Non-technical skills in rail accidents: Panacea or pariah?

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Abstract. Non-technical skills (NTS) have been identified as a causal factor in several rail accident investigations, resulting in a substantial movement within the UK rail industry to incorporate NTS training into its competence management systems. However, there are questions regarding the application of NTS within the wider sociotechnical systems perspective of human factors. In this paper, we review the evolution of NTS, present case studies of accident investigations, and offer our own perspectives on investigating the role of NTS in accidents.

Keywords. non-technical skills, rail accidents, investigation, sociotechnical systems.

1. Introduction

Just after midnight on 21 July 2013, a passenger train was slowly approaching its final stop at Norwich station when it collided with another train already in the platform. Eight passengers were injured and taken to hospital.

One potential factor identified in the Rail Accident Investigation Branch's report (RAIB, 2014) was that the train driver had a lapse in concentration on the approach to the station. The report also noted that, based on the driver's incident records, he was 'prone to lapses in concentration', and that this had not been identified by his employer's competence management system.

The RAIB's analysis of this accident drew attention to the significance of non-technical skills (NTS), referring to recent work by RSSB (e.g., RSSB, 2012) in developing NTS training for the UK rail industry. In this work, 'maintaining concentration' is cited as a non-technical skill, but it was not included in the competence management system for the driver at Norwich. As a result, the RAIB recommended that the train operator should include NTS in its competence management system as well as in its incident investigations.

The accident at Norwich is just one example that can be used to demonstrate the importance of considering NTS both in competence management and in investigations. It is a subject that has attracted great interest in the UK rail industry in recent years, with training and assessment in NTS now featuring prominently in the competence management systems of many train operating companies and the infrastructure manager. However, such application is not without contention, raising questions regarding the definition, training and implications of adopting NTS within the wider sociotechnical systems perspective of human factors.

In this paper, we begin with a review of the evolution of non-technical skills, from its genesis in aviation to the latest developments in rail. We then describe a selection of case studies from the RAIB's archives in which NTS was identified as a factor. Finally, we offer our own perspectives on investigating the role of NTS in accidents.

2. The evolution of non-technical skills

In what is perhaps the most authoritative text on the subject, Flin et al. (2008; p. 1) defined non-technical skills as '…the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance'. Specifically, Flin et al. (2008) identified these skills as:

- situation awareness;
- decision making;
- communication;
- team working;
- leadership;
- managing stress; and
- coping with fatigue.

It is worth noting that there are interrelationships both within the non-technical skill sets themselves, and between technical and non-technical skills. Take situation awareness (SA) as an example: Flin et al. (2008) stated that maintaining SA involves (amongst other things) speaking up (i.e., assertiveness – akin to leadership skills), team coordination (team working skills) and communication. Furthermore, training in SA often amounts to practical training in a simulator – essentially practicing the technical skills of the task. Experience and training also help an individual with managing stress, by ensuring that they have adequate resources to cope with a given situation.

The contemporary position on NTS espoused by Flin et al. (2008) reflects some 30 years of evolution in this field, largely borne from the development of crew resource management (CRM) in aviation.

2.1 Crew resource management

A number of air accidents in the 1970s led to an increased awareness of non-technical factors, such as cognitive and interpersonal skills, as playing an important part in the causation of such accidents. The crash of a BEA Trident at Staines in 1972 revealed significant concerns with relationships on the flight deck, centred around a steep power gradient between the Captain and First Officer and some difficult industrial relations issues in the company. The 1977 disaster at Tenerife involving two Boeing 747 aircraft highlighted a number of factors regarding communications and coordination, as well as interpersonal issues between members of the flight crew. Again, a senior Captain and inexperienced co-pilot resulted in an unwillingness to challenge the decisions of a superior officer. This, coupled with operational pressures at the airport, led to inappropriate decision-making on the flight deck (McCreary et al., 1998). After a United Airlines crash at Portland, Oregon in 1978, the NTSB recommended that all air carriers adopt flight deck resource management training for flight crew (NTSB, 1979).

The introduction of cockpit voice recorders and flight data recorders allowed a better understanding of air accidents, shining the spotlight on non-technical factors. In 1979, NASA convened a workshop on 'resource management on the flight deck', focusing on communications, decision making and leadership (Cooper et al., 1980). This has been noted as the beginning of the development of CRM (Helmreich et al., 1999).

