IRSE

Institution of Railway Signal Engineers

INSTITUTION OF RAILWAY SIGNAL ENGINEERS

BODY OF KNOWLEDGE ISSUE 1.0

For Railway Signalling and Telecommunications Engineers

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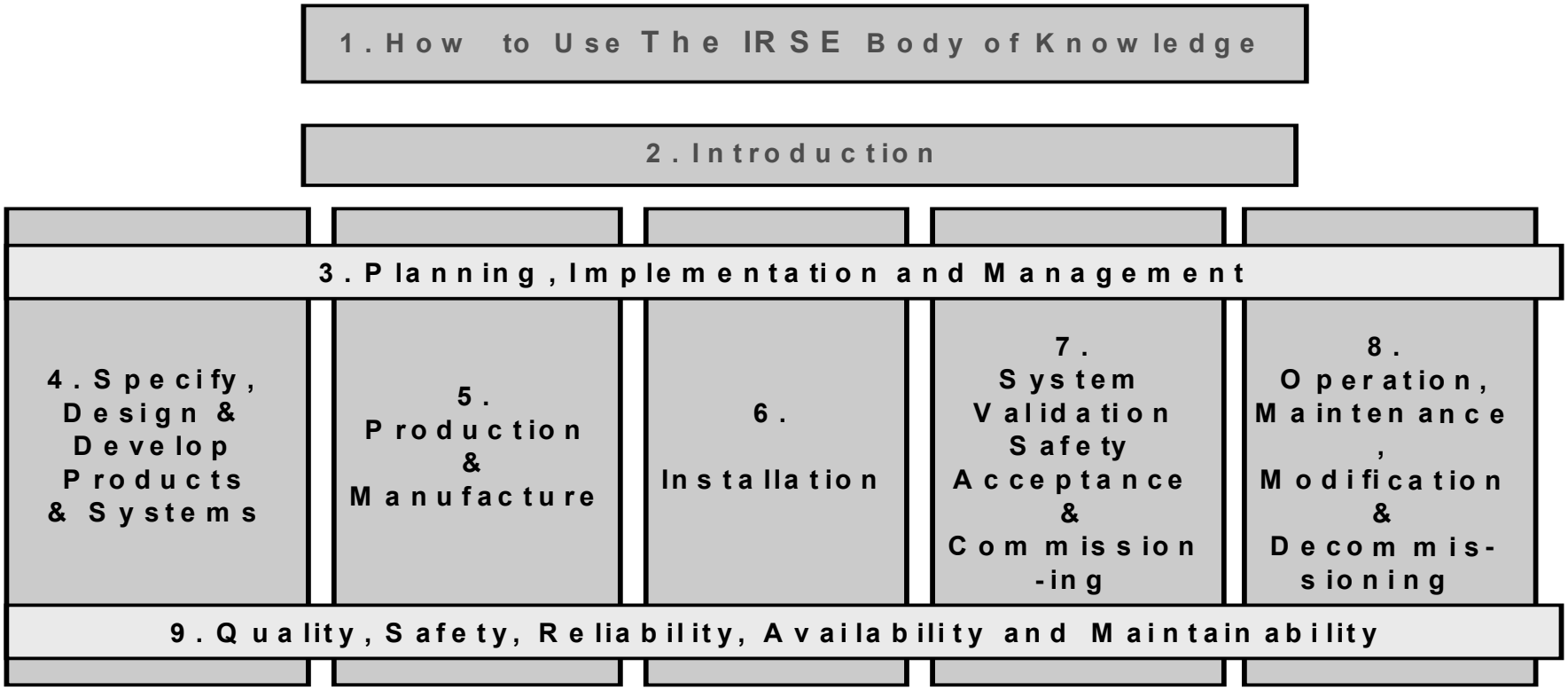
Organisation of Information



It can be seen from the above diagram that Section 3 (Planning, Implementation and Management) is very relevant to all other activities. Rather than repeat similar information in every section it has been decided to emphasise the importance of these disciplines in Section 3, although they apply to all sections of this document. Section 9 (Quality, Safety Reliability, Availability and Maintainability) has been treated in a similar fashion and it is therefore necessary to emphasise the need for these disciplines to be resolutely applied to other tasks in other Sections. The user is strongly advised to read the entire document rather than expecting one Section to provide the total information on a particular subject.

Preface

This Body of Knowledge has been produced as part of the IRSE's commitment to promote for the public benefit, the advancement of the science and practice of railway signalling and telecommunications and to maintain high standards of practice and professional care amongst those working within the industry. The term 'signalling' as used throughout this Body of Knowledge therefore includes signalling and railway / operational telecommunications in the context of train control, but has been shortened to 'signalling' to avoid repetition.

Commissioned by the Strategic Rail Authority in the UK, this Body of Knowledge has been provided to act as a reference for those seeking to gain and maintain competence in the profession within the UK context. It is derived from, and combines the earlier work of the IRSE Examination, Licensing, and Training & Development Committees and draws on the experience of the Institution's international membership as appropriate (there are distinct differences between UK practices and those adopted in Europe, USA and elsewhere world-wide).

This is a handbook rather than a textbook, and has been designed to be used by individuals and organisations alike, from initial entry into the profession, right the way through to the most seasoned of practitioners seeking to update and continue their professional development in an increasingly competitive, technology advancing and safety sensitive market place.

It may be used by those providing initial training and education to new entrants to the profession or, as a self-help tool for those wishing to maintain and improve their own professional competence as part of their continuing professional development. It may also be used to refresh or update members who are returning to the industry, or to a particular topic, after a break.

In addition, the IRSE's recent 'Signalling Philosophy Review' forms the most comprehensive and up to date reference document, and is most essential reading for the professional development of the Railway Signalling Engineer.

As methodologies, technologies and their uses change, there will undoubtedly be a need to revisit this work and update it in line with later thinking and best practice. Current developments such as ERTMS (European Rail Traffic Management System) and ETCS (European Train Control System) will inevitably lead to convergence of different practices and approaches to international projects. This work can not therefore be a definitive text, and the IRSE does not accept liability for its use. The reader is advised to seek further guidance if in doubt.

In the meantime, this work represents the most comprehensive tool in the profession for the initial training, and continuing development, of competent professional signalling engineers.

Acknowledgements

IRSE policy is to avoid listing the participants, because this Body of Knowledge is the formal considered view of the Institution as a body. Nonetheless, the IRSE wishes to acknowledge the assistance in the preparation of this Body of Knowledge document that has been provided by the Strategic Railway Authority, Members of the Institution and railway industry companies and staff.

1 How to Use the IRSE Body of Knowledge for Professional Development

The IRSE recognises Professional Development as an integral part of its mission. In keeping with this, the IRSE Council has issued a Continuing Professional Development Policy, which states that all members, regardless of level of Engineering Council Registration, are expected to honour their professional obligation to take all reasonable steps to maintain and develop their professional competence.

This Body of Knowledge has therefore been produced to highlight the topics that the professional signalling engineer needs to be familiar with, to act as a guide to relevant competence standards, and source useful reference materials.

It is suggested that this Body of Knowledge be read, as a whole in the first instance, remembering that Railway Signalling is a specialist area of Railway Systems engineering. It is therefore important to consider the interfaces between topics, and consider the overlapping and adjoining areas, rather than try to deal with each topic in isolation. Many of the topics are closely linked or interdependent, but have been grouped into the stages of the engineering lifecycle for clarity.

1.1 Domain Specific Knowledge

The subject matter has been broken down into chapters covering the general engineering lifecycle stages. Each chapter starts with a general description of the lifecycle stage and the key topic areas. It is then followed up with bullet points of the knowledge that is specific to the signalling domain. The professional signalling engineer should aim to have at least a cursory knowledge of the domain specific knowledge within each of the chapters. A more detailed knowledge can then be more easily be acquired and / or updated as appropriate.

It is this domain specific knowledge that will be of greatest interest to those cross training from other engineering disciplines.

1.2 Indicative References

In addition to the references listed in each of the chapters, the IRSE Text books 'Introduction to Railway Signalling', 'Railway Signalling', and 'Railway Control Systems' are recommended. The IRSE's annual programme of Lectures, Conferences and Seminars will act as interim updates, by providing additional reference material, addressing topics that are most relevant at the time.

A complete catalogue of IRSE Technical Papers (at the time of issue), has been included in Appendix J. The latest listing can be found on the IRSE website www.irse.org.

1.3 Relevant International Standards

There has been a great deal of debate about the use of the various standards, which have been referenced in this Body of Knowledge. Many existing products and systems were constructed and implemented using former British Railways Board specifications or LUL specifications, or other appropriate railway administration documentation. The references to, for example, Railtrack Group and Company Standards and subsequent

Railway Group Standards have not been included as they are client and application specific, nevertheless the readers must make themselves aware of all relevant standards in specific area of activity.

Many administration specific documents and standards direct the user to generic norms such as BS IEC 61508, or railway specific standards such as BS EN 50121, BS EN 50126, BS EN 50128 and pr EN 50129 (where pr = provisional), the latter being legally binding in the UK. Those who prefer the IEC standard do so because it gives better and clearer guidance on some issues, whilst the BS EN standards are tailored to the specific needs of the railway, but they have limitations as follows:

- BS EN 50121 (Railway applications – Electromagnetic Compatibility) states that it does not cover safety issues, thus compliance is based on testing when fully operational and not under subsequent failure modes, also the frequencies employed in testing are higher than those used for signalling safety. The benefit of using this specification is to manage EMC (electromagnetic compatibility) with respect to all system stakeholders on, or near the railway.

- BS EN 50126 (Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)) covers system life-cycle but omits installation and testing of new systems adjacent to an existing working railway where the Safety Case for the Stage Works needs to show that the existing systems need to be kept safe. The specification does not cover issues such as the integration of equipment alongside existing equipment. Consideration must be given to methods of ensuring the overall system performance is not detrimentally affected.

- BS EN 50128 (Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems) is written to ensure good and traceable practice is used in developing software. The claims it makes for the integrity of software, developed using these processes, derives from the evidence collected during the process of creating and accepting that software, but it is almost impossible to support claims for the higher safety integrity levels for the software that is already written. The processes in 50128 depend on proving that the software fulfils its specification, and are based on that specification requiring only serial processing. Those who wish to provide safety assurance of signalling by only following the principles of 50128 must not specify any parallel processing requirements.

- pr EN 50129 (Railway applications - Safety related electronic systems for signalling) assumes that a whole safety case can be compiled from first principles. This is very useful for a new metro or other isolated line. Consideration must also be given to implementing systems which make use of existing infrastructure, such as grandfather rights and cross-acceptance.

Because of these limitations, compliance with these standards is necessary, but in itself not sufficient, to ensure reliability, availability, maintainability and the safety of the railway system. For further guidance on the use and applicability of BS EN 50126, BS EN 50128, pr EN 50129 and IEC 61508, please refer to appendices F - I.

1.4 Competence Standards

It is important to remember that reading of the reference material in itself does not necessarily increase competence.

Competence is defined as the ability to perform activities to the standards expected in employment, and is the **combination of practical and thinking skills, experience and knowledge** (*Source – HSE - Railway Safety Principles and Guidance Part 3 section A*).

Relevant competence standards have therefore been referenced to include information about the practical and thinking skills required to apply underpinning knowledge, and to provide guidance on the necessary experience that needs to be gained for competent performance.

The most relevant competence standards for those involved in applications engineering, are the IRSE Licensing Scheme standards. These are specific to the profession, and have been cross-referenced to the UK National Occupational Standards, (in particular, the Occupational Standing Council for Engineering (OSCEng) Standards) to help ease the transition and recognition of skills when cross-training from other industries and engineering disciplines.

Relevant OSCEng standards have also been included in their own right as they form the engineering 'root standard' for railway specific National Vocational Qualifications. (NVQs), are currently being written / updated for this domain, and combine the domain knowledge of the IRSE Licensing Scheme, with the generic 'key skills' required by the NVQ.

The Engineering Council (EC UK) Standards and Routes to Registration (SARTOR) competencies have also been referenced, as these are the root standards used by the IRSE for registration purposes. IRSE evidence guides for these standards are available from the IRSE Membership Manager.

Other competence standards that have been referenced are the Institution of Electrical Engineers / British Computer Society's Competency guidelines for Safety Related System practitioners. These competence standards relate directly to BS IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems. They are very appropriate to those involved in the development of products, systems and applications, and are particularly relevant to those working on the European Rail Traffic Management System (ERTMS) and Safety Integrity Levels (SIL).

1.5 Prioritising and Recording

Regardless of whether this Body of Knowledge is used for initial, or continuing professional development purposes, it is suggested that learning and development be recorded in a systematic way. This may be done as part of an annual performance appraisal within the employment or training context, or on a personal, self-directed basis.

The IRSE Professional Development Record & Licensing Scheme Log Book is specifically designed for this purpose and includes a section to help with the production of a development action plan and the recording of learning experiences. Copies are available from the IRSE Licensing Registrar at the IRSE Head Office.

Once the Body of Knowledge has been read as a whole, it is suggested that it be read again for the specific purposes of identifying areas for development. These opportunities can then be prioritised, and goals and dates for achievement should be set.

It is then possible to plan, record and carry out development actions using the most appropriate learning methods and opportunities.

Methods may include:

- Reading the recommended Indicative References
- Attending training courses, lectures, seminars or conferences
- Open, flexible or distance learning materials including printed matter, audio tapes, video tapes, interactive video, interactive CD or via the internet
- Reading professional and specialist magazines and journals
- Discussion with colleagues, a mentor, a supervisor, or contacts in discussion groups or professional networks

What ever method is chosen it is important to plan opportunities to gain experience and develop skills in applying newly acquired knowledge by undertaking new tasks or projects. If such opportunities are not readily available in the workplace, then it may be appropriate to consider using extra curricular activities such as: membership of IRSE committees or working groups, or the IRSE Professional Examinations to develop a range of skills including, mentoring and lecturing skills.

The act of recording learning and development helps to develop competence and commit newly acquired knowledge to memory. The Learning Experience Record available in the CPD section of the IRSE Professional Development Record & Licensing Scheme Logbook places emphasis on what has been learned rather than what has been done. It is suggested that this is used to follow through learning by thinking about what has been learnt and how this may be applied in the future. Any follow-up actions should also be noted. The process of thinking through what has been learned and keeping a record will in itself greatly enhance learning.

Developing and maintaining competence is part of an on-going process. It is necessary to review progress regularly and keep up to date with latest developments in light of changing needs, technologies and working methods. This may also be done as part of an annual appraisal system, or on a personal, self-directed basis.

Information and recording mechanisms to help carry out the review process have been included in the IRSE Professional Development Record & Licensing Scheme Log Book.

1.6 Relevant OSCEng Standards

1.6.1 Engineering Competence Standards

8.01 Develop yourself in the work role

1.6.2 Higher Level Standards

8.1.1.1 Maintain and Develop own engineering expertise

8.1.1.2 Apply professional ethics and values

1.7 Relevant Engineering Council (EC (UK)) Standards

1.7.1 EngTech (Engineering Technician)

A1.1 Identifies limits of personal knowledge, understanding and skills and strives to maintain currency in new applications
A1.2 Extends limits of personal knowledge, understanding and skills to reflect best practice in relevant field of work
E4.1 Undertakes professional development to enhance technical and supervisory competence
E4.2 Sets goals to achieve personal and organisational objectives
E4.3 Prepares and maintains a personal development action plan
E4.4 Maintains records of professional development activities

1.7.2 IEng (Incorporated Engineer)

A1.1 Identifies limits of personal knowledge, understanding and skills, and strives to maintain currency in new applications by accessing and exploiting relevant sources
A1.2 Broadens knowledge base through the internet, the media, journals, attendance at professional seminars and networking
A1.3 Deepens knowledge base systematically, by focussing on the understanding of new applications and techniques
E4.1 Undertakes professional development to enhance technical and management competence
E4.2 Sets goals to achieve personal and organisational objectives
E4.3 Prepares and maintains a career action plan
E4.4 Maintains records of professional development activities

1.7.3 CEng (Chartered Engineer)

A1.1 Identifies limits of personal knowledge, understanding and skills, and continually strives to extend capabilities by accessing and exploiting all relevant personal and professional development sources
A1.2 Exercises information retrieval skills to keep abreast of current and future technological or other relevant developments
A1.3 Broadens knowledge base through the Internet, the media, professional journals, attendance at professional seminars and networking
A1.3 Deepens knowledge base systematically, through research and experimentation
E4.1 Undertakes professional development to enhance technical and management competence
E4.2 Sets goals to achieve personal and organisational objectives
E4.3 Prepares and maintains a career action plan
E4.4 Maintains records of professional development activities

2 Introduction

The Railway Signalling profession embraces one of the most diverse sets of technologies and concepts to be found. Despite utilising the latest leading edge, safety-critical, real-time software systems the traditional techniques of mechanical signalling, wires levers and pulleys remain widespread.

There is some common ground with other industry sectors, primarily those providing and operating high integrity and/or high availability systems and products especially in real-time and process control environments. Listed briefly below are generic headings of systems and theory, which the professional engineer must address.

Each of these headings may itself encompass a range of diverse equipments, designs and unique installations. Few individuals will be expert in all or most of these areas but all participants need to appreciate their fundamental purpose and characteristics particularly with respect to their interfaces and role in providing the overall system. It is this extremely challenging arena in which overall competence as well as particular expertise requires building.

The subject continues to expand. It is no longer sufficient to be only a signal engineer; train control and, indeed, many business issues regarding trade-off in capacity, performance and costs have become the responsibility of the signal engineer.

An understanding of the interfaces between the many disciplines that contribute to the overall railway system is essential for the competent signal engineer.
Preferably all the expert guidance necessary to plan a successful system should be available from the time that the scheme enters its conceptual stage. The participants could include representatives from-

- The Client
- The Operator who will plan the requirements for train movements that will lead to the anticipated track layout, the time table, the frequency of train movements and resultant headways between trains etc. Bi-directional working may be a requirement. The location of Control Centres and equipment rooms will be influenced by the Operator.
- The Civil Engineer responsible for the track bed, bridges, tunnels, cuttings, embankments, buildings, stations, platforms and other structures etc.
- The Permanent Way Engineer responsible for sleepers, rail, rail mountings, points and crossings etc.
- The Electrical and Mechanical Engineer responsible for the provision of lighting and access to power supplies for other rail systems as well as the electrification of the track by overhead catenary or rail based systems, should electric traction be used.
- The Rolling Stock Engineer responsible for the provision of locomotives, carriages and wagons.
- The Infrastructure Engineer responsible for the implementation and maintenance of the railway systems.
- The Signal Control Engineer responsible for the signalling, telecommunications, safety related public address and passenger information systems etc.
- Local Authorities for any level crossing interfaces etc.
- Planning, Risk Assessment, Health and Safety, Quality Assurance inputs.

It must be clearly understood that a decision by one participant can have a profound affect on some or all of the others. Simple examples of these include-

- The signal engineer has a choice of technologies for train detection. If track circuits are used then the type of traction system will influence the choice of train detection. Normally DC track circuits should be used in AC electrified territory and conversely AC track circuits in DC electrified areas.
- If non-insulated metal sleepers are to be used then conventional track circuits cannot be employed and axle counters, for example, could be utilised.
- Some types of equipment on board trains can interfere with signalling systems if not protected against.
- The gradient of the line and the train characteristics affect the layout of the signalling.
- Clearly equipment provided by anyone must not foul the structure gauge above or below the rail, as this could interfere with train movements and possibly cause derailments and collisions.
- The frequency of trains will influence the choice of signalling control system but could also affect the capacity of an electric traction supply.
- Catenary systems can affect signal sighting and positioning.
- The trend towards train borne signalling control will increase the need for close interfaces with train control systems.

Each project will be unique because of location and layout. In some the signal engineer will be presented with an existing layout and the major decisions already taken before being required to provide a signalling solution.

2.1 Major Types of System

- Train detection
- Point operation
- Signals – types, sighting, sequence
- Interlockings –mechanical, relay, computer and ERTMS Level 2 and 3
- Remote control systems – Frequency Division Multiplex (FDM) / Time Division Multiplex (TDM) / coding for public switched transmission
- Level crossings
- Defect detection systems – hot axle box, wheel impact, wide to gauge
- Data and incident recording
- Automatic Train Operation (ATO) / Automatic Train Protection (ATP) and driver warning / advisory systems
- On board radio signalling
- Safety critical communications - telephone / radio / data/ Global System for Mobile-communications - Railways (GSMR)
- Transmission systems - copper / fibre / microwave / satellite
- Passenger information and security systems – Public Address (PA) / clock / display boards / Closed Circuit Television (CCTV)
- Power supplies
- Cables & earthing
- Staff protection & warning systems
- Train brake and traction characteristics
- Special needs – subsurface and underground installations, Tramways

- Control centres / systems, including train describers

2.2 Theory, Principles and Concepts

- Multi-aspect signalling
- Interlocking
- Block controls – absolute & permissive working; single, double and bi-directional requirements
- Train protection and warning systems
- Radio propagation
- Transmission Theory
- Control centres automation and decision support tools
- Safety critical and related system engineering, Safety Integrity Levels (SIL)
- Safety critical and related software (SIL)
- Management of safety including configuration and change control (Quantified Risk Assessment, Safety Cases, etc)
- Asset management including life-extension/safety issues
- Verification & validation theory and practice including signalling testing and formal methods
- Life-cycle and human performance / interface issues
- Materials and environment
- Electromagnetic Compatibility (EMC) and in particular between signalling and electric traction systems
- Rules & safe working of trains /railways (including human failure)
- Scheme Design requirements, Reliability, Availability, Maintainability & Safety (RAMS) and Life Cycle Costs (LCC)
- Signalling the layout
- Incident and accident investigation and preservation of evidence

2.3 Systems Integration & Complementary Disciplines

The railway is a system. As such it is helpful for those working in any specialist area to have some knowledge of related and interfacing areas. In particular, Permanent Way engineers need to have some knowledge of both overhead and 3rd /4th rail traction power systems and operators need some knowledge of the normal and degraded protection offered by signalling systems.

The train control and signal engineer, however, needs to be the systems integrator. There must be an understanding of the effects on signalling's vital control systems of the consequences of Permanent Way and traction power design and engineering choices (both fixed and traction units). There also needs to be an understanding of the perspective of the industry's users, the drivers and signallers. Similarly an appreciation of the choices for commercial benefit of maintenance and renewal options as well as new designs is necessary. Allowing for train design characteristics such as braking performance has always been a requirement, but now there is also a need to get involved in detail in train-borne systems for measuring speed and position and in interfacing with train management systems.

This is a developing expertise and the profession is generally starting to recognise its responsibility for helping to set out frameworks to help other disciplines to collaborate towards known outcomes rather than patch and mend the results of independent developments afterwards.

2.4 Prior Knowledge and Experience

It will be apparent that a range of academic training and work experience can be helpful and appropriate for those wishing to master the art and science of train control and signal engineering. It will be increasingly rare for practitioners to be successful without at least some knowledge of electrical and/or software systems but expertise is relevant and necessary in a wide range of topics.

Academic disciplines would include:

- Mechanical engineering, Fluid & hydraulic systems
- Electrical engineering
- Electronic engineering
- Control systems engineering
- Software engineering
- Materials science
- Mathematics & logic
- Communications engineering
- Safety & Reliability Engineering

Work experience would include:

- Design and Development
- Project engineering,
- Asset management
- Maintenance, Installation, Testing, Fault finding and similar roles

Safety related industry sectors would include:

- automotive
- power transmission / nuclear
- aeronautics – aeroplane and air traffic control
- military engineering
- marine engineering
- gas & petro-chemical engineering

2.5 Complementary Knowledge

The Body of Knowledge is intended to be domain-specific and does not, therefore, deal with related and common matters in any detail. However, it is obviously essential to understand and have the necessary knowledge of Health and Safety and other legislation. On a personal basis it is also essential to understand Personal Track Safety and Personal Protective Equipment and to appreciate the risks which must be managed both for oneself and others in applying domain knowledge and working in the railway environment.

