Railway commissioning using a human factors testing approach

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ABSTRACT

In October 2018, Denmark commissioned a new era of Railway operation, using the European Railway Traffic Management System (ERTMS). The change in operational practices from lineside signalling and no Automatic Train Protection to a fully integrated in-cab Driver Machine Interface solution and a central Traffic Control Centre required a lot of organisational preparation. This case study describes the important role of the Human Factors (HF) testing and Trial Running approach adopted by Banedanmark to test and introduce the new system. The testing process required a lot of preparation, which assisted in the smooth execution of the testing and further analysis. The test scenarios were developed by the HF team, with test responsibility also managed by HF coordinators. Any negative findings and outputs were fed into an improvement cycle which highlighted where technical, operational rules and training changes were necessary. Positive findings were used to provide evidence that the system would be safe to put into service. There are now opportunities to reuse the approach to enable a more efficient roll out of the new system because of the systematic approach and the use of Human Component Mapping (HCM). The outcome has delivered evidence to close operational hazards, which in turn, has provided confidence to put the railway into service. This fills an integration gap, left by the interoperability standards and this testing approach will be reused until the year 2030, when the whole of Denmark will eventually be changed to the new signalling system.

KEYWORDS

Railway Commissioning, Human Factors Testing, Human Components,

Introduction

The Danish Signalling Programme for the mainline (Fjernbane) has been running for over 10 years. The requirements phase started when there was an acknowledgement that the infrastructure was "life-expired". Basically, this means that maintenance and replacement of existing equipment has become very difficult; with faults and failures causing more delays and cancellations than acceptable. The upgrade to the new European Railway Traffic Management System (ERTMS) will cost over 3billion Euros and has been funded by public money and grants from the European Union. Therefore, its success is critical to the country and future railway operations.

The Signalling Programme is very much focused upon solving some very intense technical delivery and installation issues. However, the technical system is only one part of the story. With the introduction of a different signalling system, there are:

- New ways of working (new operational rules);

- New organisation structure (with new and changed roles using different equipment);
- Significant changes to the Safety Management System (and a necessity to show that operational risks are managed).

The new ERTMS solution (specifically Level 2, Baseline 3) is the first implementation into service in the World. Operational experience is available from other ERTMS projects but the technical differences and the implementation onto a "brown field" site mean that there are a lot of challenges to testing in the field.

The problem

The key problem associated with introducing ERTMS into Denmark (as an upgrade to the existing railway) is how to show that operational risks are being managed and to feel comfortable about the overall operational safety, such that rail services can commence.

The reason why this has been a challenge is because there are elements of the upgrade that are covered by legislation and require National Safety Authority (NSA) approval; and they ***don't include an integrated operation***! The European Interoperability Standards and the approvals for putting into service take each part of the railway and handle it separately.

For example:

- The train-based equipment (called "Onboard") has its own Safety Approval;
- Each signalling system delivery has its own Safety Approval;
- The operational rules have a standalone Safety Approval;
- The training specification has a Safety Approval.
- But, due to competition rules and basis of interoperability standards, there is no requirement for an inclusive Safety Approval for the whole system that includes the trains, signalling system and people.

Human Factors practitioners will realise that this raises a number of concerns associated with the potential for real-life operational issues to fall between the cracks of responsibility. For the organisation that has the overall responsibility for the safety management of operations (the Infrastructure Company), there is a need to complete work to provide confidence that they are prepared and ready for full service, with no operational safety issues.

High-level approach

The approach taken has been to seek a way to provide evidence that the integrated railway, at the operational level, is fit for service by introducing a railway level safety package. This is not presented for NSA approval and it is not expected to be introduced as legislation. It is a safety package that contains what is needed for the Infrastructure Company to feel prepared and comfortable for themselves.

The package is reviewed by an Independent Safety Assessor and requires a large number of critical inputs in order to gain the confidence. A key feature of the Railway Safety Package is the input of Trial Running, which is the Human Factors testing approach used by Banedanmark. The Trial Running is live, real-life testing of operational scenarios. The scenarios are based upon a set of Test Intentions, which can be put together into a variety of combinations. The combinations chosen depending upon the topography of the part of the railway being commissioned, the staff involved and the maturity of the technical and functional delivery.

Human Factors involvement

The Human Factors Team have developed the set of operational Test Intentions, put them together into the Scenarios and ensured that they are relevant in the context of the particular locations and topography. The suite of Scenarios (or testing paths) has been created in a way that they are reusable and can be placed one-after-the-other, to effectively escalate a situation.

For each testing session, the Human Factors Team worked with the Test Manager to develop an operationally relevant schedule and place the Scenarios within it.

The Human Factors Team have created a set of Trial Running Observation Sheets, which are delivered to the people observing the tests in electronic format. The Trial Running Observers are able to complete their observations quickly and the data can be collected into one place for analysis. The Trial Running Observers have been trained on the Operational Rules, the operational aspects of the technical user interfaces that they will be observing and in observation skills. They are presented with an explanation of the trigger for the Scenario, together with Key Measure Questions that they must answer (as an observation of "Pass", "Difficult" or "Fail" – P, D, F).

As the tests progress, there is a Trial Running Coordinator, who triggers the Scenarios and coordinates the Trial Running Observers. The operational personnel (Signallers, Drivers, etc.) do not know what will happen next. They are of course aware that this is a Trial Running condition, however, the operations are live (trains are moving) and staff must behave according to the correct practices laid out in their training. There is a potential for something unsafe to occur, if the people do not perform as expected; so there are Operational Rules experts and a Test Safety Manager included in the Trial Running team. They are alert to each Scenario, and they can halt the train movements or cancel an operational command should something incorrect happen.

