Good Practice Guide on Simulation as a Tool for Training and Assessment

Synopsis:

This document provides guidelines and advice for the use of simulation techniques in training and assessment.
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Introduction

1. Purpose and scope

The purpose of this Good Practice Guide (GPG) is to provide guidance on the specification, procurement and use of simulation as an aid to training and assessment in the GB rail industry. Simulation should be seen simply as a tool for such activities, so this GPG will help those who deliver training and carry out assessments to select the right tool and to use it effectively.

The GPG is based on desk research and a series of interviews carried out during the period May to September 2004 with Network Rail, existing users of simulation within GB train operating companies (TOCs) and with third party rail training and competency assessment providers.

The GPG also draws on similar applications of simulation in the civil aviation, maritime and defence industries, where simulation has played an important role in training and competency assessment for many years.

Simulation can also be used for other activities including human factors (HF) research, operational planning and to reproduce situations for incident investigations. These latter applications are not covered by this GPG in any detail but should be considered when specifying simulation projects intended for training and assessment.

2. Definitions

The definition of simulation (and, by default, simulators) used in this GPG is taken from ‘How to use Simulation in National Occupational Standards – A Toolkit’, produced by the Rail Industry Training Council (RITC), which defines simulation as:

‘A model of real activity created for training purposes or to solve a problem’.

A similar definition, this time from the HSE, is adopted in GO/RT3251 (Train Driving):

‘a situation or environment, which is reproduced, but not necessarily by a machine’

In either case, the main point is that a simulator need not involve a full replica of the real equipment, complete with computer software, motion systems, and high-quality graphics. Simulation can range from non-technology applications (such as paper-based schematics and cardboard mock-ups, classroom exercises, or face-to-face role-play), through simple computer based simulations (including multi-media graphics and animations), desk-top computer based training and assessment, situation and equipment emulations, to part-task trainers and high fidelity driving and signalling simulators. It also includes real equipment used in a non-operational training context, but excludes on-the-job-training (OJT), which is outside the scope of this document.

Closely associated with simulation is the concept of fidelity, which relates to the degree to which the simulator accurately reproduces the characteristics of the real environment. The key areas of concern can broadly be divided into physical fidelity (that is, the degree to which the simulated environment looks like the real environment) and functional fidelity (that is, the degree to which the simulated environment behaves like the real environment). Fidelity also has a subjective or perceptual component, which concerns the performance and control strategies of the operator in the simulated environment.

Deciding what level of fidelity is ‘appropriate’ for a given simulator is often controversial, but is usually driven by the application needs and goals of the users. Further advice is provided where relevant throughout this GPG.

In the context of this GPG the following definitions of training and assessment apply:

Training is a feedback process that involves:

- Providing information, familiarisation and understanding of the task environment
- Transfer of knowledge (cognitive training)
• Practice of skills to carry out tasks (psychomotor training).

In particular, training goes beyond mere knowledge delivery via books, manuals, group or company standards etc., and focuses on interactive involvement of trainees with such equipment and situations as they are expected to deal with during their jobs.

**Assessment** is an evaluation process that involves:

- Collecting evidence of performance (for example, via a test)
- Judging such evidence against objective criteria
- Using these results to make decisions about competence.
Simulation methods

3. Categories
This GPG covers a wide range of simulation technologies and methods and their application to training and assessment across the rail industry workforce. Media and methods purely aimed at knowledge delivery (books, electronic page turning) have not been included in this GPG, as the focus is on interactive training rather than passive learning. The broad categories of training and assessment media and methods covered in this GPG are as follows, generally ranging from high to low fidelity:

a) Original equipment (OE) – the use of original equipment in a non-operational environment. Particularly applied for hands-on skills training, and for live training exercises. Examples include:

- Sections of track, points engines, track circuit and signalling equipment used at rail maintenance training schools
- Real rolling stock used for service crew training, evacuation training and practice in handling derailments
- Driving of real trains on greased rails on a specially treated section of track for low-adhesion training
- Off-line signal boxes
- Live drill exercises involving emergency services for incident and accident response training.

b) Full simulators (FS) – these often include the use of real or accurate replica workstations or equipment to create a high fidelity simulated learning environment in a training school, capable of presenting the trainee with the closest possible representation of operating conditions. The most common examples of such simulators used in rail include:

- Full cab simulators for driver training and assessment
- Control rooms with integrated electronic control centre (IECC) simulators for signallers.

Such simulators provide an opportunity to encounter those situations and tasks where detailed dynamic aspects of the environment can affect the development of situation awareness and psychomotor skills, and where these skills are important elements of performance.
c) **Part task trainers (PTT)** – these devices often focus on specific aspects of a role and are usually employed to supplement or fill critical training gaps within the context of an overall training and assessment programme. Since the PTT is generally associated with medium-fidelity devices, it can provide lower cost training facilities for specific tasks where exact replication of the operator’s workstation is not necessary. Examples of this include:

- Route-learning devices for drivers
- Multi-function generic driving simulators used to train or assess principles rather than traction unit specific training
- Generic signalling simulators
- Communications trainers
- Mock-up station and customer service areas for the training of ticketing, customer service and station staff
- Screen based emulators providing free-play practice in fault diagnosis for maintainer training.

d) **Computer based training (CBT)** – self paced interactive learning/assessment. Implemented on personal computer (PC) desktop equipment in the form of interactive courseware, CBT can include delivery of knowledge followed by facilitating practice, application of knowledge and problem solving in context-specific simulated scenarios. Training material is presented sequentially as the trainee moves through the material, and can include remedial loops if the trainee has difficulty with a topic. Such applications often include formative and summative testing to assess comprehension and competence. The same hardware can be used to host courseware for a wide range of topics. CBT is often used in distributed learning applications including e-learning, that is material delivered over company Intranets or the Internet. Widely used across many industries for a range of technical and
procedural **training** and **assessment**, and largely representing mid to low fidelity simulation. Applications in rail include:

- Rule Book **training**
- Signalling circuits
- Engineering **training**
- Driving procedures
- Signalling procedures.

C-BT classroom Rule Book CBT

e) **Computer assisted instruction (CAI)** – instructor led classroom **training** using interactive technology. CAI is still a common and popular form of **training** and **assessment** in many industries for wide range of applications. CAI courseware or PowerPoint slides hosted on PCs, videos and DVDs are used as the means of knowledge delivery. Demonstrations/trainee interaction through scenarios are often used to reinforce knowledge and allow instructors to assess performance. Common applications in rail include:

- The Sentinel courseware for the various roles in track working
- Rule Book **training**
- Customer services.

f) **Group discussions including situational role-play (GD/RP)** – used mostly in a classroom environment with non-technology based situations to support development of interpersonal skills and to train appropriate reactions to operational situations. A low-fidelity solution, used in many industries to provide relatively low cost practice and development of skills. Common applications are:

- Communications
- Customer service
- Handling conflict
- Giving evidence to inquiry boards.
4. **Applications**

The use of simulation in the GB rail industry is not new. Driving simulators and part task trainers have been used for many years with some legacy signalling trainers, lengths of track and equipment used in training for even longer. The decision of where and when to use simulation needs to be seen in the context of the current training programmes for the various worker groups. This section details the current applications of simulation in the main railway worker groups at the time of writing.

a) **Drivers**

Whilst a large proportion of driver training is still conducted in the cab, training courses are increasingly being modified to accommodate simulation tools. These can range from group exercises (GD/RP), through films and videos (CAI or PTT), to computer-based Rule Book training (CBT). In the light of the Cullen recommendations, there has also been wider investment in high fidelity driving simulators (PTT and FS). However, there is not yet sufficient evidence to justify a reduction in cab time as a result of training in the simulator.