2.6 Characteristics of the Railway Signal and Telecommunications Engineer

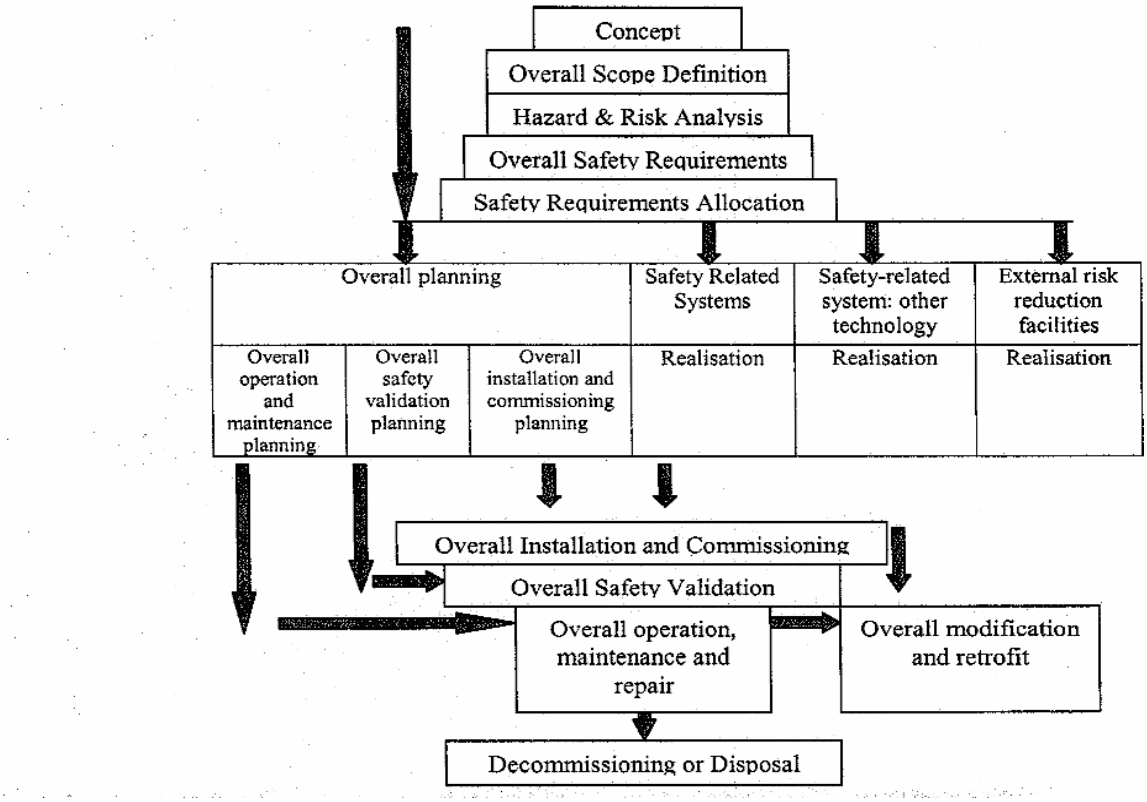
The characteristics of a successful train control and signal engineer are not rigid, however, the following characteristics are generally recognised as important: cautious & analytical, open-minded & creative, an ability to explain in lay terms, deal with commercial pressures, possessing a positive and fair attitude and a commitment to the profession. These characteristics are shared with many in the engineering community and particularly where safety related work is involved.

2.7 The Profession & Range of Roles

The purpose of Train Control and Signalling is not just signal engineering. The IRSE was founded for: "The advancement for the public benefit of the science and practice of signalling (which… shall mean the whole of the apparatus, electrical mechanical or otherwise, methods, regulations and principles whereby movement of railway or other traffic is controlled) by the promotion of research, the collection and publication of educational material and the holding of conferences, seminars…".

The profession offers a career of great intellectual and creative challenge. It can be both absorbing and fulfilling and there is always more to learn. It requires knowledge and understanding of not only engineering but also the human factors and Man Machine Interfaces. There is the usual spread of roles within the profession from design and project engineering through the whole of the project lifecycle to maintenance engineering and fault finding, but there are also a couple of roles which have special significance to the industry, i.e. 'tester' & 'scheme designer'. Testing is traditional and becoming different in nature quite quickly, whilst scheme design is unique to this industry.

It is important to recognise the different contexts of Product and Applications for railway train control engineering. On the one hand is the design and development of railway control products and systems, whilst on the other is the application of existing products or systems to a particular section of railway. The knowledge required is not separate but nevertheless people can tend to specialise in either the design and development of products and systems, or their application. (See Appendix J for further reading).



Project Lifecycle Diagram

3 Planning, Implementation and Management

Planning, implementation and Management relate to all stages of the engineering lifecycle. Engineering Managers working in the Railway Signalling field need to have an in-depth knowledge of the structure of the industry in order to take critical decisions. In particular, a knowledge and understanding of the contractual interfaces and legislative framework is essential.

Planning must commence at the earliest stage of a project. However distant these items may appear at the start of the planning process it must address those items such as the safety assurance programme, producing the safety case and the safety acceptance strategy

A key part of planning, implementation and management is the assessment of risk. Care must be taken when establishing the requirements to identify the complete range of foreseeable hazards, including business, managerial and technical risks, and provide a means of preventing or controlling such risks. It is important to consider the hazards that arise from outside the signalling system, as well as those from adjacent railway systems. Where the project does not have an applicable safety case, additional care must be taken in this area.

Where the competence of individuals is to be relied upon to control such risks, it is necessary to use a Competence Management System (CMS) that is both auditable and proportionate to the risks, which it seeks to control. The CMS must be operated at an engineering management level to ensure that individuals are not allocated work that they are not competent to perform, unless another adequate control measure can be put in place. Engineering Managers must also consider their own competence to operate the CMS effectively. Where contractors or sub-contractors are used, care must be taken to ensure that the systems employed to control risk are extended to the contracting organisation and that any additional risk that may be introduced by the contractor, is also clearly identified and controlled.

Changes to technology and working practices will all have an impact on the risks identified and it is important to reconsider the implications and hazards when such change takes place. Change management, management of information and communication are therefore key competence areas for the train control & signal engineer.

3.1 Domain Specific Knowledge

- Industry structure and organisation
- Knowledge of signalling or operational communication engineering principles, systems and working practices relevant to the industry
- Working knowledge of other railway engineering disciplines and their impact on interfaces with S&T Engineering
- Legislation relevant to S&T activities
- Risk Management techniques
- Safety, quality and environmental standards
- Procurement Policies and Practices
- Professional Codes of Conduct
- Incident and emergency procedures

- Abilities and competence of staff
- The demands of each job
- Changes in technology, materials and legislation
- Safety approval methodology for new or modified equipment, systems and practices

3.2 Indicative References

IRSE Conference Proceedings 'Keep it Safe, Keep it Legal' Dec 1999
IRSE Conference Proceedings 'Competence Assurance in the S&T Business', May 2000.
IRSE Conference Proceedings 'The Pitfalls of Commercial Contracting in the S&T Business' Jan 2000.
Patel SD, Procurement Strategy for Train Control and Signalling – The West Rail Paradigm, IRSE Aspect '99 Proceedings p191.
Bell PD, Alliance Projects, IRSE Aspect '99 Proceedings p204
Williams R and Corrie JD, Simplifying the Safety Case for New Signalling, IRSE Aspect '99 Proceedings p339.
HSE Railway Safety Principles and Guidance Part 3 Section A Developing and maintaining staff competence ISBN 0-7176-1732-7
Railway (Safety Case Regulations) 2000 including 2001 amendments Guidance on Regulations ISBN 0-7176-2127-B
Railway Safety Critical Work Regulations Approved Code of Practice & Guidance 1994, ISBN 0-7176-1260-0
Engineering Safety Management - Yellow Book Volume 1 www.yellowbook-rail.org.uk
Engineering Council - Guidelines on Risk Issues, ISBN 0-9516611-7-5
Hazards Forum-Safety-Related Systems: Guidance for Engineers ISBN 0-9525103-0-8

See Appendix J for further reading.

3.3 Relevant International Standards

BS 6079 Project Management
BS ISO 10005 Quality Management – Guidelines for Quality Plans
BS EN 12973 Value Management
BSI OHSAS 18001 Occupational Health and Safety Management Systems
BS EN ISO 14001 Environmental Management Systems
BS EN ISO Series 9000, 10000 and 11000 on Quality Assurance
BS EN 10007 Guidelines for Configuration Management
BS IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
BS EN 50126 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50128 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems
pr EN 50129 Electronic Systems Railway applications - Safety related electronic systems for signalling

*3.4 **IRSE Licensing Standards** (including Management Charter Initiative standards)*

2.2.230 Project Engineer
6.8.110 Engineering Manager
6.8.130 Senior Engineering Manager

3.5 IEE Competency Guidelines for Safety-Related System Practitioners

CMF Corporate Functional Safety Management
HRA Safety Hazard and Risk Analysis
PSM Project Safety Assurance Management
SRP Safety-Related System or Services Procurement
SRS Safety Requirements Specification

3.6 OSCEng Standards

3.6.1 Engineering Competence Standards 1.xx Series, in particular:

1.01 Establish engineering objectives
1.18 Plan engineering activities
1.26 Control allocated resources to achieve requirements

3.6.2 Higher Level Standards 7.x.x Series, in particular:

7.1.2 Plan the delivery of projects
7.2.1 Establish project management systems
7.2.2 Manage the implementation of projects

3.7 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

4 Specify, Design and Develop Products and Systems

The user is reminded of the fact that Planning, Implementation and Management are very relevant to all the other activities. Rather than repeat similar information in every section it has been decided to emphasise the importance of these disciplines in Section 3, although they apply to all sections of this document.

Specification, design and development may be separated out into two distinct categories:

a) Development of generic systems, generic products and generic applications, which could include domain specifics such as new signalling / safety philosophies, practices and operating rules etc, but could be the domain of the generic electrical/electronics engineer or software designer.

Here, the designer must know and understand how to completely specify a system or equipment so as to achieve the intended functionality and performance (including preventing unwanted behaviours). Design may be considered the creation of a known good original.

The output may be specifications, tender documents, hardware or software, or a tool to facilitate the design process etc. Hardware can range from a component through sub-assemblies to complete equipments. Software may be program or data, including rules for parameterisation or use.

It is important to develop a level of understanding at the concept stage, to a sufficient level, to enable safety lifecycle activities to be satisfactorily carried out. Such activities include the establishment of the scope and purpose, definition of the project concept, financial analysis and feasibility studies.

The design process must take place in a controlled environment and employ systematic methodologies, including formal methods as required according to the required characteristics of the product – for example high reliability or safety critical applications. It is important to select and apply consistently the appropriate standards, tools and procedures – and to document these as necessary (Verification and validation processes may rely on this evidence.).

For product design, railway domain knowledge requirements vary from low (e.g. design of a defined electrical printed circuit board) to high (defining failure protection and degraded modes of a point machine / controller). A range of the skills and knowledge will be common to other industries especially safety related process control and/or high integrity or redundant hardware.

b) The application of generic products and applications in a specific application, performed to specifications and rules that have been predefined in a) above.

System definition for specific applications encompasses the most domain specific area of railway control and signalling system design, and is referred to as Scheme Design.

Scheme Design is the generation of a fully specified design for a signalling system to serve a specific location, which, if faithfully executed, will achieve the intended performance and functionality in service use. It requires interaction with railway operating and commercial management as well as the infrastructure disciplines, especially Permanent Way, Maintenance and Electrification, to clarify and codify the existing infrastructure constraints and the agreed intentions in unambiguous language and drawings (e.g. control tables, scheme plans, bonding plans etc).

The signalling designer must have the knowledge and understanding to identify, compare and contrast options and explain the consequences to other parties in useful (possibly lay) terms. It is necessary to know and understand the relative characteristics, features and benefits of the system or equipment available, and requires domain knowledge in depth.

It is by this process that the hazards and risks for all reasonably foreseeable circumstances, including fault conditions and misuse (i.e. signals passed at danger) can be determined, and the safety requirements and integrity levels specified to achieve the required functional safety. Specific safety measures may then be allocated which may include other safety-related systems i.e. Hot Axle Box Detectors, or other external risk reduction measures. It is also the responsibility of the signalling designer to define acceptance criteria in order to establish a validation plan.

4.1 Domain Specific Knowledge

- Operating requirements – normal conditions, failures and environmental conditions
- Requirements Management
- Production, Installation, Testing and Maintenance requirements
- Human factor issues – human reliability in design, ergonomics
- Independent Safety Assessment and Safety Management Systems
- Architectures for availability, and Quality, Safety and Reliability, Availability and Maintainability
- Legal requirements and Codes of Practice
- Environmental factors – Electromagnetic Compatibility (EMC), temperature and humidity, Hazardous Materials etc
- Architectures for safety, Safe failure modes, ALARP (As Low As Reasonably Practicable)
- Track protection – integration of the system
- Specification – equipment, rules for preparing applications software
- Materials – Fire properties, ageing, mechanical strength
- Design and QA standards, and Design Principles
- Signalling and Interlocking principles
- Train Detection and Train Protection
- Scheme Application and Development
- Control tables, Track plans, Aspect/Code sequence charts, Site surveys and Bonding plans
- Safety Distances and Movements authorities, Headway design
- Visual signals
- Level Crossings
- Control Centre Techniques
- Signalling power requirements

- Secure Communications, Global Satellite Mobile-communications – Railway (GSMR), Terrestrial European Trunked Radio (TETRA)
- Passenger Information and Train Describers
- Safety acceptance and cross acceptance
- Verification, Validation, Configuration and Change management

4.2 Indicative References

General - product design and characteristics for railway signalling use:

Perkins B; Engineering quality into signal equipment; IRSE Proceedings 1993/94

Use of microprocessors:

Wobig KH; Micro processors in failsafe systems; IRSE Proceedings 1986/87

Barnard REB; Electronic interlockings: a survey of approaches to safety critical signalling systems, IEE 8th Residential Course on Railway Signalling and Control Systems April 2000.

Pilkington S, System assurance and safety assessments, IEE 8th Residential Course on Railway Signalling & Control Systems April 2000

Engineering Safety Management - Yellow Book www.yellowbook-rail.org.uk

Train detection technology:

Wood RA; Train detection by track circuit - the effect of the wheel / rail interface; IRSE Aspect 99 Proceedings, p 151

Brown CR; A review of jointless track circuits; IRSE Proceedings 1984/85

Corrie JD; Principles of train detection; IEE 8th Residential Course on Railway Signalling and Control Systems April 2000

Interference by traction systems

Mellitt B; The impact of electrification systems and traction control on signalling and communications; IEE 8th Residential Course on Railway Signalling and Control Systems April 2000 (excluding section 3 which should be treated as background material)

ERTMS / ATP

Booth PD; Development of an ERTMS moving block interlocking for Railtrack's WCML; IRSE Aspect '99 proceedings p 269

Uebel H; Mainline ATP / ATC intermittent and continuous systems; IEE 8th Residential Course on Railway Signalling and Control Systems April 2000.

Software

Application Guidance Note "Software and 50128" – Engineering Safety Management - Yellow Book 3 www.yellowbook-rail.org.uk

Railway Safety Principles and Guidance, part 1 1996 HSE Books ISBN 0-7176-0712-7

Railway Safety Principles and Guidance, part 2 HSG153/2-8 1996 HSE Books

See Appendix J for further reading.

4.3 Relevant International Standards

BS 376 – 1:1950 Railway Signalling Symbols. Schematic symbols

BS 376 – 2:1954 Railway Signalling Symbols. Wiring symbols and written symbols

BS 442: 1950 Specification for terminals for electrical apparatus for railway signalling purposes

BS 469:1995 Specification for railway signalling lamps

BS 714:1950 Specification. Cartridge fuse-links for use in railway signalling circuits

BS 3347:1961 Specification for capacitors for railway signalling track circuits

PD R008-001:1999 Railway applications. Communications, signalling & processing systems. Hazardous failure rates & safety integrity levels (SIL)

PD R009-003:1999 Guide to the specification of a guided transport system

PD R009-004:1999 Railway Specifications. Systematic allocation of safety integrity levels
BS EN 50121 series 1-5:2000 Railway applications - Electromagnetic compatibility
pr EN 50125-3 Railway applications - Environmental conditions for equipment part three-Equipment for signalling and telecommunications
BS EN 50126:1999 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50128:2001 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems
DD EN 50129 Railway applications - Safety related electronic systems for signalling
BS EN 50159 series 1–2:2001 Railway applications. Communications, signalling & process systems. Software for railway control & protection systems
BS EN 50261:1999 Railway applications - Mounting of electronic equipment.
BS IEC 61508 series 1-7 Functional safety of electrical/electronic/programmable electronic safety-related systems
BS EN 61000 series Electromagnetic compatibility (EMC)
BS IEC 60050-821:1998 International electro technical vocabulary
HB 10187 Reliability, maintainability & risk 6th edition
BS EN ISO 9001:1994 Quality systems. Model for quality assurance in design, development, production, installation and servicing
Technical Standards for Interoperability (TSI's)

4.4 Relevant IRSE Licence Categories

1.1.100 / 2.1.110	Assistant Designer
1.1.110 / 2.1.110	Designer
2.1.210	Electronic Systems Designer
1.1.130	Principles Designer
1.1.140	Design Manager
2.2.230	Project Engineer
6.8.110	Engineering Manager

4.5 Relevant IEE Competency Guidelines for Safety-Related System Practitioners

PSM	Project Safety Assurance Management
HRA	Safety Hazard and Risk Analysis
SRS	Safety Requirements Specification
SV	Safety Validation
SAD	Safety-Related System Architectural Design
SHR	Safety-Related System Hardware Realisation
SSR	Safety-Related System Software Realisation
HF	Human Factors Safety Engineering

4.6 Relevant OSCEng Standards

4.6.1 Engineering Competence Standards 1.xx Series, in particular:

1.02 Complete designs for engineering products
1.03 Read and extract information from engineering drawings and specifications

4.6.2 Higher Level Standards 1.x.x and 6.x.x Series, in particular:

6.1.1 Analyse the risks arising from engineering products or processes

6.1.2 Specify methods and procedures to reduce risks
1.1.2 Produce specifications for engineering products or processes
1.4.3 Create designs for engineering products or processes

4.7 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

5 Production and Manufacture

The Production and Manufacturing Engineer must know and understand how to ensure that a finished product conforms to the authorised specification with the required degree of confidence. The dividing line between scheme design and production can vary from organisation to organisation, production being the creation of accurate copies (even single) for service use, and specification may include one off parameterisation or configuration for an intended specific use and/or site.

Although helpful context, little domain specific knowledge is required as long as the processes involved in accurate replication and configuration are secure. The product may be hardware, firmware, or copies of software (creating software is considered a design activity). The quantity of replication is immaterial, varying from a single copy upwards. These skills and knowledge are common to other industries.

Manufacturing always requires a controlled environment and is often a team activity with QA, supervision and checks constantly available. Production and manufacturing may well take place away from the project offices and projects site. This does not lessen the need for rigorous processes to ensure that faults that could affect safety are not introduced.

5.1 Domain Specific Knowledge

Safety procedures and requirements
Equipment, component and cable identification
Interpretation of drawings and schedules
Use of hand and power tools
Methods of wire and cable termination
Equipment and component handling
Electrical installation knowledge and practices
Installation standards and codes of practice
Installation documentation procedures
Legislative requirements
Content and scope of testing
What constitutes a defect and a discrepancy
Documentation / Test procedures
Configuration Management, hardware and software
Copying and verification of specific application data

5.2 Indicative References

No specific references.

See Appendix J for further reading.

5.3 Relevant International Standards

BS 376 – 1:1950 Railway Signalling Symbols. Schematic symbols
BS 376 – 2:1954 Railway Signalling Symbols. Wiring symbols and written symbols
BS 442: 1950 Specification for terminals for electrical apparatus for railway signalling purposes
BS 469:1995 Specification for railway signalling lamps
BS 714:1950 Specification. Cartridge fuse-links for use in railway signalling circuits

BS EN 50121 series 1-5:2000 Railway applications - Electromagnetic compatibility
pr EN 50125-3 Railway applications - Environmental conditions for equipment part three-Equipment for signalling and telecommunications
BS EN 50126:1999 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50261:1999 Railway applications. Mounting of electronic equipment.

BS EN 61000 series Electromagnetic compatibility (EMC)
HB 10187 Reliability, maintainability & risk 6th edition
BS EN ISO 9001:1994 Quality systems. Model for quality assurance in design, development, production, installation and servicing

5.4 Relevant IRSE Licence Categories

6.2.115 Factory Installer
6.2.165 Factory Tester
6.8.110 Engineering Manager

5.5 Relevant IEE Competency Guidelines for Safety-Related System Practitioners

SRS Safety-Related System Procurement

5.6 Relevant OSCEng Standards

5.6.1 Engineering Competence Standards 2.xx Series, especially

2.13 Prepare work areas and materials for engineering activities
2.14 Prepare equipment for engineering activities
2.15 Reinstate the work area after engineering activities

5.6.2 Higher Level Standards Series 2.x.x and Series 6.x.x, especially:

2.1.1 Determine the production requirements of engineering products or processes
2.1.2 Specify production methods and procedures to achieve production requirements
6.1.1 Analyse the risks arising from engineering products or processes
6.1.2 Specify methods and procedures to reduce risks

5.7 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

6 Installation

The Installation engineer must have domain knowledge both for personal safety and effectiveness and also with respect to railway systems and operations, including other disciplines and interfaces. It is important that the Installation Engineer works within the limits of authority and knowledge, in particular, liaising with external parties and communicating clearly with a distributed team.

Installation is often carried out on site (including line side) with intermittent contact with others. Whilst the equipment installed is usually standard, the railway itself is far from standard, each site having its own characteristics of gradients, stations, curves crossings etc. Every installation is therefore unique, almost a prototype, and relies heavily on the skill and judgement of the installation engineer. Some installation work may be carried out in the factory environment.

In the past not a great deal of technical information on installation has been available in one place. It has tended to be mainly in individual company or product installation instructions. Installation requirements in British, European and International Standards tend to be mainly for product designers and technical authors but contain little direct information for "on the tools" installation staff.

Poor installation can lead to an overall short life of a signalling project, so it is important that installation standards and techniques are kept under constant review as new systems and equipment are constantly being developed. Worse still poor installation can adversely affect the safety of the system so it is critical that the installation phase of the life cycle is addressed adequately in the system assurance plan and safety case.

6.1 Domain Specific Knowledge

- Appreciation and application of Signalling or Telecoms Principles
- Identification and resolution of contradictory, ambiguous, or inadequate information
- Procedures for working on operational equipment
- Railway Specific Installation methods
- Organisational structures, responsibilities, and sources of information
- Installation Specifications, Procedures and Standards
- Protection, possession and safe working procedures and practices
- Understanding and interpretation of installation drawings and schedules
- Reliability, Maintainability, Availability and Safety (RAMS)
- Conditions that must be fulfilled prior to the hand-over of the allocated tasks
- User Training
- Verification

6.2 Indicative References

IRSE Green Booklet No 10 Mechanical Signalling
Hidden A, Accident Report Clapham Junction 12.12.88. HMSO 1989
ISBN 0-10 108202-9
Corrie J D, Human Reliability For Railway Signalling Trackside Installation Work, IBC Conference Task analysis for industry 06/12/94
Whitehouse W H, On Track Signalling Problems relative to Modern P-Way Practice.
IRSE Proceedings 1971/72

Wittamore D, Installation, & Testing of the Signalling System, IEE 6th Vacation School on Railway Signalling and Control Systems July 1996
Railway Signalling, ed O.S. Nock, pub IRSE, ISBN 0-902390-15-5
Fault Free Infrastructure IMechE Professional Engineering Publishing ISBN 1 86058 233 8
IRSE Technical Briefing – Testing & Commissioning 1995

See Appendix J for further reading.

