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Synopsis:
This document provides guidelines and advice for the use of simulation techniques in training and assessment.
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GOOD PRACTICE GUIDE ON SIMULATION

PREFACE

Issue Record
This document will be updated when necessary by distribution of a complete replacement.

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Content

Approved by: Richard Evans, Head of Delivery, Traffic, Operations and Management
Enquiries to be directed to RSSB – Tel: 020 7904 7518.

Application
RSSB Good Practice Guides are non-mandatory documents providing information relating to the control of hazards and often set out a suggested approach, which may be appropriate for Railway Group members to follow.

Health and Safety Responsibilities
In issuing this document, RSSB makes no warranties, express or implied, that compliance with all or any document published by the Rail Safety & Standards Board is sufficient on its own to ensure safe systems of work or operation. Each user is reminded of its own responsibilities to ensure health and safety at work and its individual duties under health and safety legislation.

Supply
Controlled and uncontrolled copies of this document may be obtained from the Rail Safety & Standards Board, Evergreen House, 160 Euston Road, London, NW1 2DX

GLOSSARY

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<thead>
<tr>
<th>Abbreviation</th>
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<tr>
<td>CAA</td>
<td>Civil Aviation Authority</td>
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<tr>
<td>CAI</td>
<td>Computer assisted instruction</td>
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<td>CBA</td>
<td>Cost benefit analysis</td>
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<td>CBT</td>
<td>Computer-based training</td>
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<tr>
<td>COTS</td>
<td>Commercial off the shelf</td>
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<td>DIF</td>
<td>Difficulty, importance and frequency (analysis)</td>
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<td>EO</td>
<td>Enabling objective</td>
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<tr>
<td>ERTMS</td>
<td>European rail traffic management system</td>
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<td>FAA</td>
<td>Federal aviation authority</td>
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<td>FS</td>
<td>Full simulator</td>
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<td>Group discussions</td>
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<td>GPG</td>
<td>Good practice guide</td>
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<td>HF</td>
<td>Human factors</td>
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<tr>
<td>HTA</td>
<td>Hierarchical task analysis</td>
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<tr>
<td>IECC</td>
<td>Integrated electronic control centre</td>
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<td>IT</td>
<td>Invitation to tender</td>
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<td>ITT</td>
<td>Information technology</td>
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<td>KSA</td>
<td>Knowledge, skills and attitudes</td>
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<td>LMS</td>
<td>Learning management system</td>
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<td>MMI</td>
<td>Man-machine interface</td>
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<td>NOS</td>
<td>National Occupational Standards</td>
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<td>NTO</td>
<td>National training organisation</td>
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<td>NVQ</td>
<td>National Vocational Qualification</td>
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<td>OE</td>
<td>Original equipment</td>
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<td>Original equipment manufacturer</td>
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<td>OJT</td>
<td>On-the-job training</td>
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<td>OTA</td>
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<td>PC</td>
<td>Personal computer</td>
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<td>Post project evaluation</td>
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<td>Personal track safety</td>
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<td>Part-task trainer</td>
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<td>QC</td>
<td>Quality control</td>
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<td>RACOP</td>
<td>Railway Safety Approved Code of Practice</td>
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<td>RFTD</td>
<td>Ready for training date</td>
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<td>RGS</td>
<td>Railway Group Standard</td>
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<td>Railway industry training council</td>
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<td>RP</td>
<td>Role-play</td>
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<td>Rail Safety and Standards Board</td>
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<td>RU</td>
<td>Railway Undertakings</td>
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<td>SpaD</td>
<td>Signal passed at danger</td>
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<td>S&amp;T</td>
<td>Signalling and telecommunications</td>
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<td>TD</td>
<td>Training design</td>
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<td>TDA</td>
<td>Training definition analysis</td>
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<td>Training needs analysis</td>
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<td>TO</td>
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<td>Training options analysis</td>
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<td>TPWS</td>
<td>Train protection warning system</td>
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<td>VR</td>
<td>Virtual reality</td>
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2 Introduction

This document will be updated when necessary by distribution of a complete replacement.

2.1 Purpose and scope

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

The GPG is based on research and information provided by the Simulator User Group which is made up of railway undertakings (RU’s) which use simulation and simulators for training and competency assessment.

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.

2.2 Definition

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;

‘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

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.

### References

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MODULE 1 WHY USE SIMULATION IN TRAINING AND ASSESSMENT?

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1 Why use simulation in training and assessment?

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 module 2 'Methods and types of simulation'.

2 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 without presenting risk to other operators or members of the public.

Typical situations would include:

a) out-of-course events
b) adverse climatic conditions
c) fire
d) equipment failures
e) rail incidents
f) challenging customer service situations.

Trainees can use simulation to gain experience through making mistakes within a safe environment.

Examples of these include:

- a) SPaD situations – both in training the driver to deal with a SPaD as well as practising professional driving to avoid future SPaD’s
- b) Signalers assessing different strategies to deal with operational restriction situations. The ‘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.
- c) Evacuation procedures - can be simulated to identify options in different situations, increasing efficiency both amongst emergency staff and in the procedures themselves.
- d) An error in track maintenance on a section of simulated track can be identified and corrected in a simulated environment exercise without the catastrophic consequences of the mistake having been made on the operational network.
- e) 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.

3 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:

- a) train driving
- b) signaler operations
- c) practical application of the Rule Book procedures
- d) fault finding on a train for drivers and maintenance staff
- e) fault diagnosis on signalling systems, power supplies and other complex track side equipments.
4 Specific benefits/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:

a) adverse weather conditions such as fog, rain, snow
b) low adhesion conditions
c) safety incident training for drivers or signallers
d) track safety and engineering training
e) 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.

4.1 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 candidate can experience the same conditions, receive or experience the same level of training, and be assessed under the same conditions.

This is important for assessment so that the performance of the candidate against the required standard and other trainees can be reliably measured. Simulators and computer-based training can also provide performance recording and assessment facilities that automatically and objectively compare the candidate’s performance against pre-set standards.

4.2 Improved throughput

The availability and consistency of training using simulation assists the planning and throughput of candidates. 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 resource to deliver training and assessment.

Furthermore, the nature of simulation means that candidates 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 candidate’s place of work thereby reducing the need to travel to a training or assessment centre and reducing time off the job.

4.3 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 candidates can make mistakes without risk to themselves, other people, equipment, and operations.

Simulation can therefore be used to mitigate the risks inherent in ‘on-the-job training’ (OJT.)
1 WHY USE SIMULATION IN TRAINING AND ASSESSMENT? cont...

4.4 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:

a) SPaDs and action to be taken following them
b) signal failures
c) objects on the line
d) train failure and fault remedy
e) fire and safety incidents
f) passenger emergencies.

Situations 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.

They also provide an environment where complete ‘end-to-end’ training and assessment can take place.

This can involve the experience of initial anticipation through to the dealing with a situation in real time and the reporting process afterwards (eg drivers simulation of low adhesion - initial anticipation through to correct reporting and controlled test stop).

This gives the candidate the benefit of seeing the training or assessment as a complete task and can practice all the steps needed in the real world.

4.5 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:

a) rolling stock
b) train warning systems such as TPWS
c) signalling equipment
d) shunting routes
e) operational rules.

4.6 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

a) reducing the need to use operational assets
b) increasing candidate throughput and reducing the time spent in training courses
c) has the potential to improve candidate performance and therefore reduce operating error

d) robust automatic scores assessment reports (eg CBT) can reduce the assessors ‘face-to-face’ time with the candidate.