Advanced driving simulators vary in their implementation, depending on the particular requirements of the operator. A fully specified replica cab has potential advantages of fidelity and transfer of training, at the cost of being restricted to one particular cab or traction type. Conversely, generic or re-configurable cabs can be use to train drivers on a range of locomotives, but could potentially disrupt performance in the real world. The trade-off between these will depend on the training programme and the target population of drivers, and Driver Training Managers from all TOCs have been willing to share experiences through a ‘user group’.

b) **Signallers**

In a similar way as driving simulators, traditional signalling simulators are relatively old, relatively limited and sometimes poorly maintained. Examples include model train sets (GD/RP) and bespoke fixed block simulation (PTT). More recently, high fidelity simulators have been brought in for IECC systems (FS).

A training report titled ‘Signaller’s Training Needs Analysis: Optimising the Role of Simulation’ produced recommendations on the way forward for training this group of workers. In particular, the report focused on the forms of simulation available and how they should be applied within the overall training courses. A blended solution was proposed combining proven practices from past implementations with new technology, including:

- High fidelity simulators
- PTTs
- CBT/e-learning
- CAI
- 3D Models
- Games.
Communication between all workers has been highlighted as a risk area during recent incident inquiries. Safety-critical communications can be practiced in a simulated environment by joint exercises between drivers and signallers, with the additional benefit of promoting better understanding between these groups. Although there are currently no formal arrangements in place for such cross exchanges, anecdotal evidence suggests there is potential in exploring this further.

c) Trackside workers
Safety training is carried out using simulation in the form of scenario-based courseware supported by video, photographs, diagrams and animations (CAI). Assessment is by written test and one-to-one assessment by an authorised instructor. Many training facilities also have sections of non-operational track available to conduct PTS training (OE).

Similarly, much of the technical training is classroom based via PowerPoint scenarios, animations, videos etc (CAI) but there is significant hands-on practical training using original equipment assets, such as actual lengths of track, points, signal heads etc (OE). Often there are live track circuits, on which the instructor can introduce faults for the students to diagnose and rectify.

Whilst it is difficult to envisage a further role of simulation for manual activities, there are areas of track maintenance (such as track inspection or fault detection) that would be more amenable to virtual environments or interactive screen-based emulation (PTT).

d) Engineering maintenance staff
The formal courseware for training professional rolling stock engineers typically comprise instructor-led sessions using PowerPoint enriched with animations/video etc (CAI), with reinforcement through interactive group exercises or role-playing of incident panels – that is, non-technology based simulation (OE; GD/RP). CBT is not used in this training since it is considered too expensive to develop and maintain currency for a relatively small number of trainees.

Although the use of technology-based simulation is very limited, due mainly to the relatively small number of trainees, some form of screen-based simulation (PTT) would be relevant to support the technical specialisations. As trains and their systems become more complex lessons could be learned from the aerospace industry where emulations are used to support diagnosis of faults through an interactive engineering model of the equipment. Use of this technique in the aerospace industry has resulted in better competence in the timely diagnosis and rectification of system faults and reductions in down time for valuable assets. In addition, there are now a number of PC-based applications that could be used to support training in areas such as signal sighting principles or the visualisation and construction of rail and signalling layouts.

e) Operations planners
Current practice is for classroom sessions (CAI) coupled with some group role-play (GD/RP). However, some PC based rail network simulations developed for the hobbyist market and a professional tool have been identified that could have potential application to training in the principles of network planning (PTT/CBT). Whilst PC games and similar off-the-shelf software might seem quite accurate, it is recommended that validation trials be carried out as to their actual utility and effectiveness before formally incorporating them into training programmes.

f) Train crews
Train Managers, as customer facing personnel, undergo training in customer services. Much of this is classroom based involving non-technology scenario based simulation, working groups, discussion groups etc (GD/RP) to promote active learning through interaction backed up by periods of mentoring and on-the-job training in which trainees shadow experienced staff. The objective of this training is to give practice in dealing with customers. This has been found to be effective and no other form of simulation is currently envisaged for this part of the role.

In safety aspects of the role, both guards and train managers have to know the relevant rules associated with assisting drivers to make the train safe in the event of breakdown, and evacuation procedures as appropriate. Some TOCs use a ‘training train’ to provide practice facilities (OE). Training carriages that can be filled with synthetic smoke to make evacuation exercises more realistic
are also used. Some TOCs have informal sessions for guards to ‘drive’ the cab simulators (FS) to experience train management from the driver’s viewpoint.

g) Customer services
Simulation to enhance training of customer facing personnel largely takes the form of increased trainee interactivity and participation in the courses, sometimes employing low cost “props” to enhance the fidelity of the training environment. Courses generally incorporate videos and student participation (CAI), with an emphasis on group role-play (GD/RP). The interaction includes dealing with other levels of staff, including senior management, which can help to engender teamwork and improve morale.

Physical systems (OE) are used to provide practice in using ticketing equipment, onboard tills etc, and a simulated service room containing a mock-up shop with actual refreshment equipment and service trolley. Students take it in turns to play the role of customer and service staff. The use of professional actors can be useful in stimulating the group exercises and steering the role-play to the training goals.

The main lesson learned from these applications of simulation is that there has been a significant improvement in training through greater interactivity, and that this approach has made training more enjoyable and has been well received by both trainees and management. These are relatively low cost initiatives that have been shown to have a positive effect on training.

h) Summary
Table 1 summarises the range of current and potential applications for training and assessment related to the railway group user roles, and the classifications of simulation appropriate to each.
### Table 1  Current and potential applications of simulation to rail worker roles

