



**IRSE**  
INSTITUTION OF  
RAILWAY SIGNAL  
ENGINEERS

# COMPETENCE GUIDANCE for TRAIN-BORNE TRAIN CONTROL SYSTEMS

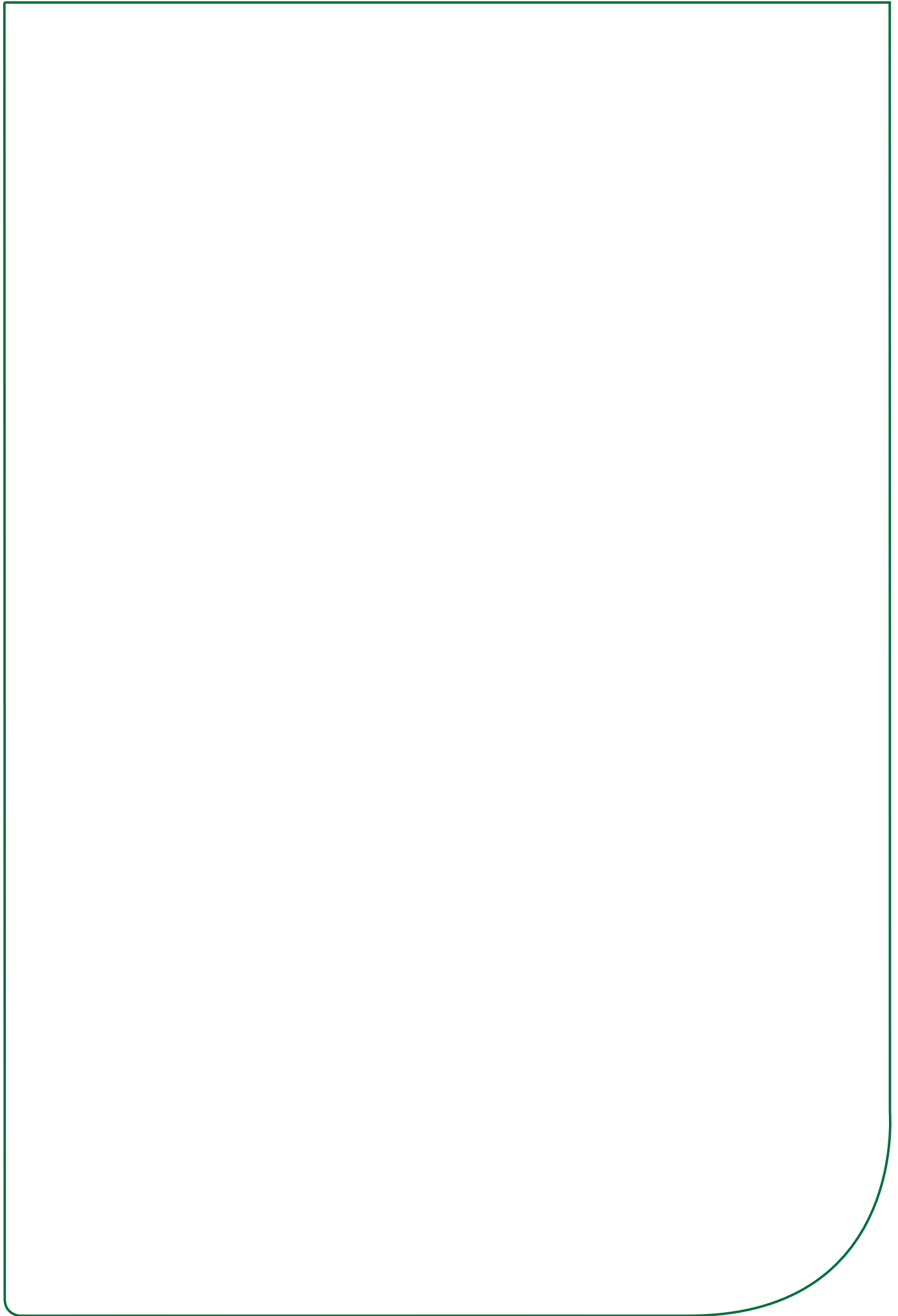
September 2009





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## Executive Summary

This Guidance has been produced by the IRSE following approaches from industry to help organisations make pragmatic risk-based decisions about how to manage the competence of persons working on train-borne train control systems at all phases of the system life cycle.

The most effective way to tackle competence for train-borne train control systems is not to “re-invent the wheel” but to build upon the competence management processes and knowledge that already exist. Most organisations will already have documentation in place. Items such as hazard logs, system descriptions, maintenance manuals, task lists, job descriptions, all of which provide core information upon which to build.

Within this document we have provided Key Guidance Points that are intended to help organisations involved in managing competence for work on train-borne train control systems. It is important to note that these key guidance points are read in context, not in isolation. More generally, it should be observed that this document does not constitute a comprehensive set of instructions on competence management for train-borne train control systems. The intent is to offer advice about the application of established good practice for competence, taking into account the specific features of such systems.

In summary, the sections of this document and the Key Guidance Points address:

- *The UK legal and regulatory context*
- *The benefits of good competence management*
- *Making use of established good practice*
- *System architectures and interfaces*
- *System software and data*
- *System complexity and configuration control*
- *Organisational issues*
- *Identifying tasks and assessing risks*
- *Selecting and using competence standards*

## Foreword

*This guidance material has been produced by the Institution of Railway Signal Engineers (IRSE) to assist organisations that are responsible for managing the competence of people engaged in the design, manufacture, implementation, operation and maintenance of train-borne train control systems.*

### Background

The IRSE was founded in 1912 as a professional body, whose objectives are:

- to advance the science and practice of railway signalling and telecommunications engineering for the public benefit;
- to promote high standards of practice and professional care amongst those working within the industry;
- and to promote improved safety standards for the protection of the general public.

The Institution is authorised by the Engineering Council UK to register Chartered Engineers, Incorporated Engineers and Engineering Technicians and on behalf of industry the IRSE sets competence standards and manages a Licensing Scheme for certifying the competence of persons working on safety critical signalling and telecommunications systems.

Modern developments in signalling and telecommunications systems for train control purposes increasingly place the equipment on board the train. In 2007, following approaches from industry, the IRSE Council established a Working Group to consider the competence requirements for persons undertaking work on train-borne train control systems and whether the IRSE's Licensing Scheme should be expanded to include such systems.

The Working Group, comprising representatives with a broad and varied experience of train-borne signalling systems, initially under the chairmanship of Francis How, Deputy Chairman of the IRSE Licensing Committee and later under Thomas Godfrey, a member of the IRSE Licensing Committee, have produced this guidance document on competence issues for train-borne train control systems. The document is intended to inform and guide those responsible for the design, manufacture, implementation, operation and maintenance of train-borne train control systems and assist them in making appropriate risk based decisions concerning the competence standards and competence assurance requirements for all those persons who undertake safety critical work on such systems.

**This guidance is written specifically in the context of the UK railways but is likely to be applicable to other railways around the world having regard to the particular legal requirements and railway regulations of the relevant country.**

## Introduction

The purpose of this guidance document is to help organisations make pragmatic risk-based decisions about how to manage the competence of personnel working on train-borne train control systems at the various stages of the system life cycle.

The way that an organisation introduces a train-borne train control system, whether it is a new system, or retrofitting an existing system, will require careful consideration as part of its overall business and technical strategies and with due regard to the arrangements for the operation of the railway. The emphasis within this guidance is to encourage a logical and balanced assessment of the system and of the performance expected, in order to arrive at the best solution for the competence of personnel who will work on it.

The document explores those facets of train-borne train control systems that have competence implications, and introduces task-based risk assessment as a way of identifying competence requirements for such systems, including some practical examples of hazards that can occur at the various stages of the life-cycle.

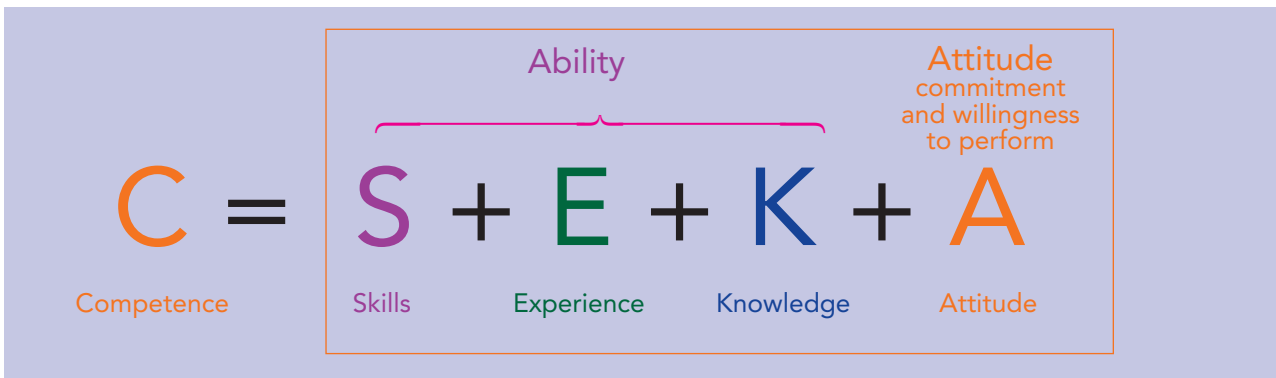
The guidance builds upon the UK's Office of Rail Regulation (ORR) publication "Developing and Maintaining Staff Competence" which provides a well-established framework for developing a Competence Management System.

This guidance was been written originally with Metros in mind, but the principles are equally applicable to Mainline and Light Rail systems.

## Glossary of Terms

**"Train Control System"**, within the context of this paper, is defined as "those train-borne sub-systems that are involved in the giving, withholding or withdrawing of a movement authority for a train".

**"Competence"** is defined by the ORR as "the ability to undertake responsibilities and to perform activities to a recognized standard on a regular basis"<sup>1</sup>. It includes not only skills, experience and knowledge, but also "attitude", that is the commitment and willingness to perform to required standards<sup>2</sup>:



**"Collective Competence"** is a term used to describe the ability of an organisation, (as opposed to an individual), to undertake responsibilities and to perform activities to a recognised standard on a regular basis.

**"Competence Management System" (CMS)** is defined as a logical and integrated cycle of activities within an organization that will assure and further develop competent performance at work.

