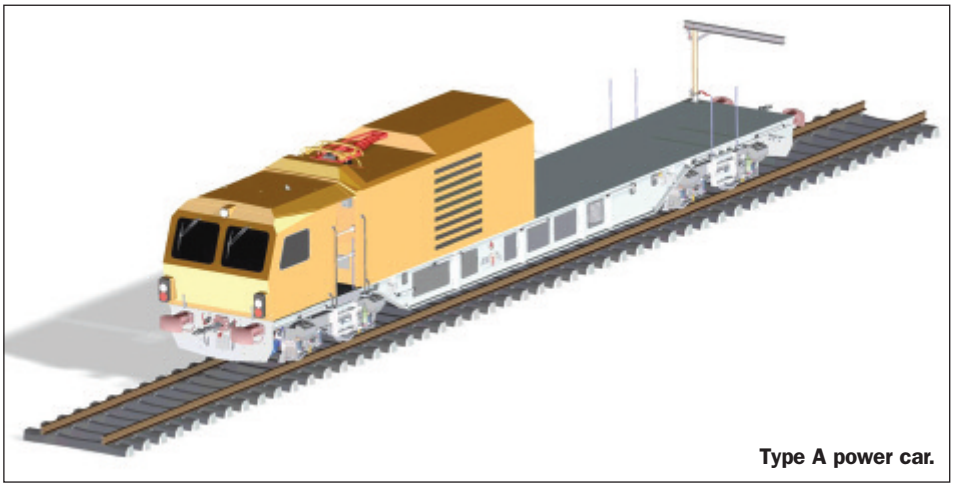
Crossrail's new engineering trains

Plasser UK's Mark Simmons details the group of machines that have been ordered and their uses.

Rail for London has ordered two engineering trains from Plasser UK. These multifunctional, modular on-track machines will be used to carry out a number of maintenance tasks essential to the smooth operation of the tunnel section of Crossrail (Elizabeth Line). The trains, Robel model 40.55, will be built at the company's factory in Freilassing, Germany. In total, the delivery will consist of four power vehicles and two modular transport wagons which can be configured together to form trains to carry out specific maintenance tasks. There will be three types of power vehicle which will all include a driving cabin at one end and have four hydrostatically-driven axles in two bogies.



Type A power car.

The vehicles

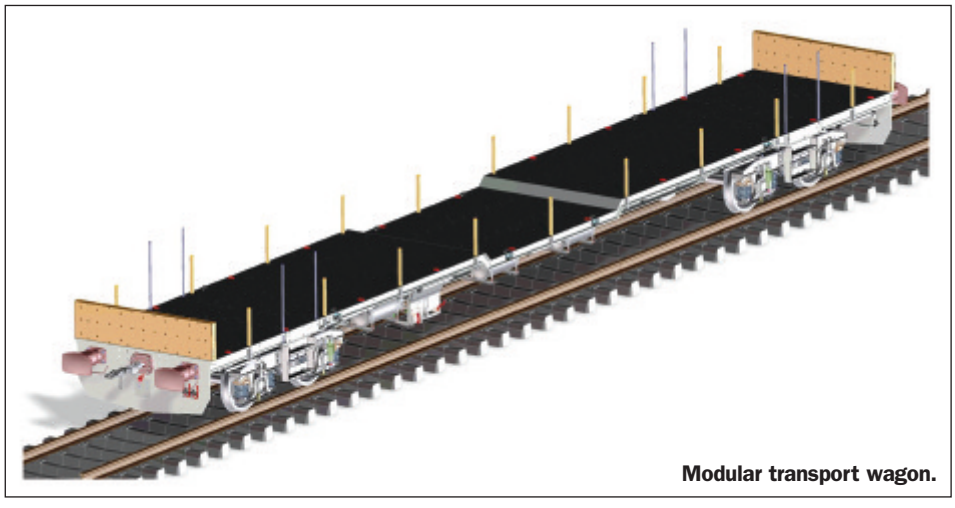
Power car type A has a large loading area at the rear and there will be two type B variants which will have a reduced loading area. Additionally, the latter will have a mess room with transit seating for 12 operators, a microwave, kettle, toilet and hand-washing facilities. The last power car - the type E - will also be equipped with a Palfinger crane mounted at the rear. Along with the transport wagons, which will be fitted with twist-locks, will be a number of modules. These modules will be set up for each task the engineering train will be allocated. There will also be a manual gantry system for the replacement of half-sets of switches, a scissors lift access platform and wiring drum for OLE work, plus a drainage-cleaning module.

Type B power car.

Configurations

To configure a train requires one power vehicle with the driving cabins at each end of the formation. At least one of these will be a type B power vehicle to carry the operational staff. In-between can be none, one or two modular transport wagons depending on the task to be undertaken. For example, to replace a half-set of switches will require a type B power car, two modular transport wagons including the gantry system and one other power vehicle of any type. To replace a single rail section will require a type B power vehicle, one modular transport vehicle and a type E power car that is fitted with the crane for handling the lengths of rail. For OLE replacement, the requirement will be a type B power vehicle, one transport wagon for the OLE materials, another transport wagon fitted with the scissors lift and cable drum and one power vehicle of any type. Drain cleaning will be carried out with a similar configuration, but the drainage module will take the place of the OLE modules.

Type E power car.



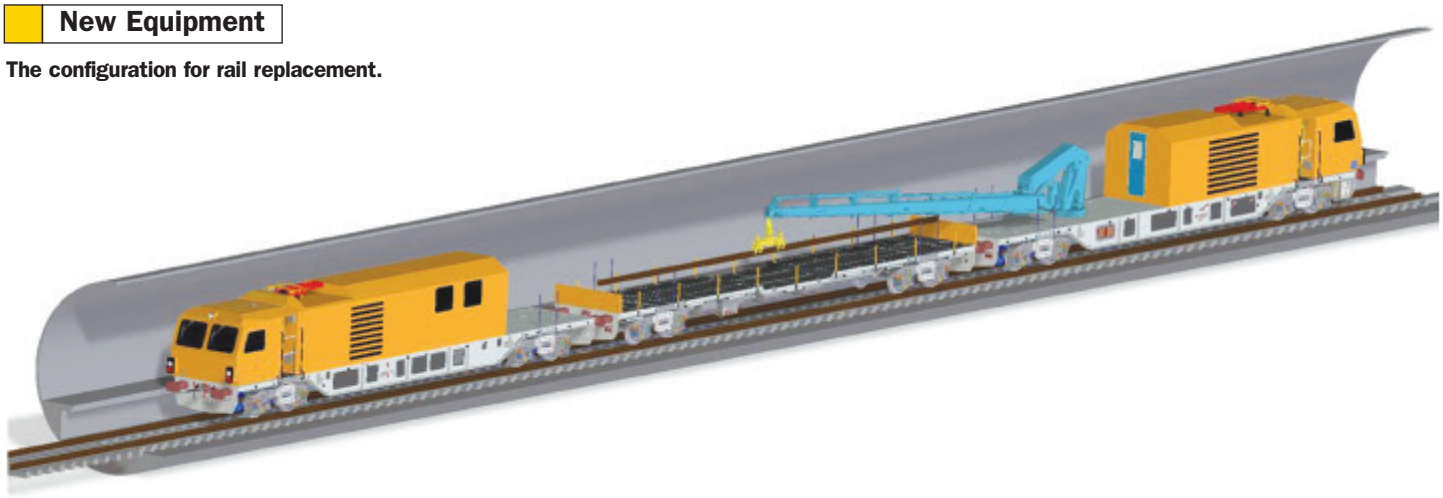
Modular transport wagon.