<table>
<thead>
<tr>
<th>User group</th>
<th>Category</th>
<th>Example applications</th>
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<tr>
<td><strong>Drivers</strong></td>
<td>FS</td>
<td>Full cab driving simulators</td>
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<tr>
<td></td>
<td>PTT</td>
<td>Part-task multi-function driving simulators; Route learning interactive video; Communication simulators</td>
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<tr>
<td></td>
<td>CBT</td>
<td>Rule Book; Fault procedures</td>
</tr>
<tr>
<td></td>
<td>CAI, GD/RP</td>
<td>Classroom and safety day exercises; Communications training</td>
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<tr>
<td><strong>Signallers</strong></td>
<td>FS</td>
<td>Screen based IECC simulators</td>
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<tr>
<td></td>
<td>PTT</td>
<td>NX system simulators; Lever frame simulators; Model railways; Communication simulators</td>
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<tr>
<td></td>
<td>CBT</td>
<td>Rules and procedures</td>
</tr>
<tr>
<td></td>
<td>CAI, GD/RP</td>
<td>Classroom and safety day exercises; Communications training</td>
</tr>
<tr>
<td><strong>Trackside workers</strong></td>
<td>OE</td>
<td>Sections of operational track or training track</td>
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<tr>
<td></td>
<td>PTT</td>
<td>Track inspection; Fault diagnosis</td>
</tr>
<tr>
<td></td>
<td>CAI</td>
<td>Videos/multi-media graphics and animation; Classroom instructor led training</td>
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<tr>
<td><strong>Engineering maintenance staff</strong></td>
<td>OE</td>
<td>Sections of track, track circuits, point machines, signalling equipment at training centre; Rolling stock used for maintenance training</td>
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<tr>
<td></td>
<td>PTT</td>
<td>Fault diagnosis; Planning signalling layouts</td>
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<tr>
<td></td>
<td>CAI</td>
<td>Videos/DVD, multi-media graphics and animation</td>
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<tr>
<td></td>
<td>GD/RP</td>
<td>Classroom exercises</td>
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<tr>
<td><strong>Operations planners</strong></td>
<td>PTT</td>
<td>Commercial PC railway games</td>
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<tr>
<td></td>
<td>CBT</td>
<td>Computer based network and operations simulations</td>
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<tr>
<td></td>
<td>CAI, GD/RP</td>
<td>Classroom instruction; Group exercises and role-play</td>
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<td><strong>Train crews</strong></td>
<td>OE</td>
<td>Mock-up and real carriages; Smoke and evacuation trainers</td>
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<td></td>
<td>FS</td>
<td>Cross-over training</td>
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<tr>
<td></td>
<td>GD/RP</td>
<td>Customer services</td>
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<tr>
<td><strong>Customer services</strong></td>
<td>OE</td>
<td>Mock-up ticket offices, carriage and retail areas</td>
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<tr>
<td></td>
<td>CAI, GD/RP</td>
<td>Classroom instruction; Group exercises and role-play</td>
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Why use simulation in training?

As we have seen so far, simulation is now widely used as an important tool in training and assessment activities, exploiting the benefits of extended practice in skill acquisition. These benefits are particularly apparent where the task involves procedural or psychomotor activities, which are not suited to learning via traditional classroom or textbook means.

All types of simulation have benefits and drawbacks in their application to training and assessment, which can therefore influence the decision of what type of simulation is needed. General benefits of all types of simulation are described below. Relative and specific benefits and drawbacks for each type of simulation are summarised in the following sections and at the end of this chapter in Table 2.

5. General benefits

Simulation is especially suited for training situations which are impractical, difficult, dangerous or expensive to reproduce in a live environment. There are many potentially dangerous situations that workers may only encounter infrequently, if at all. Nonetheless when these situations are encountered they need to be dealt with efficiently to avoid serious consequences. Simulators can be used to present trainees with such unusual scenarios in a repeatable and controllable fashion.

Typical situations would include:

- Out-of-course events
- Adverse climatic conditions
- Fire
- Equipment failures
- Rail incidents
- Challenging customer service situations.

Similarly, trainees can use simulation to gain experience through making mistakes within a safe environment. Examples of these include:

- SPAD situations – both in training the driver to deal with a SPAD as well as practising professional driving to avoid future SPADs
- Signallers assessing different strategies to deal with operational restriction situations. A 'what if' approach can be employed to guide the operator to the correct options, with any inefficient strategies being identified without risk or operational consequences
- Evacuation procedures - can be simulated to identify options in different situations, increasing efficiency both amongst emergency staff and in the procedures themselves
- An error in track maintenance on a section of simulated track can be identified and corrected in a simulated environment exercise without the dangerous consequences of the mistake having been made on the operational network
- Mistakes in handling customer complaints or enquiries can be identified and corrected in a private simulated situation without adverse consequence to customers or undue public embarrassment to trainees.

Finally, simulation is useful in teaching and practicing complex technical skills, where there are set procedures to follow. Examples would include but not be limited to:

- Train driving
- Signaller operations
- Practical application of the Rule Book procedures
- Fault finding on a train for drivers and maintainers
- Fault diagnosis on signalling systems, power supplies and other complex track side equipments.

6. Specific benefits

a) Training and assessment available on demand

A major benefit of simulation is the ready availability of realistic training environments on demand. In the real world, it can be difficult or unfeasible to find training opportunities for situations such as:
• Adverse weather conditions such as fog, rain, snow
• Low adhesion conditions
• Safety incident training for drivers or signallers
• Track safety and engineering training
• Customer service incidents for station staff or guards.

Simulation, on the other hand, can create these conditions as and when required and at the appropriate part of the training course where trainees will benefit most.

b) Better consistency and control
Simulation provides consistency of training and assessment that is not possible in the operational environment. Because the simulated conditions are controllable and repeatable, every trainee can experience the same conditions, receive the same level of training, and be assessed under the same conditions. This is important for assessment so that the performance of the trainee against the required standard and other trainees can be reliably measured. Simulators and CBT can also provide performance recording and assessment facilities that automatically and objectively compare the trainee’s performance against pre-set standards.

c) Improved throughput
The availability and consistency of training using simulation assists the planning and throughput of trainees. Traditional training and assessment on live assets is limited by the availability of those assets and the appropriate environmental conditions. Simulation assets can be operated on a 7 day, 24 hour basis, should the throughput requirements demand, limited only by the availability of instructors. Furthermore, the nature of simulation means that trainees can experience a wide range of scenarios in a compressed time frame.

Throughput optimisation is achieved by having the correct number and mix of training and assessment assets at each stage of training. Computer based training, either stand-alone or web based, can also be installed at the trainee’s place of work thereby reducing the need to travel to a training centre and reducing time off the job.

d) Reduced risk
One of the most effective forms of learning is by practice and from making mistakes. Simulation and simulators provide safe environments in which the actions can be repeated over and over again, and trainees can make mistakes without risk to themselves, equipment, and operations. Simulation can therefore be used to mitigate the risks inherent in OJT.

e) Out-of-course events
Simulation also allows training in abnormal, degraded or emergency conditions that may be dangerous, impractical or impossible to reproduce in real world training. Situations such as:

• SPADs
• Signal failures
• Objects on the line
• Breakdowns
• Fire and safety incidents

can be reproduced at will to ensure that the first time the trainee experiences these cases is in training and not in the real world.

f) Introduction of new equipment and procedures
Simulation can be provided in advance of the introduction of new equipment or procedures to support their smooth introduction into service and to mitigate any associated risks. Examples include:

• New rolling stock
• New train warning systems such as TPWS
• New signalling equipment
• New shunting routes
• New operational rules.

g) **Cost saving potential**
Simulation has the potential to save costs by virtue of the following:

• Reducing the staffing burden for on-the job training and assessment
• Reducing the need to use operational assets
• Increasing trainee throughput and reducing the time spent in training courses.

h) **Better knowledge retention**
There is good evidence that people learn best through doing. Having the knowledge is different from learning how to apply it. Knowledge retention and application is improved by interaction at all levels and with all learning populations. Simulation is a cost effective way of providing this.

i) **Visible commitment to training and safety**
Previous incident inquiries have highlighted the need for simulation in high profile occupational roles such as train drivers and signallers. Investment in simulators provides visible commitment that the recommendations of influential reports and franchise commitments have been complied with.