4.7 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.

4.8 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.

4.9 Predictive assessment & human factors

Conventional methods of assessing out-of-course situations frequently rely on a candidates underpinning knowledge of the tasks that have to be performed.

This ensures that the candidate has a full understanding of what is required in any assessed out-of-course situation.

The use of high fidelity simulators now give the opportunity to place a candidate in an environment that is faithful to the real environment and reacts accordingly to the candidates input (full mission).

This can give a more predictive assessment of the candidate’s behaviour because the same operating pressures can be placed upon them that they would undertake within the work place.

This type of assessment should be accompanied by a robust scoring output report that complements any existing competence management system and the criteria that the candidate is being assessed against.

This can enable the assessor to identify any slips or lapses that occur out of environment design, procedural inappropriateness or human factors as well as a skill or knowledge gap on behalf of the candidate.

Owing to the high fidelity of simulation, an acceptable assessment decision may be made should a candidate over-speed when aware of the maximum permissible speed, makes an error of judgement or a breach of rule during a task, if this slip in behaviour replicates the slip that would take place in a live work place.

If the candidate is to be judged on the omission of an action during a procedural task then the environment that they are being assessed in needs to be faithful to the live environment and is able to facilitate the complete task.

If an automated sub-routine learnt from a procedural task means that the candidate will always perform certain skills in a pre-set order then the simulator will need to facilitate this.

The candidate may have to enter a cab and switch on equipment in a preset order (eg train preparation) and if some of this equipment were not present this may interrupt his automatic skills and could have the potential to cause an omission of action in the ‘real world’.

If a candidate is being assessed against the underpinning knowledge that supports a procedure and is to be judged on their ability for the general application of this then a lower level fidelity may be suitable as this would normally be a conscious set of tasks rather than a learnt automatic sub-routine.
1. WHY USE SIMULATION IN TRAINING AND ASSESSMENT? cont...

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.

5.2 Consciously increased, unnatural performance

It is a natural human characteristic when people are being observed as closely as is possible with simulators, to try harder and increase personal performance.

Not only can candidates consciously behave in a way that increases their performance but in some cases this enhanced performance may be so uncharacteristic of them, that it can force errors.

All of this must be taken into consideration when judging a candidate's performance if using simulation as a primary means of evidence.

5.3 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 candidate, who may fail to appreciate the difference in consequences between the simulated environment and the real world.

There may also be complacency with the low risk environment provided with the simulator that transfers to the workplace.

All candidates must see the simulator as a professional training and assessment tool and although it provides a safe environment to make mistakes in, the results of those mistakes must be realised and acted upon accordingly dependant on the candidate's stage in training or assessment.

The more the simulator and its whole environment is treated as a live but simulated one, the higher the user acceptance will be, which in turn has a bearing on the candidate's performance.

The professional live approach to the complete simulator environment (e.g. prior briefing, use of PPE, authentic signage) can add to this acceptance and diminish the 'games console/arcade' mentality that some candidates may bring with them.
5.4 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 candidates. 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. This may be personal to the individual (e.g., general motion sickness) and each candidate’s ability to continue to perform a task or duty needs to be taken into account after a simulator session.

c) designing out obsolescence

d) adding performance improvement/additional features

e) power consumption

5.5 Capital cost and whole-life support

Technology based simulation has inherent high initial costs and also needs to be supported throughout its life with additional maintenance programmes and continued technical support. It also needs to be housed in suitable environments, often air-conditioned.

Whole life costs include:

a) training managers

b) spares and repairs

c) hardware and software support

d) ensuring continuing currency with the real-world situation

e) designing out obsolescence

f) adding performance improvement/additional features

g) power consumption

h) training staff and support managers.

5.6 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. There may be other requirements from the supplier such as upgraded air conditioning, back-up power supplies and store rooms.

All of this needs to be taken into account when allocating a suitable facility for the simulator.
1 WHY USE SIMULATION IN TRAINING AND ASSESSMENT? cont...

6 How to use simulation effectively
6.1 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 Good Practice in Training (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:

a) the difficulty, importance and frequency of the tasks (DIF)

b) the starting skill set of the trainees

c) the operational standard the trainees have to attain

d) the trainee throughput aptitude profile

e) affordability.

All training requirements are unique, and are affected by company culture, existing workforce competency levels, the tasks/situations for which training is required, and 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 of:

Operational task analysis which identifies, categorises and prioritises 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. This may also have a bearing on the number of simulators required.

If it is imperative that all candidates perform all scenarios, then the effect of the down time for the other candidates will need to be evaluated and planned accordingly, either in the training program or against the resource planning recruitment plan.

a) Other solutions to accommodate large groups of candidates on a small number of simulators may be to provide facilitated collaborative learning by means of remote viewing of the simulator visual outputs by an observation room.
b) This would enable all candidates to learn, input or score at decision points from all the scenarios experienced, but only perform a certain selection of scenarios personally.

A gap analysis will identify the gap between the current level of performance achieved by current training methods and that required to meet the above. This will produce a set of training objectives for the application.

An options analysis provides 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 determines the 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 TNA.

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.
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2 METHODS AND TYPES OF SIMULATION

1 Methods and types

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.

1.1 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:

a) sections of track, point’s engines, track circuit and signalling equipment used at rail maintenance training schools
b) rolling stock can be used for service crew training, evacuation training and practice in handling derailments
c) rolling stock is also used for the training of trainee drivers in fault find procedure and the operation of safety equipment
d) driving of real trains on greased rails on a specially treated section of track for low-adhesion training
e) off-line signal boxes
f) live drill exercises involving emergency services for incident and accident response training
g) classroom training involving models, role play, communication and table top exercises.

1.1.1 Original equipment (OE) benefits:

a) nothing can be as physically realistic as the original equipment
b) provides the correct look and feel of the real thing
c) optimal validity and transfer of training
d) no training programme incorporating other levels of simulation has yet reduced training time on OE or live equipment.

1.1.2 Original equipment (OE) drawbacks:

a) can be expensive to make available and maintain for training use
b) heavy demand on instructors’ resources – typically small groups per instructor, and often one-to-one
c) may require large facility eg large track layout or rolling stock shed
d) may not be available when required if ‘borrowed’ equipment used in the implementation
e) may not be suitable for training (not designed for regular misuse)
f) instructor control is limited (cannot demonstrate sufficient range of fault / out-of-course conditions etc)
g) may impose additional risks when training involves the live operational railway.
1.2 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.

Customer services role-play ‘stage’

The coupling rig is used during driver and shunter training to practise coupling.

Coupling rig

Common applications are:

- a) communications
- b) customer service
- c) handling conflict
- d) giving evidence to inquiry boards.

Role-play (booking office)

d) very inexpensive method, requiring only low cost assets, eg classroom facilities/simple mock-ups

e) trainees benefit from group learning situations learning from instructors and experience of their peers

f) the only method by which social situations can be trained (eg customer service, team working, communications etc); can be combined with other methods and media

g) instructors can easily react to class dynamics and address any difficulties on the spot.

1.2.2 Group discussions including situational role-play (GD/RP) drawbacks:

- a) assessment by instructor or through test paper is largely subjective and difficult to quantify

- b) sometimes difficult to get all trainees to participate fully particularly if group is large

- c) variability within and between groups can affect assessment standards and results.
1.3 Computer-based training and assessment

1.3.1 Computer-based training (CBT)

Self-paced interactive learning/assessment. This can be implemented on personal computer (PC) desktop equipment in the form of interactive courseware or using a web-based solution that can operate either on internal intranet or external internet.