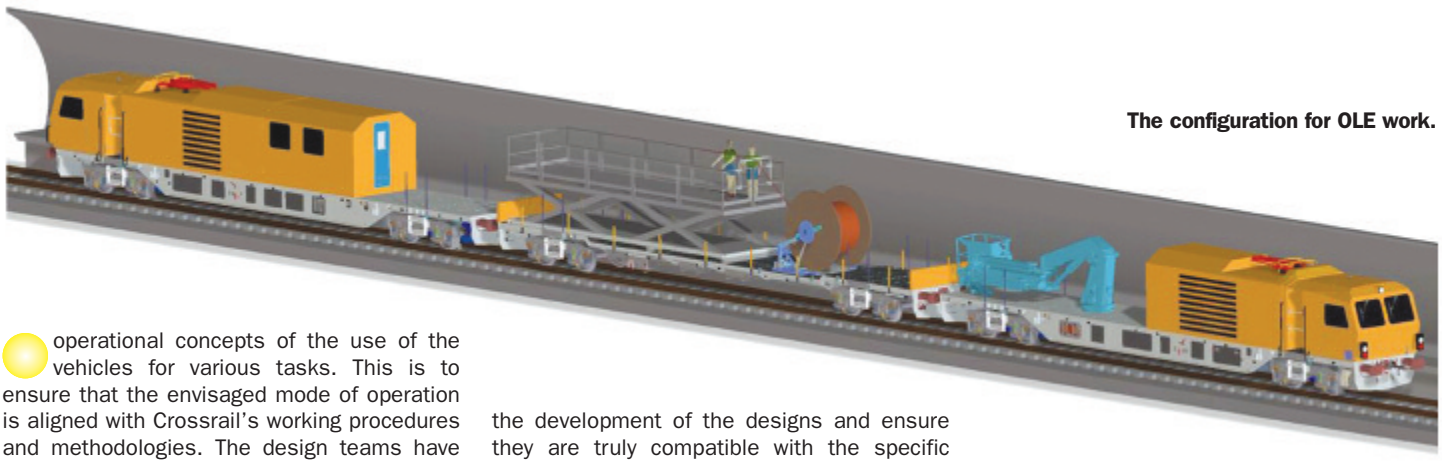
Of course, the vehicles will also be able to be used for a number of other routine maintenance tasks, for example cleaning the platform doors or loading/unloading equipment - such as replacement transformers - on to platforms in the tunnels.

Work begins

The preliminary design phase of the project is now well under way with regular progress review meetings, technical queries and reviews and submission of documents. In fact, as part of this review process, the teams have met to discuss the detailed

The configuration for rail replacement.





The configuration for OLE work.

operational concepts of the use of the vehicles for various tasks. This is to ensure that the envisaged mode of operation is aligned with Crossrail's working procedures and methodologies. The design teams have also had their first opportunity to walk through the Crossrail tunnel system to experience at first-hand what they have only seen in drawings or photographs. This will help with the development of the designs and ensure they are truly compatible with the specific environment of the Crossrail tunnels.

The first unit will be delivered into service in August 2018 and the second by the end of September 2018. Of course, readers of *Rail Infrastructure* will be kept up-to-date on the progress of the machines once the detailed designs begin to transform into metal.

Multi-functional maintenance trains for the Elizabeth Line

Andrew Keens, Track Consultant, AJK Rail, details the new Robel equipment Plasser UK is supplying.

The Elizabeth Line is scheduled to open in December 2018. Key to Transport for London's future operation of the new railway is the commissioning of the fleet of multi-purpose maintenance trains to undertake essential inspection and maintenance works as well as rapid response.

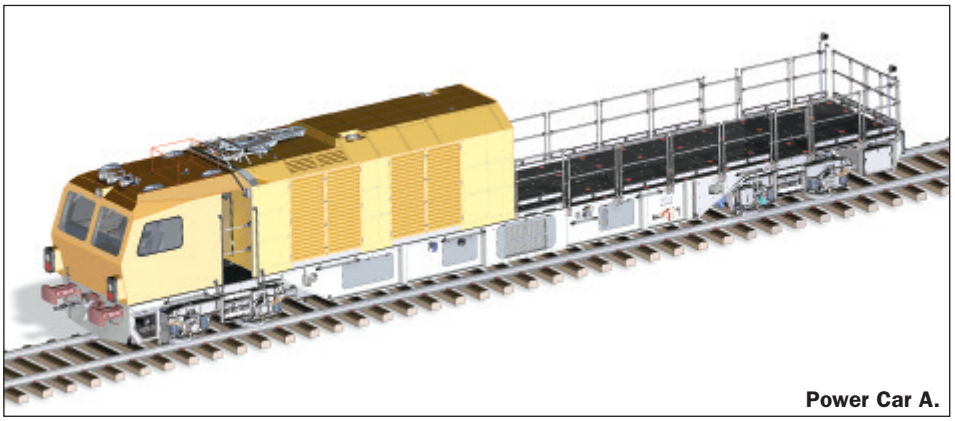
Contract award

Readers will recall in *Rail Infrastructure* Issue No: 114 the announcement that Transport for London had awarded the contract to Plasser UK to manufacture two multi-functional Robel maintenance trains. The trains are being designed to undertake a range of maintenance activities on the Elizabeth Line's central operating section. From rail replacement to asset inspection, equipment delivery to ultrasonic and track geometry recording, conductor wire replacement to drain jetting - these trains are designed to do it all.

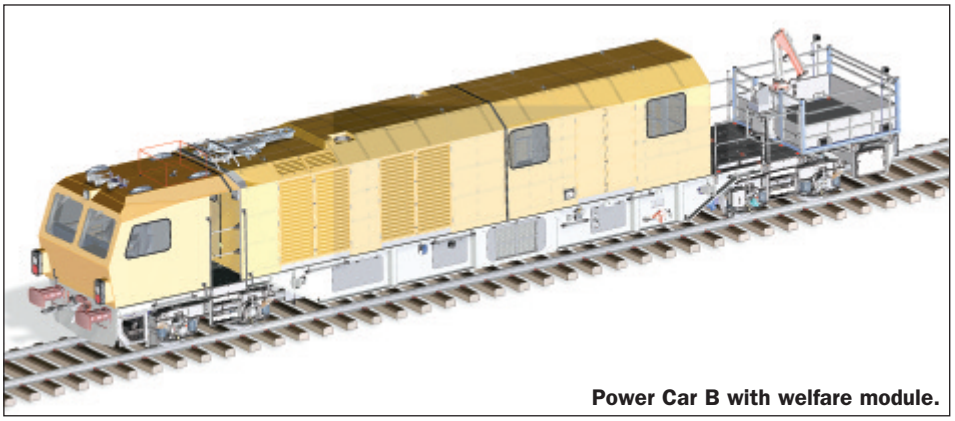
Key to this operational flexibility is a modular approach in the design of the transport wagons and power car units. The train has a basic consist of two power cars, a master and slave unit, but thereafter any configuration is possible. The power car will be built to W6A gauge and route availability 5. It is designed to be a base unit readily adaptable for all potential future market opportunities in the UK, such as seasonal treatment capability, OHL inspection and maintenance, drainage maintenance, vegetation clearance and mobile maintenance concepts.

