

Assessment of competence of track workers ♦

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This is the report of a study carried out in 1994-5 into the feasibility of using a Personal Digital Assistant as a job aid for workplace assessment in hostile environments. The work was jointly funded by the Learning Methods Branch of the UK Employment Department, British Rail Production Services and PA Consulting Group.

British Rail was chosen as a specific example of an organisation needing to carry out workplace assessment in a hostile environment. The study built upon the Training Development and Delivery Programme which re-engineered the training system for signal and telecommunications staff in British Rail. The issue of workplace assessment and the resources needed to implement it sensibly were a continuing cause of concern to the Programme and the study was driven by that need. The 'ideal' process and the specification for a data collection system were derived from discussions with staff at all levels: technicians, supervisors, those training supervisors in assessment techniques, managers and engineers.

The Project examined a number of possible PDA devices to determine how well they met the functional requirements and technical specification. The Apple Newton MessagePad was selected as the most appropriate device for the demonstration system which was then evaluated in the workplace of West Anglia Infrastructure Support Unit.

A workplace study was devised to evaluate the concept of PDAs as job aids for workplace assessment in the signal and telecommunications environment of British Rail. The study concluded that PDAs are effective job aids for workplace assessment in this environment and that, given the need to be certain that staff are competent to undertake safety critical work, the cost-benefit of the approach can be demonstrated. Where there is less emphasis on safety critical work, then the case is less clear, unless workplace assessment in one of a portfolio of performance support applications provided through a PDA.

It is important to bear in mind when reading the paper, that it was originally written in 1995 – nearly ten years ago. Things have moved on: the technology is more compact, more robust, more powerful – and less expensive. The client, British Rail, no longer exists and its successors are structured very differently. Nevertheless, the competence issues faced by the UK rail industry are very similar to those of ten years ago and it is interesting to review this work in the current context to see what lessons might be learned.

♦ This white paper is an updated report of work carried out in 1994-5 when the author was at PA Consulting Group leading the Mobile Solutions team. It has been updated and re-published because of its relevance to the current competence management needs of the rail industry.

The problems with assessment

The assessment of competence in the workplace is moving to the heart of effective training systems. Companies such as British Rail, companies in the petrochemical, offshore, nuclear and aerospace industries, need the means to assure themselves that their staff are competent to carry out safety critical work. This often involves:

- Complex equipment
- A dispersed workforce
- Unpredictability of work patterns and the need for spontaneous assessment
- A hostile environment

As the numbers of people working towards NVQs and SVQs increases, the logistics and costs of workplace assessment are emerging as a critical factor, demanding significant numbers of trained assessors and limiting progress towards the Government's declared targets (in 1994) that:

By age 21:

35% to achieve N/SVQ level 3 in the core skills of communication, numeracy and IT

60% to reach N/SVQ level 3 or equivalent

Lifetime learning:

60% of workforce to reach N/SVQ level 3 or equivalent

30% of workforce to reach N/SVQ level 4 or equivalent

70% of 200 employee organisations and 35% of those with more than 50 staff to gain IIP.

An accurate understanding of what staff know and can do now, and of what they need to know and be able to do, enables training to be focused more accurately and at the appropriate time, resulting in substantial cost savings through reduced wastage.

Educational organisations too, are being encouraged to place greater importance on assessment and to align assessment more closely with the knowledge and skills required in the real world. This is not the place to debate the wisdom of focusing on output measures rather than process, or to comment on the validity of vocational qualifications (NVQs/SVQs) for our students. This paper starts from the reality that, both in education and in training, there is a greater emphasis on assessment against detailed objectives or competences.

Unless that assessment is managed carefully it becomes an impossible burden. A significant improvement in productivity is required if these goals are to be achieved within reasonable costs and it appears that technology may hold the key to that increased productivity.

A putative solution

Personal Digital Assistants are a new class of mobile computing device characterised by being light, hand-held and battery powered, typically used with a pen rather than a keyboard, with built-in communications facilities (fax/modem or wireless data) and with 'intelligence' that enables them to recognise handwriting and anticipate standard tasks (such as turning a handwritten note into a fax and sending it automatically) PDAs can provide:

- Direct access to information by workers at the coalface;
- Quantifiable improvements in cost, time and quality; and
- The opportunity to improve *how* things are done.