The Human Factors Team are involved throughout the Trial Running and very soon after each session, the initial feedback is collated and feed into an improvement cycle. There are feedback sessions, which are attended by the Training Team, Safety Team, Operations and Operational Rules. The feedback session states what was observed, with an intention not to presuppose why. The improvement cycle identifies what elements need updating (e.g. the Rules, Training, product understanding, etc.) and by when they can make a change. Re-testing takes place after operational personnel have been re-trained or briefed appropriately.

New methods

The Trial Running has required a large number of Test Intentions to be created, each of which has a purpose in terms of providing evidence that the operational personnel are prepared (in terms of clear Operational Rules, product and Rules training, etc.). Where a less than fully positive result means that improvements are required, the Training content, Rules and other content may be updated. The end goal is to close Operational Hazards and provide an appropriate level of confidence that the people are ready to run an operational service safely, with good performance levels.

As the reader might imagine, there are hundreds of Rules to be followed, multiple training modules to keep track of, a lot of operational hazards and the potential for thousands of pieces of data collected during the Trial Running sessions. Therefore, there is a large challenge to keep track of which result relates to other content. The solution has been the use of a new method called "Human Component Mapping" (HCM), developed by the author in collaboration with others. It is a

culmination of approaches started on other projects and further developed with input from other Human Factors practitioners.

The HCM methodology focuses upon the allocation of "Human Components" to each situation, test, hazard, rule, training module, application condition, etc. These Human Components are used as the central hub of a relational database that allows one part of the database to be linked and thus related to one another.

The approach is quite simple; the allocation of Human Components requires skill, HF thinking and application knowledge. The result is that you can query the database and find out the answer to any combination of elements.

For example: which rules, training content and hazards are relevant to a particular test; or if a rule is changed, what training needs updating and what Trial Running Test Intentions should be performed to check out whether the change has filtered through the operational personnel.

Lessons learnt

The purpose of the Trial Running (TR) is to determine whether the operational personnel are ready and well-prepared for running an operational service. It was very important to ensure that operational personnel were aware that they were not "on trial" themselves. Of course, people do not like being watched and so there have been ways developed to make the situation somewhat more palatable. The use of the standard phrase "for the purpose of the test" has been an effective way of communicating the need for a particular action to be triggered. Briefings have emphasised a request for the operational personnel to feedback whether they felt they were prepared for the session by their training in the products, systems and Operational Rules. The number of people in the vicinity of the Trial Run and who is allowed to talk, and when, is also regulated. Having an Operational Rules expert on hand has also made the environment more comfortable for those who have to perform safety-critical tasks, often for the first time in real-life, during the Trial Runs.

Preparation has been key and there is a constant internal improvement cycle for the Trial Running itself. There are a lot of activities, people and content to manage. Iterative improvements to the design of the schedules, the TR Observer sheets, feedback meetings and logistical items have helped to make each session normally slightly easier to participate in. For example, the original TR observations were made on paper; TR Observers were only trained in observing and completing forms but not in the operations; and testing/ train movement schedules needed a lot of concentration to follow.

The use of a relational database and populating it has taken a long time. The creation of the Key Measures followed a Task Analysis approach, which provided surety that the right questions were being asked. However, it also took a long time to complete correctly. Internal and external Quality Assurance checks were needed to build up a robust set of links with the Human Component Mapping, with a number of domain experts from rules and training giving a great deal of time to agree with the content contained in the database. That being said, the database is now reusable and is applicable across the railway. New Scenarios are easy to add in and, as the topography changed, new functionality and rules will become applicable. Other disciplines have asked to add into the database, as they can see the benefits and are keen to be able to tap into the power of the linkage already available.

Outcomes

This project has provided the opportunity for Human Factors thinking to take a central role in the development and delivery of a method for operational testing. The Trial Running approach has heavily relied upon HF involvement and has resulted in some important observations, requiring improvements prior to placing into service. Some findings have resulted in the need for updates, discussions and actions at the highest managerial briefing sessions within the Programme.

The overall outcome has been a strong belief that the HF-led approach to Operational Trial Running provides valid results and has been key in the successful introduction of the new system. The testing has been supported and championed by management and also by the operational teams. The Safety Team now relies upon the output from HF to create confidence that the railway can be brought into service.

In the long term, the systematic use of the database, HCM, Trial Running Observations and the reuse of Test Intentions as a series of reality-driven Scenarios will be vital to the speed of delivery. The processes followed allow for a "delta approach", so that testing (or re-testing) is only necessary when there is a change or difference to the last part of the railway line. Since all Operational Hazard closure arguments can be traced to tests, training content and rules, it has become easier to identify how much operation testing is actually needed. This is crucial, since it will take until the year 2030 to complete every roll out of the Signalling System across Denmark.

The challenge explained at the beginning of this paper was to indicate that there are no standards for Safety Approvals for the integration of the ERTMS railway. This potentially leaves a gap in confidence levels for the overall operator, and whether they are prepared for the operational aspects of the railway, using newly trained operators with new rules and new products. This case study shows that using HF-led Trial Running, with the support of HCM in a relational database, is an essential part of the Railway Safety Package in Denmark that provides the confidence for operational readiness.