6.3 Relevant International Standards

BS 376 – 1:1950 Railway Signalling Symbols. Schematic symbols
BS 376 – 2:1954 Railway Signalling Symbols. Wiring symbols and written symbols
BS 442: 1950 Specification for terminals for electrical apparatus for railway signalling purposes
BS 469:1995 Specification for railway signalling lamps
BS 714:1950 Specification. Cartridge fuse-links for use in railway signalling circuits
BS 3347:1961 Specification for capacitors for railway signalling track circuits
BS EN 50121 series 1-5:2000 Railway applications - Electromagnetic compatibility
pr EN 50125-3 Railway applications - Environmental conditions for equipment part three-Equipment for signalling and telecommunications
BS EN 50261:1999 Railway applications. Mounting of electronic equipment.
BS EN 50126 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50128 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems
pr EN 50129 Electronic Systems Railway applications - Safety related electronic systems for signalling
BS EN 61000 series Electromagnetic compatibility (EMC)
BS IEC 60050-821:1998 International electro technical vocabulary
HB 10187 Reliability, maintainability & risk 6th edition
BS EN ISO 9001:1994 Quality systems. Model for quality assurance in design, development, production, installation and servicing
BS EN 50122-1:199 Railway Applications – Fixed Installations. Protective provisions relating to electrical safety & earthing.
BS 7671 Requirements for electrical installations (IEE wiring regulations)
BS 6701 Code of Practice for installation of equipment for connections to telecomms equipment.
BS IEC 61508 Functional Safety of Electrical / Electronic / Programmable Electronic Safety – Related Systems Parts 1 – 7.13 and 7.14

6.4 Relevant IRSE Licence Categories

1.2.120 / 2.2.110	Installer
1.2.130	Installation Team Leader
1.2.140	Installation Manager
1.2.230 / 2.2.230	Project Engineer
6.8.110	Engineering Manager

6.5 Relevant IEE Competency Guidelines for Safety-Related System Practitioners

PSM Project Safety Assurance Management
HRA Safety Hazard and Risk Analysis

SV Safety Validation

6.6 Relevant OSCEng Standards

6.6.1 Engineering Competence Standards Series 4.x.x, and in particular

1.12 Interpret detailed information
1.21 Determine Requirements for safe access to work locations
2.15 Reinstate the work area after engineering activities
4.02 Install engineering products or assets
6.01 Establish compliance with specifications

6.6.2 Higher Level Standards Series 3.x.x, in particular

3.2.2 Solve installation problems with engineering solutions
3.3.1 Monitor the installation process
3.3.2 Evaluate the installation process

6.7 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

7 System Validation, Safety Acceptance and Commissioning

System Validation is a technique used to check and confirm that a delivered project meets its defined requirements. These techniques may include reviews, testing and analysis. Safety Acceptance of a system or project will be linked to a Safety Case, which should provide a clear, complete and valid line of reasoning that a system is acceptably safe to operate in a specific context, this is usually a documented process. The degree of documentation will vary, but must always address that the system Safety Requirements have been met and are adequate for the application.

Within standard protocols testing is a sub-set of verification and validation that relates to activities performed on both products and their application. In the railway environment verification testing almost exclusively refers to the physical confirmation of the correct disposition, configuration and operation of products and systems. Functional testing is undertaken to confirm that the sub-system or product complies with the design specification and meets the application requirements and is fit for entry into service.

Railway infrastructure has the characteristic of site uniqueness; the principles having to be correctly interpreted on a location-by-location basis. Thus, there is a need to validate the application of the Safety Authority and Railway Administration each time an Interlocking is created or amended. This activity is commonly referred to as Principles Testing.

The testing activity is commonly considered to be a sub-project within a programme of Works. The sub-project is controlled and co-ordinated by a person in overall charge, this person often being referred to as the Tester-in-Charge.

Within the life-cycle of a signalling scheme there is a demand also for testing during maintenance activities; these activities contribute to the continuing assurance of system safety.

7.1 Domain Specific Knowledge

- Operational understanding of signalling equipment and systems
- Document requirements, management and completion procedures
- Independent test methods, options, and procedures
- Safety and protection requirements and procedures (personal and system)
- Content and Scope of testing in relation to level, type and amount
- Correct tools, instrument and equipment identification, condition and calibration
- Provision of temporary labelling
- Defects and discrepancies
- Acceptable test results and checks
- Unacceptable test results and checks, or equipment condition
- Relevant legislation; company rules, regulations, procedures and instructions
- Signalling principles
- Interlocking principles
- Installation practices and procedures
- Interpretation of diagrams, charts and testing and commissioning plans

- Verification of completion of testing, incomplete testing or tests not carried out in accordance with procedures
- Returning the system and equipment to operational use
- Limits of own authority, responsibility and competence
- Lines and methods of effective communication

7.2 Indicative References

IRSE Technical Report - Testing and Commissioning 1995
Accident Report Clapham Junction 12.12.88. Hidden A HMSO 1989 ISBN 0-10-108202-9
Henley C, Tillin J, Testing and Commissioning the Class 92 Cab Signalling, The Channel tunnel experience: lessons for the future, Lille, France, 20-21 March 1997, IEE CONF 433 p 61-70.
Marriot D, Installation and Testing of the Signalling System, IEE 7th Vacation School on Railway Signalling and Control Systems Mar 1998
Marshall N, Testing Methods as applied to Power Signalling, IRSE Proceedings 1950/51
Cartwright WL, Testing of Mechanical Interlocking, IRSE Proceedings 1954/55
Howker AC, Testing and Commissioning of Computer Based Signalling Systems, IRSE Proceedings 1984/5
Corrie JD, Testing and Commissioning, IRSE Proceedings1991/92
Tillin J, Developing Systems and People for Signalling Testing, IRSE Proceedings 1997/98
Neave M, An investigation into Post installation Testing Methods used on LUL Signalling Systems, The Skill of the Tester; Past, Present and Future, IRSE Seminar Nov 1998
Fowler J, & Rogers J, Exploring the Boundaries between the Installation and Testing Disciplines, The Skill of the Tester; Past, Present and Future, IRSE Seminar Nov 1998
Fabbian F, The MTR Experience, The Skill of the Tester; Past, Present and Future, IRSE Seminar Nov 1998
Brookes M, Tester in Charge – Engineer, Manager or Clerk? The Skill of the Tester; Past, Present and Future, IRSE Seminar Nov 1998
Mills D, Focused testing following alleged wrong side failures – using fault trees to devise an appropriate test plan, The Skill of the Tester; Past, Present and Future, IRSE Seminar Nov 1998
Woodbridge P, Have we learnt the lessons of Clapham, and are we teaching it right? The Skill of the Tester; Past, Present and Future, IRSE Seminar Nov 1998
Engineering Safety Management - Yellow Book www.yellowbook-rail.org.uk
A guide to the approval of railway works, plant and equipment, HSE 1994, ISBN 0-7176-0741-0

See Appendix J for further reading.

7.3 Relevant International Standards

BS EN 50121 series 1-5:2000 Railway applications - Electromagnetic compatibility
pr EN 50125-3 Railway applications - Environmental conditions for equipment part three-Equipment for signalling and telecommunications
BS EN 50126:1999 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50261:1999 Railway applications. Mounting of electronic equipment.
BS EN 50128:2001 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems

DD EN 50129 Railway applications - Safety related electronic systems for signalling
BS IEC 61508 series 1-7 Functional safety of electrical/electronic/programmable electronic safety-related systems
BS EN ISO 9001:1994 Quality systems. Model for quality assurance in design, development, production, installation and servicing

7.4 Relevant IRSE Licence Categories

1.3.150 Assistant Tester
1.3.155 Technical Verifier
1.4.160 Maintenance Tester
1.3.170 Functional Tester
1.2.180 Principles Tester
1.2.190 Tester in Charge
2.2.230 Project Engineer
2.3.260 Electronic Systems Tester
2.3.290 Testing Manager
6.8.110 Engineering Manager

7.5 Relevant IEE Competency Guidelines for Safety-Related System Practitioners

PSM Project Safety Assurance Management
HRA Safety Hazard and Risk Analysis
SRS Safety Requirements Specification
SV Safety Validation
SAD Safety-Related System Architectural Design

7.6 Relevant OSCEng Standards

7.6.1 Engineering Competence Standards Series 6.xx, and especially
1.19 Plan engineering activities
6.01 Establish compliance with specifications
6.02 Conduct specified testing of engineering products or assets
6.03 Analyse and interpret the results of engineering tests

7.6.2 Higher Level Standards
3.4.1 Commission engineering products or processes

7.7 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

8 Operation, Maintenance, Modification and Decommissioning

It is essential that the above items are included in the ongoing safety management of the project, in accordance with the requirements that should have been documented in the system assurance plan and the safety case.

The Maintainer is accountable for a signalling system or installation throughout most of the time and needs to appreciate all the other phases of its life. In particular the Maintainer must know when to call on the specific skills of others, e.g. Designers or Testers. The Maintainer must take the responsibility of signing the system into and out of service whenever there is doubt about the functionality or performance of the signalling – with due regard for the introduction of risk to train movements by withdrawing whatever protection remains.

It is rare that wholesale decommissioning takes place of a signalling system. More usually stage-works take place where parts of it are modified and the old system is gradually withdrawn as part of maintenance or new works activities.

The maintenance task encompasses the balancing of many priorities. The Maintainer must have the knowledge and confidence to make decisions to take the system out of service for technical work, or not do it, (and be able to justify these decisions) sometimes against the opposition of users or engineering colleagues.

The Maintainer should understand, and be able to explain in lay terms, what are the options for enhancing the performance or reliability of the system or why and when it must be replaced. These issues become particularly difficult and subtle towards life-expiry of systems and the Maintainer must be willing and able to take accountability for related decisions and consequences.

As more of the signalling system is train-borne, the Maintainer must be able to take an overview and liaise with and manage the related engineering activities to optimise service to users. This is particularly important for intermittent or niggling 'systems' problems.

The Maintainer is also responsible for investigating allegations of abnormal behaviours and must understand his responsibilities for preserving evidence and bringing the investigation to a satisfactory conclusion – often amongst the stress of non-technical officialdom and incident investigations.

8.1 Domain Specific Knowledge

Documentation requirements, management and completion procedures
Organisational structures & responsibilities
Infrastructure controllers requirements, regulations and procedures
Maintenance plan acceptance procedures, asset population and characteristics
Operating requirements
Signalling and interlocking principles and equipment
Application of signalling principles relevant to maintenance
Maintenance and testing requirements, methods, procedures and standards
Limits of own authority, responsibility and competence
Protection, possession and safety procedures

Identification of outstanding tasks
Resource availability capability & limitation
What constitutes a significant defect
Procedures for the preservation of evidence
Quality assurance, fault and change control procedures
Acceptance hand over
Verification
Failure investigation and replacement procedures
Change Management
Requirements for the disposal of materials

8.2 Indicative References

Penney R, Maintaining the Signalling Infrastructure, IEE 8th Vacation School on Railway Signalling and Control Systems, April 2000
Railway Signalling, ed O.S. Nock, Pub IRSE, ISBN 0-902390-15-5
Railway Technology International 1993, Allan, G Freeman, Stirling publications Ltd London Pbk
Railway Signalling and Communications: installation and maintenance, Lascelles, TS, St Margaret's Technical Press: London
Fault Free Infrastructure, IMechE, Professional Eng Publish, ISBN 1-86058-233-8
Brown AR, Signalling Equipment and Systems: Performance and Reliability in Service, IRSE Proceedings 1972/3
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Pore J, Towards a More Reliable Railway – Integrated Maintenance on RATP, IRSE Proceedings 1993/94
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Harrison A, Managing Obsolescence, Improvements in the delivery of Signalling Projects and Products, IRSE Seminar March 1998
Venter K & West MR, Asset Information Management Strategies for the Railways, IRSE Aspect '99
Webb AK & Hamlyn MJ, Signalling Asset Whole Life Modelling, IRSE Aspect '99
Boddy WG, A Modern Approach to Infrastructure Maintenance, IRSE Aspect '99
Errington, S, The Long-Term Support and Maintenance of Computer Based Railways Control Systems, IRSE Aspect '99
Gutteridge KJ, Developing Performance Based Control Train Control System Maintenance Contracts: Can they be made to Work? IRSE Aspect '99
Knowlton & Godber AM, Commissioning and Maintenance of an Integrated System, IRSE Aspect'99
The Future of accident investigation in the railway industry, Railtrack PLC Consultation Document, Keep it Safe, Keep it Legal, IRSE Technical Conference Dec 1999

See Appendix J for further reading.

8.3 Relevant International Standards

BS 442: 1950 Specification for terminals for electrical apparatus for railway signalling purposes
BS 469:1995 Specification for railway signalling lamps
BS 714:1950 Specification. Cartridge fuse-links for use in railway signalling circuits
BS 3347:1961 Specification for capacitors for railway signalling track circuits
BS EN 50121 series 1-5:2000 Railway applications - Electromagnetic compatibility
pr EN 50125-3 Railway applications - Environmental conditions for equipment part three-Equipment for signalling and telecommunications
BS EN 50126:1999 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50261:1999 Railway applications. Mounting of electronic equipment.
BS EN 50128:2001 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems
DD EN 50129 Railway applications - Safety related electronic systems for signalling
BS EN 50159 series 1–2:2001 Railway applications. Communications, signalling & process systems. Software for railway control & protection systems
BS IEC 61508 series 1-7 Functional safety of electrical/electronic/programmable electronic safety-related systems
BS EN 61000 series Electromagnetic compatibility (EMC)
BS IEC 60050-821:1998 International electro technical vocabulary
HB 10187 Reliability, maintainability & risk 6th edition
BS EN ISO 9001:1994 Quality systems. Model for quality assurance in design, development, production, installation and servicing

Relevant IRSE Licence Categories

1.4.100	Assistant Maintainer
1.4.110/2.4.110	Maintainer
1.4.161	Maintenance Tester
1.4.120	Signalling Fault Finder
1.4.125	Incident Investigator
1.4.130	Maintenance Team Leader
1.4.140/2.4.145	Maintenance Manager
6.8.110	Engineering Manager

8.4 IEE Competency Guidelines for Safety-Related System Practitioners

HRA Safety Hazard and Risk Analysis
SRS Safety Requirements Specification
SV Safety Validation
HF Human Factors Safety Engineering

8.5 Relevant OSCEng Standards

8.5.1 Engineering Competence Standards Series 5.xx, and especially:

1.12 Interpret detailed information
1.21 Determine requirements for safe access to work locations
2.15 Reinstate the work area after engineering activities
5.01 Carry out planned maintenance procedures
5.02 Adjust engineering asset to meet operating requirements
5.03 Remove components from assemblies or sub-assemblies
5.04 Replace assembly or sub-assembly components

6.04 Monitor the performance and condition of engineering assets
7.03 Hand-over engineering products or asset to the control of others

8.5.2 Higher Level Standards Series 5.x.x, and especially

5.1.1 Determine the maintenance requirements of engineering products or processes
5.1.2 Specify maintenance methods and procedures to achieve maintenance requirements
5.1.3 Schedule maintenance activities to implement the maintenance methods and procedures
5.2.2 Solve maintenance problems with engineering solutions
5.3.1 Monitor maintenance processes
5.3.2 Evaluate maintenance processes
6.1.3 Investigate incidents relating to engineering products or processes

8.6 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

9 Quality, Safety, Reliability, Availability and Maintainability

Railways achieve a very high standard of safety. Much of this in the past has been due to established practice that has been passed down from generation to generation, and evolved further as a result of accidents and technology. With today's privatised and globalised railways it has become necessary to evolve even further to cope with cross acceptance of safety systems. European norms –aimed at encouraging standardisation of supply are being mandated, but with each railway having its own inherited rules and practices it is not always easy to be sure that the application of these norms will not compromise the safety of the system. Practices from other safety related industries and high hazard sectors are now often employed to ensure the safety of the system.

The system assurance plan must be established adequately at the front end of the project and applied throughout all stages of the total lifecycle.

Today's Railway Signal Engineer needs to have a basic knowledge of each of the following areas and how they may be applied to the Railway control system Life cycle:

- **Quality** – Standards, procedures, work instructions and method statements. Configuration management and Change Control
- **Safety Plan** – Policy, legal and functional requirements and targets, Hazard and Risk Analysis and Assessment, architectures and change management. System Assurance and Safety case.
- **Reliability, Availability and Maintainability (RAM) Programme** - policy, requirements, acceptance criteria, programme and management, Failure Reporting and Corrective Action Systems (FRACAS), availability architectures and reliability centred maintenance.

9.1 Domain Specific Knowledge

Design and QA standards
Verification of Design
Legal requirements and Codes of Practice
Safety Plan
Safety Assurance
Safety Management Systems
Safety Acceptance Arrangements
Cross Acceptance
Notified bodies
Independent Safety Assessment
Change Management
Procedures for the preservation of evidence
Health and Safety requirements
Fault and Change Control Procedures
Configuration Control Procedures
Production of evidence for safety cases
Architectures for safety
Architectures for availability
Safe failure modes
ALARP

9.2 Indicative References

Report by the IRSE Technical Committee – Cross Acceptance of Vital Signalling Systems 1992
Stanley PW, Operational Availability of Railway Control Systems, IRSE Proceedings 1993/94
Lamb D and Davis R , Are Microprocessors and Signal Engineers Incompatible? IRSE Proceedings 1994/95
Pore J, European Standards, IRSE Proceedings 1996/97
Allan J and Williams J, The Fundamentals of System Engineering in Major Railway Projects, IRSE Proceedings1995/96
Corrie JD and Gilmartin BP, Managing Safety in Railways – Theory and Reality, in Safety and Reliability Volume 21, No 3 Autumn 2001 ISSN 0961 7353
Williams R and Corrie JD, Simplifying the Safety Case for New Signalling, IRSE Aspect '99 Proceedings p339.
Engineering Safety Management - Yellow Book 3 Volumes 1 & 2 Fundamentals and Guidance www.yellowbook-rail.org.uk
Reducing Risk, Protecting People, 1999, HSE discussion document, DDE11
Regulating Higher Hazards: Exploring the issues, 2000, HSE Discussion Document
Railway Safety Case Regulations 2000/2 (& Guidance)
Pilkington S, System Assurance and Safety Assessment, IEE 8th Vacation School on Railway Signalling and Control Systems, April 2000.

See Appendix J for further reading.

9.3 Relevant International Standards

PD R008-001:1999 Railway applications. Communications, signalling & processing systems. Hazardous failure rates & safety integrity levels (SIL)
PD R009-004:1999 Railway Specifications. Systematic allocation of safety integrity levels
BS EN 50121 series 1-5:2000 Railway applications - Electromagnetic compatibility
pr EN 50125-3 Railway applications - Environmental conditions for equipment part three-Equipment for signalling and telecommunications
BS EN 50126:1999 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
BS EN 50261:1999 Railway applications. Mounting of electronic equipment.
BS EN 50128:2001 Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems
DD EN 50129 Railway applications - Safety related electronic systems for signalling
BS EN 50159 series 1–2:2001 Railway applications. Communications, signalling & process systems. Software for railway control & protection systems
BS IEC 61508 series 1-7 Functional safety of electrical/electronic/programmable electronic safety-related systems
BS EN 61000 series Electromagnetic compatibility (EMC)
BS IEC 60050-821:1998 International electro technical vocabulary
HB 10187 Reliability, maintainability & risk 6th edition
BS EN ISO 9001:1994 Quality systems. Model for quality assurance in design, development, production, installation and servicing

Relevant IRSE Licence Categories

6.8.110 Engineering Manager

9.4 Relevant IEE Competency Guidelines for Safety-Related System Practitioners

CMF Corporate Functional Safety Management
HF Human Factors Safety Engineering
HRA Safety Hazard and Risk Analysis
ISA Independent Safety Assessment
PSM Project Safety Assurance Management
SAD Safety-Related System Architectural Design
SHR Safety-Related System Hardware Realisation
SRM Safety-Related System Maintenance and Modification
SRP Safety-Related System or Services Procurement
SRS Safety Requirements Specification
SSR Safety-Related System Software Realisation
SV Safety Validation

9.5 Relevant OSCEng Standards

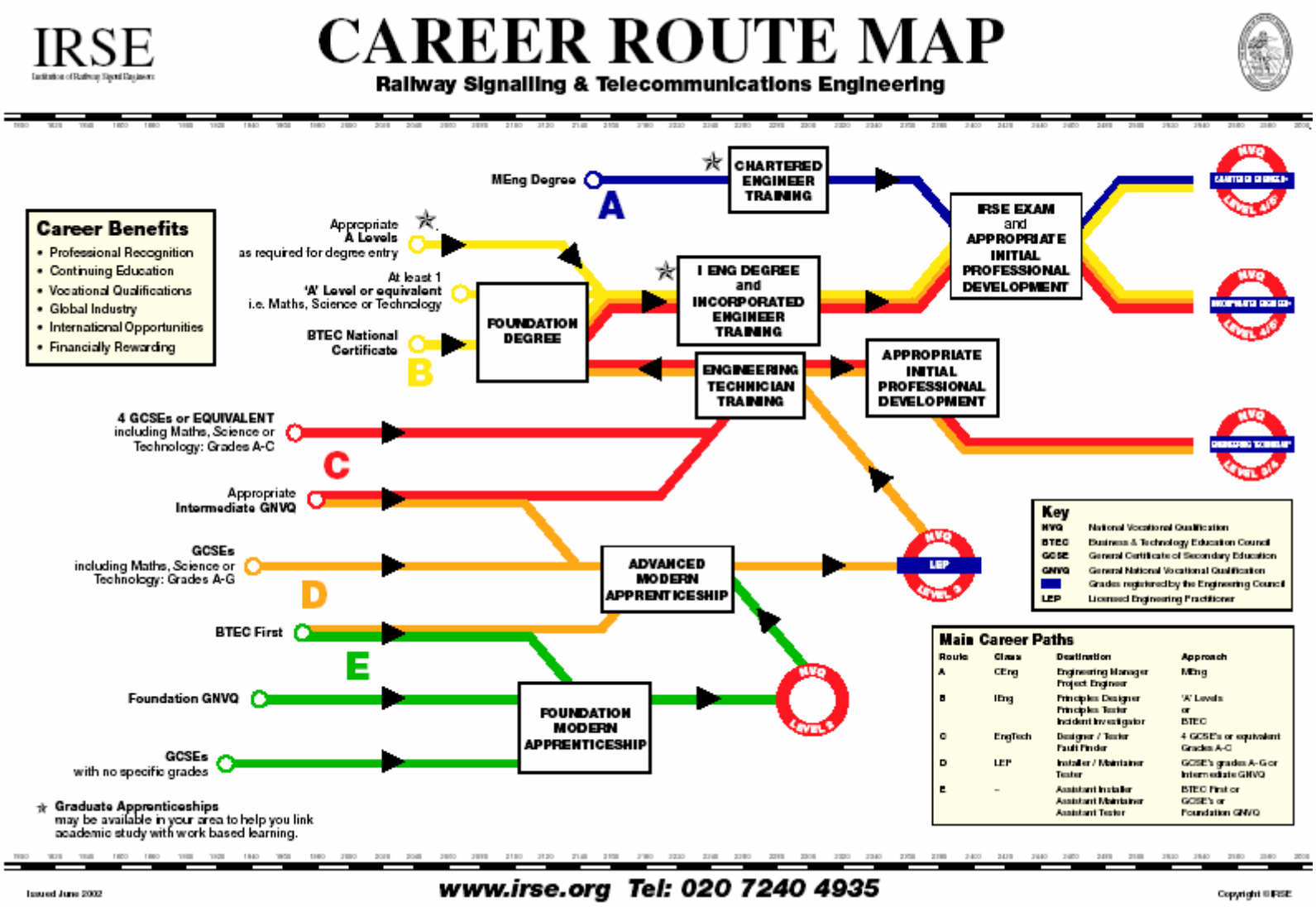
9.5.1 Engineering Competence Standards Series 6.xx

9.5.2 Higher Level Standards Series 6.x.x

9.6 Relevant Engineering Council (EC (UK)) Standards

EngTech (Engineering Technician) A1 – E4 Series
IEng (Incorporated Engineer) A1 – E4 Series
CEng (Chartered Engineer) A1 – E4 Series

10 APPENDIX A - IRSE CAREER ROUTE MAP



11 APPENDIX B – A Career in Railway Signalling / Telecommunications - GETTING STARTED

The following table shows the preferred training routes towards a career in Railway Signalling/Telecommunications engineering. Adult apprenticeships are also sometimes available in each of these routes.