Our findings are that they do have significant implications for the way in which we work and handle information. The objective of this study was to demonstrate that PDAs can function as an effective and efficient job aid for the purpose of assessment in the workplace. For this purpose we developed a demonstration application that would:

- Test as many as possible of the key functions required;
- Allow any procedural problems with this approach to be investigated and resolved;
- Allow any potential problems with the technology to be assessed;
- Permit us to refine the specification of an 'ideal' PDA to perform the task;
- Allow the response of staff to be assessed;
- Test, as far as possible, the interface to other parts of the real training system - eg exchange of data on competence.

British Rail was chosen as a specific example of an organisation needing to carry out workplace assessment in a hostile environment. The study built upon the Training Development and Delivery Programme (described in Rushby, 1994) which re-engineered the training system for signal and telecommunications staff in British Rail. The issue of workplace assessment and the resources needed to implement it sensibly were a continuing cause of concern to the Programme and the study was driven by that need.

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Knowing that Bryn, one person in a three man fault team, is not yet competent in fault finding and repairing a specific kind of level crossing barrier, the supervisor checks the relevant performance criteria and joins the fault team. Unfortunately, that night there are no faults of that kind.

However, the team is called out to a fault on a certain type of point machine. The supervisor is not sure whether Bryn has already displayed his competence on that point machine - or whether it is important to Bryn and his employer that he is competent to repair it. There are many different types of equipment on British Rail and this is one of about 1000 equipment specific competences that the operators require of their signal and telecommunications staff if they are to run a safe railway (as they are required to do by law). The supervisor's task is further complicated by trying to recall the 20 or more performance criteria that relate to that competence. Since he or she did not know they were going to observe the competence, there was no chance to prepare.

It is night time and the rain is being driven by the wind. They are 15 minutes walk from the van along the ballast beside the track and trains travelling at 125 mph are passing every few minutes. OMR sheets are reduced to pulp in seconds and the little pink boxes on the form are invisible in the torch light. Yet, Bryn is displaying the workplace competence that should be recorded so that his employer knows he is safe to work on this specific equipment and so that eventually he can be awarded his next vocational qualification.

It may also be helpful (so that the Railway operators have a continuing assurance of safe working) to record whether a previously observed competence is no longer present - that is, whether Bryn is now failing to display the competences he displayed previously and so should now be assessed as not competent.

Figure 1: a case study

Selecting a PDA

The Project examined a number of possible PDA devices against agreed criteria to determine how well they met the functional requirements and technical specification. The Apple Newton stood out for four principal reasons:

- It is immediately attractive to use and has the most intuitive interface. This is critical in gaining user acceptance and in minimising support costs.
- The object oriented software toolkit allows very rapid prototyping and reuse of software components. Our experience in developing applications indicates that this minimises the effort required to set up an operational system which can be easily modified and updated. The valuable software investment can thus be protected. We believe that this toolkit will become an industry standard and will allow the building of libraries of software objects which can be exchanged and used to construct larger applications.
- It is based on custom designed RISC technology rather than on a processor designed for a desk top PC. This has important implications for power management and battery life.
- Apple originated the term PDA, are investing heavily in developing Newton technology world-wide, and are committed to establishing it as an industry standard. Of all suppliers, we judge that Apple is the most committed to producing a long term technology base that will be stable enough to protect investment in software applications.

In 1995 the Apple Newton MessagePad set the standards for PDAs and was chosen as the most suitable device. Details of the evaluation are given in Rushby, Fairbrother, Vincent and Roberts (1994).

Setting up a study

The objective of the study was to test whether and to what extent PDAs are a useful tool in helping British Rail supervisors to assess technicians at their place of work; which may be in a variety of environments associated with running a railway. For the purposes of the study we focused on first line maintenance and faulting of signalling systems in the expectation that the results and experience would be transferable to other environments and other industries.