CBT can include delivery of knowledge followed by facilitating practice, application of knowledge and problem solving in context-specific simulated scenarios.

A typical screen layout for train driver CBT

Training material is presented sequentially as the trainee moves through the screens, and can include remedial ‘loops’ if the trainee has difficulty with a certain topic.

Such applications often include ‘formative’ and ‘summative’ testing to assess comprehension and competence.

CBT with Powerpoint

A typical screen layout

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, which is material delivered over company intranets or internet.

Widely used across many industries for a range of technical and procedural training and assessment, and largely representing mid to low fidelity simulation.
1.3.2 Computer-based assessment (CBA)

This can be used as a means of both practicing assessments and performing them. The CBA can be used to augment or enhance existing question-based assessment, but would need to include predictive assessment in order to replace it.

The outputs and assessment result score needs to be designed around any existing task analysis and competence management system if this is its intended use.

It can have the ability to standardise the assessment processes and produce results that can measure candidates performance against a pre-set criteria or rule based environment.

If the environment that the CBA is based in is subject to controlled or uncontrolled changes then it may be prudent to evaluate the inclusion of the ability to edit the content without returning to the initial supplier (eg Rule Book changes).
### 1.3.3 Computer-based training and assessment (CBT/A) benefits:

- **a)** consistency of material delivery – linear progression through structured courseware
- **b)** trainees are able to learn at their own pace with formative testing applied throughout the courseware for knowledge reinforcement
- **c)** provides objective, automatic summative performance assessment of trainees at the end of each lesson
- **d)** provides high throughput at relatively low cost per trainee through low cost hardware and multiple use of courseware
- **e)** provides efficient collection/storage of student records under the control of a tailored learning management system
- **f)** facilitates statistical analysis of trainee responses to support courseware development and improvement
- **g)** less instructor intensive than simulators and part task trainer; instructors are less involved during training as trainees control delivery
- **h)** instructor role is one of allocating lessons, providing assistance when requested and giving feedback to improve course
- **i)** can be used in distributed learning applications to reduce the amount of travelling between places of work and training centres
- **j)** more efficient training, increasing knowledge retention through interaction and reducing instructor contact time
- **k)** a good level of service support with software issues.

### 1.3.4 Computer-based training and assessment (CBT/A) drawbacks:

- **a)** initial cost of training/assessment courseware production
- **b)** typical production ratio is two hundred and fifty hours development for one hour of courseware
- **c)** courseware modifications can be expensive if subject matter changes frequently
- **d)** instructor staff need training for editing/producing courseware and working with the learning management system
- **e)** trainees may miss out on direct feedback from instructor if courseware is being undertaken offline
- **f)** does not generally provide practice/development of psychomotor skills
- **g)** a poor level of service support with software issues.

### 1.4 Computer-based Instruction and demonstration (CBI/T)

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.

**Classroom trainer**

CAI courseware or PowerPoint slides hosted on PCs, videos and DVDs are used as the means of knowledge delivery.

Demonstrations/trainee interactions through scenarios are often used to reinforce knowledge and allow instructors to assess performance.

It may be possible to use other media, including simulator visuals, CBT/A within the classroom environment depending on the application.

Consideration needs to be given in how this might be integrated into the training program and what the candidates input will be?
Some existing methods include passive learning using classroom demonstration, where procedural information is delivered to the group. Active learning is where collaborative facilitated learning encourages the candidate to contribute to decision making points and score the operator’s performance.

1.4.1 Computer-based instruction and demonstration (CBI/T) benefits:

a) usually the least costly to procure or develop and the most flexible form of training delivery
b) courseware can be delivered by existing instructors without the need for special training
c) flexible – can be easily and quickly updated by existing instructional staff with minimal hardware support
d) can incorporate multimedia representation of real situations eg video, DVD, photographs
e) trainees can benefit from group learning situations and interaction in well controlled and operated courses
f) assessment can be achieved through simple questionnaires/test papers
g) low cost delivery through standard classroom media delivery equipment (PC, projectors, interactive whiteboards etc)
h) low maintenance if subject material stable or not likely to date
i) a good level of service support with software issues.

1.4.2 Computer-based instruction and demonstration (CBI/T) drawbacks:

a) 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)
b) training quality dependent on the skill and experience of individual instructors
c) less effective with larger class sizes
d) individuals receive less personal attention and help in larger classes
e) optimal class size dependent on training goals, but typically no more than 20 students
f) assessment largely subjective through course with test papers, exams etc being inevitably less detailed than performance recording in a full simulator
g) good trainees can ‘coast’ in class situations and are not, perhaps, fully stretched
h) less able trainees may not get the extra attention they need
i) marking and recording results can be a time consuming process for instructors
j) a poor level of service support with software issues.
1.5 Full simulators (FS)

These often include the use of real or accurate replicas of workstations or equipment to create a high fidelity simulated learning environment in a training school/centre, capable of presenting the trainee with the closest possible representation of operating conditions.

The most common examples of such simulators used in rail include:

a) full cab simulators for driver training and assessment

b) control rooms with integrated electronic control centre (IECC) simulators for signallers

c) absolute block simulator and NX panel simulator.

Such simulators provide an opportunity to encounter those situations and tasks where detailed dynamic aspects of the environment can affect the development of situational awareness and psychomotor skills, and where these skills are important elements of performance.

The term ‘full mission’ can also be applied. This is based not only on the look and feel but on the functional operations that the simulator can perform.

In order to be a full mission simulator, the simulator should be able to recreate operational situations that dictate the candidate’s interaction with the simulator and is faithful to the real equipment using the same operational procedures, although still simulated.

In a full cab driving simulator the candidate would be able to rectify faults using the correct equipment, either by using the actual equipment or by a means of virtual replication.

Full cab simulator

Example of Network Rail simulators

IECC signalling simulator

Absolute block simulator

Trainees use an NX panel

The set up and building of the virtual environment for these types of simulators can be costly and time consuming, along with the creation of scenarios for exercises.

Care must be taken in the initial purchase to create a user friendly operator interface which can reduce the time taken for these tasks.
1.5.1 Full simulators (FS) benefits:

a) facility to train/practice/assess for out-of-course events

b) a range of scenarios are able to 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’

c) high fidelity immersive training environment to put trainees into ‘near real world’ situations but without the associated risks

d) repeatability of scenarios and conditions for all trainees

e) provides consistent and definable scenarios to cover the wide range of training goals

f) provide practice/development of psychomotor and procedural skills

g) provide opportunity to practice implementation of Rule Book against realistic environments in real-time or compressed time-frame

h) can provide event recording and automatic performance evaluation to support audit trail requirements and maintain objectivity in assessment

i) can include facilities for a relatively large number of other students to observe through computer/video displays and learn from the experience.

1.5.2 Full simulators (FS) drawbacks:

a) high initial procurement cost and on-going support cost, particularly for visual database and scenario development

b) resource intensive – generally a similar instructor/assessor to candidate ratio as with OJE, yet with additional investment for instructors or other staff to be trained in operating the simulator

c) set-up time for training sessions can be longer than the session itself, especially if the user interface has been poorly designed

d) usually found in fixed location training centres

e) costs can be incurred on travelling time and expenses for candidates who are not based at the simulator location and may also require more time away from the job

f) often requires special building arrangements (especially regarding HVAC) or significant alterations to existing buildings

g) not easily portable due to the complexity of installations and cabling between simulator and computer hardware.

