Rail Accident Investigation Branch

Rail Accident Report

Station overrun at Stonegate, East Sussex
8 November 2010

Department for Transport

Report 18/2011
November 2011

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Station overrun at Stonegate, East Sussex 8 November 2010

Contents

Summary

Shortly after 08:00 hrs on Monday 8 November 2010, a passenger train running from London Charing Cross to Hastings failed to stop at Stonegate station in East Sussex. The train ran for a further 2.45 miles (3.94 km) with the emergency brake applied, passing the level crossing at Crowhurst Bridge before coming to a stop 3.22 miles (5.18 km) after first applying the brakes.

No-one was hurt and there was no damage to the train or to the track. The train completed the journey to Hastings after a short delay.

Rail adhesion conditions were poor on that day due to high winds causing fresh leaf fall, and the onset of rain. The line had been treated to improve adhesion the previous evening.

It is likely that the train failed to stop at Stonegate station because there was almost certainly no sand in the sand hoppers at the leading end. If sand had been present, the train braking system would have deposited sand onto the rail head, improving the available adhesion and allowing the train to stop in a much shorter distance.

The RAIB has made three recommendations to London & South Eastern Railway Ltd, covering improvements in maintenance processes, restrictions on the use of trains that need servicing, driver awareness of low sand conditions and the responsiveness of the sand replenishment regime.

Preface

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame or liability, nor carry out prosecutions.

Key definitions

3 All dimensions and speeds in this report are given in metric units, except speed and locations on Network Rail managed infrastructure, which are given in imperial dimensions, in accordance with Network Rail practice. In this case the equivalent metric value is also given.

4 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

5 All mileages in this report are measured from a zero datum point at London Charing Cross.

The incident

Summary of the incident

6 At 08:05 hrs on Monday 8 November 2010, train 1H08 (the 06:45 hrs London Charing Cross to Hastings service) was approaching Stonegate station in Sussex.

7 The train was formed of a single four-car class 375 *electric multiple unit*, operated by Southeastern.

8 The train was travelling at approximately 64 mph (103 km/h) when the driver applied the brakes to make the scheduled stop at Stonegate station. The initial brake application did not reduce the speed of the train as quickly as intended, so the driver increased the brake application until *emergency braking* had been applied.

9 This did not significantly improve the deceleration rate, and the train passed through Stonegate station at approximately 50 mph (80 km/h) with the emergency brake applied. The train continued, with the emergency brake continuously applied, until coming to a stand 2.45 miles (3.94 km) beyond Stonegate station. The train ran for a total of 3.22 miles (5.18 km) from when the brakes were first applied, taking six and a half minutes, until it came to a stop.

10 The train was running under clear signals throughout the incident, and correctly operated and traversed Crowhurst Bridge *automatic half barrier level crossing* (AHBC) before coming to a stand.

11 The driver reported the incident to the signaller while the train was still moving.

12 After the train had stopped, the driver restarted the train and continued the journey to Hastings.

13 No-one was injured in the incident. No damage was caused to the infrastructure, or to the train. In particular, the use of the emergency brake did not result in any *wheel flats* on the train.

Organisations involved

14 Network Rail owns, operates and maintains the railway infrastructure of the line through Stonegate.

15 London & South Eastern Railway Limited (trading as Southeastern) operated the train involved in the incident. It was also responsible for servicing the train, including replenishing the sanding equipment, between routine examinations.

16 Network Rail and London & South Eastern Railway Limited freely co-operated with the investigation.

Location

17 Stonegate station is located at 43 miles 66 chains, on the route between Tonbridge and Hastings, approximately 9 miles (14.5 km) south-east of Tunbridge Wells (figure 1).

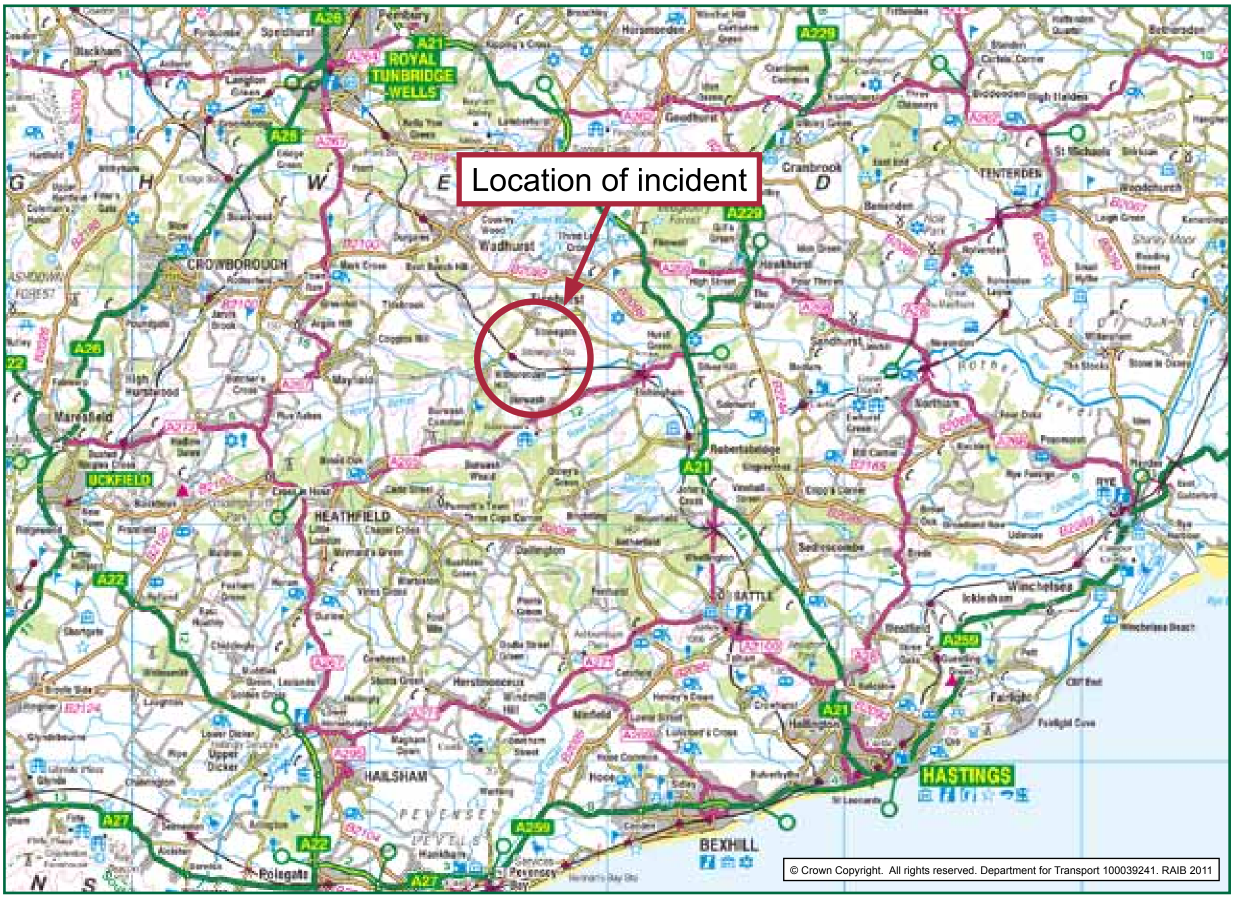

Figure 1: Extract from Ordnance Survey map showing location of incident

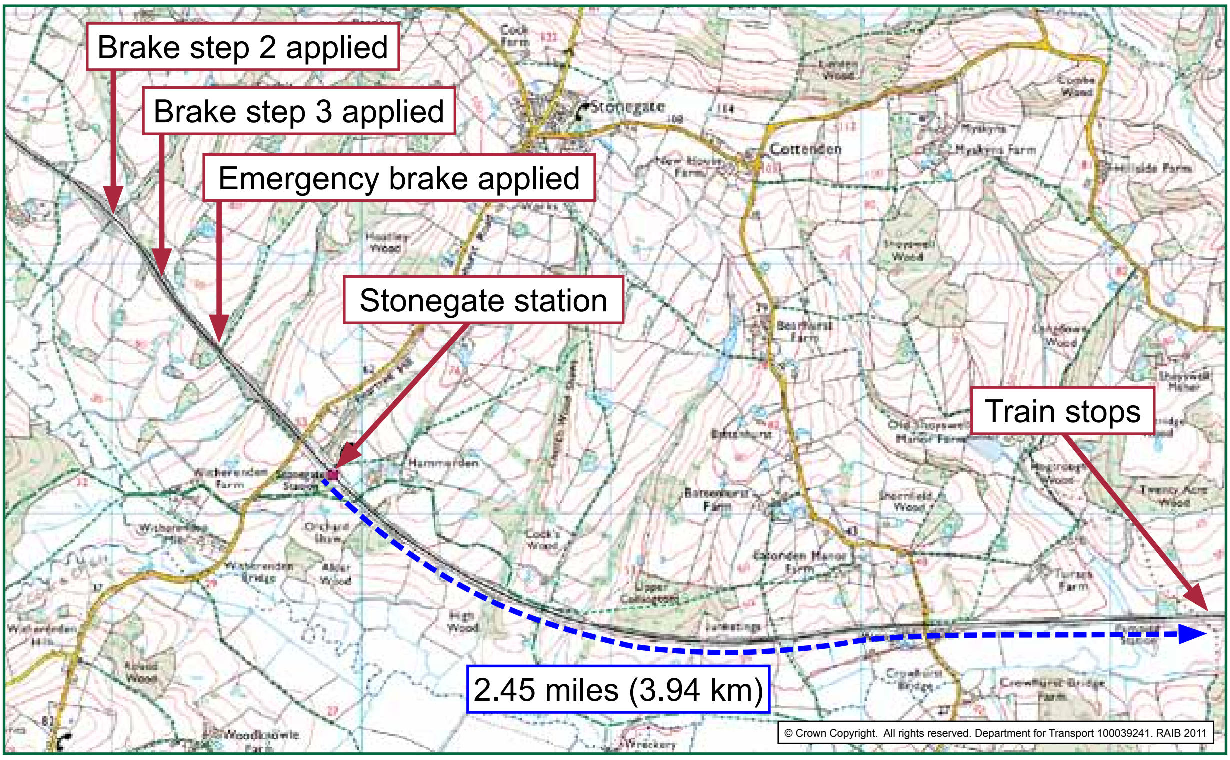

Figure 2: Overview of incident

18 The route from Tonbridge to Hastings is mostly double track, although there are some short sections of single track through tunnels. The section through Stonegate station, on which the incident occurred, is entirely double track. *Third rail DC electrification* on the route is controlled from the electrical control room at Paddock Wood.

19 The incident occurred on the 'down line', which is used by trains travelling towards Hastings.

20 The signalling on the route through Stonegate station is controlled from the signal box at Robertsbridge (at 49 miles 54 chains).

21 From 41 miles 60 chains, approximately 2 miles (3.2 km) before Stonegate station, the maximum permitted speed is 80 mph (129 km/h). From 0.43 miles (0.7 km) before Stonegate station, the permitted speed increases to 90 mph (145 km/h). It remains at 90 mph until 49 miles 59 chains, which is more than 3 miles (4.8 km) beyond the point at which the train stopped.

22 From the location where the brakes were first applied to the location where the train stopped, the line is on a varying downhill gradient, with the exception of a 540 metre level stretch approaching and through Stonegate station. Figure 3 shows the gradients and line speeds in the area.

External circumstances

23 The incident took place during the hours of daylight. On the day of the incident, sunrise was at 07:03 hrs.

24 The sky was overcast and light rain had started to fall as the train travelled from Tonbridge towards Stonegate. Records indicate that winds in the area were around 15 mph (24 km/h), gusting to around 35 mph (56 km/h), and potentially bringing down leaves from trees and disturbing those that had already fallen.

Train involved

25 The train involved in the incident was a four-car Class 375 '*Electrostar*' electric multiple unit, number 375711. The train was built by Bombardier Transportation, at Derby in 2001. At the time of the incident, it was leased to Southeastern by Eversholt Rail Group.

26 The train was fitted with sanding equipment from new. This was designed to apply sand to the wheel/rail interface to improve *adhesion* levels when required (paragraph 54).

27 The train was also fitted with a w*heel slide protection* (WSP) system from new. WSP systems are provided on trains to limit the extent of *wheelslide* by modulating[1] the braking effort applied when wheelslide is detected.

