TODAY'S RAILWAY SAFETY

PROGRESS SINCE 1940

Human error

Understanding the causes of human error became a recognised discipline in the aviation industry during the Second World War when new and complex machinery made increasing demands on pilots. This resulted in the loss of aircrew and aircraft when the pilot failed to take the correct action. Research and the resulting understanding of how humans interact with technological and managerial systems has become known as 'human factors'.

In the 1890 accident, signaller Rice forgot the train left standing in the path of an approaching express. Failing to remember something critical is a known type of memory failure that, in aviation, is attributed to about 20% of incidents. The likelihood of a memory failure increases when we are tired, as Rice may well have been in 1890. Reminder devices, to prevent memory failures, are now a common feature of engineered systems. These include alarms, alerts (for example a seat belt warning light and alarm in cars), physical barriers (such as a 'collar' on a railway signalling lever, which prevents a signal from being operated), or electronic interlocking.

In 1940, there is uncertainty about what driver Stacey saw at Taunton station. In his statement he was adamant that he saw the signals for his train cleared for the main line. Because the signals were visible from his side of the cab, fireman Seabridge would probably have looked out and confirmed that the signal was clear. If this scenario is correct, then there must have been a failure in communication between driver and fireman - not confirming which signals were clear. Driver Stacey proceeded under the assumption that he was on the main line (the 'normal' route for that train in his experience), and fireman Seabridge assuming that the driver knew he was on the relief line, not the main line. Although fireman Seabridge had a duty to look out for signals when possible, he would probably have been preparing his fire and water levels for the challenging ascent of Wellington Bank, a steep climb of about 1 in 80 with a total train weight of over 610 tonnes (including locomotive and tender) and poor rail conditions.
If this scenario reflects what actually happened that night, then at some point the signals must have been put back to danger and the route (and signals) set for driver Stacey's train to travel along the relief line. In this case, the signaller, Wadham, had a duty to put the signals to danger for both trains and then make sure driver Stacey was aware that the signal was going to be set for the relief line.

Fireman Seabridge was killed in the accident, and so this vital evidence was lost with him. The inquiry dismissed this scenario as unlikely because the route for the passenger train was likely to have been set for the relief line before it even arrived at Taunton. There is still a 'conspiracy theory' that Wadham's actions were not pursued at the time because he was a magistrate and an important figure in the local community. In researching this accident we have encountered hearsay that Wadham (and the other signallers) later admitted changing the signals for the passenger train: we have not found evidence to support this.

The conclusion reached by Lieutenant-Colonel Mount was that, for some inexplicable reason, driver Stacey misread the signals at Taunton and proceeded under the assumption that he was on the main line. In this case, driver Stacey's actions may have been influenced by his expectations: in his previous experience of working this train he had always been routed along the main line. This error type is also well know – we see what we expect to see. Even post-accident, driver Stacey would have been convinced that he saw the signals cleared for the main line. Fatigue may also have played a part. As with the previous scenario, it is likely that the final check of the signal would have been carried out by fireman Seabridge.

Managing human factors in today's railway

Fitness to work
Signaller George Rice had been involved in a serious accident at work ten months before his error that led to the crash. He was seriously injured on Friday 10 January 1890, just after 22:00, when he was hit by a locomotive whilst crossing the track at Norton Fitzwarren. Rice apparently did not notice the locomotive approaching him (and the driver and fireman did not see him). The locomotive buffer struck him on the right side of his body and carried him about 20 feet when he fell onto the ballast and hit his head. The crew of the locomotive noticed him at that point and managed to flag down a special train that was heading into Taunton. He was transferred to the Taunton & Somerset Hospital where it was found he had a fractured skull and four broken ribs. For a while he was not expected to live. However, he did recover and after 14 weeks was able to return to work.

He told the inquiry that since the accident he had been "very forgetful". When GWR company officials came to ask him how he felt he told them "I am pretty well, except in the head". The GWR (Campfield) had offered to put him on lighter work, but Rice wanted to continue in the signal box at Norton. His doctor, Mr Meade, had given him a certificate to say he was fit to continue and gave him a 'bottle or two of medicine', which he had been taking for three weeks leading up to the accident.