In carrying out the trial we sought to demonstrate a number of key benefits. We also noted difficulties which arose in the course of the trial, and whether and how these may be overcome. We expected such difficulties to fall into three categories:

- Problems with the technology itself;
- Human and organisational problems associated with the use of the technology;
- Human and organisational problems associated with different work practices which may need to be adopted in order to carry out the trial.

We had a number of specific concerns about battery life, robustness and reliability which were satisfactorily resolved during the project. In the event, the PDAs and their software were much less trouble than the organisational issues! A key difficulty in conducting this trial was that paper-based workplace assessment was only then being introduced. We were therefore in effect trialling, at the same time, both workplace assessment itself and the method of carrying it out.

In carrying out the trial, we sought a location and a group of signal technicians which:

- Was reasonably self-contained;
- Was representatives of different applications within the business;
- Was willing to participate in the trial;
- Would allow testing of the key functions;
- If possible, already had a management system into which the trial could be linked.

The original intention was to build upon a trial of the paper-based assessment process due to take place in the Birmingham area at the end of 1993 and beginning of 1994. This would use and evaluate the detailed occupational standards and assessment instruments. We expected that, by March 1994, these instruments would have been validated and that there would be significant experience of their use in the workplace. Our project would then use PDAs as job aids for assessment in the same occupational areas and the two methods would be compared. This aspect of the project was beset by major difficulties beyond our control: the disruption caused by the British Rail privatisation was far greater than our most pessimistic estimates. From the beginning of March it was not possible to get decisions or commitment from engineers on the ground in respect of the workplace study. As a result, we were forced to delay the workplace study and lost much of evidence from the earlier study of the paper based system in the Birmingham area.

The broader assignment we were undertaking for British Rail Production Services came to an end on 31st March 1994. Because of the disorganisation and breakdown in decision-making the planned transfer of management from Production Services and British Rail Infrastructure Services (BRIS) was not completed by the end of March and that too, became bogged down in the aftermath of privatisation. Given this situation we decided not to attempt to set up another paper-based evaluation, but to retrieve what information we could from the Birmingham study and to compare that with data from supervisors within West Anglia Infrastructure Support Unit (ISU) using PDAs.

It was British Rail policy that all supervisors should be trained to assess their staff in the workplace and should be accredited as assessors, using the syllabus based on unit D32 from the Training and Development Lead Body standards - or an appropriate alternative. After the initial training workshop (but before they were accredited) they were briefed on the procedures to be followed in the trial. Following the study, the supervisors were interviewed by members of the project team. All of the supervisors were very committed: "Our future is on the line".

PA's experience in developing PDA applications is that, unlike traditional software which should be carefully designed before coding starts, the best results are obtained through a highly interactive process of successive prototypes. Our approach to this application was therefore to:

- Develop the prototype interactively in close consultation with experienced British Rail signalling engineers;
- Trial with continuous feedback, issuing revised versions of the application throughout the workplace study;
- Introduce to fit existing work practices, rather than requiring immediate changes to work practices to meet the demands or constraints of the technology;
- Evolve to exploit the benefits, both predicted and unexpected.

From the first prototype, the Project team exposed the application to any signal or telecommunications engineer or technician who would give five minutes of their time to comment and criticise. This enabled us to find and eliminate many of the smaller errors and misapprehensions in the design.

The application running in the PDA is used to guide the supervisor through the collection of evidence and record that evidence. It then communicates with a training management system that maintains a database of competences and tracks the technicians' progress towards vocational qualifications and licences that are specific to the railway. The British Rail pilot used the *Monitor* system from Performance Monitoring Systems. Subsequently we have investigated interfaces with alternative tracking systems.

Subjective evidence

We had major difficulties in collecting accurate information on workplace assessment in the often hostile working environment. Much of the evidence comes from experiences observed while the study was running and from interviews with supervisors.