[1] This is achieved by releasing the brakes to allow the skidding wheel to start turning again, and then re-applying them.

Staff involved

28 The driver of the incident train had more than 10 years driving experience, including more than 7 years on this type of train. He had spent all his driving career based at the same depot, and was familiar with the Tonbridge to Hastings route.

29 The signaller also had more than 10 years experience as a signaller, with 7 years of this based at Robertsbridge. He was familiar with the area covered by this signal box.

Events preceding the incident

30 Network Rail's weather forecaster had categorised 8 November 2010 as having an Autumn Adhesion Index of 9. This index indicates the expected rail adhesion conditions on a scale from 1 (Good) to 10 (Bad). A score of 9 or 10 indicates a 'black' day, corresponding to 'extreme leaf fall contamination' being expected (Network Rail company standard NR/L3/OCS/043/7.1 'National Control Instructions and Approved Code of Practice', section 7.1 'Weather Management').

31 Network Rail's *rail head treatment train* (RHTT) had treated the Tonbridge to Hastings route the previous evening. The RHTT water jetted the rail head along the entire route to remove surface contamination, and applied a friction material, known as *Track Grip 60*, at specific sites where low adhesion was a known problem. Track Grip 60 was applied from 41 miles 12 chains to 45 miles 40 chains, covering from 2.7 miles (4.3 km) on the approach to Stonegate station to 1.7 miles (2.7 km) beyond it.

32 On the morning of Monday 8 November 2010, the incident train 1H08 left Charing Cross as an eight-car train. At Tonbridge, the rear four-car unit was detached, with unit 375711 continuing as a four-car train to Hastings, with the 'A' end leading. The driver involved in the incident took over the train at Tonbridge, departing four minutes late at 07:35 hrs.

33 When he booked on at Tonbridge, the driver read a notice saying that the day had been classified as 'black'. He experienced some low adhesion between Tonbridge and Wadhurst, but did not consider this as abnormal for the time of year.

34 The driver had to make intermittent use of the windscreen wiper, because it was starting to rain lightly.

Events during the incident

35 At 08:05 hrs, approximately 1400 metres before Stonegate station, the driver applied the train brakes in step two[2] (figure 2). This was in accordance with the Southeastern driving policy. The *on-train data recorder* (OTDR) shows that at this point the train was travelling at 64 mph (103 km/h) (figure 3).

[2] The train has four brake steps. These are step one, step two, step three and emergency, in increasing order of *brake retardation*.

36 With the brakes applied in step two, the driver found that the train was not slowing down as quickly as he expected. After travelling approximately 200 metres in step two, he increased the brake application to step three. At this point the train was travelling at 61 mph (98 km/h).

37 The train was still not slowing down as quickly as the driver expected, so after a further 740 metres he increased the brake application to the emergency position. At this point the train was still travelling at 54 mph (87 km/h).

38 Even though the emergency brake was applied, the train was still not slowing down as quickly as the driver believed it should.

39 As the train passed through Stonegate station at 50 mph (80 km/h), the driver spoke to the conductor over the train intercom and told him why he had been unable to stop the train at Stonegate.

40 At 08:08 hrs, the driver contacted the signaller at Robertsbridge by radio, to advise him of the incident. At this time, the train was still moving at approximately 35 mph (56 km/h). The signaller was aware that the train was still moving, and confirmed to the driver that the train had activated the level crossing barriers at Crowhurst Bridge AHBC, closing the crossing to road traffic, and that all signals were clear.

41 The signaller then contacted the joint Network Rail/Southeastern Kent Integrated Control Centre to advise them of the overrun. This was incorrectly reported by the signaller to have been an overrun of 200 yards. The signaller also advised the Tonbridge signaller of the low adhesion conditions, so that subsequent trains could be alerted.

42 The conductor entered the cab, and saw that the brake was in the emergency position and that the train was still travelling at speed. The driver told him that the signaller had confirmed that the signals were clear and that the level crossing had been correctly activated. The conductor then returned to the passenger accommodation and confirmed that no passengers had intended to alight at Stonegate.

43 The train traversed Crowhurst Bridge AHBC at 25 mph (40 km/h), and finally stopped at 08:12 hrs, at 46 miles 29 chains, a distance of 2.45 miles (3.94 km) after passing through Stonegate station.

44 Figure 3 shows the speed profile of the train throughout the incident.

Events following the incident

45 After a pause of 20 seconds, the driver restarted the train and continued in service towards Hastings.

46 In response to the difficulties experienced at Stonegate, the driver changed his driving technique to make use of brake step one, braking much earlier and lighter than previously. Using this technique he made the normal service stops on the uphill section of the line at Etchingham, Robertsbridge and Battle stations.

47 After Battle, the driver returned to the Southeastern driving policy of using brake step two as the initial application. He then had more adhesion difficulties, and had to use the emergency brake on the downhill approaches to both Crowhurst and West St Leonards.

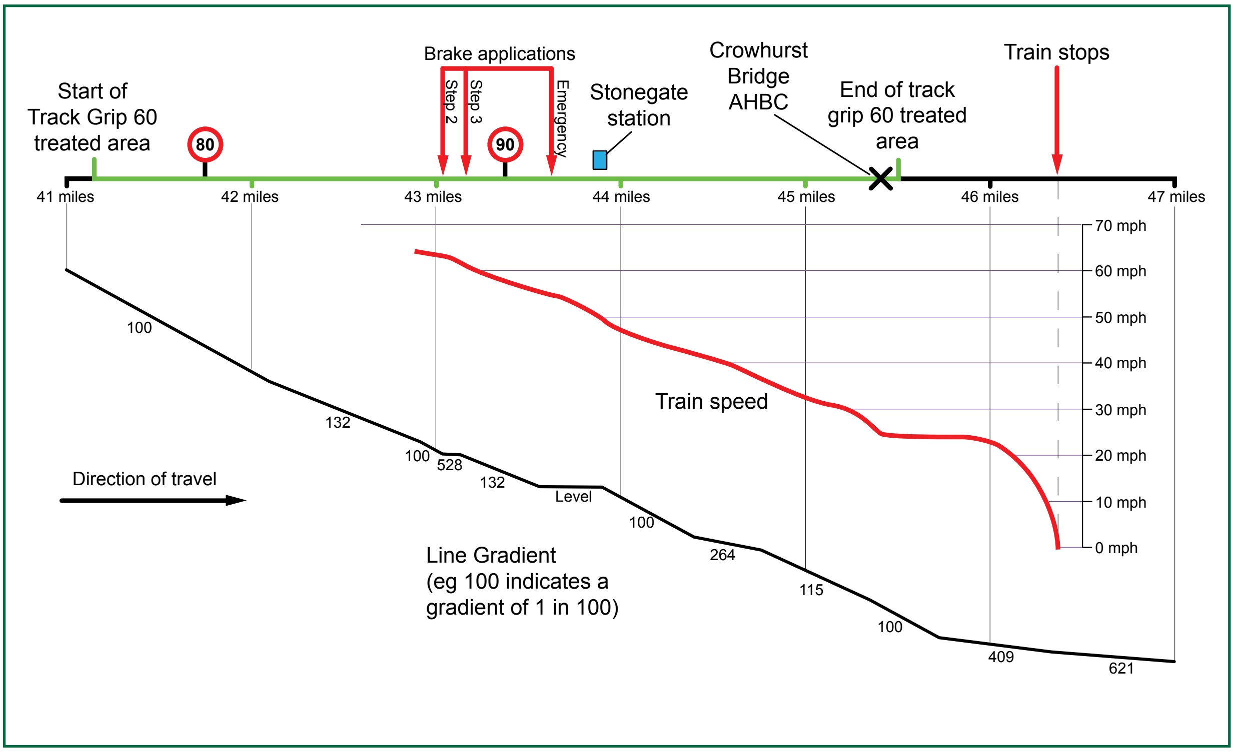

Figure 3: Details of line characteristics and train movement at Stonegate

48 The driver reported these emergency brake applications to the signaller at Bo Peep Junction, because he had now reached the area controlled by this signal box. These were correctly recorded as low adhesion incidents and subsequent trains were alerted.

49 At Hastings, the driver changed ends, and returned the train in service to Tunbridge Wells. He then returned to Tonbridge depot as a passenger on that train. At Tonbridge depot, the driver verbally reported the length of the overrun to a driver manager.

50 Two subsequent southbound stopping passenger services passed through Stonegate station, both of which were advised of low adhesion conditions by the Tonbridge signaller. These were then followed by the RHTT, which again water jetted the rail head along the entire route, and applied Track Grip 60 in the vicinity of Stonegate station. A Network Rail *Mobile Operations Manager* (MOM) arrived at Stonegate at 09:20 to assess the rail head condition, just after the RHTT had passed through. The next passenger train was asked by the signaller to make a *controlled test stop* at Stonegate to check the adhesion conditions, and no problem was reported.

51 On Thursday 11 November 2010, as part of a routine analysis of the reported incident, Southeastern identified that the incident train had overrun Stonegate station by 2.45 miles (3.94 km), and not by the 200 yards that had been reported by the signaller at Robertsbridge (paragraph 41). This resulted in Southeastern removing the train from service for investigation, and reporting the incident to the RAIB.

Consequences of the incident

52 No-one was injured in the incident. No damage was caused to the infrastructure or to the train. During examination of the train, it was found that the wheels were in good condition and there were no signs of wheel flats. This was consistent with the WSP system functioning correctly, thus minimising the sliding of wheels on the rail head, and very low adhesion conditions being present at Stonegate on 8 November 2010.

The investigation

Sources of evidence

53 The following sources of evidence were used:

- witness interviews and statements;
- analysis of OTDR and other on train data sources to establish:
  a. brake and WSP performance; and
  b. likely sand usage before and during the incident journey;
- signalling system voice communications records;
- records of the train involved in the incident in respect of:
  a. previous sand replenishment;
  b. reporting of sand usage before the incident; and
  c. arrangements for replenishment, and reasons for failure to replenish;
- records of the servicing regime for train sanding systems;
- RAIB questionnaires on train sanding, completed by other *train operating companies* (TOCs);
- the Southeastern train driving policy;
- records relating to the rail head treatment (RHT) regime in Kent;
- Network Rail adhesion performance data for Kent/Sussex, and nationally;
- weather reports; and
- review of previous RAIB investigations that are relevant to this incident.

Key facts and analysis

Background information

Sanding equipment

54 Sanding equipment is provided on most modern rolling stock and has been required by Railway Group Standards on new rolling stock since 2003. Its purpose is to apply sand to the interface between the wheel and the rail, in order to increase friction when adhesion conditions are low. Sand can be used to improve adhesion both during braking and during acceleration. This allows the driver to have more control of the train in low adhesion conditions, thus improving safety.

55 On the class 375 electric multiple units, the sanding equipment is fitted to the third *wheelset* from each end of the unit. Each of these wheelsets has two associated sand hoppers (each with a capacity of 45 kg), with one mounted on each side of the underframe of the vehicle, and pipes through which the sand is delivered to the rail head. Figure 4 shows the locations of the sanding equipment in relation to the train.

56 Tests undertaken by Siemens and South West Trains at Wildenrath in Germany during January and February 2006 demonstrated the value of sand in minimising the extension of stopping distances under low adhesion conditions. These tests are referenced in RAIB Report 25/2006 Part 3[3].

57 Testing carried out by Southern Railway, on the Dorking to Horsham line in April 2011, showed that the stopping distance of a train running at 60 mph (96 km/h), in simulated low adhesion conditions[4], could be reduced by up to 45% when sand was applied between wheel and rail head. It also showed that the deceleration rate with the emergency brake applied could be improved from approximately 6 %g to approximately 12 %g, when sand is applied in simulated low adhesion conditions (see Table 1, note 1 for an explanation of deceleration rates).

58 Similar results were achieved in lower speed tests carried out by Southeastern on the Bromley North branch in April 2011.

59 All of the above tests indicated that the deposition of sand at the wheel/rail interface would have increased the rate of deceleration of the train in the low adhesion conditions experienced. Although some of the tests showed a deceleration improvement of up to 6 %g when sand was applied, it is more generally accepted by the rail industry that an improvement of 3 %g can be expected. Caution is required when comparing these results to the incident at Stonegate, because the tests were unable to replicate the very low adhesion conditions that were present on 8 November 2010.

