Experiences from the rail industry

Developing & maintaining competence

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Abstract
Competence plays a very important role in controlling risks – especially in degraded and emergency situations where it is often the actions of people which are critical in returning the system to a ‘normal’ state. This paper draws on experiences in the UK rail industry where organisations have been required to have formal ‘competence management systems’ for safety critical work for many years. Rail industry organizations are required to develop, maintain and assess the competence of individuals on an ongoing basis – training and once-off assessment is no longer an acceptable means of inferring competence. We explore some of the issues that the rail industry has faced when developing systems for managing competence in degraded and emergency situations and which may be equally relevant to other hazardous industries.

1 Introduction
Railway operations are still largely a human activity where competence of individual operators is often a significant risk control measure. Given this feature of its operations, and several major accidents where human performance was a significant contributory factor, the industry has required its various constituent organisations to have formal processes in place for managing the competence of staff carrying out safety critical work [1]. An important aspect of this is to ensure that the risks associated with abnormal/degraded operations and emergency situations are assessed and that appropriate methods are used to develop, monitor and maintain competence.

2 What is ‘competence’?
There are many definitions of what ‘competence’ is, reflecting that it is a complex concept. Certainly, ‘competence’ must be more than just technical skill or depth of knowledge alone. ‘Competence’ also seems to develop over time, as the individual becomes more practised at the activities they are performing, indicating that experience is an important factor. An equally important consideration should surely also be whether the individual chooses to apply their skills, knowledge and experience; their willingness to perform. From this a simple working model of the components of competence could be expressed as shown in figure 1 below:

![Figure 1: Components of competence.](image-url)
From this it can be seen that competence management activities (e.g. training, briefing, coaching, mentoring and assessment) must therefore touch on each of these component parts to provide a robust means of developing, maintaining and monitoring an individual’s competence. This has significant implications for high risk/low frequency events such as operating in degraded and emergency situations where the opportunity to practise skills in a real situation is likely to be impossible.

3 Degraded and emergency situations

Giving workers the opportunities to practise their skills (and for assessors to monitor this performance) in normal operations is relatively easy; these are ‘normal’ operations and so are occurring frequently. The rail industry’s definition of ‘normal’ operations includes the peaks in demand that are experienced in the mornings and evenings when the train service is more intense. When things go wrong, individual performance is often crucial in achieving a safe and prompt return to normal operation and avoiding the situation becoming worse, eventually to the point of an emergency situation, as shown in Figure 2 below:

Research in both the rail and civil aviation sectors [2] has shown that during these degraded modes of operation operators are likely to take actions that may undermine or erode safety margins in an attempt to maintain services. These actions, whilst often taken for the right reasons, can have significant consequences for safe operation. Operators are often ill-prepared for such situations as their training may never have addressed it (or if it did, it may not have used methods that allowed practise and encouraged retention) and may never experienced such a situation since their training.

Figure 2: Effect of competence during different modes of operation
This is crucial, as such situations often require almost automatic performance, which can only be achieved when an operator is well practised in the necessary skills and has sufficient knowledge to understand the implications of his/her actions.

Examples of ‘degraded’ situations in the railway operating environment include:

- One or more lifts out of use at a busy underground station
- A section of track out of use, requiring trains to take diversionary routes or operate under special rules (such as single line working)
- Failure of lineside signalling equipment requiring the introduction of special rules (passing signals at danger, temporary block working)
- Adverse weather conditions, reducing adhesion levels between rail and wheel affecting braking and acceleration
- Service disruption, causing station overcrowding and volatile customers

Organisations demonstrating best practice in the rail industry have considered these degraded and emergency situations when defining what is required to perform safely when these situations occur.