One of the main challenges for the design team was the delivery and installation of Switch and Crossing (S&C) units inside the confined area of the central operating tunnel within a four-hour possession time. With the largest component being a G switch at nearly 6 tonnes in weight and 33 metres in length, conventional tandem lifting using cranes within the tunnel was not possible. A gantry and trolley system is, therefore, going to be used to collect S&C from the lineside storage cavern, transit to the junction and exchange the units on-site.

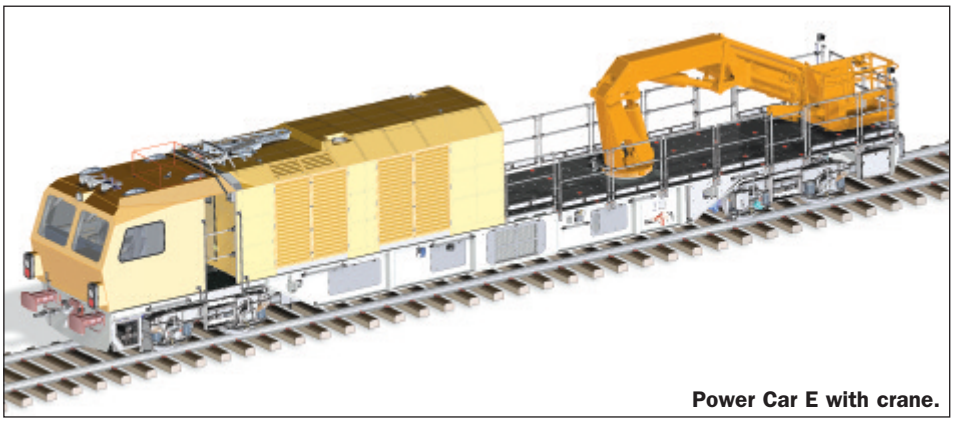
For a more efficient and safer operation, the gantries will be pre-assembled and delivered to site on a special 'gantry loading and off-loading device'. This is a modular unit, carrying six assembled gantries, which will be loaded on to Power Car A platform and secured with standard twist locks. This system employs special lifting and tipping armatures, which locate on the gantry crossbeam and permit automatic lifting and positioning of the gantry from the Power Car A on to the worksite. The proposed system will greatly reduce manual handling and the time to assemble the gantries and thereby deliver a safer and quicker process of operation.



Power Car A.



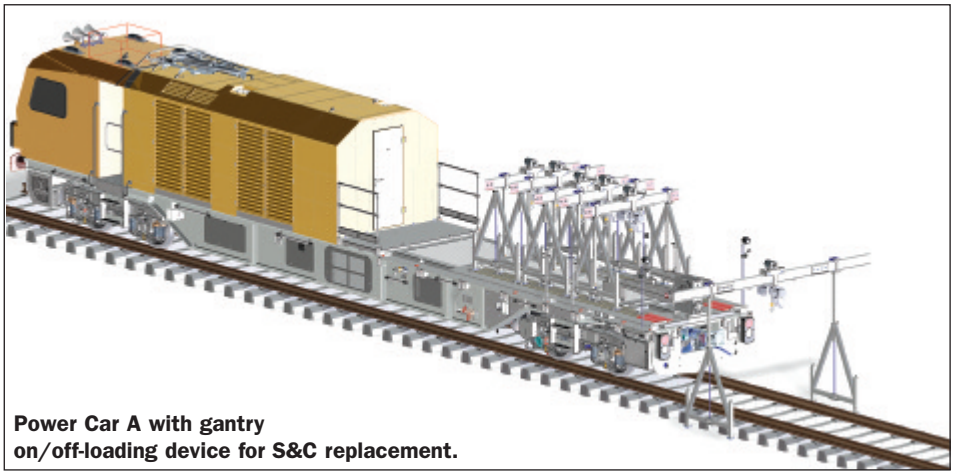
Power Car B with welfare module.



Power Car E with crane.

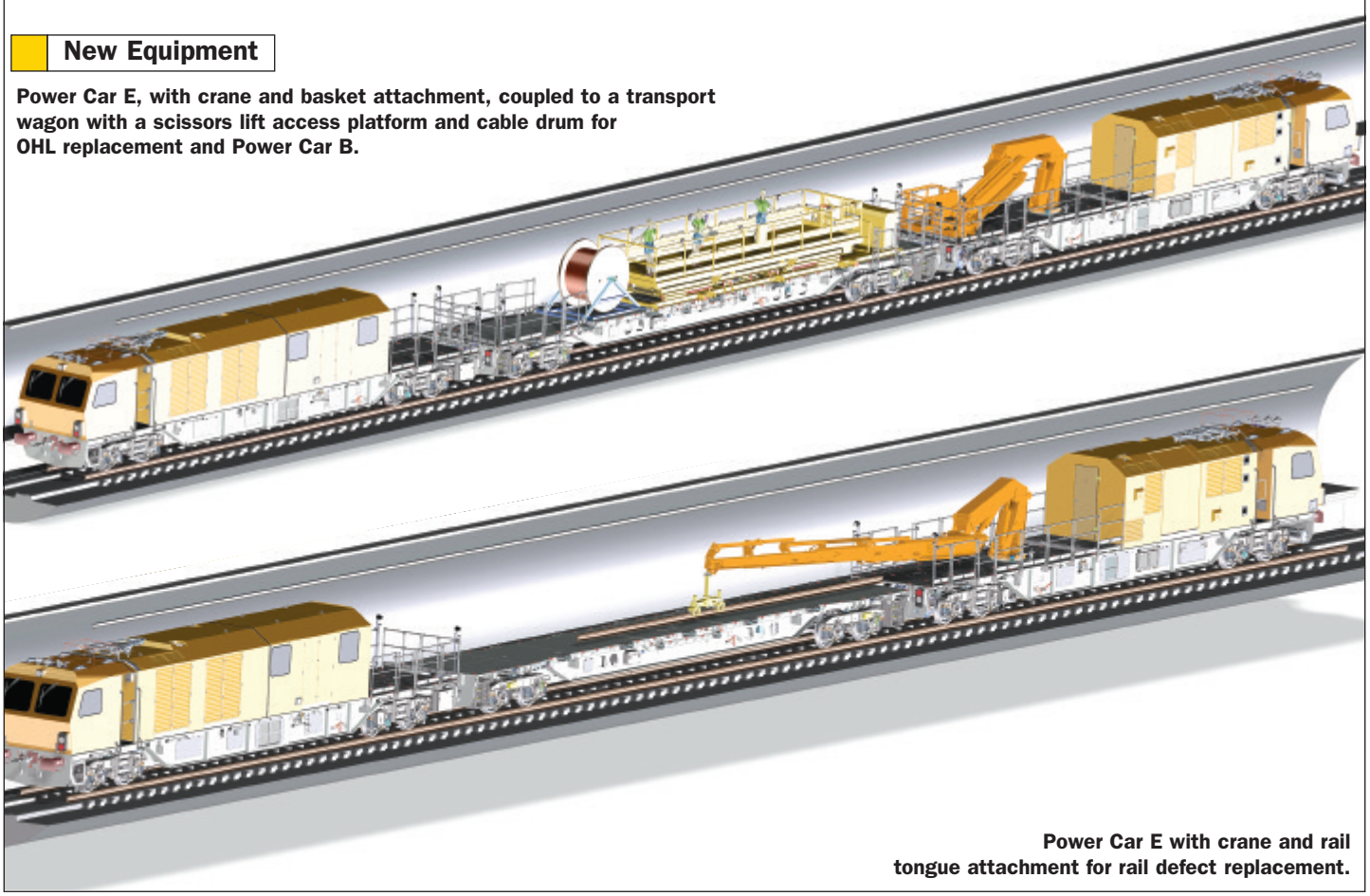
The vehicles and equipment required for the contract are as follows:

- One Power Car A - providing a large working platform with twist locks for maximised storage and an integrated automatic off-loading device for the gantry system. To minimise emissions, an important consideration in the design of the power cars, particularly when working in tunnel sections, was the decision to use a hydrostatic transmission.
- Two Power Cars B - with transport and welfare for a total of 12 people on each and smaller working platform.
- One Power Car E - with integrated crane with an optional basket attachment.
- Two transport wagons fitted with twist locks for modular attachments including scissors lift, drainage vacuum system and cable drum. These wagons will be designed to carry a variety of equipment including S&C units up to 33 metres in length, platform glass screens and 7 tonne transformers.
- One transport wagon specially adapted for the recording of track geometry and ultrasonic rail testing.
- Gantry off-loading and loading device as an optional fitment on Power Car A.
- A gantry system for the replacement of S&C units.



Power Car A with gantry on/off-loading device for S&C replacement.

Power Car E, with crane and basket attachment, coupled to a transport wagon with a scissors lift access platform and cable drum for OHL replacement and Power Car B.



Power Car E with crane and rail tongue attachment for rail defect replacement.

Technical assurance and detailed design

In order to manage a progressive assurance process, and thereby demonstrate compliance with the Technical Requirement Specification (TRS), the design team submitted a Technical Assurance Plan (TAP) covering all key elements from design and manufacture to testing, commissioning and final takeover. Essentially, the TAP contains the system engineering techniques to be used in the assurance process including the 'V' life-cycle model and associated gate stage reviews.

To pass the design gate stage, a key requirement is conformance with engineering safety management regulations, which include the Common Safety Method on Risk Evaluation and Assessment (CSM-REA) and Reliability, Availability and Maintainability (RAM) assessment.

As part of the CSM-REA regulations, the project team - working closely with Crossrail Limited who are delivering the Elizabeth Line central section and under the direction of NoBo/DeBo SNC-Lavalin - have undertaken a series of hazard identification workshops to ascertain all potential operational risks, documenting them in a hazard log. The project team have then been working hard to develop design measures to manage the risk to as low as reasonably practicable. Any residual risk is then to be mitigated with operational procedures.

The Robel design team have also developed a RAM plan. Essentially, this sets out how they will reach the meantime between service affecting failures and shift completion rate as stipulated in the TRS. This includes a review of all potential failures, mapping out design contingency, scheduled and preventative maintenance plans and evaluation of the parts and spares strategy.

From design to production

At the Robel works in Freilassing, Germany, the detailed design stage for Power Cars A, B and E has now been successfully

Above: Power Car B's sub-frame with the pneumatic system fitted.

Right: Power Car E's sub-frame with Deutz engines, hydraulic, pneumatic and electrical systems fitted.

Right: The driver's cab for Power Car E being painted.

Below: The driver's cab and machine room positioned on the main frame of Power Car E.

concluded and the project has moved on to the production stage for these elements.

Power Car E, the traction supply unit with the crane, was the first vehicle on the production line. Fabrication and assembly of the sub-frame, driver's cab and machine room is now all complete together with the installation of all hydraulic, pneumatic and electrical systems. The two Deutz engines (16.0l V8 520kW and 7.8l V6 240kW) have been fitted along with the hydrostatic transmission, 1,000 litre fuel tank and bogies. With all quality assurance checks now completed, the frames are currently being disassembled ready for painting. At the time of writing, the first driving cab had received its undercoat. Meanwhile, work continues on schedule with Power Car E which is due for completion in August.

The first of the two Power Car B (the traction supply with the welfare centre) is also now well under construction. The main frame, and frames for the driver's cab, machine room and welfare centre are all near to completion. The pneumatic systems have just recently been fitted, with the hydraulic and electric to follow shortly. The sub-frame will then be turned and the cab, machine and welfare rooms pre-assembled.

The second Power Car B and Power Car A are now at the pre-fabrication stage with final assembly scheduled for October and December, respectively.

The completion of the design stage for all elements of the build was in July. The build on the transport wagons is set to commence this summer with completion later in the year. The gantry off-loading device and gantries build is also due for completion by the end of the year.

The project plan is complex with the high demands at the design stage to stay in accordance with the technical assurance plan, but the key stages in design and production remain on schedule. It is on plan to enter the commissioning and approvals phase in early 2018 followed by the first unit's delivery to Plasser UK at West Ealing in summer 2018 with the second unit thereafter.

Multi-functional maintenance trains for the Elizabeth Line - update

AJK Rail's Andrew Keens details the latest progress on the new Robel equipment Plasser UK is supplying.

The last issue of *Rail Infrastructure* gave a detailed report on the engineering trains currently being built by Robel for inspection and maintenance tasks on the new Elizabeth Line scheduled to open in December 2018. To quickly recap, in August 2016, Plasser UK was awarded the contract by Crossrail to deliver two engineering trains to carry out a multitude of work tasks:

- Inspection, maintenance and renewal of the rigid overhead catenary system.
- Replacement of switches and crossings.
- Replacement of 20 metre rail lengths.
- Jetting and vacuum clearance of the drainage system.
- Platform glass screen cleaning.
- High level tunnel access for inspection and repair.
- General transportation of material, plant and workforce.
- Emergency recovery of other Crossrail vehicles.

Robel is acting as subcontractor to Plasser UK for the design and construction of the trains. To maximise fleet utilisation, Robel has developed a modular, multi-functional design solution consisting of four power cars of three types (A, B and E) and three transport wagons, accompanied by a number of modules.

Power Car E - viewed from the front (above) showing the completion of painting, assembly of all major component including bogies, engine and transmission system and final assembly of hydraulic, electric and pneumatic systems. The crane installation at the rear (below).

Latest progress

Since the last update there has been significant progress with a number of key build milestones achieved in the design and construction of the power cars. Approval of the detailed design, known as 'design freeze', of the core vehicle fleet has been one key milestone achieved following the hard work of the Robel design team through the rigorous assurance process.

With regard to the actual construction, build on Power Car A, the traction supply unit with large loading platform, is now in pre-assembly phase and stands at 10% completion. Power Car B (No: 2) has also now commenced in to pre-assembly, and stands at 10% completion. Power Car B (No: 1), with the welfare module, has moved from

Power Car A - the driver's cab welded and ready for painting (above left) and the pre-assembled engine room (above right).

Power Car A - the subframe complete with part assembly of hydraulic, electric and pneumatic systems, prior to strip down and painting.