60 Sand is deposited only by the equipment associated with the leading cab on a train. No sand is deposited by the equipment associated with the trailing cab on a unit. Similarly, when a train is formed of more than one unit, no sand is deposited by the equipment associated with any of the cabs on the trailing units.

[3] Autumn Adhesion Investigation Part 3: Review of adhesion-related incidents, Autumn 2005, published January 2007. Available from the RAIB website (www.raib.gov.uk).

[4] During these tests, low adhesion conditions were simulated by spraying a water and detergent mixture onto the rail head ahead of the leading wheelset on the train.

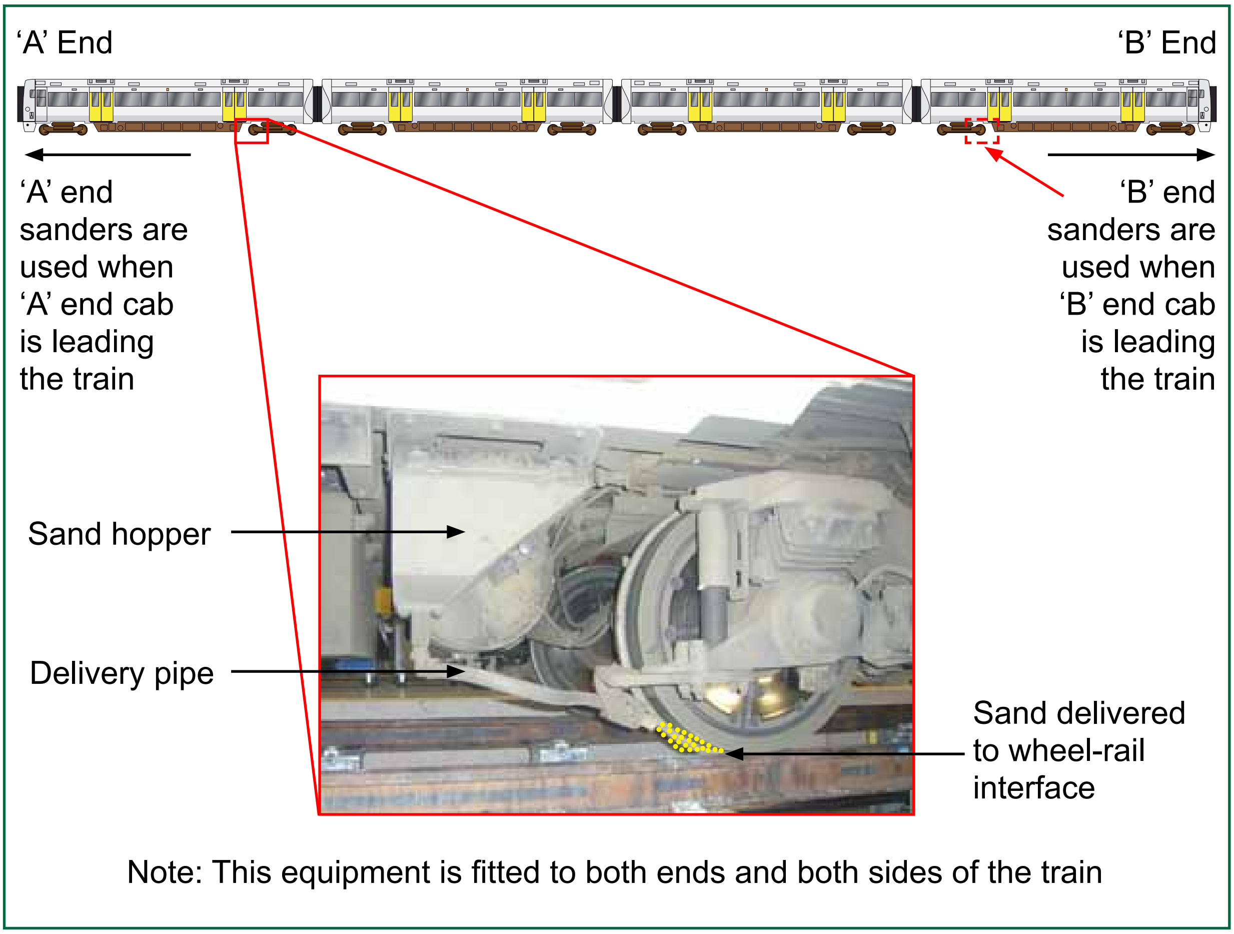

Figure 4: Diagram showing sanding equipment on the train

61 The class 375 trains first entered service between 2001 and 2005 (paragraph 158). The design was modified in 2003 so that sand would be applied automatically in brake step two when the WSP system activates because it detects that one or more axles are not rotating at the same speed as the remainder (in addition to step three and emergency as had been originally provided). This was initiated by Connex, the operator of the trains at that time, in response to a number of instances of wheelslide resulting in station overruns in brake step two. The maximum time that the sanding equipment was permitted to apply sand was also increased from 10 seconds to 60 seconds, as experience had shown that 10 seconds of sanding was insufficient in low adhesion conditions.

62 The class 375 trains were further modified by Southeastern in autumn 2006 so that the maximum time that the sanding equipment was permitted to apply sand was increased from 60 seconds to 180 seconds. This was in response to further operational experience and an *Adhesion Working Group* (AWG) review of low adhesion incident performance during autumn 2005 (AWG report of 28 April 2006). It also pre-empted recommendations that were made by the RAIB following investigations into a series of low adhesion incidents in 2005 (see RAIB Report 25/2006 Part 3).

63 At this time, the class 375 units were also modified so that the rate at which sand was applied to the rail-wheel interface was increased from a maximum of 2 kg/minute to a maximum of 3 kg/minute. Low adhesion testing carried out by Southern Railway on the Dorking to Horsham line in August 2006, using similar class 377 units, had shown a reduction of up to 10% in stopping distance when the flow rate was increased to 3 kg/minute. At this flow rate, the maximum available sanding time available from the 45 kg sand hoppers is 15 minutes. Risk assessments of these changes were carried out (paragraph 191).

Maintenance personnel, processes and systems

64 Maintenance (including servicing and repairs) of Southeastern operated trains is carried out at a variety of locations on the network on which they operate. This can be at depots (eg Ramsgate) or stabling points (eg St Leonards West Marina), while non-routine repairs can be carried out at stations or other locations by mobile technicians.

65 Work can either be scheduled on a regular periodic basis, or on a reactive basis as faults and defects arise. Scheduled work can be planned in advance, and train movements organised to remove units from service for this work to be undertaken.

66 Replenishment of sand is normally a scheduled activity. During the leaf fall season (early October to mid-December) trains are planned to have the sand hoppers refilled at least every seven days. However, if there is higher than normal sand usage, this can become a reactive activity. Processes are in place that are intended to identify when sand is running low on a unit and to arrange for refilling of that unit.

67 There are a number of key personnel who are involved in the planning and implementation of maintenance activities, including implementation of the processes controlling sand replenishment.

68 The fleet delivery engineer post is based at Kent Integrated Control Centre, in London, and is continuously covered by a day shift, starting at 07:00 hrs, and a night shift starting at 19:00 hrs. This role includes managing train defects that can be dealt with at locations other than the depots, known as ‘line of route’. This includes overseeing a team of ‘line of route’ mobile technicians, based at certain outstations, who can travel to where trains are stabled (other than depots), and carry out minor maintenance activities as required.

69 The fleet planning engineer post is based at Slade Green depot and is staffed on a day and a night shift, with a two hour gap between shifts that is not staffed. This role includes planning and prioritising train maintenance that will be carried out at depots, such as Ramsgate, for the class 375 units. Typically work is planned seven days ahead, but the plan is adapted on a daily basis as other defect priorities arise.

70 The technical service engineer post is based at Ramsgate depot and is normally staffed on a day and a night shift, with a two hour gap between shifts that is not staffed. Part of this role is to review data from various sources to identify events that could affect the safety of trains, and to raise a work report categorised with a level of priority for each event. During the leaf fall season, this included carrying out the ‘sanding critical event review’ (paragraph 74) to identify units that had low levels of sand.

71 The stock maintenance controller post is based at Slade Green depot. This role includes planning the movements of trains so that they are scheduled to be stabled at locations where both routine and unexpected maintenance activities can be carried out.

Sand tracker spreadsheet

72 A spreadsheet listing all the class 375 units and the dates at which the sand hoppers were last filled is kept up to date by planning support personnel during the leaf fall season. Each unit is highlighted in colours to identify where in the scheduled seven day cycle it stands. Green is used to show units that have been replenished with sand in the previous five days, whereas orange and red are used to highlight those refilled up to and over seven days ago respectively.

73 This spreadsheet is provided to the stock maintenance controller and the fleet planning engineer on a daily basis. The stock maintenance controller annotates the spreadsheet for that day to show where units are intended to stable that night, and passes this to the fleet planning engineer. The fleet planning engineer can then identify if units marked orange or red are scheduled to end up at a depot, and add these to the work list. If any orange or red units are scheduled to stable elsewhere, he should pass the spreadsheet on to the fleet delivery engineer to action as 'line of route' work.

Sanding critical event review process

74 The sanding critical event review process is additional to the routine sand replenishment controlled by the sand tracker spreadsheet. This was put in place in 2007 following the risk assessments arising from modifications to the sanding equipment (paragraph 191).

75 The technical service engineer was responsible for checking the data obtained from trains in the preceding 24 hours to identify units with low sand. This consisted of filtering a spreadsheet of event codes that had been uploaded by trains to a central computer, such that only codes 567 (accumulated sanding time > 10 min) and 568 (sanding EP valve counter reset) were shown. Note that event code 568 is manually set by maintenance staff when the sand hoppers have been refilled.

76 The technical service engineer should then manually search this spreadsheet for instances when a train raised event code 567 and this was not followed by an event code 568. This means that the train has identified that the sand is running low, but the timer has not been reset during sand refilling, suggesting that it has not been refilled. This identifies units that have low sand and require attention to have it filled.

77 The technical service engineer should then raise a work report in the 'engineering management system' (EMS) (paragraph 83) for any units requiring filling, giving this a prioritisation requiring attention by the end of the same day.

78 Additionally, the process requires the technical service engineer to contact the fleet delivery engineer by telephone and advise him of any units requiring sand replenishment. The fleet delivery engineer should then action replenishment through the 'defect management process' and determine whether he would arrange this at an outstation, or pass it to the fleet planning engineer for action at the depot.

79 In practice, witness evidence indicated that the technical service engineer could identify the stabling location for the affected unit that night, and anticipate whether the work would be the responsibility of the fleet delivery engineer or the fleet planning engineer. He could then contact either the fleet delivery engineer (for 'line of route' work), as per the documented process, or the fleet planning engineer (for depot work), bypassing the fleet delivery engineer who was intended to make this decision.

Fleet delivery engineer defect management process

80 For a known defect, such as low sand, the fleet delivery engineer should identify where the affected unit was due to stable that night. The fleet delivery engineer would then have two options as to how the work should be carried out:

- If it was to be done at a depot such as Ramsgate, the work report would be passed to the fleet planning engineer to be implemented. This would be communicated by telephone and the fleet delivery engineer would have no further involvement.
- If not, the fleet delivery engineer should take responsibility for the work, and arrange for it to be carried out on 'line of route'. This means that the work would be done at a non-depot stabling location, such as St Leonards West Marina, or Gillingham. The fleet delivery engineer would then ensure that the work report and associated job cards were completed.

Fleet planning engineer depot list of work process

81 When advised of any additional work that was to be carried out at a depot, such as sand replenishment, the fleet planning engineer should have added it to the work list for the depot concerned. He should then have verified that the unit could be stabled in a position where the work could be carried out, and that the necessary resources were available. The fleet planning engineer should then have ensured that the work report and associated job cards were completed.

82 A daily telephone conference call was held at 21:30 hrs chaired by the fleet delivery engineer. This involved the fleet planning engineer and depot staff, as well as the technical service engineer, if one was on duty. This call discussed the work that was due to be undertaken that night and where that work was to be carried out. This included both work to be completed at a depot and that intended for 'line of route' locations. This provided a verbal means by which work that had been scheduled was alerted to the personnel responsible for ensuring it was done.

Engineering management system

83 The EMS is an IT system that tracks train defects, and records the current status of these. A work report is raised when a defect, such as low sand, is identified. When the train has reached the location at which the work is to be carried out, such as a depot or 'line of route' outstation, a job card is raised by personnel at that location to initiate the required work activity. When a job card is raised, it is possible for it to address more than one work report for a given unit.

