An Overview of the Development, Testing and Application of the Workload Toolkit

IOE/ RAIL/06/02R

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Executive Summary

This report is a summary of the work that has been delivered as part of the Signaller Workload Project completed by the Institute for Occupational Ergonomics, The University of Nottingham for Network Rail.

The main deliverables of the Signaller Workload Project included a series of reports (referenced within section 14.0 of this report) outlining the research completed to provide Network Rail with a comprehensive framework of the concept of mental workload and workload tools specifically for the railway signaller.

The workload framework was used to identify the key areas of signaller work requiring investigation during field based workload assessments. This focused the search for existing workload tools capable of capturing relevant information within a live operating environment. However, in the absence of suitable tools the reports describe the need for and the development of a set of workload tools. The set of tools developed are represented within the workload framework in the figure below and sign post the reader for further information to the relevant sections within this report.

This current report provides an outline of the tools contained within the Network Rail Workload Toolkit version 1.0 and provides information about the tools aims, development, evaluation, application, data management, limitations and validity. The table below summarises the content of this toolkit and how each tool is currently applied and can be used to judge levels of existing workload.
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<td>The Workload Principles</td>
<td>This tool provides an assessment of the work system in relation to the degree to which it meets a number of ergonomics principles in order to contribute to a total understanding of signaller workload. Inadequacies of the ergonomics factors embedded in these principles will be likely to increase workload experienced by the signaller</td>
<td>This can be used at the start of a workload assessment to help define the nature of the workload problem or to contribute to a preliminary assessment of workload, or assist in the judgement of findings obtained from a more in depth study of the influencing factors. Using the tool simply involves considering all the information obtained through observation or discussion with the signaller or signalling manager and identifying whether each principle is met. A yes or no answer should be given to indicate whether the principle has been met.</td>
<td>A paired comparison exercise has suggested that principles 1-5 and 9 have greatest priority. Therefore an assessment that considers one of these that is not met requires remedial action to be taken.</td>
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<td>Integrated Workload Scale (IWS)</td>
<td>The IWS collects perceptions of signaller workload based on a nine-point scale. This tool can be used to identify peaks and troughs in the effort and demand experienced by signallers when responding to dynamically changing work conditions. They recall their rating at the time they are carrying out their work.</td>
<td>The tool is used by asking signallers to provide a rating of their workload at a suitable time interval. A particular period of time within a shift and the duration for recording is specified. If it is used in conjunction with video recording, subject matter expert commentary or an activity analysis, it will assist in highlighting which combinations of tasks, systems or scenarios are considered to produce high and low levels of effort and demand (workload).</td>
<td>A rating of 4 or more may suggest that the system and working environment is or is about to demand considerable effort from the signaller. This may be sufficient to cause observable deterioration in signallers completing all activities required of them within the necessary time available. Trials have not been completed for extended periods of low levels of workload. However, if a system consistently rates ‘1’ for an extended period of time this should also be considered as likely to impact on their concentration and potentially impair performance.</td>
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<td>Operational Demand Evaluation Checklist (ODEC)</td>
<td>ODEC provides a systematic process to evaluate the entities within a signalling system, in order to represent the influence the overall system has on the signallers’ workload.</td>
<td>ODEC is an evaluation checklist presented as an excel spreadsheet. Within the tool a number of entities e.g. number of controlled signals, number of incidents are explained and information given on how they can be observed or measured. Details of the data values must be recorded within the spreadsheet. This will automatically enter a ‘Y’ under one of the categories high, medium or low to represent the data collected. The output of the ODEC tool is the percentage of entities categorised as having high, medium or low workload attributes recorded for the workstation assessed.</td>
<td>An approximately equal split of elements as possible between high, medium and low would appear to suggest a reasonable balance for a system to be controlled. Greater than 40% of elements within the high category should suggest caution about adding any further elements to a system without compensatory actions.</td>
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<td>Adapted Subjective Workload Analysis Tool (ASWAT)</td>
<td>ASWAT is a self report workload tool that assesses workload on three dimensions - time load, mental effort and pressure.</td>
<td>The tool provides a retrospective comparison of signaller workload between two situations or different times in the day. It also allows some degree of diagnosis about where the signaller’s greatest demands or effort might be, i.e. time pressure, mental demand or pressure generally.</td>
<td>The original tool SWAT was intended to compare between two or more situations. Data produced by ASWAT can suggest one system or situation as having a greater subjective workload than another based on having the higher score, but not by how much.</td>
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<td>Activity Analysis</td>
<td>The Activity Analysis Tool (AAT) tool involves observing and recording</td>
<td>The AAT tool can be applied to capture either a snap shot of the tasks being completed by the signaller at a pre set time interval, or the type and duration of tasks to represent the percentage of time that is occupied by specific tasks. It is most effective when combined with workload scores from the Integrated Workload Scale (IWS) and/or with subject matter expert (SME) commentary.</td>
<td><strong>Snapshot:</strong> A human factors expert should interpret data collected from the Snapshot recordings. The incompatibility or anxiety associated with certain combinations of activities should be highlighted to identify sources of high or low demand.  <strong>Task occupancy:</strong> Task occupancy recordings traditionally compare the percentage of time taken up by activities against time available. Where less than 50% and greater than 80% of a signaller’s time is occupied by tasks, caution should be shown towards removing or adding (respectively) any further tasks to a system without compensatory actions (Parks. and Boucek 1989, Kirwan, and Ainsworth 1992).  <strong>SME commentary</strong> highlights situations where a signaller’s approach to managing the system may change to accommodate the demand they experience. Evidence of changes in strategies, dropping activities or becoming less accurate or efficient should all be collected by SMEs and used to explain IWS and Task Activity data.</td>
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<td>(AAT) Tool</td>
<td>signallers activities at certain times.</td>
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<td>Workload Probe</td>
<td>The workload probe examines the context in which work is being completed and understands the workload experienced through signaller’s reports on task characteristics, individual characteristics and the relevant goals and strategies necessary to operate the system under control. This tool also seeks to explore the impact of all of these on system/signaller performance and/or signaller wellbeing.</td>
<td>The workload probe is an analytical interview based tool that explores workload issues considered to exist within the signaller’s working environment. An interview is completed by a human factors specialist either with an individual or a group of signallers. The interview questions aim to elicit information on positive and negative experiences that influence the signaller’s workload at the site being visited. The interview involves general questions about the workload at a site and then systematically asks the signaller to consider a number of loading factors that have been previously recognised as specifically influencing signaller workload. A voice recorder can be used to record the interview but at the very least notes should be taken and a fishbone diagram with a table is provided to facilitate the documentation of why signallers believe each loading factor influences their workload.</td>
<td>The Workload Probe should assist in judging if mismatches exist between the work (tasks, time pressures and mental demand) required by the signaller (individual capacity to complete the work) and the context (the work place and system status) that they have to complete the work in. Assessing the content of the data collected from the Workload Probe against the Workload Principles will systematically explain why certain principles are not achievable within a workplace.</td>
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Annex 3 Top level overview of contextual, environmental and cognitive factors within the Workload Probe questions

Annex 4 A sample of Workload Probe questions
1.0 Introduction

This report provides a final summary of the work completed and reports produced during the four-year (2002 –2006) Signaller Workload Project completed by the Institute for Occupational Ergonomics, The University of Nottingham for Network Rail. The five phases of work that were completed within this project were:

These are summarised and an overview given of the development and validation of the assessment tools produced for Network Rail’s workload toolkit. Finally the report outlines how Network Rail intends the toolkit to be applied and findings presented.

All of the tools in their current form can be found within the workload toolkit version 1.0 in the Ergonomics National Specialist Team (ENST) at Network Rail (contact Emma Lowe) and are not included within this report.

2.0 Background

The aim of the project was to understand the concept of workload in the context of the rail industry and propose an approach and toolkit for a field based assessment of the railway signaller’s workload. A number of reports and guidance documents have been produced throughout the course of this project. This final report intends to summarise the contents of all of these documents and provide a high level overview of the development and format of Network Rail’s Workload Toolkit version 1.0. For greater detail and understanding behind the research
approach and methods chosen and applied during this work reference to Pickup (2007) is advised.

The Signaller Workload Project consisted of five key phases:

**Phase 1 – August 2002**

**Literature Review and Field Data Collection**

A literature review on the theory and measurement of mental workload was initially completed and a review undertaken with human factors consultants within the industry relating to workload measurement techniques currently used and what would be desirable within the rail industry. Observations and interviews of railway signallers provided data on the work and workload of the railway signaller. A working note, (Pickup et al., 2002) summarises these initial findings. A workload framework was proposed to direct further investigation and communication of the workload concept within the rail industry and its human factors community. This phase of work identified the need for a set of workload tools capable of assessing the whole workload concept as represented by the framework.

**Phase 2 – August 2002 - April 2003**

**Initial Workload Tool Development**

Phase 2 expanded upon the findings from the initial investigation completed in phase 1 (Pickup and Wilson, 2003). It considered the fundamental theories relevant to the workload concept and a final version of the workload framework was developed, see figure 1, and applied during the subsequent phases of this project. In addition a, review of existing workload tools identified within the literature or by human factors experts as deserving consideration for use with the
Figure 1 Conceptual Workload Framework
railway signaller was undertaken. This review did not suggest any workload tools that were immediately transferable and the remainder of the phase two work attempted to address this void by reviewing the field data collected in phase 1 and applying it to understand the work and workload of the railway signaller in the context of the whole sociotechnical system they work within.

The outcome of the phase 2 work was an initial set of workload tools designed to:

a) Provide a self report signaller workload scale
b) Evaluate the signalling system and its impact on the demand on the signaller
c) Evaluate the functions of a signaller and sociotechnical factors influencing their work/workload
d) Evaluate signaller wellbeing.

**Phase 3 – April 2003 – January 2004**

**Preparation of Workload Tools for Field Use**

This phase further progressed workload tools developed in phase 2 for their application in the field and provided accompanying documentation as a set of guidance notes (Pickup and Wilson, 2004). As a consequence of phase 2 the need for additional tools had been identified and phase 3 involved the development and presentation of seven tools considered necessary to interpret the signaller’s workload. They included: the Workload Principles, the Operational Demand Checklist (ODEC), Workload Probes (previously called ladders), Adapted SWAT (ASWAT), wellbeing assessment, Rail Adapted Modified Cooper Harper (RMCH), Integrated Workload Scale (IWS) and the
Timeline analysis tool. The introduction to this set of guidance notes summarises previous work and maps the tools within the conceptual framework (figure 1) to indicate which attribute of workload they intend to assess. The introduction to this document provides some guidance on the combination of tools that may be useful in addressing particular workload issues/questions.