7. **Drawbacks**

a) **Negative training risk**
The simulation must be appropriate to the task being trained. There is still some debate about the transfer of training in a simulator to real world performance, hence the need remains to include some OJT in the training programme. If the performance of the simulation is inadequate, there is a danger that actions undertaken in training may prove ineffective or inappropriate in the real environment and hence lead to negative training and safety implications. Evidence from other domains (such as aviation) suggests that functional fidelity is of greatest importance to transfer effects (the degree to which behaviour in the simulator transfers to the real operational environment). Physical fidelity may help convince the experimental participant that the task should be taken seriously, which would be less convincing in a more abstract environment.

b) **False sense of security**
While the simulated environment is excellent for building confidence and competence, there is some potential that a false sense of security can be induced in the trainees, who may fail to appreciate the difference in consequences between the simulated environment and the real world.

c) **Physiological impact**
Some types of simulation, notably with high fidelity visual simulations and motion cueing systems, or immersive virtual reality (VR) systems, can have adverse physiological effects on some trainees. These can include disorientation, dizziness or nausea after a session in the simulator. Train driver simulators are no exception and, on occasion, it has been unsafe for a trainee to drive a vehicle immediately after a simulator session.

d) **Capital cost and whole-life support**
Technology based simulation assets have inherent high initial cost and also need to be supported through life. They also need to be housed in suitable environments, often air-conditioned. Whole life costs include:

• Training managers
• Spares and repairs
• Hardware and software support
• Ensuring continuing currency with the real-world situation
• Designing out obsolescence
• Adding performance improvement/additional features
• Power consumption
• Training staff and support managers.
e) Associated facilities costs
All simulation methods have building/accommodation implications for providing classrooms, rest areas, offices, and space and facilities for simulators, part task trainers, and computer based training or equipment mock-ups.
### 8. Relative benefits/drawbacks summary

#### Table 2  Specific benefits/drawbacks of the different forms of simulation

<table>
<thead>
<tr>
<th>Category</th>
<th>Benefits</th>
<th>Drawbacks</th>
<th>Suitable for</th>
</tr>
</thead>
</table>
| Original Equipment  | Nothing can be as physically realistic as the original equipment  
Provider the correct look and feel of the real thing  
Optimal validity and transfer of training  
No training programme incorporating other levels of simulation has yet reduced training time on OE or live equipment | Can be expensive to make available and maintain for training use  
Heavy demand on instructors’ resources – typically small groups per instructor, and often one-to-one  
May require large facility e.g. large track layout or rolling stock shed  
May not be available when required if ‘borrowed’ equipment used in the implementation  
May not be suitable for training e.g. not designed for regular misuse  
Instructor control is limited e.g. cannot demonstrate sufficient range of fault / out-of-course conditions etc.  
May impose additional risks when training involves the live operational railway | Manual skills, e.g.: Trackside workers  
Engineering maintenance staff  
Train crews  
Customer services |
| FS                  | Facility to train/practice/assess for out of course events. A range of scenarios can be presented to address different teaching points in dealing with abnormal or degraded conditions that cannot be practiced safely or practically in the real world | High initial procurement cost and on-going support cost, particularly for visual database and scenario development | Psychomotor skills, e.g.:  
- Drivers  
- Signallers |
### High fidelity immersive training environment

- **Training** environment to put trainees into ‘near real world’ situations but without risk
- Repeatability of scenarios and conditions for all trainees. Provides consistent and definable scenarios to cover the wide range of training goals
- Provide practice /development of psychomotor and procedural skills
- Provide opportunity to practice implementation of Rule Book against realistic environments in real-time or compressed time-frame
- Can provide event recording and automatic performance evaluation to support audit trail requirements and maintain objectivity in assessment
- Can include facilities for relatively large numbers of other students to observe through computer/video displays and learn from the experience

**Crossover training**, eg:
- Train crews

### Resource intensive

- Generally a similar instructor to student ratio as with OE, yet with additional investment for instructors or other staff to be trained in operating the simulator. Set-up time for training sessions can be longer than the session itself, especially if the user interface has been poorly designed
- Usually fixed location training centre. Costs can be incurred on travelling and expenses for trainees not based at the simulator location and may also require more time away from the job
- Often requires special building arrangements (especially regarding HVAC) or significant alterations to existing buildings
- Not easily portable due to the complexity of installations and cabling between simulator and computer hardware.
- Fidelity and realism of the simulator can have a large effect on trainee’s performance if they cannot immerse themselves in the environment

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### Part Task Trainer (PTT)

- Provide real-time **training/practice/assessment** against specific tasks or skills
- Usually based on relatively low cost Commercial off the Shelf (COTS) hardware
- Often comprise standard PC workstations and will generally fit within a standard classroom or office environment

**Psychomotor skills**, eg:
- Drivers
- Signallers

**Fault diagnosis**, eg:
- Trackside workers
- Engineering maintenance

- By definition, only covers **training/assessment** for part of the overall role. Usually a complement to other assets needed to complete the training eg real equipment or full simulator
- Do not usually include automatic assessment facilities for ‘free play’ modes. Assessment usually by instructor, and therefore subjective
- Instructors sometimes need special **training** to optimise use of trainer
Can provide multiple trainee seats at relatively low additional cost. Since functionality usually defined by software, the additional cost of extra workstations is generally limited to workstation hardware cost

Less instructor intensive than full simulation or OJT. Instructor commonly in charge of a class of typically six to ten trainees all working at same or different scenarios (although instructor is required to monitor and support each trainee throughout the session, which may degrade quality of feedback)

Can be configured as multi-purpose or to support different training configurations. This provides significant flexibility - particularly useful if to be used to support different equipment types, eg a TOC may have several different traction units. Re-configurability provides flexibility and reduced overall cost

Can be used to release time on full task simulators and/or original equipment to increase throughput

Less costly to procure and support than a full simulator due to the simpler hardware build – typically PC network

More easily re-located than a full simulator. Operational flexibility

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<tr>
<th>staff</th>
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<tr>
<td>Operations planners</td>
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<tr>
<td>Computer Based Training (CBT)</td>
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Rules and procedures, eg:
- Drivers
- Signallers