1.6 Part environment simulators (PE)

Part environment simulators are those that produce the majority of the operational and functional equipment to operate the simulator (e.g., drivers desk in a part cab simulator). It is reproduced to a degree of fidelity that faithfully replicates the original equipment’s look and feel, along with a visual image, but the environment of the work place surroundings is not present.

These can sometimes be confused with full simulators as they often have a high level of fidelity with the equipment that has been provided, but the geography of the immediate environment is not present and therefore does not constitute a ‘full simulator’.

Reconfigurable ‘part cab’ driver simulator

The physical environment geography of a drivers cab beyond the driver’s desk, walls, ceiling, etc needs to be present to constitute a full cab.

These are normally used for initial or refresher training, rather than assessment and are generally associated with high to medium fidelity.

These can also include the ability to reconfigure the operational controls to replicate other forms of similar operational equipment.

This is more commonly done with the use of touch screen technology.
2 METHODS AND TYPES OF SIMULATION cont...

This increases their target audience but reduces the operational fidelity as the actual motor skills required to perform a positive or negative action (the pushing of a button, pulling of a lever, etc) has no feedback or neutron loading.

The automatic sub-routines that a candidate would normally employ would then be interrupted by these reductions in fidelity.

If the placement of these part (cab) simulators is also within a shared environment (such as part of a training room) then there is an issue of internal distractions that may affect candidate performance.

1.6.1 Part environment simulators (PE) benefits:

a) high fidelity operating controls at a lower initial cost than FS

b) hardware can be re-configured to replicate other equipment (traction) types.

1.6.2 Part environment simulators (PE) drawbacks:

a) fidelity and realism of the simulator can have a large effect on trainee performance if they cannot immerse themselves in the environment

b) reconfigurable operating controls such as touch screens, can significantly reduce the operational fidelity as the ‘hands on positive action’ is lost.

1.7 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 part task trainer (PTT) is generally associated with medium to low 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:

a) route-learning devices for drivers

b) multi-function generic driving simulators used to train or assess principles rather than traction unit specific training

c) generic signalling simulators

d) communications trainers

e) mock-up station and customer service areas for the training of ticketing, customer service and station staff

f) screen based emulators providing free-play practice in fault diagnosis for maintainer training.

1.7.1 Part-task trainers (PTT) benefits

a) provide real-time training/practice/assessment against specific tasks or skills

b) usually based on relatively low cost commercial off the shelf (COTS) hardware

c) often comprise standard PC workstations and will generally fit within a standard classroom or office environment

d) can provide multiple trainee seats at relatively low additional cost

e) since functionality is usually defined by software, the additional cost of extra workstations is generally limited to workstation hardware cost

f) less instructor intensive than full simulation or OJT

g) instructor commonly in charge of a class of typically mid to large groups of 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)

h) can be configured as multi-purpose or to support different training configurations

i) this provides significant flexibility - particularly useful if it is to be used to support different equipment types, eg a RU may have several different traction units.

j) re-configurability provides flexibility and reduced overall cost.
2 METHODS AND TYPES OF SIMULATION

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

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

m) more easily re-located than a full simulator

n) operational flexibility.

1.7.2 Part-task trainers (PTT) drawbacks:

a) by definition, these only cover training/assessment for part of the overall role and are usually a complement to other assets needed to complete the training, eg real equipment or full simulator

b) do not usually include automatic assessment facilities for ‘free play’ modes; assessment usually by instructor, and therefore subjective

c) instructors sometimes need special training to optimise use of trainer.

2 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.

2.1 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, PTT 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.

2.2 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.
2.3 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 may include but not be limited to:

a) conversion training for drivers on new traction units
b) conversion of drivers and signallers to new signalling systems and procedures
c) introduction to new train protection systems
d) introduction of new track equipment – for example points engines
e) introduction of new communications systems and procedure
f) supporting re-skilling and role conversion.

2.4 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 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.

If the intended usage of the simulator is to be for assessment the fidelity and functionality will have to be taken into account.

This must replicate the look and feel of the real environment and function accordingly if it is to be used as a primary form of evidence for a candidate’s assessment. They will be expected to perform as if it was a real environment.

The assessment report and records that the simulator produces should be analysed against the existing competency management system and original task analysis for the job role.

Most simulators will produce a complete data output but this may be too onerous or non-specific to the tasks being demonstrated for the assessor to produce an assessment decision from it.

An automatic robust scoring template that scores the task against a pre-determined set of rules can give an automatic assessment score that would be more beneficial to an assessor.

Driving simulator data output may give details that the warning horn was sounded, but a scoring template will score the action if it was done at the correct location and time rather than inappropriately.

3 Applications

The use of simulation in the British rail industry is becoming more widespread than of late. Driving simulators and part-task trainers have been used for many years with some 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.
3.1 Drivers

Whilst a large proportion of driver training is still conducted in the driving 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, PC and FS).

There has been a move within the rail industry to use simulation and CBT in the initial and ongoing competence assessment of drivers, but where simulators are used as a primary form of assessment or training media, there still currently exists the need to use the on-the-job training and assessment as well.

The fidelity and outputs required to conduct assessment themselves need to be assessed as suitable and sufficient prior to replacing any existing system of on-the-job training or assessment.

There has been evidence provided where this assessment has taken place and on-the-job training reduced and existing assessment methods replaced in favour of high fidelity simulators, but there is insufficient data available due to the fact that this has been a recent occurrence to indicate if this has been successful or not.

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. A conversion from existing traction competence to simulator traction would have to take place, thus reducing the live fidelity as this would be a different environment to the traction experienced ‘on-the-job’.

Conversely, generic or re-configurable cabs can be used to train drivers on a range of locomotives, but could potentially disrupt performance in the real world and have restrictions as the fidelity and user acceptance into their immediate environment is reduced.

The trade-off between these will depend on the training programme and the target population of drivers with the simulators intended use. Increasingly, driver training managers from all RU’s have been willing to share experiences through a ‘Simulator User Group’.

3.2 Signallers

In a similar way to driving simulators, traditional signalling simulators are relatively old, relatively limited and at times 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).

When using simulation in training, it is sometimes preferable to offer a blended solution of methods involving new technology, which could include:

a) high fidelity simulators
b) PTTs
c) CBT/e-learning
d) CAI
e) 3D models
f) games.

Safety-critical 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 exchanges, anecdotal evidence suggests there is potential in exploring this further.
3.3 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 for 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).

3.4 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.
3.5 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 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.

3.6 Train crews

Train managers, as customer facing personnel, undergo training in areas of customer service.

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.

For 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 RU’s 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 RU’s have informal sessions for guards to ‘drive’ the cab simulators (FS) to experience train management from the driver’s viewpoint.

3.7 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 stimulate 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 simulating the group exercises and steering the role-play to meet the training goals.

The main lesson learnt 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 which has subsequently been well received by both trainees and training management.

These are relatively low cost initiatives that have been shown to have a positive effect on training.
## 3.8 Current and potential applications of simulation to rail worker roles

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4 Operators, trainers and assessors competence

4.1 Operator competence

A simulator operator’s competence needs to reflect both the intended usage and interaction with the candidate.

If the simulator operator has no need to interact with the candidate then only a basic understanding of the task being performed may be necessary.

If the interaction level increases then a full understanding or formal competence may be necessary.

In each case a task analysis and possibly a risk assessment depending on the task may have to be performed to determine the exact level of competence required.

4.2 Trainer competence

If the training programme is going to be changed to accommodate new technology then an assessment must take place to establish any skills gaps that may be present in the intended group of trainers that will be delivering the training.