**Phase 4 – January 2004 – September 2004**

**Field Trials**

Having had a period of time for the application of the tools in the field, this phase of work was concerned with obtaining feedback from Network Rail staff and independent consultants who had been using the tools on Network Rail’s behalf, reviewed their use and identifying modifications to the tools. This directed the next iteration of three of the key tools namely: IWS, ODEC and the Workload Probe.

**Phase 5 – August 2005 – May 2006**

**Implementation and Validation**

This final phase of the workload project provided a review of all the workload tools. Further modifications and iterations of the tools were completed following further evaluation and validation. Phase 5 also involved packaging the workload tools considered as most capable of providing a comprehensive workload toolkit. These included: the Workload Principles, ODEC, Timeline analysis now referred to as the Activity Analysis Tool (AAT), ASWAT, IWS and the Workload Probe. This last tool continues to undergo further evaluation and testing within the field, modifications are necessary before this tool is physically placed within the toolkit.
The signaller wellbeing assessment and Rail Adapted Modified Cooper Harper (RMCH) are currently not included within the toolkit. These tools have not been considered as essential to the workload assessments completed to date by Network Rail human factor’s staff. This is mainly due to signaller workload assessments being requested as a consequence of issues in performance or wellbeing having already been identified.

For further information on these tools consultation of Pickup and Wilson (2004) is recommended.

The instructions, guidance and software (where appropriate) were developed and reviewed and version 1.0 of Network Rail’s workload toolkit was issued in May 2006 and includes:

- The Workload Principles
- IWS
- ODEC
- ASWAT
- AAT
3.0 Report Structure

This report provides a synopsis of the workload literature and how it has been interpreted and applied in the context of a signaller’s workload. (section 4.0). Subsequently each tool contained within version 1.0 of Network Rail’s toolkit is described using the structure illustrated in figure 2. Validity is explained in general in section 5.0.

![Diagram of report structure]

**Figure 2** Report structure summarising development and testing of version 1.0 of Network Rails’ workload toolkit
4.0 The Concept of Mental Workload

Workload appears an intuitive term to use when assessing a signaller’s work and workplace, but the term workload means different things to different people. To some it means having too few staff, for others it means difficulties with equipment. There has yet to be a consensus on one formal definition of workload but an overview of several suggests that workload should be considered as a combination of factors concerned with the task, the context and the individual. This indicates that workload is a multi-dimensional concept, which therefore requires a number of different techniques in order to assess it in an operational context. For a better understanding of the workload concept and relationships between workload dimensions please see the introduction to the Workload Toolkit.

A literature review on the subject (Pickup et al 2005) concluded that, the diversity and the contradictions that exist within the mental workload literature continue to make a generally accepted theoretical model elusive. The mental workload framework (Figure 1) is intended to visually represent the common themes that appear within the literature. This framework is not intended as a cause and effect diagram but arrows have been inserted where key factors are suggested as being strongly linked. The framework is intended to provide a common language and representation of the term workload which in turn will help to facilitate communication of workload related issues between human factors and operational staff within Network Rail.

In most workload investigations it will be normal good practice to make assessment of a number of different factors or indicators in a number of different ways using a combination of different tools. This is because workload is a multidimensional concept, with both objective
(observation or analytical) and subjective (self report) understandings being relevant (although there is subjectivity in the use of any method or measure including that of the investigator). The Workload Toolkit addresses this by providing a variety of tools.

## 5.0 Validity

Throughout phases 2 - 4, the workload tools have received differing levels of validation to ensure they were measuring workload in the way they were intended. This section of the report describes the different types of validity that are relevant to demonstrating the overall validity of the tools as described in Sections 6 - 10.

The term validity can be interpreted in a number of ways. Testing the validity of a tool implies the need to demonstrate that a tool does what it claims to do. The development and evaluation of the workload tools presented within this report have included an assessment of their validity for assessing signaller workload within the current working environment. There are a number of types of validity that are relevant when demonstrating the overall validity of a tool for its intended use. (Oppenheim, 1992) suggests any method or measurement technique can have more than one type of validity depending on the type of conclusions we want to draw from it.

### 5.1. Content validity

Content validity requires a tool to reflect the content of the domain where the tool is due to be used. Subject Matter Experts (SMEs) are typically used to ensure a tool sufficiently represents the domain. In terms of the workload tools how well they represent the work and work domain of a signaller will demonstrate their content validity.
5.2. **Construct validity**

Construct validity refers to the extent to which a tool captures the concept it is intended to assess, implying that it captures a theory well. The concept of workload suffers from an absence of one widely accepted definition and many different theories relating to how workload is best measured. The workload framework in figure 1 is based on a review of relevant workload theories. Where each tool sits in the context of this framework (and therefore workload theory) is highlighted in figure 3 and will be considered when referring to the construct validity of each tool. For example the IWS rating scale uses scale descriptors grounded in an understanding of workload theory and signaller work. This aims to ensure this tool can be considered as capturing the concept of workload in terms familiar to the signaller.

5.3. **Concurrent/convergent validity**

These types of validity are concerned with how well a new tool compares to an existing tool assessing the same concept. This is a very common approach to validity testing that aims to compare the new measure to a ‘true measure’ of the concept in question. However, it is unlikely that a ‘true measure’ ever exists and this is certainly true in the case of mental workload (Brewer and Hunter, 1989); essentially a hypothetical construct. This type of validity is only relevant if similar tools already exist and has only been considered for the present workload tools where this is the case.

5.4. **Face validity**

Face validity refers to a measure appearing to be appropriate for the assessment of a particular concept within a particular domain. Face validity assessment is a subjective assessment, tending to be
Figure 3 The Workload tools in the context of the conceptual workload framework
undertaken by multiple SMEs or in terms of acceptability to the user community.

The extent to which the workload tools ability to appear valid in assessing the concept of workload to the intended user group (signallers) is sufficient to demonstrate face validity. This is irrespective of what any tool may actually measure which is considered within construct validity.

6.0 The Workload Principles

6.1. Aim

The Workload Principles Tool provides an assessment of the work system in relation to the degree to which it meets a number of generally accepted ergonomics principles for work system design. They provide an overview assessment of the signaller’s working arrangements and contribute to a total understanding of signaller workload. If any particular workstation/panel is inadequate in terms of the ergonomics factors embedded in these principles, this will be likely to increase workload experienced by the signaller. Therefore the extent to which the principles are met is an indication of the impact workload is having on the signaller’s ability to perform safely and efficiently whilst retaining their well-being.

6.2. Developmental stages

An understanding of the work, functions and goals of the railway signaller was obtained through visiting over 70 signal boxes operating a range of signalling systems and completing both formal and informal observations and interviews. Systematic data analysis using
recognised qualitative research methods (Pickup 2006) and signaller workshops assisted in assimilation of the information gained.

Three top level functions of the signaller were considered representative of the signaller’s work; to be aware and assess the current situation, to make decisions and plan strategies to deal with the situation and to act to implement this plan. The nature of the signaller’s work involves communication, evaluation of information, decision-making and taking actions within the necessary time frame. These were represented as a series of goals, which were considered by signalling subject matter experts (SMEs) as generic to all contexts (Annex 1). This implied that the top level goals of the signaller are constant and that task circumstances and associated pressures (in the form of the environment, time restrictions or performance and safety requirements) will determine the workload associated with the order, combination or ability to complete these goals.

This examination of the work of a signaller allowed a set of principles to be developed based on theories associated with workload; information processing, attention and decision-making, Pickup et al (2005) and general ergonomics principles of work design. The assessment approach using the principles identified any mismatches in these principles that meant the work and goals of the signaller could not be achieved without unacceptable levels of workload in the context of the workplaces being considered. The principles were developed to impose a ‘yes’ or ‘no’ answer on analysis where, ‘yes’ suggests a satisfactory level of workload.

Originally nine principles were developed and applied during a workload investigation within a NX panel signal box. A review of the
data collected (Pickup and Wilson 2002a) suggested the need for a further three principles.

6.3. Evaluation

The twelve principles were reevaluated during a subsequent workload investigation (Pickup and Wilson 2002b) and have received ongoing evaluation over two years during their application in the field to assess the relevance and wording of the principles with signallers and signalling SMEs in a wide and representative sample of signalling systems.

Further evaluation was conducted to reflect on the experience gained by human factors experts over this two-year period.

A workshop that involved human factors experts, both internal and external to Network Rail, in combination with Network Rail’s signalling SMEs provided an opportunity to review the wording, the relevance and the priority of the Workload Principles. The priority or importance of each Workload Principle was also established so the Workload Principles could provide a workload tool that would be sufficiently sensitive to distinguish between workplaces with greater or lesser potential workload issues.

A questionnaire was designed to facilitate discussions relating to the wording and relevance of each workload principle. Each principle received some form of modification and a consensus was achieved on the final workload principles. All principles were considered relevant.
A paired comparison exercise\(^1\) was then completed. Each person considered a grid with each principle represented within a row and a header and identified the priority of each principle compared to all other principles. These data were analysed to represent the overall percentage of times each principle was placed above another. This suggested that Workload Principles 1-5 and 9 have greater priority in ensuring a workplace provides an acceptable level of workload.

**6.4. Application**

The Workload Principles Tool is available as either a laminated hard copy or electronically. Details describing how each principle is related to understanding the signaller’s workload and the type of human factors issues that are relevant can be found within the tool. This tool can be used either:

a) at the start of a workload assessment to help define the nature of the workload problem or to contribute to a preliminary assessment of workload, or

b) to assist in the judgement of findings obtained from a more in-depth study of the influencing factors.

To use the tool involves considering all the information obtained through observation or discussion with the signaller or signalling manager and identifying whether each principle is met. A yes or no answer indicates whether the principle has been met. Further details of why a principle has not been met are also recorded.