84 When the work has been completed, the job card will be marked as completed in the EMS by the fleet delivery engineer (or the fleet planning engineer for depot work), and this will automatically complete any associated work report if there are no other outstanding job cards associated with it.

85 The EMS does not interact with other systems to prevent rolling stock from entering service when either job cards or work reports are still open or incomplete. The fleet planning engineer and fleet delivery engineer have to manually review the status of work reports in order to control which units are prevented from entering service.

Genius

86 This is an IT system that is used for planning of rolling stock movements, and can be used to identify where units are scheduled to end service on any given day. The stock maintenance controller can make changes to train movements in this system, so that any defects that require urgent attention at a specific location can be addressed.

87 Restrictions can also be put on the movements of trains, if certain faults are identified. An example of this would be to 'box in' one end of a unit, by coupling it up to another unit and running it as a longer train. This could be done if a defect on one end of a unit, such as low sand, was present. This would allow the unit to remain in service, as part of a longer train, in a way that meant that the defect did not affect the operation of the whole train. Such restrictions have to be manually input to Genius.

Rail head treatment

88 During the leaf fall season the line through Stonegate was subject to routine rail head treatment to mitigate foreseeable low adhesion conditions. This consisted of a RHTT water jetting the rail head on the entire route, and applying a friction improving substance at selected high risk sites. Such sites are identified using a risk assessment approach as detailed in Network Rail company standard NR/L3/OCS/096 'Low Rail Adhesion Sites – Risk Assessment Process'.

89 Water jetting is intended to remove any contamination from the rail head that could produce low adhesion conditions. Three parallel water jets spray water at the surface of each running rail at high pressure, to clean the rail surface. Up to 2007, the water jetting pressure was 1000 bar, but this was increased to 1500 bar for the 2008 leaf fall season. The increase in water jetting pressure was in preparation for an increase in the speed of rail treatment from 40 mph to 60 mph (64 km/h to 96 km/h).

90 Up to the 2009 leaf fall season, the friction improving substance applied to the route had been *Sandite*. This consisted of particles (primarily sand) suspended in a clay-based fluid. This was sprayed at the rail head from the RHTT as it travelled along the route, at a rate proportional to the train speed. An operator controlled at which locations Sandite was applied. Because the effectiveness of spraying Sandite diminished as the speed was increased, it could only be applied by the RHTT at speeds of up to 40 mph (64 km/h).

91 For the 2010 leaf fall season, Network Rail replaced Sandite with a new substance, known as Track Grip 60. This consists of very similar particles to those contained in Sandite (primarily sand), but suspended in a more viscous gel-like material. This is applied to the rail head by the RHTT and smeared onto the rail surface. This method of application means that the RHTT can travel faster, at speeds of up to 60 mph (96 km/h), with the same quantity of friction-improving particles being deposited on the rail head.

92 Between 2008 and 2010, Network Rail carried out a series of trials in Lincolnshire, East Anglia and Lancashire to assess the effectiveness of Track Grip 60, when applied at 60 mph (96 km/h). These tests showed that train braking performance on contaminated rails water jetted at 1500 bar and treated with Track Grip 60 at 60 mph (96 km/h) was comparable to that on rails water jetted at 1000 bar and treated with Sandite at 40 mph (64 km/h).

93 An important reason for increasing the maximum speed at which rail treatment could be carried out was minimisation of the disruption to service trains. On busy lines, running the RHTT at 40 mph (64 km/h) meant that service delays could be incurred. Running at up to 60 mph (96 km/h) meant that the RHTT could operate between scheduled services, with fewer consequential delays. This in turn allowed more flexibility in when, and how often, the RHTT could be operated.

94 During the 2009 leaf fall season, the route through Stonegate was being treated with both water jetting at 1500 bar and Sandite, twice a day at a maximum speed of 40 mph (64 km/h). One treatment was applied in the late evening, and another in the morning. Exact times varied depending on the day of the week.

95 For the 2010 leaf fall season, the route through Stonegate was again treated twice a day, once in the late evening, and again in the morning. However, the treatment was carried out at a maximum speed of 60 mph (96 km/h), with Track Grip 60 and water jetting at 1500 bar.

96 The change from Sandite to Track Grip 60, and the increase in water jetting pressure from 1000 bar to 1500 bar, was implemented to provide equivalent effectiveness as the RHTT speed was increased. However, the water pressure increase had been implemented in 2008, but the RHTT speed was not increased until 2010. This meant that there was potentially an improvement in the water jetting performance in 2008 and 2009, followed by a potential reduction in performance in 2010 back to around the 2007 levels. However, this is not considered to be significant to the incident because the rail head would have become freshly contaminated in the ten hours of high leaf fall between the passage of the RHTT and the incident train.

97 For the 2011 leaf fall season, Network Rail returned to the use of Sandite, spread at 40 mph (64 km/h) (paragraph 231).

Identification of the immediate cause[5]

98 The immediate cause of the incident was that the train did not decelerate at the desired rate on application of the brakes approaching Stonegate station.

99 The driver initially applied the brakes in step two, 1400 metres before Stonegate station. In good adhesion conditions, allowing for the downhill gradient, brake step two should have been able to stop the train from 64 mph (103 km/h) within 800 metres[6].

[5] The condition, event or behaviour that directly resulted in the occurrence.

[6] Calculations show that brake step 2 retardation (6 %g), on a downhill gradient of 1 in 132, gives a stopping distance of approximately 765 metres from 64 mph (103 km/h).

100 The driver's use of brake step two, and subsequent increases to step three and emergency, were in accordance with Southeastern's driving policy for low adhesion conditions.

101 Analysis of data from the OTDR shows that the train did not decelerate at the rates that would have been expected for the brake steps that were applied.

102 Table 1 shows the *brake retardation* rates (allowing for the gradient) achieved in each of the brake steps applied during the incident.

103 When brake step two was applied, the average braking retardation rate achieved was 1.7 %g, instead of 6 %g as would be expected in dry conditions with no rail head contamination. This reduced to 1.3 %g as the brake step applied was increased to emergency.

104 Over the 2.4 miles (3.86 km) of line, from where the brakes were applied to the end of the Track Grip 60 treated area, the average braking retardation rate was 1.5 %g. Calculations show that a braking retardation rate of 3.4 %g would have been required for the train to have stopped in the station at Stonegate, with no overrun. This corresponds to an improvement in rail adhesion of 1.9 %g, compared to the 3 %g improvement that sand can normally be expected to provide (paragraph 59). It is possible that the extremely low adhesion conditions on the day of the incident made the expected 3 %g improvement unachievable, and therefore it is possible that the train would still have overrun Stonegate station if sand had been deposited. However, even a small increase in adhesion, due to the use of sand, would have considerably reduced the length of overrun.

Brake step	**Designed Retardation**	**Achieved Retardation**
1	3 %g	Not Used
2	6 %g	1.7 %g
3	9 %g	1.7 %g
Emergency	12 %g	1.3 %g
Note 1: Brake retardation rates are quoted in percentage of g, where g is the rate of downwards acceleration experienced by an object due to gravity (9.81 ms^{-2}). Hence 1 %g is equivalent to a braking retardation rate of 0.0981 ms^{-2}.		
Note 2: The brake retardations stated above take account of the line gradient. The retardation will be greater than the deceleration rate of the train when it is on a downhill gradient, and less when it is on an uphill gradient. Removing the effect of the gradient from the train deceleration rate allows the effectiveness of the train braking to be assessed more accurately.		

Table 1: Brake retardation rates during the incident

Identification of causal[7] factors and contributory factors[8]

Rail head conditions

105 **Very low adhesion conditions were present at Stonegate on 8 November 2010. This was a causal factor.**

106 On receipt of the low adhesion report from the signaller at Robertsbridge (paragraph 41), the Network Rail controller at the Kent Integrated Control Centre sent a MOM to Stonegate to investigate rail head conditions. By the time he arrived at site, at around 09:20 hrs, the RHTT had passed through and water jetted the down line and applied Track Grip 60. This meant that it was not possible for the MOM to confirm the rail head conditions at the time of the incident.

107 Analysis of the train's OTDR data shows that the train experienced WSP system activity throughout the morning of the incident. This was consistent with the absence of wheel flats on the train (paragraph 52).

108 Witness evidence indicates that the drivers of the incident train and the train that preceded it experienced low adhesion conditions at a number of locations on the journey from Tonbridge to Stonegate. In particular, the preceding train overran its stopping point at Stonegate station by approximately 2.5 metres, due to adhesion problems on braking, but did not overrun the end of the platform.

109 Network Rail's weather data for autumn 2010 shows that leaf fall was particularly heavy in the first half of November, whereas that in October had been unusually low. This was reflected in a much lower than normal rate of overruns in October, both nationally and in Kent/Sussex, followed by a much higher rate in early November.

110 Network Rail categorised 8 November as a 'black' day (paragraph 30), and this was communicated to drivers based at Tonbridge depot, including the driver of the incident train, when they booked on. This was to make them aware of the likely adhesion conditions on that day. Witness evidence indicates that drivers were not clear about what, if any, actions this required, but generally understood that it meant that adhesion conditions were expected to be very poor.

111 **The effect of the rail head treatment applied to the line at Stonegate on 7 November 2010 had largely dissipated by the morning of 8 November. Although this was a normal event, it was a causal factor in the incident.**

112 Stonegate was a known low adhesion site, and Network Rail had specified both the up and the down lines as 'drop sites' for the RHTT. A 'drop site' is a location where a friction modifier substance (Track Grip 60) is applied to the rail head by the RHTT to improve the adhesion levels available to trains.

113 Records indicate that the rail head on the down line through Stonegate was treated by the RHTT at 22:08 hrs on 7 November. The section of line between 41 miles 12 chains and 45 miles 40 chains was recorded as having Track Grip 60 applied. This extends from 2.7 miles (4.3 km) on the approach to Stonegate station to 1.7 miles (2.7 km) beyond, and is marked in green in figure 3.

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[7] Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

[8] Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

114 Approximately 10 hours elapsed between the application of Track Grip 60 to the line at Stonegate and the passage of the incident train. During this time five passenger trains and one freight train had passed through Stonegate on the down line, amounting to over 150 axles. A report published in 2007, on behalf of Network Rail, indicates that the expected lifespan of a friction modifying rail treatment is less than 200 axle passes in the absence of other factors.

115 Weather records show that conditions were windy overnight, gusting to over 30 mph in the early morning, on what was forecast, by Network Rail, to be a high leaf fall day. This would have resulted in fresh leaf fall in the area, re-contaminating the rail head. Witness evidence also indicates that it started to rain lightly as the incident train travelled from Tonbridge to Stonegate. These factors would have compromised the rail treatment applied the previous evening, contributing to low adhesion conditions.

116 However, figure 3 shows that the deceleration rate of the train remained generally constant on the falling gradient, while the train was on the section that had been treated with Track Grip 60 the previous evening. It also shows that the deceleration rate appeared to reduce when entering the section of line that had not had the Track Grip 60 applied, even though the gradient did not change significantly. RAIB calculations show that the adhesion levels on the treated section of line were approximately 0.5 %g better than on the untreated section.

117 The time delay between treatment of the rail head and passage of the incident train was a factor that resulted in low adhesion conditions on the morning of 8 November 2010, but this is not considered to be an unusual event. Scheduling the RHTT shortly before the first service of the day could have reduced the risk of low adhesion conditions for this train. However, this would not be practicable to achieve for all lines, given the total route mileage in Kent and Sussex that has to be treated.

118 The National Task Force, acting on behalf of train operating companies, published a “Review of autumn 2010 performance” in March 2011. This commented on a reduction in the effectiveness in treatment at problem sites when carried out at 60 mph (96 km/h) and a reduction in delivered network coverage due to lower reliability of RHTT planning and operation. The perceived reduction in treatment effectiveness is probably due to the delay between implementation of the increased water jetting pressure and the increase in treatment speed (paragraph 96). No evidence has been seen to suggest that the use of Track Grip 60 instead of Sandite had a negative effect in 2010. As a result, the review recommended that Kent and Sussex RHTT planning be reviewed to improve reliability, and that treatment at selected sites is reduced in speed to 40 mph (64 km/h).

