Modern track renewal on the West Coast Main Line

The West Coast Main Line, of which a 250 km long section is four-track, is the busiest railway line in the United Kingdom (UK). The line is characterised by tight curves and extremely narrow track distances. For maintenance of the ballasted tracks, Network Rail made a new approach: "High Output" track renewal in weeknight work is the new standard.

The railway from London to Birmingham, Manchester, Liverpool, Preston and Glasgow is the United Kingdom's busiest railway line (Fig. 1). The route was pioneered in the mid nineteenth century, when so much of Britain's railway infrastructure was built, but not as one route. It was in fact the 'joining up' of several independent routes developed between 1836 and 1888. It is important to recall that in those days train speeds were no greater than 100 kph and the land necessary to build the embankments and cuttings had to be purchased by private companies funded from public subscription. Whilst there was little shortage of funds, the new private railway companies developed their infrastructure specifications to meet the requirements of the day and therefore curves, gradients and clearances were the minimum necessary to meet the current level of traction development.

As traffic grew the busier sections of the route were enlarged from two tracks to four, indeed between Rugby and London this 130 km of the route was made into a four track railway as early as 1870. By the end of steam traction the line speed had risen to 140 kph using the original route infrastructure gradients and alignments laid down over 100 years earlier. Electrification of the route was completed in two stages, between London and the West Midlands and Manchester in 1966 and finally to Glasgow in 1974. Investment in track was limited to laying new continuous welded rails, an improved ballast quality and the introduction of stronger concrete sleepers. This enabled a maximum line speed of 170 kph to be introduced with only minor improvements to the track geometry.

It is worth noting that the topography over which the route was constructed includes sections at sea level and two heavily graded sections at Shap and Beattock where the line climbs to 279 metres and 310 metres above sea level respectively. 70% of the route is curved. It is this route topography that has until recently limited opportunities to reduce journey times. In the 1970's British Rail, through their research centre in Derby, developed the novel concept of trains tilting through curves to maintain passenger comfort whilst increasing lateral track forces up to safety limits. This created an opportunity to give passengers on this route faster journey times at affordable capital costs. However, the train developed to deliver this opportunity, the Advanced

Richard Spoors

Railway Civil Engineer
and past president of the
Permanent Way Institution

North Buckinghamshire, England

richardjspoors@aol.com

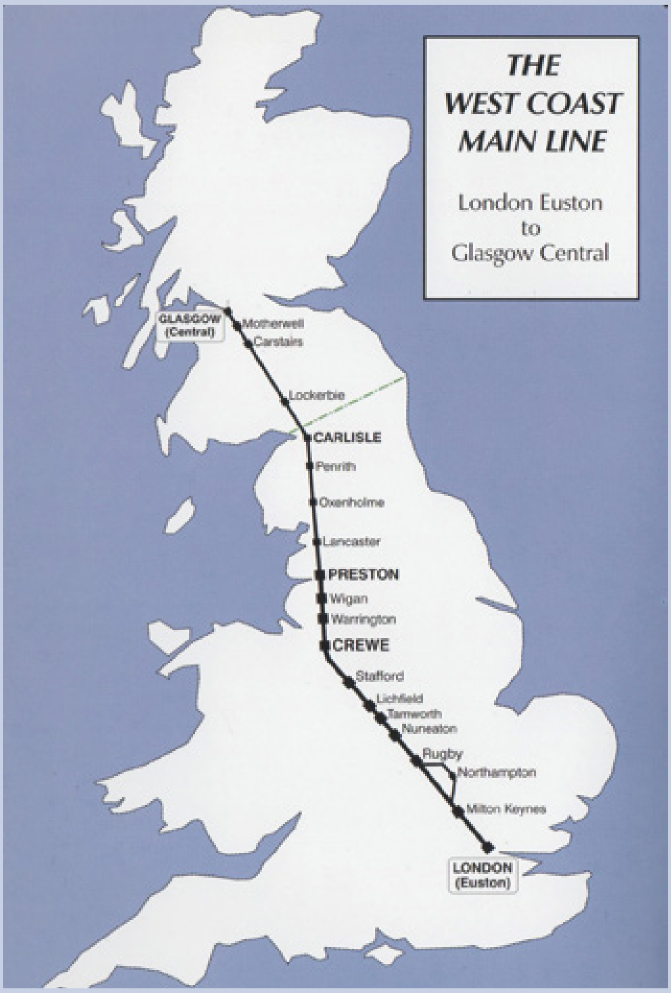

Fig 1: The route of the West Coast Main Line

(all figures by the author and by permission of Plasser and Theurer and Freightmaster publishing)