4 Defining competent performance
As we have discussed, ‘competence’ is quite a complex concept; this makes defining ‘competent performance’ for a range of activities equally difficult. We can recognise competent performance in others when we experience it (or when we experience its absence!), but trying to make this explicit, codifying it in simple words is a challenging, perhaps impossible, task. However, there are ways to make this more achievable:

a. Focus on the critical activities; those things that, if not done competently would have significant adverse consequences
b. Identify the things that people must do and know to perform these critical activities and write them down in unambiguous terms
c. Use assessors who have carried out the activities themselves so they are able to make reasonable judgements of performance and give guidance and advice on better ways of working
d. Use training and assessment methods that get as close as possible to the reality of the activity (i.e. moving away from classroom training and assessment through questioning and more towards activity-based training and assessment)

In the rail industry’s approach [3], risk assessment underpins the development of an effective competence management system – this ensures that the most important activities are focused on and appropriate methods are used to develop and assess competence. This approach requires some expertise to apply and also means that National Occupational Standards (used to award National/Scottish Vocational Qualifications) are of little use other than as a starting point. This is because National Occupational Standards not risk-based and are therefore likely to either to miss critical activities entirely or use terms that have little relevance to the specific operations of an individual organisation. For example, it is reasonable to suppose that a safety critical worker at a station should be able to ‘respond to out of course and emergency situations on platforms’ (unit 35 of the railway ‘Passenger Services’ National Occupational Standards). Two specific activities that you would hope such a worker would be competent to perform would be stopping trains in an emergency and (if operating on part of the railway with 750v 3rd rail, 4th rail or 25kv overhead live wires) be able to get traction current switched off. Surprisingly, neither of these two activities are listed in the national standards, being subsumed within the generic performance criteria of ‘promptly take action to minimise risk to people, platform operations and the environment in accordance with procedures’. This is clearly too vague to identify all of the essential high-risk activities.
5 Achieving competent performance
As discussed above, risk assessment is a central part of a competence management system, as indicated in Figure 3 below:

This model indicates that risk assessment provides a critical input into the following decisions:

- In which activities should we develop, monitor and maintain the competence of our people?
- What parts of the learning programme should be a high priority?
- What methods of delivery will be appropriate for different parts of a learning programme?
- What methods will be appropriate for assessing competence?

![Figure 3: The central role of risk assessment in competence management](image)
5.1 Selecting an appropriate learning method
Experience of some sort is critical in the learning process – it is how we as humans naturally develop our understanding and mastery of our environment. This pattern of learning is represented in this well-known model [4] with more accessible wording:

![Experiential Learning Cycle Diagram](image)

Figure 4: The experiential learning cycle

It is logical to suggest that learning programmes for operational personnel (whose jobs typically involve a greater proportion of physical activity compared to the amount of reading, thinking and reflecting that typifies management roles) should include a significant amount of doing rather than traditional ‘chalk and talk’ training. If this is accepted, then the objective of any learning programme should be to get as close to reality as reasonably practicable. A natural hierarchy exists in the various learning delivery methods that are available to an organisation, as shown in Figure 5.

![Hierarchy of Learning Delivery Methods](image)

Figure 5: Hierarchy of learning delivery methods

General rule of application:
Only drop down to the method in the next lower box if the higher one is impossible or justifiably impractical.
The decision of what is ‘reasonably practicable’ should be informed by the risk assessment and by what is likely to be feasible in the workplace. This means that high risk activities that occur frequently (driving a train over simple track layouts for example) can be delivered through practical application but with appropriate controls in place to ensure that the safety of others is not compromised. For the train driving example this could mean driving an empty train on a test track (or quiet stretch of track) under the instruction of an experienced operator who can intervene if an error is made.

For high-risk activities that occur rarely (our degraded and emergency situations) different solutions will be required as practical experience of a real situation is unlikely to be possible. The objective is still to get as close to reality as possible, so in such cases some form of simulation is likely to be required.

For rarely-occurring low-risk activities the cost of either waiting for the situation to naturally occur or of generating a suitable simulation may be unreasonably high. In such cases, the more traditional, classroom-based approach is likely to be acceptable.

