RailKonsult

Office of Rail Regulation

Further Assessment of Approaches to Improve Efficiency

Technical Appendix Number 10

The Use of Bespoke Plant to Undertake Track Renewals

Reference BBRT-2071-RP-0010

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Executive Summary

This paper is one of a series commissioned by the Office of Rail Regulation in order to gain an improved understanding of the maintenance and renewal techniques used outside Great Britain. These reports have been produced as part of the PR08 process.

This report focuses on the benefits of moving towards the more frequent use of specialist bespoke On Track Machinery (OTM) rather than Road Rail Machinery (RRM's) to undertake track renewal work in Great Britain.

In Britain, a large percentage of work is undertaken in a 'conventional' manner rather than by using bespoke high output track renewal equipment. Network Rail are aspiring to significantly change this balance towards high output equipment over the next few years, with several items of such plant successfully introduced over the last few years.

Much of the conventional renewal undertaken in Britain today is based on the extensive use of RRM's. The industry has a view that there use delivers value due to the flexibility and contingency provided. This paper indicates that this view is not correct.

In Europe far less of their track renewals are undertaken in a conventional manner with the use of their high output equipment being optimised wherever possible. Production Engineers use bespoke machinery far more with decisions on methodology and equipment normally based on experience and modelling software. This ensures that the most efficient delivery method is selected for the work and time constraints involved.

Current track access periods for track renewal operations are being severely eroded as congestion demands more time for traffic operation and less for engineering delivery. In response to these pressures, Network Rail and its contractors will need to optimise the high output equipment and transition their conventional track renewal activities towards more use of bespoke machinery.

However, a procurement policy needs to be developed that supports innovation and investment in specialised plant, whilst ensuring value for money is delivered. It will also require a move towards a "route improvement" approach to renewals planning.

Acknowledgements

RailKonsult wish to acknowledge the support and assistance received from the following organisations in compiling this report:

- Sersa
- Plasser and Theurer
- Swietelsky International

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1.0 CONVENTIONAL RENEWALS

1.1 Background

1.1.1 High Output Systems versus Conventional Plain Line

Two distinct types of generic plain line renewal are currently undertaken in Great Britain. These are normally referred to as high output and conventional.

High output renewals are undertaken using bespoke track renewal and track reballasting systems. High output equipment has been successfully introduced into Britain by Network Rail and First Swietelsky. This has demonstrated that bespoke machinery systems can work safely and productively with trains operating alongside the renewal sites.

These bespoke machines are operated under contract in Great Britain, employed on the prime high speed routes and usually operate in short track access periods with traffic operating on the adjacent track.

The remaining plain line track renewal work undertaken in Great Britain is delivered using a 'conventional' approach. This work ranges from complete renewal through to component renewal. The amount of work undertaken during 2007/8 was 2011ckm (composite kilometres[1]) conventionally and 313 ckm using the high output equipment. That is, less than 15% of plain line renewals were delivered using the high output approach. It is anticipated that the high output proportion of work will increase through CP4.

1.1.2 Switch and Crossing Renewals

Currently, all switch and crossing renewal undertaken in Britain can be broadly considered to be conventional. The only differences between a variety of approaches employed being as a result of the plant used for installation of the new track panels. Although items of European high output equipment, such as Kirow rail cranes are used they are not incorporated into a high-output process.

Network Rail is currently introducing a 'Modular Switch' renewal concept that is proposed for full introduction by 2012/13. This will cover some 70% of the renewal programme and uses bespoke equipment, wagons (e.g. Kirow cranes and tilting wagons) and a proposed high output reballasting system. Significant efficiency improvement is anticipated from this renewal method, which has been based on the best of current European practice. It is probable that the use of specialist bespoke plant will be maximised in the proposed methodology.

1.1.3 Bespoke versus RRM's

Bespoke machines are built to deliver a specific track renewal activity. They are designed to operate either with rails wheels or using caterpillar tracks on the work site. They are designed and manufactured to be able to perform safely in accordance with predetermined performance specifications.

The scope of track renewal activities undertaken by bespoke machines ranges from large high output systems, through reballasting systems to finishing equipment. All have been developed over many years and been upgraded with the latest technology as it has developed.

Excavators, in one form or another have been used on railways in Britain since the Second World War. Originally, they were solely used to excavate the old ballast and install the new ballast. However, since the 1980's they have been used for an ever increasing range of activities within the railway environment. Their capability now include tandem lifting to remove or install track panels. Much of the RRM equipment built is used on non-railway construction work in the week and railway works at the weekend.

[1] A composite unit indicates the number of components that are being renewed, e.g. a 1km renewal comprising rail, sleepers and ballast equates to 3 km of composite renewal.

1.2 Extent of Methodology

The use of bespoke high output equipment such as reballasting, complete renewal, track only renewal and formation trains is widespread throughout Europe and in many other parts of the world. The market in Europe is continually evolving as more sophisticated machines and technology are introduced to reduce track occupation times and increase output.

1.3 Applicability

The use of bespoke machines can apply to track renewals, track maintenance and partial renewals. In addition many types of equipment have been specially produced and are used extensively for such work as OHLE maintenance and renewal. This is a process that replaces a maintenance practice that used extensive labour resources.

