Detailed Requirements Document (DRD)
Rail Engineering Advanced Technician Level 4
Rail Systems Knowledge & Skills Content

Purpose

The purpose of this Detailed Requirements Document (DRD) is to provide employers, colleges and training providers and those developing qualifications with an additional level of detail behind the Standard. The DRD should be used to support the delivery of the Railway Engineering Advanced Technician Apprenticeship

This document sets out the Knowledge and Skills required for anyone following the Signalling pathway. These requirements are in addition to the Rail Engineering Advanced Technician core knowledge and skills.

Once complete this document this document will form part of the Employer Occupational Brief (EOB).

Development process and sources

The detail within this document has been developed from Rail Engineering Technician DRDS which in turn was developed from existing National Occupational Standards (NOS) to which additional requirements were added or items that were deemed no longer necessary (very few) were removed.

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The Standard: Rail Systems Specialism

Core Knowledge. Within a Railway context all Rail Engineering Advanced Technicians need an in-depth knowledge and understanding of:

1. Safe and Professional working practices including legislation, regulation, industry procedures, safety requirements, risk management and environmental impact together with an understanding of human factors and techniques to address these.

2. The scientific, technical, engineering, mathematical and design principles (some of them complex) that are required in undertaking and directing maintenance, renewal and construction of and across The Railway.

3. How to work effectively to design and develop engineering solutions and innovation including understanding of failure modes and their causes; advanced problem solving, diagnostic systems and development of preventative maintenance; asset management and whole life asset costs.

4. How to deliver engineering solutions effectively including project management principles and systems to manage, time, resource, asset and quality management and assurance systems; business improvement and innovation systems, processes and techniques.

5. How the Railway works as a system and their role within it. The critical interfaces across the Railway system and how those interfaces are managed.

6. The importance of 3rd party and internal business requirements and operational interfaces. The need for and understanding of client confidentiality and compliance with corporate policies including ethics, equality and diversity and sustainability.

7. How the Railway works commercially including contractual principles and financial systems, forecasts and budgets, and performance implications and performance management techniques.

8. How the Railway is evolving. Awareness and understanding of new technological developments across the Railway and how these will impact the future operation of The Railway.

The above to include the Rail Systems specific Knowledge requirements of the Standard:

Rail Systems Advanced Technicians will have the following specific knowledge regarding different techniques and methods used to construct, install, maintain and renew The Railway and to avoid Railway asset, equipment, process and systems failures:

This is a specialism in its own right and requires knowledge and skills from across the rail engineering disciplines above to be able to provide technical support, solutions and direction across a number of disciplines including traffic management systems, new train control systems, the wheel/rail interface, remote condition monitoring and the design, implementation and operation and evolving requirements of a digital railway.

It will require an understanding of systems engineering and information systems and security and detailed understanding of the physical and systems interfaces across The Railway and the operating requirements, implications and constraints of these.

Further knowledge requirement are yet to be identified and agreed

Core Skills. Within a Railway context all Rail Engineering Advanced Technicians need to be able to:
9. Keep themselves and others safe by leading and demonstrating safe working practices. Understand, reinforce and comply with statutory regulations and organisational safety requirements, including competence and safe access to work locations.
10. Produce a work plan based on safe systems of work that is informed by technical drawings, schematics and programmes of work needed for the development of rail engineering activity. Prepare contingency arrangements to manage change and risk as appropriate.
11. Undertake and direct a high standard of technical work. Take responsibility for the efficient and effective delivery of technical work activities and projects. Undertake and supervise the operation of equipment & systems. Complete integrity & compliance checks on own work and that of others and ensure appropriate testing is undertaken. Transfer responsibility of assets once work has been completed. Be responsible and accountable for their own work and that of others.
12. Solve problems: Design and develop a structured and/or innovative approach to problem solving and diagnosis. Apply appropriate methods and business improvement techniques. Predict and prevent failures through the analysis of data and the ability to provide feedback on these.
13. Make informed and considered decisions and complex critical judgements as appropriate; bounded by the use of data or evidence based decision making
14. Supervise and manage resources including the efficient utilisation of individuals, teams, tools, materials and equipment.
15. Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public. Support the development of others through coaching and mentoring.
16. Communicate effectively across all management levels. Use oral, written, electronic and IT based methods and systems for the accurate communication, technical reporting & recording of information and management reporting.