119 The review also commented on lineside vegetation management. It acknowledged that nationally there was significant non-compliance with Network Rail standard NR/L2/TRK/5201 (Management of lineside vegetation), largely due to financial constraints. The only associated recommendation was to ensure that a three year rolling budget for vegetation management is developed.

120 In order to assess the state of lineside vegetation, Network Rail undertook video surveys of routes in Kent and Sussex, in May/June 2010, including the line through Stonegate. Through analysis of this video, Network Rail allocated compliance scores to 20 chain (402 m) lengths of the line, in accordance with the above standard. The score for each length of the lineside was based on the areas within it where the vegetation required most urgent attention.

121 The linesides between 43 miles 20 chains and 43 miles 40 chains and also between 44 miles 40 chains and 44 miles 60 chains, were deemed to require some clearance work within one year, with most of the rest of the route requiring attention within two to five years. This survey prompted targeted vegetation clearance work for the worst vegetation at both locations. The work at the latter location was completed by 11 October 2010, and that at the former by 16 November 2010. Both of these were within the accepted timescale of 1 year for the identified risk categories. Additional clearance of vegetation took place on other selected areas of the lineside between Stonegate and Etchingham stations between May and December 2010.

Condition of the sand hoppers on the incident train

122 **The train did not deposit sand when demanded because the leading sand hoppers were almost certainly empty. This is an explanation for the length of the overrun and was a causal factor.**

123 When unit 375711 was examined by Southeastern on the night of 8/9 November, after the incident, one of the sand hoppers on the 'A' end was found to be empty (the other could not be checked, but is likely to have been empty as well). Analysis of the OTDR data enabled the RAIB to estimate that the unit's sand had run out by approximately 18:00 hrs on 5 November. It is therefore almost certain that the sand hoppers had been empty on the morning of 8 November.

124 The sequence of events that resulted in the sand hoppers being almost certainly empty on the morning of the incident is described in paragraphs 125 to 145 below.

Thursday 4 November 2010

125 At approximately 11:00 hrs, unit 375711 had its sand hoppers at both ends refilled, while stabled at Victoria Grosvenor carriage shed, in London. The unit then entered service, finishing the day at Tonbridge sidings around midnight.

Friday 5 November 2010

126 The day was forecast by Network Rail to have an Adhesion Index of 6, corresponding to a 'red' day. This means that the expected adhesion levels were 'poor'. Weather records show that the average wind speed in Kent/Sussex on that day was around 11 mph (18 km/h), with gusts up to 30 mph (48 km/h).

127 Unit 375711 entered service from Tonbridge sidings at approximately 04:30 hrs, and made three round trips between Ramsgate and London, running a total of 696 miles (1120 km) before stabling at Rochester. The 'A' end cab of unit 375711 was leading on all journeys towards Ramsgate, with the exception of part of the last trip, when the unit was coupled behind another class 375 unit as far as Ashford International.

128 The sanding system is designed to deposit sand into the wheel/rail interface when there is WSP activity combined with a brake application of step two and above. The RAIB analysed the train's OTDR data to identify periods when these conditions were met, indicating when sand would be deposited. The OTDR data shows that during the morning and afternoon, the unit experienced repeated WSP activity while braking in step two, resulting in considerable sand usage. The RAIB estimates that more than 60% of the unit's sand capacity at the 'A' end had been used between entering service and 12:00 hrs.

129 At 06:36 hrs, unit 375711, with the 'A' end cab leading, while operating the 04:51 hrs service from Tonbridge to Ramsgate, overran the station platform at Sandwich by about a coach length. The driver reported this overrun to the signaller at Sandwich, and indicated that the cause was low adhesion conditions on the rail head. The train would have had sand available at this time, and the driver had used brake step two and above in accordance with the driving policy.

130 At 11:59 hrs, the internal monitoring system on the train recorded an event code 567 (accumulated sanding time > 10 min) for the 'A' end cab. This event code is raised when the train recognises that the sanding system has been used for a total of 10 minutes since it was last filled. Because the total sanding time available is approximately 15 minutes, this code records when the sand is running low. This event code is not made visible to drivers, so they are not made aware that the sand hopper level is running low. However, the event code is uploaded to a central computer, as part of a daily train status request, and is used for planning maintenance. This low sand event code was raised despite the sand hoppers having been filled on the previous day, and confirms that there was high sand usage on 5 November.

131 Event records from other trains show that an unusually high number of units raised event code 567 on 5 November. Ten class 375 units logged 'low sand' events on that day (approximately 9% of the fleet), compared to a total of only seven over the previous three days combined. This indicates that high sand usage was not confined to unit 375711 on that day.

132 The train does not raise an event code to indicate when all the sand has been used. However, subsequent analysis of the OTDR data for 5 November shows that the train experienced WSP activity, during braking, through the entire day. This gives an indication of the periods during which sand was being demanded.

133 At 22:14 hrs, the unit uploaded its event data to the Southeastern central computer by radio. All units are interrogated in a sequence, every day between 17:00 hrs and the early hours of the next morning, but on a typical night only approximately 75% of them successfully upload the data. The upload included event code 567, indicating that the sand level had been flagged as low at 11:59 hrs that day.

134 At 23:50 hrs, the unit, with the 'A' end cab leading, was braking from 68 mph (109 km/h) towards a 20 mph (32 km/h) speed restriction at Minster South Junction, from the Dover direction. During this brake application, the train experienced 1400 metres (0.89 miles) of WSP activity. This required the driver to apply the emergency brake step at approximately 45 mph (72 km/h), taking 540 metres to stop. Calculations show that there is a high probability that there was no sand left in the sand hoppers at this time (paragraph 184), and the long distance the train took to stop with the emergency brake applied appears to confirm this. The driver reported this to the Minster signaller, who forwarded the report to Kent Integrated Control Centre as a low adhesion incident, because no station overrun or *signal passed at danger* incident had occurred.

135 The unit then stabled overnight at Rochester, where there were no facilities for refilling sand hoppers. On that night, due to planned engineering works connected with a resignalling project, trains were unable to reach Ramsgate depot, where this unit would have normally stabled. The train was not rerouted to stable at a location where sand could be replenished, because its low sand condition, although now stored on the Southeastern central computer, had not yet been identified by staff.

Saturday 6 November 2010

136 The sanding critical event review (paragraph 74) is intended to identify units that have indicated low sand hopper levels, so that arrangements can be made to have them refilled. This process was intended to be carried out three times daily – once during the day shift, and twice during the night shift. The first night shift review at 20:00 hrs identified low sand events on units that had uploaded data between 17:00 hrs and 20:00 hrs. The second review at 02:00 hrs identified low sand events on the units that uploaded data after 20:00 hrs. The third review, on the day shift, was intended to identify any low sand events on units that had uploaded data outside the normal sequence (data can fail to be uploaded due to radio communications problems, but can be manually requested later). This process was not carried out at the scheduled time of 02:00 hrs on 6 November because the night shift technical service engineer post had not been covered during staff leave.

137 At 07:45 hrs the unit entered service from Rochester, almost certainly with no sand in the 'A' end hoppers. No significant WSP activity was experienced on that day, indicating that adhesion levels were better than had been experienced on 5 November. Weather records show that the average wind speed in Kent/Sussex on that day was around 5 mph (8 km/h), which was much lower than on 5 November.

138 At 13:34 hrs, the sanding critical event review was carried out by the day shift technical services engineer. This identified that unit 375711 had raised event code 567 for the 'A' end, signifying low sand. The technical service engineer raised a work report, using the EMS, for action by the end of that day (6 November).

139 The technical services engineer identified that the unit was to end service at Gillingham. At the time of the incident, the fleet delivery engineer was responsible for work at Gillingham, so the requirement to refill the sand hoppers on the unit that night should have been communicated directly to him.

140 It has not been possible to determine whether the technical services engineer telephoned the fleet delivery engineer, or the fleet planning engineer, to advise them of the required work. However, the day shift fleet delivery engineer was informed of the sand replenishment work report for 375711, and he added it to the list of work identified for action on 'Line of Route' at Gillingham that night.

141 At approximately 00:30 hrs on Sunday 7 November the unit stabled at Gillingham sidings.

Sunday 7 November 2010

142 Overnight at Gillingham, maintenance personnel did not enter any job card into the EMS for the sand replenishment work on unit 375711. It has not been possible to determine why no job card was raised. As a result, the sand replenishment was not carried out. The absence of this from the list of work done at the depot that night was not identified by the fleet delivery engineer. As a result, the work report was left open and no action was taken to prevent the train from returning into service.

143 At 08:04 hrs, the unit entered service, with the 'A' end sand hoppers still reported as low, and almost certainly empty, and the associated work report incomplete.

144 The unit ran in service for the rest of the day. Again, no significant WSP activity was experienced on that day, indicating that adhesion levels were better than those experienced on 5 November. Weather records show that the average wind speed in Kent/Sussex on that day was around 5 mph (8 km/h), which was again less severe than on 5 November.

145 At approximately 00:15 hrs, on 8 November 2010, unit 375711 stabled overnight at Dover Priory sidings, where there were no facilities to refill sand hoppers. The event code 567 (accumulated sanding time > 10 min) was not uploaded by the train that day, because it is only recorded once, when the sand timer passes the low threshold, and it does not give a continuous indication of the sand hopper level.

Maintenance processes

146 **The maintenance processes involved in the replenishment of sand did not ensure that the sand hoppers were refilled, despite there being information that the sand was low. This was a causal factor.**

147 Although the sanding critical event review process required the technical service engineer to examine the train data three times every day, the two examinations scheduled during the night shift were not carried out on 5/6 November 2010 (paragraph 136). If the sanding critical event review that was scheduled for 02:00 hrs had taken place, the work report raised at that time would still have been for action by the end of that day (6 November) because the unit was berthed at Rochester where it was not possible to replenish the sand hoppers the same night.

148 The day-shift sanding critical event process check was carried out as intended on 6 November and identified the unit as requiring attention that night. The failure to complete the night shift checks did not therefore affect the time at which the sand replenishment would have been carried out (paragraph 138). It is possible that the unit could have been rerouted to a location where the sand hoppers could be filled during the day but sand filling was categorised as an 'end of day' activity, which did not require this response.

149 The sanding critical event process required the technical service engineer to inform the fleet delivery engineer of any units that required their sand hoppers filled. The fleet delivery engineer should then allocate the task to either himself, for 'line of route' or to the fleet planning engineer for action at the depot. Witness evidence indicates that the technical service engineer, believing that the unit was to be stabled at a depot, directly contacted the fleet planning engineer to advise him of the work report that he had raised. Because the unit was scheduled to berth at Gillingham, this was not within the responsibility of the fleet planning engineer. However, witness evidence also shows that the day shift fleet delivery engineer was aware of the work report, and correctly identified that the unit was to stable at Gillingham, which was within his responsibility ('line of route'). The day shift fleet delivery engineer added the work report to the 'plan of work' for the night of 6 November, allocated for action at Gillingham.

150 The night shift fleet delivery engineer took over at 19:00 hrs on 6 November. At 21:30 hrs he chaired the daily conference call between the fleet delivery engineer, fleet planning engineer and depot staff to discuss that night's 'plan of work'. This was intended to highlight work due to be carried out on rolling stock that night and make any changes to priorities. The refilling of the sand hoppers on 375711 at Gillingham was included on the discussed plan of work. After the conference call, a copy of the plan of work should have been sent to Gillingham and a telephone call made to confirm the content. Staff at Gillingham should then have raised a job card for the sand hopper replenishment and completed the work. No job card was raised at Gillingham and hence the work was not carried out. It has not been possible to determine why a job card was not raised for the sand to be replenished. Because other work from the fleet delivery engineer's plan of work was carried out at Gillingham that night, it suggests that the plan of work had been communicated to Gillingham.

151 The EMS does not automatically highlight work reports that have not been completed at the end of a shift. Witness evidence identified that it was normal practice for the fleet delivery engineers to search for job cards raised to address work that had been scheduled to take place that night at outstations, such as Gillingham. This allowed them to identify if the work associated with those job cards had been completed so that they could mark the job card as complete in the EMS, which then automatically completed the work report. Because no job card had been raised on the night of 6 November, the fleet delivery engineer's search did not identify that the work had not been completed.