The definitions of terms such as **"Hazards"** and **"Risks"** are given in the Yellow Book<sup>3</sup>.

<sup>1</sup> ORR Publication "Developing and Maintaining Staff Competence".

<sup>2</sup> "Developing and Maintaining Staff Competence, Comparisons with Rail Industry Experience" John P Baker / Paul Durrant.

<sup>3</sup> Engineering Safety Management "The Yellow Book", ISBN 0 9537595 0 4.

# 1 Regulatory and Business Background

## 1.1 Legal obligations

Obligations relating to competence and competence management have evolved with time and have been progressively reflected in various legislative requirements. There is an abundance of guidance information in the public domain that the reader can consult to help interpret these obligations. Key guidance documents are detailed in Section 3.

The legal obligations referred to in this section are based on UK legislation. Most countries will have similar laws governing health and safety at work and transportation but it is important to check the specific requirements relating to an individual country.

## 1.2 General legal obligations (UK)

The **UK Health and Safety at Work Act 1974** places general duties on employers to ensure that employees and other parties (e.g. passengers) are not, as far as is reasonably practicable, exposed to risks to their health and safety. In particular this includes putting in place safe systems of work, supervision and training.

The **UK Management of Health and Safety at Work Regulations 1999** requires employers to perform risk assessments on their activities and to develop risk mitigation measures that encompass training, knowledge and experience.

## 1.3 Railway-specific legal obligations (UK)

The **UK Railways and Other Guided Transport Systems (Safety) Regulations 2006** (ROGS) places a broad requirement on organisations to make a suitable and sufficient assessment of the risks to the safety of any persons to ensure the safe operation of the transport system

ROGS places a specific requirement on “controllers of safety critical work” to ensure that persons carrying out safety critical activities have been assessed as being competent and fit. This requirement includes the provision for monitoring and recording the competence and fitness of individuals.

ROGS also transposes into UK law the European Commission’s Safety Directive requirements for railway undertakings (train operators) and infrastructure managers to have certificated and authorised Safety Management Systems in place. By implication, although not explicitly in law, a Safety Management System would be expected to contain arrangements relating to the management of competence.

ROGS also places upon railway undertakings and infrastructure managers a “duty of co-operation”, which is of particular relevance to train operators and infrastructure managers that operate on a “shared responsibility” basis (such as the mainline railway in Great Britain), as distinct from the “vertically integrated” approach used by London Underground.



Co-operation between infrastructure managers and train operators is especially important for the safe management of train control systems where the system is physically shared between the two parties.

#### **1.4 Company standards for competence**

Many organisations such as Network Rail and London Underground have their own company standards that place additional mandatory requirements relating to the competence of persons. These are, in effect, part of those companies' Safety Management Systems (see section 2). By way of example, the London Underground standard "Competence of personnel working on signal and signal control systems" mandates a form of licensing for all critical signalling tasks, including design and installation.

#### **1.5 Business benefits**

In the rail industry, competence tends to be thought of in the context of safety, but good competence management will bring other benefits as well, such as:

- greater system availability (i.e. better reliability and reduced down-time)
- improved reputation
- cost reductions
- better transferability of skills
- improved innovation capability

At an individual level, competence management encourages a self-disciplined approach to learning, the acquisition of new skills and career development.

In compiling this guidance, the authors have encountered many examples of where the introduction of competence management for train control systems has contributed to the achievement of substantial reliability improvements. The following Automatic Train Control failure statistics are taken from one London Underground Line and illustrate well how systematically improving knowledge and experience of working on systems can dramatically improve reliability:

2002 – approx. 100 failures per period

2003 – approx. 60 failures per period

2005 – approx. 20 failures per period

2008 – approx. 8 failures per period

The authors have also observed good examples of how competence management has enabled maintenance organisations to acquire new skills, such as:

- printed circuit board repair;
- design modification;
- factory testing of components and sub-systems.

This has resulted in significant cost reductions, reduced mean time to repair and greater ownership of problems by maintainers. In turn this has encouraged innovation, such as developing better diagnostic software and modifying the train-borne equipment to make it more tolerant of its operational environment (e.g. to counter the effects of vibration and heat).

The costs and benefits of establishing formal competence management systems are sometimes called into question. However, the work undertaken in preparing this guidance illustrates not only that the business benefits can be very significant, but also that there is a wealth of information, models, standards and examples that can be used to tailor a CMS so that the effort and cost is proportional to the risks and the needs of the organisation.

## 2 Managing Competence

### 2.1 Competence Management Systems

A competence management system (CMS) is an essential pre-requisite for any organisation engaged in activities that are safety critical or safety related.

There are various CMS models, and the “Competence Management System Cycle” model that is defined in the ORR Guidance (see section 3) and illustrated in Figure A below, is one that provides a sound approach to the development of a CMS, and has the advantage that it has been developed in a railway context. The cycle begins with the key activity of establishing the CMS requirements by the identification of activities and risks, and the identification of appropriate competence standards. Both of these topics are addressed later in this Guidance document.

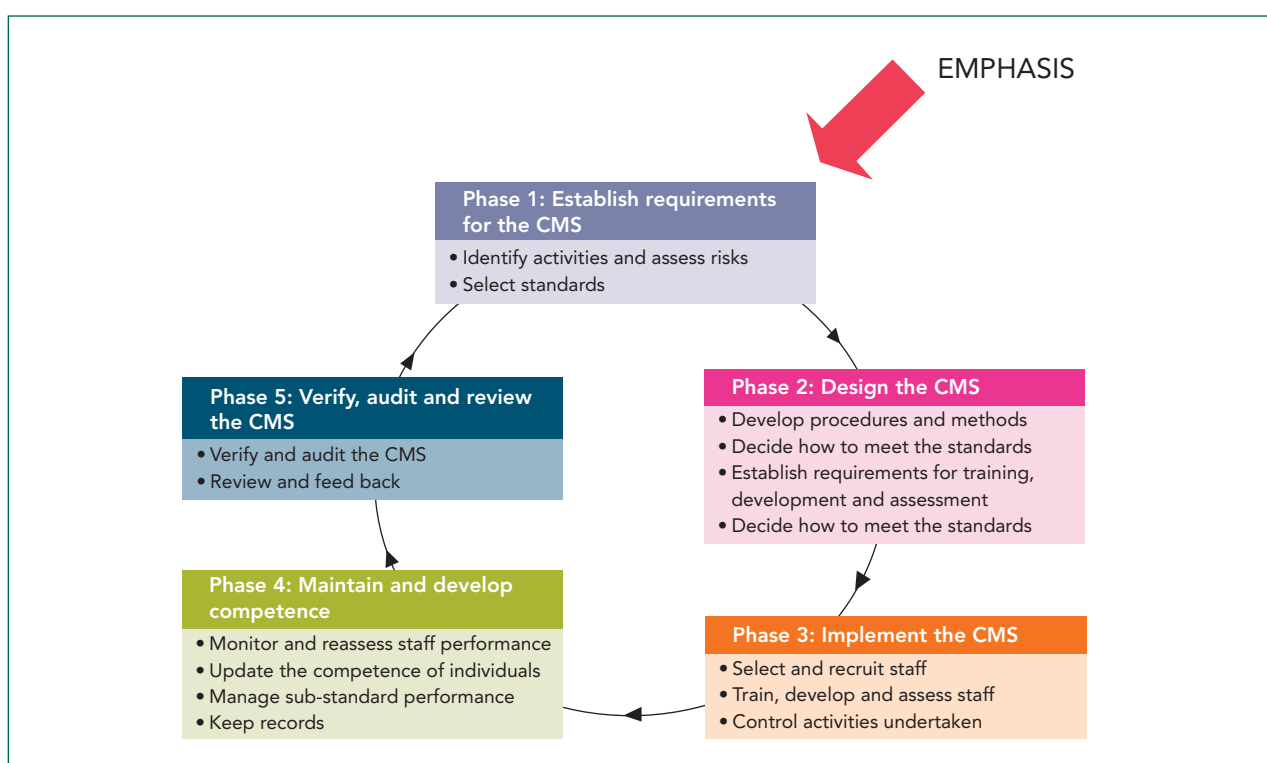


Figure A: The ORR “Competence Management System Cycle”

### 2.2 Competence requirements through the system life-cycle

As with all complex systems, the competence requirements for those working on train-borne train control systems vary at the different stages of the system life-cycle, from development of the system concept through to de-commissioning.

These requirements are related to the activities being undertaken and the risks that these activities present to the safety and availability of the system. They also vary depending upon the overall system design philosophy, such as the extent to which faults are self-protecting and the quality of diagnostic information available.

The familiar system life-cycle V-diagram (Figure B below) shows the key system life-cycle stages, annotated with examples of the types of activities and competence-related issues that arise.

This guidance document focuses primarily on the life-cycle phases from application design onwards. However, the significance of the system concept development phase (addressing the system architecture, integrity level and core functionality) should not be under-estimated, from two perspectives:

- Firstly, the system architecture, including the provision of self-protecting and self-diagnostic capabilities, is critical in determining the levels of competence required of those who will work on the system in its later life-cycle phases – including design, testing, commissioning, maintenance, operation and modification.
- Secondly, this criticality demonstrates that the competence of those who undertake system concept development is paramount. In particular, it is important to recognise the need to bring together both experts in system development/design and also people who understand in detail the technical and operational requirements of rolling stock and train control systems. This rail expertise should have as broad a base as possible, particularly if the system is to be used in railways internationally, rather than in just one country, since the operational practices of railways vary considerably around the world.