However this paper focuses on the use of bespoke equipment for track renewals. The scope of this report does not include OTM finishing equipment such as tamping and regulating machines, or the recently introduced AFM track finishing machines.

Note that, whilst references are made to specific products and systems that are in use in particular countries, there may be other products available that provide a similar functionality. The report does not review all available alternatives, or consider their comparative merits. The case studies are included as being indicative of alternative approaches in asset management.

2.0 EUROPEAN APPROACH

2.1 Method Deployed

2.1.1 European Attitude to Renewals Machinery and Technology

The following conclusion is from an article by Jurgen Konz, Head of Maintenance, Railion Deutschland AG published recently in the European Rail Review journal:

> *'The experience in Germany has shown that the present challenges and the requirements for efficient track work can be mastered with the help of state-of-the-art technologies and machines. The investments into the most modern machinery have led to a significant increase of the efficiency. The utilisation of the machines in Germany has basically shown positive results, so that in the future more emphasis is placed on their additional use abroad, especially in European countries like Italy, Spain, Great Britain or Scandinavia. The machines are designed in such a way that they meet the European requirements. In the end, the higher quality is not only to the benefit of the railway infrastructure operators but also to the benefit of its users.'*

The following is an extract from a presentation made to the PWI Autumn conference in 2007 by Craig Goldie a Director of Swietelsky when referring to the challenges that need to be overcome within track renewals in Great Britain:

> *'The improvements and developments required for the industry within Great Britain to meet these needs require the harnessing of the most modern systems available in order that the applied pressure of reduced cost and access together with improved track quality and sustainability may be achieved.'*

2.1.2 European Use of Bespoke High Output Equipment

It is understood that this equipment is used to undertake 90% of the work in Austria. European practice often allows for major works to provide route improvements. This supports the use of high output equipment. In Germany and Austria high output operations may be undertaken in single line closures with 2 km of work being undertaken in 40 hours or up to 6 km of work during a single week's closure.

This is feasible as the operational railway is managed to allow services to co-exist with on-track operations. This includes extensive provision of bi-directional working. The latest

example of such an approach is the introduction of the world's fastest tamping system, the 64 tool 09-4X, which has effectively enabled "between trains" tamping operations.

Only the shorter length renewal items are undertaken by conventional renewal techniques. However, even these sites will involve the use of bespoke equipment such as single line gantries and cranes.

2.1.3 Optimising High Output Techniques Using Bespoke Machinery

RRM's had been used in Europe for many years. Over the last 20 to 30 years there have been increasing demands to maximise productivity and improve efficiency within allowed possession times, as well as the need to maintain and renew the network while services continue to operate on adjacent open track. This has progressively led to the development of the high output equipment regularly used in Europe today.

This has meant that, whilst RRM's are still used in continental Europe, they are normally confined to smaller items of work in stations or on minor lines, or in a discreet support role as part of the high output process. They are generally considered to be useful in supplementing bespoke machinery where required. Some authorities have placed restrictions on their use as cranes and will not permit tandem lifting using RRM;s.

As described above, high output type equipment has been in existence for many years, with continual development in line with new technology and the requirement for higher production levels. The equipment in use has been optimised so that utilisation is high, the production rate is maximised and hence real financial benefit is obtained by the Infrastructure Manager from their operation.

The use of production line technology, which is inherent to the high output process, allows the "factory" to be moved from site to site. The same operation is repeated at different locations, with the process constantly fine tuned to further enhance performance.

European production engineers have software systems that enable production analysis to be undertaken to review the use of these different types of plant. This ensures that they select the most efficient solution to deliver the clients workload. Similar analysis systems are not yet in regular use in Britain.

2.2 Management Approach

The mainland European management approach is to fully optimise their high output equipment and then to use bespoke equipment to undertaken the remainder of their work with significantly less use of RRM's.

It is not normal practice for Infrastructure Managers to directly own plant in Europe. It is usually owned by track renewal contractors who have more confidence than their British counterparts in investing in new plant items as the Infrastructure Manager's support for this investment is more tangible than in Britain.

In many parts of Europe trusting relationships have developed between Infrastructure Managers and track renewals contractors, over investment in new technology. This encourages procurement of innovative plant to deliver added value to the client, whilst maintaining a competitive market as those who employ innovative ideas and technologies are rewarded through hire contracts that ensure such plant is supported by guaranteed minimum levels of utilisation. It is rare for modern equipment to be introduced and not fully embraced operationally.

The Infrastructure Manager manages the allocation of resource to work items so as to meet the levels of utilisation agreed in the contract. Both sides win. The contractor is encouraged to invest in innovative solutions to drive costs down and build their business, whilst the client achieves increased efficiency and the benefits of higher production rates.

2.3 Technology Involved

Bespoke equipment used in Europe incorporates the use of the latest technology. This includes latest design of low emission engines, sophisticated computer control of operations and laser guidance systems for excavation control. This technology enables track renewal and reballasting to be undertaken simultaneously, whilst achieving high levels of productivity and quality.