\(^1\) The method of paired comparisons allows the relevance of several options or items to each other. This method can establish the priority or importance of each item in the context being considered Guildford (1954)
Principles 1-5 and 9 as primary principles are essential for safety and performance. If they are not met then remedial action is required. The remaining (secondary) principles are desirable; if it is apparent (either through observation or suggestion by those working or managing the workstation) that these are not achievable then further investigation is encouraged, although failure to meet the primary principles would obviously take priority.

6.5. Data management

The data collected via the Workload Principles are in a text format. The advice provided in the Instructions and Guidance within the workload toolkit recommends that data are presented within a table with three columns indicating the principle that has not been achieved, contributing factors and the implications for the system and the signaller. The data presented are intended to provide supporting evidence as to why a principle has not been met but also facilitate the development of an action plan that can address tangible issues relevant to a specific working environment.

Reported applications of the Workload Principles and the data collected can be studied to understand any patterns in the type of factors influential to preventing the achievement of each principle. Reflecting upon these could in the future facilitate the development of best practice guidance on the work and working environment for the railway signaller, to minimise unacceptable levels of workload.
6.6. Limitations

Use of the Principles relies on the judgement of the investigator to state whether each principle is fulfilled or not. This judgement is only as good as the skill of the investigator and the quality of the information gained from signallers and their manager. Although a redline does not exist for each Workload Principle fulfilling the primary principles (numbers 1-5 and 9) can be considered as providing a high level judgement to distinguish between workplaces with greater or lesser potential workload issues.

6.7. Validity

The Workload Principles have been found useful, meaningful and generally consistent with other observations made during a number of workload assessments of signal boxes. Their exposure to signalling SMEs during all workload assessments completed by Network Rail Ergonomics team within the last two years has suggested they have face validity.

The development process that based the principles on a detailed understanding of the work and working environment typical to the railway signaller was adopted to promote the content validity of the final tool. The workshop which reviewed this tool (with human factors and operational experts) ensured the relevance and suitability of the wording used within the final tool. The workshop provided the opportunity to review the content validity of the final tool and its ability to suitably represent the relevant human factors issues in an operational context for the railway signaller.
The paired comparison exercise has provided additional evidence to support the content and construct validity of the workload principles; six of the twelve principles were considered to have greater priority in ensuring that working conditions did not impose unacceptable levels of workload. A lack of validity and sensitivity in this tool would have inhibited the completion of this exercise, as the principles would have been judged inappropriate and all of equal value.

7.0 The Integrated Workload Scale (IWS)

7.1. Aim
The IWS collects real time perceptions of signaller workload based on a nine-point scale. This tool can be used to identify peaks and troughs in the effort and demand experienced by signallers when responding to dynamically changing work conditions.

7.2. Developmental stages
The literature review of traditional workload assessment tools suggested that self-report tools were considered of great benefit in workload assessments in reflecting the mental workload experienced by an individual. Some authors believe that subjective ratings are the most sensitive and accurate reflection of mental workload (Hart 1988) and benefit from the operator’s insight into an increase in effort prior to performance degradation (Muckler 1992). The self report tool needed for signallers was to allow an assessment of the fluctuations in the global workload experienced, with needs for the scale to be quickly administered, minimally intrusive and to use recognisable terminology for it to be acceptable within the field.
The Thurstone approach (Guildford 1954, Oppenheim 1992) for scale development with equal appearing intervals was used to develop a signaller self report tool. The scale descriptors were produced following a literature review of the workload concept and interviews with signallers. This approach is described fully in (Pickup et al 2005). The method provided scale anchors relevant to the concept of mental workload and meaningful to the railway signaller. A representative sample of signallers was used to judge the suitability of each descriptor and complete the Thurstone method.

The final nine point scale was presented with colour boxes adjacent to highlighted text that summarises each scale descriptor, see figure 4 below.

Figure 4 IWS Scale
The interface for applying the IWS was designed to ensure the final tool was usable and with minimal intrusiveness to the signaller. A software program was developed to allow the IWS scale to be completed via a touch screen laptop and a 9 point keypad directly into any laptop. This provides immediate data collection and graphical representation within an excel spreadsheet.

7.3. Evaluation

Two experimental simulator trials were completed to assess:

- the intrusiveness of the IWS tool on the work of the signaller,
- the usability and practicalities of the IWS tool,
- the validity, sensitivity and diagnosticity of the IWS tool.

The first trial used four conditions to compare how the signallers’ work was influenced whilst operating within a normal and degraded (Hot Axle Box Failure) scenario both with and without the IWS tool (Mitchell et al 2003). The findings did not suggest the IWS was intrusive to the signaller’s work and received positive comments relating to its usability. The tool captured peaks and troughs as predicted within the scenarios, suggesting it to be sensitive and at a very basic level diagnostic of changes in perceived workload. Construct and content validity was demonstrated through questionnaire data completed by signallers and concurrent validity through comparison of IWS data to Adapted SWAT data recorded during the scenarios (see section 9.0 for a description of this tool).

During the first trial the higher end of the scale was not used by signallers. This was either due to the degraded scenario being insufficiently demanding or the IWS scale being insufficiently sensitive.
in this area of the scale. A second trial was completed to test these hypotheses (Mitchell and Thomas 2003). A realistic scenario considered to be more demanding was developed. This provided a period of low traffic and then a gradual increase followed by two failures within the infrastructure (a points and track circuit failure). The data recorded included IWS ratings, activity data and expert commentary on the activities completed by the signaller in relation to their IWS ratings. This trial demonstrated the sensitivity of the scale as higher ratings were received during the predicted periods of greater complexity. Expert commentary further supported the shift in signaller strategy or dropping of activities where higher ratings of IWS were recorded. This behaviour was suggested as typical to signallers working at relatively high levels of workload. Eight out of the nine scale descriptors were used during this trial suggesting that the IWS scale length is sensitive to capturing greater demands in the signaller’s workload. The absence of a rating of ‘9’ is more likely to be due to recognised patterns in human behaviour that prevents people from rating at extreme ranges of the scale.

Several usability issues were highlighted relating to the IWS software and touch screen interface. These have since been rectified within the IWS tool.

**7.4. Application**

The tool is used by asking signallers to provide a rating of their workload at a suitable time interval over a particular period of time within a shift for a specified duration. The time interval considered acceptable in the field is 5 minutes. The period of time chosen will depend on the workload issue under investigation and may include a particular scenario e.g. possessions, use of level crossings, peak in
timetable. The time chosen must characterise the workload to be investigated. The duration that the IWS is applied over depends on the period considered necessary to provide a good representation of the situation to be investigated. The recommended duration during field assessments is one hour.

There are four ways of applying IWS:

1. Keypad input device
2. Touch screen laptop
3. Paper and pencil
4. Actiwatch

The instructions within the toolkit explain how to load the IWS software depending on which application of the IWS you are using. The Ergonomics Team at Network Rail holds the input devices and the Actiwatches.

For the paper and pencil application use a stopwatch and the laminated IWS scale provided and record data onto your notepad in two columns. The first column should be for a record of the time a rating is obtained, the second the rating provided. To assist in the recording of ratings (with all methods of recording) numbers 1 to 9 can be used to represent each descriptor, with 1 representing ‘Not demanding’ and 9 ‘Work too demanding’ (see table below for example).

<table>
<thead>
<tr>
<th>Time Recorded</th>
<th>IWS Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.05</td>
<td>3</td>
</tr>
<tr>
<td>10.10</td>
<td>3</td>
</tr>
<tr>
<td>10.15</td>
<td>4</td>
</tr>
<tr>
<td>10.20</td>
<td>3</td>
</tr>
</tbody>
</table>
There are several actions necessary to ensure the IWS is used correctly and a standard explanation for signallers is provided within the instructions for this tool.

The IWS can be applied both in the field and in simulated signalling environments. It can be used in conjunction with video recording, subject matter expert commentary or the Activity Analysis Tool (AAT), described later. This approach will assist in highlighting which combinations of tasks or situations are considered to produce high and low levels of effort and demand (workload).

7.5. Data management

The ‘Getting Started with the IWS tool’ booklet, within the toolkit explains where to find the excel spread sheet ‘to create IWS Graphs from IWS data v3.0’. This can be transferred onto any computer and used for data collected from all input devices. Instructions on how to use this spread sheet are contained within the first worksheet of this excel spreadsheet.

The output from this tool is a graph that highlights peaks and troughs in workload experienced. This can be presented in parallel with activity analysis data and the AAT combines both IWS ratings and AAT data graphically. Debriefing with signallers will increase the richness of these data and the level of diagnostic insight obtained.

Calculating the mode or frequency with which each rating was selected over a period of time will reflect the most frequently scored rating.
7.6. Limitations

The strength of the IWS lies in its ability to quickly and effectively provide data, which can be compared from minute to minute if necessary, from situation to situation or even between individuals. However, it does not differentiate between the different dimensions that are the essence of the multi-factorial concept of workload.

One risk is that inappropriate interpretations are made from the data. This includes calculations of a ‘mean workload score;’ as this may not represent the dynamic nature or multiple dimensions of workload and misleading conclusions could potentially be drawn. Another risk with any self-report rating data is that unwarranted confidence is invested in the data produced as they appear quantitative but remain fundamentally subjective.

7.7. Validity

The developmental process adopted for the IWS tool considered the relevance of construct and content validity. The scale descriptors were grounded in an understanding of workload theory and signaller work. The process involved signallers in the evaluation of the scale descriptors and therefore ensuring construct and content validity of the final tool. Further testing of the scale descriptors during the two experimental trials did not reveal any reason to suggest the scale should not be considered to have these two forms of validity. Concurrent validity was formally tested and demonstrated in the comparison to ASWAT data. Finally the use of the IWS in the field has provided evidence of good face validity.
The Operational Demand Evaluation
Checklist (ODEC)

8.1. Aim
A signalling system or signalling workplace can be described in terms of a number of entities, which are relatively constant (static characteristics, such as the number of signals or level crossings) or relatively variable (dynamic characteristics, such as the number of unplanned or emergency possessions). All of these entities can influence the workload of a signaller. ODEC provides a systematic process to evaluate these entities within any one particular workstation/panel, in order to represent the influence the overall system has on the signallers’ workload.