CRM has been described as 'using all available resources – information, equipment and people – to achieve safe and efficient flight operations' (Lauber, 1984). Initially, the training was termed 'cockpit resource management', and the first CRM course (run by United Airlines in 1981) concentrated on concepts such as assertiveness and leadership. Later generations extended both the scope and the coverage of such training, to include cabin crew and other operational staff, and adding factors such as situation awareness, stress management and organisational culture – thus the evolution of 'crew resource management' (Helmreich et al., 1999).

The impetus for these developments came from further significant air accidents in the 1980s and 1990s. The Kegworth crash in 1989 resulted from a confusion on the flight deck about which of the aircraft's two engines had failed. Cabin crew and passengers had seen flames coming from the left-hand engine but did not inform the Captain. The flight crew shut down the right-hand engine, leaving the aircraft without power. The AAIB investigation report (AAIB, 1990) recommended training to improve coordination between pilots and cabin crew. Two months later, similar issues contributed to an Air Ontario crash at Dryden (Moshansky, 1992), in which a member of cabin crew noticed snow and ice on the wings but felt that calling the flight crew with such operational information would not be welcome (Chute and Wiener, 1996).

In the early days of CRM development, such skills were thought of as good airmanship; as the field developed, though, NTS became formalised in training (Flin et al., 2008). In the US, the FAA set out requirements for the integration of CRM into technical training (Helmreich et al., 1999). In the UK, CRM training became mandatory for all flight crew in 1998 (Jarvis, 2016), with CAP 737 (CAA, 2006) detailing that such training should cover communications, SA, problem solving, decision making, and teamwork. Meanwhile, Flin et al. (2003) developed the European NOTECHS system for assessing pilots' CRM skills, with four categories: cooperation, leadership and managerial skills, SA, and decision making.

Thus we see that throughout these developments, the core components of NTS in CRM are common (i.e., communications, decision making, leadership, SA, team working). Whilst NTS training has since been applied in other safety-critical industries (e.g., nuclear, maritime, healthcare; Flin et al., 2008), we now turn to its recent development in rail.

2.2 Non-technical skills in the rail industry

Similar training schemes – sometimes referred to as 'rail resource management' (RRM) – have emerged in rail industries around the world. As with aviation, these developments have typically been in response to major accidents.

In the US, an accident at Butler, Indiana, in 1998 led to a recommendation that CRM be introduced after the investigation found a primary cause to be a lack of coordination, teamwork and communication among the crew (NTSB, 1999). The report suggested such training should address crew member proficiency, SA, communication, teamwork and leadership issues, following the aviation model. In 2002, a collision between a passenger train and a derailed ballast train near Bargo in New South Wales resulted in a recommendation for rail workers in Australia to undertake CRM training (Klampfer et al., 2012). Guidelines and a toolkit for RRM were subsequently introduced in Australia in 2007.

In the UK, the driving forces behind the development of NTS training have primarily been RSSB (addressing train crew, station staff and engineers) and the infrastructure manager, Network Rail (addressing track workers and signallers). RSSB (2012) defined NTS as 'generic skills that underpin and enhance technical tasks and improve safety by helping people to anticipate, identify and mitigate against errors'. Its categories are somewhat more extensive than the core CRM skills reviewed above, comprising: SA, conscientiousness, communication, decision making and action, cooperation and working with others, workload management, and self-management. Initially targeted at train drivers, this work has recently been extended and applied to dispatch staff, guards, shunters, train running control staff, fitters and engineers (RSSB, 2016). Meanwhile, Network Rail has developed its own list based on a task analysis of a key track worker role (the controller of site safety – COSS), which covers: controlled under pressure, conscientious, communications, attention management, willingness and ability to learn, relationships with people, multi-task capacity, and planning and decision making (see Baldwin and Lowe, 2014). Whilst there are clear overlaps between the taxonomies of RSSB and Network Rail, there are also subtle distinctions – table 1 compares the two schemes.