Equipment utilisation is simpler on the continent than in Britain. This is because the infrastructure has extensive bi-directional working and a wider track space. The work that Network Rail and First Swietelsky have accomplished in operating high output equipment with trains passing on the adjacent line within the W6A gauge profile is recognised throughout Europe as being 'World Class'.

3.0 CURRENT BRITISH APPROACH

3.1 Construction Methodology

In Great Britain, as in Europe, construction is split between conventional and high output type renewals. Unlike Europe, far more conventional renewal is currently undertaken. Most of this is undertaken using RRM machines rather than using modern 'bespoke' on track machinery owned by the track renewal contractors.

The reason for this is partly historic. In the 1970's and early 1980's, BR procured several items of on-track plant that became the normal items of plant for conventional track renewals. These were:

- Track relaying machines (TRM);
- 12 tonne general purpose cranes (12tGP); and
- Automatic reballasting machines (ABC).

These were extensively used until, during the late 1980's and early 1990's, BR started to use RRM's to remove and install sleepers in addition to their use for excavation duties. In parallel, BR wound down investment for the refurbishment or replacement of on-track plant. Therefore the use of RRM's became more commonplace as old on-track machinery became less reliable and the versatility of RRM's increased.

The use of SLW operations within conventional renewals has decreased to virtually nil with the increased use of RRM's. Important train operation flexibility has been lost with the majority of track renewal works now being undertaken in track access periods of double line possessions.

Since privatisation, further development of the use of RRM's machine has been ongoing. They are used for virtually all of the activities within a track renewal job. Their use is commonplace and widespread throughout the country with only a few locations where older bespoke on-track machinery has been upgraded and retained in regular use.

For the front line staff of the industry the key incentive for delivery, after safety, is to avoid incurring an overrun of the possession. Their motivation for efficiency and quality improvements is far less pronounced. Front line staff believe that the use of RRM's helps reduce the risk of overrun caused by machine failure. Most of these staff have not been exposed to renewal techniques with modern bespoke machines.

As already noted, high output equipment has been introduced in to the British market. However, in European terms, the use of high output equipment in Great Britain is in its infancy and the industry is still learning how to optimise its use and maximise the considerable benefits of using the equipment in overall railway benefit terms. This includes full understanding of the whole cost benefits of using this equipment in weeknight possessions to maximise advantages for train operators.

The rail industry has not achieved full optimisation of high output equipment in Britain yet. This is a consequence of not taking a 'route improvement approach' to improving track asset as is often practiced in Europe. In Great Britain the practice of identifying short sections of renewal (known as 'pot-holing') has been the standard for years. This 'short item' approach does not help utilisation of high output equipment and on high speed routes, in particular, can have a profound effect on track quality.

3.2 Management Approach

Track renewals contracts cover both switch & crossing plus plain line renewals. Delivery teams within contractors' organisations are required to be proficient in both types of work. In Europe dedicated teams are frequently used to deliver specific parts of the work activities with contracts let for the delivery of a single product.

In Britain work-banks for delivery programmes are very variable and this reflects on the effectiveness of delivery. An example of this is where work teams have developed more effectiveness on relaying switch and crossing work only to find that their work-bank for switch and crossing renewals then disappears.

The lack of long term visibility of workload affects decision making on plant investment. The contractor is unaware of the types of work that will form the high volumes within their forward programmes. Therefore, they are unaware of what plant will provide the maximum benefit in productivity, efficiency and quality terms. This lack of visibility encourages the use of RRM's as this approach reduces the business risk of buying the wrong specialist equipment. The situation is worsened by the long lead times and complex approvals process required to introduce new technology. The environment for investment in new plant in Britain is not one that stimulates speculative investment.

The selection of the methodology to undertake track renewals is not standardised to ensure that the most efficient method is used. Regional preferences come into play. Jobs of longer lengths that could be undertaken more efficiently using specialist plant like the Slinger train or NTC renewal gantries or Kirow relaying crane systems are relayed using RRM's. This not only constrains output, but can increase the cost per metre of the renewal. It also results in the specialist plant being underutilised and shift costs increase as a consequence of suppliers struggling to recover their investment costs.

In Britain, relationships between Infrastructure Manager and track renewal contractors are developing towards more cooperation particularly through Network Rail's modular teams. However the industry still needs to identify a process that jointly supports the procurement and utilisation of new technology within conventional renewals.

Several initiatives have been launched by Network Rail over the last two years to address the above and focus the industry on faster, safer and better track renewals.

Network Rail are running an initiative (end to end process review for renewals) to address process improvements in downstream activities that will improve timescales and information affecting delivery. This includes earlier development of specifications and programmes and the submission of earlier track designs. All of this should provide greater visibility of future work-banks, which would in turn give greater certainty towards the investment of new plant.

3.3 Technology Involved

3.3.1 Road Rail Machines

The majority of plant used in Britain today is RRM's that have been developed from models produced for work in the construction industry. The ability to modify the machines for road rail operation is proven and the technology involved with the equipment's operation in the railway environment has grown in sophistication.