Passenger Train, proved unreliable in trials during the early 1980's and the project was cancelled.

1 Upgrading for Pendolinos

Some 20 years had to pass before UK rail privatisation in 1996 led to a new initiative to upgrade the route infrastructure and introduce a fleet of 53 nine coach 200 kph tilting Pendolino trains (Fig. 2). The infrastructure upgrade project was undertaken with the majority of the route open for business over a six year period and was completed in December 2006. During construction traffic had to be disrupted, especially at weekends, and passenger numbers fell.

Fig 2: A Pendolino heading south on the WCML

However, this was soon reversed by introducing new timetables that exploited the capacity that had been previously reserved for infrastructure engineering work. This was done in two ways. Firstly by reducing the allowable minutes in journey times to recover from delays caused by running at reduced speed following major engineering works, and secondly by planning more services to be timetabled at weekends, especially on Sundays. This new timetable was introduced in December 2008, and has resulted in a further increase in passenger journeys just in the two years since the upgrade works were completed. In fact this growth is not confined to the West Coast Main Line. Statistics show that the UK's railway network is today carrying more people than at any time since 1920, which is the year with the highest recorded total since passenger railways began in 1825.

Further improvements are planned for December 2012 when the Pendolino fleet will be enhanced by 62 new coaches and four new 11 car train sets.

The successive introduction of new timetables since the completion of the upgrade project clearly required a new delivery policy from Network Rail, the infrastructure owner and operator. This would entail a transfer of work traditionally undertaken in long weekend track occupations to shorter successive weeknights. Notwithstanding the upgrade project, there is a fairly constant volume of annual track maintenance and renewal activity necessary to keep the 3,500 km of track on the WCML to the required standard for both 200 kph passen-

Fig 3: HOBC ready to leave Linz, Austria for England

ger trains and the growing freight traffic with its 25 tonne axle loads.

2 Birth of the "High Output" track renewal

Independently of the upgrade project, in 2004, Network Rail established within its track renewal organisation a small dedicated team to draw up plans for a new range of "high output" renewal systems. These would be procured and deployed on their principle routes, starting with the Great Western main line. The UK definition of "High Output" is typically bespoke on track machinery that can renew up to 400 metres of track or track ballast in an eight hour track possession.

The choice of a ballast cleaner was based on the successful Plasser and Theurer RM 900, with two screens and a capacity of 900 cubic metres per hour (Fig. 3). For the rail and sleeper renewal system, the Swiss manufacturer Matisa was chosen. The challenge for both suppliers was to design new versions of their proven machines to fit the tight and narrow UK loading gauge. As the Network Rail team developed their programme a second pair of machines was approved and ordered, together with specialist wagons to handle old and new materials (MFS wagons), and supporting machines to tamp, regulate and stabilise the track.

Following competitive tender, a joint delivery team made up of First Engineering (now Babcock Rail) and the Austrian firm Swietelsky was appointed to manage the two systems and the programme of renewals.

Unlike the deployment of similar machines in Europe, where they might be used in a continuous track occupation of a week and longer to renew several kilometres of track, their deployment in the UK would be designed around weeknight work in track occupations of six hours! This type of usage, particularly with the ability to deploy track stabilising machines, meant that there would be no disruption to daytime train services and only slight delays caused by an opening line speed of 130 kph after each nights work. When ballast to a depth of 300 mm is renewed under the sleepers, and the track is double tamped, ballast regulated and stabilised, the quality of geometry for 130 kph running can only be assured in the short term. However, as the horizontal level of the rails has been maintained during the ballast cleaning operation, and new stone has replaced the old, the first tamping pass has little effect on the lower 150 mm of disturbed ballast. A pass of the dynamic track stabiliser (DTS), followed by a second tamp puts the track to a good geometry, but that lower 150 mm has still had little consolidation. As a consequence, additional follow up passes of a tamping machine is required after train traffic has provided final consolidation of the lower ballast bed.