Along with their existing mandatory skills in instruction it may be necessary to provide additional training for the trainers in lecturer style delivery (CBT and CAI), collaborative facilitated learning (CIA or other media) as well as the general operation and interaction available with the intended media.

4.3 Assessor competence

If the intended use for the new technology is to be assessment then the operators must also have a full assessment to establish any skills gaps that may be present in their knowledge.

Along with their mandatory skills as assessors they may need training in the basic operation and interactivity of the new technology and understand any limitations that it provides.

An understanding of the fidelity and how faithfully the new technology replicated the real environment along with the level of candidate interaction and functionality it provides may be necessary in order for the assessor to correctly judge a candidate’s behaviour.

An assessor must be able to fully understand and interpret any automatic reports or scores that the equipment provides and if there is a requirement to validate or interact with these outputs.

In some cases an assessor may need to understand that they need to re-evaluate a candidate’s performance based on these outputs and provide evidence that this has been performed.
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3 PROCUREMENT GUIDELINES

1 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, however, they can be compatible with data input from OTDRs and are capable of replaying an incident but this may not be a true reflection of what took place as it may not replicate the detail of the exact environmental conditions (weather, temperature, etc).

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.

1.1 Procurement checklist

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 and/or assessment cycle, 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 RU’s, to bodies undertaking human factors research, incident investigation or to provide a training and assessment media based on their need, 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.

The manager 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.

Care should be taken to understand the requirement and skills that a simulator manager needs to possess. With limited simulator experience within the rail industry a solution may be to employ the expert knowledge of a simulator expert, but this may come at the cost of a loss of railway understanding and have a negative effect on the overall project.

It may be better to ensure that the candidate has preserved railway knowledge and gathers simulator expertise from user groups and other RU’s that have purchased simulators.

This will build on the expertise foundation that has now been established by the Simulator User Group, (SUG), bring railway integrity to the project and create ownership, all of which can be missing with the employment of an external self-confessed simulator expert.

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 (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 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 on-going 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.

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 (briefing/de-briefing rooms, observation areas), instructors (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.

j) Data availability on the system to be simulated (route databases, and 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.

k) 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.
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.

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.

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.

2 General advice and lessons learnt from simulator procurement

Before choosing to start the business case and procurement process for simulators you will need to perform a robust training needs analysis to find out if you do really need to buy simulators.

It may be more cost effective to rent time on other companies’ simulators if they are suitable and geographically available. Other lower cost options may provide adequate solutions as well.

You will have to answer the question ‘do we really need to buy a simulator?’

If you do not go through this process and provide justifiable answers to this and other questions it will become difficult to support a business case.

You will have to really define what you want to use the simulators for before issuing an ITT, as this will drive the content of the return bids. If you do not define the usage there is a risk that the equipment will not deliver the performance required.

Some guidance for determining areas of simulator usage are:

- initial training, additional support or replacement
- on-going assessment, additional support or replacement

What you want to use the simulator for will help determine its fidelity. If it is to replace existing training or assessment then the fidelity would probably be high, this will be both the cab and visual environments.

If it is to assist in existing training or assessment to help procedural tasks then this will be a lower level of fidelity and therefore lower cost.

The types of scoring outputs required also need to be included. This will also give a good idea if the usage is correct.

‘Does it score this, how does it record that that, is it compatible with our existing assessment process?’
This process needs to happen prior to issuing an ITT.

It may be more useful to the customer to specify the layout of the tender as you are more likely to understand the content. The other option is to give the suppliers a free hand and let them lay their bid out how they like. This can add confusion to the scoring and comparison if they are all of an individual format.

An example of structure and content is below but should only be used as advice and guidance on how to produce a tender. An internal company procedure may already exist that sets out a template for your individual procurement guidelines. It is normally better to seek advice from your procurement experts or departments prior to starting this process.

### 3 Structure and content of the tender

#### 3.1 Overview

Any tender submitted must strictly adhere to the structure defined in the Form of Tender description outlined in the preceding letter.

This will allow the customer to efficiently and fairly evaluate tenders from multiple potential suppliers.

The tender shall include all the information required under each of the sections. Bidders are advised to review their tenders thoroughly before submission to ensure that all the requested information has been provided.

The tender must include 8 sections and appendices as shown to right.

#### 3.3 Form of tender

##### 3.3.1 Section 1 - Supplier overview

A supplier overview is to be provided that will contain the following:

- **a)** company introduction
- **b)** history
- **c)** staff profiles
- **d)** customer base
- **e)** audited annual report for the financial year
- **f)** quality assurance policy.
3.3.2 Section 2 - Proposal

Section 2 shall contain a complete and detailed functional specification of the system being offered by the bidder.

The functional specification should cover all the functionality described by the driver simulator(s) requirements in Appendix A of this ITT.

Section 2 should also contain a summary table which will detail and cross-reference to the driver simulator(s) requirements. It should indicate compliance/non-compliance/workaround solution.

Bidders should be aware that the driver simulator(s) requirements provided in this ITT represents the minimum functionality required by the system.

Tenders should clearly identify functionality that is over and above that which is described in the driver simulator(s) requirements. The evaluation of the tender will include an appraisal of these areas of additional functionality.

Section 2 should also contain a product brief to contain the following:

a) ease of use
b) flexibility
c) security, to include an information security policy
d) software compatibilities
e) details of regular upgrades and enhancements.

Section 2 must also contain a proposed service level agreement (SLA) which covers the following as a minimum:

a) help desk support during working hours of 8.30 am to 6.00 pm
b) method of logging calls and monitoring progress of the issue
c) response time matrix for scale of issue
d) scale is to include example issues
e) on-site attendance for critical issues, eg failure prior to training session
f) escalation route for issues
g) remote/on-line support.

Implementation brief: A detailed summary of the support that is to be offered during the implementation of the system until the client's acceptance.

This is to detail the following:

a) proposed implementation team
b) implementation stages
c) supplier and customer responsibilities
d) proposed timescales
e) on-site and remote levels of support and the client's escalation route.

Support brief: To contain additional services offered including membership of user and product development groups.

3.3.3 Section 3 - I.T. brief example

From Q3 2004 the Customer will be running a Windows 2000 (or current operating system that is compatible) server based environment using IP as the core network protocol.

Up to that time the server environment is a Novelle Netware system. Microsoft Terminal Services will be in use and may be considered as a suitable means to deliver the system to the customer desktop.

All printing is network based.

SQL server is the default database environment in use. The supplier will need to explicitly state the database used by the application. A firewall is provided within the network infrastructure.

Section 3 to include the following:

Product

a) SQL Server or Oracle are supported databases. The supplier will need to specify the database used by the application along with all other supported databases.
b) It is suggested the development language used will be seamless to the customer. However, if this is relevant the supplier should make specific mention of this.

c) The supplier must specify the desktop delivery methods supported, eg full customer installation only, terminal services etc. Explanation of the services provided within each delivery method must be provided.

d) The technical specification requirements of the server required for the simulator must be provided.

e) The customer specification requirements are identified in this document. The printing environment is based on IP printing and network bandwidth requirements should be identified. However, it is possible that the server and simulator will be located at either end of a LAN extension connected by a 100 mbps fibre optic link.

f) A report generator is required with a facility to generate electronic files and hard copies.

g) Web browser functions should be included if available in the application.

h) A full description of how these facilities will work must be provided.