Age	Entry Requirements	Training and Further Study	Training is initially undertaken for one or more of the following roles:	Possible career progression on successful completion of training	Contact
16+	An appropriate BTEC First Certificate or An appropriate Foundation GNVQ or GCSE's with no specific grades	**Foundation Modern Apprenticeship** **NVQ Level 2** Approved Technical Certificate Typical duration 1 year.	An **Assistant Installer** installs and wires electrical signal/telecomms equipment under the direction of an Installer. The work includes both the preparation for, and installation of equipment, wiring and cabling. An **Assistant Maintainer** maintains signalling/telecommunications equipment and systems under the direction of a Maintainer. An **Assistant Tester** is responsible for selecting and applying appropriate tools or instruments, reporting results: and carrying out all requests precisely and reporting unambiguously on the outcomes. The Test Assistant responds to the nominated Tester The above roles may involve being outdoors on the railway line, in equipment rooms, or office locations. Shift work, especially weekends and bank holidays may be required.	Trainees who do well may progress to an Advanced Modern Apprenticeship	**CfRS** for list of Employers offering Foundation Modern Apprenticeships Tel: 0207 313 1035 Email: enquiries@cfrs.org.uk **EDEXCEL** for details of BTEC syllabus www.edexcel.org.uk

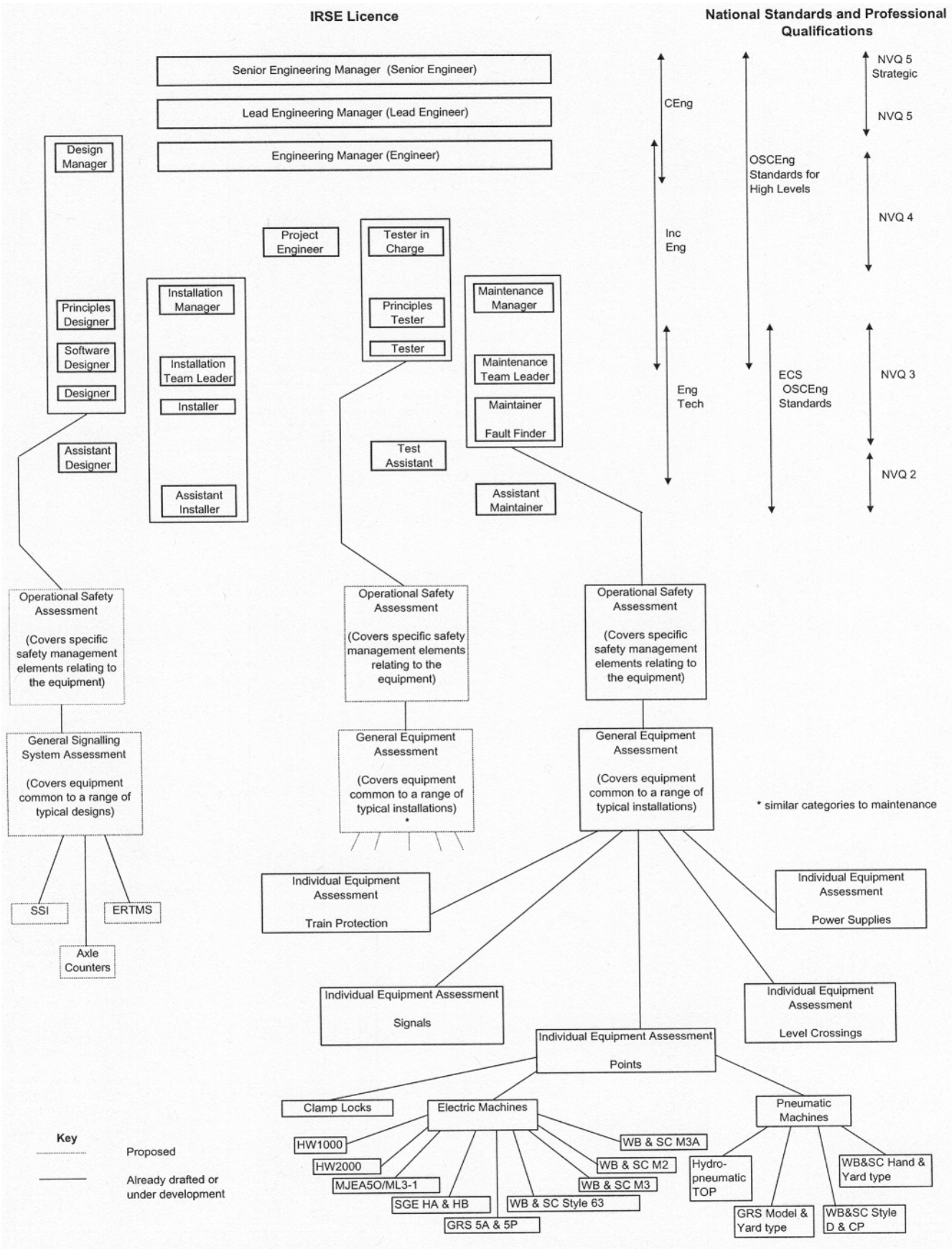
Age	Entry Requirements	Training and Further Study	Training is initially undertaken for one or more of the following roles:	With experience, progression is possible as follows	Contact
16+	An appropriate Intermediate GNVQ or GCSE's passes grades A –G including Maths, Science or Technology or An appropriate BTEC First Certificate Or NVQ Level 2 Approved Technical Certificate	**Advanced Modern Apprenticeship** **NVQ Level 3** Approved Technical Certificate Typical duration 2 years.	An **Installer** installing and wiring signalling/ telecommunications equipment, using measuring equipment, and carrying out installation integrity checks, such as wire counts and continuity checks. **Technical Verifier** responsible for undertaking the testing and inspection activities of signalling/ telecommunications sub-systems, or components; to confirm that it complies with the design specification. **Maintainer** maintaining or rectifying signalling/ telecommunications equipment and systems, completing integrity checks on own work, and where necessary will instigate testing. **Maintenance Tester** responsible for confirming that renewed or replaced signalling/telecommunications equipment is fit for entry into service The above roles may involve being outdoors on the railway line, in equipment rooms, or office locations. Shift work, especially weekends and bank holidays may be required.	**Installation Team Leader** – leading a team of staff installing and wiring signalling/telecommunications equipment. Setting up safe systems of work, including working on operational equipment, and completing integrity checks. **Maintenance Team Leader** – directing a team undertaking the maintenance and rectification of signalling/telecommunications systems and equipment, and setting up safe systems of work. Trainees progressing through this route may become eligible to register with the **IRSE** as an **Accredited Technician** and Register with the Engineering Council as a **Licensed Engineering Practitioner** (**LEP**). Those who do well and additionally train as a Technical Verifier may progress to an Engineering Technician Training Scheme and become a **Fault Finder.**	**CfRS** for list of Employers offering Advanced Modern Apprenticeships Tel: 0207 313 1035 Email: enquiries@cfrs.org.uk **EDEXCEL** for details of BTEC syllabus www.edexcel.org.uk

Age	Entry Requirements	Training and Further Study	Training is initially undertaken for one or more of the following roles:	With experience, progression is possible as follows	Contact
16+ Or 18+	An appropriate Intermediate GNVQ or 4 GCSE's passes grades A –C including Maths, Science or Technology or Appropriate Vocational A Levels Or At least 1 A level or Equivalent in Maths, Science or Technology Or NVQ Level 3 Approved Technical Certificate	**IRSE Accredited Engineering Technician Training Scheme** NVQ Level 3 Approved Technical Certificate or BTEC National Certificate or Diploma in Electrical/Electronic Engineering, or Operations and Maintenance Engineering Typical duration 3 years	An **Assistant Designer** designs or modifies signalling/telecommunications systems under the direction of a Designer. Design work is usually office based, in usual office hours, but may involve occasional trips to site. Some people choose to broaden their careers by additionally training as a **Functional Tester -** responsible for undertaking the testing and inspection activities of signalling/ telecommunications sub-systems, or products; to confirm that it complies with the design specification and is fit for entry into service. A **Maintenance Tester** is responsible for confirming that renewed or replaced signalling/telecommunications equipment is fit for entry into service Testing and Fault Finding may involve being outdoors on the railway line, in equipment rooms, or office locations. Shift work, especially weekends and bank holidays may be required.	**Designer -** capable of designing or modifying signalling/ telecommunications systems from a user specification, to comply with the applicable standards and regulations **Fault Finder:-** capable of locating and rectifying faults, or ensuring the safety of the system and preservation of evidence to hand over to an incident investigator. Trainees progressing through this route may go on to become **Associate Members** of the **IRSE (AMIRSE)** and register with the Engineering Council as an **Engineering Technician (Eng Tech)** Trainees who additionally train as Functional Testers may wish to progress their careers by becoming Principles Designers or Principles Testers through an Incorporated Engineer Training Scheme.	**IRSE** for list of Employers offering Accredited Engineering Technician Training Schemes Tel: 020 7240 4935 www.irse.org **EDEXCEL** for details of BTEC syllabus www.edexcel.org.uk

Age	Entry Requirements	Training and Further Study	Training is initially undertaken for one or more of the allowing roles:	With experience, progression is possible as follows	Contact
18+	At least 1 'A' level or equivalent in Maths, Science or Technology Or Appropriate Vocational 'A' Levels Or An appropriate BTEC National Certificate / Diploma	**IRSE Accredited Incorporated Engineer Training Scheme** An appropriate BTEC Higher National Certificate Engineering plus a matching section Or A foundation degree followed by a an appropriate IEng Degree And IRSE Professional Examination, and a period of monitored responsible experience Typical duration 3-4 years	A **Designer** – capable of designing or modifying signalling/ telecommunications systems from a user specification, to comply with applicable standards and regulations. Design work is usually office based, normally in usual office hours, but may involve occasional trips to site. Designers may choose to broaden their career by additionally training as a **Functional Tester -** responsible for confirming that the system complies with the design specification and is fit for entry into service. An **Electronic Systems Designer** – specifying, modifying and integrating high integrity control and information systems. A **Fault Finder -** locating and rectifying faults, or ensuring the safety of the system and preservation of evidence to hand over to an incident investigator. Testing and fault finding may involve being outdoors on the railway line, in equipment rooms, or office locations. Shift work, especially weekends and bank holidays may be required.	Designers who have undertaken Functional Testing may become **Principles Designers** designing or modifying designs in accordance with signalling principles**.** Those interested in engineering management may progress to **Design Manager**. Those specifically interested in Functional Testing may become **Principles Testers** responsible for verifying that system is operationally fit for purpose. Progression to **Tester in Charge is** also possible**.** Those who enjoy diagnostics may wish to train as an **Incident Investigator** who investigates incidents and irregularities and ensures system safety. Progression to **Maintenance Manager, Installation Manager** or **Project Engineer** is also possible for those wishing to broaden their careers. Trainees progressing through this route may go on to become a **Member** of the **IRSE (MIRSE)** and register with the Engineering Council as an **Incorporated Engineer (IEng)**	**IRSE** for list of Employers offering Accredited Incorporated Engineer Training Schemes Tel: 020 7240 4935 www.irse.org **EDEXCEL** for details of BTEC syllabus www.edexcel.org.uk

Age	Entry Requirements	Training and Further Study	Training is initially undertaken for one or more of the following roles:	With experience, progression is possible as follows	Contact
21+	An appropriate BTEC Higher National Certificate Engineering plus an IEng matching section Or An approved BEng Degree in Electrical / Electronic Engineering or Control Systems Engineering Or An accredited MEng Degree	**IRSE Accredited CEng Training Scheme** BTEC HNC and BEng graduates will be required to undertake a further period of study, approved as a CEng matching section, and pass the IRSE Professional Examination MEng graduates will be required to pass the IRSE Professional Examination And A period of monitored responsible experience Typical duration 4 years	A **Designer** – capable of designing or modifying signalling/ telecommunications systems from a user specification, to comply with applicable standards and regulations. Design work is usually office based, normally in usual office hours, but may involve occasional trips to site. Designers may also broaden their understanding of principles as a **Functional Tester -** responsible for confirming that the system complies with the design specification and is fit for entry into service. An **Electronic Systems Designer** – specifying, modifying and integrating high integrity control and information systems. Testing may involve being outdoors on the railway line, in equipment rooms, or office locations. Shift work, especially weekends and bank holidays may be required.	**Project Engineer** responsible for the signalling/telecommunications systems part of the project and capable of managing integration of the project in the railway environment. May be part of a multi-disciplinary team and may also cover Project Management activities for engineering aspects of a project. Activities may include design, implementation, system assurance, installation, test & commissioning activities. Project Engineering is often office based, but may involve site and shift work, and weekend and bank holiday work during commissioning periods. **Engineering Manager –** Day to day management of a department, interpreting and implementing either or both S&T policy and making critical decisions. Responsible for converting organisational strategy and policy into practical objectives for implementation. Trainees progressing through this route may go on to become a **Member** of the **IRSE (MIRSE)** and register with the Engineering Council as a **Chartered Engineer (CEng)**	**IRSE** for list of Employers offering Accredited Chartered Engineer Graduate Training Schemes Tel: 020 7240 4935 www.irse.org **EDEXCEL** for details of BTEC syllabus www.edexcel.org.uk

12 APPENDIX C -Relationship of IRSE Licences to other Competence Assessment Systems



13 Appendix D - IRSE Licence Category Scope Statements

Category No	Scope Statement
Signalling	
1.1.100	Assistant Designer(S) (Due Major Review – Q3/2003) An Assistant Designer is capable of designing or modifying signalling systems under the direction of a licensed designer.
1.1.110	Designer(S) (Due Major Review – Q3/2003) A Designer is capable of designing or modifying signalling systems from a user specification, to comply with the applicable standards and regulations.
1.1.130	Principles Designer(S) (Due Major Review – Q3/2003) A Principles Designer is capable of designing or modifying the design of signalling systems in accordance with signalling principles. The resulting design will be 'fit for purpose' and comply with legal requirements.
1.1.140	Design Manager (Due Major Review – Q3/2003) (Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module E - Design) Capable of the engineering management of a design group consisting of a number of design teams engaged on separate projects or discrete parts of a larger project.
1.2.100	Assistant Installer(S) An Assistant Installer is capable of installing and wiring electrical signalling equipment under the direction of a licensed installer. The work includes both the preparation for, and installation of equipment, wiring and cabling, undertaken by installers of electrical signalling equipment.
1.2.105	Point Fitter(S) Capable of installing and maintaining at least one, (two if one is mechanical), of the following types of points: - Mechanical, Electrical, Pneumatic, or Hydraulic and other associated equipment. Capable of performing basic electrical integrity checks, to check the function and set-up of the installed detection components. Capable of setting up safe systems of work at all times This competence standard does not assess competencies relating to the running and terminating of cables. Evidence that has been collected solely during work on mechanical points is insufficient to meet the requirements of this competence standard. Point Fitters who supervise teams of other staff should hold either an Installation Team Leader(S) {1.2.130} or Maintenance Team Leader(S) {1.4.130} licence.

1.2.110 Installer(S) (Due Issue Q2 2003)
v2.00 An installer is capable of installing and wiring signalling equipment, using measuring equipment, and carrying out installation integrity checks, such as wire counts and continuity checks.

A clear distinction must be made between functional testing and the installer's own integrity checks. When working on safety-related tasks an installer should not be responsible for the integrity checks of his own installation work.

1.2.115 Locking Fitter(S) v2.00
This licence category may be held by locking fitters capable of installing and maintaining Signal Locking Frames and/or associated Electrical Equipment.

A locking fitter holding the 1.2.115M (Mechanical) category will be capable of making, installing, and maintaining Mechanical Locking in accordance with approved designs and specifications.

A locking fitter holding the 1.2.115E (Electrical) category will be capable of installing and maintaining Electrical Locking Equipment, such as circuit controllers and level locks, in accordance with approved designs and specifications.

A locking fitter holding the full 1.2.115 Locking Fitter category will be competent in both the 1.2.115M (Mechanical) and the 1.2.115E (Electrical) sub-categories.

All locking fitters will be capable of setting up a safe system of work at all times, and in particular when working on operational equipment.

[Performance criteria specific to either the electrical or mechanical sub-category have an 'E' or 'M' suffix to the performance criteria number. Where the evidence required to demonstrate competence is different for the two sub-categories, the applicant for both sub-categories is required to provide relevant evidence for both sub-categories.]

Locking fitters who supervise teams of other staff should hold either an Installation Team Leader(S) or Maintenance Team Leader(S) licence.

1.2.130 Installation Team Leader(S)
Capable of leading a team of staff installing and wiring signalling equipment. Capable of setting up safe systems of work, including working on operational equipment. Capable of completing integrity checks of team's work.

An applicant for the Installation Team Leader(S) licence category is required to hold either a Point Fitter (1.2.105) licence category, or an Installer(S) (1.2.110) licence category, or a Locking Fitter (1.2.115) licence category.

1.2.140 Installation Manager(S)
(Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module B - Installation)
Capable of managing installation groups, each consisting of a number of teams engaged in the installation of signalling equipment.

1.2.150 Test Assistant(S) – To be replaced by 1.3.150
1.2.160 Tester(S) - Replaced by 1.3.160
1.2.180 Principles Tester(S) – To be replaced by 1.3.180
1.2.190 Tester-in-Charge(S) – To be replaced by 1.3.190

1.2.230 Project Engineer(S)
(Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module F – Project Engineer)
As a Project Engineers you will be responsible for the signalling systems part of the project. You may be part of a multidisciplinary team and may also cover Project Management activities for engineering aspects of a project. These activities may include any or all of the design, implementation, system assurance, installation, test & commission and post commissioning activities.

As a Project Engineers you will be responsible for the effective use of signalling engineering resources within the project, you will advise the project manager on decisions effecting signalling systems, and you will also identify signalling problems and identify those responsible for their solution, using appropriate internal and external experts. You must be capable of managing the integration of the project in the railway environment.

1.3.150 Assistant Tester v1.00 (Replaces 1.2.150 Test Assistant (S))
An assistant tester is responsible for selecting and applying the appropriate tools or instruments, reporting results; and, carrying out all requests precisely and reporting unambiguously on the outcomes. The assistant tester responds to the nominated Tester.

1.3.155 Verification Tester v1.00 (Issue by 28 Feb 03)
The Verification Tester is responsible for undertaking tests on signalling components and equipment in accordance with the test specifications and plans (typically in preparation for Functional Testing).
The Verification Tester is given the test plan for the work to be completed, rather than being required to develop it.

The Verification Tester licence category may be awarded for the following modules:

1.3.155X Module X Verification Tester – Operational Environment
1.3.155Y Module Y Verification Tester – Non-operational Environment
1.3.155Z Module Z Verification Tester – Cables

1.3.160 Signalling Tester(S) - Replaced in part or whole by 1.3.155, 1.4.160, and 1.3.170

1.3.170 Functional Tester v1.00 (Due Issue Q1 2003)

The Functional Tester is responsible for undertaking the testing and inspection activities of signalling systems and equipment to provide suitable and sufficient evidence to confirm that they comply with the design specification, meet the requirements appropriate to the application and are fit for entry into service.

1.3.180 Principles Tester v2.00

The Principles Tester is responsible for undertaking the testing activities; to provide suitable and sufficient evidence to confirm that the technical safety principles demanded by the designated authorities have been validated, and the system is fit for entry into service.

1.3.190 Tester-in-Charge v2.00

The Tester in Charge (TiC) is responsible for defining and controlling the testing activities; ensuring that suitable and sufficient evidence is gathered to confirm that the system meets the requirements appropriate to the application; and is fit for entry into service.

Applicants for the award of a licence in this category must hold a current Signalling/Functional Tester licence (1.3.160 or 1.3.170), or Principles Tester (1.2.180 or 1.3.180) or qualify for an exemption as specified in the IRSE Licensing Scheme Pre-Requisite List.

1.4.100 Assistant Maintainer(S)

A Signalling Assistant Maintainer is capable of maintaining signalling equipment and systems under the direction of a licensed maintainer.

The Test Assistant (1.2.150) licence category should also be held by personnel who assist Fault Finders (1.4.120) with the investigation of faults.

1.4.110 Signalling Maintainer v2.00 (Due Issue Q1 2003)
v3.00 As a Signalling Maintainer, you will be capable of:

- maintaining or rectifying signalling equipment and systems
- completing integrity checks on your own work
- instigating testing where necessary
- identifying where independent testing is required.

Signalling systems and equipment include:

- train control
- train detection
- power supplies
- points

Train control equipment may include signal or some other method of authorising train movements, train detection may include track circuits or axle counters.

The assessment should normally cover three of the four systems listed. Exceptionally the assessment may cover an applicant who specialises in a more limited range of systems, where an appropriate level of competence can be demonstrated

1.4.120 Signalling Fault Finder v2.00 (Issue by 28 Feb 03)

v3.00 As a Signalling Fault Finder are to be capable of locating and diagnosing faults in signalling equipment and systems where the preservation of evidence is not necessarily required. The type and range of problems and faults cover both simple and complex faults due to environmental factors, ageing, human error, inherent design problem and may be either right side or wrong side failures. If the work will go beyond your limits of authority as a faultfinder then you are to ensure the safety of the system and preservation of evidence, and hand over the work to an incident investigator or other authorised person

Signalling systems and equipment include:

- train detection
- power supplies
- points
- train control

Train control equipment may include signal or some other method of authorising train movements, train detection may include track circuits or axle counters.

The assessment should normally cover three of the four systems listed. Exceptionally the assessment may cover an applicant who specialises in a more limited range of systems, where an appropriate level of competence can be demonstrated

1.4.125 Incident Investigator (S)

(Issued – NB Proposal to combine with the 1.4.210 Technical Investigator category)

An Incident Investigator shall be capable of:

- Initiating investigations based on reports concerning incidents and irregularities.
- Identifying relevant evidence and arranging for its preservation.
- Identifying the need for, and where necessary obtaining, additional technical expertise.
- Preparing action plans for testing.
- Identifying the need to summon more senior and experienced investigators before arranging rectification work and the resumption of train operations.
- Ensuring system safety by managing the risks.
- Implementing the required procedures in connection with any of the above tasks.

1.4.130 Maintenance Team Leader(S)

The Maintenance Team Leader is to be capable of directing a team undertaking the maintenance and rectification of signalling systems and equipment, and setting up safe systems of work.

An applicant for a Maintenance Team Leader licence is required to hold a Maintainer licence (1.4.110).

1.4.140 Maintenance Manager(S)
(Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module A - Maintenance)
Capable of managing a maintenance group or supervising a number of teams engaged in the maintenance, fault finding, and asset management of train control equipment.

1.4.160 Maintenance Tester (S) (Due Issue Q1 2003)
The Maintenance Tester is responsible for undertaking the testing activities in support of the maintenance of operational signalling equipment:
Whilst undertaking testing activities the Maintenance Tester:

- Identifies the testing requirements
- Undertakes defined tests
- Identify where systems and equipment are not to specification.
- Provide suitable and sufficient evidence to confirm that renewed and repaired signalling equipment is fit for entry into service

Testing is normally required following the reinstatement of operational signalling systems or equipment. Reinstatement will normally have been carried out following disconnection, repair, adjustment or replacement on a like-for-like or operationally equivalent basis. Equipment or components will normally have been repaired, adjusted, or replaced because they are out of specification, missing, or life-expired.

1.4.210 Technical Investigator(S)
(Planned – To include the proposed 1.4.125 Incident Investigator category)
The Technical Investigator shall be capable of in-depth technical investigation to:

- Identify relevant information regarding failures and incidents
- Establish equipment and system condition and performance
- Give advice and make recommendations on suitability of equipment and systems and identify appropriate remedial actions.

A detailed technical knowledge of equipment and systems relating to the area of responsibility is required.

Telecommunications

2.1.100 Assistant Designer(T)
An Assistant Designer is capable of designing or modifying telecommunications systems under the direction of a licensed designer.

2.1.110 Designer(T)
A Designer is capable of designing or modifying telecommunications systems from a specification, to comply with the applicable standards and regulations

2.1.140 Design Manager(T)
(Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module E - Design)

Capable of the engineering management of a design group consisting of a number of design teams engaged on separate projects or discrete parts of a larger project.

2.1.210 Electronic Systems Designer
An Electronic Systems Designer is capable of specifying, modifying and integrating high integrity control and information systems. The resulting design will be 'fit for purpose' and comply with legal requirements.

A high integrity electronic system is defined as a hardware or software based system used for the control of and interface to the operational railway. Examples of such systems include train describers; automatic train operation; remote control; hot axlebox detectors; train radio; telecommunications switching, transmission and cable networks; and closed circuit TV. Further examples for sub-surface stations are the passenger information systems and ticket barrier gates that are linked to the station's fire alarm systems.