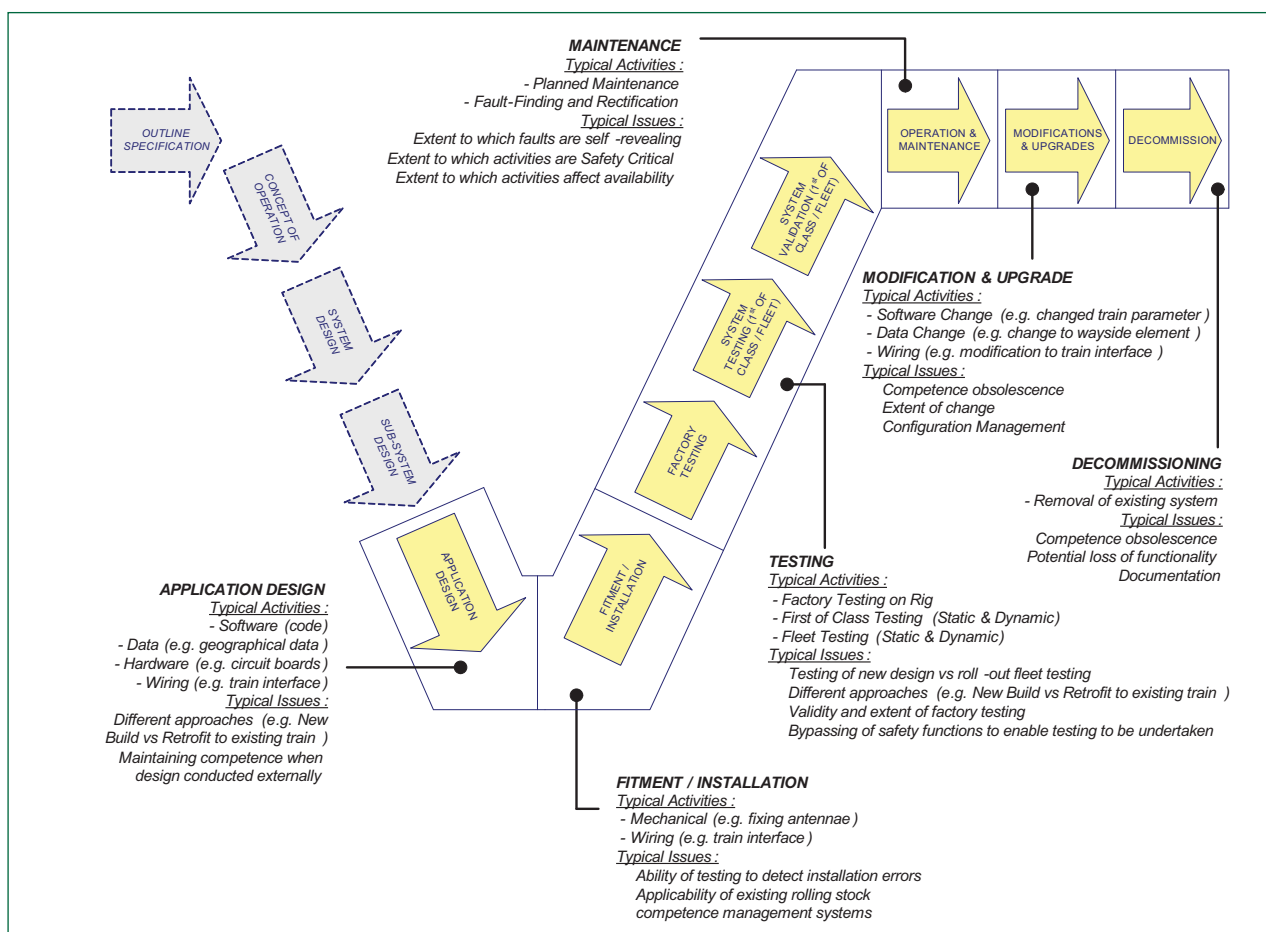


Figure B: The System Life-cycle V-diagram

## 3 Published Guidance Material

### 3 Published Guidance Material

This section provides pointers to other generic sources of UK published information that may be helpful in the context of developing competence management systems for persons working on train-borne train control systems.

#### 3.1 ORR Guidance: “Developing and Maintaining Staff Competence”

This guidance, originally published in 2002, was updated in 2007 to take into account the implementation of the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS).

The guidance material provides an excellent framework for competence management, and has been developed and applied primarily with railways in mind.

The guidance defines a five phase model with fifteen supporting principles for Competence Management (see Figure A for a diagrammatic representation of the model):

Phase 1: Establish Requirements for the CMS

Phase 2: Design the CMS

Phase 3: Implement the CMS

Phase 4: Maintain and Develop Competence

Phase 5: Verify, Audit and Review the CMS

#### Key Guidance Point 1

Make use of the ORR Guidance “Developing and Maintaining Staff Competence” as a primary source for a structured approach to competence management. This guidance is available on the ORR website (<http://www.rail-reg.gov.uk/server/show/nav.1647>).

#### 3.2 HSE “Managing Competence for Safety Related Systems”

This Health and Safety Executive (HSE) publication is relevant to any organisation that is engaged in safety-related activities, and also includes consideration of other responsibilities such as financial management and sub-contracting, which can impact upon competence management.

The main objective of the publication is to define the core requirements for a CMS. The HSE is careful to emphasize that a CMS solution should be proportional to the risks (including those posed by human error), and it highlights the importance of cost effectiveness.

The guidance itself has been restructured to be similar to the ORR Guidance, with 4 Main Phases and 15 Principles.

### **3.3 IET “Competence Criteria for Safety Related System Practitioners”**

This Institution of Engineering and Technology publication was developed in collaboration with the HSE and the British Computer Society, and the latest edition is also aligned with the ORR Guidance referred to above. It provides twelve example roles for an organisation, several of which are directly relevant to train control systems. It suggests competence criteria that can be applied to each role, and splits these into functional “tasks” and behavioural “attributes”.

The document also recommends three levels of competence, and the competence criteria are based on these three levels:

- Supervised Practitioner
- Practitioner
- Expert

### **3.4 The Yellow Book**

The UK’s Rail Safety and Standards Board (RSSB), an independent non-profit organisation, publishes the document known as the Yellow Book (the formal title is Engineering Safety Management). This guidance material addresses the principles and practices of good safety management of systems throughout the whole system life-cycle.

The current version can be downloaded from the website;  
[www.yellowbookrail.org.uk](http://www.yellowbookrail.org.uk). Version 4 is split into two volumes:

- Volume 1; Engineering Safety Management Fundamentals
- Volume 2; Engineering Safety Management Guidance

Competence is dealt with briefly in Volume 1 where the Yellow Book emphasises the principles relating to competence. In Volume 2 the Yellow Book expands the principles, and includes material on the themes of competence standards, assessment, development, monitoring, and review/audit.

Other sections of the Yellow Book, particularly Volume 2, Part 4, “Risk Assessment Fundamentals”, provide good background material that is recommended for use in conjunction with this guidance document.

## 4 Understanding the System

This section of the guidance provides a brief overview of the typical architecture, interfaces, software and configuration aspects of train control systems, and in particular the train-borne elements of such a system. It is recommended that this overview is used as a prompt for searching out more detailed system-specific information and to identify key areas where greater understanding is needed.

The manufacturer or supplier of the system will normally provide a “System Description” document that can be used as an initial source of information about the system. However, on its own this is unlikely to be sufficient for the purposes of identifying the strengths and weaknesses of the system that are relevant to the competence requirements of those who will work it through the various life-cycle phases. Dialogue with the manufacturer is likely to be essential to supplement the core information contained in the system description.

### **Key Guidance Point 2**

Before considering the competence requirements for working on a train control system, it is important to build a good foundational knowledge of the system in terms of its functionality, architecture and interfaces.

### **4.1 Train Control System Architecture and Interfaces**

Although there are many different types of train control systems that make use of train-borne sub-systems, their system architectures tend to be broadly similar in terms of the main components and interfaces. This is not true, however, of simpler systems that provide only basic “stop” and/or “warning” functionality such as the TPWS/AWS systems in Great Britain. Unlike the more complex systems, these simpler systems vary considerably in terms of functionality, architectures and technology.

The remainder of this section focuses mainly on the more complex types of systems, ie. those that include ATP (and in some cases ATO) functionality, although some of the observations made are also true of the simpler software-based systems.

#### **4.1.1 Architecture**

A typical train-borne train control system architecture diagram is shown in Figure C.

As has already been indicated in relation to the development of the system concept, the competence required of those who work on a train-borne train control system from application design through to decommissioning depends significantly on the design philosophy and architecture of the system. Where provided, such protection can facilitate error-free design, effective maintenance and safe operational use, and thereby impact upon the training and competence required of designers, maintainers and operators for the tasks they are required to undertake.

The design philosophy underpinning modern software-based safety-related systems almost invariably incorporates a measure of duplication of hardware and/or software, although an architecture diagram of the sort shown in Figure C does not necessarily indicate this. Duplication/redundancy of hardware/software may be used for safety (i.e. 'checked-redundant') and/or for availability reasons.

The means by which duplication/redundancy is used to deliver safety and availability is a significant differentiator between various systems. It is important that this facet of the specific system under consideration is understood, as it has a significant bearing on both the application design and maintenance stages of the life-cycle.

For example, the safety architecture may be based on a single/mono-processor design or on a 'checked-redundant' two-out-of-two (2oo2) design. Availability may be achieved using a cold/warm/hot standby arrangement with redundant mono-processor or 2oo2 units, or using a two-out-of-three (2oo3) design where safety is assured and continued operations can be maintained providing at least two of the three processors are functioning correctly. Safety critical sub-systems of the train-borne system, e.g. the Automatic Train Protection (ATP) function, tend to be "two out of two" (2oo2) or "two out of three" (2oo3) to provide adequate safety and availability performance, but often the ATP will be also duplicated in a cold/warm/hot standby arrangement. For some systems this is achieved by allowing the ATP in the rear cab to take control whereas others will simply have two ATP systems in each cab.

Redundant architectures and stand-by arrangements can provide major improvements in availability, but the overall system performance is at risk of being compromised unless the maintainer is competent to identify a problem with a redundant sub-system at the earliest opportunity (eg via diagnostic sub-systems) and the repair is executed quickly and efficiently, before it becomes a service-affecting failure.