The above to include the Rail Systems specific Skills requirements of the Standard:

Rail Systems Advanced Technicians will have the following specific skills regarding different techniques and methods used to construct, install, maintain and renew The Railway and to avoid Railway asset, equipment, process and systems failures
This is a specialism in its own right and requires knowledge and skills from across the rail engineering disciplines above to be able to provide technical support, solutions and direction across a number of disciplines including traffic management systems, new train control systems, the wheel/rail interface, remote condition monitoring and the design, implementation and operation and evolving requirements of a digital railway.
It will require an understanding of systems engineering and information systems and security and detailed understanding of the physical and systems interfaces across The Railway and the operating requirements, implications and constraints of these.
The specific skills requirements are yet to be identified and agreed

Rail Systems Advanced Technicians (RSAT)

Background

Rail Systems includes infrastructure and operational systems

The core differentiators of a Rail Systems Advanced Technician from Advanced Technicians following other pathways is that they:
- Will have data, analytical and IT type skills
- Will also have softer people skills to be able to work with a range of people e.g. facilitation
- Will need an understanding (rather than awareness) of all disciplines across Rail Engineering
- Should be able to take any asset and represent it in a digital way in order to build and understanding of how to optimise the system
- They will have the ability to design and represent systems visually

Expected routes into the RSAT apprenticeship include:
- L3 Rail Engineering apprenticeship non Rail Systems pathway
- L3 Rail Engineering apprenticeship Rail Systems pathway
- A Levels / ONC
- Upskilling

How the RSAT apprenticeship would be used by the contributors to these notes:
- Network Rail, mostly upskilling
- TfL, mostly new people

Knowledge

2. The scientific, technical, engineering, mathematical and design principles *(some of them complex) that are required in undertaking and directing maintenance, renewal and construction of and across The Railway.*

Systems Engineering principles at L4 are not rail specific

Rail technical principles include:
- A broad understanding across the spectrum of rail Engineering together with a detailed understanding of the systems discipline
- An understanding of track, train and signalling design principles and how they are inter-dependent
- How traffic management systems work (traditionally and digitally)
- The aspects of a digitally enabled railway

Traffic Management Systems including:
- Scheduling & timetabling
- Operational requirements
- Scheduling for headway and punctuality

3. How to work effectively to design and develop engineering solutions and innovation *including understanding of failure modes and their causes; advanced problem solving, diagnostic systems and development of preventative maintenance; asset management and whole life asset costs.*

 (This maybe core content depending on whether all Rail Engineering Advanced Technician pathway require this.) Should include:

- Understanding user requirements
- Techniques for capturing and managing requirements
- Know the difference between and be able to differentiate between:
    - functional requirements (what do I want) and
    - Non-functional requirements (how do I want you to provide it to me)
- How to determine a solution
- How to validate the design against user requirements i.e. verification & validation, tests & measurements.

Data analysis & management (knowledge and ability to apply / use) including:
- Knowledge of big data,
- Trend analysis
- Management systems and analysis
- Data acquisition techniques

5. How the Railway works as a system and their role within it. *The critical interfaces across the Railway system and how those interfaces are managed.*

For each asset type* need to understand:
- A basic understanding of :
    - each asset type – how everything works and what it is doing
    - The design principles and capability
    - How the systems work
- In depth understanding of the system / asset interfaces
    - The impact on the rest of the Railway
    - The data systems involved
    - The latencies within the systems and impact on overall railway performance
    - The risks related to the system sub optimization or system failure

*Asset types being:
- Signalling
- T&RS
- Track
- Electrification
- OLE
- Telecoms
- Stations

Signalling – need to know (and be able to):
- Principles of railway signaling
- What's involved to:
  - Set a signal
  - Clear a route
- Understand operational aspects
- For a particular set up need to understand the wiring diagram and the logic for clearing a signal (signal selection) and protecting conflicting moves (interlocking)
- How to read circuit diagrams
- Understand the principles of what the circuit is doing