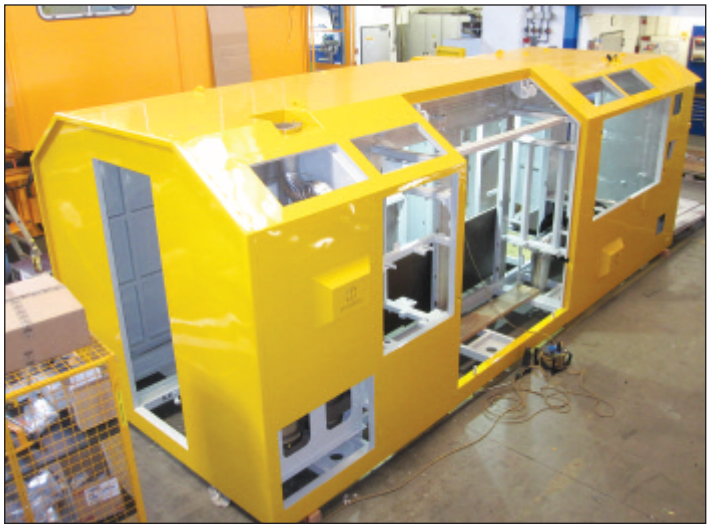
pre-assembly and is now going through the painting phase. Production on this vehicle currently stands at 50% completion. Power Car E, which is fitted with a crane, has now progressed into final assembly and stands at 70% completion.

The next two months will see another major milestone with build completion of Power Car E and Power Car B (No: 1), allowing progression to the testing and commissioning phase. Power Car B (No: 2) and Power Car A will enter final assembly and the construction of the transport wagons will commence with the assembly of their parts.

Power Car B (No: 2) - the driver's cab after painting (above left) and the engine room and welfare module frame before painting (above right).

Power Car B (No: 2) - the subframe complete with part assembly of hydraulic, electric and pneumatic systems, prior to strip down and painting (above).

Power Car B (No: 1) - the painted subframe with the coupling installed and part installation of hydraulic, electric and pneumatic systems (above).



Power Car B (No: 1) - the painted cab and start of final assembly (above left) and welfare module painted and start of final assembly (above right).

Multifunctional maintenance trains for the Elizabeth Line - update

AJK Rail's Andrew Keens details the latest progress on the new Robel equipment Plasser UK is supplying.

Throughout this year, *Rail Infrastructure* has given regular updates on the design and build of the new engineering trains and equipment being built by Robel for maintenance on Transport for London's (TfL's) Elizabeth Line. AJK Rail's Andrew Keens recently had the opportunity to speak to Crossrail's Project Manager Stuart Hines-Randle and Lead Plant Engineer Chris Parker to gain further insight on the project from the front line of operations as they gear up for services next year.

Above: Power Car E being put through its paces at Robel's workshops at Frielassing, Germany, during the commissioning of the vehicle.

Below: Testing of the crane and access platform basket on Power Car E.

Crossrail's view of the project

Andrew: Given the basic contract, how do the trains integrate into the delivery of the project?

Stuart: 'Robel has been contracted to design, manufacture and deliver two engineering trains to enable Rail for London to meet the demanding maintenance requirements of the Elizabeth Line. There are a number of requirements that the engineering vehicles need to meet including track and Switch and Crossing replacements, OLE repairs, drainage clearance and carrying infrastructure monitoring equipment.'

Andrew: Why are these trains being introduced for maintenance work?

Chris: 'One of Rail for London's key aspirations is to change existing maintenance practices for the better. Improvement in safety and efficiency is critical to the successful operation of the Elizabeth Line. The engineering trains are at the centre of this initiative, providing innovative new methods of undertaking delivering maintenance more safely and speedily than would otherwise be possible.'

Andrew: What will be the engineering train's main tasks?

Chris: 'The engineering trains will be used almost every night to conduct maintenance of almost everything within the tunnels, mainly track and overhead line. They will generally be operated as one train for overhead line and one for track, but with the capability to reconfigure to undertake specialist tasks, such as replacement of switch rails.'

Andrew: What are the restrictions in working on the Elizabeth Line and what design innovations have been developed to meet these challenges?

Chris: 'Simply put, the main challenges for maintenance on the Elizabeth Line are time and space. All maintenance activities need to be completed in overnight engineering hours and working in tunnels places unique constraints on the ways in which it is done. For example, there is a need to replace critical switches and crossings over night. There is not sufficient space to bring in a crane capable of lifting the switch components (which are 33 metres long and weigh

Left: View of the inside of the driver's cab of Power Car E.

Right: The build of Power Car B No. 1 is nearing completion.

nearly 6 tonnes). To enable work to be done, Robel has designed a unique gantry system, integrated with the engineering train to lift, replace and remove the switch rails safely and efficiently within engineering hours, with no impact on passenger services.'

Andrew: What have been the most challenging tasks of the project so far?

Stuart: 'A major challenge is fitting bespoke in-cab signalling equipment to the trains. We are particularly impressed with the proactive and positive manner in which Robel is working with our signalling supplier. It is great to work alongside a team that is passionate and so experienced about rail maintenance plant and who can design out issues to complex maintenance challenges with imaginative technology.'

Above: The welfare area in Power Car B No. 1 being fitted out. Once completed, it will be able to accomodate up to 12 people.

Andrew: How is the project going?

Stuart: 'The project is progressing quickly. One power car is already in the commissioning phase, just over a year after the contract commenced, with the other three close behind. The next stage is the most exciting for TfL with the static testing starting in January 2018 followed by dynamic testing in February 2018.'

Latest progress

To get more detail on the latest on the build status, Andrew spoke to Robert Graz, Project Manager, Robel.

Andrew: How is the build and commissioning phase of the engineering trains progressing?

Robert: 'The project is progressing to plan, with the build on Power Car E complete and commissioning phase underway. It is remarkable to see, in less than a year since the contract was signed, the first unit coming off the production line and running on the test track. The two Power Cars B, with the welfare module, follow fast on Power Car E's heels with build and commissioning completion scheduled for mid-December. The build on the final unit, Power Car A, is also progressing well. Build is due for completion in November with commissioning finalised in December.'

Andrew: And how is the build on the ancillary equipment going?

Robert: 'The scissors lift will be finished mid-November, the two flat wagons mid-December and the drainage cleaning system next February. Design on the novel gantry off-loading device, essential for exchange switch and crossing, is now complete and construction will commence early in the new year.'

Multifunctional maintenance trains for the Elizabeth Line - update

The start of the New Year brings the next exciting phase in the Crossrail project as test and commissioning commences on the engineering trains and associated equipment for maintaining TfL's Elizabeth Line. To mark this important milestone, Jon Jarrett, Head of Infrastructure Crossrail, visited the Robel project team at its factory in Freilassing, Germany, and gives a personal summary of his findings.

Above: Testing the crane on Power Car E at Robel's workshops at Freilassing.

Below: Suspension testing in progress on Power Car E of the new vehicles.

The visit

As the accountable manager for the infrastructure maintenance and renewal of the new £15 billion Elizabeth Line, choosing quality maintenance equipment that delivers 'right first time' is absolutely key for our future success. In December, I had the opportunity to visit the Freilassing team to see how manufacture, construction and testing was progressing on our two new exciting Robel maintenance trains; to visit the team, discuss opportunities and risks, to witness the Communications-Based Train Control (CBTC) factory acceptance tests and participate in an important operation proving test ride.