Network planning, eg:
- Operations planners
<table>
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<tr>
<th><strong>Computer Assisted Instruction (CAI)</strong></th>
<th><strong>Usually the least costly to procure or develop and the most flexible form of training delivery</strong></th>
<th><strong>Need to gather a class at a central location. Additional cost of travelling and time away from place of work unless distributed delivery used (which itself negates the benefits of group learning and direct feedback from instructor)</strong></th>
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<tr>
<td>Courseware can be delivered by existing instructors without the need for special training</td>
<td><strong>Training</strong> quality dependent on the skill and experience of individual instructors</td>
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<tr>
<td>Flexible – can be easily and quickly updated by existing instructional staff with minimal hardware support</td>
<td>Less effective with larger class sizes. Individuals receive less personal attention and help in larger classes. Optimal class size dependent on training goals, but typically no more than 20 students</td>
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<tr>
<td>Can incorporate multimedia representation of real situations eg video, DVD, photographs</td>
<td><strong>Assessment</strong> largely subjective through course with test papers, exams etc being inevitably less detailed than performance recording in a full simulator</td>
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<tr>
<td>Trainees can benefit from group learning situations and interaction in well controlled and operated courses</td>
<td>Good trainees can “coast” in class situations and are not, perhaps, fully stretched</td>
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<tr>
<td><strong>Assessment</strong> can be achieved through simple questionnaires/test papers</td>
<td>Less able trainees may not get the extra attention they need</td>
<td>Less able trainees may not get the extra attention they need</td>
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<td>Low cost delivery through standard classroom media delivery equipment (PC, projectors, interactive whiteboards etc)</td>
<td>Marking and recording results can be a time consuming process for instructors</td>
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<td>Low maintenance if subject material stable</td>
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<tr>
<th><strong>Group discussions and role-play exercises (GD/RP)</strong></th>
<th><strong>Provides interactivity and participation in classroom presented material</strong></th>
<th><strong>Assessment</strong> by instructor or through test paper is largely subjective and difficult to quantify</th>
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<tr>
<td>Flexible – can by easily and quickly updated</td>
<td>Sometimes difficult to get all trainees to participate fully particularly if group is large</td>
<td>Sometimes difficult to get all trainees to participate fully particularly if group is large</td>
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<tr>
<td>Use of actors can be used to enhance interpersonal skills based roles/aspects</td>
<td>Variability within and between groups can affect assessment standards and results</td>
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<tr>
<th><strong>Classroom instruction, eg:</strong></th>
<th><strong>Drivers</strong></th>
<th><strong>Signallers</strong></th>
<th><strong>Trackside workers</strong></th>
<th><strong>Engineering maintenance staff</strong></th>
<th><strong>Operations planners</strong></th>
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<td><strong>Communications, eg:</strong></td>
<td><strong>Drivers</strong></td>
<td><strong>Signallers</strong></td>
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<td></td>
<td><strong>Teamwork and role-play exercises, eg:</strong></td>
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<td><strong>Very inexpensive method, requiring only low cost assets, <em>e.g.</em> classroom facilities/simple mock ups</strong></td>
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<tr>
<td>Trainees benefit from group learning situations, learning from instructors and experience of their peers</td>
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<td>The only method by which social situations can be trained (<em>e.g.</em> customer service, teamworking, communications <em>etc.</em>); can be combined with other methods and media</td>
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<td>Instructors can easily react to class dynamics and address any difficulties on the spot</td>
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**Maintenance staff**
- Operations planners
- Train crews
- Customer services
How to use simulation effectively

9. **Training needs analysis (TNA)**

Successful training and assessment applications in an adult learning situation, often use a ‘blended’ mix of different types of simulation at different stages of the course, for example classroom training followed by group discussions, followed by CBT, followed by exercises on original equipment or FS/PTT simulators. The training interfaces between the various stages and types of simulation used should be defined through a training needs analysis (TNA) process, such as outlined in the Good Practice in Training Guide (RS/220). The TNA process provides analyses of the operational tasks, training needs and objectives against a matrix of potential training strategies, media and simulation devices in order to determine the most effective solution. The choice of simulation media is a complex function including consideration of:

- The difficulty, importance and frequency of the tasks (DIF)
- The starting skill set of the trainees
- The operational standard the trainees have to attain
- The trainee throughput aptitude profile
- Affordability.

All training requirements are unique, and are affected by company culture, existing workforce competency levels, the tasks/situations for which training is required, the required level of competency after training etc. All these factors will affect the specification of the simulation. Investment in all simulation, and particularly high cost simulation assets, should start with a formal and documented training needs analysis as referenced above.

The TNA should as a minimum comprise:

- Operational task analysis - identify, categorise and prioritise all the tasks that the trainees need to be trained to perform, to what standards and under what conditions. This should include both individual and collective tasks involving working with and communicating with others.
- Gap analysis – identify the gap between the current level of performance achieved by current training methods and that required to meet the above. This produces a set of training objectives for the application.
- Options analysis – identification, comparison and trade-offs between possible training solutions, and assessment of their training effectiveness and cost effectiveness in meeting the training objectives. Options will also be affected by the training throughput required of the programme.
- Training design - defining the role of the training methods, the objectives they are designed to meet and how they fit into existing media and methods used. It is at this point that the various categories of simulation may be considered, in the context of the whole training and assessment programme.

The TNA can be undertaken by internal personnel, familiar with the TNA process, but this is a time consuming task and consideration should be given to having this task carried out by an independent person or company specialising in TNAs.

One area commonly overlooked is the need to gather statistics from the various simulations in order to review the effectiveness of the simulation applications and use this feedback to improve the quality of the training and assessment programmes and their duration.

For the purpose of this GPG the example of a full cab simulator is used but many of the issues are similar for other forms of simulation. One of the key cost drivers is the level of fidelity required. The most obvious approach is to specify that the simulator elements should have the same form, feel and function as the real cab. However, replicating each feature of the cab to the highest level can be an unnecessarily expensive approach and high fidelity in some of the replicated equipment may not be essential to meet the defined training objectives. Selective fidelity appropriate to training needs generally produces significant savings.
The more usual approach is to look at the overall training programme, using TNA processes and/or risk analysis to define what training objectives are to be achieved in the simulator and from that make decisions on the simulator features and level of fidelity required in the training environment. This will generally result in a less costly device tailored to the particular requirements, thus becoming an integral part of the overall training programme.

10. Stages of training for which simulation could be considered

As stated at the outset of this GPG, simulation is a tool to aid existing training and assessment, and as such should be an integral part of the programme from initial training, to refresher and conversion training. It would not be so effective if treated as an adjunct or ‘bolt-on’ to an existing regime.

a) Initial training
In initial training simulation can be used to enhance and enliven classroom instruction using its interactive nature to provide facilities for trainees to practice what they have learned. The simulation can take the form of non-technology group exercises, games, PTTs or simulator sessions. Simulation is often used as the first method for novice or new recruits to get hands-on experience of the task, once they have the requisite classroom knowledge. It can either be used in conjunction with, or as a precursor to on-the-job training with live equipment.

b) Continuation training
Technology-based simulation is becoming increasingly used to support the advanced stages of training with its ability to present complex scenarios which enhance the trainee’s knowledge and skills. Simulation can provide facilities for on-going or continuation training to mitigate against skills fade and rectify bad habits. It can also be used for retraining/reassessment after a period away from work or following an incident.

c) Conversion
Simulation can be used to enable experienced operators or maintainers to become familiar with new equipment and processes before they become operational and thereby facilitate the smooth and safe introduction of such equipment or processes into service. Examples of these applications would include but not be limited to:

- Conversion training for drivers on new traction units
- Conversion of drivers and signallers to new signalling systems and procedures
- Introduction to new train protection systems
- Introduction of new track equipment – for example points engines
- Introduction of new communications systems and procedures
- Supporting re-skilling and role conversion.

d) Performance assessment
Simulation is particularly useful for enabling the development of repeatable test scenarios for training and objective performance assessment. This characteristic enables instructors to develop standards across the training population, and provide statistical evidence and an audit trail for the on-going improvement of the courses. Some forms of simulation have built-in assessment methods which facilitate this process. The ability to reproduce training conditions and scenarios, as and when required, allows a consistency of training and assessment scenarios that may not otherwise be available. Performance can be compared directly between trainees. A reassessment of a trainee’s performance after, for example, 12 months can be carried out under exactly the same conditions as the previous assessment or training course. This facility is useful for objectively identifying and quantifying areas of skill fade to support future development options.

11. Procurement guidelines

The procurement of simulation has much in common with other project types with regard to the tendering process, commercial terms and conditions, project management, payment plans and
through-life support. Where it differs is in the specification, development and acceptance of the final product.

The most complex procurement difficulties are experienced with full simulators, particularly regarding specification and acceptance into service – areas which are currently less well understood in the rail industry.