Traction & Rolling Stock – includes
- Vehicle diagnostics
- Adhesion (wheel track interface)
- Capacity of the train including usable space3m where people standard, location of doors etc.
- Platform / train interface
- Propulsion equipment i.e. the traction characteristics of the train
- Braking equipment and characteristics – service brake and emergency brake
- Rolling resistance and aerodynamics of the train
- Application of Newton's laws of motion

Track knowledge includes:
- Track design principles
- Understanding of what speed can be achieved as a result of the track design , geometry and it environment
- Cant and curvature design (Pure maths)
- Rail environment including: bridges, platforms, tunnels etc.
- Kinetic envelope of the train & ability to use the tool to help understand this

Electrification knowledge includes:
- Electrical characteristics
- Voltage profiles
- Ratings of transformers and rectifiers
- Load demand
- Power sizing
- AC / DC – how much you can also a particular section
- Protection setting – the system can't differential between a fault and a high number of trains
- Need to know the whole typology of the system so that it can be:
  - represented in a modelling tool
  - optimised using using the modelling tool

OHL or Traction Conductor Rails
OHL is primarily seen as a conductor by the RRSAT. They need to know:
- The general arrangement of the OLE system and how the conductors are connected

Telecoms (the RSAT will not be a telecoms expert). They need to know:
- How telecommunication is enabling / supporting command and control
- What telecommunication technologies are available e.g. as an enabler to remote condition monitoring
- The digital aspects of Rail related telecommunications

Stations

- Platform heights, lengths etc.
- Station bridges
- Station layout, signage, facilities – impact on passenger flow
- Platform train interface and impact on boarding and alighting

Remote Condition Monitoring (for reliability)
- What it is and how to analyse it
- Awareness of Remote Condition Monitoring techniques
- Understand advances I technology for data capture e.g.
    o How crowded is a station
    o Monitoring currents & voltages across a traction supply network
    o Sensor technologies

How people interact with the Railway
This is a key interface with the Transport (rather than just Rail) system which covers the movement of people. People's behavior on and around The Railway is a key unreliable factor which needs to be considered for both customers and staff. Including
- Human Factors elements of hub, station, rolling stock and control centre design
- Signage
- Customer information
- Lead times / notice for down time etc.
- Task analysis

A good example is TfL and NR management of the Olympic Games. As Rail Systems Advanced Technician may be required to understand how to improve this digitally.

Security on the Railway
RSAT needs to be aware but does not need to know anything more than other pathways

Skills

12. Solve problems: Design and develop a structured and/or innovative approach to problem solving and diagnosis. Apply appropriate methods and business improvement techniques. Predict railway capacity and reliability constraints and develop technical solutions through the analysis of data and the ability to provide feedback on these

Systems discipline skills (not nec. Rail specific) include:
- Developing and applying railway system modeling & simulation
- Ability to model processes
- CAD, 2D CAS & 3D CAD
- Building Information Modelling (BIM)
- Whole life asset modelling – its purpose and how it is undertaken. Should be able to understand and build complex whole life cost models to run scenarios and find optimal options
- Business improvement techniques, including understanding of public transportation business cases
- Systems optimisation techniques, e.g. optimise capacity, energy efficiency, etc.
- Process mapping RSAT needs to be able to map out processes to represent the whole flow e.g.to improve reliability, and/or to move things through a depot

Programming skills
- Python
- C++

Rail Systems Skills include:

Rail Systems Engineering

- Service reliability analysis – what are the service bottle necks and how can it be optimized

Train system performance modelling including:
- capacity
- reliability
- RAMs (asset reliability)
- Lost customer hours

Infrastructure Systems Modelling including:
- Power & energy
- Air velocity
- Heat
- Machinery (toxic fumes)

Railway System Design (RSD) **–** high level requirements layer
This includes requirements capture and requirements management
It includes the whole V cycle (design, build maintain etc.) and could include all rail asset types:
- Track
- Signalling
- Telecoms
- Electrification
- OLE
- T&RS
- Stations

Whatever the asset the RSAT needs to be able to visualize it as a system, how it is connected and the characteristics of all the connecting parts and their contribution towards system performance metrics

Analysis
- Reliability block diagram (RBD) modelling of systems
- Quantified Risk Assessment (QRA) i.e. identification of risk through interrogation of the system and comparison of the overall likelihood or an event happening.
- Risk analysis techniques e.g. fault trees, root-cause
- Failure modes and effects
- Ability to develop prognosis and algorithms to predict and prevent events

Systems Modelling
Ability to build a model to represent the systems architecture to support requirements management, requirements modelling, system design and verification
- Approach to selection of modelling tools
- Understanding of deterministic and stochastic techniques
- Understanding of relative importance of model accuracy and adequacy of model calibration techniques

15. Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public. Support the development of others through coaching and mentoring.