8.2. Developmental stages
Observations and interviews were initially completed to provide a map of the key and generic components representative of the signaller’s operating system. The Repertory Grid Technique (RGT) (Fransella and Bannister 1977) was then applied to capture knowledge from signalling SMEs to understand the significance and priority that each component had on influencing signaller workload.

A tool was envisaged that could provide a profile of a signalling system to suggest if the overall system should be considered as having a greater proportion of components that influence a high or low workload. This would allow documentation and transparency in representing the extent to which the signalling system contributes to the workload of the signaller.
A checklist format within an Excel spreadsheet was adopted to represent each of the final components. The data recorded for each component are numerical.

Three forms of ODEC exist representative of the main signalling systems - Lever frame, NX/IECC and RETBs. High, medium and low categories were initially estimated for each component on the basis of experience and these have since been validated by data collected from representative workplaces. The quantitative data for each component are entered within ODEC and automatically compared within the spreadsheet to the range of data representing high, medium and low. The number of high, medium and low categories recorded are calculated and represented as percentages.

A number of the components were identified during the RGT process as having a greater influence on the signaller workload and were highlighted within the tool and weighted more heavily within the final calculation.

Following six months of field trials by the Ergonomics team at Network Rail with ODEC several amendments were made. A workshop was held to review the format and application of ODEC. As a consequence of this:

1. A non applicable (N/A) box was inserted
2. Discussions justified the removal or reinstatement of certain elements and the weighting they should receive (annex 2)
3. A final score was retained but with strong guidance advising that this should not provide a redline value to judge a signalling system as being operational with safe levels of workload or not.
Further applications of ODEC within the field revealed that local managers were misinterpreting the final single score provided by ODEC, which does not nor cannot clearly represent the profile of the component scores for the elements within ODEC. Therefore this has been removed and the current version of the ODEC tool (Network Rail version 1.0) exists as a tool that is transparent in its application and data management providing a documentation of how to categorise a signalling system with regard to the demand it imposes upon a signaller.

8.3. Application

ODEC is an evaluation checklist presented as an excel spreadsheet. There are different versions depending on the type of signalling system you are assessing (i.e. Manual, NX or IECC). The categories for high, medium and low values for each entity vary between the type of signalling systems.

ODEC can be used before employing any of the other workload tools, to understand and give context to the work of a signaller. ODEC may also be employed in early predictions of potential workload within new or proposed signalling systems.

Within the tool the worksheet labelled ‘Data Descriptions’ will explain what the entity is, where it can be observed or measured and what it represents in terms of the demand upon the signaller.

The nature of the information required by ODEC is available from a number of sources, as indicated within the tool itself. These rarely require interrupting the signaller. Indeed, a lot of the information can be easily collated by the local manager in advance of any visit or in a meeting at the location.
ODEC should be applied to one workstation/panel at a time and in the case of a two-manned panel ODEC should be applied for each area controlled by a single signaller (there may be some overlap between the areas controlled). Hybrid systems require the appropriate version of ODEC to be used for each system.

**8.4. Data management**

The output of the ODEC tool is the percentage of entities categorised as having high, medium or low workload attributes recorded for the workstation assessed. These data provide a representation of a single workstation, allowing comparison between workstations and the identification of entities most responsible for the demands imposed upon the signaller by the system they operate.

An approximately equal split of elements as possible between high, medium and low would appear to suggest a reasonable balance for a system to be controlled. Greater than 40% of elements within the high category should suggest caution about adding any further elements to a system without compensatory actions.

**8.5. Limitations**

The tool is a structured method of data collection relevant to signaller workload; it is not intended to impose a cut off point to suggest that any one system or workstation should or should not include a particular number of entities.

The categorisations of low, medium or high do not refer to workload per se, but to the extent that different entities are found in the target system or workstation as compared to other systems. That is, the scores are relative.
The implications of Automatic Route Setting (ARS) for the workload associated with a system are yet to be fully understood. A simple exercise comparing systems suggested that a system with 100% ARS active should be considered as being 75% less demanding than a fully manual IECC system (which could be considered as being equivalent to a traditional NX panel). A fully manual system should be considered as 33.3% less demanding than a system with part ARS and part manual. These crude estimates may assist when comparing the ODEC outputs for systems with ARS in operation with other systems. The assumptions and values continue to be validated in the field, which means that feedback must be received by the Ergonomics Team after every application of the ODEC tool by any consultant or member of Network Rail Ergonomics team.

8.6. Validity

The developmental process of ODEC has ensured that the large number of components of the signalling system were representative of a wide range of systems and using terminology familiar to the domain of signalling. Signalling SMEs were involved consistently, both in the field during collection of these components and at the later stages in reviewing all of the elements proposed. This approach has ensured that the content validity of ODEC has been considered.

The construct validity of the tool again is shown through the developmental process. The RGT has focused on understanding which components of the system are more or less likely to load the signaller and create a subsequent demand. Both of these are directly related to the concept of workload. ODEC can therefore be considered as
identifying systems which have components likely to have more or less of a load upon the signaller’s work.

ODEC is an original tool and an exact or even similar tool for comparison does not exist. However, as a practical approach, likening the tool to an existing assessment method it was compared to the signaller grading system. ODEC data collected for the NX panels, Lever frame and IECC systems are illustrated in figure 5.

The comparison with the grade of each signal box was to see if the grade order reflected the order by the percentages of components recorded within the high, medium and low categories. A signal box with a higher percentage of components within the high or medium categories would be placed above those with less. Table 1 illustrates the rank order of systems based on their ODEC data. Due to few data from the IECC Systems these were omitted from this evaluation.

The RETB ODEC is based on data from two of the existing three of the RETB systems in the country and is therefore considered to sufficiently represent these systems and have content validity.

The lever frame data do appear to compare very well with just one anomaly - Codsall Madeley - where grading had been an issue anyway.
Figure 5 Spread of data collected from ODEC 2003-2004
The NX panel data appears slightly different at first glance. However, when we understand that one ODEC was completed for Saltley and West Hampstead, which two signallers operate, this makes some sense of their positioning within the Table 1. The reason given for only one ODEC being applied during this assessment was that at night one man controls the whole panel, however, with considerably less traffic running. This explains why ODEC reflects the system as imposing a higher demand on the signaller than Manchester Piccadilly (recognised for its high demand by SMEs) yet in reality the panel at Saltley and West Hampstead is controlled by two signallers and could be considered as two panels, requiring a separate ODEC assessment for each area controlled.

<table>
<thead>
<tr>
<th>Lever Frame Boxes</th>
<th>ODEC Position</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heaton Norris</td>
<td>6</td>
<td>Saltly</td>
</tr>
<tr>
<td>Edgley 2</td>
<td>6</td>
<td>W.Hampstead</td>
</tr>
<tr>
<td>Edgley 1</td>
<td>6</td>
<td>Manchester Piccadilly</td>
</tr>
<tr>
<td>Codsall-Madeley</td>
<td>4</td>
<td>Tweedmouth</td>
</tr>
<tr>
<td>Severn tunnel junction</td>
<td>5</td>
<td>Trent</td>
</tr>
<tr>
<td>Stirling Central</td>
<td>4</td>
<td>Coventry</td>
</tr>
<tr>
<td>Croft</td>
<td>3</td>
<td>Deansgate</td>
</tr>
<tr>
<td>Hinkley</td>
<td>3</td>
<td>Stourbridge</td>
</tr>
<tr>
<td>Narborough</td>
<td>3</td>
<td>Rochester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NX Panels</th>
<th>ODEC Position</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Saltly</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>W.Hampstead</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Manchester Piccadilly</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Tweedmouth</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Trent</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Coventry</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Deansgate</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Stourbridge</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rochester</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1 ODEC data compared to signal box grade**

These findings show how ODEC data could potentially misrepresent the demand of a signaller’s system and this was addressed through changes to the instructions and guidance outlined in section 8.3. However, the findings did suggest that comparisons could be drawn with ODEC data and the current grading system, suggesting that concurrent validity was evident across these two forms of assessment.
9.0 The Adapted Subjective Workload Assessment Technique (ASWAT)

9.1. Aim

The Subjective Workload Assessment Technique (SWAT) (Reid and Nygren 1988) was developed in other industries, but none the less seems to be generic in terms of workload dimensions. It includes dimensions that signallers had suggested as representing their interpretation of the term workload. SWAT has therefore been considered as potentially the most relevant existing multidimensional workload scale for signallers.

The original SWAT has been adapted in 2 main ways to facilitate use within the signalling context; firstly in relation to terminology and secondly the method of applying the scale.

The tool provides a relatively quick and easy general comparison scale for signallers to assess three dimensions of workload retrospectively. It allows a comparison of signaller workload between two situations (e.g., change in timetable) or different times in the day over a period of time. It also allows some degree of diagnosis about where the signaller’s greatest demands or effort might be.

9.2. Developmental stages

The original SWAT has three dimensions - time load, mental effort and psychological stress load. Testing with signallers suggested that the term ‘stress’ was inappropriate. The culture of signallers appears to view stress as a weakness; the term ‘pressure’ was more frequently associated with workload and was suggested by signallers as a suitable
alternative. Hence the Adapted SWAT refers to pressure rather than psychological stress load.

The original SWAT normally involves a 2 stage scale development. However, using the SWAT scale by considering the dimensions as continuous and having equal weighting avoids the need for the first phase of scale development. This use of SWAT has actually shown a higher level of sensitivity than the original SWAT in assessment between tasks of medium workload (Biers and McInerney 1988, Luximon and Goonetilleke 2001). This more simplistic version has been adopted for the Adapted SWAT tool to provide a practical tool for use in the field of signalling.

**9.3. Evaluation**

The original terminology used in SWAT was considered during a structured analysis of data collected from signaller interviews aiming to identify sources of signaller workload. The coding of these data highlighted the relevance of the terms ‘time’, ‘effort’, ‘stress’ and ‘pressure’ to describe signaller workload. Further interviews asked a sample of signallers directly about the appropriateness of these terms to explain workload in the context of signallers. These findings supported the relevance of all terms except stress (See section 9.2).

ASWAT was applied during the IWS experimental trials referred to in section 7.3 and received positive feedback in relation to its usability and suitability for assessing signaller workload.
9.4. Application

It is intended that this tool should be applied retrospectively as a signaller becomes available or when a second signaller can temporarily provide relief from signalling duties to allow the main signaller to respond to ASWAT almost concurrently with their work. Alternatively a video recording of events may be useful to prompt retrospective ratings.