Alternative applications for simulation, such as human factors research or incident investigations, can be used to generate revenue and are therefore worth considering at the specification and procurement stage as a way of strengthening the business case. In general, current training simulators do not collect sufficient or appropriate data for research purposes, nor are they compatible with data input from OTMRs in order to replay an incident. To modify the compatibility of an existing simulator would be an expensive exercise, but including these requirements in the original specification should not significantly increase the cost.

The following checklist is intended to help ensure that the procurement and development phases of acquiring a simulator runs as smoothly as possible.

a) The decision to procure a simulator in the first place will have been based on a business case outlining the economical and performance advantages for the company (that is, outlining the benefits already discussed in this GPG). Considerations for the business case will include the level of simulation required to meet the needs of the training programme, as well as any support facilities or ancillary equipment. However, it is also worth bearing in mind potential revenue generation from other users as part of the business case. For example time on a driving simulator could be sold to other TOCs, to bodies undertaking human factors research or incident investigation, or to rail enthusiasts during non-core training time.

b) Consider leasing as a procurement strategy. Simulators can be leased along with rolling stock as part of the package and reduce the risk inherent in short franchises and equipment ownership.

c) Consider appointing a simulation manager to ensure that the project has the appropriate level of technical and management support throughout. S/he should be responsible for everything from specification to acceptance of the simulator, to ensure that training requirements are met by the solution. The manager will also be responsible for allocating time and resources within the project to train the simulator staff in its operation. Ideally this will be provided by the supplier as soon as possible, so that when the simulator is commissioned it can begin operational use immediately.

d) Ensure that a TNA has been carried out to define the required functionality and purpose. This will provide an audit trail on the requirements and can be used as a basis for defining the functional specification of the simulator. The TNA will also help to determine the level of simulation required.

e) The specification needs to be firmly based on the training requirement defined by the TNA and required training outcome. Unless there is suitable expertise within the company, it is probably sufficient to develop a detailed functional specification, and allow the supplier to propose the technical specification. For example, instead of specifying visual display resolution in terms of pixels, specify the requirement to be able to read a signal or sign at a prescribed distance and put the onus on the supplier to demonstrate compliance with this functional specification. Consider also the level of flexibility desired (for example, in manipulating route databases, visual objects, scenario development, data collection).

f) Talk to other users about their experiences with potential suppliers. There is a significant body of experience of simulation in the rail industry and a perceived willingness to share experiences. There may be wider benefits in selecting a supplier
whose simulator data are universally compatible, so that visual databases, scenarios, and even output may be shared and compared.

g) Ensure that the original equipment manufacturer or potential supplier stays within their technical remit without altering the functional specification, as this may introduce a risk that the solution will not address your training needs.

h) In simulations that have visual simulation requirements, do not underestimate the resources involved in production of the visual databases. They are time consuming to produce and acceptance is subjective. Generic databases are generally less costly and more flexible in training than geo specific databases. Geo-specific databases need to be kept current with operational routes and equipment, and this can add significantly to the ongoing costs of ownership.

i) The high rate of technological advancement means that there is significant cost versus performance advantage in delaying the procurement of the computer hardware and, in particular, visual simulation systems, as late in the project as possible.

j) Ensure that the buildings to house and operate the simulation are available to the right specification and, if not, that budget is available to develop them. All simulations have space, power and operating environment requirements that need to be taken into account. Some have sound insulation requirements and others may have special floor loading requirements (especially full simulators with motion platforms) and may require false floors to accommodate cabling. Further accommodation for trainees (for example, briefing/de-briefing rooms, observation areas), instructors (for example, control room), and ancillary equipment (for example, utilities, office space, mess facilities) should also be considered. Failure to provide suitable accommodation, if this is the buyer’s responsibility, in time to accept the supplier’s installation schedule will delay the project and may incur penalties.

k) Data availability on the system to be simulated (for example, route databases, traction models) is crucial to the success of the project. Late or incomplete data will cause project delays. Put the onus on the simulation contractor to obtain the data and ensure that the contractor has the appropriate commercial arrangements in place with the original equipment manufacturer. The contractor will know what information is required and when it is needed.

l) Draw up a clear and explicit list of acceptance criteria at the start of the project, which the supplier should agree to. The criteria should be based on the functional specification, and is an auditable way of ensuring that the product delivered by the supplier meets your needs and expectations.

m) During the life of the simulation, there will be a need to update the facilities in line with changes to the original equipment and/or operating procedures. Ensure that the contractor understands the need for such adaptability and makes provision for this in the proposed solution.

n) A simulator can be expected to have a long life and will need to be supported throughout. Ensure that the contractor understands the availability, reliability and maintainability required from the simulation and that suitable support plans are in place to meet these requirements. Support issues are best negotiated as part of the procurement negotiations.

o) Be aware that computing and other IT equipment is generally not supported for more than five years and it is now commonly accepted that such equipment and associated software operating systems need to be replaced at approximately 5 year intervals.
12. Issues to consider

The lessons learned in the acquisition and use of simulators have been many, and the key factors are illustrated in this section, together with possible avenues for avoiding such issues. Many of these are drawn from driving, as this is the area in which the most significant developments have been made since the publication of GO/RT3251 (Train Driving), and its associated Code of Practice (GO/RC3551), mandates the use of simulation in training and performance monitoring of drivers. However, unless otherwise noted in the text, the principles are generally applicable across domains.

a) Significant delays between specification, procurement, design and introduction into service

With few exceptions driver simulators prove more difficult and take longer than planned to enter training service. Common contributory factors include:

- Delays in the provision and availability of rolling stock parts and data,
- Definition and construction of visual databases
- Supplier's inexperience with the GB rail industry
- Building facilities not ready
- Extended acceptance trials.

Lessons learned include:

- Ensure that the supplier has good access to data and parts
- Define visual simulation requirements early in the programme – visual databases take time
- Define building requirements early – building alterations or construction take time
- Involve trainers at the specification phase through to commissioning – continuity is important and involvement throughout the programme often assists acceptance.

Furthermore instructors can be trained to operate the simulator during development, thus reducing lead time once the simulator is commissioned.

b) Impact on core training programme

Using simulation involves a significant change to traditional on-the-job training supported by classroom CAI and requires dedicated training managers.

Lesson learned:

- Take the time to review the whole training course and define the role of the simulation through the TNA process. This can save money, time and effort and will lead to a better overall training solution.
- Introduction of simulation need not imply major changes to the programme, unless the current programme isn’t working. If the programme is working well, specify the simulation so that it complements the programme material; if not, the TNA provides the opportunity to redesign the programme around the new simulation.
- Involve trainers at the specification phase through to commissioning.

c) Original equipment replication

Some operators believe that a full driver’s cab, populated with original real equipment, is necessary to provide an authentic training environment, while others consider that a generic cab is sufficient.

Lessons learned include:

- High fidelity cab replication adds significant cost. Define what the simulation will be used for and assess what additional training or fidelity value a full cab simulation will contribute.
- If operating a mixed fleet a generic or re-configurable cab may be the most cost effective solution and can provide better flexibility and utility.
- A high fidelity cab can generally only provide one training seat. If you have many drivers, multiple generic or re-configurable workstations may be a better option.
d) Criticism of lack of scene detail and currency
Reproducing the visual scenes of the outside world is the most technically challenging part of the driver simulator. Computer generated imagery has advanced considerably but cannot produce the scene detail observed by the driver in the operational environment. The case for generic versus geo-specific visual databases depends on the application and the identified training objectives.