The Electronic Systems Designer may also undertake the systems design of the following systems which have higher levels of safety criticality; electronic track circuits; axle counters; electronic interlockings; signalling control; automatic train protection. Their design will however exclude the applications engineering design of such electronic systems. The applications engineering design of these systems requires a detailed knowledge of signalling principles and practices and is to be undertaken by applicants holding the relevant signalling design licence categories. {1.1.100 Assistant Designer(S), 1.1.110 Designer(S), 1.1.130 Principles Designer(S)}

2.2. 110 Installer(T) (Due issue Q2 2003)
v2.00 As a telecommunications installer you will be capable of installing operational railway telecommunications systems and equipment and carrying out integrity checks.

Licence applicants will typically work in one or more of the following areas of telecommunications systems and equipment: transmission systems including radio, bearer systems, SCADA, operational telephone switches and systems, operational safety-critical information systems, or safety-critical operational CCTV systems.

2.2.130 Installation Team Leader(T)

Capable of leading a team of staff installing and wiring telecommunications equipment. Capable of setting up safe systems of work, including working on or near operational equipment. Capable of checking the team's work.

An applicant for the Installation Team Leader(T) must hold an Installer(T) (2.2.110) licence.

2.2.230 Project Engineer(T)

(Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module F – Project Engineer)

Project Engineers would be responsible for the implementation of the Telecommunications engineering part of the project. The Project Engineer may form part of a multidisciplinary team directed by a project manager, who may also cover Project Manager duties for engineering aspects.

Project engineers would be responsible for the effective use of telecommunications engineering resources within the project, which may include directly employed staff, contractors, and sub-contractors. They would be required to assess the impact of requested changes to the telecommunications system, and propose effective solutions in co-operation with the other engineering functions and the customer. They would be responsible for the operation of the system to ensure that the implemented design, including any changes, is approved by the appropriate authorities. The approved design is to comply with project and external engineering standards, and regulatory requirements and guidance.

2.3.260 Electronic Systems Tester

Electronic Systems Testers are responsible for ensuring the conformity of high integrity electronic systems to the authorised design as part of the tester's installation ('new works') and maintenance activities. Electronic Systems Testers are also to be capable of introducing, or reintroducing, the system and equipment to service following such work, as long as it does not directly interface with the safety-critical signalling.

A high integrity electronic system is defined as a hardware or software based system used for the control of and interface to the operational railway. Examples of such systems include train describers; automatic train operation; remote control; hot axlebox detectors; train radio; telecommunications switching, transmission and cable networks; and closed circuit TV. Further examples for sub-surface stations are the passenger information systems and ticket barrier gates that are linked to the station's fire alarm systems.

The Electronic Systems Tester may also undertake the functional testing of the following electronic systems which have higher levels of safety criticality: electronic track circuits; axle counters; electronic interlockings; signalling control; automatic train protection. Their testing work will however exclude the testing and commissioning of the signalling control systems, which consist of such electronic sub-systems. The testing and commissioning of signalling control systems requires a detailed knowledge of signalling principles and practices and is to be undertaken by applicants holding the relevant signalling testing licence categories. {1.3.160 Signalling Tester(S), and 1.2.180 Principles Tester(S)}

2.3.290 Testing Manager(T)

A Testing Manager is capable of generating the Test Plan for the testing of telecomms or electronic systems. The Testing Manager also ensures that there are sufficient resources to implement the plan, and carry the plan through to the point of the handover to the customer or maintainer.

2.4.110 Maintainer (T) Replaced by 2.4.115 Telecommunications Maintainer & Fault Finder

2.4.115 Telecommunications Maintainer & Fault Finder

As a telecommunications maintainer & fault finder you will be capable of:

- maintaining operational railway telecommunications systems and equipment
- rectifying defects
- locating and diagnosing failures
- carrying out integrity checks and testing
- returning system to service.

You will typically work in one or more of the following areas of telecommunications systems and equipment: transmission systems including radio, bearer systems, SCADA, operational telephone switches and systems, CCTV and information systems on or about the railway.

2.4.135 Maintenance Team Manager(T)
The Maintenance Team Manager is to be capable of directing a number of sub-units undertaking the maintenance and rectification of faults on telecomms systems and equipment. The Maintenance Team Manager is to be responsible for the setting up safe systems of work.

2.4.145 Maintenance Manager(T)
(Obsolescent – to be replaced by 6.8.105 Engineer + 6.8.110 Module A Maintenance)
Capable of managing maintenance groups; each consisting of a number of teams engaged in the maintenance, fault investigation and asset management of telecommunications equipment.

2.4.160 Telecommunications Maintenance Testing and Failure Investigation (T)
(Due Issue Q1 2003)
You will be capable of undertaking the testing activities on alterations to previously working and commissioned operational telecomms systems where the equipment has been replaced on a like-for-like or operationally equivalent basis. You will also follow a systematic process when undertaking investigations into reported safety related telecomms failures

Whilst undertaking testing/investigation activities you

- Identify testing requirements
- Identify and report where systems and equipment are not to specifications
- Provide suitable and sufficient evidence to confirm that renewed or replaced telecomms equipment is fit for entry into service.

Power Supplies & Distribution

4.2.100 Assistant Traction Distribution Technician
Capable of installing and maintaining low voltage (LV) power supplies for traction and associated equipment, and providing relevant safety protection, under the direction of an Electrical Traction Technician (4.2.110). This licence category covers low voltage overhead, and 3, and 4 rail systems. It does not cover high voltage systems.

4.2.110 Electrical Traction Distribution Technician
The licence holder is capable of installing, maintaining, fault finding, and cable jointing on low voltage (LV) traction power distribution systems and associated circuits. The licence holder is also capable of setting up a safe system of work in both the electrical and railway environments, and directing the work of assistants. This licence category covers low voltage overhead, and 3, and 4 rail systems. It does not cover high voltage systems.

S & T

6.2.115 Factory Installer(S&T)

Factory Installers assemble and wire electrical and electro-mechanical signalling and telecommunications equipment to specification, and undertake integrity checks of their own work. This licence category does not cover work undertaken on, or adjacent to commissioned safety critical equipment.

6.2.165 Factory Tester (S&T) - Replaced by 1.3.155 Module Y, Verification Tester – Non-operational Environment

6.8.050 Team Leader (Proposed replacement for 'activity specific' Team Leaders {1.#.130, and 2.#.130})

As a Team Leader you will be capable of organising and controlling work activities of the team, ensuring that sufficient resources are available and contributing to technical leadership on engineering activities. You will also be responsible for the work of the team and the handover of the equipment

6.8.105 Engineer (Planned)

As an Engineer you will:

- Contribute to decision making
- Manage activities

within the field of either railway signalling or telecommunications engineering.

You will also be required to gain at least one of the modules A-H, or L listed below, and if your role includes people management, you will be required to gain an additional 'Manage People' module.

6.8.110 Engineering Manager(S&T) (Obsolescent)

Mandatory Units

As an Engineering Manager you will have the responsibility for converting your organisation's strategy and policy into practical objectives for implementation within your areas of responsibility. You will be capable of initiating change to existing policies or suggesting new ones. You will be capable of managing the day to day work of your department, interpreting and implementing either or both S & T policy and making critical decisions. *You must satisfy the requirements of the mandatory units, and at least two of the optional units, which cover the sphere of activity in which you are engaged.* Additional optional units will be required should these activities change, and Engineering Managers will be expected to acquire the competencies in these additional optional units pending formal assessment. (National Occupational Standard for Management Units D6 and A2. The new National Occupational Standard for Management was developed by the MCI with DfEE funding. This material is Crown copyright and is reproduced under licence from the Controller of Her Majesty's Stationary Office.)

6.8.110 Lead Engineer (Planned to replace Engineering Manager (S&T))
v2.00 As a Lead Engineer you will:

- Take critical decisions
- Manage activities

within the field of either railway signalling or telecommunications engineering.
You will also be required to gain at least one of the modules A-H, or L listed below, and if your role includes people management, you will be required to gain an additional 'Manage People' module.

6.8.110 Module A – Corrective & Preventive Maintenance
You would, as part of your Engineering Manager's duties in managing the Corrective & Preventive Maintenance activity, be responsible for managing the maintenance requirements and for ensuring faulty equipment is returned to a safe operation state in a timely manner, you would also be responsible for monitoring of trends.

6.8.110 Module B – Installation
You would, as part of your Engineering Manager's duties in managing the installation activity, be responsible for ensuring that sufficient resources are allocated to the installation work and that these resources are effectively managed. You will ensure that the installation is made available for testing in accordance with company and statutory requirements.

6.8.110 Module C – Testing & Commissioning
You would, as part of your Engineering Manager's duties in testing and commissioning, be responsible for ensuring all aspects of testing and commissioning activity are carried out in accordance company, infrastructure controller and statutory requirements.

6.8.110 Module D – Audit
You would, as part of your Engineering Manager's duties in auditing be responsible for planning and auditing compliance with statutory and company specifications, reporting on compliance and following up any non-conformities raised. (Unit based on the National Occupational Standard for Management Unit F7 'Carry out quality audits'). The new National Occupational Standard for Management was developed by the MCI with DfEE funding. This material is Crown copyright and is reproduced and adapted under licence from the Controller of Her Majesty's Stationary Office.

6.8.110 Module E – Design
You would, as part of your Engineering Manager's duties in managing the design process, be responsible for ensuring that sufficient resources are allocated to design projects and that a review of completed projects is undertaken.

6.8.110 Module F – Project Engineer

You would, as part of your Engineering Manager's duties in managing projects, be responsible for the implementation of the S or T engineering part of a project. You may be part of a multi-disciplinary team directed by a project manager. You would be responsible for the effective use of engineering resources, in either S or T or both, within the project, which may include directly employed staff, contractors and sub-contractors.

6.8.110 Module G – Equipment Manufacturing

You would, as part of your Engineering Manager's duties in equipment manufacturing be responsible for managing the assembly, testing and customer handover for electrical, electronic and electro-mechanical S or T equipment or systems to the required specification.

6.8.110 Module H – Technical Investigation (Proposed)

The licence holder is responsible for managing technical investigations into S&T engineering problems.

6.8.110 Module L – Produce Specifications (Proposed)

The licence holder is responsible for the development and production of specifications to meet clients' requirements. This involves firstly understanding the clients' needs, and then translating those needs into a formal specification using a structured process.

6.8.130 Senior Engineering Manager(S&T)

The Senior Engineering manager is capable of managing engineering groups, strategy or policy within the field of either railway signalling or telecommunications engineering. The applicant may be operating in one of these fields. Evidence from both is not required.

6.8.130 v2.00 Senior Engineer (Planned to replace Senior Engineering Manager (S&T))

As a Senior Engineer you will:

- Take critical decisions
- Manage activities
- Manage strategic activities

within the field of either railway signalling or telecommunications engineering.

If your role includes people management, you will be required to gain an additional 'Manage People' module.

14 Appendix E - IEE Competency Scope Statements

The following competence standards are for Safety-Related System Practitioners and relate directly to BS IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems

CFM Corporate Functional Safety Management involves responsibilities for ensuring that a "safety culture" exists within an organisation, appropriate to the organisation's internal and regulatory environment.

HF Human Factors Safety Engineering involves responsibility for ensuring that the impact of humans on the safety of a system is properly addressed through a systematic, risk-based approach at all stages of a system lifecycle.

HRA Safety Hazard and Risk Analysis: involves responsibilities for identifying all foreseeable hazards and assessing the risk of an accident. Additionally there is a responsibility to ensure that the results of the hazard and risk analysis activities are documented and that a hazard log is controlled throughout the development (and often throughout the lifetime) of the system.

ISA Independent Safety Assessment: is the formation of a judgement, separate and independent from any system design, development or operations personnel, that the safety requirements for the system are appropriate and adequate for the planned application and that the system satisfies those safety requirements.

PSM Project Safety Assurance Management involves responsibilities for ensuring that an appropriate level of safety assurance is applied during all lifecycle phases of the project and that the required evidence is collected and presented together with a reasoned argument to justify the safety of the system.

SAD Safety-Related System Architectural Design involves responsibility for ensuring that the system architecture is capable of meeting the identified safety requirements. This includes the requirement to ensure that the safety integrity requirements for each of the sub-systems are feasible regarding the limits of the technology proposed for the sub-system and level of complexity of the sub-system functions

SHR Safety-Related System Hardware Realisation involves responsibilities for ensuring that the realisation of the hardware components of a safety-related system is carried out in accordance with best engineering practice and that sufficient evidence is collected to demonstrate that the resulting system will be safe.

SRM Safety-Related System Maintenance and Modification involves the responsibility for keeping within and reducing to tolerable levels the likelihood of safety incidents during system use, including during degraded modes of operation such as system change, maintenance or the introduction of new systems into service.

SRP Safety-System or Service Procurement includes responsibilities for ensuring that system functional and safety assurance requirements are specified contractually and are delivered. Included within the function are responsibilities for ensuring that key safety requirements are highlighted in a procurement specification and that the supplier is managed properly to ensure that the safety requirements of the system or service are satisfied.

SRS Safety Requirements Specification: involves responsibilities for the production of a complete and consistent set of safety requirements for a safety-related system application.

SSR Safety-Related System Software Realisation involves responsibility for ensuring that the realisation of the software components of a safety-related system is carried out in accordance with best practice and that sufficient evidence is collected to demonstrate that the resulting system will be safe.

SV Safety Validation involves responsibilities for ensuring that a safety-related system meets its safety requirements and that there is sufficient validation evidence to support the claim that a safety-related system has met its safety requirements and that the hazard analysis assumptions are true.

15 Appendix F – Lifecycle Relationship with BS EN 50126

The specification and demonstration of Reliability, Availability, Maintainability and Safety

(NB This standard omits the installation period of the project lifecycle)

BS EN 50126 Applicable Sections	3. Plan, Implement, Manage	4. Specify, Design and Develop Products and Systems	5. Production and Manufacture	6. Installation	7. System validation, Safety acceptance & Commission	8. Operation, Maintenance and Decommission	9. Quality Safety and RAMS
Introduction	Y	Y	Y	Y	Y	Y	Y
1 Scope	Y	Y	Y	Y	Y	Y	Y
2 Normative references	Y	Y	Y	Y	Y	Y	Y
3 Definitions	Y	Y	Y	Y	Y	Y	Y
4 Railway RAMS	Y	Y	Y	Y	Y	Y	Y
5 Management of railway RAMS	Y	Y	Y	Y	Y	Y	Y
6 RAMS lifecycle	-	-	-	-	-	-	-
6.1 Phase 1: Concept	Y	Y	-	-	Y	Y	Y
6.2 Phase 2: System definition and application conditions	Y	Y	-	-	Y	Y	Y
6.3 Phase 3: Risk analysis	Y	Y	-	-	Y	Y	Y
6.4 Phase 4: System requirements	Y	Y	-	-	Y	Y	Y
6.5 Phase 5: Apportionment of system requirements	Y	Y	-	-	Y	Y	Y
6.6 Phase 6: Design and implementation	Y	Y	Y	Y	Y	Y	Y
6.7 Phase 7: Manufacturing	Y	Y	Y	Y	Y	-	Y
6.8 Phase 8: Installation	Y	Y	Y	Y	Y	-	Y

BS EN 50126 **Applicable Sections**	3. Plan, Implement, Manage	4. Specify, Design and Develop Products and Systems	5. Production and Manufacture	6. Installation	7. System validation, Safety acceptance & Commission	8. Operation, Maintenance and Decommission	9. Quality Safety and RAMS
6.9 Phase 9: System validation (including safety acceptance and commissioning)	Y	Y	Y	Y	Y	Y	Y
6.10 Phase 10: System acceptance	Y	Y	-	-	Y	Y	Y
6.11 Phase 11: Operation and maintenance	Y	Y	-	-	Y	Y	Y
6.12 Phase 12: Performance monitoring	Y	Y	-	-	-	Y	Y
6.13 Phase 13: Modification and retrofit	Y	Y	-	-	-	Y	Y
6.14 Phase 14: Decommissioning and disposal	Y	Y	-	-	-	Y	Y
Annex A (informative) Outline of RAMS specification – example	Y	Y	-	-	Y	Y	Y
Annex B (informative) RAMS programme	Y	Y	Y	Y	Y	Y	Y
Annex C (informative) Examples of parameters for railway	-	-	-	-	-	Y	Y
Annex D (informative) Examples of some risk acceptance principles	Y	Y	-	-	Y	Y	Y
Annex E (informative) Responsibilities within the RAMS process throughout the lifecycle	Y	Y	Y	Y	Y	Y	Y

16 Appendix G – Lifecycle Relationship with BS EN 50128

Software - Railway Applications - Communications, Signalling and Processing Systems

(NB this standard relies on the specification to capture assumptions).

BS EN 50128 Applicable Sections	3. Plan, Implement, Manage	4. Specify, Design and Develop Products and Systems	5. Production and Manufacture	6. Installation	7. System validation, Safety acceptance & Commission	8. Operation, Maintenance and Decommission	9. Quality Safety and RAMS
Introduction	Y	Y	Y	Y	Y	Y	Y
1. Scope	Y	Y	Y	Y	Y	Y	Y
2. Normative references	Y	Y	Y	Y	Y	Y	Y
3 Definitions	Y	Y	Y	Y	Y	Y	Y
4 Objectives and conformance	Y	Y	Y	Y	Y	Y	Y
5 Software safety integrity levels	-	Y	-	-	Y	-	Y
6 Personnel and responsibilities	Y	Y	Y	Y	Y	Y	Y
7 Lifecycle issues and documentation	Y	Y	Y	Y	Y	Y	Y
8 Software requirements specification	-	Y	-	-	Y	-	Y
9 Software architecture	-	Y	-	-	Y	-	Y
10 Software Design & Implementation	-	Y	-	-	Y	-	Y
11 Software Verification and Testing	-	Y	-	-	Y	-	Y
12 Software/Hardware Integration	-	Y	-	-	Y	-	Y
13 Software Validation	-	Y	-	-	Y	-	Y
14 Software assessment	-	Y	-	-	Y	-	Y
15 Software quality assurance	Y	Y	Y	Y	Y	Y	Y
16 Software maintenance	Y	Y	Y	Y	Y	Y	Y

BS EN 50128 **Applicable Sections**	3. Plan, Implement, Manage	4. Specify, Design and Develop Products and Systems	5. Production and Manufacture	6. Installation	7. System validation, Safety acceptance & Commission	8. Operation, Maintenance and Decommission	9. Quality Safety and RAMS
17 Systems configured by application data	Y	Y	Y	Y	Y	Y	Y
Annex A (normative) Criteria for the selection of techniques and measures	Y	Y	Y	Y	Y	Y	Y

17 Appendix H – Lifecycle Relationship with pr EN 50129

Electronic Systems Railway Applications –Safety Related Electronic Systems for Signalling

pr EN 50129 Applicable Sections	3. Plan, Implement, Manage	4. Specify, Design and Develop Products and Systems	5. Production and Manufacture	6. Installation	7. System validation, Safety acceptance & Commission	8. Operation, Maintenance and Decommission	9. Quality Safety and RAMS
Introduction	Y	Y	Y	Y	Y	Y	Y
1. Scope	Y	Y	Y	Y	Y	Y	Y
2. Normative references	Y	Y	Y	Y	Y	Y	Y
3 Definitions and abbreviations	Y	Y	Y	Y	Y	Y	Y
4 Overall framework of this standard	Y	Y	Y	Y	Y	Y	Y
5 Conditions for safety acceptance and approval	Y	Y	Y	Y	Y	Y	Y
5.1 The Safety Case	Y	Y	Y	Y	Y	Y	Y
5.2 Evidence of quality management	Y	Y	Y	Y	Y	Y	Y
5.3 Evidence of safety management	Y	Y	Y	Y	Y	Y	Y
5.4 Evidence of functional and technical safety	Y	Y	Y	Y	Y	Y	Y
5.5 Safety acceptance and approval	Y	Y	Y	Y	Y	Y	Y
A Safety Integrity Levels	-	Y	-	-	Y	Y	Y
B Additional technical requirements	-	Y	Y	Y	Y	Y	Y
C Identification of hardware component failure modes	-	Y	-	-	Y	-	Y
D Supplementary technical information	-	Y	-	-	Y	-	Y
E Techniques and Measures… for avoidance of systematic faults and control of random and systematic faults.	Y	Y	Y	Y	Y	Y	Y

18 Appendix I – Relationship with BS IEC 61508

Functional Safety of Electrical/Electronic/Programmable Electronic Safety- Related Systems

BS IEC 61508 covers all safety-related systems, which are electro-technical in nature (i.e. electromechanical systems, solid-state electronic systems and computer-based systems). The standard is generic and can be used directly by industry (as a 'standalone' standard) and also by international standards organisations as a basis for the development of sector standards (e.g. for the machinery sector, for the process sector or for the nuclear sector). The standard will therefore influence the development of electrical, electronic and programmable electronic (E/E/PE) safety-related systems across all sectors

BS IEC 61508 Applicability of Sections	3. Plan, Implement, Manage	4. Specify, Design and Develop Products and Systems	5. Production and Manufacture	6. Installation	7. System validation, Safety acceptance & Commission	8. Operation, Maintenance and Decommission	9. Quality Safety and RAMS
Part 1: General requirements	Y	Y	-	Y	Y	Y	Y
Part 2: Requirements for E/E/PE safety-related systems	-	Y	-	-	Y	Y	Y
Part 3: Software requirements	-	Y	-	-	Y	Y	Y
Part 4: Definitions and abbreviations	Y	Y	-	-	Y	Y	Y
Part 5: Examples of methods for the determination of safety integrity levels	-	Y	-	-	Y	-	Y
Part 6: Guidelines on the application of BS IEC 61508-2 and BS IEC 61508-3	-	Y	Y	Y	Y	Y	Y
Part 7: Overview of techniques and measures	Y	Y	-	-	Y	Y	Y

19 Appendix J – Index of IRSE Technical Papers

The following index of IRSE Technical Papers has been included in this Body of Knowledge for completeness. The index is a listing of all identified IRSE (UK) papers up until the time of publishing. Updates will be posted on the IRSE website from time to time. www.irse.org

An Exam Module number under the column marked 'IRSE Exam Modules' indicates papers that have been identified as recommended reading for the IRSE Professional Examination

Where a chapter number has been given under the column marked 'Body of Knowledge' it indicates a paper where the content is significantly relevant to the chapter indicated in the Body of Knowledge.