152 Witness evidence indicates that the fleet delivery engineer did not check that a job card had been raised for each of the planned work reports, but instead normally relied on staff at the work location to advise him if a job card was not raised. The fleet delivery engineer was not advised by Gillingham that a job card for the sand replenishment had not been raised, and therefore the sand hoppers had not been refilled. As a result, the fleet delivery engineer did not take steps to prevent 375711 from entering service. At the end of the night shift, the fleet delivery engineer compiled a list of work carried out on 'line of route' that night, but this did not include any work on unit 375711. The work report remained open until 12 November, after the unit had been removed from service for investigation.

153 The missed work activity at Gillingham on the night of 6 November meant that the train was allowed to return to service without the 'A' end sand hoppers being refilled. There was no automatic interaction between the work reports raised on the EMS and the control of train movements through Genius to ensure that trains with incomplete work reports did not enter service. These two IT systems were not connected together, making any automatic link between them technically difficult to achieve. However, it was possible for this interaction to happen through discussions between the fleet delivery engineer/fleet planning engineer and the stock maintenance controller, and manual intervention in Genius. Witness evidence suggests that this was rarely, if ever, done for sand replenishment work reports, because sand replenishment was not appreciated as being a safety critical activity, and there was no procedure requiring this to be done.

154 Because the fleet delivery engineers primarily searched for work reports and job cards scheduled for the current day, it meant that any searches on subsequent days would not identify uncompleted work that that been scheduled for previous days.

155 Examination of train data for the period from 1 November to 11 November 2010 showed 13 class 375 cabs that recorded a low sand event followed by a delay of more than three days before the sand timer was reset (when the sand hoppers were refilled). It is acknowledged that this does not mean that all, or any, of these units entered service with no sand. However, it does suggest that the processes that were in place to ensure that trains with low levels of sand were refilled within the intended timescales were not fully effective.

156 To summarise, there were a number of deficiencies in the operation of the maintenance processes:

- the night shift sanding critical event reviews were not carried out as planned due to technical service engineer annual leave not being covered;
- no job card was raised at Gillingham for the safety critical work scheduled to be completed on 6 November;
- the fleet delivery engineer did not identify that the sand replenishment had not taken place;
- the EMS highlighted the non-completion of safety critical maintenance activities, but sand replenishment was not included among these;
- the EMS did not automatically place restrictions on the train (in Genius) to prevent it from entering service with an incomplete, safety critical work report; and
- recognition of work activities scheduled at different locations was reliant on verbal communications between the fleet delivery engineer, fleet planning engineer and depot and outstation personnel.

Driver awareness of low sand condition

157 **The driver had no information about the availability of sand, and so was unable to take action to mitigate the lack of it. This was a causal factor.**

158 The first batch of class 375 units were ordered from Adtranz (later to become Bombardier Transportation) in 1997. The complete fleet entered public service between 2001 and 2005. Event code 567 was added to the train configuration by the manufacturer in 2001. This was part of a change request to incorporate controls for manual sanding, that was raised by Connex, which was the train operating company at that time. This change added a timer, which flagged up when 15 minutes of sand had been used (equivalent to 30 kg sand use, out of 45 kg maximum, at 2 kg/minute sanding rate). This timer raised an error code that was visible, on request, to the driver on a cab display. When the sand flow rate was increased to 3 kg/minute (paragraph 63) the timer was adjusted to raise event code 567 when 10 minutes of sand had been used.

159 In April 2002, following a modification to the original change request, event code 567 was changed so that it was only visible to maintenance personnel, and not to the driver. This clarified the original change request, which did not explicitly state that the code was not intended to be accessible by the driver. This change was implemented on subsequent trains from new, and on earlier ones after entering service.

160 The daily upload of event codes from the train to the central computer means there is a potential delay of up to 24 hours between the low sand event occurring and the first possibility of anyone becoming aware that the sand on the train was running low. Additional delays occur between the event code being received on the central computer and the low sand condition being identified by maintenance personnel, as well as between identification of the condition and refilling of the sand hoppers.

161 This means that since the driver is provided with no indication that the sand level is low, the only visibility anyone has of a shortage of sand on a unit is on interrogation of the data uploaded to the central computer each night, which is subject to a time delay.

162 Additionally, no event code is raised when the sand runs out, meaning that this information is not recorded or made visible to anyone. As a result no action can be taken in response to this.

163 Rule 28.1 in module TW5 of the Rule Book (Railway Group Standard GE/RT8000/TW5 'Preparation and movement of trains - defective or isolated vehicles and on-train equipment') states (in respect of drivers and train preparers):

> **You must not allow a traction unit to enter service if:**
> **• the sanding equipment is defective**
> **• there is no sand in the sand box.**

164 In common with most UK trains, there is no equipment on the class 375 units to provide the driver or train preparer with any indication of sand level. As a result, the driver or train preparer is unable to confirm that they are complying with this rule, without physically checking the sand hoppers. Southeastern does not require train preparers or drivers to carry out any checks of the sand hoppers as part of train preparation before trains enter service.

165 Southeastern has interpreted this rule as meaning that the train cannot enter service if it is known that the sand hoppers are empty, and that the rule does not mandate that the sand hoppers are checked before entering service. In addition, because checking the sand hoppers requires access from ground level, Southeastern does not consider such a check to be practical for trains entering service from berthing locations that have walkways or conductor rail adjacent to trains. As a result Southeastern relies on maintenance processes to ensure that trains do not enter service with no sand.

166 Witness evidence indicates that drivers understand that they have no indication of the sand level on the class 375 units. It also indicates that if drivers did have information that sand levels were either low or empty, they are aware that the train braking characteristics, in low adhesion conditions, could be compromised. However, the Southeastern driving policy requires the initial use of brake step two at all times during the leaf fall season, and takes no account of the possibility of low or empty sand hoppers on the train.

167 If drivers were provided with sand level information, it would provide the opportunity for mitigation measures to be put in place without the delays present in the current system. A possible mitigation measure could be the removal of the train from service immediately, or at a suitable opportunity.

Driving policy

168 **The driving policy required the driver to initially apply brake step two, rather than step one, in order to deposit sand, and thus to improve adhesion. This was a possible contributory factor.**

169 In low adhesion conditions, the Southeastern driving policy requires:

- frequent *running brake tests* to assess the rail head condition;
- earlier braking;
- use of step two as the initial application;
- use of step three, or emergency brake, if WSP activity occurs and the train will not meet the correct stopping point; and
- use of step two, and the release of brakes, if no WSP activity occurs, to achieve the stopping point.

170 The driver of the train used brake step two initially, on the approach to Stonegate station, in accordance with the policy. When it was clear that the train was not decelerating as intended, and that WSP activity was present, the driver increased the brake application to step three and then to emergency, again in accordance with the policy.

171 The driving policy specifies the use of brake step two in low adhesion conditions, because this is the first step at which sand is applied to the wheel/rail interface to improve adhesion. Previous industry testing has shown that the application of sand significantly improves adhesion, when low adhesion conditions are present (paragraphs 56 and 57).

172 Witness evidence, and Southeastern reviews of OTDR data, confirmed that, in general, drivers understood and complied with the requirement to use brake step two in low adhesion conditions. They also understood that non-compliance with the policy was monitored by Southeastern through random, and targeted, analysis of OTDR data.

173 This driving policy was introduced in 2006. This was in response to an Adhesion Working Group (AWG) review of low adhesion incident performance during autumn 2005 (AWG report of 28 April 2006). It also pre-empted recommendations made by the RAIB following investigations into a series of low adhesion incidents in 2005 (See RAIB Report 25/2006 Parts 1 to 3). Prior to this, the policy had required the use of earlier and lighter initial braking (step one) in low adhesion conditions.

174 The OTDR data showed that, during the incident at Stonegate, the rate of brake retardation achieved reduced from 1.7 %g to 1.3 %g as the brake step was increased from two to emergency (see figure 4). This drop in retardation was similar to that seen in the low adhesion testing carried out by Southern Railway in April 2011. This showed a reduction in brake retardation from approximately 7 %g to 6 %g, in low adhesion conditions with no sand, as the brake was increased from step two to emergency. This reduction in retardation as braking is increased could be explained by the WSP system having to work harder to release the brakes more often to match the higher train braking to the low available rail adhesion.

175 Immediately following the incident, the driver reverted to the older 'lighter and earlier' driving policy. Using this technique, he was able to stop correctly at Etchingham, Robertsbridge and Battle stations whilst experiencing some WSP activity. However, the approaches to these three stations are on uphill gradients, which would have assisted braking.

176 At Crowhurst, the driver, after making an initial brake application in step one, reverted to the current driving policy, because he was concerned that the OTDR data would be analysed and his non-compliance identified. Here, the train experienced significant WSP activity, and the driver had to use the emergency brake to stop correctly in the platform. The OTDR data from the stop at Crowhurst shows that the average brake retardation achieved in brake step one was 3.0 %g, reducing to 1.9 %g in both steps two and three (all with almost certainly no sand). The retardation rate in emergency increased to 4.2 %g after the speed had fallen to below 20 mph (32 km/h).

177 At West St Leonards the driver again had to use the emergency brake to stop the train in the platform, due to low adhesion. Both Crowhurst and West St Leonards are approached on a downhill gradient.

178 The data from the incident shows that when no sand is available the use of brake step two and above can reduce the achievable train deceleration when compared to the use of brake step one, in the type of low adhesion conditions experienced at Stonegate. When the adhesion conditions improve, the deceleration achieved in higher brake steps will be better than that achievable in step one.

179 This demonstrates that the availability of train sand, during low adhesion conditions, is necessary for the Southeastern driving policy to be fully effective.

Identification of underlying factors[9]

180 **The sand replenishment process was not responsive enough to deal with potential rates of sand usage. This was an underlying factor.**

181 The combination of sand application in brake step two (paragraph 61), the increased permitted sanding time (paragraph 62), and the higher sand flow rate (paragraph 63) all had the effect of increasing the sand usage of the class 375 units. This in turn reduced the time that a full hopper of sand would last before requiring refilling, particularly in low adhesion conditions.

182 The train maintenance data from unit 375711 indicates that the sand hoppers at both ends were filled at approximately 10:55 hrs on 4 November. This also shows that the low sand event code for the 'A' end was initiated at 11:59 hrs on 5 November.

183 The on-train data shows that unit 375711 experienced very little WSP activity on 4 November, so very little sand would have been used on that date. The data also shows that there was considerable WSP activity, on 5 November, and this would have triggered sand usage. This strongly indicates that the train had used most of its sand in the 7½ hours between entering service at 04:30 hrs and the low sand event (code 567) being recorded at 11:59 hrs on 5 November.

184 Further analysis of the data estimated that the rest of the train's sand would have been used up by approximately 18:00 hrs on 5 November. This demonstrates that a class 375 unit is capable of using up all of its sand within 13½ hours, in severe low adhesion conditions.

185 The Class 375 units are requested to upload their on-board event data, by radio, to a central maintenance computer once every 24 hours. Any events on the train that are not alerted to the driver are thus subject to a delay of up to 24 hours before they are available to be identified by maintenance personnel.

186 The sanding critical event process was intended to identify train low sand events from the previous 24 hours, on the central computer, that had not been manually reset by maintenance staff as part of sand hopper refilling. This process was scheduled to take place twice during the night shift, and once during the day shift. When a low sand event was identified, a work report would be input to the EMS for action by the end of the same day.

187 This means that, in the worst case, a low sand event identified during the night shift would be scheduled for action on the following night shift. This means there was another possible delay, of up to 24 hours, in filling the sand hoppers.

188 If the processes had operated as intended, the sequence of events would have been:

- 5 November 11:58 hrs – unit records low sand event.
- 5 November 18:00 hrs (approximately) – unit almost certainly runs out of sand.
- 5 November 22:14 hrs – unit uploads low sand event to central computer.
- 6 November 02:00 hrs – sanding critical event process identifies low sand and a work report is opened.
- 6/7 November overnight – sand hoppers refilled.

[9] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

189 The sanding critical event process was not carried out until the afternoon of 6 November (paragraph 136), but this would not have delayed the intended replenishment that night. However, the replenishment on the night of 6 November was not carried out, and the train was returned to service without the hoppers at the 'A' end being refilled (paragraphs 142 and 143).

190 This shows that if the processes had operated as designed, there could have been a period of over 30 hours with the train in service, no sand in the hoppers, and no restriction in place on its movements.