The laminated scale should be used and the signaller instructed to indicate one of the three descriptions that best represents their perception of each of the three workload dimensions in relation to the period of time and situation being assessed.

Recommendations on frequency of rating are difficult to provide, as this is dependent upon the nature of the workload issue under investigation. One example of how the tool may be applied is assessment of the workload impact from granting and withdrawing possessions. In this instance you may wish to take an ASWAT rating for the key stages involved in this activity. This would reflect which of the key stages were more likely to contribute to time load, mental load and pressure for the signaller. Consequently the frequency of rating is determined by the occurrence of each key event.

9.5. Data management

Each dimension within the adapted SWAT has three levels, scored one to three from the top to the bottom level. An example is given on the next page showing the dimension of ‘Time Load’.
A total score can be calculated by adding the rating obtained from the signaller for each dimension. The total represents an individual’s perception of the workload experienced in relation to the time available, mental effort and pressure experienced across different situations, events or time periods.

Alternatively calculating the mode or frequency with which each scale descriptor was selected over a period of time will reflect the most frequently used descriptor for each workload dimension.

Please tick the phrase a), b), c) that best describes how you feel about the time you had.

<table>
<thead>
<tr>
<th>Option</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Often have spare time. Interruptions or overlap among activities occur infrequently</td>
<td>1</td>
</tr>
<tr>
<td>b) Occasionally have spare time. Interruptions or overlap among activities occur frequently.</td>
<td>2</td>
</tr>
<tr>
<td>c) Almost never have spare time. Interruptions or overlap among activities are very frequent, or occur all the time.</td>
<td>3</td>
</tr>
</tbody>
</table>

**9.6. Limitations**

The data collected should be treated as ordinal data (categorical data). This implies it is not valid to calculate a ‘mean’ (average) of multiple ASWAT ratings over the period of time where the tool has been applied. Any statistical testing will require the use of non-parametric statistical tests.
This tool relies on the retrospective rating of a situation by signallers. A delay in rating workload may inhibit the accuracy of this rating. A delay of up to 30 minutes will not distort ratings, but where a delay of greater than 30 minutes is likely, a signaller may benefit from reviewing the situation using either a video recording or CCF data.

9.7. Validity

ASWAT received some testing of its validity during its application in the IWS experimental trials. These revealed concurrent validity with the IWS tool.

The development process aimed to test the relevance of the terminology used within SWAT, and subsequently ASWAT, for the domain of signalling. This demonstrated the content validity of the tool.

The construct validity of the tool, although not formally assessed, is assumed based on the depth of theory and knowledge applied to the original version of SWAT (Reid and Nygren 1988).
10.0 The Activity Analysis Tool (AAT)

10.1. Aim

It is useful to be able to relate workload to activity. This can assist in assessing which activities or scenarios in signalling are more or less demanding than others.

The Activity Analysis Tool (AAT) involves observing and recording signaller’s activities at certain times. It is most effective when combined with workload scores from the Integrated Workload Scale (IWS) and/or with subject matter expert (SME) commentary. This allows the relationship between workload and activities to be explored and may highlight which combinations of activities or situations are considered to produce high and low levels of effort and demand.

The AAT can be applied to capture either:
- a snap shot of the activities being completed by the signaller at a pre set time interval, or
- the type and duration of activities to represent the percentage of time that is occupied by specific activities.

10.2. Developmental stages

The AAT is based on traditional ergonomic tools that aim to capture the number and nature of tasks occurring within a set time period. This tool was developed following consideration of a number of such tools currently used by human factors consultants actively involved in workplace assessments of railway signallers. This tool was designed to be flexible in its application. Data can reflect either the combination of tasks being completed at one point in time or
the time required to complete tasks within a designated time period. These two approaches to capturing data were recognised as being most frequently used by ergonomists.

The tool is presented in an Excel workbook, with worksheets providing instructions, examples and the tool itself in its two main forms.

The graphical output of AAT data has been merged with the graphical output of IWS data to provide two forms of information to be considered in parallel. Additionally the benefit of SME commentary was recognised from the experimental trials completed with the IWS tool and has been incorporated within the AAT and can also be mapped onto the graphs.

10.3. Evaluation

The tool has been internally reviewed by human factors experts within Network Rail and consultants have been provided with the opportunity to comment. Minor amendments were necessary relating to wording; however, the tool is yet to be formally tested in the field environment. Problems are not predicted as the tool follows a recognised format familiar to ergonomists and the development of the tool was mainly intended to standardise this form of assessment amongst consultants working for Network Rail.

10.4. Application

The method of capturing the duration of activities has been applied both in the field and simulated signalling environments. Human factors experts or operational experts can use this tool, however, SME
commentary should only be provided by suitably experienced operational experts.

The AAT can be applied at a particular period during a shift that requires investigation or during a particular scenario e.g. possessions or use of level crossings. The duration of the assessment depends on the period considered necessary to provide a good representation of the situation to be investigated. Experience has suggested a period of one hour as most appropriate in the field.

The AAT is presented as an excel spreadsheet ‘Activity Analysis Tool V1.0’. It includes two methods to record activity: Snapshot and Activity Occupancy. The choice of method will be determined from the question that needs to be addressed by the workload assessment and the time available to complete the assessment.

The AAT includes spreadsheets which contain:

- Examples of the data recording tables and the graphs which are produced as the output
- Activity Record forms that can be used to collate data in the field
- Data tables which are generated using the information from the Activity Record forms
- Graphs which are generated from the information in the data tables and form the basis of the output from this tool.

A list of signaller activities has been provided and is designed to standardise how signaller’s activities are captured.
**Snapshot**
The snapshot method is an efficient approach to sampling the combination of activities that are associated with particular IWS ratings.

Data are collected using a print out of the Snapshot Activity Record sheet to record the activities that the signaller is carrying out at the time the IWS rating is provided. This is then entered into the AAT and a graph is automatically generated to present the results.

**Activity Occupancy**
The Activity occupancy method is intended to represent the percentage of time occupied by an activity within a specified time period.

Activity Occupancy records the total time each activity occupies during a 5 minute period.

Data are collected using the Activity Occupancy Record sheet. Data can either be collected in 5 minute intervals or continuously.

Data entered into the Activity Occupancy Record within the AAT automatically generates a graph to present the results.

**SME Commentary**
The SME commentary can provide rich information with regard to the nature of the work completed and an insight into the effectiveness and efficiency of the individual completing signalling activities. Any compensatory strategies or deterioration in the signaller maintaining
the timetable or safety can be highlighted and any insight into possible causes cited.

SME commentary supports all applications of this tool. A worksheet labelled ‘SME commentary’ is provided to record the commentary. This can be printed off, completed and the data input later. SME commentary can be collected continuously or at the very least it should be collected at the pre-set time intervals.

The SME commentary can be represented with the activity and IWS data to offer an explanation or comment about a particular time in the observation period. A number can be entered in the column titled ‘Comment No.’ which will correlate with a numbered text box inserted into the appropriate graph.

**Using AAT with IWS**

The AAT should be synchronised with the IWS time interval. The time interval that has been adopted for the IWS tool in the field is 5 minutes. This can obviously be reduced but implications of intrusiveness need to be considered.

For a greater understanding of the IWS Scale read the guidance document IOE/RAIL/03/20 and report IOE/RAIL/06/02/R prior to using it.

**10.5. Data management**

The output of the AAT is graphical. Three graphs can be produced determined by the type of data collected within the Activity Record. Each of the graphs present the activity observed from the signaller with IWS ratings and number of trains active in parallel.
The SME commentary is supplemented onto these graphs once they have been imported into the final report. These comments should be presented as numbered text boxes within the graph, referring to an attached table to elaborate on each comment.

The graphs provide an illustration of how activity duration, combination and number of trains may contribute to a signaller’s perception of workload captured by the IWS rating.

**10.6. Limitations**

The use of the AAT in conjunction with other workload tools (ideally IWS) provides a more comprehensive understanding of signaller workload. However, it should be recognised that there is not necessarily a direct relationship between actions, events and workload.

The AAT cannot account for unobservable events such as mental processing, which may vary independent of the observable actions and events within the job. However, the SME commentary aims to provide some interpretation of the ‘hidden’ nature of the work being completed by the signaller.

The percentage of time that an activity occupies is useful information to understand the implications of time pressure as a dimension of workload. However, the term activity occupancy is not synonymous with workload and does not highlight how the interference of information processing resources influences the demand experienced from a combination of certain activities.
10.7. Validity
This tool is intended to record activities and does not attempt to
manipulate data or claim to assess workload per se; therefore to prove
its validity may not be relevant. However, future use of the tool in the
field or simulated environment should aim to establish the reliability of
the tool in its ability to accurately capture activities over time.

11.0 Progress of the Workload Probe

11.1. Aim
The dynamic nature and complexity of the rail industry and signalling
environments suggested the need for analytical approaches to take a
broader view of the workload concept and consider the interaction of
sociotechnical and information processing demands placed upon the
signaller.

The Workload Probe aims to provide an analytical tool transparent in
the sources of information it relies upon and to offer an easily
accessible output usable by local management to address potential or
existing workload issues.

The tool is intended to consider the context of the sociotechnical
system by being grounded in field data, whilst also reflecting cognitive
theories relating to human cognition and workload. Combining these
sources of information provides the mechanism for identifying how and
where a mismatch exists in the signaller achieving their goals in the
time available and the context of their workplace.
11.2. Developmental stages

The background work described earlier in section 6.2 to understand the functions and goals of the signaller provided important information for the development of this tool (Annex 1). The representations of the goals captured the essence of signaller work. To produce a tool capable of capturing mismatches in the ability of the signaller to achieve these goals required a more in depth understanding of what is required of the signaller to fulfil these goals in the context of the signallers working and organisational environment. A framework based on cognitive theories was initially developed to analyse the signaller’s goals in terms of their cognitive demand. This included consideration to the degree to which each goal required: attention, perception, identifying and integrating information, diagnosing, evaluating, planning, decision making and actions.