Firstly, I was delighted with the progress and quality of the production. It was clear from the whole Freilassing team that the quality 'can do, will do' team are committed to delivering the very best - and what I saw showed that to be the case, too. I am very pleased with how the maintenance trains are emerging and progressing.

On test

Then we completed some key tests. These were undertaken with us present on the train so there was no hiding the emerging results. What I witnessed was a triumph, a critically important CBTC emergency brake test followed by a full power engine test on the ÖBB main line - passed successfully, too. Both these tests showed great quality and maturity of delivery but also the method of working collaboratively with other suppliers pulling together into one high quality, successful product.

It was great for the project team to receive such positive feedback from a key stakeholder, but they realise that there are still a number of significant milestones and challenges to meet before handover this summer.

Functional testing, CBTC, ride and braking tests are now underway and progressing well on all power cars. Crane testing on Power Car E is also progressing well.

Right: Ride and braking tests on Power Car B with welfare facilities.

Other progress

A prototype of the electrical gantry system, which will be used to exchange switch and crossing units within the central operating tunnel section, has been constructed and is now undergoing testing. The gantry off-loading device, a modular unit, used to deploy the electrical gantries from the power car, is also now under production and due for completion in February.

Above: The first completed example of the three transport wagons.

The construction of the three transport wagons is going according to plan with completion scheduled for February.

The drainage vacuum and jetting module and scissor lift module, for high level works, are due for completion in February ready for site trials scheduled to commence in March.

At this trial stage, all major work activities, such as rail changing, switch replacement and overhead conductor works, will be simulated in a real track situation. Constraints in the working environment from the tunnel, including the rigid overhead conductor and emergency walkway, will be replicated to make sure all equipment functions as it was designed. The working procedures will also be reviewed to ensure the tasks can be undertaken with the correct resource level and within the tight possession timescales demanded as part of the contract delivery. These trials will also be used to demonstrate mitigation of hazards, by the introduction of design measures, that have been identified as part of the Common Safety Method for Risk Evaluation and Assessment (CSMREA) process.

Jon Jarrett,
Head of Infrastructure, Crossrail.

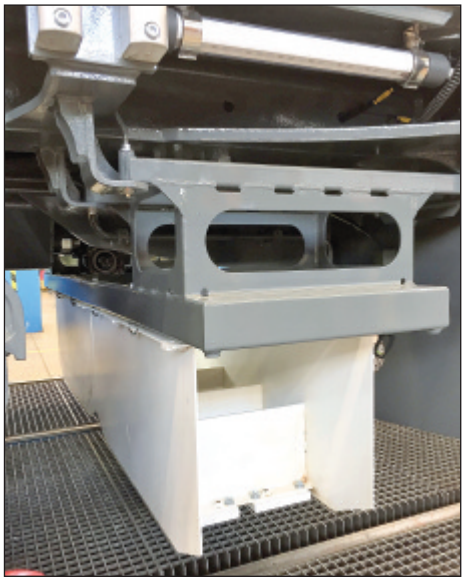
The progress on power car design, build and testing has been very successful to date as recognised by the customer. However, the Robel team knows the delivery of the maintenance equipment and modules is also vital to project success. The next phase will see all efforts focussed on completing this phase ready for track testing of the work processes in the spring. Exciting and challenging times to look forward to in 2018.

Multifunctional maintenance trains for the Elizabeth Line - update

AJK Rail's Andrew Keens details the latest progress on the new Robel equipment Plasser UK is supplying.

When fully operational in December 2019, the new Elizabeth Line is expected to carry some 200 million passengers per year with 24 services per hour at peak times in each direction through central London and 20 at off-peak times. Such high traffic levels will cause wear and tear to the infrastructure. One key element, in demonstrating operational 'go live' compliance, is the delivery of the maintenance trains and associated equipment, as these will be essential in delivering a safe and reliable service. It was, therefore, reassuring to hear from the Robel project team that progress on the build continues with work trials set to commence in March, factory acceptance testing in April and an expected delivery still on course for July.

The beginning of March marked a significant milestone for the project as Robel finished all the elements of the construction works, with completion of the third transport wagon to be used for track monitoring, as well as all associated working modules and transport systems. In this article, the focus will be on the ancillary equipment; the track monitoring wagon, the demountable work modules and transport and stillage systems.



Bracket for geometry and rail profile equipment (above left) and bracket for visual recognition equipment (above right). The white boxes simulate equipment for the ride tests.

Track monitoring wagon

The third and final transport wagon is of particular interest as this vehicle incorporates a number of modifications to integrate specialised track monitoring equipment. This included a rail integrity monitoring system (ultrasonic and eddy current testing), track geometry and rail profile systems monitoring as well as defect visual recognition mounted equipment.

To accommodate the geometry and rail profile monitoring equipment, an additional bracket arrangement has been welded to the one bogie set.

A special frame has been built around the second bogie to suspend the ultrasonic and eddy current equipment for rail integrity testing. A balise antenna is also mounted to this bogie to monitor track position and a tachograph is attached to the axle to monitor speed.

A support bracket has also been secured to the underside of the transport wagon frame for the visual defect recognition equipment.

Demountable modules

At the start of March, the construction and commissioning phase of all the demountable modules were completed. These modules allow a flexible work concept. All units are designed with housings for forklift or crane loading and twist locks for connection to either power car or transport wagon.

Drainage module

The vacuum and jetting drainage system has a self-contained engine and pump compartment, a 3,000 litre clean water tank and a 7,000 litre vacuum tank. The 48kW diesel engine powers a high pressure pump generating a flow of 60 litres/minute and maximum pressure of 170 bar. The engine also powers a vacuum pump with 9.7 litres/minute flow rate. Two high pressure hose reels are supplied. One with a 80 metre length and ½ inch diameter, to be used with the jetting nozzle, which operates at 245 bar maximum and 900 bar burst pressure. A second hose, with 50 metre length and 3/8 inch diameter, is to be used with a high pressure lance and has 280 bar maximum and 1,100 bar burst water pressure. Worker platforms and portholes are incorporated to permit cleaning and maintenance of the tanks while storage trays are mounted to carry the hoses and spare tools and equipment.

Electric gantries and 'on-off' loading device

Rail Infrastructure Issue No: 118 detailed the gantry solution Robel had developed for the exchange of Switch and Crossing (S&C) units within the confines of the central operating section of the Elizabeth Line. For a more efficient and safer operation, these gantries are pre-assembled and delivered on a special 'on-off" loading device mounted with twist locks to Power Car A. To offload the gantries, the engineering train must be uncoupled between Power Car A and the transport wagon.

The gantries have wheels, which run on rails mounted on the base of the loading device. Each gantry is unlocked and a deadman handle device used to move it to the hydraulic rotary actuator, mounted at the end of the loading device. This rotary actuator has two arms with hydraulic claws that clamp the cross beam of the gantry and lift it from the train to the track. The clamps are fitted with self-levelling rods to prevent gantry swing during loading and off-loading. The target time for off-loading

Left: Frame mounted on the bogie to house ultrasonic and eddy current test equipment.

Right: Electric gantry mounted on the on-off loading device.

Below: Drainage module mounted on its ISO twist lock frame.

and set up is seven minutes per gantry and to reload five minutes.