# TYPICAL TRAIN CONTROL SYSTEM CONTEXT DIAGRAM

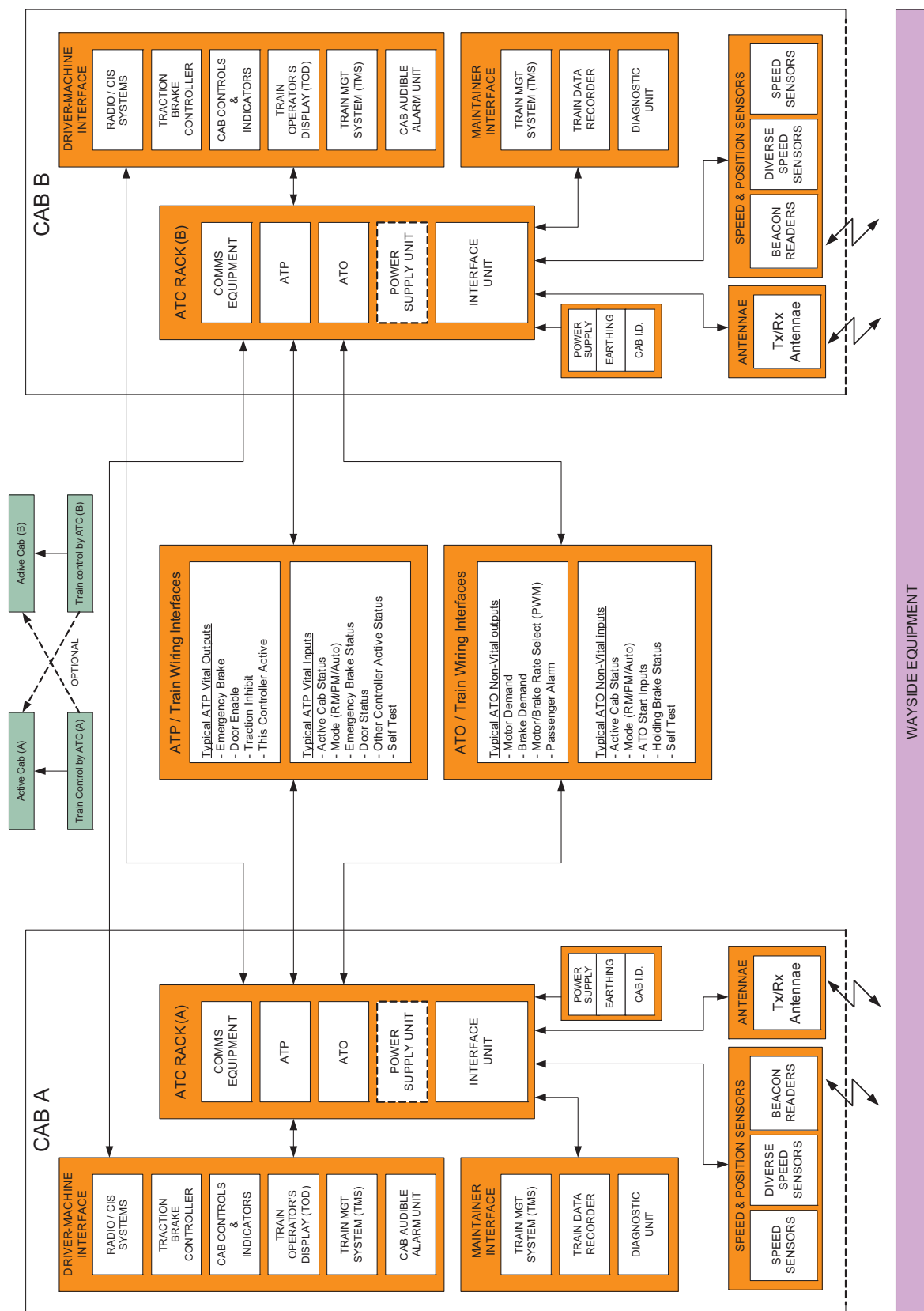


Figure C : Typical architecture of the train-borne part of a train control system

Modern system designs tend to make considerable use of modularity (“Line Replaceable Units”). This is good from a maintainability and availability point of view, as faulty modules can be replaced quickly at the depot during the train maintenance activities, but often the module will need to be sent back to the supplier for repair, as depots generally do not normally possess the equipment or skills necessary to carry out anything except simple diagnosis of the fault. Thus whilst availability can be improved by modularity, undue focus on minimising spares-holding can negate any benefits brought about, and at a cost that can quickly outweigh the costs of the spares themselves.

The provision of good documentation such as fault-finding diagrams is essential both to the driver/operator (in terms of short term solutions such as resetting/restoring the system after a fault, operating a bypass switch or running in a lesser mode), and also to the Maintainer (in terms of identifying a fault and executing the repair).

The design of the driver/operator controls, indications and display of system status/faults, and of the maintainer’s diagnostic, monitoring and programming facilities, are both areas where good practice continues to evolve. On modern rolling stock the Train Management System will almost certainly include monitoring of the train control system and as such offers an additional and valuable diagnostic facility, provided of course that personnel are competent in using it.

### **Key Guidance Point 3**

Obtain accurate details of the design philosophy and system architecture for the specific application of the system under consideration, and make sure that the implications, strengths and weaknesses of the system are understood and taken into account when undertaking task analysis and producing training plans for designers, testers, operators and maintainers.

#### **4.1.2 Interfaces**

The physical and electrical/radio interfaces between the train-borne train control system and other equipment on the train represent a potential point of weakness for system and application designers, who may understand the control system but not adequately understand the equipment with which it interfaces on the train. It can also be a competence challenge for maintainers, who may well understand either the rolling stock or the train control system, but possibly not both, nor specifically how the two interface and interact with each other.

Some parts of the train control system are intrinsically part of the train. For instance the safety brake circuits and round train circuits, common to most rolling stock, will be conditioned by the outputs from the train control system. Therefore staff engaged in fault finding of these circuits must have a solid understanding of both the train and the train control system.

Having accurate, clear information about interfaces between the system and the rest of the equipment, and the dependencies between them, is important for both designers and maintainers.

Some parts of the train control system, for instance any equipment mounted to the bogies, will be affected every time the bogies are removed or replaced, and therefore existing rolling stock procedures will need to be modified to include the necessary uncoupling / coupling / re-testing of these devices. Typical examples are speed sensors, antennae, and balise readers.

Interactions between the train control system and other equipment on the train are not restricted only to interfaces. Systems can also suffer from “unintended interactions”, and designers need to be aware of these and of the limits of performance of the systems, as well as the environment in which they are expected to work. For example, the inability of speed sensors to cope with the level of shock and vibration transmitted from the track has been a common problem with many train control systems. Similarly, excessive heat in an equipment cubicle has necessitated in some cases the installation of fans to cool electronic components.

#### **Key Guidance Point 4**

Make sure that information relating to the interfaces, interactions and dependencies between the train control system and other equipment on the train is clear, accurate and complete, and that it is made available to, and understood by, all those whose competence depends upon it.

## **4.2 Software and data**

Figure D illustrates a typical Software / Data Context Diagram for a train control system. The diagram suggests a highly modularised structure for the software and data contained within the train control system and although modern systems tend to adopt this approach, the same is not always true of older systems.

Like other critical software-based systems, train control systems use a variety of well-established techniques to defend against unauthorised / poorly executed modifications to software and data, but ultimately there is inevitably a dependency upon the competence of personnel engaged in programming and data preparation, particularly for non-standard elements.

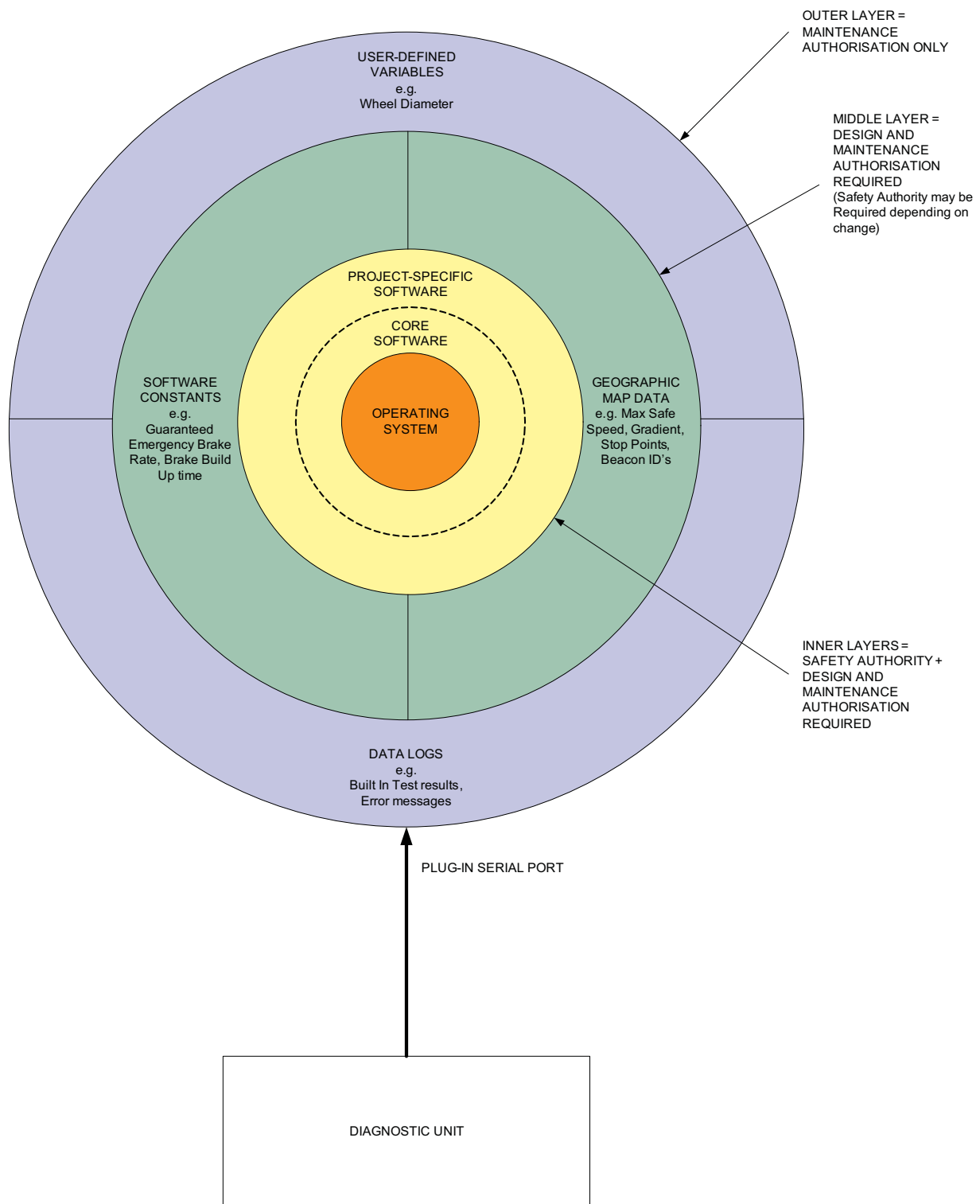


Figure D : Software/data context diagram

The **Operating System** (or “Kernel”) of train control systems presents a challenge for suppliers, as most “off the shelf” systems cannot achieve the required safety integrity level. As a result, most suppliers use their own, very simple, cut-down Operating Systems. Key features of the system such as handling of communication between sub-systems, sizing of databases, and reading/writing to/from memory and polling cycles, are dictated by the Operating System.