The limitations that this equipment has are:

- Production Limitations
  RRM's have a productivity limitation based on the capacity and rate of speed of operation, e.g. excavation rate is based on bucket size, power of machine and operator competency. Larger machines have problems with access to track.
- Capability Limitations
  RRM's, whilst being more versatile than individual items of OTM equipment, are restricted in their output capability for all of the activities required of them. An example of this is the laying in of loose sleepers, where they can typically install 7 sleepers at a time. Bespoke machinery such as Kirow KRC 250 can quickly install multiples of 28 sleepers at a time with no manpower interface, whilst a Slinger train can install in excess of 280 at a time. The bespoke equipment also spaces and aligns the sleepers.
- Safety Limitations
  RRM's can only lift relatively light loads because of stability problems. These are very small compared with loads lifted by bespoke equipment such as TRM's and rail cranes. Modern rail cranes are fitted with sophisticated lifting programmes that are an invaluable tool in the safe management of what can be complex lifting operations carried out in tight locations with acute time pressures often applying.
- Compatibility Limitations
  To achieve relatively low hire rates for the rail industry plant suppliers need to also use RRM plant on general construction work. However as the demand has grown for ever more specialist RRM's this has proved more difficult for the suppliers and hire costs have increased

3.3.2 Bespoke Machines

Much of the on-track machinery currently existing in Britain dates from BR days and is either life expired or requires some refurbishment to achieve acceptable levels of reliability. Several companies have already successfully refurbished plant such as TRM's for use within current track renewal operations.

New bespoke machines have been introduced over the last decade by either:

- Developing existing technology, such as the Slinger train concept;
- Adapting proven American technology such as the NTC relaying gantries; or
- Adapting European technology, such as the Kirow rail cranes.

All have required investment from the track renewal companies who have procured them. Some of this new technology has been downgraded in capability in comparison with existing (legacy) plant that is able to operate using "grandfather" rights. These enable them to avoid compliance with all current standards. They have suffered to varying degrees from the following issues as they have been introduced into service:

- Lack of clear industry process to consider, agree and deliver the specialist plant.
- Under-use since implementation due to the industry failing to understand how to facilitate efficient methods for renewal;
- Delays due to unforeseen issues such as crane axle weights on under-bridges; and
- An industry culture of risk minimisation and resistance to change.

The introduction of new equipment, already proven in other markets should provide a low risk opportunity for possible introduction of further equipment, if the industry can manage the issues shown above.

Large manufacturers, such as Matisa or Plasser and Theurer, are introducing new technology into their equipment that provides solutions to problems found through operation.

An example of this is the use of vacuum technology being introduced to the next high output relaying train for preparing the cutter bar hole. This removes the need for a RRM on site.

4.0 BENEFITS

The benefits of using specialist bespoke machinery to deliver track renewals in Britain are as detailed below:

- Cost per Metre and Production Rates

  Appendix A contains models that demonstrate that the replacement of RRM's with bespoke equipment provides improved efficiency. Both models are for the complete renewal of 600yds of track.

  The first model shows the renewal delivered in 18 hours. This model relies on conventional track removal and reballasting using RRM equipment, but utilises the Slinger train to install the sleepers and rail. The cost per metre is £521, using 2006 rates. This approach requires eleven machines, nine of which are RRM's

  The second model shows the renewal now being delivered in 14½ hrs at a cost per metre of £518. This model relies on using bespoke plant for track removal, reballasting and track replacement. The number of machines is reduced to five, of which only one is an RRM machine (working in a support role). Note that for this model, design production rates and costs are used for the reballasting system.

- Safety

  In the models shown in Appendix A it can be seen that the items of plant on site are reduced from eleven to five. This reduces the accident and incident risk on site. In addition to the reduction in the number of machines, the items of plant are constrained to either only working statically, (e.g. Slinger) or in a single direction (e.g. Kirow / Sersa reballasting system). This again reduces the risk in comparison with RRM machines that move in both directions and can also swing around in both directions.

  Each item of on-track plant would also be operated by a dedicated operator. RRM operators will have varying experience and expertise working on the rail infrastructure.

- Quality

  The delivery of quality on site is not just a consequence of successful operation of plant. Use of bespoke on track machinery for track renewals provides major benefits such as:
  - Accurate placement of sleepers;
  - High quality excavation; and
  - Compaction control.

  The renewal industry has achieved success with track quality improvement over the last two years. However, further improvements are likely to be achieved through more attention to detail, e.g. putting sleepers in to tight tolerances. This is more likely to be achieved by the extended use of specialist bespoke machines.

The following table compares the relative benefits and weaknesses of using RRM's.

Road Rail Machines	
Benefits	Weaknesses

• Flexible and can be used to multitask
• Relatively low shift cost
• Single machine failures will not necessarily stop the whole worksite
• Generally perceived as reliable
• Facilitate several activities occurring at the same time
• Productivity has probably reached maximum output per machine
	• Suitable access to worksites can be difficult, resulting in long transfers along the track
	• Lifting duties have narrow selectable bands, with failure to lift in the correct manner resulting in overturning
	• There are good and poor operators
	• Increased risk of serious accidents as a result of multi-directional movements on site
	• Machine Controllers required with machines
	• Output increases are achieved by increasing number of machines, resulting in:
	  ○ Complex operational management issues on worksite
	  ○ Increased road haulage trips, with consequential traffic and parking issues
	  ○ Environmental issues from increased trips and machines

The following table identifies the relative benefits and weaknesses of using bespoke machinery.