During the off-loading, the side arms on the top crossbeam of the gantry are swung out 90° and locked into the horizontal position. Whilst still suspended on the off-loading device, the A frame legs can be moved laterally on the top crossbeam and then also locked into position. This gives a total span of 5.2 metres. A worm drive, at the base of the A frame, can then be deployed with a power wrench to raise the crossbeam elevated to a maximum height of 3.2 metres. The gantry is then grounded and the height on each foot adjusted with the same power wrench to compensate for track gradient and cross level. The electric winch is operated by remote control and has a safe working load of 1,000kg. To handle the largest switch, which weighs at nearly six tonnes, requires six gantries operating in tandem. Load cell indicators are integrated to self-guard against individual gantry overload.

When in position, the gantries are then used to lift the new S&C unit from the transport wagons, exchange the old with the new unit and then finally reload the old unit back on the wagons. The gantry design must, therefore, allow sufficient height and width clearance for the passage of the transport wagons.

Construction of the electrical gantries and on-off loading device are now complete and the equipment is due to commence site trials towards the end of March.

Above: Gantry on-off loading device with crossbeam and legs deployed.

Scissor lift module

A modular scissor lift will be used for inspection, cleaning and maintenance of high level assets, including the replacement of 10 metre sections of the rigid overhead conductor system and renewal of conductor cable. The scissors lift has a safe working load of 1,000kg, a working platform area of 10 x 2.5 metres and can be deployed and retract in 25 seconds. The platform can be slewed a maximum of 1 metre and has a maximum lift above solebar of 2.6 metres. Limiters are fitted to allow adjacent line working.

Above left: Scissor lift mounted on its ISO twistlock frame.

Power car and transport wagon testing

And finally, to give an update on the power cars, the last two months have seen significant progress in the testing and commissioning phase. The two Power Car B have now been taken to Robel's test site, for static and dynamic testing. The other two Power Cars A and E are currently being prepared for work trials, with the intention to simulate the required work activities. These are set to commence in March and, if successful, will allow factory acceptance testing to follow in April and delivery in July.

Above right: On-off loading device with armature mounted on hydraulic rotary actuator mounted on Power Car A.

Multifunctional maintenance trains for the Elizabeth Line - update

AJK Rail's Andrew Keens details the latest progress on the new Robel equipment Plasser UK is supplying.

When tendering the contract for the new engineering trains that will maintain the Elizabeth Line, Transport for London (TfL) and Crossrail Limited devised a quite novel approach for testing and evaluating bidders. They set three case studies and invited bidders to devise equipment to deliver a working solution, documenting each process step with a time and resource.

The case studies were as follows:

- Case Study 1: Change half set of F switches at Stepney Green in 5 hours 30 minutes.
- Case Study 2: Change an 18 metre rail section in four hours' working time.
- Case Study 3: Maintenance and inspection of the Rigid Overhead Catenary (ROC) and other high level assets.

Bidders were then assessed on the best technical solution, which delivered the case studies in the shortest time and with the least resource.

Above: On/off-loading module mounted on Power Car A off-loading one of six electrical gantries. Part of Case Study 1 to change F switches within a tunnel.

Below: Electrical gantries in position for use to exchange a switch as part of Case Study 1.

Theory becomes reality

So, at the end of April, some two years later, the factory acceptance tests began. The equipment would not only have to work, but would also need to demonstrate that it could deliver the case studies within the time and resources promised at the bidding stage. Needless to say, the pressure was on!

Tests were demonstrated on a replica site, which was set up on sidings at Salzburg Station, a short distance from Robel's manufacturing site in Freilassing, Germany. Under the tight scrutiny of expert teams from TfL and Crossrail, each step of delivering the case studies was timed and monitored. The speed of operation and resource levels were recorded as part of the test protocol along with any observations on design modifications to improve the working process and safety.

Case Study 1 test

The test started with the most technically challenging process, Case Study 1. As outlined in *Rail Infrastructure* Issue No: 122, Robel developed an electrical gantry solution to exchange the switch within the tunnel confines. To make the process more efficient and safer, these electrical gantries came pre-assembled and loaded on a specially designed on-off loading device, a modular unit which secures with twist locks to the platform on Power Car A.

The solution to Case Study 1 allowed for two options; with the F switch either delivered from a lineside cavern about 50 metres from the junction (using a second cavern gantry system and trolleys) or delivered from Plumstead Depot on two transport wagons. The contractual requirement would include the time and resource to set the worksite, deliver and exchange the switches, demobilise and depart the worksite. Tests also had to demonstrate contingency arrangements

Left: Switch loaded on to the transport wagon using the electric gantries. Part of factory acceptance tests for Case Study 1.

Right: Power Car B, scissor lift and cable drum transporter wagon and Power E with basket mounted on the crane, undergoing factory acceptance tests for Case Study 3 - inspection and maintainence of high level assets.

in the case of equipment failure and recovery.

The full demonstration was planned for two days, but proceeded so well that all trials were completed satisfactorily in a single day. The contractual times pledged at the bidding stage were not only matched, but greatly improved with an overall reduction of 44 minutes. There were a few minor design and process modifications requested by the TfL and Crossrail teams, but on the whole a hugely successful day and a significant step forward towards contractual delivery.

Case Study 2 test

Next up was Case Study 2 - changing an 18 metre rail section. Regular readers will recall this task is delivered with Power Car E, a standard Robel engineering train with a PKR540E crane. Again, the contractual requirement included the time and resource to set up the worksite, deliver and exchange the rails, demobilise the worksite and finally depart. Tests also had to demonstrate contingency arrangements in the case of crane failure using an emergency gantry system. The trials progressed well, with the teams from TfL and Crossrail extremely satisfied with the rail exchanged working process using the crane and emergency recovery plan. Times could again be demonstrated to be well within contractual times with an overall improvement of 28 minutes.

Case Study 3 test

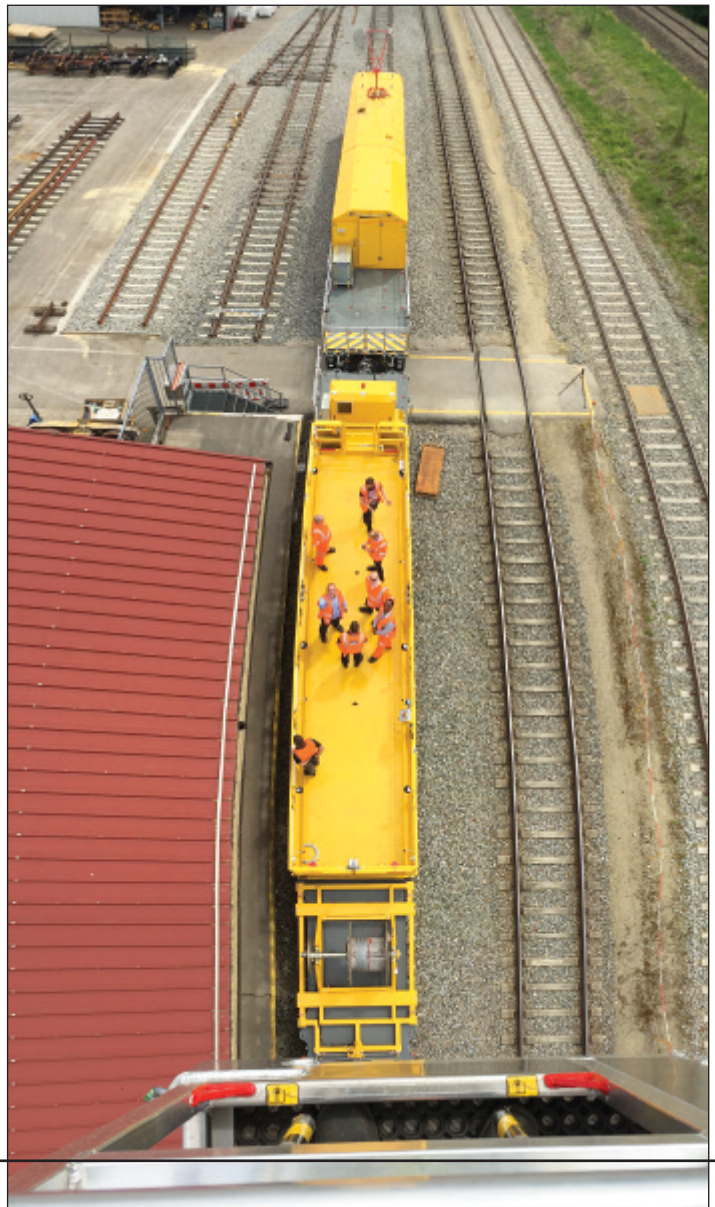
Finally, Case Study 3 - maintenance and inspect of the ROC and other high level assets, using a combination of scissor lift and basket on the crane on Power Car E. For this trial, the essential element was machine set-up, deployment and demobilisation time together with platform flexibility, stability and suitability for purpose. The trials proved the times were well within the contractual requirement with a reduction in the total set and demobilisation period of 23 minutes. On the whole, TfL was really impressed with the scissor lift and basket functionality, stability control and potential for delivering its maintenance tasks.