Typically the **Core Software** will be based on a generic platform, frequently adapted on a project-specific basis. The Core Software will contain the “inner workings” of the train control system, for instance the key ATP (Automatic Train Protection) and ATO (Automatic Train Operation) algorithms. During the development and early testing phases of the system there are likely to be frequent modifications to the core software as systematic failures are progressively eradicated. Later in the life-cycle, when development has stabilised, changes to core software should be a fairly rare occurrence and, when they do occur, are more likely to be driven more by the customer requiring changes in functionality.

**Software Constants** embedded in the design of the system will normally remain fixed unless there is a fundamental change in the design parameters of the rolling stock or infrastructure. Software constants include parameters such as emergency brake rates, acceleration rates, brake build up time, communication time-out limits, and driver alert times.

The amount of train-borne **Geographical Data** (i.e. data relating to the routes over which the rolling stock operates) can vary considerably between systems, fundamentally being determined by the design philosophy for the system. In some systems, most commonly where the rolling stock is captive on a particular route, all the geographical data for the route may be held on the train. In other situations, where rolling stock moves more widely between routes, the geographical data may be held in the trackside systems and only communicated to each train on an “as needs” basis as it travels over a route. ERTMS is an example of the latter approach.

Whereas the Core Software and Software Constants are usually defined by Systems Engineers, Geographical Data is usually produced on an application-specific basis. Geographical Data is also likely to change during the service life of the rolling stock, since there is always a likelihood of revised track layouts, changes to switches, gradient modifications, different stopping positions etc. In systems where this data is held on the train, rather than in the infrastructure systems, there need to be arrangements in place for updating the data on each train in a fleet whenever required. The extent to which this is an automated process and contains in-built protection against human error will determine the competence requirements of those involved both in generating the data and in downloading it onto the trains.

**User-defined variables** are intended to be modified at regular intervals by the Maintainer. On modern systems, if the wrong value is inputted, the system should always fail in a safe manner, although there will of course be an impact on availability.

The most common example of a user-defined variable is the wheel diameter, which needs to be modified following wheel replacement or turning. On some systems there will be a user-defined variable for train length, eg for freight trains which are not usually of a fixed formation, and this variable may have to be inputted by the train operator/driver or train preparer. Again, competence issues in relation to error-free data input are heavily dependent upon the system design and the associated procedures.

Finally, **data logs** of system performance are usually available and can be downloaded and interrogated by the Maintainer. On modern systems this is achieved using a diagnostic tool, often a PC or sometimes a specially adapted hand-held type device.

#### **Key Guidance Point 5**

Consider the following types of software and data and, for each one identify who, during the system life-cycle, will be responsible for producing, modifying and implementing each type. Consider also who could make changes to other parameters of the infrastructure or rolling stock that could render the software/data invalid or even unsafe. Use this information to understand the potential for human error (both those associated with the software/data itself and those associated with other tasks associated with the rolling stock), and consequently to identify the dependencies upon competent personnel.

- a) Operating System
- b) Core Software
- c) Software Constants
- d) Geographical Data
- e) User Defined Variables
- f) Data Logs

### **4.3 System complexity and configuration control**

System complexity is an important factor in terms of assessing the risks and determining the appropriate level of competence of personnel working on train-borne train control systems, at all stages of the life-cycle.

Most train control systems are inherently complex, and ones that involve both trackside and train-borne systems particularly so. Not only that, but also different versions of the same basic system will almost certainly exist. These versions and permutations are driven by multipliers such as:

- the number of different customers
- the number and variety of types of trains on which they are fitted
- the number of sub-systems offered by the manufacturer

- the number and variety of types of interfaces
- the number of hardware modification states
- the number of software/data versions.

The overall trend is towards greater interoperability (allowing trains to operate across different rail networks, rather than being constrained by the peculiarities of the train control system on each network) and, to some extent, physical inter-changeability of different manufacturers' subsystems. These advances bring with them additional systems integration, safety assurance and configuration management issues, which then impact upon the competence requirements of designers, maintainers and others.

Configuration management of both hardware and software is essential in order to track the system configuration through the life-cycle, and in particular to exercise effective change control when system modifications are required. This is true even in what appears to be a relatively simple case where a single train operator is responsible for a single fleet of near-identical trains all fitted with essentially the same system.

Managing the complexity necessitates that any change to the configuration must go through an approval process, usually involving the system designer and the owner, primarily to consider the impact of the change, the associated risks and implications for persons using or working on the system, and to identify an appropriate level of regression testing (i.e. how much of the changed system needs to be re-tested, taking into account that the previous version had worked safely in service).

The complexity of train-borne train control systems, and the importance of good configuration management, is exacerbated by the fact that the design configuration of trains vary, even within fleets, and this may affect the configuration of the train control system.

All the projects that were examined when preparing this guidance have undergone significant changes from start-up (for example, establishing the configuration of existing trains prior to retrofitting) through to service operation (for example, reliability improvements to printed circuit board design).

Modern train control systems usually include design features to prevent the maintainer from making unauthorised changes to the configuration. These are provided primarily to protect against safety hazards and will include features such as hardwired cab identification codes, pin-codes (for plug-in components), checksums (for uploading of new software/data) and access restrictions (to prevent unauthorised users from using diagnostic and programming devices). But there will be aspects of the configuration that have no such defences other than relying on the competence of the individual making the change.

### Key Guidance Point 6

Make sure you understand how the system configuration is managed, and the processes for making and implementing changes to the configuration throughout the system life-cycle. Know where the points of vulnerability in the processes are, and where competence is therefore most critical for ensuring system safety and availability.

## 4.4 Differences between Train Control Systems

Whatever their superficial similarities, not all train-borne train control systems are the same in terms of their design and modes of operation, and it is helpful to be aware of the significant differences between them.

We have already referred to one key difference, namely the approach taken by system designers to the achievement of acceptable levels of safety and availability, by the use of duplication/redundancy. The table below provides a list of the most significant differences between systems, including the duplication/redundancy feature.

Function	Examples of Different approaches to achieving the function
Movement Authority	<ul style="list-style-type: none"><li>• Distance Based (target stopping location) vs</li><li>• Speed Based (e.g. speed code / target speed)</li></ul>
Speed and Location Determination	<ul style="list-style-type: none"><li>• Tacho-generators</li><li>• Doppler Radar</li><li>• Accelerometers</li><li>• Loop Crossovers</li><li>• Transponders</li></ul>
Track / Train Communication	<ul style="list-style-type: none"><li>• Digital Radio</li><li>• Wave-Guide Systems</li><li>• Inductive Loops</li><li>• Running Rail</li><li>• Transponders</li></ul>
Redundancy	<ul style="list-style-type: none"><li>• 2oo2 systems,</li><li>• 2oo3 systems,</li><li>• hot / warm / cold standby</li></ul>
Geographical Data	<ul style="list-style-type: none"><li>• Trackside, transmitted to train as required</li><li>• Train-borne (ATP and ATO)</li></ul>



## 5 Organisational Issues

During the life-cycle of a typical train control system from application design onwards there are two key organisational groups that have an interest in the competence issues associated with the system. They are:

- The Project organisation (including the supplier and designers), which is normally responsible for all stages up to commissioning; and
- The Operations and Maintenance organisation, which takes over thereafter.

Every train control system project studied when preparing this guidance had examples of modifications that were needed in the latter phases as a result of initial misunderstandings over the exact functionality that the system provided, the electrical characteristics of the systems, and their interfaces with the rolling stock to which the systems were being fitted.

It is self-evident, therefore, that successful implementation of a train control system depends upon early exchange of knowledge and experience between the supplier/designer and the operator/maintainer.

### **Key Guidance Point 7**

Involve operations and maintenance staff as early as possible in the planning and application design of train-borne train control systems. Use formal methods such as "Day In The Life Of" studies to promote knowledge transfer between supplier and operator/maintainer

Organisations and projects vary from railway to railway, and the guidance given below for a typical project has been produced primarily with a "vertically integrated" railway in mind, and in a context where the train-borne and trackside elements of a train control system are both being delivered in parallel, with a single overall client. The organizational and project arrangements will be different in a "shared system" railway, where the train operators and the infrastructure manager are independent of each other, and where it is more likely that the trackside and trainborne parts of a train control system are delivered as independent projects, possibly separated in time as well.

### **5.1 The Project Organisation**

A typical high-level project organisation for the delivery of a train control system in a vertically integrated railway is shown in Figure E. A signalling supplier will be engaged to provide the train control system and to work with the rolling stock manufacturer/integrator (or with the existing train operator/owner in the case of upgrades). Each has the role of Design Authority for their respective technical scope of work, but the overall safety and availability of the train control system requires collaboration by both organisations. Clarity about responsibilities and co-operation, including expectations in relation to competence, is therefore key to success.

### Key Guidance Point 8

Ensure that the responsibilities for safety and for design of train-borne train control systems (including in particular interface design) are clearly understood, with people appointed to be responsible for managing competence early in the project life-cycle.