Bespoke Machines	
Benefits	Weaknesseses
• Single or multi purpose built machines designed to operate safely on track and at high productively for task assigned • Operated by dedicated operator and team • Latest equipment has reliability levels with fault diagnosis computer systems • Developed to optimise production • Less machines on site, usually with single directional movement for each activity • Brought to site by train (possession can be taken around them) • Higher production rates enable higher renewal output per shift	• Lower capability to undertake multiple activities • Failure of machine can cause catastrophic breakdown of operations. • Expensive to maintain (by comparison to RRM's) • High investment, hence higher shift rate for hire • Less flexible in movement on site

4.1 Asset Management

A move towards the use of bespoke on track machinery will avoid the high cost of providing suitable access points required for RRM type equipment.

It will also avoid the risk of damage caused to infrastructure components such as signalling cables and sleepers as a result of the machines traversing the infrastructure during engineering works.

4.2 Efficiency Savings

The efficiency savings indicated by the models in Appendix A demonstrate the efficiency that can be achieved by using bespoke plant and equipment. In previous work undertaken in 2007 by Lloyds Register Rail for the ORR, an efficiency improvement averaging 33% was shown for five different track renewal work categories.

4.3 Life Cycle Costs

As noted above, the transfer from use of RRMs to bespoke plant reduces the risk of infrastructure damage during track renewal work. This risk is reduced due to:

- Removal of requirement to on- and off-track at access points eliminates risk of line-side equipment such as signalling and power cables being damaged;
- Removal of requirement to on- and off-track at access points eliminates risk of track components being damaged during the transfer from road to rail wheels;
- Delivery to site by train reduces the risks of general infrastructure damage during extended transits by RRMs from access point; and
- Reduction in number of machines and complexity of site movements reduces the risk of points run-throughs.

In addition, bespoke plant is by its nature designed to correctly handle the specific components at each stage of the renewal. As a result, there is less installation damage caused, resulting in higher likelihood of the theoretical life span being achieved.

5.0 SAFETY ISSUES

The following risks and potential consequences have been identified from numerous incidents involving RRM's over the last decade.

Risk	Potential Consequences
RRM strikes infrastructure or staff on work site	Injuries or fatalities, possible derailment, train delays whilst repairs are effected
Objects hauled by machine strikes infrastructure or staff on site	Injuries or fatalities, possible derailment, train delays whilst repairs are effected
RRM skids, unable to stop or aquaplanes along track	Collision with other machine, staff or possible derailment, safety related costs
RRM runs away through brake failure or incorrect operation	Collision with other machine, staff or possible derailment, safety related costs
RRM moves in wrong direction through miscommunication.	Rail traffic safety compromised, collision with staff or other objects, safety related costs
RRM's collide through lack of control on site	Collision with other machine, staff or possible derailment, safety related costs
RRM's collide through numbers being used in confined sites	Collision with other machine, staff or possible derailment, safety related costs
RRM not on- or off-tracked correctly	Injuries or fatalities

The use of bespoke machines reduces these risks as:
- Number of items of plant are reduced;
- Number of potential movement that require managing are reduced;
- Access and egress requirements are simplified; and
- Machines are specifically designed for the railway environment with suitable control mechanisms inherent within the design.

6.0 IMPLEMENTATION INTO GREAT BRITAIN

6.1 Estimated Implementation Duration

The refurbishment and reintroduction into service of existing bespoke on-track machinery can generally be achieved in timescales of between six to twelve months. The period from procurement through to full implementation of new machinery varies depending on the complexity and novelty of the item of plant. Recent experience indicates that a time frame of two years is reasonable. It is worth noting that a number of different types of bespoke plant items have already successfully completed the safety validation and product approval processes, including Kirow rail cranes and Slinger trains.

6.2 Constraints and Dependencies

Since privatisation, few items of new bespoke on-track plant have been procured by contractors to undertake renewals. Where this has happened, industry constraints have often resulted in lower than planned utilisation of them. The reasons for this are seen as:
- High capital cost of procuring bespoke on track machines compared with lower hire cost from RRM plant suppliers;
- Conflicting messages to the industry about whether they should invest in specialised bespoke rail plant;
- In Britain track renewal contractors have to rely on a single client, whereas their European counterparts have the potential for work for several Infrastructure Managers;
- Restraint by contractors who risk being removed from track renewal works thus looking for early returns on investment to address uncertainty over the longer term;
- General lack of detailed renewals knowledge by the industry and a widespread belief that RRM's provide the most efficient renewal solution in all situations;
- A lack of industry understanding about the availability and capability of bespoke on-track machines when compared to RRM equipment; and
- Plant being procured without the necessary adjustments in renewals methodologies to optimise plant use and minimise costs of production.

To achieve the transfer towards more extensive use of bespoke plant instead of RRM machines will not be easy. It will require:
- Leadership for the change needs to be shown by the various stakeholders;
- Encouragement to procure the plant will have to be given to the contractors, supported by appropriate industry stability; and
- Improved communication at all levels to demonstrate the clear benefits of using bespoke plant and its capabilities.