191 Risk assessments had been carried out by Southeastern in Autumn 2006, in conjunction with the modifications to increase the sand timer and the sand flow rate (paragraphs 62 and 63). These recognised the potential for increased sand usage, and advised that the adequacy of the processes for replenishing sand hopper levels be monitored to see if more frequent filling was required. The sanding critical event process was introduced in 2007, as a result of the risk assessments, when a new system for uploading and recording the train event code data was commissioned. This provided the data required to identify trains with low sand, and to reactively action refilling of the sand hoppers.

192 An additional factor that affected the responsiveness of the sanding replenishment regime was the limited availability of locations at which train sand hoppers could be filled. There were defined places within specific depot/stabling locations at which sand could be refilled, so stabling needed to be carefully planned so that trains were positioned on a line where the hoppers could be refilled when required. Such locations included Gillingham. Platforms or walkways adjacent to lines where trains were stabled could obstruct access meaning that replenishment could not be carried out. Additionally, in wet weather, replenishment could not be done outside, because the sand has to remain completely dry to avoid clogging the sand hoppers, valves and nozzles.

193 Evidence from other TOCs shows a number of different approaches to monitoring sand hopper levels during the leaf fall season. Some TOCs proactively monitor sand as part of daily train preparation for service, replenishing as necessary, while others rely on fixed interval sand filling. Southeastern does not carry out any sand level checks as part of daily train preparation, instead relying on weekly refilling of the sand hoppers (now increased to every five days), supported by train data monitoring and reactively scheduling replenishment.

194 Railway Group Standard GM/RT2461 (Sanding Equipment Fitted to Multiple Units and On-Track Machines) requires "adequate inspection and sand top-up regimes based on known or predicted worst case consumption rates" to be considered so that braking is not impaired by a lack of sand.

195 **The process in place to restrict the movement of trains prior to the completion of safety-related work activities did not operate adequately in respect of sand replenishment during the leaf fall season. This was an underlying factor.**

196 Any changes to, or restrictions on, train movements had to be manually input into Genius (paragraph 87). This could be initiated by the fleet delivery engineer, in conjunction with the stock maintenance controller.

197 When a work report was raised, such as for sand replenishment, it was allocated a priority, such as 'end of day'. This did not automatically ensure that the train was scheduled to end its service at a location where the work could be carried out. This required a positive action from the fleet delivery engineer to ensure that the train was rescheduled to stable at a suitable location.

198 Similarly, the raising of a work report did not automatically place any restriction on future movements of the train. This meant that in the absence of any manual intervention, Genius would allow trains that were scheduled for maintenance work to re-enter service, or to continue in service, if that work was not carried out.

199 The system relied on the fleet delivery engineer monitoring the status of maintenance work as it was carried out, and then implementing any restrictions that were necessary. This relied on the fleet delivery engineer confirming that job cards had been raised as scheduled, and that they had been completed.

200 On the night of 6/7 November, the fleet delivery engineer did not identify that the work activity to replenish the sand hoppers on unit 375711 had not been carried out (paragraph 152). As a result the fleet delivery engineer did not place any restrictions on the return to service of the train.

201 Because there were no automatic restrictions associated with the sand replenishment work scheduled for that night, the train was able to be allocated for service on 7 November as if the work had been completed. This resulted in the train running in service, without replenishment of sand, until the night of 8/9 November, after the incident.

Previous occurrences of a similar character

202 A number of low adhesion incidents take place each leaf fall season. Network Rail statistics for 2009 show that 68 station overruns were recorded across the network during the leaf fall season (74 days) as a result of leaf contamination. The statistics for the same period in 2010 showed that 85 leaf contamination related station overruns were recorded. This reflects the fact that the bulk of leaf fall during the 2010 season was concentrated over a shorter period than normal in early November. Only a small number of low adhesion incidents are investigated by the RAIB.

203 The low adhesion incidents that occurred at Esher and Lewes in November 2005, and resulted in SPADs and narrowly avoided collisions, were investigated by the RAIB. At the same time, the RAIB carried out a review of adhesion related incidents during the Autumn of 2005. These are detailed in RAIB Report 25/2006, which was published in three parts. The relevant recommendations from this report are shown in paragraphs 234 to 239.

204 A low adhesion accident, resulting in a collision between two trains in a platform, occurred on 3 October 2009 at Darlington station. This incident involved a train that did not deposit sand. However, this was because it was a class 142 *diesel multiple unit*, which was not fitted with sanding equipment. This accident was investigated by the RAIB and is detailed in RAIB Bulletin 01/2010.

Observations[10]

Reporting of the incident

205 The driver informed the signaller of the incident while the train was still moving (paragraph 40). When the train stopped, the driver restarted the train after a 20 second pause without contacting the signaller again (paragraph 45) because he was concerned about his schedule. As a result, the signaller had incomplete information about the incident. There was no requirement in module TW1 of the rule book (GE/RT8000 – TW1 Preparation and movement of trains: General) for the driver to contact the signaller for permission to proceed. Section 15.5 states 'When your train has been stopped out of course because of an accident or other exceptional cause, you must not restart until … you have made sure it is safe to do so'. The driver had already informed the signaller of the incident and of the low adhesion conditions, and had been informed that he was running under clear signals.

206 The driver mentioned the incident to a driver manager later in his shift (paragraph 49). No action was taken, as a result of this report, to investigate the circumstances of the overrun.

207 The signaller at Robertsbridge had reported the incident to Kent Integrated Control Centre. When the signaller was asked by the controller how far the overrun had been, he said it had been 200 yards, which the controller recorded as 200 metres. The signaller was aware that the train had still been moving as it passed Crowhurst Bridge AHBC and was also aware that this was over 2000 metres beyond Stonegate station. The RAIB has been unable to identify the reason for the misreporting of the length of the overrun.

208 Had the overrun been accurately reported as being over 400 metres, Southeastern's Engineering Department Standard 111 'Low Adhesion Overrun Testing Requirements' would have required the train to have been removed from service immediately for investigation. This would have had no effect on the overrun at Stonegate, but would have prevented the train from continuing to run in service with almost certainly no sand in the 'A' end hoppers.

Delayed replenishment of the sand hoppers following the incident

209 After the incident, the sand hoppers on the train were not fully replenished before it was withdrawn from service on 11 November 2010. The sequence of events that resulted in this further delay in replenishing the sand hoppers is described below:

Monday 8 November 2010

210 At 09:54 hrs, Southeastern's fleet delivery engineer raised a work report for unit 375711 to be checked by the end of that day at St Leonards West Marina, where the unit was due to berth for the night, in response to the reported overrun of 200 metres (paragraph 205). Because the reported overrun was less than 400 metres, the check required the train OTDR data to be downloaded and a functional check of the brakes and sanders to be carried out.

[10] An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

Tuesday 9 November 2010

211 A job card was raised and the left side sand hopper on the 'A' end of unit 375711 was found to be empty, with that at the 'B' end about one third full. The sand hopper on the 'B' end was not empty because it had seen less sand usage on 5 November due to the 'B' end cab having been coupled to other units for some of the day. However, only the sand hoppers on the left side of the train could be checked and refilled, due to a walkway obstructing access to the right side. The train was not shunted to allow access to the sand hoppers on the other side.

212 In addition, some of the other work report actions, such as the brake and sander tests, could only be carried out at a depot, and so could not be done at St Leonards. This meant that the job card could not be completed. The outstanding work was then deferred, for action at a depot, by the fleet delivery engineer so that the job card could be closed, with the work report remaining incomplete. No changes were made to the diagramming of the unit so that it would end service at a depot where the outstanding work could be completed.

213 At 04:50 hrs, the unit re-entered service with no sand in the right side hopper at the 'A' end. No restriction was placed on the use of the unit as a result of the incomplete work report. However, the affected 'A' end cab was 'boxed in' when the unit went into service. This meant that the 'A' end cab was coupled up to another unit, to form a longer train, and in this configuration, no sand could be deployed by the 'A' end cab sanders. The 'A' end cab was boxed in because of an operational requirement to use the unit as part of a longer train, and not because the work to refill the sand hoppers had not been completed.

214 The unit then berthed overnight at Hastings, but the deferred work report was not highlighted by the fleet delivery engineer as requiring completion. The outstanding work on this work report would not have been able to be completed at Hastings, because the braking system tests can only be carried out at a depot, and so no job cards were raised for any work to be carried out. Still no changes were made to the unit's diagramming to get it back to a depot where the work could be completed.

Wednesday 10 November 2010

215 At 05:54 hrs, unit 375711 re-entered service with the work report still incomplete, and no operational restriction applied. However, the 'A' end cab was still boxed in for operational reasons, and not as a result of the incomplete work report.

216 That night the unit berthed at Ashford sidings and the deferred work report was still not flagged as requiring completion. Again the work could not be done at Ashford sidings, and no steps had been taken to ensure that the unit went to a depot where it could be completed. No job card was raised and the work report remained incomplete.

Thursday 11 November 2010

217 At 06:39 hrs, the unit re-entered service with the work report still incomplete. This time the 'A' end cab was not boxed in, because the unit was required to run as a four-car train. This meant that it was put into service with the 'A' end cab leading for part of the day, while it was known that one sand hopper had not been filled.

218 During the morning, an operational standards specialist at Southeastern analysed the OTDR data from the incident at Stonegate, to determine the braking performance of the train. This analysis is carried out by Southeastern for all station overruns, so that any trends in train and driver performance can be identified. As a result, he recognised that the overrun had been 2.45 miles (3.94 km) and not the 200 metres that had been reported (paragraph 207). He then urgently requested that unit 375711 be removed from service, and initiated an investigation. At this point, the RAIB was informed of the incident by Southeastern.

219 At 15:15 hrs, unit 375711 was berthed at Ramsgate Depot having been taken out of service for investigation. A job card was raised to address the outstanding work report, as well as the additional testing mandated for an over 400 metres station overrun by Southeastern's Engineering Department Standard 111 (paragraph 208). This job card and work report were completed on 22 November 2010.

220 This sequence of events, after the incident, further illustrates the potential for the processes for refilling sand hoppers, when levels become low, to break down.

Summary of conclusions

Immediate cause

221 The train did not decelerate at the desired rate on application of the brakes approaching Stonegate station (**paragraph 98**).

Causal factors

222 The causal factors were:

a. Very low adhesion conditions were present at Stonegate on 8 November 2010 (**paragraph 105**). Network Rail reports that a traction gel applicator has subsequently been installed on the down line, approaching Stonegate station (paragraph 232). No recommendation is made, but the RAIB is writing to Network Rail to reinforce previous recommendations (paragraph 233).

b. The effect of the rail head treatment applied to the line at Stonegate on 7 November 2010 had largely dissipated by the morning of 8 November (**paragraph 111**). Although this was a normal event, it was a causal factor in the incident. No recommendation is made.

c. The train did not deposit sand when demanded because the leading sand hoppers were almost certainly empty (**paragraph 122**). Southeastern has reported that its procedures have been amended to remove trains that require sand replenishment from service (paragraphs 225 and 229).

d. The maintenance processes involved in the replenishment of sand did not ensure that the sand hoppers were refilled, despite there being information that the sand was low (**paragraph 146, Recommendation 1**).

e. The driver had no information about the availability of sand, and so was unable to take action to mitigate the lack of it (**paragraph 157**). Southeastern has reported that its class 375 trains have been modified to provide the driver with an alarm when sand levels become low (paragraph 229).

Contributory factors

223 The possible contributory factor was:

a. the driving policy required the driver to initially apply brake step 2, rather than step 1, in order to deposit sand, and thus to improve adhesion (**paragraph 168**). Southeastern has reported that the driving policy has since been amended (paragraph 228).

Underlying factors

224 The underlying factors were:

a. the sand replenishment process was not responsive enough to deal with potential rates of sand usage (**paragraph 180, Recommendation 3**); and

b. the process in place to restrict the movement of trains prior to the completion of safety-related work activities did not operate adequately in respect of sand replenishment during the leaf fall season (**paragraph 195, Recommendation 2**).

Actions reported as already taken or in progress relevant to this report

225 Following the incident, Southeastern put in place amended sander replenishment processes, for the remainder of 2010, aiming to reduce the opportunities for miscommunication. The sanding critical event process was amended to be initiated by the fleet delivery engineer, instead of the technical support engineer. This avoided the need for the technical service engineer to communicate the results of this stage to the fleet delivery engineer for action. In addition, the processes were amended so that trains that had recorded a low sand event (code 567) were removed from service until the sand hoppers were refilled. Subsequently Southeastern has carried out an organisational change whereby the post of fleet delivery engineer has been withdrawn with the transfer of work to additional depot-based production delivery engineers. These have designated responsibility for dealing with all defect management within specific train fleets, including sand replenishment.