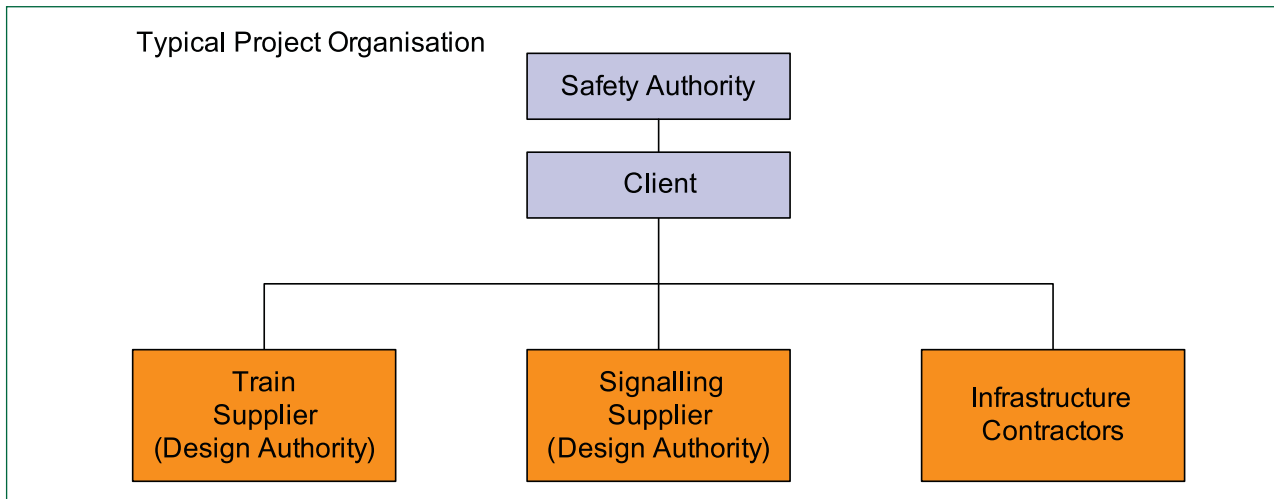


Figure E: Typical project organisation (vertically integrated railway)

## 5.2 The Maintenance Organisation

The introduction of train-borne train control systems can pose a dilemma in determining where the specialist system maintenance personnel should fit within the organisation(s).

There will be many factors that determine the best approach, not least the overall organisation of the railway (ie, a vertically integrated or a “shared system” approach), and it is recommended that an assessment be conducted to weigh up the benefits and disadvantages of each option. Factors that should be considered are:

- Accountability
  - Who is ultimately responsible for the safety and availability of the rolling stock and the train-borne train control systems?
- Logistics
  - Are any elements of the maintenance to be contracted out?
  - What are the operational availability and performance requirements, and to what extent do these dictate factors such as depot locations, response times etc?
- Design Authority
  - Is the Design Authority for the train control trackside sub-system the same as the Design Authority for the trainborne sub-system?
  - How often will the maintainer need to revert to the Design Authority for expertise?

- How will interactions with the Design Authority (or Design Authorities) be managed?
- Competence Management System
  - Which part of the organisation is best placed to manage the competence of train control system maintenance personnel?
  - Where does the real system expertise lie?
- Interfaces
  - Which train-borne train control system interfaces are the least reliable, and therefore needing the greatest maintenance effort/expertise?
  - How dependable are the interfaces between the trackside and train-borne elements, and how will maintainers of the trackside and train-borne sub-systems collaborate to identify and rectify the causes of interface faults?
- Failures
  - How will failures get reported and allocated for rectification?
  - What arrangements exist for recording faults and the corrective actions taken, so as to build knowledge about system performance and thereby enhance competence?

### Key Guidance Point 9

It is recommended that an assessment is conducted of the benefits versus the disadvantages of possible options for the maintenance organisation(s), to establish the optimum arrangements.

Two examples of maintenance organisations are shown in Figures F and G. Both are applicable to a vertically integrated railway (ie where there is a single operator responsible for both the infrastructure and the rolling stock). In the first, responsibility for the train-borne train control system rests with the part of the organisation responsible for the rolling stock; in the second responsibility rests with the part of the organisation responsible for the trackside part of the train control system.

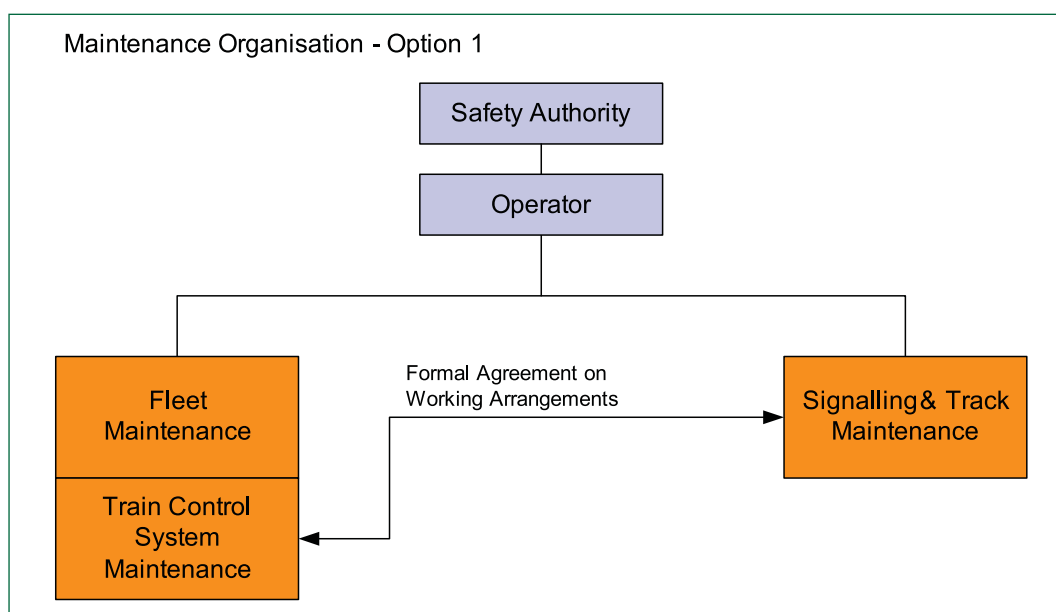
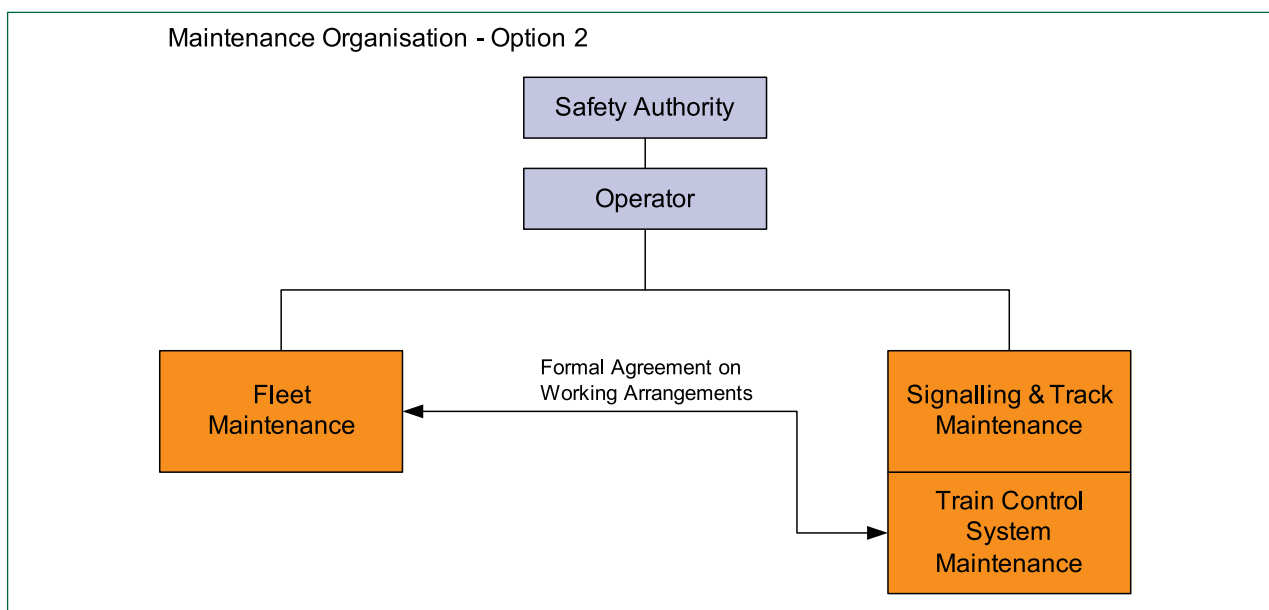


Figure F : Typical maintenance organisation in a vertically integrated railway



**Figure G : Alternative maintenance organisation in a vertically integrated railway**

Once the best organisational approach has been established and responsibilities defined, it is important that the day-to-day working arrangements for the Rolling Stock and Infrastructure maintenance teams are clearly defined and understood. The train control system straddles both areas, and consequently any failure on one side is likely to have an impact on the other, and in some cases it may not be straightforward to diagnose whether the failure is infrastructure or rolling stock based, or indeed whether the fault is a manifestation of an underlying system weakness (eg. where train-borne ATO failures are attributed to the trackside Platform ATO Communicator equipment).

In many cases the design of the maintenance organisation will be a modification of existing Rolling Stock and Infrastructure organisations, and therefore current roles and responsibilities will need to be modified or augmented, and new roles/jobs may need to be created. As a guide, it is worth considering the need for, and responsibilities of, the following roles (the list is not intended to be exhaustive or cover all circumstances):

- Managerial/Supervisory roles
  - Depot Manager
  - Signalling Operations Manager
  - Train Control System Manager
- Technician roles
  - Rolling Stock Technician
  - Signalling Technician
  - Train Control System Technician
- Maintenance roles
  - Rolling Stock Maintainer
  - Signalling Maintainer
  - Train Control System Maintainer

### **Key Guidance Point 10**

When introducing a train-borne train control system, consider the existing organisational structure (if it exists) to ascertain which roles will need to be enhanced to include additional responsibilities, and whether new roles need to be created.

## **5.3 Collective Competence**

The links between organisational structure and the collective competence of the organisation deserve attention in this guidance document.

Over the past decades many countries have experienced a significant change in the railway industry, mainly due to the impact of globalisation, out-sourcing and legislation affecting the operation and interoperability of railways (particularly in Europe). While this has led to improvements, it has made the task of maintaining collective competence more challenging, particularly where operational responsibilities and system boundaries do not align well with boundaries imposed by legislation or by the high level organisational structure.

At its best, an organisation's collective competence is significantly greater than the competence of the individuals in that organisation, but it can easily be undermined by a weak link. This weak link could be a member of that organisation, the arrangements for supporting functions, the supervisory / management team, the processes and procedures by which the organisation operates, or a poor organisational culture.