A workshop was arranged involving signallers representative of the three main types of signalling systems (lever frame, NX panel and IECCs) and incorporating both novice and experts in signalling. Questions focused on which factors influenced a signaller in achieving each cognitive requirement identified as necessary for each goal and how this was done. These data and data from earlier interviews during workload assessments were considered to understand the implications of the environmental constraints upon the cognitive capabilities of the signaller whilst completing their work.

Subsequently a series of questions were developed to investigate the presence of mismatches in the context of the signaller’s working environment and the signaller’s cognitive capabilities (see Annexes 3 and 4 for a top level overview of the contextual, environmental and
cognitive factors included within the Workload Probe and a sample of questions).

Initially the questions were presented in a paper based flow chart format and referred to as the Workload ladders. However, following feedback and usability issues, it received several modifications.

The questions were transferred into a tabular format that has since been developed into an electronically interactive database. This provides an interface that allows the user to either choose the contextual/environmental factors they wish to ask questions about or by completing the Workload Principles, within this electronic tool, identify a series of questions considered appropriate to explore why a principle has not been achieved.

Ongoing development and testing of this tool is currently under way to fully assess the usability and sensitivity of this tool in the field of signalling. An update on its progress will be reported in future reports.

12.0 Application of the Workload Toolkit

The workload toolkit contains:
- An introductory note providing an overview of the aim and contents of the toolkit
- A copy of the workload assessment tools
- Guidance and instructions on how to use each tool and capture and analyse the data

It is available as a paper-based version contained within a single briefcase. Alternatively a CD is also available that uses a web site
format to present each tool and the appropriate instructions and information.

The toolkit is currently being applied by the Ergonomics Team at Network Rail and consultants employed by them to investigate workload issues. Each workload investigation is considered independently to identify the questions to be addressed and identify the most relevant tools within the toolkit. However, it is envisaged that the data collected by anyone using the toolkit will be collated centrally to facilitate with the periodic review and development of the tools and to monitor for national trends and issues.

A procedure is currently being developed by Network Rail to assist in guiding necessary decisions and a report pro forma will be available to assist in structuring the presentation of data.

The table provided within the Executive Summary to this report describes the aim and format of each tool and also provides some initial guidance on how to judge the output from each of the tools based on a combination of data collected, SME and human factors expert review and literature where available.

This current Workload Toolkit Network Rail version 1.0 will be reviewed in December 2006 and amendments made as identified following the previous six month period of its application.

13.0 Future Work

At the time of the implementation of the Network Rail toolkit version 1.0 in May 2006 a number of issues had already been identified as requiring further attention. These included:
• Evaluation and further development of the Workload Probe.
• Addition of a predictive workload assessment tool
• Further development of the web based toolkit.
• Review of the ODEC tool to be able to account for the impact of automation within signalling systems.
• Development of a format for capturing data from workload reports to facilitate central collation of the workload data
• Development of a formal process for logging feedback and suggestions for future developments to the workload tools following field-based applications and updating tools on a periodic basis rather than ad hoc basis

The Workload Toolkit will continue to evolve as experience is gained with its use. Feedback is encouraged from those familiar with the tools which aims to promote a learning culture to support the implementation of this growing form of assessment.
14.0 References


Pickup L, Wilson JR (2002b) Investigation into Signaller Workload at Derby PSB. The Institute for Occupational Ergonomics. Centre for Rail Human Factors. The University of Nottingham, Nottingham, pp 1-22


Part one. IOE/RAIL/03/03/R. Institute for Occupational Ergonomics. Centre for Rail Human Factors. Nottingham University, Nottingham, pp 1-19


Part two. IOE/RAIL/03/04/R. Institute for Occupational Ergonomics. Centre for Rail Human Factors. Nottingham University, Nottingham, pp 1-11


15.0  Publications


Annex 1 Railway signaller goals

- Goal: Manage Departures
- Goal: Manage Arrivals
- Goal: Protect traffic and personnel
- Goal: Assess and accommodate current and projected train and infrastructure status
- Goal: Identify incidents and occurrences
- Goal: Relieve and assume control
- Goal: Receive and assess information

Signaller Function: Control timetable and avoid potential conflicts.

Diagram shows connections between goals and functions.
### A Relieve and assume control

<table>
<thead>
<tr>
<th>Goal</th>
<th>Perceive/Attention to Identify and Integrate</th>
<th>Evaluate and Diagnose &amp; Plan</th>
<th>Decision</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relieve and assume control</strong></td>
<td><strong>Attend:</strong></td>
<td><strong>Evaluate:</strong></td>
<td><strong>Decide:</strong></td>
<td><strong>Act:</strong></td>
</tr>
<tr>
<td></td>
<td>• Information from previous signaller on system status</td>
<td>• Information from previous signaller and their ability to recall information</td>
<td>• Is a conflict present or predicted in traffic, simplifier (timetable), infrastructure</td>
<td>• Officially relieve and assume control by signing on all entries in the log book</td>
</tr>
<tr>
<td></td>
<td>• panel/overview</td>
<td>• approach necessary to route setting</td>
<td></td>
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<tr>
<td></td>
<td>• documentation for current events (isolations, possessions, weather, WONs, PONs etc)</td>
<td>• commitments within infrastructure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Further incoming information</td>
<td>• accuracy of panel/overview to reflect information relating to infrastructure restrictions</td>
<td></td>
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<tr>
<td><strong>Identify System Status</strong></td>
<td><strong>Identify:</strong></td>
<td><strong>Identify:</strong></td>
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</tr>
<tr>
<td></td>
<td>• traffic and infrastructure status on panel/overview</td>
<td>• mismatch in information</td>
<td></td>
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<tr>
<td></td>
<td>• reminders in place</td>
<td>• effort required to regulate traffic</td>
<td></td>
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<tr>
<td></td>
<td>• level of automation impacting on route setting</td>
<td>• conflict between TDs and simplifier exists</td>
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<tr>
<td></td>
<td></td>
<td>• points are locked in position suitable for engineering work</td>
<td></td>
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<tr>
<td><strong>Observe New incoming information</strong></td>
<td><strong>Integrate:</strong></td>
<td><strong>Integrate:</strong></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• panel/overview to information obtained</td>
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<td></td>
<td></td>
<td>• panel/overview to simplifier (timetable)</td>
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<tr>
<td></td>
<td></td>
<td>• reminder appliances mimic information within documentation</td>
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</tr>
</tbody>
</table>
Receive and Assess Information

### Goal
- Perceive/Attention
  - Attend:
    - Block Instruments
    - Alarms
    - Light alerts e.g. TOs
    - Time
    - Simplifier
    - TRUST
    - Telephone
    - Fax
  - Identify:
    - Conflict
    - Incident or occurrence
    - Emergency situation
  - Integrate:
    - Train Advisory (control)
    - Weather Updates
    - VSTPs
    - Unit Failure
    - Printouts
    - Emergency Speed Restrictions
    - Possessions (Maintenance)
    - Platform Staff
    - SG40s (public)
    - Radio (driver)
    - Signaller to signaller communications
    - Delay Attribution Clerks

### Evaluate and Diagnose & Plan
- Evaluate:
  - Priority evaluated on type of information and probability of effect on:
    - Safety
    - Traffic delay
    - Simplifier conflict
    - Personnel
    - Impact on signaller’s work
    - Infrastructure status
  - Evaluate implications:
    - Safety of traffic or personnel
    - Availability of infrastructure to traffic or personnel
    - Traffic stopping patterns
    - Disruption to timetable
    - Impact on adjoining signalling centres
    - Conflict with procedures and rules
  - Diagnose:
    - Identify incidents and occurrences
    - Reduced system safety
    - Increased system complexity
    - Insufficient options for regulating
    - Simplifier conflict and delay of arrivals and departures
    - Insufficient infrastructure capacity
    - Reduced accessibility of infrastructure to traffic or personnel

### Decision
- Decide:
  - Priority with which each piece of information is dealt with.
  - The need and urgency with which to deal with information.
  - Severity of action required which may range from regulating traffic, protecting personnel on or near the line, to requesting support or sending emergency alarm to stop traffic.

### Action
- Act:
  - Scan panel/overview and incoming information relative to traffic and infrastructure
  - Manage information
  - Adhere with confidence to decision made on how to act
  - React as information is updated and complete signalling duties necessary to achieve decision

<table>
<thead>
<tr>
<th>Execute signalling duties appropriate to respond to interpretation of information</th>
<th>Receive and Assess Information</th>
<th>Goal</th>
<th>Perceive/Attention to Identify and Integrate</th>
<th>Evaluate and Diagnose &amp; Plan</th>
<th>Decision</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify relevant information</td>
<td>Attend:</td>
<td>Evaluate and Diagnose &amp; Plan</td>
<td>Decide:</td>
<td>Act:</td>
<td></td>
<td></td>
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<tr>
<td>Identify priority of information in relation to system safety and status</td>
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<tr>
<td>Integrate information impacting on system safety and status</td>
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<tr>
<td>Diagnose conflict within system</td>
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<tr>
<td>Interpret existing or potential consequences of information on system safety and complexity, simplifier, traffic and infrastructure status</td>
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</tbody>
</table>
### Assess and accommodate current and projected train and infrastructure status

**Goal:** Perceive/ Attention to Identify and Integrate

- **Attend:**
  - All information received
  - TD and headcode for train
  - Special handling requirements
  - Review panel/overview and track circuit indicators
  - Train position relative to other trains
  - Train position and timing relative to timetable/simplifier
  - Projected route for train
  - All related traffic relative to timetable/simplifier
  - Current and projected routes of related traffic
  - Identify impact of system on routing of traffic (e.g. ARS, automated signals)
  - Identify impact of infrastructure status on projected routes
  - System responds to signalers action as required

- **Identify:**
  - Conformance with timetable
  - Conflict with traffic, timetable, infrastructure commitments
  - Incident or occurrence
  - Emergency situation

- **Integrate:**
  - Current time with train position and timing relative to timetable/simplifier and related traffic
  - Information attended to as outlined above
  - Continual integration of information updated relating to projected train route and related routes

- **Evaluate:**
  - Accuracy of information
  - Train capabilities, characteristics and stopping patterns
  - Train priority
  - Train position relative to all traffic and potential for conflict (in route, other traffic or timetable/simplifier)
  - Train position within rules and regulations (e.g. SPAD)
  - Time available to change route without conflicting with rules and regulations
  - The influence on the system levels of automation or interlocking influencing routing
  - Infrastructure, commitments and characteristics capacity to regulate traffic or restrict traffic
  - Demand on signaler within personal capabilities
  - Urgency and nature of signaler intervention necessary