Year	Title of Paper	Author(s)	Date Read	Publication	Page/ Section	No. of Pages	IRSE Exam Modules	Body of Knowlegde Section
1910	Detectors	Johnson AH	08-Nov-10	ISE Proceedings 1910	19	14 (1)		4
1911	The Installation & Maintenance of Track Circuit	Bound A F	02-May-11	ISE Paper in IRSE Proceedings 1910-1914	1	43 (1)		6
1911	The Theory of Track Circuit	Crook GH	N/K	ISE Paper in IRSE Proceedings 1910-1914	1	22 (1)		4
1913	Signalling and its Connection with the Construction and Management of Railways	Insell R J	25-Feb-13	IRSE Proceedings 1913	14	18 (1)		3
1913	Sympathetic Numbering and Grouping of Levers	Parsons J	02-Dec-13	IRSE Proceedings 1913	57	20 (2)		4
1913	Colours and Colour Blindness	Hurst A	N/K	IRSE Proceedings 1913	32	23 (1)		4
1914	Characteristics and Efficiency Factors of some typical Electric Signalling Circuits	Crook GH	21-Apr-14	IRSE Proceedings 1914	19	50 (2)		4
1914	American Signal Practice as compared with British Practice	Rudd A H	28-May-14	IRSE Proceedings 1914	69	62 (2)		3
1915	A Review of the Art of Signalling, and some Suggestions	Bound A F	24-Feb-15	IRSE Proceedings 1915	14	125 (2)		3
1916	The Relative Merits of Track Circuits and Bars for Fouling Point Protection	(Discussion introduced by) Brown HG	01-Feb-16	IRSE Proceedings 1916	12	13		4
1916	Faults on Telegraph and Telephone Circuits	Edmondson G	06-Jun-16	IRSE Proceedings 1916	25	20		9
1916	The Economical Signalling of a Colonial Railway	Rose A C	07-Nov-16	IRSE Proceedings 1916	45	15		3
1917	Automatic Signalling	Ellison C H	06-Mar-17	IRSE Proceedings 1917	9	70 (9)		4
1917	Some Impressions of Continental Signalling Practice	Griffiths R S	24-Oct-17	IRSE Proceedings 1917	79	41 (3)		3
1918	The Maximum Regulating Resistance and Maximum Shunt Resistance of Track Circuits	Thorrowgood W J	09-Apr-18	IRSE Proceedings 1918	11	83 (6)		4
1918	A Graphical Method of Solving DC Track Circuit Problems	Proud H M	11-Jun-18	IRSE Proceedings 1918	94	82 (5)		4
1919	Renovation of Leclanche Porous Pots and the Re-use of the Interiors of Spent Dry Cells	Thorrowgood W J	30-Apr-19	IRSE Proceedings 1919	15	53		4
1919	Report of the Committee on Track Circuit Nomenclature	-	22-Oct-19	IRSE Proceedings 1919	68	6		3
1920	British Railway Telegraphs, France 1914-1919	Tweedie MG	07-Jan-20	IRSE Proceedings 1920	9	28		4

1920	Some Problems of Track Circuit Layout	Acfield WC	16-Nov-20	IRSE Proceedings 1920	66	50 (2)		4
1920	Discussion on Track Circuit Nomenclature	-	07-Jul-20	IRSE Proceedings 1920	62	3		3
1921	Some Fundamental Calculations of AC Track Circuits	Gall D C	23-Mar-21	IRSE Proceedings 1921	40	58		4
1921	Magnetic Storms: Their Effects upon Railway Signal & Telegraph Apparatus	Thorrowgood W J	27-Apr-21	IRSE Proceedings 1921	105	38 (3)		4
1921	Some Problems of Automatic Train Control	Thorrowgood W J	07-Jul-21	IRSE Proceedings 1921	165	49		4
1921	Some Recent Developments of Token Working on Single Line Railways	Roberts WS	28-Oct-21	IRSE Proceedings 1921	214	34		4
1921	Three-Position Signalling	Tattersall A E	02-Nov-21	IRSE Proceedings 1921	247	25 (4)		4
1921	Signal Repeaters and Light Indicators	Dyer H H	22-Dec-21	IRSE Proceedings 1922	26	9		4
1921	Discussion on Track Circuit Forms	-	11-May-21	IRSE Proceedings 1921	143	21		4
1921	Light Signals	Sadler W J	24-Nov-21	IRSE Proceedings 1921	272	12		4
1922	Intermediate Block Signalling	Carslake C	06-Mar-22	IRSE Proceedings 1922	59	26(2)		4
1922	Signal Replacers	Cooke B W	08-Mar-22	IRSE Proceedings 1922	44	15		4
1922	Location of Signals as an Aid to Traffic-Working	Proud R S	20-Apr-22	IRSE Proceedings 1922	85	23		3
1922	The Rotary Interlocking Block	Wallis A B	26-Apr-22	IRSE Proceedings 1922	117	19 (6)		4
1922	Training of Maintenance Staff	Tonge JH	01-May-22	IRSE Proceedings 1922	136	23		8
1922	Weissenbruch's Signal System on the Belgian State Railways	Lascelles T S	14-Jun-22	IRSE Proceedings 1922	149	35 (14)		3
1922	Light Signals	Fawkes H E	21-Jun-22	IRSE Proceedings 1922	184	18 (4)		4
1922	Compensation of Point Rodding	Guest T	22-Feb-22	IRSE Proceedings 1922	34	10		4
1922	Railway Accidents	Holt G	22-Mar-22	IRSE Proceedings 1923	40	92 (2)		3
1923	Signalling Apparatus for use in Foggy Weather and Snow on the Metropolitan Railway	Challis W	16-May-23	IRSE Proceedings 1923	132	24 (4)		4
1923	Theory of Interlocking	Moore J S	18-Jul-23	IRSE Proceedings 1923	148	21(3)		3
1923	Automatic Telephone Switchboards, Waterloo, Eastleigh and Southampton	Thorrowgood W J	03-Oct-23	IRSE Proceedings 1923-4 Part II	200	24(3)		4
1923	Signalling Colours	Lankshear FR/Bound AF	07-Nov-23	IRSE Proceedings 1923-4 Part II	226	19 (6)		4
1923	Transient Track Circuits	Hudd A E	05-Dec-23	IRSE Proceedings 1923	245	47		4
1924	Signalling on the London Underground Railways	Every W S	12-Nov-24	IRSE Proceedings 1924-5 Part II	154	46 (9)		4
1924	Electric Signal Machines	Boot J	12-Mar-24	IRSE Proceedings 1924	33	17		4
1924	A Survey of Indian Signalling	Rose A C	09-Apr-24	IRSE Proceedings 1924	50	25 (3)		3
1924	Open Discussion on Mechanical and Electrical Detection	-	14-May-24	IRSE Proceedings 1924	75	15		4
1924	Mechanical Interlocking	Addis F R	16-Jul-24	IRSE Proceedings 1924	92	21(10)		4

1924	Open Discussion on Possibilities of Railway Signalling from an economic point of view	-	01-Oct-24	IRSE Proceedings 1924-5 Part II	137	16		3
1924	Report of the Committee on Three-Position Signalling	-	10-Dec-24	IRSE Proceedings 1924-5 Part II	202	47		3
1925	Ministry of Transport Requirements, 1925, and their Application to Modern Signalling Practice	Holt G	30-Sep-25	IRSE Proceedings 1925-6 Part II	165	27		3
1925	Continental Practice in the working of Points and Signals by the Compensated Double-wire Transmission System	Sadler W J	11-Nov-25	IRSE Proceedings 1925-6 Part II	197	60 (1)		4
1925	Long Burning Signal Lamps	Morgan H E/Hookman F J	09-Dec-25	IRSE Proceedings 1925-6 Part II	257	30 (4)		4
1925	The Double Wire System of Mechanical Signalling	Griffiths R S	11-Mar-25	IRSE Proceedings 1925	36	42 (3)		4
1925	Some Recent Developments in AC Track Circuits	Dell R	08-Apr-25	IRSE Proceedings 1925	79	23 (6)		4
1925	Lock and Block	Lascelles T S	13-May-25	IRSE Proceedings 1925	103	29 (4)		4
1926	The Construction of Aerial, Covered, and Underground Lines as applied to Railways	Wood W	13-Jan-26	IRSE Proceedings 1925-6 Part II	287	32 (3)		4
1926	Four Aspect Colour Light Signals	Thorrowgood W J	10-Mar-26	IRSE Proceedings 1926	29	29 (2)		4
1926	A Comparative Survey of American and British Signalling	Parsons J	21-Apr-26	IRSE Proceedings 1926-7 Part II	117	27 (8)		3
1926	Selection, Inspection and Control of Materials used in Railway Signalling	Woods R C	02-Jun-26	IRSE Proceedings 1926	58	29 (1)		5
1926	The Fundamentals of Automatic Telephone Switching	Harrison H H	10-Nov-26	IRSE Proceedings 1926-7 Part II	148	28 (3)		4
1926	Electrical Power for Railway Signalling and Communications	Tweedie M G	08-Dec-26	IRSE Proceedings 1926-7 Part II	176	46 (3)		4
1927	Railway Level Crossings	Horler F	02-Mar-27	IRSE Proceedings 1927	31	37		4
1927	Some Signalling Overseas	Proud H M	13-Apr-27	IRSE Proceedings 1927	68	21 (1)		3
1927	Four Aspect Colour Light Signals and Power Signalling in Practice	Thorrowgood W J	18-May-27	IRSE Proceedings 1927	89	41(3)		3
1927	Route Signalling	Boot J	09-Nov-27	IRSE Proceedings 1927-8 Part II	178	39 (4)		3
1927	Automatic and Power Signalling Economics	Crook G H	14-Dec-27	IRSE Proceedings 1927-8 Part II	220	40 (6)		3
1927	Railway Signalling in Germany	Lascelles T S	12-Jan-27	IRSE Proceedings 1926-7 Part II	222	35 (3)		3
1928	The Square Sheet Locking Table	Rose A C	09-May-28	IRSE Proceedings 1928	92	27 (2)		3

1928	Short Papers on Some Recent Signalling Developments & Problems: Notes on some Recent Signalling Developments on the Great Western Railway	Crook G H	14-Nov-28	IRSE Proceedings 1928-9 Part II	171	7 (3)		3
1928	Methods of Holding the Road by Mechanical or Electrical Means, or both, during the passage of trains	Discussion	11-Jan-28	IRSE Proceedings 1927-8 Part II	260	26 (2)		4
1928	Speed and Route Signal Aspects Compared	Prescott C W	14-Mar-28	IRSE Proceedings 1928	26	28 (3)		3
1928	A Short Account of Siemens and Halske Lock and Block System	Lascelles T S	04-Apr-28	IRSE Proceedings 1928	54	38 (4)		4
1928	Short Papers on Some Recent Signalling Developments & Problems: Description of Trains between boxes where there are two or more Block Sections	Challis W	14-Nov-28	IRSE Proceedings 1928-9 Part II	167	5		3
1928	Short Papers on Some Recent Signalling Developments & Problems: Utilisation of Discarded Single Needle Telegraph Instruments as Three-wire Block Instruments	Guyatt G	14-Nov-28	IRSE Proceedings 1928-9 Part II	178	5		3
1928	Short Papers on Some Recent Signalling Developments & Problems: discussion	-	14-Nov-28	IRSE Proceedings 1928-9 Part II	182	31		3
1929	Token Instruments and their use in securing Safety in Single Line Working	Leake F W	09-Jan-29	IRSE Proceedings 1928-9 Part II	213	31(3)		3
1929	Early History of Railway Signalling	Deakin W H	13-Mar-29	IRSE Proceedings 1929	22	22 (3)		3
1929	Electric Locking Releases - Their Use and Possible Abuse	Bound A F	17-Apr-29	IRSE Proceedings 1929	44	31 (1)		3
1929	Inter-Communication Telegraph Working	Webster J A	08-May-29	IRSE Proceedings 1929	75	27 (7)		3
1929	Specification, Installation and Maintenance of Power Signalling Systems	Moore H W	13-Nov-29	IRSE Proceedings 1929-30 Part 2	163	21 (6)		4
1929	Some Notes on AC Rectifiers	Downes F A	11-Dec-29	IRSE Proceedings 1929-30 Part 2	184	35 (5)		4
1930	Some further Electrical Details of the Bow Road - Barking Signalling	Dyer H H	08-Jan-30	IRSE Proceedings 1929-30 Part 2	219	30 (5)		3
1930	Reminiscences of an Early Signal Engineer	Deakin W H	12-Mar-30	IRSE Proceedings 1930	25	22 (2)		-
1930	The Problem of Signal Aspects: What Must We Tell the Man on the Footplate?	Griffiths R S/Lascelles T S	09-Apr-30	IRSE Proceedings 1930	47	38 (3)		3
1930	The Training of the Railway Signal Engineer	Raynar-Wilson F	14-May-30	IRSE Proceedings 1930	85	23		-
1930	Railway Signalling in Holland	De Vos Van Nederveen Cappel G J	13-Nov-30	IRSE Proceedings 1930-31 Part 2	154	20 (5)		3

1930	Street Traffic Signals	Castle FL/Horler F	10-Dec-30	IRSE Proceedings 1930-31 Part 2	179	35 (4)		3
1931	The Installation of Double-Wire Interlocking on the Assam-Bengal Railway	Baker E W	14-Jan-31	IRSE Proceedings 1931	11	56 (5)		6
1931	A Contribution to the Question of Route Lever Working	Lascelles T S	11-Mar-31	IRSE Proceedings 1931	79	43 (4)		3
1931	Ethics and Economics of Speed Signalling	Crook G H	23-Apr-31	IRSE Proceedings 1931	122	46 (3)		3
1931	Electric Lever Interlocking and Intermittent Fed Track Circuits	Challis W	13-May-31	IRSE Proceedings 1931	168	19 (5)		4
1931	Railway Signalling Economies	Prescott C W	11-Nov-31	IRSE Proceedings 1932	13	29		3
1931	Indicators and Repeaters	Buckingham W/Weir A	09-Dec-31	IRSE Proceedings 1931-2 Part II	242	25 (3)		4
1931	Automatic Train Control (Student Prize Essay, 1931)	Myers H	-	IRSE Proceedings 1931-2 Part II	292	15		3
1931	Developments in Signalling on the Bombay Suburban Section of the BB&CI Railway (India) since 1925	Davies C E	-	IRSE Proceedings 1931-2 Part II	308	23 (1)		3
1932	Disc and Miniature Signals for Shunting and Setback Movements	Wagenrieder B F	13-Jan-32	IRSE Proceedings 1931-2 Part II	267	25 (2)		4
1932	Railway Colour Light Signalling in Relation to Manual Block and Multiple Aspect Signals	Bound A F	14-Mar-32	IRSE Proceedings 1932	57	93 (6)		3
1932	The Reform of the Signal Aspects on the French Railways	Lascelles T S	13-Apr-32	IRSE Proceedings 1932	150	22 (3)		3
1932	Signal Lamps and Kerosene Oils	Baker E W	11-May-32	IRSE Proceedings 1932-3 Part II	241	77 (4)		4
1932	Signals and Sand Drags	Rose A C	09-Nov-32	IRSE Proceedings 1932-3 Part II	318	24 (2)		4
1932	Lightning Protection and Interference from High Voltages	Wood W	14-Dec-32	IRSE Proceedings 1932-3 Part II	342	31 (6)		4
1932	The Uses of Electricity in Signalling (Student Prize Essay, 1932)	Lang LC	-	IRSE Proceedings 1932-3 Part II	390	11		3
1933	Token Exchange Apparatus in Scotland (LMSR)	Bryson W	11-Jan-33	IRSE Proceedings 1932-3 Part II	378	12 (4)		3
1933	Discussion on the Running of Electric Wires and Cables and the Class of Cable and Wire used	-	08-Mar-33	IRSE Proceedings 1933	28	25 (1)		3
1933	Automatic Train Control	Crook G H	11-Apr-33	IRSE Proceedings 1933	53	63 (8)		3
1933	Railway Telephony	Edwards J R	10-May-33	IRSE Proceedings 1933	116	31(8)		3

1933	Discussion on the Problem of Overcoming Wrong-side Failures of Track Circuits, caused by Sand, Rust, Grease etc	-	08-Nov-33	IRSE Proceedings 1933-4 Part II	210	19 (1)		3
1933	Railway Signalling in Australia	Prescott C W	13-Dec-33	IRSE Proceedings 1934	14	35 (2)		3
1933	The Component Parts of a Mechanical Signalling Plant and their Functions (Student Prize Essay, 1933)	Davis JS	-	IRSE Proceedings 1933-4 Part II	259	11		3
1934	The Financial Side of Signalling Economies	Dyer H H	17-Jan-34	IRSE Proceedings 1933-4 Part II	229	30		3
1934	Some Notes on Centralised Traffic Control	Peter L H	11-Mar-34	IRSE Proceedings 1934	65	27 (3)		3
1934	Single Line Switching-out Problems	Roberts W S	17-Apr-34	IRSE Proceedings 1934	92	27 (3)		3
1934	The Railway Rule Book and its Relation to Signalling	Rickett A G /Wagenrieder B F	09-May-34	IRSE Proceedings 1934	119	30		3
1934	The Distant Signal (Discussion)	-	10-Oct-34	IRSE Proceedings 1934-5 Part II	219	18		3
1934	Electrically Controlled Gravity Marshalling Yards	Jackson F S	14-Nov-34	IRSE Proceedings 1934-5 Part II	237	33 (3)		3
1934	Some Developments in Intermediate Block Signalling	Spendlove S W	12-Dec-34	IRSE Proceedings 1934-5 Part II	270	51 (4)		3
1935	Some Applications of Rectifiers to Railway Signalling	Peter L H	16-Jan-35	IRSE Proceedings 1934-5 Part II	321	24 (3)		4
1935	Nomenclature of Interlocking Signals	Egginton F B	13-Mar-35	IRSE Proceedings 1935	34	28 (3)		3
1935	Economic Aspects of Railway Signalling	Pearson A J	10-Apr-35	IRSE Proceedings 1935	62	25		3
1935	Traffic Actuated Road Signals	Edwards F	28-May-35	IRSE Proceedings 1935	87	33 (6)		3
1935	Discussion on the Comparison between Mechanical and Electrical Interlocking	-	09-Oct-35	IRSE Proceedings 1935-6 Part II	187	19		3
1935	Discussion on Standardisation of Methods and Practice	-	20-Nov-35	IRSE Proceedings 1935-6 Part II	206	19		3
1935	Switching of Block Sections	Burton F	18-Dec-35	IRSE Proceedings 1935-6 Part II	225	31 (1)		3
1935	General Characteristics of Colour and Position Light Signals (Student's Prize Essay, 1935)	Young F W	-	IRSE Proceedings 1935-6 Part II	283	12		3
1936	Design, Manufacture and Examination of Mechanical Signalling Apparatus	Hardman P W	22-Jan-36	IRSE Proceedings 1935-6 Part II	256	27 (2)		4
1936	Remote Control and Operation of Outlying Points	Langley P A	11-Mar-36	IRSE Proceedings 1936	34	39 (11)		4
1936	Some Notes on Electric Interlocking	Webb W H R	08-Apr-36	IRSE Proceedings 1936	75	28 (4)		3
1936	Electro-Pneumatic Operation for Signalling Apparatus	Proud R S	20-May-36	IRSE Proceedings 1936	103	28 (2)		4

1936	Signalling Developments in the Irish Free State	Guthrie H J	14-Oct-36	IRSE Proceedings 1936-7 Part II	200	23 (4)		3
1936	How Telephones Help to Work Railways	Green W E	25-Nov-36	IRSE Proceedings 1936-7 Part II	223	29		3
1936	A Chronological Record of the Protection of Facing Points	Griffiths R S	16-Dec-36	IRSE Proceedings 1936-7 Part II	252	21 (7)		3
1937	The Design of Signal Structures	Birchenhough H/Wright J	27-Jan-37	IRSE Proceedings 1936-7 Part II	273	49 (7)		4
1937	Running Signals	Wagenrieder B F	24-Mar-37	IRSE Proceedings 1937	38	30 (1)		3
1937	The Training of Maintenance Staff for Signal and Telegraph Work	Fraser J H	14-Apr-37	IRSE Proceedings 1937	68	23 (1)		8
1937	Rubber Insulated Cables and the effect of Outside Conditions and Agencies upon the Dielectric	Bayles E A	26-May-37	IRSE Proceedings 1937	92	17		5
1937	Discussion on Central Box Amalgamation Schemes	-	06-Oct-37	IRSE Proceedings 1937-8 Part II	187	16		3
1937	The Human Element	Horler F	10-Nov-37	IRSE Proceedings 1937-8 Part II	203	29		3
1937	Relay Interlocking	Golding A J	08-Dec-37	IRSE Proceedings 1937-8 Part II	232	35 (4)		4
1938	Signalling Developments on the New Zealand Government Railways	Wyles G W	26-Jan-38	IRSE Proceedings 1937-8 Part II	267	24 (5)		3
1938	High Speed Trains and their Effect on Signalling	Egginton F B	23-Mar-38	IRSE Proceedings 1938	39	22		3
1938	Principles of Selectivity as applied to Railway Telephony and Telegraphy	Quelch R P	27-Apr-38	IRSE Proceedings 1938	62	25 (3)		3
1938	Gravitation Yards	Kubale J C	25-May-38	IRSE Proceedings 1938	89	30 (4)		3
1938	Some Notes on Acceleration, Speed and Retardation of Trains and their Relation to Signalling	Woodbridge A W	05-Oct-38	IRSE Proceedings 1938-9 Part II	184	31 (2)		3
1938	Train Describers	Mott J E	16-Nov-38	IRSE Proceedings 1938-9 Part II	218	38 (6)		4
1938	A Comparison between Relay and Electric Lever Interlocking	Challis E W	21-Dec-38	IRSE Proceedings 1938-9 Part II	256	37 (3)		3
1939	Optical Systems for Light Signals	Candler J E	25-Jan-39	IRSE Proceedings 1938-9 Part II	294	28 (4)		4
1939	Safety and Design of Signal Circuits	Bruce F C	22-Mar-39	IRSE Proceedings 1939	31	25 (2)		7
1939	Electric Lamps for Railway Signalling	Vowler JCG/Sturgess P J	19-Apr-39	IRSE Proceedings 1939	56	28 (5)		4

1939	Signalling and Interlocking on the Metre Gauge System of the BB&CI Railway	Towers H C	17-May-39	IRSE Proceedings 1939	85	33 (6)		3
1940	Centenary of Railway Inspection (reprinted from The Railway Gazette)	-	12-Jul-40	IRSE Proceedings 1940	131	16		3
1940	An Old Outdoor Track Indicator (reprinted from The Railway Gazette)	-	26-Jul-40	IRSE Proceedings 1940	11	3		3
1940	The Signal Manufacturer and the National Effort	Griffiths RS	-	IRSE Proceedings 1940	10	1		5
1940	Report of the Committee on a Recommended Standard Form of Table for Electric Lever Interlocking	-	-	IRSE Proceedings 1940	14	21		3
1940	Signalling Developments on the Great Indian Peninsular Railway	Cox H E	-	IRSE Proceedings 1940	55	58 (6)		3
1940	Historical Note on Indian Signalling and Interlocking 1890-1898	Cox H E	-	IRSE Proceedings 1940	113	6		3
1940	Signals and Maximum Track Capacity	Rose A C	-	IRSE Proceedings 1940	119	12 (1)		3
1941	New Signalling in the Severn Tunnel	Lascelles T S	Jun 1942	IRSE Proceedings 1941	98			3
1941	Early Tube Railway Signalling	Lascelles T S	Mar 1941	IRSE Proceedings 1941	40			3
1941	Models for Training Railway Staff	Towers H C	Mar 1941	IRSE Proceedings 1941	66			3
1941	C E Spagnoletti	Lascelles T S	Mar 1941	IRSE Proceedings 1941	70			-
1941	Accumulators and their Ailments	Elliott T C	Mar 1941	IRSE Proceedings 1941	73			4
1941	Special Catch Point Interlocking	Rose A C	Mar 1941	IRSE Proceedings 1941	86			4
1941	Signalling on the Swedish State Railways	Lascelles T S	Mar 1941	IRSE Proceedings 1941	90			3
1942	Fifty Years of Signalling in the United States	Rudd A H	Jun 1942	IRSE Proceedings 1942	41			3
1942	A Note on the Great Northern and City Line Signalling	Lascelles T S	Jun 1942	IRSE Proceedings 1942	84			3
1942	Power Worked Lever Remote Control Signalling System	Dell R	Jun 1942	IRSE Proceedings 1942	87			4
1943	Development in Electric Cables	Fairfield R M	15-Sep-43	IRSE Proceedings 1943	24			4
1943	History and Development of Signalling on the Railways of South Africa	Starkey S	Oct 1943	IRSE Proceedings 1943	37			3
1943	Some Recollections, 1878 - 1925	Moore J S	Oct 1943	IRSE Proceedings 1943	78			-
1943	Notes on Broken Wire Locks of Double-wire Point Mechanisms	Cox H E	Oct 1943	IRSE Proceedings 1943	89			3
1943	The Signal Engineer and some of his Inventions	Rose A C	Oct 1943	IRSE Proceedings 1943	91			3
1943	The Abbots Ripton Accident and the Origin of the Centrally Balanced Semaphore	Lascelles T S	Oct 1943	IRSE Proceedings 1943	103			3