**Services**

a) Technical support for physical access will be provided 08.00 to 17.00. Otherwise support must be provided remotely at times identified by the customer.

b) Service upgrades are expected only in the event of the software becoming unusable during the life of the contract.

c) However, service patches and bug fixes must be provided within a reasonable time of the problem being identified. The supplier must document these policies.

d) The supplier must identify the preferred ‘object distribution’ method.

However, it may be a company policy to protect your network with VPN (virtual private networks) so this must also be specified.

e) Database administration and maintenance requirements must be undertaken by the supplier. A description of these arrangements is required.

3.3.4 Section 4 -Additional information

Section 4 shall contain a statement of factors and issues not contained in other sections of the tender and may be provided should the bidder believe such information should be brought to the attention of the client. The length of this section shall be limited to 2 pages.

3.3.5 Section 5 -Product range

Section 5 shall contain an overview of the suppliers product range offered and is to include the functionality of each product.
3.3.6 Section 6 - Pricing brief

This section shall contain the price offered by the bidder to the client. Any assumptions that have been made when calculating prices must be stated.

Calculation of prices must be stated where a charge is applicable.

The bidder shall complete the pricing matrix (possibly attaching a pro-forma as an appendix).

Along with completing the pricing matrix, the bidder is required to provide explanatory notes of the service provided. This is particularly relevant in the case of training and ad-hoc consultancy.

It should be noted that travel expenses should not be included for on-site visits as free travel will be provided by the client.

The bidder must also state payment options offered along with the associated terms and conditions.

The bidder must also list in full, any other areas where it is believed that charges may/will be applicable.

Prices quoted are to be fixed for the duration of the agreement.

3.3.7 Section 7 - Planning and management

Section 7 will contain a description of how the delivery of the system and the service will be planned and managed by the bidder.

The tender must clearly state the date on which the bidder proposes to deliver the final solution to the customer for ‘user acceptance testing.’

The following elements should be included as a minimum:

a) project plan: showing dependencies, resources, critical path, contingencies and milestones

b) organisation plan: showing team structures, roles and responsibilities

c) business continuity plan: describing the procedures that will be in place to provide contingency for the service provided to the client

d) customer review plan: description of areas where the client’s input is required, eg document reviews, progress meetings, acceptance testing, project management practices etc

e) quality plan: statement how the bidder will ensure quality is maintained throughout the project phases.

If the bidder intends to make use of any sub-contractors for either implementing or providing any component of the system or the service then this must be clearly stated in this section.

The sub-contractor should be named and a description provided of the components they would be asked to supply.

3.3.8 Section 8 - References and documentation

Section 8 must include a description of similar projects completed by the bidder in the past. Named individuals complete with contact details should be provided to enable the customer to canvass references.

4 Driver simulator(s) requirements for invitation to tender (ITT)

Introduction

An introduction into the company issuing the ITT and its basic requirements, use and possible location of the equipment must be identified within the ITT.

An example of the more detailed requirements including numbers of simulators (which will have an effect on the strategic bidding from the suppliers as well as the price) and a strategy of ‘core’ or ‘specific’ equipment types are detailed below.

It is worth reviewing at this stage what the bargaining power of the customer is and consulting with any owning groups or collective procurement departments. This will add strength to the negotiations if there is a group purchase.
If this is a group purchase there may be merits in first obtaining a framework supply agreement, which may not promise to deliver specifics but determine the selected supplier against broader technical specification and functionality.

The specifics of the deliverables will then be determined buy the technical specifications and the individual needs of any affiliate that wishes to purchase from the framework supply.

**The requirements**

Lay out in broad terms what you are asking the suppliers to bid for: how many simulators, are they full cab, full mission, with or without cab environment, part-task trainers, CBT, with a projected type and quantity of each?

All simulation equipment must include the capability to assess and measure the training session and individual performance in using the simulator or in being assessed against a set of criteria. Interface with OTDR systems is desirable to enable the re-creation of incidents.

In addition to meeting cost, quality and specification requirements, the successful bidder will have demonstrated a complete conformance with the core elements of the tender with clear pricing and description for the add-ons and options. Any further enhancements may be included provided they are described and clearly priced separately.

The customer may want to give an indicative timescale to encourage the suppliers, or if it is part of other procurements or franchise bidding there may be merits to disclosing a more delayed timescale for purchase and delivery. This may also be due to site availability.

Bidders will be given an opportunity to seek clarification of any details contained in the specification. Procedures for this are contained in the ITT document.

The customer should also give a broad specification with requirements that have been formed out of the training needs analysis and invite the suppliers to provide their solutions.

Being too specific will truncate some of the bidding process and also not encourage the suppliers to view this as development, they may try to provide more off the shelf solutions rather than a bespoke answer.

A good deal of time and effort should be allocated to getting the ITT specification correct, as this will then govern the scoring and ultimately, the selection of the supplier.

Individual suppliers cannot be asked for anything that has not been included in the ITT, as they all need to be given the same opportunity to bid.

The specification should be broad enough to capture all the functionality requirements of what the customer wants the simulator and equipment to achieve, with the use of high level statements, this will ensure that the training needs are met and also give a view on how all the suppliers achieve these performance statements.

These should be determined from the task analysis, initial and projected usage, so each performance statement should be able to deliver the requirements needed.

There is a danger in specifying too much detail that can prove costly if anything is left out or underestimated. Level of functionality is also outside the scope of supply within the contract.

The high level statements that the suppliers need to find solutions to, need to encompass all the requirements but be at a high enough level of statement that protects against error or misinterpretation.

**Statement** - the simulator needs to faithfully replicate all communications and record them in conjunction with the candidate's actions: Cab secure radio must function to enable the driver to speak to the operator

**Note:** you should always feel like the customer and tell the suppliers what you want or need the equipment to do. It is then up to them to go and find a suitable solution. They should do all the work!
An example of a broad specification is below:

**Driver simulator(s) specification for ITT**

**Functionality:**

a) Must be of simple design and suitable for use by personnel with only basic computer skills.

b) Full drivers cab. Options for simulators without full drivers cab environment. Both must be of durable and realistic construction, but need not be real cabs or desks.

c) If two or more simulators are co-located, one operator is to be able to supervise them simultaneously.

d) Must include a secure, auditable usage database, recording instructor and driver details, type and duration of training, critical events etc. This data must be available for external electronic archiving.

e) Must incorporate a ‘timeline’ or similar control, where events can be produced in real time and positioned in advance of the train. System control should maximize the use of mouse and ‘point and click/drag and drop’ functionality with minimal keyboard usage.

f) Must be able to build, catalogue and save standardised scenarios with ease. The ability to transfer scenarios from one simulator to another would be desirable.

g) The control system must be capable of analysing, printing/storing/recording and external archiving of post run performance and assessment data. Instant playback of the audio and graphics for debriefing and post-run assessment is required.

h) A minimum of 20 pre-programmable and ad-hoc train faults and failures will be required, featuring comprehensive, driver initiated fault rectification. The system should have a degree of intelligence by where it can recognise correct or erroneous driver actions and recreate realistic responses to those actions.

i) All key safety systems must be capable of covert disablement (no warning indications) to assess driver awareness and reaction to unannounced failures.

The operator’s station must be a fully integrated design. To include:

a) display of the driver’s external view

b) CCTV of driver’s station

c) control of both the above, which need to be capable of remote viewing in an adjacent classroom if required

d) display of route schematics and events

e) simple and ergonomic control features

f) intercom between instructor and driver’s station including the touch screen, fault finding station

g) simulated driver to signaller to guard communications equipment
h) simulated driver to passenger emergency communications equipment to include recorded messages from virtual passengers, such as fire, passenger in distress, etc

i) health and safety compliant displays and seating

j) low maintenance and robust.