6.3 Investment Requirements

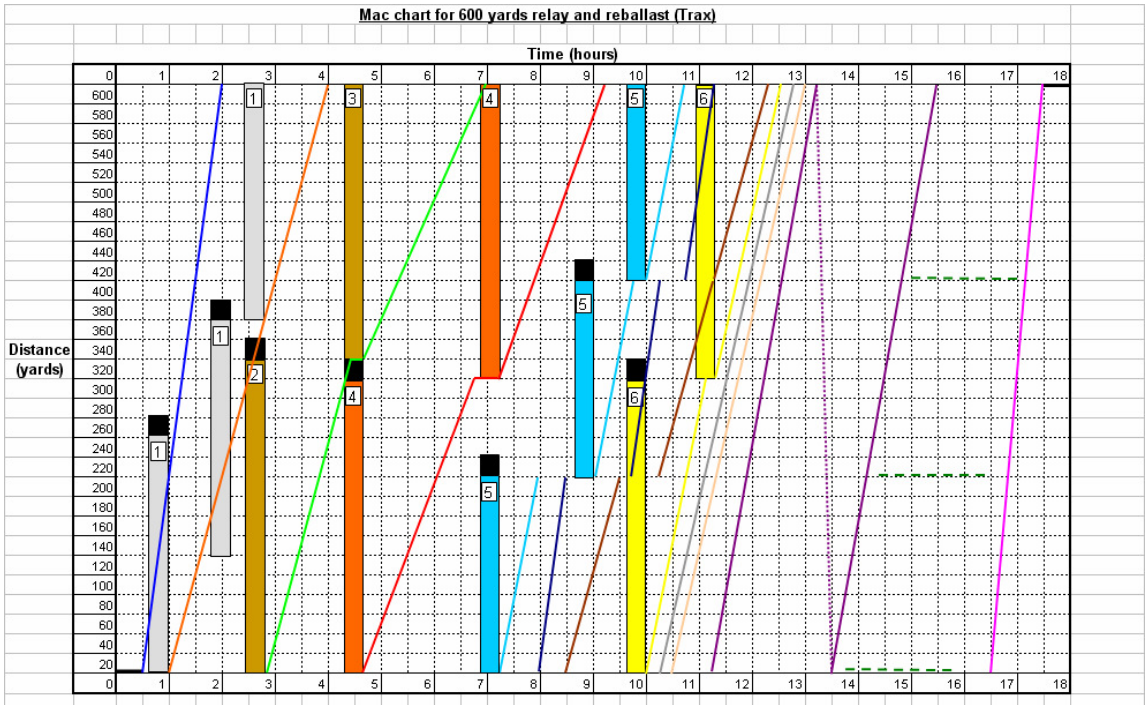
Investment in refurbished or new plant can vary from £150k to several million for more advanced equipment. Examples of approximate procurement figures for bespoke large rail cranes are approximately £1.8m to £2.5m depending on capacity. A bespoke ballast excavation machine is currently being developed at a cost of £3.1m.

APPENDIX A

Model 1 (RRM conventional track removal and reballasting, Slinger insertion of sleepers)

Cost per metre = £521 metre
Lloyds Register rates used late 2006/2007

MAC Chart



Sequence of operations and timings

00:00 - 00:30	Take possession	
00:30 - 02:00	Cut track into 60 foot panels and disconnect S&T	(62 cuts - 2 burning teams / 4 burners @3 mins per burn)
01:00 - 04:00	Remove 60 foot track panels with 2 x Monster Bugs (working off line of renewal)	(30 panels @ 6 mins per panel - includes train movements)
02:45 - 07:00	Remove spoil to wagons on adjacent line (3 excavators for first 15 lengths - 2 excavators for second 15 lengths)	
	(rate of 3 lengths per hour per machine - train movement times included)	
04:40 - 09:10	Insert bottom ballast doze and compact	
	(rate of 7 lengths per hour - train movement times included)	
07:10 - 10:45	Install sleepers with slinger train	(45 mins per 10 lengths includes placing loose sleepers)
08:00 - 11:15	Thimble in rails	(30 minutes per pair of rails)
08:30 - 12:15	Clamp rails and fasten down	(10 lengths per hour)
10:00 - 12:30	Unload top stone from opens on adjacent line	(45 mins per 10 lengths + 1 train movement)
10:15 - 12:45	Regulate / brush ballast	(Follow through after stone dropped)
10:30 - 13:00	Mark up for tamper	
11:15 - 13:15	First Tamp	(15 lengths per hour)
13:30 - 15:30	Second Tamp	(15 lengths per hour)
13:45 - 17:00	Weld (6 number welds) and reconnect S&T	(3 teams at 1 hour per weld)
16:30 - 17:30	S&T testing	
17:30 - 18:00	Give up possession	

Plant resources

2 x RRV Monster bugs
Excavators x 5
Dozer x 2
Triple wacker plate
Slinger train
Cembre clippers x 2
Tamper
Ballast brush and thimble

Trains

1	Loco + 12 salmon wagons
2	Loco + empty spoil
3	Loco + empty spoil
4	Loco + loaded ballast (opens)
5	Slinger train (10 wagons)
6	Loco + loaded ballast (opens)
7	Tamper