The Great Western Railway did not carry out its own medical checks to determine whether Rice was capable of resuming his safety critical role as signaller. On the day of the accident, and the day before, he said he had been feeling very unwell, but had not told anyone that he was unfit to carry out his signalling duties.

Personnel carrying out safety-critical tasks on today's railway are required to have their fitness monitored. Someone who had suffered such serious injuries as Rice would not return to the same kind of work – even without the symptoms that he was still suffering.

The modern rail industry also has very strict controls for detecting drug and alcohol use. Limits are much lower than are applicable to driving on the road. Employees are tested when first employed, if they are involved in an incident and at random intervals throughout their career. There are also arrangements for people to declare they are taking 'over the counter' medicines, so that the effect on their performance to be assessed. George Rice had, by his own admission, been taking some form of pain relief leading up to the accident. The type of drug was never mentioned, but would undoubtedly have resulted in him being removed from safety-critical work in today's railway.

Fatigue
Fatigue is now acknowledged as a significant factor in accidents. Fatigue has similar effectsToday's railway companies are required to have 'fatigue management systems' to assess how fatiguing shift patterns may be and to monitor the fatigue of people carrying out safety critical work.

Fatigue in the 1890 accident
Both Driver Noble, and Signaller Rice had been on duty for long hours. Rice in particular had a prolonged period where he had been busy and had to keep a mental picture of where trains were. This, coupled with his health problems would have been very fatiguing.

Fatigue in the 1940 accident
Both driver Stacey and fireman Seabridge lived in London, and both had seen their homes damaged by bombs in the Blitz. The stress of living in wartime London, and the effect this had on sleep patterns is hard to imagine today. It is likely that both men were chronically fatigued.

Today's signallers have visual representations of the network on computer screens and electronic interlocking prevents routes being set towards a stationary train. Unauthorised train movements (for example a train passing a signal displaying a 'stop' aspect) sound an alarm in the signalling centre which allows the signaller to take action. This could be involve contacting the driver directly by radio and stopping other trains.

Track layout and signalling systems
Another factor in the 1890 accident was the complexity of the track layout at Norton Fitzwarren. Not only were there sidings, but the track was a mixture of gauges – some standard gauge, some broad gauge and some a mixture of both. This would have significantly increased the mental workload of signaller Rice as he tried to work out where to put the assisting engine (being broad gauge it could not go into the standard gauge sidings), deal with the shunting movements and deal with all the normal train movements on the main line. Each of these movements required manual operation of signalling equipment (points and signals), so signalling could be physically demanding too.

Today's railway layout has been significantly simplified – shunting goods at stations is a thing of the past. Modern signalling systems detect where trains are on the network and automatically set routes. During normal working signallers monitor train movements and only intervene when things go wrong (infrastructure or train defects, passenger action, trespassers and the like).

Crashworthiness of railway carriages
The concept of rail vehicle structural crashworthiness has developed significantly since the two accidents at Norton Fitzwarren. Wooden-bodied coaches have been replaced by welded steel or aluminium bodies which provide a strong 'survival cell' if there is a serious crash. 'Telescoping' of coaches is further prevented by having strong pillars at the end of vehicles and devices that prevent carriages from 'climbing' over each other. Inside the carriages, the likelihood of secondary injuries is reduced by improved furnishings at fittings (that do not become detached when there is a crash) and by using fire-resistant materials.

The crashworthiness of modern rolling stock was shown in an accident very similar to the 1940 Norton Fitzwarren accident - at Grayrigg in 2007. Here, a train derailed at a set of defective points. The train was travelling at 95 mph, and eight of the nine vehicles fell down an embankment. One passenger was fatally injured and the train was seriously damaged. However, there was no significant loss of passenger or crew survival space.

Visibility of signals, head and tail lamps
In both the 1890 and 1940 accidents, signals were of the 'semaphore' type (a wooden arm, pivoted so that it could move up or down), supplemented by paraffin lamps for poor lighting conditions. Vehicle head and tail lights were also paraffin lamps. Modern signalling equipment, and vehicle lights, use high-intensity LED technology and can be seen at great distances. The latest signalling systems do not require lineside signals at all – the state of the line ahead is communicated directly to each train and speed controlled automatically.
In the 1940 accident, signal visibility was further complicated by the presence of blackout screens and the poor weather.