We postulated that for success, there has to be something in this new system for the supervisors, for example:

- Reducing the paperwork. Workplace assessment is a necessary but additional burden on them. If it, and other tasks, can be made easier then they are more likely to welcome it. The comments received so far indicate that the job aid does make these tasks easier.
- Providing things that are useful in their professional lives. While workplace assessment and surveillance checklists are not intrinsically useful, the information obtained from the activity is. The supervisors recognise the value of that information.
- Increasing participation and involvement. Supervisors have traditionally been the best technicians. Their role is now changing from managing the job to managing the men. They would like to feel ownership of their job. It is too soon to tell whether the PDA is supporting ownership.

In practice, we found this was borne out by the supervisors who concluded that the PDA is, on the whole, a robust and very useful piece of equipment. Their comments reflected the evolving state of the software and the facilities, but were supportive of the PDA application which they found very easy to use:

"Although I have not got all the facilities on my Newton to enable me to carry out workplace assessments up to the standard required by the Institute of Personnel and Development [in D32], I do feel that the potential to use the Newton to carry out this task is definitely there. It is small, unobtrusive and capable of storing a lot of information/data that would otherwise have to be stored on a paper system. Although at this time I would not be able to carry out a complete assessment using only the Newton, I do feel that with a little bit of work on the software side of things, it will not be unattainable."

We should note that our experience in developing applications for the Newton MessagePad demonstrates that modifications, such as those needed to add missing facilities, are easy to incorporate.

Although we did not promote the use of the PDAs as personal organisers, the supervisors found the diary and notebook functions useful to them in their personal lives.

It is arguable that the supervisors were a very small sample of atypical users. By definition they were all technically minded and comfortable with technology. Their experiences cannot necessarily be extended to other groups such as civil engineering or mechanical engineering supervisors. However, results from other studies carried out by PA indicate significant levels of acceptance of the Newton MessagePad for information gathering applications. Typically over 50% of users prefer the Newton MessagePad to a paper based system with less than 25% preferring paper and the remainder expressing no preference. Crucially, there appears to be no correlation between acceptance of the Newton MessagePad and age, gender or general comfort with technology (in the form of remote control for video cassette recorders, computer games, personal computers etc).

A key benefit of PDAs is that they can support a number of parallel applications that build into a suite of job aids for a specific class of user. A portfolio of job aids and performance support systems can offer significant cost-benefits and makes a stronger case for introducing PDAs. Clearly, the portfolio of job aids will vary from industry to industry and from organisation to organisation. Throughout the study we considered the possibility of using the PDA to support the supervisor in other tasks such as the provision of technical information, health and safety checklists, scheduling of planned maintenance, automatic diagnosis of faults on equipment and systems and sending messages between staff and/or central controllers.

Issues for assessment

We made an initial assumption, based on our conversations with signal and telecommunications staff over the two years of the main programme, that it would be difficult to plan in advance for some of the assessment. We supposed that at times the supervisor/assessor may have some intention of assessing a specific competence - for example in fault finding on a specific piece of equipment - but that the reality in the workplace is that things will change and this task will not be required - although another may be. Since the supervisor did not know this in advance, there would be no chance to prepare.

This assumption was strongly challenged by the trainer who ran the assessment workshop. She maintained that *ad-hoc* assessments were unsatisfactory and that all assessment activity must be pre-planned. This view has not yet been fully tested and it is not possible to say whether it is wholly practical. It may be more desirable to take the opportunity of an unplanned assessment than to forgo it, particularly if another opportunity may not arise for a considerable time.

Another, possibly transitory problem, is that the awarding bodies assume and require paper-based documents for the portfolios of evidence. Rather than enter into discussions to gain the acceptability of computer based records, we modified the application to print out suitable forms for the:

- Assessment Plan
- Record of Assessment and
- Feedback Sheet.

Given that the relevant information is stored within the computer system stamped with the supervisor's name and the date on which it was collected, a more

satisfactory solution may be to produce the required paper reports from the *Performance Monitoring System*. In the longer term, the awarding bodies may be persuaded to accept this evidence in machine readable form.