Lessons learned include:

- A generic database is less costly to buy and maintain.
- A generic database is more flexible in giving the instructor more freedom to create training runs comprising key features to suit the training need. With a geo-specific database the route is fixed and the instructor has limited control over the scenario.
- Geo-specific databases can be a distraction to experienced drivers who perceive any deviation from the real route as a negative influence.
- Geo-specific databases can be used to reinforce route learning, to introduce new route features, such as a new signal, to prepare drivers for change or to practice new shunts
- A track builder tool is a useful facility giving the instructor the flexibility to change route features, maintain currency and reduce through-life support costs.
- Specifying resolution in technical terms such as pixels and lumens can be confusing. Specify resolution in terms of outcome, for example the ability to detect a signal at the required yardage, and let the supplier propose how this will be achieved.
- Visual simulation technology is advancing at a significant rate. Buy visual simulation hardware as late in the programme as possible to optimise cost/performance.

e) Need to manage student expectations
Simulation is not the same as the real thing. Trainees should be briefed as to the objectives of a training session and the limitations of the simulation. With this information, the trainee is more likely to concentrate on the achievement of the objectives and less likely to look for shortcomings in the simulation.

f) Computerised performance assessment systems
Some simulations have structured, built-in assessment systems designed to assess trainees against pre-determined criteria which do not necessarily match the needs of the trainer. If these facilities are to be included, make sure the trainers define the assessment criteria and required performance levels, otherwise the assessment tool may be of little use.

g) Difficulty in re-creating incidents on the simulator
Re-creating incidents is generally recognised as a useful feature whereby operational events can be replayed on the driver simulator for use in inquiries or retraining after an incident. This can be achieved in two ways. The most accurate reproduction would be to provide an interface into the simulator from the OTMR and allow the event to replay through the simulator. The alternative would be to reconstruct the event with a track builder tool based on the data from the OTMR and replay the run. This method would be easier to implement with currently available tools but would be a relatively labour intensive exercise.

h) Issues on the use of motion systems
Whilst motion systems are more specifically associated with driving simulators, few simulators in the GB have a full cab mounted on motion platforms. The benefits of a motion system for rail applications are questionable, given the limited reliance on motion cues and the potential drawbacks of simulator sickness and cost – the added benefits do not generally match the increased investment. Money may be better spent on a high quality visual system with a wide field-of-view, which can induce a sense of motion even in a fixed-base simulator. Nevertheless, a good quality motion system could increase acceptability of the simulator, potentially improve transfer of training, and could even reduce simulator sickness.
Lessons learned include:

- Consider carefully what training or fidelity value is added by motion cueing – for example, movement information can alert a driver to a sudden brake application before this is perceived in the visual system.
- What type of motion is required? Consider, as a less costly alternative, vibration and cab sound which is relatively inexpensive to provide and maintain.
- Motion platforms are poor for representing prolonged periods of acceleration/deceleration.
- Motion platforms are expensive to buy and maintain.
- There is no clear evidence that motion systems improve transfer of training to the real environment.
- A poor motion system can result in adverse physiological effects.
- A good visual system, combined with vibration and cab sound, can provide sufficiently strong motion cues.

i) Beware of simulator sickness

In a related vein, simulator sickness is commonly attributed to poor synchronisation between the motion and visual systems of a simulator. Latency between the two systems can cause nausea in some people. These effects may also result from fixed-base simulators, due to there being only visual motion cues. However, unless the motion system is very good, simulator sickness rates will generally be lower in a fixed base simulator.

Care should be taken in monitoring trainees and, if necessary, allowing sufficient recovery time after a simulation session before returning to duties or other safety-critical activities (for example, operating machinery, driving). Similar effects have also been observed with virtual reality systems involving the use of head-mounted displays.
Future developments

The previous sections of this GPG have examined current usage of simulation, benefits and drawbacks, application to different types of training and assessment, lessons learned and guidance to training managers and procurement officers. This section of the GPG draws on the previous sections and examines future trends and developments in processes, methods and technology, and new potential areas for application. Users of simulation in the rail industry can help to realise these developments by collecting data and cooperating in research with bodies such as RSSB.

13. Linked training

Most simulators are designed to deliver training on a one-to-one basis. In the case of driver training, drivers have the opportunity to exercise against instructor-controlled crossing traffic and out of course events. There may be training value in having multiple seat linked simulators in which drivers could interact with each other in a combined scenario. This has been used effectively in the military to facilitate team training and communications practice. This might be particularly valuable in exercising drivers operating in particularly busy and complex areas of the network.

Similarly there would be perceived value in drivers and signallers exercising on a combined driving/signalling simulator, as well as for other groups to experience similar ‘crossover’ training (for example, providing sessions for train crew in a driving simulator). This could assist in helping drivers and signallers to understand each other’s respective viewpoints and issues. No such facilities yet exist and the commercial constraints of the various companies involved may make it difficult to achieve. Nonetheless, such a facility has been recognised as being potentially useful for human factors research and incident investigation. Further exploration into the feasibility of crossover training initiatives is encouraged.

14. Web-based assessment

Computer based training solutions have the capability to deliver knowledge, assess and record performance and create student records through a learning management system (LMS). There are many applications in rail but these are mostly on closed computer networks and do not work between various locations. This is partly due to the IT infrastructure but also because high fidelity graphics and interaction on the Internet are not yet able to support high quality training material. Distributed training, where it exists, is by CD-ROM or DVD. The web and company intranets may eventually support such facilities but currently complex web delivered courseware is not a real option.

Regular safety assessments, that have to be taken by all track workers, could be implemented on the web to provide a means of on-line tracking of competency, skill fade and any need for retraining. This could be an effective way of gathering information to test the required periodicity of assessment and reduce overall costs in the industry assessment requirements. It could also be used as a tool to improve competency test pass rates by using the on-line assessment, in advance of a formal assessment, which would then identify areas of weakness and recommended remedial training to be undertaken before formal assessment. Such a process would only require limited interactivity and graphics content and could be supported on most company networks and the intranet. Adoption of this method could save the industry a great deal of money through better and consistent assessment and through reducing the number of days currently lost to training and assessment. It could also be used to address the reported backlogs in assessing certain competences.

15. Certification and driver licensing

TOCs, and other bodies employing drivers, currently have the responsibility of ensuring that their drivers are competent on the routes they operate. Through the Association of Train Operating Companies (ATOC), some TOCs have internal licensing schemes, while others have less formal arrangements. The European Interoperability Directive will bring about a common licensing scheme across Europe. This will lead to a Europe-wide training and assessment syllabus. This type of regime is currently operated within the civil aviation industry where training and assessment methods and media are controlled and licensed for use by the Civil Aviation Authority (CAA) with different training assets approved for the various stages of training. This has led to a hierarchy of simulation assets summarised as:
• CBT – for knowledge transfer and testing
• Cockpit training - for acquaintance with instrumentation, controls and procedures
• Flight training simulators of different complexities – for instrument flying, and some with limited visual and motion systems for take-off and landing practice
• Different categories of full flight simulator for advanced training and assessment, type conversion training and practice in out of course events.