Final stages

Other associated equipment, such as the drainage module and transport equipment that did not form part of the contracted case studies, was also inspected and functional suitability checked. Again, with the exception of a few minor modifications, the equipment passed the acceptance tests with flying colours.

In the next few weeks, final tests are planned on the wheel slip protection before the engineering trains are really put through their paces embarking on an Alpine tour with senior management teams from TfL, Robel and Plasser UK. If the trains pass this test run then arrangements will be made for their transportation to the UK for the final acceptance process.

Above: An 18 metre plain rail exchange in progress as part of Case Study 2 tests.



Right: Cable drum carrier and scissor lift on transport wagon and Power Car B viewed from the basket mounted on Power Car E's crane during factory acceptance tests for Case Study 3.

Multifunctional maintenance trains for the Elizabeth Line - update

AJK Rail's Andrew Keens details the latest progress on the new Robel equipment Plasser UK is supplying.

Following the successful completion of the factory acceptance test, the final hurdle for the Transport for London (TfL) engineering trains, before transport to the UK, was a demanding 870km Alpine test run.

This was undertaken with the senior Elizabeth Line management team of Howard Smith, Operations Director, and Jon Jarrett, Operations Infrastructure Manager. The route took the team from Salzburg, in the west of Austria, to the capital Vienna. Then onwards from Vienna to Villach over the UNESCO world heritage Semmeringbahn route; the oldest mountain railroad in Europe that was built in 1854. This section is 42km long, climbing to a height of 898 metres, with a maximum gradient of 2.8% and contains 14 tunnels, 16 viaducts and more than 100 bridges! The final leg emanated from Villach to Salzburg covering the Tauernbahn route. This section is 79km long, reaching a maximum height of 1,226 metres, with 2% gradient over 40km and maximum gradient of 2.6%.

The Alpine test run was a great success, summed up by this feedback from Jon Jarrett: 'Spending a day on one of the new Elizabeth Line Plasser UK Robel maintenance trains as it undertook a key dynamic test over the Alps was fantastic. The train exceeded all performance test criteria over the challenging inclines and descents of the route keeping up excellent time in amongst fast passenger trains. To be on the train with the Plasser UK Robel team and witness the tests first hand has allowed us specifically to see the benefits of the investment made by TfL. What a great day on a great new Elizabeth Line maintenance train.'

Above: The Alpine test run team with the machines prior to departure.

Below: On the Alpine test run with the Alps in the distance.

On the move

Following the successful completion of the Alpine run, the next step was the transport of the trains, and all the associated equipment, from the Robel premises in Freilassing to the UK, which turned out to be quite a challenge. The original intention was to dead haul the trains through France and the Channel Tunnel. However, because of the uncertainty of strike action affecting the delivery timescale, it was decided to transport the trains up to the port of Cuxhaven on the northern coast of Germany, load on to low loaders and then ship to the UK port of Immingham by ferry. From Immingham, the trains were then transferred by road down to Plasser UK in West Ealing.

In the past few weeks, the trains have undergone commissioning on the radio communication system (GSM-R) and the train monitoring recorder (OTMR). Training for the Elizabeth Line staff who will operate the train and equipment has also now commenced. The contract to operate and maintain the engineering trains has recently been awarded to GB Railfreight and training for the company's staff will begin towards the end of July.

Authorisation

The technical file was submitted to the ORR in early June and, with the authorisation granted in early July, the engineering train reached another important milestone on schedule. So, with the deadline for

Full engineering train configuration ready for hauling to Cuxhaven.

Above: The train and modules at Cuxhaven port waiting to be loaded.

Above: Power Car A on-board a low loader ready for shipment.

qualified takeover fast approaching, all aspects of the project are drawing to a satisfactory conclusion.

Robert Gratz, Project Manager, gave this summary: 'We are proud to have the new engineering trains in Great Britain just as they should be - in action and on schedule. It was the close cooperation between Transport for London's Elizabeth Line team, Plasser UK and Robel throughout the whole project that made this achievement possible.'

Delivery of the first unit to Plumstead Depot is due in August and the project team is confident they will meet this deadline.

Right: The Transport for London - Elizabeth Line, Plasser UK and Robel project teams with Power Car A at Plasser UK's West Ealing workshops.

Multifunctional maintenance trains for the Elizabeth Line - update

AJK Rail's Andrew Keens details the final progress on the new Robel equipment Plasser UK is supplying.

September marked the official handover of the TfL engineering trains from manufacturer Robel Bahnbaumaschinen to Transport for London's (TfL's) Elizabeth Line operations team. Handing over the machines were Wolfgang Fally, Chief Executive, Robel, and Mark Simmons, Managing Director, Plasser UK, with Howard Smith, Operations Director, TfL, receiving them on behalf of TfL. Wolfgang Fally commented: 'The past two years have shown that it is possible to translate a functional requirement specification of the customer directly into a product. The RORUNNER System is the proof - a real milestone - also for the successful cooperation of all partners involved.' This step, just two years after contract award in August 2016, marks the end of the project phase.

All photographs by Alex Hall.

Power Car A equipped with on-off loading gantries along with scissor lift and cable drum transporter wagon.

Wolfgang Fally, Chief Executive, Robel (left), and Mark Simmons, Managing Director, Plasser UK (right), present the new engineering trains to Howard Smith, Operations Director, TfL.

Robel, Plasser UK and TfL senior management and project team with one of the new Elizabeth Line engineering trains. Left to right: Robel's Wolfgang Fally, Robert Gratz and Michael Seeleithner, Plasser UK's Mark Simmons and TfL's Jon Jarrett, Stuart Hines-Randle, Howard Smith and Chris Parker.

Power Car B, drainage module transporter wagon and Power Car E with crane at Plasser UK, West Ealing.