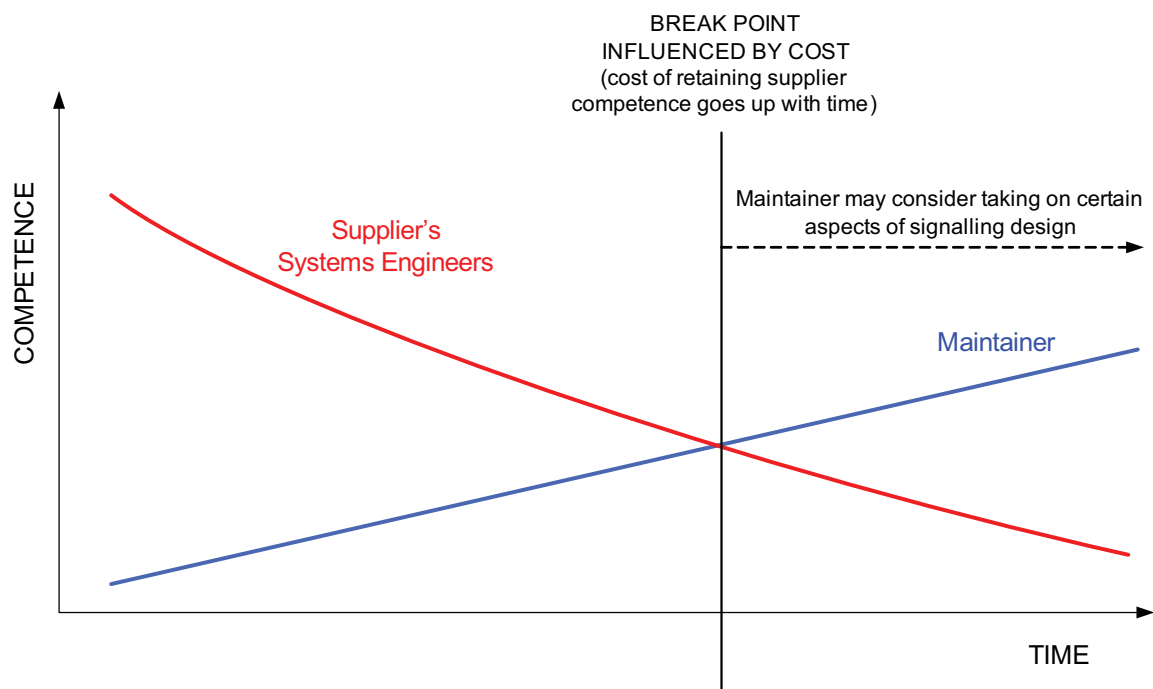
A sound approach to competence management, including mentoring, on-going assessments, and regular training will help to minimise the risk of poor collective competence, although it does not address all the issues. Collective competence is undermined by an approach to competence that, whilst acknowledging the need for individual skills, qualifications and experience, fails to embed that fully within the organisation. It is therefore important for an organisation to nurture a culture and develop processes that complement and make best use of the competence of its people.

## **5.4 Competence Obsolescence**

Competence is not static, but depends, upon other things, upon continuing to exercise the skills and knowledge relevant to the system in its current configuration.

The graph illustrated below shows the effect that "Competence Obsolescence" can have on the supplier's and maintainer's organisation, and the fact that the maintainer's organisation will ultimately become the competent body with regard to particular applications.

GRAPH OF ORGANISATIONAL COMPETENCE VERSUS TIME



### Competence growth and obsolescence

An example of Competence Obsolescence occurred on a project where a fault was occurring on some trains at a specific station. Eventually it was discovered that when the trains were travelling around a low radius corner at high speed the couplers were separating for a short period, leading to an unexpected reaction. The work to resolve the problem required a number of design and test activities. However the original project team had been disbanded as the main project had been completed some years earlier, and consequently the designer's knowledge of the system proved to be insufficient. As a result the new software, which was loaded onto the fleet to resolve the issue, had the unfortunate side effect of creating several new faults.

In a second example, a hazard associated with modifications to validated software arose when a change to the brake control software on the trains caused two slow speed collisions with the buffer stops. The subsequent enquiry found that the modifications (intended to reduce the occurrence of wheel flats) had unwittingly introduced some anomalies in the validated software that delayed the application of friction brakes under certain scenarios. The regression testing undertaken for the modifications had not been sufficiently thorough to find these anomalies and they were only revealed in operational service.

## 6 Identifying Activities and Assessing Risks (ORR Principle 1)

This section of the guidance outlines how to identify the activities that people undertake during the system life-cycle, together with the risks that those activities will present when the system is in service. This facilitates the subsequent development of appropriate competence standards to address those risks.

Issues related to the occupational health and safety of those undertaking the activities are not considered here.

### 6.1 Identification of Activities and Tasks

The generic system life-cycle phases to be considered are listed in Figure H, along with details of the types of personnel and disciplines likely to be needed. Note that the fundamental system design and train driver operation are excluded from the table, as these are largely outwith the scope of this guidance.

#### **Key Guidance Point 11**

As a starting point for the identification of competence-related risks associated with the system, develop a list of all the key organisational roles and activities/tasks relevant to the various stages of the system life-cycle.

Task identification and allocation should be based initially on the system supplier's documentation, provided that it is sufficiently detailed for the purpose. Depending on the system life-cycle this information could be drawn from the following types of documents:

- Data preparation manuals
- Factory Test Specifications
- Static and Dynamic Test Specifications
- Maintenance Manuals
- Diagnostic Equipment User Guides

Clearly, the task definitions will be refined as knowledge about the system is acquired, including in-service knowledge, such as information from those performing the tasks, information arising from modifications to the system, and information relating to the need to address any safety or reliability issues that may have arisen. It is important that the task list, and indeed the risk assessments (see below) are reviewed at regular intervals to incorporate changes that reflect experience.

	Lifecycle Phase	Personnel involved	Levels	Disciplines
1	Application Design	Designers	Preparer, Checker, Approver	Data, Wiring
2a	Fitment / Installation (first of class)	Installers		
2b	Fitment / Installation (fleet)			
3a	Factory Test	Testers	Basic, Functional, Principles	Electronic Systems, Data, Wiring
3b	Test (first of class)			
3c	Test (fleet)			
4a	Planned Maintenance	Maintainers, Technicians, Factory Testers		
4b	Fault finding and Rectification			
5	Modification and upgrade	Designers, Installers, Testers		
6	Decommission	Designers, Maintainers, Technicians		

**Figure H : System Life-cycle Phases and Classification of Personnel**

## 6.2 Identifying and Assessing Risks

Having listed the tasks associated with the system through the life-cycle, the next step is to identify and assess the safety risks associated with the system, and in particular those associated with the tasks, ie, where there is a dependence upon competence as the control measure for the hazard. By so doing, an assessment can be made of the level of competence required, and whether additional or alternative measures are required, such as procedures or even re-design of part of the system.

The risk assessment should address both normal and abnormal operating circumstances for the system. This is relevant throughout the life-cycle, but particularly so for personnel engaged in the maintenance and fault-finding phases, where they may encounter the system operating in a degraded, failed or emergency operational state.



### Key Guidance Point 12

Identify the safety hazards and risks associated with the use of the system in all its modes of operation, and the control measures for them. Understand in particular those hazards where there is reliance on competence as the control measure, and assess whether or not reliance on competence (of an appropriate level) will be adequate, or whether additional/alternative measures are required.

The standard approach to risk management is well known and documented in sources such as the Yellow Book (see Section 3 of this guidance) and does not need to be repeated here. However, in the context of train-borne train control systems, the following examples may help to illustrate the challenges associated with dependence upon competence.

In terms of **Application Design** one of the hazards relates to missing, out of date, or incorrect source documentation. Accurate information can be difficult to locate, for example with old rolling stock the important design parameters may not be available (such as brake rates, with no clear understanding of brake fade). Problems can also occur when older drawings use obsolete symbols and abbreviations, so it is essential that the designers have the knowledge to interpret the drawings correctly.

During **Factory Testing** hazards can be missed if the testers do not have knowledge of the overall system in its operational context, and instead consider only the sub-system behaviour. On one specific project a problem occurred when interference affected the accelerometer output but the system design led to the tachometer outputs (which were correct) being ignored and the incorrect accelerometer information being used instead, which in turn led to errors in calculating the true train position.

The variety of configurations of both infrastructure and rolling stock encountered during **Site Testing** can present many problems for testers. On some projects new rolling stock is introduced into a green-field site, but on most projects the rolling stock is either being upgraded at the same time as the signalling, or new rolling stock is being introduced in parallel with the old stock being removed. In addition, the signalling system is often introduced over a number of phases and therefore the rolling stock has to perform correctly with two or more different signalling systems. It is also not unusual to have several train configurations running simultaneously, especially if problems are found during the fitment programme and are progressively being rectified on each train. This can lead not only to a risk of loss of configuration control but also to more numerous, more complex and more unusual hazards that are not associated with the final configuration. An example of a real hazard that materialised on one project was associated with the Passenger Emergency Alarm. This alarm was required to operate in two different modes, interim and final. The hazard arose when the train interface wiring was modified correctly for the final configuration but the system was still at the interim configuration.

A particular area to focus upon is '**First of Class' Testing** where systems will be unproven and sometimes safety systems will be deliberately not fully operational in order to test other aspects of functionality. It is essential that the testers have a solid understanding of how the system functionality has been temporarily modified for the purposes of testing, coupled with a sound regime for managing the configuration of the system and for ensuring it is eventually restored to its correct and full functionality.

Hazards can occur during **Fault Finding** if maintenance personnel do not have the ability to interpret diagnostic information, or do not have the ability to identify and run the tests required to prove correct operation after a fault has been rectified.

During **Planned Maintenance** it is important that staff can understand and interpret configuration information and have the appropriate discipline and attitude for checking the configuration. For example on one project a Train Operator Display failed and as a result the maintainer took one from a spare train that was undergoing heavy maintenance. Although the display was the correct type it was fitted with different software. Fortunately in this case there were only differences in the diagnostics software, but more significant issues could have arisen had the circumstances been slightly different.

Hazards also occur during **Modification and Upgrade** of the design. As a system becomes older components can become difficult to obtain and may require a modern replacement. This can also lead to hazards as the performance of the new components may not exactly match those replaced. Those involved in the change may not appreciate the significance of apparently minor variations between components, particularly if the original system design information is not available or is not sufficiently comprehensive.

### **6.3 Competence in assessing risks associated with train-borne systems**

It should be evident from the examples given above that risk assessment is central to developing the competence management arrangements for personnel engaged on train-borne train control systems.