226 Southeastern has amended routine maintenance schedules such that, during the leaf fall season, class 375 units have their sand hoppers refilled every five days, instead of every seven days.

227 Southeastern has reviewed OTDR data from historical station overruns to determine the effects of its driving policy on the retardation achieved in low adhesion conditions. It has also carried out low adhesion testing of the class 375 units to quantify the effect of sand on retardation rates in different brake steps. Another TOC (Southern Railway) has co-operated with Southeastern, and carried out the same tests on similar trains (class 377) at higher speeds. Results from these tests confirmed that the application of sand in low adhesion conditions, when using the 2010 driving policy, greatly improves the effectiveness of the brakes in stopping a train. It also demonstrates that the effectiveness of the driving policy relied on sand being available for use during low adhesion conditions.

228 Southeastern has carried out a risk review of its driving policy, and have revised this so that it no longer requires mandatory use of Step 2 for initial braking during low adhesion. This has been implemented in preparation for the 2011 leaf fall season, and incorporated in briefings to drivers.

229 Southeastern has made changes to the class 375 fleet, so that drivers are alerted to the low sand condition on the in-cab display. Operational instructions have been revised so that this condition is immediately reported and sand replenishment can be scheduled at the end of that day’s service. During the leaf fall season, trains that report low sand are now removed from service at the end of the journey, whereas they are removed from service at the end of the day at other times of the year. In addition, if a train with low sand experiences difficulty in stopping at any time of the year, the train is removed from service at the first suitable station.

230 Southeastern is implementing software changes to the EMS and Genius, so that restrictions on train movement placed in the EMS are automatically communicated to Genius. This project was initiated before the incident at Stonegate.

231 Network Rail has returned to using Sandite applied at 40 mph (64 km/h) for the 2011 leaf fall season in Sussex and Kent. Although Network Rail had no evidence to suggest that Track Grip 60 applied at 60 mph (96 km/h) was less effective, it responded to requests from TOCs, including Southeastern, in the light of the recommendation made by the National Task Force “Review of autumn 2010 performance” (paragraph 118). The effectiveness of water jetting at 1500 bar at 40 mph (64 km/h) (paragraph 96), the need to use the same RHTTs to apply de-icer at 40 mph (64 km/h) during part of the leaf fall season, and possible unreliability issues with operating RHTTs at 60 mph (96 km/h), were factors in making this change.

232 Network Rail has installed a new *traction gel applicator* on the down line approaching Stonegate station, at the request of Southeastern. This equipment applies a friction improving substance onto the rail head, activated by the passage of trains, targeted at improving rail adhesion at that specific location.

233 The RAIB is writing to Network Rail to re-emphasise the role of rail head treatment and vegetation management in the control of rail adhesion levels during the leaf fall season. These controls should be proportionate to the risks arising from low adhesion, and should be such as to mitigate these risks so far as is reasonably practicable. This was covered by a previous recommendation in RAIB Report 25/2006 Part 3 (paragraph 236).

Previous recommendations relevant to this investigation

234 The following recommendations were made by the RAIB in Report 25/2006 Part 3 (Autumn Adhesion Investigation Part 3: Review of adhesion-related incidents, Autumn 2005), published in January 2007. These are not remade so as to avoid duplication:

235 Recommendation 1 (relevant item only)

Train operators to:

- *adjust, as appropriate, rolling stock maintenance activities during the autumn low adhesion period to include enhanced monitoring of sand hoppers to ensure that sand is always available.*

The Office of Rail Regulation received responses from a number of train operators, including Southeastern. Southeastern responded that this recommendation had been implemented. This was subsequently reviewed by the Office of Rail Regulation who accepted that Southeastern had implemented this recommendation.

236 Recommendation 4

Network Rail to develop and implement a risk-based strategy for rail head treatment and vegetation control in consultation with train operators. The strategy should be based on a review of recent data and take particular account of locations such as the approaches to junctions and level crossings where the consequences of an overrun could be severe. At high risk locations such as junctions, level crossings and steep gradients, consideration should be given to one or more of the following solutions:

- *the targeted application of Sandite;*
- *application of Sandite using strategically placed fixed applicators;*
- *temporary restrictions in operational use (eg avoiding the use of a junction);*
- *temporary modification of signalling controls to extend effective overlaps beyond signals;*
- *instructions to selected trains to perform running brake tests in order to assess the state of adhesion;*
- *other effective measures defined by parties involved in managing the risk from low adhesion.*

The Office of Rail Regulation considered this recommendation to be implemented, following the issue of Network Rail Standard NR/PRC/OCS/096 (Low rail adhesion sites – risk assessment process).

237 Recommendation 8

RSSB to extend research and testing into how severe low adhesion conditions occur with particular reference to the phenomenon of micro layers of contamination on rail surfaces, invisible to the eye. The research will seek to establish the nature of the contaminant, how it reaches the rail and bonds with it, the circumstances under which the contaminant poses a particular threat to train braking (eg the factors that exacerbate its impact), the factors that determine how long it endures, possible methods for identifying its presence and methods for preventing its formation and dispersing it.

The Office of Rail Regulation has previously reported that this recommendation was implemented, on the basis that existing and ongoing industry research had examined causes of low adhesion. However, the Office of Rail Regulation has recently advised that the railway industry will be commencing further research in this area in November 2011. The RAIB has not seen any details of the scope of the proposed research, but hopes it will make a significant contribution to addressing the risk identified in this recommendation.

238 Recommendation 15

RSSB to establish a project to:

- *Measure the accuracy of existing WSP simulation rigs that could be used to support rolling stock approvals. This validation should include reference to records obtained from train data recorders following actual incidents and full-scale testing as appropriate. The latter should include a direct comparison between UIC detergent test data and a simulation of the same.*
- *Examine the feasibility of extending the capability of an existing WSP simulation tool in order to predict more accurately the behaviour of an entire train in low adhesion conditions (eg allowing for rail head conditioning, the effect of sanding and more than one vehicle).*

The results from the project should be used to inform the developing Euronorm on WSP equipment testing.

239 Recommendation 16

Subject to the successful development of the simulation tool described in Recommendation 15, RSSB to undertake a programme of modelling to evaluate the impact of different control strategies for minimising stopping distances under various low adhesion conditions. The simulation should specifically address potential alternative strategies for extreme circumstances including:

- *changing WSP control algorithms for the level of slip permitted from the current value of 17-20%;*
- *permitting different levels of slip on wheels on the same train to optimise overall braking during low adhesion conditions.*

All the simulations should be designed to evaluate the effect of different strategies on braking performance and rail head conditioning and should include simulations with sanding operative. The results from the programme should be shared with those responsible for drafting relevant highspeed and conventional TSIs for possible inclusion in new or revised versions of those documents.

The Office of Rail Regulation initially reported that Recommendations 15 and 16 should not be implemented, as they would bring little benefit to the industry. However, it has since reported that some of the objectives of these recommendations will be met by ongoing industry research. The Office of Rail Regulation has undertaken to provide an update on the status of these recommendations that will take into account recent and proposed railway industry research and initiatives in this area.

Recommendations

240 The following recommendations are made[11]:

Recommendations to address causal, contributory, and underlying factors

1 *The purpose of this recommendation is to ensure that safety related maintenance activities are managed effectively.*

London & South Eastern Railway Ltd should carry out a management review to examine why the deficiencies in the processes for replenishment of sand had not been identified and rectified prior to the overrun at Stonegate. The lessons learnt from this review should be implemented by making suitable changes to management systems to provide confidence that such deficiencies will be identified in the future for all safety related maintenance activities (paragraph 222d).

2 *The purpose of this recommendation is to ensure that missed work activities do not affect the safe operation of trains.*

London & South Eastern Railway Ltd should introduce management systems to prevent trains that require safety related maintenance work from re-entering service until that work has been completed (paragraph 224b).

Recommendation to address other matters observed during the investigation

3 *The purpose of this recommendation is to ensure that trains that rely on sand for braking in low adhesion conditions always have that sand available.*

London & South Eastern Railway Ltd should review the arrangements and processes for train sand replenishment, so that they are compatible with known worst case rates of sand usage and take account of any inherent delays in actioning replenishment, and implement any revised arrangements arising from this review (paragraph 224a).

[11] Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's website www.raib.gov.uk.

Appendices

Appendix A - Glossary of abbreviations and acronyms

AHBC	Automatic Half Barrier Crossing
AWG	Adhesion Working Group
DC	Direct Current
EMS	Engineering Management System
EP Valve	Electro-Pneumatic Valve
MOM	Mobile Operations Manager
OTDR	On Train Data Recorder
RHT	Rail Head Treatment
RHTT	Rail Head Treatment Train
TOC	Train Operating Company
WSP	Wheel Slide Protection

Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com.

Adhesion	The friction produced between a rail and a rail wheel.*
Adhesion Working Group	A group consisting of representatives of Network Rail and members of the Association of Train Operating Companies which carries out research and publishes guidance for railway companies on adhesion-related issues.
Automatic half barrier level crossing	A level crossing where the warning to highway users is given automatically, triggered by the approach of a train, and is fitted with half barriers, traffic lights on the highway and a telephone to the relevant signal box.*
Brake retardation	The deceleration rate of a train that would be achieved by application of the brakes on a level track. The actual deceleration rate achieved by the train will be affected by the gradient of the track.
Controlled test stop	A test of rail adhesion that requires the driver to brake the train as if expecting normal rail adhesion conditions and to report the experienced adhesion conditions to the signaller.[12]
Diesel Multiple Unit	A train consisting of one or more vehicles (semi-permanently coupled together) with a driving cab at both ends and whose source of power is diesel engine(s).*
Electric Multiple Unit	A train consisting of one or more vehicles (semi-permanently coupled together) with a driving cab at both ends and whose motive power is electricity supplied externally from overhead line equipment or conductor rails.*
Electrostar	Generic name for a family of electric multiple units manufactured by Bombardier Transportation.
Emergency braking	The (abnormal) full application of all available braking effort, sometimes using a more direct and separate part of the control system to signal the requirement for a brake application than that used for the full service application.*
Mobile Operations Manager	A member of Network Rail's staff whose duties include rapid deployment to incidents and accidents to assist in the process of restoring the railway to normal operations and investigating the cause of the incident/accident.
On Train Data Recorder	A data recorder collecting information about the performance of the train, including speed, brake control positions, etc.
Rail Head Treatment Train	A train designed to clean the rail head by water jetting, and to apply friction modifying treatment, such as Sandite or Track Grip 60.

[12] From Rule Book GE/RT8000/TW1 'Preparation and Movement of Trains – General'.

Running brake test	A brake test preformed by the driver whilst the train is in motion.*
Sandite	A suspension of sand and metal particles in a clay based gel, applied to the rail head during the leaf fall season to improve adhesion. This is designed to be applied at up to 40 mph (64 km/h).
Signal Passed At Danger	A train failing to stop correctly at a signal displaying a stop aspect.*
Third rail DC electrification	A general term used to cover the type of electrification that involves the supply of DC traction current to trains by means of a conductor rail laid along one side of the track, known as the third rail.*
Track Grip 60	A suspension of sand and metal particles in a viscous gel, applied to the rail head during the leaf fall season to improve adhesion. This is designed to be applied at up to 60 mph (96 km/h).
Traction gel applicator	A lineside installation consisting of a hopper containing 75 litres of traction gel (a friction improving substance), which is dispensed on to the rail head via an applicator. The application is triggered by a train sensor on the approach to the unit.*
Train Operating Company	A company that is franchised to run train services over a designated area of the national rail network.
Wheel flat	A flat area worn into the tyre of a rail wheel by prolonged braking or a failure of the brakes to release.*
Wheelset	Two rail wheels mounted on their joining axle.*
Wheelslide	Condition where the actual rotational speed of the wheel is lower than the rotational speed corresponding to the actual linear speed of the train.
Wheel Slide Protection	A control system fitted to modern locomotives and multiple unit trains that prevents the driving wheels spinning out of control or locking up during times of reduced adhesion. They work by automatically releasing and re-applying the brake on slipping wheelsets in order to find and make use of the maximum level of adhesion available. It is analogous to anti-lock braking and traction control on a motor car.*

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