Details of the training and support package for simulator instructors/operators must be included.

Integrating an interactive graphical display of the simulated route and signalling which would be familiar to Network Rail signallers. Allowing them to set signals in a similar way to which they do in a power signal box. This would allow joint training of drivers and signallers and would be considered a desirable option.

The ability to interface OTDR systems with the simulator to aid post incident analysis and training would be desirable.

Depending on traction type and space available, those traction types where there is limited peripheral cueing may only need to be single channel, high resolution, with a smaller arc of coverage.

5 Visual requirements

a) up to 3 channels: main view high resolution / supplementary views for DOO or peripheral cueing may be medium resolution

b) at least 140 degree coverage for the main channel, incorporating quality projected image reproduction; a detailed description of the proposed projection system, its specification, area required and costs for space saving measures, must be included in the tender; this is to include bulb life, replacement costs and any ancillary equipment required such as mirrors; any additional considerations such as dust free environment or additional cooling requirements declared

c) options for: wraparound, plasma, or flat screen with minimum amount of screen frame intrusion

d) projected image or wraparound screens must be of a demonstrably high quality

e) the system must produce a fully immersive environment, with a good degree of peripheral cueing where applicable

f) the image must have a frame rate high enough to ensure flicker free, smooth running at all simulated train speeds, incorporating a high degree of anti-aliasing

g) no part of the CGI should be seen to build unrealistically close to the front of the train; good depth of field is required both laterally and to the horizon ahead

h) the landscape is to be free from sharp, unrealistic edges to scenery and objects placed therein

i) the CGI is to be capable of simulating; infinite variations of daylight and darkness, seasonal variations including ‘low winter sun effect’, variable degrees of impaired visibility, falling rain and snow, accumulations of snowfall, leaves and water on and near the track; simulation of an object hitting the driver’s front window is highly desirable, however it must also be compliant with the need for the driver to have assistance from another person who has a clear view of the track ahead

j) realistic simulation of other rail and road vehicles, animals, key trackside personnel and events are required; other rail vehicles should be ‘intelligent’ so as to simulate real traffic and provide the opportunity for interaction with the driven train; animation of the other trackside features above is highly desirable

k) if the graphics are PC card driven; the type and capabilities of this card are to be declared; where an image generator is proposed, full specification is required; a side by side demonstration of PC card graphics and image generator graphics may be requested.
6 Event requirements

a) must faithfully replicate the driving characteristics of the host traction, particularly in acceleration and braking; the effects of terrain, and track conditions on vehicle momentum and braking must also be accurately reproduced

b) must be able to build, catalogue and save standardised scenarios with ease; the ability to transfer scenarios from others RU’s that have used the same simulator provider would be desirable

c) the simulation must be capable of replicating all types of rail infrastructure found across the British rail industry; this is to include all types of signage signalling, crossings, infrastructure and procedures found in GE/RT8000

d) the simulation must be capable of replicating all types of rail infrastructure found across the various group of RU’s; this is to include all types of signage signalling, crossings, infrastructure and procedures found in GE/RT8000

e) options for geo-typical and geo-specific routes should be included; to ensure clarity, a definition of geo-typical/specific and generic routes as they apply to the proposed products is to be included; as each RU may have individual requirements the tender should quote for at least 50 miles of generic track useable in each direction; this generic route must be useable by electrified, third rail and diesel rolling stock; geo-typical and geo-specific routes should be quoted for in multiples of 10 miles

f) it is not intended to use the simulator for route learning specifically; therefore geo-typical would need to be geographically accurate, with infrastructure, signalling and signage that would be familiar to the driver; geo-specific would be expected to be a highly accurate depiction of a real route

g) it must be capable of simulating all situations where the driver needs to action an instruction from GE/RT8000; this must be consistent with driving the train during normal operations or any combination of degraded working and emergency situations; the menu of objects available to the simulation is to be extensive and must include trespassers, work parties with their associated protection arrangements, obstructions and damage of both the track and OLE

h) it must have the ability to replicate routine urban and hi-speed passenger operations; this is to include areas of complex signalling, all types of signalling and block working procedures, level crossings, third rail DC/AC; diesel power change locations, shunting movements in and around complex marshalling areas with associated ground signals and signage

i) at least one large station with permissive working arrangements and tunnel approaches; some simulators and routes will need to replicate driver only operation (DOO)

j) a programmable, ‘virtual guard’ would be required on non DOO simulators; this is to supplement the ability of the simulator operator in replicating station duties and potential procedural errors by the guard from the control desk

k) a comprehensive and simple to use track builder tool is required.

7 Driver’s environment requirements

a) all cab and desk equipment that the driver routinely uses, must replicate the appropriate functionality and be ergonomically faithful to the host traction; functional replication of in cab communications equipment is required

b) CBs or switches which would not normally be used to rectify or isolate any fault need not be functional but must be represented; minor controls whose function is not replicated (wipers/washers etc) need not be functional but must be represented

c) the cab interior and desk must be a realistic and immersive representation of the host traction and capable of simulating day and night time operation

d) although full motion is not required, use of a simple semi-active driver’s seat to enhance the perception of acceleration and braking would be desirable

e) faults and failures which can be rectified or resolved from within the provisions of GE/RT8000, without leaving the drivers cab; must be resolved from the simulated drivers cab
3 PROCUREMENT GUIDELINES

f) TMS where fitted must have appropriate functionality

g) those driver actions which require access to other parts of the train must be replicated and resolved via a touch screen faults station adjacent to, but not in the drivers cab

h) extensive surround-sound style, sound effects are required to fully replicate the driving experience, particularly wind and track noise, throttle response and brake sounds including wheel slip/slide/flats, break release and sander operation; in-cab warning sounds and train whistle are to be consistent with the unit type

i) an appropriate level of environmental control will be required to ensure the provision of an environment conducive to concentration and effective training.

8 Supplementary training and assessment

There is a need for part-task trainer (PTT) and desktop CBT, teaching and assessing those procedures and events which do not specifically need a full simulator.

The PTT will run the same scenarios that the main simulator has without the need for direct supervision. The scenarios should be preloaded and lead the student in ‘teach mode’ and ‘score’ performance in ‘assess mode’.

The image should be displayed on a TFT screen of not less than 17 inches. Options for other styles of display can be included but must clearly state the cost differential.

The driver’s controls may be of the generic type but should not be just a PC keyboard. Ancillary controls which would be required to correctly complete the given scenario must be available on the driver’s control station.

Desktop CBT which can teach and assess competency in ‘rules’, ‘fault finding’ ‘safety critical communications’ etc. The CBT must be simple to operate with on-screen help. Minimal keyboard inputs maximising the use of ‘point, click/drag and drop’ features. Multiple choice questions must incorporate cheat proof logic. The CBT should be priced per suite, each suite to be four sets of equipment.
9 Installation and development

Detailed proposals for the time and area required for installing and commissioning the simulator will be required. Any access, weight, ventilation, power supply, COSHH, health and safety or other potential limitations must be included.

Description and cost of all research and development that has taken place with regards to the product that is offered, over the past three years is to be included. This must be broken down and detailed on a year by year basis.

Description and costing that have been entered into the budget for research and development for the next two years, with regards to the product that is offered is also to be included. This must be broken down and detailed on a year by year basis. Updates which are included in the tender bid (first three years of operation) and those which would require further expenditure must be stipulated.

