regarding lifetime extension**
 - On reinforcement or replace management of local/part of the components
 - Maintenance strategies making and optimization
 - Simulation tools and approaches
- **Regarding decision making**
 - Modern Decision Theory
 - Uncertainty Decision
 - Risk based Decision
 - Digitalization solutions

4 Current research models/approaches (2/3)

Problem (incl. but not limited to):

- Online information are not used sufficiently which could lead to the lag time for detection;
- Different industry has its own study focus (components/systems); various developed process for aging management ; very vague framework/criteria in different segments on different components;
- Purely physical model based approaches or purely data driven approaches couldn't reduce the uncertainties sufficiently which may lead to bias for prediction;
- All decisions making are not studied with clear decision preference/criteria which lead to potential risk on applications;
- New approaches on detection, assessment, prediction, decision making and digitalization, etc., should be studied;
- No clear standard for the whole infrastructure system's aging management which is not good for knowledge management;
- No collaborative decision studies for the system;

4 Current research models/approaches (3/3)

Research suggestion:

- Combine with condition data, and other context data, etc., to make not only time based detection but context driven approaches;
- Develop new framework, considering structural integrity assessment with economy, safety, risk, environment, and climate, with decision theory and process;
- Develop hybrid models, considering physical models (with tests) and data driven approach (stochastic models, statistical models, ML & DL, etc.);
- Develop dynamic decision trees with Bayesian knowledge;
- Visualization on railway infrastructures aging management;
- More...

Thanks!