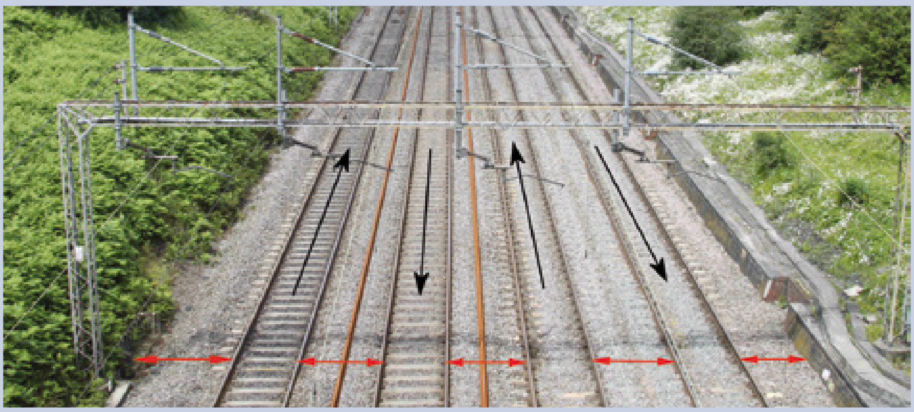

Fig 4: View of the West Coast Main Line south of Rugby

When British Rail, the UK's nationalised and vertically integrated railway administration, was broken up and privatised between 1994 and 1996, all of the resources associated with the marshalling and haulage of the specialist engineering trains necessary for renewal and heavy maintenance of the infrastructure were allocated to the embryo private freight train operating companies. Ten years later, when Network Rail embarked on its High Output Track Renewals (HOTR) programme, it found that putting in place the logistics support mechanisms was as much of a challenge as procuring the plant and a competent operator. Whether it was renewing rails and sleepers or the ballast, each process demanded a just in time approach to the delivery of new materials and the disposal of the old. It was soon realised that each of the systems was in effect a factory process that was undertaken in a short production period that moved every 24 hours from site to site. New stabling depots, called High Output Operating Bases, (HOOB) had to be created at suitable strategic locations where trains could be stabled during the day. The function of an HOOB includes plant maintenance, disposal of old materials, the return of wagons ready for the next night's work, new ballast or new sleepers brought into the depot and the next night train marshalled ready to depart that evening. A ballast cleaning system (BCS) train can be up to 800 metres long and weigh 3,200 tonnes. Careful planning is necessary from a train pathing perspective, as the engineering trains need to depart from their HOOB well before the normal passenger and freight services end for the day and arrive into their work site 'just in time'. It is also necessary to ensure that trains are not too heavy for ruling gradients which might reduce their speed and cause delays to other services. To assist the signallers with any necessary train regulation, these trains are given a special reporting number to distinguish them from other traffics.

3 Narrow track distances on the four-track section

A further challenge to Network Rail's HOTR production team has been the unique passing clearances on the West Coast Main Line between London and Rugby. The classic separation of a four track railway in the UK provides 461.9 cm between the centre line of the two middle tracks. On the West Coast Main Line south of Rugby for the 130 km into London, this is reduced to 340.7 cm, which is a consequence of the railway capacity being increased in 1870 when the need for wider spaces between running tracks was less well understood. This has repercussions when working in possession on the two left hand tracks and when trains are operating on the two right hand tracks. Reference to Fig. 4 illustrates the problem. If the track being worked on is to the extreme left, all is well as a temporary safety fence can be erected in the adjacent track to allow operatives to gain access to both sides of the machinery, and trains will be operating on the two right hand tracks. However, if the line being worked on is the central track, then there is a conflict with the traffic flowing on the adjacent open central track. This has required the introduction of special safety working arrangements to introduce reduced speeds during the engineering work for passing traffic. Where the central tracks are being worked on several 20 minute closures to traffic on the adjacent track are arranged when operatives need to gain access to both sides of the BCS train.