1944	Coded Track Circuits, their Theory and Application	Coley J P/McGregor R	Jun 1944	IRSE Proceedings 1944	39			4
1944	Petroleum Products Used in Railway Signalling	Kay W	May 1944	IRSE Proceedings 1944	24			5
1944	Carrier Telephone Systems and their Application to British Trunk Line Communications	Thompson W	Sep 1944	IRSE Proceedings 1944	65			4
1944	Construction and Maintenance Problems on the BB&CI Railway (Metre Gauge System), 1940-3	Towers H C	Sep 1944	IRSE Proceedings 1944	87			3
1944	ARP Lighting Restrictions as applied to Colour Light Signals on the BB&CI Railway	Carvey C M	Sep 1944	IRSE Proceedings 1944	96			3
1944	Multiple Aspect Signalling on the South Indian Railway	White C A	Sep 1944	IRSE Proceedings 1944	102			3
1945	The Signalling of Single Line Stations	Griffiths R S	Apr 1945	IRSE Proceedings 1945	35			3
1945	Subsidiary Signals: their Development and some Problems arising from their use	Egginton F B	Dec 1945	IRSE Proceedings 1945	131			4
1945	Loudspeakers as applied to Railway Operations	Claridge W J	Jul 1945	IRSE Proceedings 1945	82			3
1945	Running, Jointing and Terminating of Railway Signalling Cables	Discussion	Nov 1945	IRSE Proceedings 1945				6
1946	Meteorological Factors concerning the Design and Operation of Railway Signalling Apparatus	Champion D L	23-Dec-46	IRSE Proceedings 1946	89			4
1946	Some Reflections on Upper Quadrant Signals	Griffiths R S	Apr 1946	IRSE Proceedings 1946	66			3
1946	The Manufacture of Glass, with special reference to Railway Signalling Requirements	Holmes J G	Dec 1946	IRSE Proceedings 1946	130			5
1946	Manual Block Working	Wagenrieder B F	Feb 1946	IRSE Proceedings 1946	44			3
1947	The Co-relation of Signal and Permanent Way Work	Fraser J H	Apr 1947	IRSE Proceedings 1947	105			3
1947	Signalling Installation Work on the London Transport System	Firminger H W	Dec 1947	IRSE Proceedings 1947	211			6
1947	Electrical Timing Circuits	Riddle H J W	Feb 1947	IRSE Proceedings 1947	78			4
1947	Electrical Power Supplies for Railway Signalling	Insley L R	Jan 1947	IRSE Proceedings 1947	37			4
1947	New System of Signal Aspects for the Belgian National Railways	Derijckere E J F	Oct 1947	IRSE Proceedings 1947	165			3

1948	Some Aspects of Signal and Telegraph Maintenance	Old D	07-Jan-48	IRSE Proceedings 1948	31			8
1948	Signalling of Siding Connections - Development of Remote Control Electric Locking Methods	Crook G H	06-Feb-48	IRSE Proceedings 1948	52			4
1948	Automatic Switching applied to Teleprinter Working	Shaw D	Apr 1948	IRSE Proceedings 1948	92			4
1948	Workshop servicing of Signalling Equipment (Electrical & Mechanical)	Pierce E E	Dec 1948	IRSE Proceedings 1948	198			5
1948	Labelling of Wires in Signalling Circuits	Barnes H	Nov 1948	IRSE Proceedings 1948	155			3
1948	Automatic Train Control - the Link between the Track and the Moving Locomotive	Mott J E	Nov 1948	IRSE Proceedings 1948	166			3
1948	Modified Relay Interlocking in Sweden	Hård T	Oct 1948	IRSE Proceedings 1948	124			3
1949	Frequency of Signals	Wagenrieder B F	21-Jan-49	IRSE Proceedings 1949	37			3
1949	Relay Standardisation	Coley J P	16-Feb-49	IRSE Proceedings 1949	66			4
1949	Ticket Printing and Issuing Machines as applied to Railway Practice	Powers B J	08-Apr-49	IRSE Proceedings 1949	107			3
1949	The Relationship between Signalling and Brake Power in the Handling of Modern Traffic	Nock O S	12-Oct-49	IRSE Proceedings 1949	137			3
1949	Some Comments on Signal Arm Proving	Young F W	09-Nov-49	IRSE Proceedings 1949	183			3
1949	Speed Control for Close Headway Working	Owen W	09-Dec-49	IRSE Proceedings 1949	212			3
1949	Principles of the Layout of Signals (British Practice)	Challis W H	-	Green Booklet No.1	-	35	1,2,3	4
1949	Principles of Interlocking (British Practice)	Such W H	-	Green Booklet No.2	-	36	2,3	4
1949	Workshop servicing of Signalling Equipment (Electrical & Mechanical) - Discussion	Pierce E E	Mar 1949	IRSE Proceedings 1949				5
1949	All-Electric Interlocking Lever Frames versus Relay Interlocking Control Panels for Large Installations	Venning C F D		IRSE Proceedings 1949	194			3
1949	Design and Manufacture of Cables and Wires	Wright J M		IRSE Proceedings 1949	236			5
1950	Improvements in Track Circuit Shunt (Injector Track Circuit)	Hadaway H W	18-Jan-50	IRSE Proceedings 1950	43			4
1950	London Transport Telecommunications	Ottley P W	08-Feb-50	IRSE Proceedings 1950	71			3
1950	Road Traffic Signalling	Riddle H J N	09-Feb-50	IRSE Proceedings 1950	217			3
1950	Some Notes on the Introduction of Flat Bottom Rails in Britain and its Effect on Signalling	Devine J H	14-Apr-50	IRSE Proceedings 1950	98			3

1950	Signalling Developments on the BB&CI Railways	Towers H C	11-Oct-50	IRSE Proceedings 1950	126			3
1950	Centralised Traffic Control Operation and Technical Considerations of Equipment	Porter J W	13-Dec-50	IRSE Proceedings 1950	182			3
1950	Single Line Control (British Practice)	Doswell P C	-	Green Booklet No.4	-	30	1,2,3,5	4
1951	Testing Methods as Applied to Power Signalling	Marshall N	03-Jan-51	IRSE Proceedings 1951	40			7
1951	Metal Rectifiers in Railway Signalling	Thompson L E	14-Feb-51	IRSE Proceedings 1951	61			4
1951	The Signalling System of the Swedish State Railways	Hård T	04-Apr-51	IRSE Proceedings 1951	93			3
1951	Maintenance Features of Power Signal Installations	Daley JR	23-Jun-51	IRSE Proceedings 1951	200			8
1951	Modern Signalling on French National Railways	Walter J G	03-Oct-51	IRSE Proceedings 1951	133			3
1951	Notes on Dual Maintenance	Baldwin H O	07-Nov-51	IRSE Proceedings 1951	153			8
1951	Non-Token Methods of Single Line Working	McKillop A N	14-Dec-51	IRSE Proceedings 1951	169			3
1952	Special Signalling for Temporary Speed Restrictions	Owen W	09-Jan-52	IRSE Proceedings 1952	50			3
1952	Modern Developments in Signalling, their Justification and Application on the Eastern Bengal Railway, Pakistan	Dennison H F	06-Feb-52	IRSE Proceedings 1952	72			3
1952	Track Circuits in DC Electrified Areas	Shipp D G	05-Mar-52	IRSE Proceedings 1952	108			4
1952	Modern Signalling Aspects on Netherlands Railways	Verstegen J H	16-Oct-52	IRSE Proceedings 1952	149			3
1952	Running Line Capacity	Wagenrieder B F	12-Dec-52	IRSE Proceedings 1952	187			3
1952	Railway Signalling Power Supplies (British Practice)	Mitchell D L	-	Green Booklet No.11	-	38	5	3
1953	Interference from Electric Power Lines and Traction Circuits	Turner D R	13-Jan-53	IRSE Proceedings 1953	48			3
1953	Power Signalling Equipment: Design and Performance related to Installation and Maintenance	Knotts L J M	18-Feb-53	IRSE Proceedings 1953	101			6
1953	The Planning and Execution of Major Signalling Changeovers	Challis C F	10-Mar-53	IRSE Proceedings 1953	141			3
1953	Modern Signalling Developments on the Swiss Railways	Oehler K W	21-Oct-53	IRSE Proceedings 1953	162			3
1953	The Economic Aspects of Railway Signalling Cables	Russell N W	18-Nov-53	IRSE Proceedings 1953	192			5
1953	Layout of Signal Cabins	Horler F	17-Dec-53	IRSE Proceedings 1953	208			3
1954	Level Crossing Protection	Loosemore J P	12-Jan-54	IRSE Proceedings 1954	41			3

1954	Some Signalling Developments on the Western Region, British Railways, 1947-1953	Tyler J F H	17-Feb-54	IRSE Proceedings 1954	97			3
1954	Testing of Mechanically Interlocked Lever Frames	Taylor H G E	03-Mar-54	IRSE Proceedings 1954	124			7
1954	Route Indicators	Webster E A	17-Mar-54	IRSE Proceedings 1954	137			4
1954	Signalling Developments in Germany	Reschuh Dr H	28-Oct-54	IRSE Proceedings 1954	179			3
1954	Repeating of Oil Lit Signal Lamps in Signal Boxes	Pierce E E	17-Nov-54	IRSE Proceedings 1954	213			3
1954	Electric Signal Lamp Repeating and Proving	Devine J H	17-Nov-54	IRSE Proceedings 1954	223			4
1954	Loudspeakers in Marshalling Yards	Flexman B W	10-Dec-54	IRSE Proceedings 1954	231			3
1955	The Alkaline Battery	Dowsett G H	25-Jan-55	IRSE Proceedings 1955	55			4
1955	Earth Leakage Detectors	Riddle H J N	22-Feb-55	IRSE Proceedings 1955	84			4
1955	Rapid Transit Signalling in North America	McKillop A N	30-Mar-55	IRSE Proceedings 1955	110			3
1955	Multiple Aspect Signalling	Cardani A A	20-Oct-55	IRSE Proceedings 1955	142			3
1955	Point Control and Detection	Tyler J F H	22-Nov-55	IRSE Proceedings 1955	178			4
1955	Testing of Mechanical Interlocking	Cartwright W L	13-Dec-55	IRSE Proceedings 1955	195			7
1956	The Design of Signalling Apparatus	Birchenough H	18-Jan-56	IRSE Proceedings 1956	47			4
1956	Cabling in the Severn Tunnel	Jacobs P	15-Feb-56	IRSE Proceedings 1956	87			6
1956	Signalling from the Driver's Point of View	Nock O S	28-Mar-56	IRSE Proceedings 1956	111			3
1956	Signalling Facilities of German Federal Railways	Schmitz Dr W	10-May-56	IRSE Proceedings 1956	143			3
1956	Signalling Practice on the Danish State Railways	Steffensen J/Hansen W	18-Oct-56	IRSE Proceedings 1956	162			3
1956	Miniaturisation of Railway Signalling Apparatus	Discussion	19-Nov-56	IRSE Proceedings 1956	209			3
1956	Power Interlockings. Past History and Future Prospects	Nock O S	07-Dec-56	IRSE Proceedings 1956	228			3
1957	Communications as applied to Railways	Clarke D M	16-Jan-57	IRSE Proceedings 1957	27			3
1957	Automatic Operation in Marshalling Yards	Webb D C	19-Mar-57	IRSE Proceedings 1957	55			3
1957	The Corrosion of Underground Lead-covered Cables	Gerrard J/Walters W J	17-Oct-57	IRSE Proceedings 1957	81			9
1957	Work Study as applied to a Railway Signal Engineer's Department	MacKenzie W	10-Dec-57	IRSE Proceedings 1957	119			-
1957	Track Circuits (British Practice)	Challis W H	-	Green Booklet No.9	-	28	5	4
1957	Radio and Television Aids to Railway Operation	Moppett E J/Waters I	Feb 1957	IRSE Proceedings 1957				3
1958	Electronic Switching	Smart N C	15-Jan-58	IRSE Proceedings 1958	25			4
1958	The BTC Automatic Train Control System	Currey J H	12-Feb-58	IRSE Proceedings 1958	38			3

1958	Interference in Railway Lineside Telephone Cable Circuits from 25kV 50c/s Traction Systems	Rosen A	12-Mar-58	IRSE Proceedings 1958	55			3
1958	Automatic Junction Working and Route Setting by Programme	Dell R	23-Oct-58	IRSE Proceedings 1958	85			3
1958	Prefabrication of Railway Signalling installations in New Zealand	Hardman W A	20-Nov-58	IRSE Proceedings 1958	117			5
1958	Geographical Circuit Technique	Codd H A	18-Dec-58	IRSE Proceedings 1958	139			3
1958	Block Instruments (British Practice)	Currey J H	-	Green Booklet No.12	-	30	1,3	4
1958	Train Describers (British Practice)	Mott J E	-	Green Booklet No.13	-	35	5,7	4
1958	Principles of Power Point Control & Detection (British Practice)	Hadaway H W	-	Green Booklet No.5	-	43	5	4
1959	Microwave Radio for Trunk Telecommunication Networks	Hanstock P W	14-Jan-59	IRSE Proceedings 1959	25			4
1959	The Protection of Facing Points - A Survey of Practice at Home and Overseas	Nock O S	04-Feb-59	IRSE Proceedings 1959	57			3
1959	Relay Remote Control Systems	Foster G I	26-Feb-59	IRSE Proceedings 1959	90			4
1959	The Application of Ferrites to Railway Signalling Systems	Cass G R/Sagues J	11-Mar-59	IRSE Proceedings 1959	109			4
1959	Signalling Equipment on 50 c/s electrified lines	Sweetenham W M	14-Oct-59	IRSE Proceedings 1959	146			3
1959	Lifting Barriers at Level Crossings	Brentnall E G	10-Nov-59	IRSE Proceedings 1959	168			4
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1984	Failsafe Microprocessor Interlocking with Safety Assurance Logic - Establishing a Vital Benchmark	Rutherford DB	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	72	5		7
1984	The Elementary Circuits (logical elements, comparators, filters etd.) of Fundamental Importance in the Fail-Safe Comparison and Checking of the Outputs of Computer Systems which are not themselves Fail-Safe	Jaegar W and Carli L	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	77	8		7
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1984	An Unique Application of a Microprocessor to Vital Controls	Disk DR	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	97	9		4
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1984	Train Control Aspects of a Linear Motor Driven Automatic Transit System	Jeffires AEH	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	116	5		3
1984	Signalling Safety Implications of 'Chopper' Traction Control	Ware DK and Holman EPA	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	121	5		7
1984	Proposed Jubilee Control System	Shipway CD	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	126	8		3
1984	Command, Control and Communications for Singapore's Mass Rapid Transit	McKillop AN and Scott SM	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	134	8		3
1984	Communication Systems for the Railway Environment	Bell RT and Peacock DA	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	142	8		4
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1984	Single-mode Optical Systems - the answer for long haul Telecommunications	Gibson MJ, Morris P and Carter AC	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	157	4		4
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1984	Automation of Planning Procedures for a Signal Box and Safety Checks before Operation	Liverani A and Bonfigli G	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	194	8		7
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1984	Development in Passenger Information Systems	Holmes RF	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	214	8		4
1984	The Use of On-line Timetable Data in Information and Control Systems	St Johnston A	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	222	4		4
1984	Revenue Collection and Marketing Information from a Microprocessor based Ticketing System for the Modern Suburban Railway	Bulley CA	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	226	7		3
1984	Automatic Fare Collection Systems	Clayton PL	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	233	5		4
1984	Development and Application of axle Counters on the Indian Railways	Bapat MK and Kumar R	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	238	7		3
1984	New Developments in the Field of Train Detection Systems used in Germany	Uebel H	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	245	8		3
1984	Automatic Vehicle Identification	Maderer GG	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	253	5		4

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1984	Diagnostics as a method of ensuring the safety of systems	Marinetto R and Pieralli M	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	265	7		7
1984	Latest Developments in Automatic Train Control	Davies PR	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	272	8		3
1984	Some New techniques in the Coding and Transmission of Ground to Train Data	Pellegrini PF	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	280	8		4
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1984	Advanced Technologies for Third World Railways -Right or Wrong?	Gelbstein EE	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	314	3		3
1984	Economic, Social and Political Aspects of Change	Orbell GRH	25-Sep-84	IRSE International Conference Railway Safety, Control and Automation	317	5		3
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1985	Exeter Area Re-signalling Scheme	Hobson E	01-Oct-85	IRSE News No 8	2	1		3
1985	A Unique Wayside Signal - Pennsylvania	Brannen P	01-Oct-85	IRSE News No 8	3	1		4
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1986	Modern Technologies in Fail-Safe Systems	Wobig K H	14-Oct-86	IRSE Proceedings 1986/87	21			4
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1987	Waterloo Area Resignalling Scheme	Bellett CJ	01-Oct-87	IRSE News No 12	6	1		3
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1990	Designing for High Integrity	Mitchell IM	17-Sep-90	IEE Power Division Vacation School on TrainControl Systems	C2-1	19		4
1990	Electromagnetic Compatibility in Electric Railways	Mellitt B	17-Sep-90	IEE Power Division Vacation School on TrainControl Systems	C3-1	42		3
1990	Solid State Interlocking	Latarchie CW	17-Sep-90	IEE Power Division Vacation School on TrainControl Systems	D1-1	15		4
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1991	Computer-based Design and Analysis of Signalling Systems for Mass Transit Railways	Gill D C, Goodman C J	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	80	14		4
1991	Computer Simulation of Railway Operation and its Applications	Koss L, Kretschmer W, Dannenberg H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	94	14		3
1991	Modelling of Signalling in an Object Oriented Simulation Model	Taskin T, Goodman C J	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	108	21		3

1991	Knowledge-based System for the Support of maintenance and Diagnosis	Schaefer H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	139	13		8
1991	Performance Work by Signalling Safety Validations in Vienna Arsenal	Sethy A	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	159	7		7
1991	Transmission Based Train Control Systems	Uebel H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	166	5		4
1991	A New ATC-System for Swiss Suburban and Regional Railways	Stamm B	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	171	12		4
1991	Signalling and Communication System of Maglev Type HSST	Hashimoto F	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	183	17		4
1991	Control and Communication for Unmanned Transit Systems	Jeffries A E H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	200	10		4
1991	Compact Centralised Traffic SigL90	Knight A	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	210	7		4
1991	Development of ATC System using Transponders for Super High Speed Operation on Shinkansen	Sato K, Miyachi M	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	217	13		4
1991	Integrated Electronic Central Control at NMBS on the Belgian State Railway (NMBS)	Thielemans I L M F	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	230	13		3
1991	Second Generation Safe Processor Systems	Gray R J, McDonald W	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	243	19		4
1991	The Elektra System - The System for more than Just Electronic Interlocking	Steinbrecher H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	269	18		4
1991	Modernisation of the London Underground Central Line	Brown C R	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	305	6		3
1991	A Laboratory Prototype for a New Train Control System by Radio	Inage H, Yamamoto H, Hirao Y, Hasegawa Y	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	311	12		4

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1991	Signalling and Train Control Systems	Van Bloemendaal R M	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	343	10		4
1991	On Board Equipment for Indication and Control	Klaesecker K	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	353	8		4
1991	Efficient Operation of Modern Railway Systems	Braue G	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	361	8		8
1991	The Growth of the British Rail Optical Fibre Trunk Network	McGowan R D	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	369	3		3
1991	ISDN Within a Railway Telecommunication Network	Smith R	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	372	4		4
1991	The Communicating Underground	Plato M	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	376	14		3
1991	Transmission of CCTV Signals using Low Bandwidths	Harrison K	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	390			4
1991	The Use of Telecommunications for Commercial Exploitation	Borer P	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	391	4		3
1991	Development of a Monitoring System for Electric Point Machines	Shimonae T, Kawakami T, Miki H, Matsuda O, Takeuchi H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	395	8		3
1991	Maintenance Policy and Expert Systems	Wijnands M	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	403	10		8
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1991	Managing and Maintaining a Railway Data Network	Johnson P D	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	420	4		3
1991	Problems of Interference in Signalling Systems on Old Lines of the CSD	Stoll K	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	439	9	7	3
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1991	Track Circuiting for Electrified Lines - The Specification of an Unfriendly Environment	Bradley D N	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	470	15		4
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1991	Signalling Projects and Investment Control	Wyatt R S	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	503	9		3
1991	Improved Cost Effectiveness of Signalling on Spoornet (South African Railways)	van de Venter H	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	512	18		3
1991	The Training of Signalling and Telecommunications Engineering Staff	Chivers C J	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	530	9		8
1991	The Station Operations Room of the Future	Richards C S	7-9 Oct 91	Aspect 91: An International Conference on Railway Control, London	539	11	7	3
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1992	EMC in Electric Railways	Mellitt B (Prof)	28-Sep-92	IEE Power Division Third Vacation School on Railway Signalling and Train Control Systems	B5-1	41		3
1992	Train Protection Systems -An Overview	Corrie J D	28-Sep-92	IEE Power Division Third Vacation School on Railway Signalling and Train Control Systems	C1-1	19		3
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1992	Train Describers in Control for Signalmen and Management	St Johnston A	28-Sep-92	IEE Power Division Third Vacation School on Railway Signalling and Train Control Systems	D1-1	10		4
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1992	Secure Train to Signal Box Radio Systems	Sausins M	28-Sep-92	IEE Power Division Third Vacation School on Railway Signalling and Train Control Systems	D3-1	19		4
1992	Supervision and Operation of Mass Transit Systems	Goddard E O	28-Sep-92	IEE Power Division Third Vacation School on Railway Signalling and Train Control Systems	D4-1	23		3
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1994	World Wide Signalling Practices	Howker AC	19-Sep-94	IEE Power Division Fifth Vacation School on Railway Signalling and Control Systems	C5-1	10		3
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1999	Signalling Asset Whole Life Modelling	AK Webb & MJ Hamlyn	30-Sep-99	Aspect '99	50			3
1999	A Modern Approach to Infrastructure Maintenance	WG Boddy	30-Sep-99	Aspect '99	58			8
1999	The Long-Term Support and Maintenance of Computer Based Railway Control Systems	S Errington	30-Sep-99	Aspect '99	68			8
1999	The Optimisation of Engineering Decision Making Based on Cost / Risk Evaluation	MC Pilling	30-Sep-99	Aspect '99	74			3
1999	Developing Performance Based Train Control System Maintenance Contracts: Can they be Made to Work?	KJ Gutteridge	30-Sep-99	Aspect '99	79			8
1999	An Intelligent Train Operation, Control and Management System – The Railway Signalling System in the 21st Century	Bin Ning	30-Sep-99	Aspect '99	87			3
1999	Commissioning and Maintenance of an Integrated System	P Knowlton & AM Godber	30-Sep-99	Aspect '99	94			7
1999	Management Issues in the Development of Integrated Railway Traffic Control Systems	MS Baltac	30-Sep-99	Aspect '99	102			3
1999	Development of Integrated Systems for Train Operators	GP Jenkinson	30-Sep-99	Aspect '99	110			3
1999	Network Management Centre for DG AG	M Kant	30-Sep-99	Aspect '99	114			4
1999	Network Management Centres – Railtrack's Core Business Delivery System	S Roberts & DL White	30-Sep-99	Aspect '99	119			3
1999	Vital Railway Signal Cable Insulation and Sheathing - Ensuring Reliability and Safety	JP Carter	30-Sep-99	Aspect '99	128			9

1999	Selection of the EUROLOOP Technology for ERTMS/ETCS	H Bierlein, B Godziejewski & DC Balan	30-Sep-99	Aspect '99	136			4
1999	FM Demodulation in a Fading Environment Using Channel Adaptation and a Short-time Fourier Transform	B Godziejewski & DC Balan	30-Sep-99	Aspect '99	141			4
1999	CBTC with Safety Zone	T Kasai & K Kawauchi	30-Sep-99	Aspect '99	145			4
1999	Train Detection by Track Circuit - the Effect of the Wheel/Rail Interface	RA Wood	30-Sep-99	Aspect '99	151		1, 5	4
1999	A simulation Tool for the comparison of Rail Network Layout and Signalling System Alternative Solutions	G Asterngo, A Castagnola & G Cosulich	30-Sep-99	Aspect '99	160			3
1999	Condition Monitoring of Level Crossings - Event Recorders to $(RCM)^2$	MS Nash & C Roberts	30-Sep-99	Aspect '99	166			8
1999	Developing and Retaining People in the Signal Engineering Industry	C Knight	30-Sep-99	Aspect '99	172			3
1999	Retractable Buffer Stop	RL Riva	30-Sep-99	Aspect '99	177			4
1999	Operations Control Centre Development	J Chau & D Carden	30-Sep-99	Aspect '99	182			4
1999	Procurement Strategy for Train Control and Signalling - the West Rail Paradigm	SD Patel	30-Sep-99	Aspect '99	191			3
1999	Performance Based Specifications for Railway Control- the West Rail Experience	P Robins & H Cheung	30-Sep-99	Aspect '99	197			4
1999	The Needs and Expectations of Train Operators	K Winder & A Annis	30-Sep-99	Aspect '99				8
1999	Alliance Projects	PD Bell	30-Sep-99	Aspect '99	204			3
1999	Improving Employment Prospects in the 21st Century	K Gould	30-Sep-99	Aspect '99	209			-
1999	The Development of an Affordable train Protection System	DC Fenner	30-Sep-99	Aspect '99	216		1, 7	4
1999	The Introduction of American Signalling Systems to the UK Market: Cromer Branch Signalling Partnership	PR Davis	30-Sep-99	Aspect '99	223		1, 7	3
1999	GNSS 1 - Based Train Positioning System	J Winter	30-Sep-99	Aspect '99	234			4
1999	Satellite Based Train Control	W Rahn	30-Sep-99	Aspect '99	243			4
1999	ATC Transmission for Mass Transit Railway - The Hong Kong MTRC Experience	P Wong	30-Sep-99	Aspect '99	249		1, 5, 7	3
1999	Interface Between interlocking and Radio Block Centre for an ERTMS System Without Lineside Signals	M Montigel & O Scheck	30-Sep-99	Aspect '99	262			4