Cost effectiveness

The final report of the project (Rushby *et al* 1994) includes a detailed cost comparison of workplace assessment by traditional, paper-based methods and using PDAs. Tables 1 and 2 give an indication of the costs (as at 1995) that might be expected for a single Infrastructure Support Unit with 1000 technicians in signal and telecommunications, civil, mechanical and electrical engineering, and with 100 supervisors, each carrying a Newton MessagePad. The figures in this example are greatly simplified and do not take into account maintenance, residual value, return on capital etc. In comparing the costs of workplace assessment over three years it also makes the questionable assumption that a paper-based system is practical. The savings are considerable - over £300,000 (36%) of £885,000.

Table 1: Capital costs

<i>PDA-based system</i> £		<i>Paper-based system</i> £	
Assessor training: trainer time and accreditation	47,000	Assessor training: trainer time and accreditation	45,000
Assessor training: release costs	42,000	Assessor training: release costs	40,000
Acquisition and set-up of five training management systems	5,000	Acquisition and set-up of five training management systems	5,000
Acquisition of Newton MessagePads	40,000		
Totals	134,000		90,000

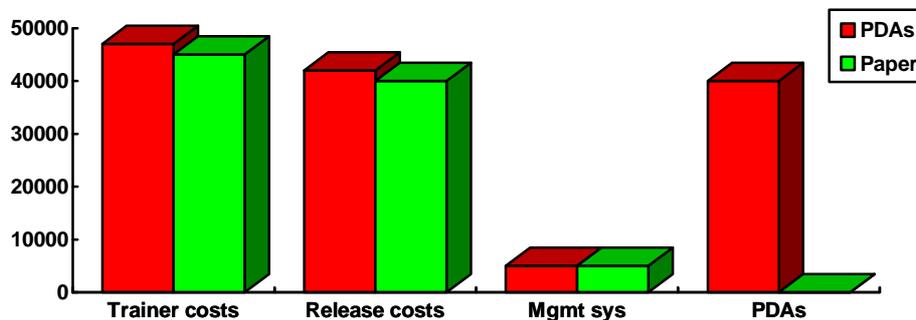
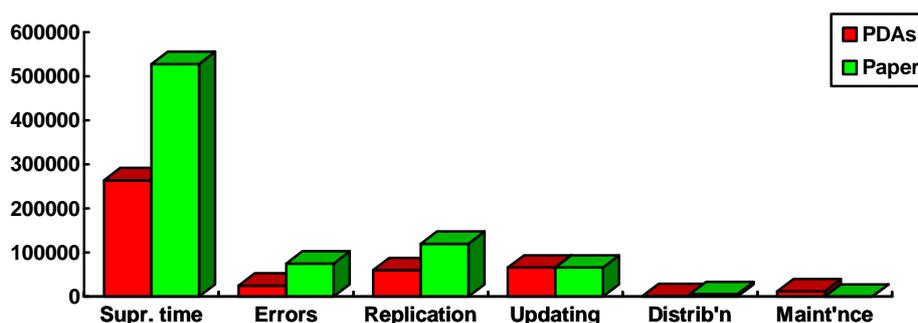


Table 2: Operating costs over three years

<i>PDA-based system</i>	£	<i>Paper-based system</i>	£
Supervisor time in assessment (2% of supervisors' time)	264,000	Supervisor time in assessment (4% of supervisors' time)	528,000
Correction of errors	25,000	Correction of errors	75,000
Replication of assessment instruments	60,000	Replication of assessment instruments	120,000
Updating of assessment instruments (50% of one person)	66,000	Updating of assessment instruments (50% of one person)	66,000
Distribution costs (disks)	1500	Distribution costs (paper)	6,000
Maintenance of Newton MessagePads	12,000		
Total savings	428,500		795,000



In organisations where safety critical work is not a driving factor, the cost benefit relies on the improved efficiency of the supervisor in carrying out workplace assessment. If we assume that workplace assessment would be one of a number of related applications running on the PDA, supporting the supervisor in his/her daily work then additional improvements in efficiency in a second or third application would make the case very strong.

A better understanding of levels of competence can enable dramatic improvements in the cost-effectiveness of training by enabling training to be focused on those who require it - when they require it.