This logical approach is represented in the model below:

![Figure 6: Determining appropriate learning delivery methods.](image)

This framework is encouraging rail industry organisations to adopt Adult or Action Learning techniques that have proven successful in other industries [5]. In recent years there has been a shift in the approach to occupational learning from the traditional pedagogic (trainer-centred) approach towards an androgogic, learner-centred approach.
5.2 Structuring learning and development programmes
Allowing learners to get experience of real-world activities means that they build up common mental models and images of their operating environment (the railway). This means that when a step away from reality has to be taken, when using simulation or classroom-based methods, all the learners in the group are likely to be able to visualise the equipment and environment being presented. This has implications for how learning and development activities should be structured; experience of normal operations should be given before moving on to degraded operations and emergency situations:

Assessment plays a key role in the learning and development process and needs to be programmed in throughout the learning process to ensure that a comprehensive picture is built up of an individual’s competence (knowledge, skills, experience and attitude). By programming in regular assessments the final assessment workload is reduced and the employing manager has a wealth of performance evidence on which to base his/her decisions for employment. This cannot be done with confidence if assessment at each stage is based mainly upon knowledge.

5.3 Assessing and maintaining competence
Up to now we have discussed competence development; we now need to discuss competence assessment. A core principle of the rail industry’s approach is that assessment should take place regularly to ensure that a picture is built up of whether an individual is performing competently, consistently. Typically a two or three year programme of assessment is used, during which all the performance and knowledge criteria will be assessed (sometimes more than once). By using numerous ‘samples’ of performance evidence a much more reliable (and fairer) picture of an individual’s competence can be established. This allows early intervention to develop and maintain an individual’s competence before it ever becomes a significant concern. In effect this is what managers and supervisors have been doing for years - managing by walking about’.

We indicated in Figure 3 that risk assessment has an important part to play in determining the assessment methods that are appropriate for different activities. Other factors to be considered are the likely skill fade (which in simple terms is dependent on the complexity of the activity and the

Figure 7: Structure of a learning and development programme
frequency that operators are able to experience it in the workplace) and the opportunity that an assessor is likely to have to see the activity taking place.

We discussed earlier that one component of ‘competence’ is attitude – the willingness of an individual to apply his/her skills and knowledge in a given situation. Assessing this component of competence is difficult to achieve – as soon as an individual is aware that they are being assessed they are likely to modify their behaviour and therefore a true picture of how the individual normally performs in the situation cannot be obtained. Rail industry organisations make use of a range of unannounced or unobtrusive monitoring techniques to counter this problem, including:

- Using downloads of on-board data recorders to analyse train driving techniques
- Using downloads of digital voice recording equipment from signalling control centres
- Travelling on board trains in passenger areas to monitor driving technique, public address announcements and observing station dispatch procedures

Operations in degraded situations and emergencies occur rarely so it is often difficult or impossible to monitor the performance of staff in these circumstances other than by chance. Appropriate methods are needed to provide workers with experience of these situations that is as close to reality as possible and allows assessors to make a judgement on their performance. As with learning programmes, appropriate methods for these situations are likely to be simulations of some form [3], including:

- Tabletop exercises (eg working through a planned and controlled scenario with one or more staff responding to a particular situation)
- Simulation of procedures using real equipment (e.g. working on fault-finding on a train and acting as if certain fault conditions existed)
- Incident simulations (eg an incident is simulated, with people made up as crash victims for the exercise)

- Use of a simulator to mirror the working environment (eg a signalling centre, or a train-driving simulator).

6 How successful has the approach been?
Industry accident reports still show that there are competence-related errors occurring during degraded and emergency situations that have had significant consequences. Investigation findings have indicated that if the respective organisation’s competence management arrangements had been more robust then the individuals involved would have been better-equipped to deal with the circumstances that eventually led to the incident. Two case studies are included below.