Each night, before the ballast cleaner cutter bar can be inserted under the rails, a pit has to be excavated by road rail machines. This becomes the first operation once the line possession has been taken, and usually takes up to 30 minutes of production time. Experience showed that a strict project plan had to be developed in order to ensure that no service train disruption would occur after completion of work. This was based on looking in detail at each activity within the track occupation and creating a standard time in minutes for it to be undertaken. This enabled a time interval from the completion of the ballast cleaning operation to the opening of the track to traffic to be determined for which strict compliance became the norm. Therefore, each night, the quantity of ballast cleaned was dependent on a varied start time and an absolute completion time. It became clear that for a constant percentage of dirt to be cleaned from the old ballast, any improvement in the volume of production was dependent upon the time it would take to insert and join up the cutter bar.

With two years of successful deployment completed with the first two systems in the west of England and on the East Coast Main Line between London and Newcastle, the team began to design a fourth HOBC system for use on the West Coast Main Line in 2010. It is this fourth system, and in particular the innovative developments incorporated into the design and functionality of the ballast cleaning system that will now be described in more detail.

4 The “system 4” track maintenance system

The principal improvements to system 4 (Fig. 5) follow lessons learned from systems 2 and 3. This includes an integrated means to excavate the ballast cutter bar chain hole more quickly and the integration into the vehicles between the excavating chain and the MFS wagons that hold the new ballast, lifting, lining, tamping and stabilizing units (Fig. 6). These latter units are designed to produce consolidated track to line and level during the ballast cleaning process. This is a further significant time saver. Experience has shown that the supporting tamping machine is only required to make one pass through the site to make the track fit for opening to traffic at 130 kph.

The front of the HOBC train handles the excavated spoil in the MFS wagons and a new addition is the integrated suction pump (Fig. 7) which creates the cutter bar hole with the adjacent line still open to traffic – eliminating one of the 20 minute closures described above. Once undercutting commences, the first lifting unit immediately behind the excavating chain positions the track such that only 150 mm of ballast is placed under the sleepers immediately behind the cutter bar. A small Dynamic Track Stabilising unit (DTS) consolidates this ballast by vibrating the track laterally under vertical load at a frequency of 35 Hz. Then the second lifting unit lifts the track 150 mm to allow a second layer of new stone to be unloaded from the rear MFS wagons. A tamping unit followed by a second half DTS unit further consolidates the ballast and puts the track to the design geometry aided by