The manufacturers preferred method of downloading CGI and other software updates must be clearly defined. Broadband connectivity or networking to all group simulators would be considered as optional.

Full details of the operating system, processor, motherboard, memory and other key system components are to be supplied. Software version numbers and any hardware expansion potential which has been incorporated are to be listed and fully explained. The information provided will be used to assess the extent of ‘future proofing’ which has been incorporated.

Comprehensive listing of any components, hardware, software, licenses or data which would need to be sourced by the customer for any part of the simulator, PTT, or CBT which are not inclusive to the tender, must be clearly detailed.

10 Service and maintenance

Service, maintenance and warranty costs are to be included, with projected routine maintenance requirements and costs for the first 3 years of operation.

The cost of and responsibility for replacement of essential consumables such as projection system components are to be detailed. Mean running time between failures and time to fix similar simulators already in use will be required.

A comprehensive product support plan detailing the cost of product support at various levels of intensity will be required. The level of ‘on-call’ support and time-to-fix must be defined for each level. A period, post commissioning, for the free rectification of ‘teething problems’ is to be defined.

Given the potential for high reliability of PC-based systems an ‘only-on-failure’ level of support would be considered. Response and rectification parameters for this option must be defined.
11 Specification compliance and transparency

To assist in conducting a fair and equitable evaluation of tenders, it is vital that all instances of non compliance with the specification are declared. Omission of detail which is requested in the specification could prejudice the proposal.

It is understood that proposed products may in some areas exceed the specification and in others be non compliant in minor detail. These factors will be taken into consideration during the evaluation process.

12 Issues to consider

The lessons learned in the acquisition and uses 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. However, the principles are generally applicable across domains.

12.1 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:

  a) delays in the provision and availability of rolling stock parts and data
  b) definition and construction of visual databases
  c) supplier’s inexperience with the British rail industry
  d) building facilities not ready
  e) extended acceptance trials.

Lessons learned include:

  a) ensure that the supplier has good access to data and parts
  b) define visual simulation requirements early in the programme; visual databases take time
  c) define building requirements early; building alterations or construction take time
  d) 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 its development, thus reducing lead time once the simulator is commissioned.

12.2 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 include:

  a) 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
  b) the 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
  c) involve trainers at the specification phase through to commissioning.
12.3 Original equipment replication

Some operators believe that a full driver’s cab, populated with original real equipment, is not necessary to provide an authentic training environment but essential for assessment, while others consider that a generic cab is sufficient.

Lessons learned include:

a) high fidelity cab replication adds significant cost; define what the simulation will be used for and assess what additional training and assessment or fidelity value a full cab simulation will contribute; if it is to replace existing on-the-job training or assessment then high fidelity may be required; if it is to enhance or be an addition to an existing training program then a lower level fidelity might be sufficient; prior to specification a fidelity assessment based on the intended usage should take place to determine the levels required

b) there has been significant improvement in the replication of real in cab equipment to a degree that may not reduce fidelity; each supplier’s solution will need to be assessed

c) 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.

12.4 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.

12.5 Virtual environment

A large number of simulators operate in a virtual environment. The operator needs to exhibit control over this environment to change the characteristics in conjunction with the scenario or exercise (eg bad weather).

It is favourable for the simulator operators to be able to adapt and edit this environment to make changes, (position on new visual indicators, line-side signage etc), or even create new virtual environments. This can be very time consuming and create down time for the simulator.

To minimise this interface between the operator and simulator it should be designed to reduce the time spent on these tasks. This ideally needs to be separate from the simulator control station to allow the environment to be constructed and the simulator to be operated simultaneously.
Careful consideration should be given to the design of this operator interface to improve the usage and time spent in construction. This can be achieved in the initial design, (eg creating macros to link pieces of virtual equipment; placing signals, AWS, TPWS so they are all placed at once, number allocation or ‘scatter function’ to items which are numerous; trees, bushes, buildings, etc).

There is a specific skill in building a virtual environment that will have to be practiced frequently or skill-fade will be evident.

Where the virtual environment is an external view of the world, (eg driving simulators), there is the issue of geo-generic vs geo-specific mapping.

It is normally seen as optimal to reproduce the real environment as faithfully as possible for all the candidates, however, geo-specific would accommodate this.

This would help immerse the candidate in a virtual environment that is familiar but can prove extremely costly to initially produce and maintain to an acceptable level.

Geo-specific can also be restricting if any changes need to be made that are then not replicated in the real environment and carry all the operational restrictions of the real environment with regard to specific scenarios or exercises.

There may also be large areas of the geo-specific routing that are not regularly used as they contribute little to the virtual environment (long tunnels, large section of plain line) except for route learning.

There has also been prior evidence that if this is not an exact replication of the live environment it can be a large distracter for the candidates, as the candidate challenges, (conscious or subconscious), the differences and may then actively seek out others, (even subtle ones such as new building colours, graffiti or detail in the distance view not replicated).

This then also carries the risk of false training as the virtual environment can train a set of automatic sub rountines based on the visual cues experienced and these cues may not be picked up in the live environment.

Geo-generic produces an environment that is not familiar to the candidate, so there can be a loss of user acceptance and distraction by no experience, (‘what comes next’).

There may also be down time where a familiarisation with the environment takes place so the environment needs to be simple enough to allow this to take place with minimal familiarisation, but this environment can be specified against the operators and candidates needs and will be at a lower initial cost than geo-specific.

The environment is more configurable to accommodate specific scenarios and exercises and any changes to accommodate new procedures or practices are more easily performed.
### MODULE 4 FUTURE DEVELOPMENTS

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4 FUTURE DEVELOPMENTS

1 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 the RSSB.

2 Linked training

Most simulators are designed to deliver training and assessment on a one-to-one basis but are capable of contributing to the classroom demonstration or facilitated collaborative learning.

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.

3 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.

4 Certification and driver licensing

RU’s, 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 RU’s 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:

a) CBT – for knowledge transfer and testing

b) cockpit training; for acquaintance with instrumentation, controls and procedures
c) flight training simulators of different complexities; for instrument flying, and some with limited visual and motion systems for take-off and landing practice
d) 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.

A small number of RU’s have reduced their driving time due to the implementation of simulators; also some training courses have generally been lengthened to accommodate the use of the simulators.

Lengthening can mitigate against the economic benefits and reflects the requirement for a TNA before the point of acquisition.
4 FUTURE DEVELOPMENTS cont...

5 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.

6 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:

a) better classroom media – better resolution and easier to use and integrate with other media

b) more flexible CBT – with easier updating of material by instructors

c) interactive CBT – could be used for customer services training

d) improved visuals simulation - for route learning and driver simulators

e) application of virtual or augmented reality technology to a range of tasks

f) easier to use control facilities for instructors

g) more choice of simulation methods as new developments become available

h) exploitation of the low cost applications (that is, those developed for the leisure and hobbyist markets) in training and assessment.
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 worthwhile including these data requirements in the overall procurement specification.

The RU’s could potentially recover these costs by selling time to the HF staff on an as-required basis.

OTDR 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.

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 British 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. PC vs PTT), the relative merits of visual and motion systems, and whether a high fidelity solution is appropriate at all or essential depending on intended or future usage.

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 key point is to satisfy the need and not to be persuaded by the competition to achieve a better product by the supplier if in direct comparison with other companies (‘I want the best yet’ or ‘I want one that’s better than theirs’).

Each simulator will have fundamental differences if the needs they were designed for are different.

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 ‘cross-over 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 co-operation 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 and assessment.