- **Diagnose:**
  - Train priority order least likely to create conflict with other traffic and timetable/simplifier
  - Factors most likely to limit train pathway as expected e.g. control system, infrastructure
  - Current and projected availability of infrastructure
  - System status, safety and need for signaler intervention
  - Identify incidents and occurrences

- **Plan:**
  - Accept or reject information as representative of traffic
  - Prioritisation on the order to route trains based on train capabilities, stopping patterns, timetable, related traffic, is necessary
  - Infrastructure status can or cannot sufficiently accommodate current and projected traffic status
  - Initiate process in response to conflict of rules and regulations
  - Whether demand from existing or projected status is beyond the signaler's capabilities and if support is necessary
  - To seek out train status information as early as possible to ‘make life easier’
  - To route set as early as possible without limiting related traffic to ‘make life easier’
  - Presence of incident/occurrence or emergency situation requires protection of traffic and personnel

### Evaluate and Diagnose & Plan

**Decision:**
- Accept or reject information as representative of traffic
- Prioritisation on the order to route trains based on train capabilities, stopping patterns, timetable, related traffic, is necessary
- Infrastructure status can or cannot sufficiently accommodate current and projected traffic status
- Initiate process in response to conflict of rules and regulations
- Whether demand from existing or projected status is beyond the signaler's capabilities and if support is necessary
- To seek out train status information as early as possible to ‘make life easier’
- To route set as early as possible without limiting related traffic to ‘make life easier’
- Presence of incident/occurrence or emergency situation requires protection of traffic and personnel

**Action:**
- Scan panel/overview and incoming information relative to traffic and infrastructure
- Adhere to decision made on traffic priority
- Route for train and related traffic to reflect assessment of train status
- Provide infrastructure to accommodate traffic status by:-
  - Re route, loop or cancel a service, to avoid conflict of timetable or traffic
  - Initiate emergency alarm to avoid conflict in train
  - Hold traffic to limit conflict in traffic or timetable
  - Inhibit personnel from accessing infrastructure
- Communicate actions to all relevant personnel
- Complete paperwork or logging of actions taken as specified by rules and regulations.
<table>
<thead>
<tr>
<th>D</th>
<th>Protect traffic and personnel</th>
<th>Goal</th>
<th>Perceive/ Attention to Identify and Integrate</th>
<th>Evaluate and Diagnose &amp; Plan</th>
<th>Decision</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attend:</strong></td>
<td><strong>Evaluate:</strong></td>
<td><strong>Decide:</strong></td>
<td><strong>Act:</strong></td>
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<tr>
<td>• Phone</td>
<td>• The safety risk to traffic or personnel</td>
<td>• Severity of situation and speed of reaction necessary</td>
<td>Incident/occurrence</td>
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<tr>
<td>• Alarms</td>
<td>• Accuracy of information received</td>
<td>• Can signaler alone deal with situation and continue to control signalling system</td>
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<tr>
<td>• Fax</td>
<td>• The priority with which to act and inform necessary personnel</td>
<td>• Method of protection necessary to ensure safety of traffic and personnel</td>
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<tr>
<td>• Block system bells</td>
<td>• The impact on commitments within infrastructure</td>
<td>• Priority of communications</td>
<td></td>
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<tr>
<td>• Panel/overview</td>
<td>• The impact of signalling system automation detrimentally impacting on situation</td>
<td>The impact of the situation on the rest of the system under control (see goal assess and accommodate current and projected train status)</td>
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<tr>
<td>• TRUST</td>
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<td>The need to intervene in previously automated aspects of the system</td>
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<td>• TOPS</td>
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<td>Complete paperwork</td>
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<td>• Outside of window (if situation is in close proximity)</td>
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<td>Emergency:</td>
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<td>• Immediate use of emergency alarm</td>
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<td>• Stop all traffic</td>
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<td>• Communicate with control, driver and all personnel impacted on by the situation</td>
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<td></td>
<td>• Request assistance if required and deal with emergency according to rules and regulations</td>
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<td></td>
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<td></td>
<td>• Complete paperwork</td>
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</tr>
</tbody>
</table>

- **Identify:**
  - Incident or occurrence
  - Emergency situation

- **Integrate:**
  - Information attended to as outlined above
  - Continual integration of information received

- **Evaluate:**
  - The impact of situation on the rest of the system under control (see goal assess and accommodate current and projected train status)

- **Act:**
  - Incident/occurrence
  - Stop or restrict traffic pathway
  - Reflect restriction within control system (e.g. reminders, memos etc)
  - Communicate with control, driver and all personnel impacted on by the situation
  - Request assistance if required and deal with incident or occurrence according to rules and regulations
  - Complete paperwork
<table>
<thead>
<tr>
<th>E</th>
<th>Manage departures</th>
<th>Goal</th>
<th>Perceive/Attention to Identify and Integrate</th>
<th>Evaluate and Diagnose &amp; Plan</th>
<th>Decision</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manage departures</td>
<td>Attend and identify:</td>
<td>Evaluate:</td>
<td>Decide:</td>
<td>Act:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execute</td>
<td>• Establish train station conditions</td>
<td>• Conformance of departures with timetable/simplifier</td>
<td>• Prioritisation on the order to route trains based on train capabilities, stopping patterns timetable, related traffic, is necessary</td>
<td>• Scan panel/overview and incoming information relative to traffic and infrastructure</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Establish if detach/attachment required</td>
<td>• Likelihood that departure sequence will conflict with timetable/simplifier, related traffic, commitments within infrastructure</td>
<td></td>
<td>• enter new headcodes as TDs</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Establish identification of train departing</td>
<td>• Characteristics of train departing</td>
<td></td>
<td>• provide infrastructure to accommodate departing service: -</td>
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</tr>
<tr>
<td></td>
<td>• Establish train routing</td>
<td>• Current and projected availability of infrastructure</td>
<td></td>
<td>➢ re route, loop or cancel a service, to avoid conflict of timetable or traffic</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Assess conformance with timetable</td>
<td>• Sequence and type of trains reflect timetable and avoids conflict with other traffic, timetable/simplifier, commitments within infrastructure</td>
<td></td>
<td>➢ initiate emergency alarm to avoid conflict in train</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Regulate sequence of trains</td>
<td></td>
<td></td>
<td>➢ hold traffic to limit conflict in traffic or timetable</td>
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<td></td>
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<td></td>
<td></td>
<td>➢ inhibit personnel from accessing infrastructure</td>
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<td></td>
<td></td>
<td>• Communicate actions to all relevant personnel</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>• Complete paperwork or logging of actions taken as specified by rules and regulations</td>
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</tr>
<tr>
<td>F</td>
<td>Manage arrivals</td>
<td>Goal</td>
<td>Perceive/Attention to Identify and Integrate</td>
<td>Evaluate and Diagnose &amp; Plan</td>
<td>Decision</td>
<td>Action</td>
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</tr>
<tr>
<td>Manage arrival</td>
<td>Manage arrivals</td>
<td>Identify arrival sequence, traffic, timetable and infrastructure status and characteristics</td>
<td>Attend and Identify:</td>
<td>Evaluate:</td>
<td>Decision:</td>
<td>Act:</td>
</tr>
</tbody>
</table>
| Execute regular scanning of information relative to incoming traffic | Evaluate: | Conformance of arrival with timetable/simplifier | Evaluate: | Prioritisation on the order to route trains based on train capabilities, stopping patterns timetable, related traffic | Infrastructure status can sufficiently accommodate current and projected traffic status | - Scan panel/overview and incoming information relative to traffic and infrastructure
- Regulate or act to ensure sufficient infrastructure to accommodate arriving service:
  - re route, loop or cancel a service, to avoid conflict of timetable or traffic
  - initiate emergency alarm to avoid conflict in train
  - hold traffic to limit conflict in traffic or timetable
  - inhibit personnel from accessing infrastructure
- Communicate actions to all relevant personnel
- Complete paperwork or logging of actions taken as specified by rules and regulations. |
| Execute regular scanning of information relative to incoming traffic | Integrate: | Current time with train position and timing relative to timetable/simplifier and related traffic | Diagnose: | Current and projected availability of infrastructure | Infrastructure status can sufficiently accommodate current and projected traffic status | - |
Annex 2 Records of decisions relating to ODEC development

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**INFORMATION ON ODEC AMENDMENTS**

**TO:** GED MORRISROE  
**FROM:** LAURA PICKUP, THE INSTITUTE FOR OCCUPATIONAL ERGONOMICS, THE UNIVERSITY OF NOTTINGHAM  
**SUBJECT:** ODEC AMENDMENTS  
**DATE:** 22/09/04

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**16.0 ODEC Workshops**

Two workshops have considered the evolution of ODEC since September 2003, as during applications within the field edits to the categories and the metrics to be collected have been made. The workshops have involved the two signalling SMEs and an Ergonomist within Network Rail's Ergonomic team, all familiar with the development and application of the ODEC tool. Opinions and comments from an independent Ergonomist, who has also applied ODEC in the field, have also been taken into consideration. Documented below are each element of the signalling system included within the original ODEC tool and justifications for changes that have now been agreed by all parties.