Working with people including:
- The RSAT is likely to be project leading but is unlikely to have any direct staff
- Requirements development - need to be able to gather information from a range of people and sources
- Run workshops to capture information
- Facilitation

- Collaborative working relationship
- Working across teams
- Building a wider desire for optimisation

1. Safe and Professional working practices

> 1. **Safe and Professional working practices** including legislation, regulation, industry procedures, safety requirements, risk management and environmental impact together with an understanding of human factors and techniques to address these.

2. The scientific, technical, engineering, mathematical and design principles

> **The scientific, technical, engineering, mathematical and design principles (some of them complex) that are required in undertaking and directing maintenance, renewal and construction of and across The Railway.**

3. How to work effectively to design and develop engineering solutions and innovation

> **How to work effectively to design and develop engineering solutions and innovation** including understanding of failure modes and their causes; advanced problem solving' diagnostic systems and development of preventative maintenance; asset management and whole life asset

4. How to deliver engineering solutions effectively

> **How to deliver engineering solutions effectively** including project management principles and systems to manage, time, resource, asset and quality management and assurance systems; business improvement and innovation systems, processes and techniques.

See Trailblazer document – no Rail Systems specific content

5. How the Railway works as a system and their role within it

> **How the Railway works as a system and their role within it.** The critical interfaces across the Railway system and how those interfaces are managed.

See Trailblazer document – no Rail Systems specific content

6. The importance of 3rd party and internal business requirements and operational interfaces

> **The importance of 3rd party and internal business requirements and operational interfaces.** The need for and understanding of client confidentiality and compliance with corporate policies including ethics, equality and diversity and sustainability.

See Trailblazer document – no Rail Systems specific content

7. How the Railway works commercially

How the Railway works commercially including contractual principles and financial systems, forecasts and budgets, and performance implications and performance management techniques.

See Trailblazer document – no Rail Systems specific content

8. How the Railway is evolving

How the Railway is evolving. Awareness and understanding of new technological developments across the Railway and how these will impact the future operation of The Railway.

See Trailblazer document – no Rail Systems specific content

9. Keep themselves and others safe by adhering to safe working practices

Keep themselves and others safe by leading and demonstrating safe working practices. Understand, reinforce and comply with statutory regulations and organisational safety requirements, including competence and safe access to work locations.

10. Produce a work plan based on safe systems of work

Produce a work plan based on safe systems of work that is informed by technical drawings, schematics and programmes of work needed for the development of rail engineering activity. Prepare contingency arrangements to manage change and risk as appropriate.

11. Under take and direct a high standard of technical work.

Undertake and direct a high standard of technical work. Take responsibility or the efficient and effective delivery of technical work activities and projects. Undertake and supervise the operation of equipment & systems. Complete integrity & compliance checks on own work and that of others and ensure appropriate testing is undertaken. Transfer responsibility of assets once work has been completed. Be responsible and accountable for their own work and that of others.

12. Solve problems

Solve problems: Design and develop a structured and/or innovative approach to problem solving and diagnosis. Apply appropriate methods and business improvement techniques. Predict and prevent failures through the analysis of data and the ability to provide feedback on these.

13. Make informed and considered decisions and complex critical judgements

Make informed and considered decisions and complex critical judgements as appropriate

14. Supervise and manage resources

Supervise and manage resources including the efficient utilisation of individuals, teams, tools, materials and equipment. Monitor and manage individual and team performance and development.

15. Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public

Work collaboratively maintaining effective relationships with colleagues, clients, suppliers and the public. Support the development of others through coaching and mentoring.

See Trailblazer document – no Rail Systems specific content

16. Communicate effectively

Communicate effectively across all management levels. Use oral, written, electronic and IT based methods and systems for the accurate communication, technical reporting & recording of information and management reporting.