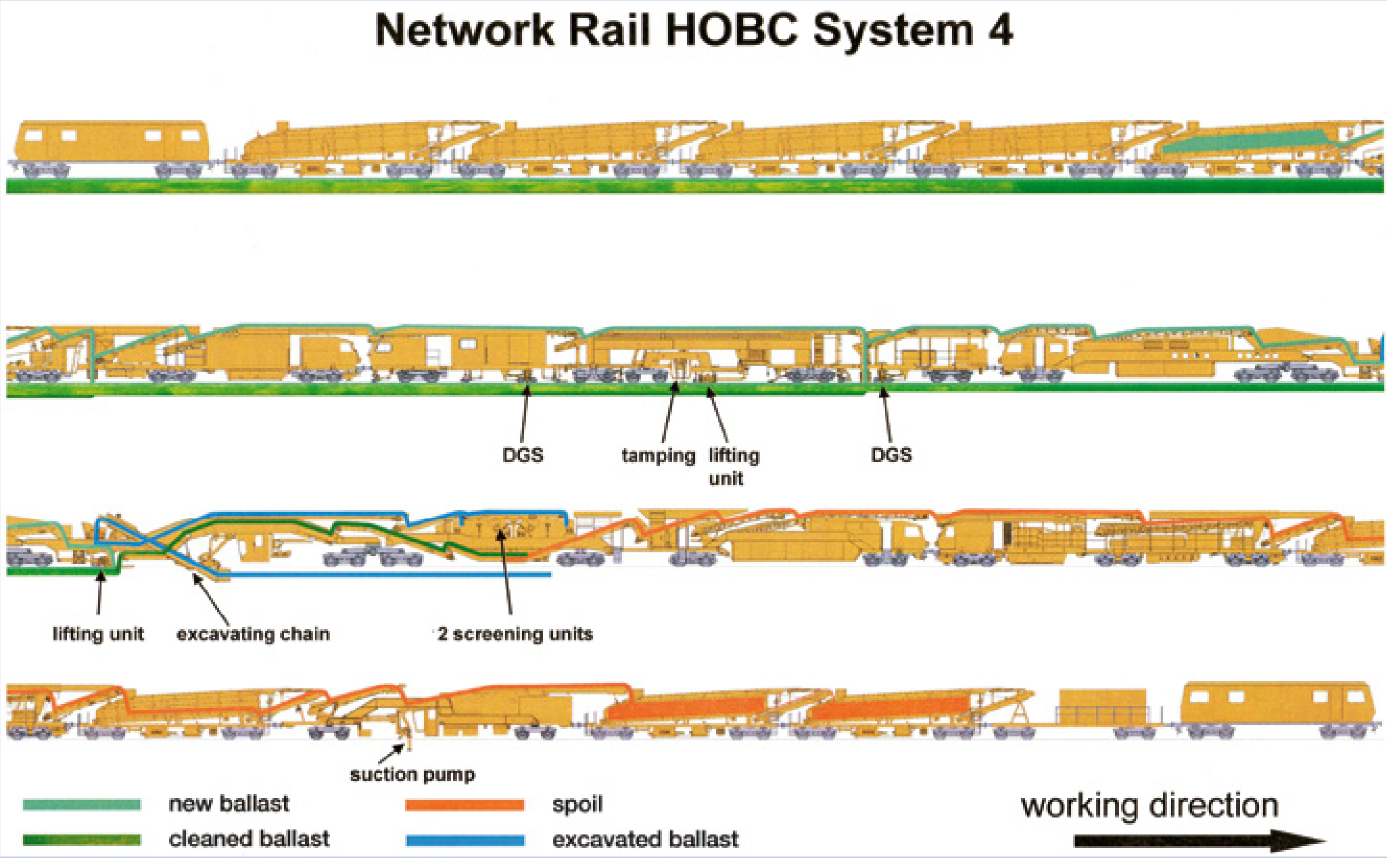

Fig 5: Configuration of Network Rail's High Output Ballast Cleaning System 4

an on board ALC guidance system. Finally, the beds and shoulders are topped up with ballast.

Cleaning is completed at the pre set time, the cutter bar put away, and the system moves forward. The track is to the design alignment; ballast has been consolidated in two 150 mm layers and it has had the equivalent of one pass of a tamping machine. The track is sitting approximately 25 mm below its final design level. One further pass of the support tamping machine (Network Rail use a Plasser and Theurer 09 3x dynamic) uploaded with the required lifts, slues and geometry file, with ballast regulation and the planned 130 kph line speed is a reliable end result. As work progresses during the week, further tamping is carried out enabling the 125 mph line speed (200 kph) to be restored. System 4 was delivered by Plasser and Theurer in 2010 and following successful acceptance trials in Austria and the UK it entered service later that year.

Network Rail took the opportunity to retender the contract for the operation of its four High Output Track Renewal systems in 2010 and the contract was awarded to Amey-Colas Joint Venture.

5 Conclusion

In the ten years since Network Rail took responsibility for the UK mainland rail infrastructure it has developed an innovative approach to the use of European standard bespoke track engineering machinery so as to maintain its main lines to a high level of reliability and create minimum disruption to its train operators. Furthermore, this is seen to be a contributing factor to the growing number of passenger and freight customers using rail as their preferred means of transport in the UK.

Fig 6: The integrated continuous action tamping unit

Fig 7: The vacuum pump used to excavate the cutter bar hole