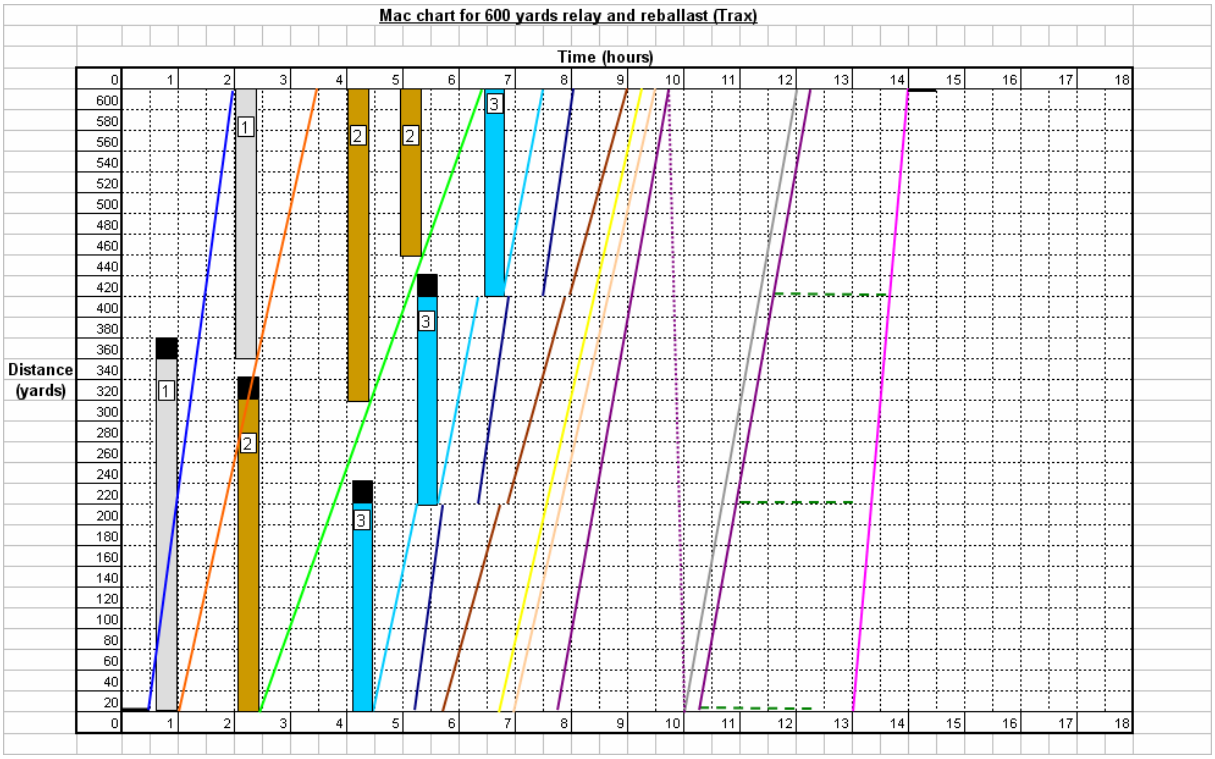
Cost Model

Plain Line Track Renewals		600yds in 18 hours + 8 hour Sunday night						
Resource estimate for relay and reballast Trax (Cat 11)								
					Vol	No.	Total	
Mid week site preparation								
Labour	Coss		275	per shift	2	2	1100	Assumes 10 hour shift
	Trackmen		225	per shift	9	2	4050	
	S&T		300	per shift	2	2	1200	
	Supervisor/technical		300	per shift	2	2	1200	
	Possession management		750	per shift	1	2	1500	
Weekend								
Labour	Coss		275	per shift	2	2	1100	Assumes 10 hour shift
	Trackmen		225	per shift	16	2	7200	
	Welding team		1480	per shift	3	1	4440	
	S&T		300	per shift	2	2	1200	
	Site supervision/technical		300	per shift	3	2	1800	
	Possession management		750	per shift	1	2	1500	
Plant	Dozer		1300	per shift	2	1	2600	Includes delivery
	Road/railer		1300	per shift	5	1	6500	
	Triple wacker		265	per shift	1	1	265	
	Monster bugs		2000	per shift	2	1	4000	
	Slinger		20000	per shift	1	1	20000	
	Tamper		9000	per shift	1	1	9000	
	Ballast brush		100	per shift	1	1	100	
	Thimble		50	per shift	1	1	50	
	Cembre clippers		100	per shift	2	2	400	
	Stressing gear		250	per shift	1	1	250	
	Small plant, lighting		2000	per shift	1	3	6000	
Materials	All in unit rate		154	per yard	600	1	92400	
Freight Haulage	Panel train		350	per hour	10	1	3500	
	Spoil		350	per hour	10	2	7000	
	Bottom ballast		350	per hour	10	1	3500	
	Top ballast		350	per hour	10	1	3500	
	CWR train		350	per hour	8	1	2800	
						20300		
Sun night follow up (8 hours)								
Labour	Coss		275	per shift	2	1	550	Assumes 10 hour shift
	Trackmen		225	per shift	16	1	3600	
	Welding team		1480	per shift	1	1	1480	
	S&T		300	per shift	2	1	600	
	Site supervision/technical		300	per shift	2	1	600	
	Possession management		750	per shift	1	1	750	
Midweek speed off tamp								
	Tamper		9000	per shift	1	1	9000	
Totals								
	Nett rate						204735	
	Prelims		15	%			13805	Not applied to F & M
	Design		12	%			19000	Not applied to F & M
	Contingency		5	%			10237	
	Profit and o/h		15	%			24000	Not applied to F & M
	Risk		8	%			14000	
	Selling rate						285777	
					Cost per linear metre		£521	