The side windows of the locomotive cab were plated over and a large tarpaulin stretched from the cab roof to the tender. This was to prevent the bright light from the locomotive fire being visible to enemy aircraft. The tarpaulin in particular made it difficult for the driver to look out of the side of the cab and view signals. The view forward through small cab windows along the locomotive boiler did not give a good view of signals or the line ahead. Today's rolling stock typically features a driving position that gives a clear view of the line ahead.

Automatic braking
Much of today's signalling system still uses a system similar to the GWR's Automatic Train Control, which was in use at the time of the 1940 accident. The system, known as the Automatic Warning System, provides the driver with an audible warning and visual reminder on the approach to signals and speed restrictions. The system was supplemented in the late 1990s by the Train Protection and Warning System (TPWS) which applies the train brakes automatically if the train has:
- passed a signal at danger without authority
- approached a signal at danger too fast
- approached a reduction in permissible speed too fast
- approached buffer stops too fast.

TPWS was implemented as a lower-cost option ahead of full automatic train protection systems which required significant changes to railway signalling and trainborne equipment.

Operational rules and national standards
There is a national Rule Book that details the safe way of operating railways in normal, degraded and emergency situations. An operating rule to protect trains in the situation that existed in the 1890 accident ('Rule 55') appears in the 1905 GWR rule book. Rule 55 says:
"When a train or vehicles… have been shunted on to the opposite running line… the Guard, Shunter or Fireman must, when the vehicles come to a stand, proceed immediately to the signal box, and remind the Signalman of the position of the train or vehicles, and remain in the Box until the Signalman can give permission for them to proceed, or to be shunted clear of the running lines."
Although not a foolproof solution, this rule provided an additional person in the signal box that could check that a train was not sent towards the stationary train.
Rule 55 still exists, in a slightly different form, in today's national rule book.

Emergency response
Until after the Second World War there was no county-based fire and rescue service, so rescue and recovery operations for train accidents were largely dealt with by the railway companies. Each main railway depot typically had a breakdown train comprising a crane and support vehicles containing heavy lifting gear.
In both accidents, the railway company was able to mobilise resources (people and equipment) and get them to the scene remarkably quickly.

Today, fire and rescue services are equipped with lifting and cutting equipment to quickly rescue trapped people. Emergency medical care can also be on the scene quickly by both road and air – Dorset and Somerset have an air ambulance.

The number of railway depots has significantly decreased and very few retain heavy lifting equipment, or the expertise to deal with major incidents.

Communication
The Great Western Railway had helped develop an electric telegraph system that allowed messages to be rapidly transmitted over long distances. Telegraph equipment was located at stations and allowed help to be summoned quickly in both 1890 and 1940.

Today's railway uses wireless communication system for voice and data communication between trains and signalling centres. This is known as GSM-R (Global System for Mobile Communications – Railway). GSM-R allows traincrew and signallers to communicate immediately when an incident occurs.

Investigation
At the time of the 1840 accident, the railway accident investigation department of the Board of Trade was very new, having only been created earlier that year. At the time it had very limited powers to force railway companies to make changes. By 1940, the Railway Inspectorate was part of the Ministry of Transport and its influence and powers had increased. Most railway inspectors came from the Corps of Royal Engineers.

Today, the Rail Accident Investigation Branch (RAIB) carries out investigations into rail accidents and incidents without apportioning blame or liability, with a view to enabling lessons to be learned to improve safety on railways and prevent similar accidents and incidents. The Office of Rail and Road (ORR) may also investigate alongside RAIB in order to see whether there have been any breaches of health and safety law. If necessary, the ORR will bring a prosecution under health and safety law.

Individual railway companies, and Network Rail, also have their own investigators. These investigators will investigate less serious accidents and may work with other bodies or more serious accidents.

Modern railway vehicles, like aircraft, have 'black boxes' (actually they're orange) fitted that record the driver's actions and data about the train (speed, location, distance travelled). This data is held in a crash-proof device that can be downloaded after an accident. Signalling centres have similar equipment and voice communications are all recorded. This all adds to the evidence available to investigators to work out what happened.