Table 1: Comparison between NTS categories of RSSB and Network Rail

RSSB	Network Rail
Workload management	Multi-task capacity
Communications	Communications
Situational awareness	Attention management
Cooperation and working with others	Relationships with people
Decision making and action	Planning and decision making
Conscientious	Conscientious
Self management	Willingness and ability to learn
	Controlled under pressure

There are analogous requirements in a European standard for track worker competence (BSI, 2016). Termed 'psychological requirements', these sit alongside the basic fitness and medical requirements and include cognitive, psychomotor, behavioural and personality factors (such as attention and concentration, memory, emotional self-control and conscientiousness).

Interest in NTS for rail has certainly gathered momentum in recent years. In its latest guidance document on staff competence, the rail regulator in the UK advocates that NTS be fully integrated into competence management systems (ORR, 2016). The justification for this is based on observations that many incidents are associated with non-technical, rather than technical, skills (e.g., RSSB, 2012). We now take a look at some of those incidents investigated by the RAIB where NTS have been implicated.

3. Case studies

3.1 Track workers

Baldwin and Lowe (2014) drew on three serious accidents involving track workers to make their case for the importance of NTS in safe working. None of the associated RAIB reports mention NTS specifically, although the findings and recommendations directly address such issues.

The first of these accidents was a fatality at Trafford Park, Manchester, on 26 October 2005 (RAIB, 2006), in which three track workers went onto the line without a defined safe system of work being set up. None of the staff challenged the arrangements, and the workers lost situation awareness while focusing on their tasks. The RAIB report stated that track safety skills training did not consider personal attitudes towards safety. One of its recommendations was addressed to Network Rail and was of direct relevance to NTS as it concerned attitudes to safety, rule adherence and interpersonal skills. Interestingly, the recommendation emphasised a review of these attributes at selection as well as in training and assessment.

Two other related accidents highlighted the importance of assertiveness for those people in charge of site safety (i.e., the COSS) when on track. A welder was fatally injured at Ruscombe Junction, near Reading, on 29 April 2007 when he did not move clear of the line after being warned of an approaching train (RAIB, 2008). Whilst it is possible that the welder assumed that the train would not be routed towards his site of work, the investigation found that the welder was the most experienced member of the group, and that the COSS would tend to follow his lead when working on site. One of the recommendations was for Network Rail to carry out human factors research into the influences of peer pressure, group communications and dynamics on safety decision making in small teams. In similar circumstances, a track worker was seriously injured at Stoats Nest Junction, near Purley, on 12 June 2011, when he did not move to a position of safety as a train approached (RAIB, 2012). Again, the COSS was a relatively junior member of staff and was in the presence of more senior managers on site, to whom he deferred during the work even when such decisions affected site safety.

A RAIB class investigation into track worker accidents and near misses (RAIB, 2017) found issues with non-technical skills were a common theme in several incidents. As well as interpersonal issues associated with challenging unsafe work, the report also identified concerns with communications and complacency, leading to a recommendation for Network Rail to review the effectiveness of its NTS training for track workers.

3.2 Train driving

We have already described the accident at Norwich (RAIB, 2014) and its findings regarding NTS. In addition, the RAIB has cited NTS in relation to two other incidents involving train working – one with a passenger train, the other with an engineering machine.

On 10 August 2012 near Arley, Warwickshire, a stoneblower collided with a stationary ballast regulator, probably because the driver assumed that the line ahead was clear, and also that the driver was possibly distracted from the driving task (RAIB, 2013). A recommendation urged Network Rail to consider NTS as part of a formal competence management for people involved in communicating instructions to drivers.

With echoes of the Norwich accident, the investigation into an overspeed incident at Fletton Junction, Peterborough, on 11 September 2015 (RAIB, 2016) found that the driver had attended non-technical skills training as a result of a previous, similar incident. That incident had been attributed by his employer to a ‘momentary loss of concentration’, although it transpired that there were also personal problems in the driver’s life. This time, the RAIB was more circumspect in its conclusions, recommending that the train operator consider the advantages and limitations of NTS training with respect to the driver’s personal circumstances, and that additional or alternative support should be provided where appropriate. In other words, it raised a question about the appropriateness of sending the driver on a NTS course without addressing fatigue or distraction due to home-related stress (although neither the driver nor his manager had appreciated that these could be affecting his driving).