Runaway of two wagons from Camden Road Tunnel 19 July 2007
When starting away from a signal the coupling between the rear two wagons and the rest of the train broke, leaving these two wagons on the track, but detached from the rest of the train. The train’s automatic brakes applied on both portions of the train, bring both to a stand. The rear two wagons came to a stand inside a tunnel and the front portion came to a stand with the last wagon approximately 24 metres away from the detached wagons. The driver went to examine the train to find out why it had come to a sudden stop. He found that the last wagon in the front portion of the train had no tail lamp (used to indicate the final wagon/coach in the train) and that the brake pipe cocks were open. The driver failed to see the two detached wagons in the tunnel and wrongly assumed that whilst the train had been stationary vandals had removed the tail lamp and opened the brake pipe cocks. The driver contacted the signaller to tell him what had been found, fitted a new tail lamp, closed the brake pipe cocks and continued on his way with the front portion of the train. After the front portion had arrived at its destination (about 30 minute’s journey time), the signaller noticed that his control panel still showed that the tracks in the tunnel as occupied and asked the driver to examine his train again. It was then found that the train was
missing two wagons. During this time the brakes on the two detached wagons had started to leak off and then eventually began to roll away, running for 200 to 300 metres in the same direction as the train (down a light gradient and then up a slight gradient), then reversed direction and came to rest about 140 metres from where they started. No-one was injured in this incident and no damage was sustained by any infrastructure, however under different circumstances the outcome could have been very different. The investigation found that the ongoing competence management system for the signaller used a computer based package to test the signaller’s understanding of all the relevant rule book requirements every three months over a three year period. This process did not include the facility to be able to practice the response required to those incidents that signallers might be expected to deal with, sometimes infrequently. This would require access to a simulator, or at least a process where specific incident scenarios were explored through a process of discussion [6]. The investigation did not comment on whether the competence management arrangements for the driver included any opportunities for practise of such situations (as opposed to knowledge tests), so we are unable to determine whether these were appropriate.

Collision with the gates at Lydney Town level crossing
In August 2007 a special passenger train on the Dean Forest steam heritage railway struck a partially open level crossing gate at Lydney Town level crossing, detaching the gate from its mountings. The gate struck and seriously injured one of the two crossing keepers. The train was of a very unusual type, with the driver operating the some of controls remotely (from a driving position in a passenger carriage) with the other crew member (the fireman) being responsible for others. Crucially, the operation of the braking equipment required both crew members to co-ordinate their actions and have a good understanding of what the other required. On the day of the accident the railway was operating in a degraded mode – safety equipment warning crossing keepers that a train was approaching was not working, the railhead conditions were poor as a result of wet weather and sanding equipment on the train (allowing sand to be dropped on the track between the wheel and rail to increase adhesion) was not working. The accident investigation showed that the locomotive crews were unaware that the lineside warning equipment was not working, were unfamiliar with this train arrangement, had not practised handling the brake in emergencies, and may not have fully understood what to do when things started to go wrong. This turned an abnormal situation into an emergency with a resultant serious injury to one of the workforce. [7].

The two cases cited above show that it’s not that the industry’s structure for managing competence is not appropriate, it’s just that organisations haven’t applied it. Therein lies the main criticism of the rail industry’s approach and published guidance; effective competence management systems are difficult to conceive without expert help (it would be difficult to develop a system using just the industry’s guidance document), and knowing who is an ‘expert’ can be difficult to judge.

Another issue to be considered is that of ‘risk’. Quantifying risk is subjective for many operations, given limited resources and expertise within railway companies. This means that different organisations, operating identical equipment over very similar parts of the railway network can arrive at very different conclusions. Rail industry research carried out in 1998 over a selection of train maintenance organisations [8] revealed that companies maintaining the same trains had selected very different competence assessment frequencies, with some refreshing/assessing competence and some choosing a 5-year period between assessments.
7 Conclusions
The approach developed by the rail industry is logical. It provides a means of structuring competence development and assessment activities which are often disjointed, separated by functional boundaries and management responsibilities. Taking a risk-based approach ensures that the activities most critical to an organisation’s operation are focused on and appropriate methods are used to develop, monitor and maintain the competence of those performing them. A similar structure for managing competence, based on the rail industry’s guidance, has recently been developed for people involved with electronic safety critical systems. This guidance was developed jointly by the Health & Safety Executive, Institution of Engineering Technology and the British Computer Society [9].

Such an approach is likely to be relevant to a wider range of business sectors, particularly where immediate safety or business performance is highly dependent on the actions human beings take.

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