The incentive for airlines to invest in the various types of simulation, from CBT to full simulators, is that their use attracts training credits that can be offset against training on real aircraft – thus representing a significant cost saving. All devices have to be approved as fit for purpose at the appropriate training level to qualify for credits. It is the user’s responsibility to obtain certification from the CAA before the simulator can be used for training. The CAA controls the specifications of the various devices and the simulation industry develops products that match with these requirements. This hierarchical definition of training assets facilitates accredited training across the industry so third party usage, where smaller airlines can book time on the training assets of the larger carriers, becomes a viable alternative to owning simulators. Many of these complex and expensive assets are often operated 24/7 apart from scheduled maintenance periods to facilitate own company and third party training and assessment.

A similar model to that used for the civil aviation industry would be one way of securing a common approach to training and assessment in interoperable situations. Such an approach would support common competences and enable interoperability across the European rail network. It should, however be recognised that the economic advantages enjoyed by the civil aviation industry through this policy may not be realisable in the rail industry where the lower cost train assets and their associated operating costs would not produce the same economic payback. On the other hand, train driving simulators are much lower cost devices than flight simulators.

It is significant that no TOC to date has considered substituting cab time for simulator time. On the contrary training courses have generally been lengthened to accommodate the use of the simulators. This mitigates against the economic benefits and reflects the requirement for a TNA before the point of acquisition.

16. Emulation for technical and maintenance training

Much of the technical and maintenance training conducted currently uses real equipment (OE) as the basis for its simulation. While this has advantages in feel, form and function, it also has significant disadvantages, such as limited ability to represent a wide range of faults, vulnerability to being repeatedly taken apart, and limited throughput capacity. As systems become more complex and electronic in nature, the screen-based emulator will become a more viable option, whereby instructors could cause ‘faults’ to individual components or sub systems. The trainee can use virtual test instruments and procedures to diagnose and correct the fault. This technique could have much to offer to rolling stock, signalling equipment and power supply maintenance training and assessment.

17. Technology improvements

Technology is advancing all the time and has the potential for delivering ever more capable simulation solutions at more affordable cost. Technology based simulation improvements can be seen in:

• Better classroom media – better resolution and easier to use and integrate with other media
• More flexible CBT – with easier updating of material by instructors
• Interactive CBT – could be used for customer services training
• Improved visuals simulation - for route learning and driver simulators
• Application of virtual or augmented reality technology to a range of tasks
• Easier to use control facilities for instructors
• More choice of simulation methods as new developments become available
• Exploitation of the low cost applications (that is, those developed for the leisure and hobbyist markets) in training and assessment.
18. Human factors and incident investigations

As discussed earlier, simulation could have application to human factors research into employee selection and for incident investigation. It is currently the case that simulators do not generally collect and make available the types of data required by HF researchers. This is not a technical problem since all the data is processed in the simulator but it is not always made available in the appropriate output form. To modify an existing simulator to output such information would be an expensive exercise. This would not be the case at the design stage since, generally, the information interface can be designed in at little additional cost. If simulators are to be used in HF research, it would be worth including these data requirements in the overall procurement specification. The TOCs could potentially recover these costs by selling time to the HF staff on an as-required basis.

OTMR data replay would likewise be easier to accommodate at the design stage and the facility could also be added into the specification. This could provide a useful tool for incident investigation.

19. Extended applications

In addition to the applications already discussed in this GPG, there is potential to exploit the benefits of simulation in other areas of workplace training and assessment, such as track inspection and look-out activities. Immersive virtual or augmented reality technology, where the trainee uses a head mounted display or glasses to navigate through a scenario and perform actions, is a possible solution to such training and assessment applications.

The use of simulation in providing realistic and practical synthetic environments for this type of training and assessment has the potential to significantly reduce associated cost and man-hours through travel and waiting for the right conditions. Possibly the ultimate goal of simulation in training is to reduce or even eliminate the requirement for on-the-job training. We are still some way from making this viable, but such a development would drastically improve the efficiency of training programmes by reducing both the timescales and costs involved.

Over all, the benefits of the use of simulation as an integral part of training in the GB rail industry, has been instrumental in improving safety and supporting competence management systems.
Summary and Conclusions

The application of simulation in the rail industry is well established, even if not always recognised as such. Although commonly associated with high fidelity driving simulators, simulation methods span a range of technologies and applications. This GPG has identified many such examples, and highlighted the relative benefits and drawbacks of each.

The overall message is to select the appropriate tool for the job in hand. When training maintenance staff in personal track safety, for instance, there is little justification for investing in a fully interactive virtual environment (even though such technology is potentially available). On the other hand, fully specified high fidelity driving simulators can offer considerable advantages over training in a real cab. Acquiring the right simulation facility is a case of identifying the need in the training programme via a TNA, rather than simulation for its own sake. It is a unique and innovative tool for training and assessment, but only when applied properly.

Once the need has been identified, it is worth spending some time on deciding the category of simulation (that is, the level of fidelity required) and defining the functional specification. Consider some of the issues highlighted in this document, such as decisions about generic versus specific equipment (or FS vs. PTT), the relative merits of visual and motion systems, and whether a high fidelity solution is appropriate at all. A good functional specification will be based on the TNA, will detail exactly what the simulation needs to achieve, and can also be used as acceptance criteria once the system is delivered.

The rapid pace of technology (particularly computing) means that simulation systems are continually increasing in quality and decreasing in price. Indeed, many high fidelity solutions are perfectly capable of running on ordinary PC-based systems. It is therefore necessary to monitor such developments, with a view to making the system ‘future-proof’ as far as possible. Also bear in mind the potential developments in areas not traditionally associated with simulation (for example, maintenance, operations), since these may well be possible in the near future. These may also offer more opportunities for ‘crossover training’ between different groups of workers – opportunities which should be exploited whenever feasible. Finally, one of the main benefits of simulation would be in reducing (or even eliminating) training time on live equipment, and making the overall training programme more efficient.

Naturally, where new possibilities do arise, it would be advantageous for the industry as a whole for such developments to be shared (within the bounds of commerce). In particular, significant data on simulator validation, transfer of training, and increasing the efficiency of training programmes would be key to RSSB’s efforts in this area, and two-way cooperation on such research is encouraged.

It is clear that simulation does, and can continue to, provide valuable and cost-effective tools to support training and assessment in the rail industry when specified appropriately. New applications will continue to be realised and existing applications will continue to contribute to the quality and effectiveness of such training.
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Glossary

CAA  Civil Aviation Authority
CAI  computer assisted instruction
CBT  computer based training
DIF  difficulty, importance, frequency
ERTMS European Rail Traffic Management System
FS  full simulator
FAA  Federal Aviation Authority
GD  group discussions
GPG  good practice guide
HF  human factors
IECC integrated electronic control centre
IT  information technology
LMS learning management system
NX  next exit
NVQ National Vocational Qualification
OE  original equipment
OEM  original equipment manufacturer
OJT  on-the-job training
PC  personal computer
PTS  personal track safety
PTT  part-task trainer
RITC Rail Industry Training Council
RP  role-play
RSSB Rail Safety and Standards Board
S&T signalling and telecommunications
SPAD signal passed at danger
TNA training needs analysis
TOC train operating company
TPWS train protection and warning system
VR  virtual reality