3.3 Track workers revisited

Our final case study raises further questions about the appropriateness of NTS in certain circumstances. A near miss involving track workers near Hest Bank in Lancashire, on 22 September 2014, was caused because a person whose task it was to look out for approaching trains did not give a warning to the work group (RAIB, 2015). The RAIB concluded that his vigilance had probably degraded after nearly two hours on task. In this case, the report did not identify NTS as a factor, but it did note that Network Rail had since introduced NTS training for lookouts, which covers attention management and, specifically, the ability to remain alert and focused. However, the RAIB also pointed out that vigilance is not amenable to training because it is a 'hard-wired' part of the human condition and not a skill as such. Its recommendations were therefore targeted at the design of the task and equipment instead.

Taken together, these case studies show that there is clear relevance of NTS to rail safety, but also that we should be cautious about extending the reach of NTS to situations where it is less applicable. In the next section, we consider the relative merits of NTS in its application to rail, using the terminology of validation to structure our arguments.

4. The evaluation of non-technical skills

4.1 Predictive validity

One key question with any such intervention is whether or not it works. Validating the effectiveness of NTS training in terms of safety outcomes is difficult, because accident rates are generally low anyway (CAA, 2006; Helmreich et al., 1999) and, in the real world, it is difficult to separate out the effects from other confounding factors. Nevertheless, an oft-cited statistic from the Canadian Pacific Railway claims a 46% reduction in human-caused incidents after the application of NTS training (Fletcher, 2017; RSSB 2012).

An alternative model of validation considers behaviours and attitudes towards the training (CAA, 2006; Flin et al., 2008; Helmreich et al., 1999). Studies of CRM in the aviation community concluded that such training has led to positive attitudes and an effective transfer of the desired behaviours to the flight deck (Flin et al., 2003; Salas et al., 2006). RSSB (2012) described how rail NTS training courses in other countries have been positively received and that improvements have been seen in (self-perceived) skills and attitudes to safety.

There is also anecdotal evidence from aviation accidents that lends support to the value of CRM training. Following the 1989 crash landing of a DC-10 aircraft at Sioux City in Iowa, the Captain lauded the collective experience on the flight deck and vociferously stated that 'if I hadn't used CRM … we wouldn't have made it'. More recently, Captain Sullenberger, who famously landed US Airways flight 1549 on the Hudson River, described the crew coordination as 'amazingly good'. The NTSB report praised the professionalism of the flight crew and their excellent CRM during the accident, increasing the survivability of the accident (NTSB, 2010).

4.2 Construct validity

Here we are referring to the question of whether the training and assessment schemes actually reflect the underlying meaning of NTS. In particular, we are concerned that some applications of NTS training may not actually offer much value in improving non-technical skills or behaviours.

Flin et al. (2008) argued that practice-based training (for instance, simulator exercises or role play) is more effective than traditional information-based courses (i.e., 'chalk and talk'). This is because ultimately, as implied above, the outcome of such training should be a change in safety performance (ORR, 2016). Nevertheless, there are examples of NTS training programmes (e.g., CAA, 2006; Helmreich et al., 1999; as well as more recent applications that we have seen) that seem to provide basic awareness of human factors principles without explicitly translating this into guidance for behaviour. Such training could fundamentally be reduced to calls to 'pay more attention' (in ironic contrast to its modules on the limitations of human cognition).

We recognise that such training does offer value by increasing self-awareness of performance limitations and the effects of potential stressors (cf. Helmreich et al., 1999; RSSB, 2016; but this is unlikely to mitigate such risks; ORR, 2016), and may even have ancillary benefits such as improved reporting of systemic incident factors. We also realise that these courses often include useful strategies to maintain awareness, such as visual scanning, risk-triggered commentary and decision-making checklists. Our point, though, is that the training should be targeted directly at developing the relevant skills and behaviours (see e.g., Flin et al., 2003, for a good example).

4.3 Concurrent validity

In a related vein to the previous discussion, concurrent validity refers to how well the training scheme aligns with previously validated versions. In this respect, we would highlight how the NTS taxonomies for rail have extended beyond the original conceptions of CRM, and would question whether some of these additions are indeed skills that can be trained (cf. RAIB, 2015).

Earlier, we described how the common elements of CRM training are communications, decision making, leadership, situation awareness, and team working. Table 1 shows how NTS in rail has gone beyond these core categories to include, in particular, conscientiousness, workload management (or multi-task capacity), and self-management (or controlled under pressure). Conscientiousness, arguably, is a trait dimension and one that is better assessed during selection than training (cf. ORR, 2016; RAIB, 2006). Workload management, we contend, should be addressed through task design, while self-management is perhaps more related to technical skills (because more experience reduces task demands and facilitates coping under pressure).