<table>
<thead>
<tr>
<th>Signalling Element within ODEC Tool</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations: Platforms used to terminate trains</td>
<td>Change high, med and low categories from 9+, 8-2, 1 to 9+, 5-8, 1-4.</td>
</tr>
<tr>
<td>Station Operations: run rounds, splits, re-running, platform occupancy, small shunts.</td>
<td>Change high, med and low categories to 10+, 5-9, 1-4.</td>
</tr>
</tbody>
</table>
| Junctions/regulating points | Junctions were considered as one type of regulating point. Regulating points was considered a preferable term to be used to capture the complexity and the options available to the signaller when regulating traffic. These should be considered separately to connections as represent a different impact on }
<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>the signaller. The high medium and low categories remained the same.</td>
<td></td>
</tr>
<tr>
<td>Connections</td>
<td>High medium and low categories were increased (8+, 6-7, 0-5,) from the Doncaster ODEC version to reflect that these exert less of a demand than junctions on signallers. Connections are a static characteristic that reflect the potential connections within the infrastructure. The category of number of points traversed is intended to capture the dynamic characteristics of how many connections are actually used in normal and complex train pathways.</td>
</tr>
<tr>
<td>Level crossings non CCTV (including SGI40)</td>
<td>No changes.</td>
</tr>
<tr>
<td>LX CCTV &amp; MCB</td>
<td>AHB were included in this category but have been deleted as were considered to have no demand on the signaller. High medium and low categories were reduced to (3+, 2, 1) reflect a greater level of demand imposed by these two categories of level crossings.</td>
</tr>
<tr>
<td>No. LX Phone calls</td>
<td>Metric changed as all agreed maximum and average per day over the last week was a better snapshot of the demand on the signaller. Maximum per day categories were reviewed, high medium and low categories were increased to 40+, 20-39, 1-19. Average per day high medium and low categories were 20+, 10-19, 1-9. Caution should be applied when considering locations with seasonal implications e.g. holiday makers, harvest etc. The weighting was removed as two scores will now be collected for this entity.</td>
</tr>
<tr>
<td>Single lines &amp; bi-directional lines</td>
<td>Bi-directional lines were deleted as it was considered that they were currently being counted as single lines and it was only the form of regulation allowed that makes them bi-directional.</td>
</tr>
<tr>
<td>Controlled signals</td>
<td>Change in definition provided to ‘signals that are controlled by the signaller to give movement authority’. Low category now 0-21.</td>
</tr>
<tr>
<td>Automatic working signals (E or R)</td>
<td>Change to include R or E on the end of this category.</td>
</tr>
<tr>
<td>Depots/yards/sidings</td>
<td>These were previously considered to have differing demands, however for the purpose of indicating a cumulative demand on the signaller they have been combined. This was reflected by an increase in the high, medium and low categories to (13+, 6-12, 1-5). The metric was also changed to maximum per day to understand the number of movements accommodated by a signaller in a normal day. These elements would previously have provided three scores within the ODEC tool and can now be considered as having a greater demand in combination. Therefore the weighting of this element was doubled to reflect this increased demand in the final version of the ODEC tool.</td>
</tr>
<tr>
<td>Ground Frames</td>
<td>The definition was changed slightly to include ‘These manually divert train into sidings and to assist in single line working’. The metric was also changed to collect data on the number of times used per week. This was considered as a better reflection of</td>
</tr>
<tr>
<td>Metric</td>
<td>Changes</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>PLODS</td>
<td>Metric to remain as in Doncaster ODEC ‘average times used per week’. A change to the high, medium and low categories (3+, 2, 1) reflected discussions that these were more demanding on signallers than originally considered.</td>
</tr>
<tr>
<td>HABDs</td>
<td>No changes</td>
</tr>
<tr>
<td>Permissive Working</td>
<td>The metric was clarified by saying ‘number of locations where permissive working is allowed’</td>
</tr>
<tr>
<td>Block systems</td>
<td>Continue to count number of types with categories of high, medium and low introduced as 3+, 2, 1.</td>
</tr>
<tr>
<td>Special Box Instructions</td>
<td>No change</td>
</tr>
<tr>
<td>Emergency / unplanned Possessions</td>
<td>Minor change to the definition to ‘emergency possession of the track having an impact on trains running in this area’. Metric to remain maximum per day over last week.</td>
</tr>
<tr>
<td>Isolations (emergency or planned)</td>
<td>A change to the high, medium and low categories (3+, 2, 1)</td>
</tr>
<tr>
<td>Infrastructure Failures</td>
<td>No changes, but should now include track circuit failures and axle counter reset restore functions completed when counting frequency of failures. Also box equipment should be included within this category.</td>
</tr>
<tr>
<td>Incidents &amp; occurrences</td>
<td>Definition edited to say ‘Incident derailment has occurred or a person has become injured, Occurrence includes train failure, door problems, trespass and vandalism’. Remove ‘major and minor’ as the impact was considered to have the same type of demand on the signaller for either and differentiating between the two in the field had proved difficult. Metric to remain as ‘number in last week’. High, medium and low categories to be 3+, 2, 1.</td>
</tr>
<tr>
<td>Line speed</td>
<td>Major change in name of this element to ‘Min and maximum class speed’ defined as the difference between the fastest class and the slowest traffic. The metric to be collected is now the value when the slowest traffic speed is subtracted from the fastest traffic speed. The high, medium and low categories are now 40+, 21-39 and 0-20. These changes have been made to reflect the range in the traffic speed controlled by the signaller. Where the greater the range the greater the demand on the signaller to monitor and react to traffic. As this element previously had 2 groups and therefore two scores within ODEC a double weighting has been applied.</td>
</tr>
<tr>
<td>No. of Trains</td>
<td>Change in metric to maximum per hour and maximum per day. The high, medium and low categories for maximum per hour stay the same and new categories of 301+, 151-300, 0-150 were introduced for maximum per day.</td>
</tr>
<tr>
<td>Non-timetabled trains: VSTP</td>
<td>Definition removed small shunts and moved into station operations as considered more appropriate.</td>
</tr>
</tbody>
</table>
| No. of Points traversed         | Metric changed to ‘number of points traversed in normal train path and complex train path’ instead of ‘simple and complex
train path’. This reflects the maximum route setting required against the normal.

<table>
<thead>
<tr>
<th>Stations: through traffic</th>
<th>Removed as with further consideration this appears to offer no obvious demand on the signaller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunnels and bridges</td>
<td>Removed - as above</td>
</tr>
<tr>
<td>Track circuits/ Axle Counters</td>
<td>The metric to be collected was the number of failures therefore this data is to be included within the infrastructure failure category</td>
</tr>
<tr>
<td>Reminder Appliances – the various types include: OHL/Possessions/Third Rail reminders.</td>
<td>Removed – as this data was intended to reflect the demand created by degraded system. This is captured in the data collected to reflect the number of possessions, isolations etc. Also this data proves difficult to capture as transient and may only reflect a very short period of time.</td>
</tr>
<tr>
<td>Delays (trains)</td>
<td>Re introduced and metric to be based on signaller’s estimation of service pattern delay minutes. The high, medium and low categories refer to percentages estimated by signaller.</td>
</tr>
<tr>
<td>Box equipment failure</td>
<td>Removed and to be included under infrastructure failures as the equipment represents the infrastructure to the signaller and without a functioning interface the signaller is unable to obtain a full insight into the status of the infrastructure.</td>
</tr>
</tbody>
</table>

This document is intended to provide a record and justifications of the changes made to the ODEC tool which will be incorporated and used from this point forward.

The categories and numerical values within high, medium and low are recognised as being based on both empirical data and expert opinion and will continue to be assessed as data is collected in the field. Therefore it will be stressed to all users of ODEC that their co-operation in providing the Network rail Ergonomics team with data from the field is essential to ensure the credibility and validity of this tool.

Finally the calculation and production of a single figure to represent the overall data collected from one workstation with ODEC will be maintained. This figure was never intended to supply a redline value for the acceptability of a workstation but more a comparison between workstations. The ODEC tool provides a systematic process to understand and reflect the demands incurred by the signalling system on the signaller and is just one piece of evidence that contributes to providing an overall workload profile. The ODEC tools that have
been developed for lever frame, RETB and IECC’s will continue to adopt the same process as the NX panel ODEC. The values for high, medium and low have been adjusted to reflect the differences within lever frame and RETB systems. IECC’s can operate in three main states with ARS fully operating, not operating at all and a part and part arrangement. In view of the industry’s recommendation that a signaller should still be able to operate a workstation if ARS fails, each workstation will be judged on the high, medium and low categories for an NX panel. As an IECC workstation without ARS is considered by SMEs to require the same demands on the signaller as a NX panel. The only exception to this is a part and part arrangement where the combination of automation and manual control is recognised both by SMEs and human factors experts as creating a greater demand than a fully manually operated system. An exercise to attempt to quantify the difference through ranking and estimation techniques has suggested that the ODEC value received for a part and part system should be increased by one third if compared to a fully manual IECC. An ODEC value of an IECC with 100% ARS should be decreased by three quarters of the value if compared to a fully manual IECC. These figures will be reflected in the excel spread sheets for the ODECs appropriate for each type of IECC system.
Annex 3 Top level overview of contextual, environmental and cognitive factors within the Workload Probe questions
## Annex 4 A sample of Workload Probe questions

<table>
<thead>
<tr>
<th>Loading Factor</th>
<th>Attribute of Loading Factor</th>
<th>Cognitive Domain</th>
<th>Question</th>
<th>Principle No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilitate</td>
<td>Attention-Perceive, Identify &amp; Integrate- Evaluate- Diagnose Plan</td>
<td></td>
<td>If you have automation in your system does this always assist you as a signaller?</td>
<td>1 – 4 - 9</td>
</tr>
<tr>
<td>facilitate-Confidence</td>
<td>Attention -Perceive-Identify &amp; Integrate- - Diagnose –Evaluate-Plan.</td>
<td></td>
<td>Do you consider the area under your control is manageable by all signallers on all shifts?</td>
<td>1 - 8</td>
</tr>
<tr>
<td>Facilitate-Confidence</td>
<td>Plan</td>
<td></td>
<td>Does the system you operate provide you with confidence facilitate and work with a signallers decision?</td>
<td>4 – 9 -12</td>
</tr>
<tr>
<td>Facilitate-Confidence</td>
<td>Arousal-Perceive-Identify &amp; Integrate- - Diagnose –Evaluate-Plan-Action</td>
<td></td>
<td>Would the system alert you to any significant changes in Traffic status Potential Route conflict Within sufficient time for you to obtain an overview of the system status and act?</td>
<td>3 - 9</td>
</tr>
<tr>
<td>Status</td>
<td>Arousal, Attention, Perceive, Identify &amp;Integrate- Evaluate</td>
<td></td>
<td>Can you compare and evaluate at all times train and system status to identify potential for delay or conflict with the timetable infrastructure characteristics?</td>
<td>1 – 4 - 6</td>
</tr>
<tr>
<td>Status</td>
<td>Arousal,- Identify &amp;Integrate- Diagnose Evaluate</td>
<td></td>
<td>Can you accurately predict the level of effort that the system status will require from, you?</td>
<td>4</td>
</tr>
</tbody>
</table>