1999	Development of an ERTMS Moving-Block Interlocking for Railtrack's West Coast Mainline Resignalling Project	PD Booth	30-Sep-99	Aspect '99	269		5, 7	4
1999	A Realistic Solution for ERTMS	G Legoff	30-Sep-99	Aspect '99	278			3
1999	The Role of Systems Engineering in West Coast Route Modernisation Acceptance	RA Davis, BR Halliday & D Newman	30-Sep-99	Aspect '99	284			3
1999	Migration from Existing ATP Systems to ERTMS/ETCS Level 1, Described by the Example of ZUB 121 in Switzerland	B Stamm	30-Sep-99	Aspect '99	292			3
1999	An Interlocking Specification Language	LH Eriksson & M Fahlen	30-Sep-99	Aspect '99	297			4
1999	Vital Platform for Railway Applications	A Vieder & J Warlitz	30-Sep-99	Aspect '99	303			4
1999	A General Discussion on Railway Signalling Layouts	B Mao, TK Ho, J Li, Z Yuan, G Xiao & J Ji	30-Sep-99	Aspect '99	310			3
1999	Customer Focussed Traffic Control: A passenger Orientated Traffic Evaluation and a Simulation Based On-Line Traffic Optimisation for Metros	CJ Goodman & S Murata	30-Sep-99	Aspect '99	316			4
1999	A Minimum Headway Running Pattern on a Moving Block System	H Nakamura	30-Sep-99	Aspect '99	324			3
1999	Safety Technologies and Guidelines for Computerised Train Control and Protection Systems in Japan	Y Hirao & I Wantabe	30-Sep-99	Aspect '99	332			7
1999	Simplifying the Safety Case for New Signalling	R Williams & JD Corrie	30-Sep-99	Aspect '99	339		1, 7	7
1999	Reducing Project Risk Whilst Gaining Low Cost Approval of Proven Equipment	J Catmur, C Adams & A Hyde, AD Little	30-Sep-99	Aspect '99	345			3
1999	Competence in the Workplace	CB Holden & MA Watson-Walker	30-Sep-99	Aspect '99	346			12
1999	Take Possession	W Hill	30-Sep-99	Aspect '99	352			7
1999	Signal Systems on China's Railways	J Ji, B Mao, TK Ho & Z Yuan	30-Sep-99	Aspect '99	355			3
1999	Level Crossing Issues in Europe	B Godziejewski & L Lochman	30-Sep-99	Aspect '99	361			3
1999	Redwing: In cab CCTV Communications	R Smith	30-Sep-99	Aspect '99	373			4
1999	The Singapore Rail Network for the 21st Century-A Driverless Mass Transit Network	PW Tow, KW Leong & TC Chew	30-Sep-99	Aspect '99	379			3

1999	Systems Engineering and London Underground Limited - Lesson Learned & Strategies for the Future	A Bourne	30-Sep-99	Aspect '99	391		7	3
1999	New York City Transit's Canarsie Line Signal Modernisation Project	AF Rumsey & N Ghaly	30-Sep-99	Aspect '99	396			3
1999	Signalling Secondary Routes	CH Porter	06-Oct-99	IRSE Proceedings 1999/00	25			3
1999	Keep Traditional Signalling Alive (Mechanical)	Francis JD	01-Nov-99	IRSE News No 63	4	1		-
1999	IEE Railway Industry Group	Sheppard P	01-Nov-99	IRSE News No 63	5	1		-
1999	Reflections on South Africa	Kessell C	01-Nov-99	IRSE News No 63	8	3		-
1999	Surviving Blocks - BR Standard Block	Stirling D	01-Nov-99	IRSE News No 63	11	1		-
1999	WESTCAD Commences Service at Liverpool Street	Francis JD	01-Nov-99	IRSE News No 63	16	1		3
1999	EIRENE and ERTMS	M Watkins	03-Nov-99	IRSE Proceedings 1999/00	38			4
1999	Safety Critical Work regulations - What they mean in day to day business	Short R	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	20		3
1999	The Role & Relevance of Group Standards	How F	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	13		3
1999	Is Safety a Barrier to Entry in the S&T Business?	Corrie J D	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	12		9
1999	The Role of the Police following a major incident	Powell R	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	5		3
1999	What is special about Railway Telecoms; can anyone be a Provider?	Hall R	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	9		3
1999	What do we want from an inquiry?	Ratcliffe G	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	16		3
1999	The Future of Accident Investigation in the Railway Industry	Railtrack PLC	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	11		3
1999	Is the Threat of Prosecution a Cause for Doing Nothing?	Appleby M	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	6		3

1999	Introduction to Health & Safety Law	Appleby M	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	10		3
1999	Safety Cases: Are they an unnecessary bureaucracy?	Howker A	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	14		7
1999	The Value of Quantified Risk Assessment	Thompson C	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	21		7
1999	Clapham Eleven Years On; Is S&T a Safer Business?	Burrage K	02-Dec-99	Keep it Safe, Keep it Legal, IRSE Technical Conference, 2 December 1999	-	10		9
1999	Channel Tunnel Rail Link Signalling and Communications	R Stokes & F van Deth	08-Dec-99	IRSE Proceedings 1999/00	45			3
2000	A Solution for the Nullarbar (Australia)	Ebzery F and Symons P	01-Jan-00	IRSE News No 64	1	3		3
2000	Glasgow Pilots New Axle Counter	McKendrick B, Cull S & Knight A	01-Jan-00	IRSE News No 64	4	3		3
2000	New SMS Book for GTRM (Signalling Maintenance Specifications)	Barrow R	01-Jan-00	IRSE News No 64	10	2		8
2000	Signalling Development and the IRSE - "A Cottage industry?" (Millennium Paper)	KW Burrage and RL Weedon	12-Jan-00	IRSE Proceedings 1999/00	58			3
2000	Who is the Customer, Who is the Supplier?	McDougle J	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	15		3
2000	What should a specification contain; is technical content necessary?	Gray R	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	11		4
2000	How will the supply industry get continuity of work?	Irvine N M	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	11		3

2000	Future Funding for Railway Research in the UK	Gostling R, Mitchell I	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	12		3
2000	A case for Telecommunications Operational Managed Service	O'Connor J	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	26		3
2000	Is Outsourcing an Abrogation of Responsibility?	Aldred B	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	7		3
2000	How can we speed up the Letting of Contracts?	Harding M	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	11		3
2000	Partnership - Myth or Reality	Clench G	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	14		3
2000	The Role of Consultants in the New Industry Paradigm; are they a substitute for engineers in-house?	Hamlyn M	20-Jan-00	The Pitfalls of Commercial Contracting in the S&T Business, IRSE Technical Conference, 20 January 2000	-	8		3
2000	The Jubilee Line Extension	Clark G & Threlfall P	03-Feb-00	IRSE Proceedings 1999/00	69			3
2000	A Taste of GSM-R and RER in Paris	Kessell C	01-Mar-00	IRSE News No 65	1	3		-
2000	Solar Power for Signalling and Communications	Hammonds M	01-Mar-00	IRSE News No 65	8	2		3
2000	Hong Kong Rail Transport Systems	Fabbian F	02-Mar-00	IRSE Proceedings 1999/00	83			3
2000	The Urban Reveller's Holy Grail - the 24-hour Metro	Love A	01-Apr-00	IRSE Proceedings 1999/00	90			3

2000	The Needs of the Business and the Operator	McKenna J	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	A1-1	8		8
2000	Statutory Requirements	Holden CB	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	A2-1	5		3
2000	Risk Management in Safety Critical Areas	Burrage K	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	A3-1	7		9
2000	Fundamentals of Signalling and Train Control Systems	Short R	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	B1-1	6		4
2000	Block Systems	Weightman C	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	B2-1	11		4
2000	Developments in World-wide Signalling Practices	Howker A	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	B3-1	6		3
2000	Electronic Interlockings: A Survey of Approaches to Safety-Critical Signalling Systems	Barnard REB	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	B4-1	18		7
2000	Application of New Interlockings	Fisher A J	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	B5-1	5		4
2000	The History and Development of railway Signalling	Hall S	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	B6-1	10		3
2000	The Principles of Train Detection	Corrie JD	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	C1-1	12		4

2000	Mainline ATP/ATC Intermittent and Continuous Systems	Uebel H	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	C2-1	22		4
2000	Application of Train Protection to British Mainlines	Fenner D	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	C3-1	10		3
2000	The Impact of Electrification Systems and Traction Control on Signalling and Communications	Mellitt B	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	C4-1	34		3
2000	European Signalling Standards and Operability	Shirlaw S	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	C5-1	6		4
2000	Control Centres, Train Describers and Automatic Route Setting	Errington S	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	D1-1	11		4
2000	Supervision and Operation of Mass Transit Systems	Goddard EO	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	D2-1	16		3
2000	Operations for Track to Train Radio Systems	Kessell C	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	D3-1	11		4
2000	Signalling Secondary Routes	Porter CH	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	D4-1	8		3
2000	System Assurance and Safety Assessments	Pilkington S	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	D5-1	14		7
2000	Resignalling a Metro Line - An Operational Experience	Thorogood B	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	D6-1	6		3

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2000	Installation and Testing of the Signalling Systems	Marriot D	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	E2-1	9		6
2000	Maintaining the Signalling Infrastructure	Penny R	10-Apr-00	IEE Railway Industry Group 8th Residential Course on Railway Signalling and Control Systems	E3-1	3		8
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2000	SPAD Prediction at Level Crossing Protection Signals	Harrisson C	01-May-00	IRSE News No 66	10	2		4
2000	The Infrastructure Owners View of Competence	Galloway E	11-May-00	Competence Assurance in the S&T Business	-	5		12
2000	Competence Assurance - What does an Asset Steward want?	Mills D	11-May-00	Competence Assurance in the S&T Business	-	5		12
2000	Competence Assurance and the Maintenance Contractor	Sadler J	11-May-00	Competence Assurance in the S&T Business	-	11		12
2000	Competence of Consultants	Corrie J D	11-May-00	Competence Assurance in the S&T Business	-	15		12
2000	Who should judge?	Fisher A J	11-May-00	Competence Assurance in the S&T Business	-	3		3
2000	Integrating Competence Assessment Systems	Gould K	11-May-00	Competence Assurance in the S&T Business	-	6		12
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2000	Role of the NTO in the Assurance of Competence in the Rail Industry	RITC	11-May-00	Competence Assurance in the S&T Business	-	6		12
2000	The Standards Approach to Competence Assurance in the Rail Industry	Catalis	11-May-00	Competence Assurance in the S&T Business	-	11		12
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2000	Introduction to Tools for Defining a System	Allan J	20-Jul-00	IRSE Younger Members' Conference 2000: The Railway as a System	S2	7		3
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2000	Human Factors: People As Part of the System	Bourne A	20-Jul-00	IRSE Younger Members' Conference 2000: The Railway as a System	S3	4		3
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2000	IECC Developments	Thomas K	01-Nov-00	IRSE News No 69	1	3		4
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2001	Perception, Attention, Automation and the Detection of Signals	Moray N Prof	26-Feb-01	Signalling Safety 2001 IQPC				8

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2001	The Safety Regulator's View of Signals Passed at Danger (SPAD)	Hall C	26-Feb-01	Signalling Safety 2001 IQPC				3
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2001	Presidential Visit to the Southern African Section	Uebel H	01-Mar-01	IRSE News No 71	8	2		-
2001	Innovation Enables Ditton Resignalling to be completed on Time (WCML)		01-Mar-01	IRSE News No 71	10	1		3
2001	Portuguese Signalling	Soares Lopes V	14-Mar-01	IRSE Proceedings 2000/01	91	14		3
2001	Brisbane Airport Rail Link Project Overview	Garrett M	16-Mar-01	IRSE Australasian Section AGM 2001	Paper 1	12		3
2001	The Railway Signalling Industry: A Millennium of Change & Management Challenges	Jackson L	16-Mar-01	IRSE Australasian Section AGM 2001	Paper 2	6		3

2001	ERTMS for Australia	Page CR	16-Mar-01	IRSE Australasian Section AGM 2001	Paper 3	13		3
2001	Virtual Site Inspections - Proving the Design	Smith L	16-Mar-01	IRSE Australasian Section AGM 2001	Paper 4	4		3
2001	The Introduction of New Risks to an Operational Railway	Woodland D	03-Apr-01	IRSE Proceedings 2000/01	106	9		3
2001	The Train Protection and Warning System	Fenner D	01-May-01	IRSE News No 72	1	3		4
2001	Independent Train Protection	Peacock F M	01-May-01	IRSE News No 72	6	1		4
2001	Signalling on the Great Cockrow Railway	Howker AC	01-May-01	IRSE News No 72	7	3		3
2001	Human Factors and York Signalling Centre		01-May-01	IRSE News No 72	10	2		3
2001	Mainline Railway Signalling in the UK - A Review		01-May-01	IRSE News No 72	12	2		3
2001	LED's Bring a Brilliant New Perspective to Signals	Mc Donald W	01-Jul-01	IRSE News No 73	1	3		4
2001	Presidential Visit to Australia	Uebel H	01-Jul-01	IRSE News No 73	8	2		-
2001	Frankfurt Technical Visit	Uebel H	01-Jul-01	IRSE News No 73	14	2		-
2001	Riding The Tiger: Lessons from the Application of LED Technology to Railway Signals	Szacsvay P	20-Jul-01	IRSE Australasian Section Technical Meeting: Technology trends - Do They Benefit?	Paper 1	6		3
2001	Blacktown's VDU Signalling Control System "SIGVIEW"	Stepniewski	20-Jul-01	IRSE Australasian Section Technical Meeting: Technology trends - Do They Benefit?	Paper 2	11		4
2001	New Passenger Information Systems for SRA	Topfer A	20-Jul-01	IRSE Australasian Section Technical Meeting: Technology trends - Do They Benefit?	Paper 3	7		3
2001	Advanced Train Running Information Control System (ATRICS)	Dwyer A	20-Jul-01	IRSE Australasian Section Technical Meeting: Technology trends - Do They Benefit?	Paper 4	9		4
2001	CityRail Safe Stations Project: CCTV Network	Moore T	20-Jul-01	IRSE Australasian Section Technical Meeting: Technology trends - Do They Benefit?	Paper 5	4		3
2001	Argus Broadband Data Network Technology	Schmits P	20-Jul-01	IRSE Australasian Section Technical Meeting: Technology trends - Do They Benefit?	Paper 6	(Missing)		4

2001	Lisbon 2001 - The Annual Convention	Edney D A	01-Sep-01	IRSE News No 74	1	4		-
2001	Dartford Area Resignalling Scheme	Bosworth R	01-Sep-01	IRSE News No 74	6	4		3
2001	A Train Protection Strategy for the UK	Muttram RI	10-Oct-01	IRSE London Technical Meeting	-	7		3
2001	Overview Technologies of Axle Counters	Knight A	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	3.1	12		3
2001	Overview Technologies of Track Circuits	Pore J	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	3.2	24		3
2001	Discussion on Technologies	-	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	3.3	2		3
2001	Electromagnetic Interference, Interoperability	Uebel H	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	4.1	25 slides/6 text		3
2001	Axle Counting & Track Circuits - from the practical point of view	Gramiger M, Kiefer J	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	4.2	10 slides/5 text		4
2001	Broken Rail Detection Systems	Holgate D	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	4.3	13		4
2001	Annex: Broken Rail Detection & Earthing Systems	van Dijk H, Janssen M, Smulders E	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	4.3	3		3
2001	Comparison Train Detection Systems	Koechli C, Pirazzi M	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	4.4	15 slides/10 text		3
2001	Discussion on Limits of application	-	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	4.5	2		3
2001	Strategy & Experience: Railtrack (Great Britain)	Bloomfield R, Short R	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	5.1	25		3
2001	Strategy & Experience: SNCF (RFF) (France)	Sevestre C	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	5.2	27 slides/10 text		3
2001	Strategy & Experience: SNCF/NNBS (Belgium)	Verschaeve J R	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	5.3	25 slides/16 text		3

2001	Strategy & Experience: DB Netz (Germany)	Kinze L	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	5.4	14 slides/7 text		3
2001	Strategy & Experience: RIB (Netherlands)	Scholten HB	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	5.5	19 slides/10 text		3
2001	Strategy & Experience: Spoornet (South Africa)	Steyn B	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	5.6	27 slides/15 text + 1		3
2001	Final Discussion	-	16-Oct-01	IRSE Train Detection Seminar Proceedings, Paris (CD-ROM)	6	2		3
2001	The Trend in UK National Network Signal Box Numbers	Francis JD	01-Nov-01	IRSE News No 75	1	3		-
2001	North Eastern Boom Gates	Blackwood D	01-Nov-01	IRSE News No 75	7	1		4
2001	Along the Medway Valley	Francis JD	01-Nov-01	IRSE News No 75	10	4		-
2001	Reiter Stellwerk Restored	Smith B	01-Nov-01	IRSE News No 75	15	1		-
2001	Signalling & Train Control for Singapore North-East Line	Chew TC, Troger L	07-Nov-01	IRSE London Technical Meeting	-	4		3
2001	The National Express Group Train Franchises and the Train Management Facility Project	Walsh W	09-Nov-01	IRSE Australasian Section Technical Meeting: New Generation Train Control Systems	Paper 1	3		3
2001	Train Management Facility Project: Beyond Train Control	Symons P	09-Nov-01	IRSE Australasian Section Technical Meeting: New Generation Train Control Systems	Paper 2	15		3
2001	Signalling Control Panels	Ackland G	09-Nov-01	IRSE Australasian Section Technical Meeting: New Generation Train Control Systems	Paper 3	15		4
2001	Pheonix Train Control	Everist G	09-Nov-01	IRSE Australasian Section Technical Meeting: New Generation Train Control Systems	Paper 4	11		4
2001	CPEng, NPER and the IRSE	Samayoa A	09-Nov-01	IRSE Australasian Section Technical Meeting: New Generation Train Control Systems	Paper 5	5		3

2001	Introduction	Barnard REB	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	a	1		3
2001	Adapting Interlockings for New Markets	Mack H	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	b	17		3
2001	Railway Modernisation of the Lisbon Suburban area - technical aspects	Vendas F R	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	c	12		3
2001	Satisfying Requirements - Telecommunications	Salgueiro J	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	d	25 + 35		3
2001	Euro-Interlocking	Konig N	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	e	14		4
2001	Euro-Interlocking	van der Werff M	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	f	8 slides/3 text		4
2001	Integrated Interlockings and Train Control on Oslo Metro	Hagbo G, Glover M	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	g	43 + 9 slides		3
2001	Encrypted Data Transmission via Public Networks	Wickinger T	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	h	10		4
2001	Extending the Technology: Using Communication Based Train Control to enhance safety at Level Crossings	Wallach N	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	i	19 text/31 slides		4
2001	Integration of an ERTMS-based Signalling System in a modern 3-phase Freight Loco	Nordmann J	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	j	22		3

2001	Control of Shanghai Transrapid Maglev	Bretschneider C	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	k siemens_ts.exe	3138KB		3
2001	Discussion	-	14-Nov-01	IRSE New Technology for Interlocking & Train Control, Seminar Proceedings, London (CD-ROM)	l	3		-
2001	ALSTOM Project Test Track France	Rodrigues C	23-Nov-01	IRSE ERTMS- Test Track France, Paris		24		-
2001	CSEET/Ansaldo views on TTF & other international projects	Pascault G	23-Nov-01	IRSE ERTMS- Test Track France, Paris		33		-
2001	The different steps for SNCF testing & progressing with ERTMS	Pignal O	23-Nov-01	IRSE ERTMS- Test Track France, Paris		24		3
2001	ERTMS Projects; ALSTOM views	Passau V	23-Nov-01	IRSE ERTMS- Test Track France, Paris		49		-
2001	Migration from existing signalling towards ERTMS	Pore J	23-Nov-01	IRSE ERTMS- Test Track France, Paris		44		3
2001	RFF views on ERTMS: Test Track & future applications	Castan P	23-Nov-01	IRSE ERTMS- Test Track France, Paris		29		-
2001	Video: ERTMS Test Track Italy	ALSTOM	23-Nov-01	IRSE ERTMS- Test Track France, Paris		160876KB		-
2001	Implications for Signalling of the Ladbroke Grove Inquiry	Cooksey A	12-Dec-01	IRSE London Technical Meeting	-	5		3
2002	The West Coast Route Modernisation	MacNeil F	01-Jan-02	IRSE News No 76	1	5		3
2002	ATP - The Train Operator's Perspective	Wright N, Hamilton A	16-Jan-02	IRSE London Technical Meeting	-	7		3
2002	Train Control Research in Europe	Schmid F	13-Feb-02	IRSE London Technical Meeting	-	14		3
2002	Australasian Signalling	Symons P	13-Mar-02	IRSE London Technical Meeting				3
2002	Railtrack Signalling Strategy - an Update	Simmons A	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				3
2002	The Network Management Centre Concept	Buckpitt M	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				4

2002	GSM-R Planning and Implemention for Level 2 ERTMS	Konrad M	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				3
2002	ERTMS - compatible Tilt Authoristation and Speed Supervision for New Virgin Train Fleets	Macfarland S	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				4
2002	TCS - The ERTMS Solution to WCML Performance Needs	Thomas P	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				8
2002	The ERTMS National Programme Team	Jones S	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				3
2002	New Maintenance Approaches for WCML	Wilkinson L	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				8
2002	Rethinking Lineside Signals	Spiers A	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				3
2002	CTRL Signalling -Bringing TGV Technology to the UK	Harman I	20-Feb-02	IRSE Seminar Proceedings,, Bringing Innovation to the UK Railway London CDROM				3
2002	Signalling, Train Control and Real time Information Systems in Queensland Rail	Kjaer - Oslen K	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	Integrated Supervisory Control System	Samuel, L	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				4
2002	City Rail Safe Stations	Bhattachacharjee, S	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	ERTMS/ETCS Benefits for the World Railways	Arpaci M	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3

2002	Geologic at Mt Baker	Page CR	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	Migration to ERTMS	Pore J	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	Melbourne Railway Privatisation	Grady, N	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	Meeting the Challenge to provide Technology that meets Operator Needs	Jackson I	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				8
2002	System Authorities in the UK	Muttram RI	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				7
2002	RIC Level Crossing Monitor	Szacsvay P	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				4
2002	Blacktown VDU Signalling Control System, SigView	Stepniewski R	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				4
2002	Phoenix Train Control	Everist G	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				4
2002	Resignalling the Botany Line with MicroLok	Allison W	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	Asset Management	Walker K	30-Apr-02	IRSE International Convention - Sydney Australia 2002 CDROM				3
2002	Eurobalise	Lundberg P	09-Oct-02	IRSE London Technical Meeting				4
2002	Euroradio and the RBC	Riley C	06-Nov-02	IRSE London Technical Meeting				4
2002	Proposed Cross-Acceptance Processess for Railway Signalling Systems and Equipment	International Technical Committee	21-Nov-02	IRSE Seminar Proceedings, London				7
2002	Network - Wide Use of ERTMS/ETCS at SBB	Stadler O	22-Nov-02	IRSE Technical Visit to the ETCS Level 2 Pilot Line - Olten, Lucerne CDROM				3

2002	Eurocab and Driver MMI	Frerichs C	10-Dec-02	IRSE London Technical Meeting				4
2003	UK Signalling Developments		12-Mar-02	IRSE London Technical Meeting				3
2003	Signalling Control Centres - Today and Tommorrow	Mitchell I	15-Jan-03	IRSE London Technical Meeting				4
2003	Migration to ERTMS on Existing Lines	Pore J	12-Feb-03	IRSE London Technical Meeting				3