Again, in the interests of balance, we note that some of these elements do reflect those found in Flin et al.'s (2008) description. Aspects of attention management can be mapped on to situation awareness, while 'controlled under pressure' mirrors 'managing stress'. In terms of stress, we should be realistic about what can be coped with: Helmreich et al. (1999) pointed out that pilots generally have unrealistic expectations about the effects of stress on performance, believing that a professional can leave their problems behind while flying. Regarding SA, we feel that although strategies for maximising attention can be taught (such as visual scanning or concurrent verbal commentaries), there is also a substantial responsibility for system designers in optimising the available information for operators (e.g., through interfaces).

4.4 Content validity

This brings us to our final concern with the trend towards implementation of NTS in rail, and it relates to how much NTS represents the wider human factors perspective. NTS is only one tool in the safety management armoury, and should be seen as part of the sociotechnical systems approach that pervades human factors thinking (cf. Flin et al., 2008; Helmreich et al., 1999).

In an excellent exposition of systems-centred versus person-centred theories of safety, Holden (2009) notes that attributing causality and blame to people is a fundamental psychological tendency on both an individual and an industrial level. In deference to the influences of Reason and Dekker, Holden (2009) reminding us that behaviour is only one factor in accident causation, and that engineering solutions which do not rely on compliance are sometimes the most effective (citing the law of human factors that 'it is better to bend metal than to twist arms').

There is a real risk, then, that NTS could be seen as a 'quick win' in the face of more challenging, but arguably more robust, systemic solutions. But this will only lead to short-lived benefits (Fletcher, 2017); what is tantamount to 'train and blame' is essentially a sticking plaster over the underlying cause and NTS should not be used in this way (ORR, 2016). NTS should not be the primary means to control error or assure safety (Helmreich et al., 1999), and is not in any way a substitute for good equipment and system design (ORR, 2016).

5. Conclusion: panacea or pariah?

It was not our aim in this paper to turn NTS into some sort of pariah for the rail industry. At the same time, though, we would be cautious about seeing NTS as a panacea for all ills. Whilst there are undoubted benefits to NTS training, we also need to be realistic that sending a train driver on a NTS course will not necessarily turn them into Captain Sullenberger.

Part of the reason for this is that Captain Sullenberger was ultimately a very experienced pilot, and such experience often shines through in case studies of averted disasters. James Reason (2008) drew on several of these case studies in espousing the human contribution in both unsafe acts and 'heroic recoveries'. Flin et al. (2008) also wrote about the 'sharp end' being the last line of defence – where the active failures occur, but also where human operators often catch and correct errors. Although a reader could interpret such examples in the context of non-technical skills, they could equally be a reflection of the depth of technical expertise (consider again the collective 103 years' experience on the flight deck of the DC-10 at Sioux City).

That said, we should not ignore the potential benefits of NTS training either. Collective experience may count for nothing in the absence of good communication, coordination and decision making. Whether qualitative or quantitative, there is plenty of evidence that NTS training can lead to improvements in behaviour, attitudes and performance.

In short, though, we advocate a back-to-basics approach, both in terms of reverting to the core elements of CRM / NTS in the literature, and a fundamental human factors approach to systems thinking. Exhortations to 'try harder' simply do not fit with 70 years of progress in human factors. Our views align closely with the latest guidance from the regulator (ORR, 2016), and we distil these to offer the following advice:

- Consider the appropriateness of the NTS training, both in terms of content and medium. Classroom-based introductions to human factors principles do not (necessarily) provide immunity to error.
- Be aware that NTS training will not address all the risks associated with cognitive abilities – some are innate, while others are more closely linked to traits. These are not amenable to training and instead are best addressed either through design (of tasks or equipment) or during selection.
- Do not be tempted to invoke NTS as a 'quick win' – whilst NTS can offer an additional layer of protection, the primary risk controls should be through equipment, task and system design.

Nevertheless, accident investigations usually begin at the sharp end and work backwards, and in doing so an examination of NTS can be a route in to look at the wider areas of sociotechnical systems design (Flin, 2017). If this ultimately leads to recommendations at the systems level, then so much the better.

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