Model 2 (Bespoke machinery removes and reinstates track and undertakes reballasting operations)

Cost per metre = £518 metre

MAC Chart



Sequence of operations and timings

00:00 - 00:30		Take possession
00:30 - 02:00		Cut track into 60 foot panels and disconnect S&T (62 cuts - 2 burning teams / 4 burners @3 mins per burn)
01:00 - 03:30		Remove 60 foot track panels with Kirow 250 track tiger (working off line of renew (30 panels @ 3 mins per panel - includes train movements)
03:45 - 07:45		Reballast with Bespoke reballasting equipment (150 metres per hour)
04:30 - 07:30		Install sleepers with slinger train (60 mins per 10 lengths includes placing loose sleepers and train movements)
05:15 - 08:00		Thimble in rails (30 minutes per pair of rails)
05:45 - 09:00		Clamp rails and fasten down (10 lengths per hour)
06:45 - 09:15		Unload stone with skako wagons on line of rene (Rate = 500yds/hour - speed goverened by preceding clipping up process)
07:00 - 09:30		Mark up for tamper
07:45 - 09:45		First Tamp (15 lengths per hour)
10:00 - 12:00		Regulate / brush ballast (Follow through after first tamp)
10:15 - 12:15		Second Tamp (15 lengths per hour)
10:15 - 13:45		Weld (6 number welds) and reconnect S&T (3 teams at 1 hour per weld)
13:00 - 14:00		S&T testing
14:00 - 14:30		Give up possession

Plant resources

Kirow 250 Track Tiger
Bespoke Reballasting Machine
Slinger train
Cembre clippers x 2
Tamper
RRV with ballast brush and thimble

Trains

1 Loco + 17 salmon wagons
2 Loco + bespoke wagons
3 Slinger train (10 wagons)
4 Loco + skako wagons
5 Tamper

Cost Model

Plain Line Track Renewals		600yds in 18 hours + 8 hour Sunday night					
Resource estimate for relay and reballast Trax (Cat 11)							
				Vol	No.	Total	
Mid week site preparation							
Labour	Coss	275	per shift	2	2	1100	Assumes 10 hour shift
	Trackmen	225	per shift	9	2	4050	
	S&T	300	per shift	2	2	1200	
	Supervisor/technical	300	per shift	2	2	1200	
	Possession management	750	per shift	1	2	1500	
Weekend							
Labour	Coss	275	per shift	2	2	1100	Assumes 10 hour shift
	Trackmen	225	per shift	16	2	7200	
	Welding team	1480	per shift	3	1	4440	
	S&T	300	per shift	2	2	1200	
	Site supervision/technical	300	per shift	3	2	1800	
	Possession management	750	per shift	1	2	1500	
Plant	Bespoke reballasting machine	12000	per shift	1	1	12000	
	Road/railer	1300	per shift	1	1	1300	
	Triple wacker	265	per shift	0	1	0	
	Kirow 250	5000	per shift	1	1	5000	
	Slinger	20000	per shift	1	1	20000	
	Tamper	9000	per shift	1	1	9000	
	Ballast brush	100	per shift	1	1	100	
	Thimble	50	per shift	1	1	50	
	Cembre clippers	100	per shift	2	2	400	
	Stressing gear	250	per shift	1	1	250	
	Small plant, lighting	2000	per shift	1	3	6000	
Materials	All in unit rate	154	per yard	600	1	92400	
Freight Haulage	Panel train	350	per hour	10	1	3500	
	Bespoke wagon train	350	per hour	10	1	3500	
	Skako Train	350	per hour	10	1	3500	
	CWR train	350	per hour	8	1	2800	
					13300		
Sun night follow up (8 hours)							
Labour	Coss	275	per shift	2	1	550	Assumes 10 hour shift
	Trackmen	225	per shift	16	1	3600	
	Welding team	1480	per shift	1	1	1480	
	S&T	300	per shift	2	1	600	
	Site supervision/technical	300	per shift	2	1	600	
	Possession management	750	per shift	1	1	750	
Midweek speed off tamp							
	Tamper	9000	per shift	1	1	9000	
Totals							
	Nett rate					202670	
	Prelims	15	%			14546	Not applied to F & M
	Design	12	%			19000	Not applied to F & M
	Contingency	5	%			10134	
	Profit and o/h	15	%			24000	Not applied to F & M
	Risk	8	%			14000	
	Selling rate					284349	
				Cost per linear metre		£518	

Balfour Beatty
Rail