A simple table, such as the example in Figure J is an effective way to perform the analysis. The risk assessment need not be complicated; additional columns for severity and probability could be added, and a simple "high", "medium" and "low" categorisation is often sufficient.

What is most important is choosing the right combination of people to perform the risk assessment. Without people with the appropriate knowledge and experience, hazards are likely to be overlooked or incorrectly assessed.

#### **Key Guidance Point 13**

When identifying and assessing the system risks, ensure that the right mix of people participate in the risk assessment, including those from design, testing, maintenance and operations.

<b>Lifecycle Phase:</b>		Planned Maintenance		
<b>Classification of personnel:</b>		Maintainer		
<b>Level / Discipline:</b>		Not Applicable		
<b>Safety Critical / Related:</b>		SC & SR		
<b>Risk Assessment Conducted by:</b>				
<b>Risk Assessment Approved by:</b>				
#	Task	Hazards arising	Overall Risk Assessment	Extent risk influenced by competence
1	Train Prep.	Allow train into service with potential safety / reliability defect.	High – train preparation is defined as a safety critical activity (ROGS). It confirms vital functions such as Emergency Brake and Door Enable. It is conducted on all operational trains at a frequency of at least every 24 hours.	High – train preparation relies on the person conducting the task to a consistently high quality. It also relies on the integrity of the person in reporting anomalies and if necessary not allowing train back into service.
2	Inspect and clean	Reliability issues plus some safety concern regarding security of equipment,	Medium – worst case an ATC component (e.g. beacon reader) could fall onto track and cause derailment. Reliability issues will occur if task is not performed well.	High – this does rely a lot on the maintainer's attitude and commitment.
3	Remove and replace ATP and ATO modules	Reliability issues caused by failure to replace module correctly and/or failure to reconfigure/test	Medium – these issues will be "caught" at Train Prep. But at worst this could cause a train to be stood down which has a big impact on availability.	Medium – the equipment is very modular and configuration is straightforward.
4	Interpret LED Statuses	Costs resulting from mis-diagnosis.	Low – the risk is that a module could be removed unnecessarily.	Medium
5	Use of diagnostic equipment	Unreliability and costs resulting from mis-diagnosis.	Medium – mis-diagnosis could result in undetected faults causing failure in service.	High – the maintainer is required to interpret Built In Test logs, and TMS logs to make correct diagnosis.
6	Wheel Diameter Calibrate	Availability issues if train has to be stood down at reception tracks.	Medium – although the severity is high, the wheel diameter is only updated following a wheel change.	Medium – relatively simple programming task, the main issue is remembering to do it.

**Figure J : Sample Risk Assessment**

## 7 Selecting Competence Standards (ORR Principle 2)

### 7.1 Overview

The ORR guidance referred to earlier recommends that procedures are developed to address all the key phases of the competence management system, but the main focus is on developing the competence standards (or “Competence Criteria”) against which each individual is assessed.

Ultimately the aim of selecting and developing competence standards is to control the identified risks (as identified in the previous section).

Broadly speaking, the recommended approach is to split the competence standards into two categories, “Generic” and “Asset Specific”. Generic standards address broad types of systems (such as train-borne train control systems), with one or more standard for each phase of the system life-cycle. “Asset Specific” standards provide additional detail for a specific manufacturer’s system, again one or more for each phase of the system life-cycle. This approach has the advantage of promoting a common approach to standard-setting, provides greater employment flexibility for personnel in the industry, and reduces complexity (and therefore cost), whilst recognising the fact that systems can be very different from each other.

#### Key Guidance Point 14

Develop competence standards for train control systems (covering the whole system life-cycle) in two categories, “Generic” and “Asset Specific”. Aim to re-use standards that are already available, rather than duplicating standards. Where variations are necessary to take account of differences between systems, incorporate the differences into the Asset Specific competence standard rather than the Generic standard.

### 7.2 Generic Competence Standards

The first step is to identify and establish the adequacy of existing generic competence standards. Here the aim is to select standards that are nationally (or internationally) recognised. The principal generic standards that are likely to be relevant in this context are as follows:

- a) **“GoSkills”** is the Sector Skills Council for passenger transport. It is the custodian of National Occupational Standards for signal engineering maintenance, fault-finding and installation, originally developed by the IRSE and other experts from the rail industry based on what were then OSCEng standards (Occupational Standards Council for Engineering). These standards can be used to achieve an NVQ through City & Guilds. Although generic in nature, the NVQs require evidence of competent performance in a range of equipment.

- b) The **“Institution of Railway Signal Engineers”** (IRSE) has developed a suite of licences, each one having its own **“Competence Assessment Checklist”** (CAC), for the main areas of conventional infrastructure-based signalling and telecommunications work activity, including design, installation, testing and maintenance. The IRSE has worked closely with GoSkills to ensure traceability between the OSC Eng standards and the Licensing Scheme’s CACs for the main licence categories. The IRSE’s Licensing Scheme has the advantage of being more closely aligned to specific job roles. The licensing scheme is currently scoped for infrastructure systems, albeit some organisations have used the Scheme for personnel working on train-borne train control systems.

### **7.3 Asset Specific Competence Standards**

It should be clear from previous sections of this guidance that at one level, train-borne train control systems are broadly similar to each other, having similar architectures and interfaces and similar basic functionality. However it is also true that there is considerable diversity between systems in terms of technology, architecture, hardware and software.

The broad similarities mean that a person deemed competent in one type of train control system ought to be able to transfer this competence to another system with relative ease, as opposed to a new entrant who has to start from first principles.

By ensuring that the generic competence standard is sufficiently widely scoped, a person can be assessed as generically competent to work on a system in a particular role in the life-cycle (eg **“application design”**), with supplementary system-specific competence requirements addressed in Asset-Specific training plans and competence standards. As the name suggests, these Asset-Specific training plans and competence standards do not duplicate material in the Generic Standards, but instead address the particular design, installation, testing, maintenance and fault-finding requirements for the system under consideration.

#### **Key Guidance point 15**

As a cost-effective solution to asset-specific competence, develop classroom and practical training plans for the specific system type under consideration, with asset-specific competence assessments to ensure that candidates have met the required standard. Use refresher training and assessment for on-going maintenance of competence.

This approach is currently employed very effectively on London Underground’s Central Line, where asset specific **“Coaching Plans”** have been developed for maintenance activities, and are used in conjunction with generic competence assessment standards (in this case, IRSE licences). This approach can be applied equally well to design and testing activities.

A simplified version of a Coaching Plan, as used by London Underground, is shown in Figure K.

#	Day	Asset Specific Module	Class Room	Practical	Assessment
1	1	Signalling System Overview			
2	1	Train Operation & familiarisation			
3	2	Architecure & Interfaces			
4	2	Train Wiring Schematics			
5	3	Automatic Train Protection (ATP)			
6	4	Automatic Train Operation (ATO)			
7	5	Radio Sub-System			
8	5	Odometry Sub-system			
9	6	Diagnostic tools and facilities			
10	6	Fault Finding			
11	7	Permit to Work Process			
12	7	Train Preparation			

Figure K : Examples of Asset Specific Competence expressed in a "Coaching Plan"

#### 7.4 The role of the competence assessor

Various arrangements exist for the assessment of competence. Some are one-stage processes, others are two stage (typically using a "workplace" assessment, followed by a "competence" assessment). They vary also in the extent to which the assessors are expected to be organisationally independent of the candidate being assessed. But they all share a common dependence upon the skill of the competence assessor in performing the assessment.

Thus it is important to recognise that the competence of the assessor is at least as important as the competence of those being assessed. The Competence Management System should include arrangements to provide assurances about the competence of the assessors.

## Closing Remarks

This Guidance has been produced following approaches from parts of the rail industry to help organisations make pragmatic risk-based decisions about how to manage the competence of persons working on train-borne train control systems at all phases of the life cycle.

Information obtained from London Underground's Central Line, an organisation that has several years' experience of operating under full ATC, has been invaluable. In addition information gleaned from London Underground's Victoria Line and Jubilee Line upgrade projects has provided a powerful insight into the practicalities of implementing competence standards for emerging train control systems.

With such practical source material available to the authors, it is hoped that this Guidance offers real and practical examples of how to tackle competence issues relating to train control systems, and the difficulties that may arise if competence is not addressed adequately.

This Guidance has deliberately not attempted to explain how to design, implement, maintain, develop and review a Competence Management System, simply because very good industry guidance already exists, as exemplified by the material referred to in Section 3.

The most effective way in which to minimise cost in tackling competence for train-borne train control systems is to avoid "re-inventing the wheel" by building upon the information and competence management processes that already exist. Most organisations will already have material such as hazard logs, system descriptions, maintenance manuals, task lists, job descriptions etc, available to them, many of which have been mentioned in the Guidance and all of which provide core information to build upon. In the wider industry there are many sources of information that are readily available in the public domain and the professional institutions such as the IET, IMechE, IRO, INCOSE and IRSE can provide contacts and networks by which the knowledge and expertise of others can be accessed.

Finally, the IRSE is always willing to work with industry colleagues to assist with information, advice and the development of competence standards to fulfil its objective to promote high standards of practice and professional care amongst those working within the industry, and to promote improved safety standards for the protection of the general public.



### *Working group membership*

The IRSE appointed Thomas Godfrey, a member of the IRSE Licensing Committee, to lead the production of the guidance document. The working group comprised the following representatives credited with a broad and varied experience of train-borne signalling systems:

- Thomas Godfrey, Bombardier (Victoria Line Upgrade Project) – Chairman
- Graham Neil, London Underground (Head of Rolling Stock)
- Gab Parris, London Underground (Signalling Maintenance and Assurance Engineer)
- Dennis Kemp, Metronet (Asset Engineer)
- Glenn McCormick, Metronet (Central Line ATC Maintenance)
- Jeff Westrop, Tube Lines (Jubilee & Northern Line Upgrade Project)
- Peter Sheppard, Lloyds Register (Principle Safety Engineer)
- Nigel Murphy, Atkins (IRO representative)

Others participated by correspondence:

- Bruce Elliott, Chair of Rail Interest Group, INCOSE
- Hong Kong Mass Transit Railway (MTR)

The Working Group met on four occasions between November 2008 and March 2009, and conducted two visits to the London Underground's Central Line and Victoria Line maintenance depots to gain further practical insight into the subject matter.





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