The British Rail Training Development and Delivery Programme concluded that up to 50% of the training currently provided is mis-targeted. Training is provided to those who do not require those particular skills, to those who already have them, or to those who are not ready to acquire them. Within the British Rail Infrastructure Support Units this is a potential saving of £5 million per year.

However, the major cost saving for British Rail and for other organisations where competence for safety critical work is an issue, is in reducing the risk of losses through lack of competence. Without an accurate identification of those who are not

yet competent, British Rail will continue to sustain costs through property and consequential business losses. An independent risk analysis, carried out in 1992 by the British Rail's own risk assessors, estimated these costs at £500 million per year across the rail network, and that if 'competence' in signal and telecommunications could be increased by 10% this would reduce the losses by up to £35 million per year. This potential saving dwarfs the costs of introducing a system of workplace assessment supported by PDAs.

The future

This project took place at a unique time for British Rail. The reorganisation that disrupted plans for the workplace study also provides an opportunity for radical change in the human resources policy of the Infrastructure Support Units and for the redesign of the systems for training and allocation of staff to task.

The study has demonstrated that the technology works well enough to continue and British Rail Infrastructure Services has now enlarged the scope with the acquisition of a large number of PDAs and the addition of more skills sets. It also raises a new set of issues for British Rail - and more widely, for other organisations moving to competence based training:

- People who are not skilled (not yet competent) will be able to see a way of acquiring those competences. No-one is locked out and it is in everyone's interest to improve performance on a continuous basis.
- Because of the auditable record of compliance to appropriate safety standards, accountability is more visible. This may raise short term problems in adjusting to higher levels of visibility.
- There is improved information on which to base individual and group training programmes. This was one of the original drivers for the project. The re-engineered training system for signal and telecommunication staff requires accurate information about existing and required competences to identify and address competence gaps. This will provide the means for the organisation to be assured that their staff are competent to undertake safety critical work - and also reduce the costs of training by focusing training activities on those who need them when they need them.
- Improved attention of all staff to quality - and to reward and assessment procedures designed to encourage this. The implications of this have not yet been appreciated.
- Is it possible to design a system in which the motivations of all are aligned in the interests of the organisation as whole?

Although this study focused on British Rail technicians, there are other organisations with similar needs, eg the other railway Businesses, the offshore industry, the mining industry, the nuclear industry and the aerospace industry. We initially underestimated the interest in the application for assessment in areas other than safety critical work. It is clear that organisations are holding back from NVQs/SVQs because of the resource implications for training assessors and carrying out workplace assessment.

The competence based approach to training is not embraced by all of the training community and could be discredited or displaced by a different approach. We

consider it unlikely that the principles of competence in the workplace will be dropped although the terminology and emphasis is already changing. For example, in its recent report, the CBI (1994) recommend that the complex language of NVQs/SVQs should be revised using the Plain English Campaign guidelines. We have examined the use of the application in the context of learning outcomes (instead of competences) and found that it still appears to be valid.

Acknowledgements

This work was part funded by the Learning Methods Branch of the UK Employment Department and carried out by PA Consulting Group. I would like to thank my colleagues Bob Fairbrother who directed the British Rail TD² Programme, Geoff Vincent, Ian Roberts who wrote the application software, Peter Burton of Transcend Technology for his support as external project manager and Hilary Stott of the Learning Methods Branch for her patience. I would also like to thank: Rebecca Davies who helped with the practicalities of workplace assessment; Fiona MacNeill of Development Processes Limited who ran the stimulating workshop on assessment for supervisors; David Arbor of Performance Monitoring Systems who developed the training management system. Special thanks go to Roy Bedlow of Apple Computer who ensured that we received all the technical support needed for the Newton MessagePad, and to Martin Pilling of West Anglia Infrastructure Support Unit who allowed his team to be used as guinea pigs for the workplace study. Finally, I thank Trevor Bradbeer, John Cockburn, Steve Elliott and Phil Neep, also of West Anglia Infrastructure Support Unit who took the PDAs into the workplace.

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