Repurposing the EM-SAT machines

Mark Simmons, Managing Director, Plasser UK, details the background to a new on-track machine for the UK.

At the 2018 InnoTrans exhibition in Berlin, Plasser & Theurer displayed an unusual exhibit on-track. Not that it is unusual for Plasser & Theurer to show on-track machines, or even measuring cars, although there have been fewer of those than tampers over the years. What was different was that the machine was built 15 years earlier - an EM-SAT. This machine, however, no longer had a 'SAT' and had, in fact, been repurposed to become a new measuring car.

When I saw it, I thought - 'We could do this in the UK'. Later I met Richard Spoors, who had introduced EM-SAT machines to the UK on the West Coast Main Line, and he said - 'Come with me, you need to see this. I think this is something we need to do in the UK' and led me to the EM100VT on display. A little later I met Sin Sin Hsu - who had been talking to Richard - and I am sure you can guess the rest.

EM100VT-1 at the 2018 InnoTrans exhibition in Berlin. *Photograph: Alex Hall.*

Background

The original EM-SAT range of vehicles was developed by Plasser & Theurer as an independent infrastructure monitoring vehicle, providing among other measurements accurate track geometry that could be supplied to tamping machines. They travelled to and from site self-propelled at up to 60mph (100kph). Once on-site, the satellite unit carried on the front of the vehicle was deployed onto the track and the system operated at up to 2.5kph, carrying out simultaneous measurement of the longitudinal level and alignment of the track to an accuracy of <1mm and provided this data for the needed lifts and slews to the ALC of tamping machines.

Two EM-SAT 100 RT machines were supplied to Network Rail in 2003 as part of the West Coast Upgrade Project that introduced the tilting trains – where the track was required to be maintained to the designed track geometry and these machines operated successfully for a number of years. Over time, however, both in the UK and across Europe, hand-held measuring trolleys, which did not require train paths to transit, became more accurate and cost-effective until eventually they replaced the EM-SAT machines.

The new repurposed EM100VT concept no longer uses the satellite and can carry out accurate track geometry measurements at up to 60mph, meaning it does not require a possession to operate - which brings a performance and cost advantage that would allow the machines to run again.

Then began a number of years of work to bring new life to the now unused EM-SAT machines in the UK. The EM-SAT machines had been mothballed for 10 years and had no planned use within Network Rail, so Plasser UK took the decision to acquire them and invest in the machines and the technology to bring this new concept to life in the UK.

New from old

Reuse is one of the first-choice options in the sustainability tool kit - all the embedded carbon that went into its creation is not wasted. Although reuse of the unchanged machines was not a practical option, repurposing still makes use of as much of the existing vehicle as feasible and means the production of only the new elements. Deciding on those new elements was a key stage in realising the concept for the UK project.

The EM100VT displayed in Berlin contained two 360° rotational lasers with colour cameras for 3D point-cloud mapping and a measuring frame around the front bogie with an inertial navigational track geometry measuring system, as well as Plasser & Theurer's own development of a stereoscopic camera-based, fixed-point reference measuring system. These are aided in their location by a combination of encoders and GPS/GNSS aerials.

Successful operation of this machine in Austria, Germany and other countries led to Plasser & Theurer developing a second machine, the EM120VT-2, which was on display at the iaf exhibition in Münster, Germany, in 2022. Although only a few years had passed, there had been significant changes since the first example was built.

In-house capability

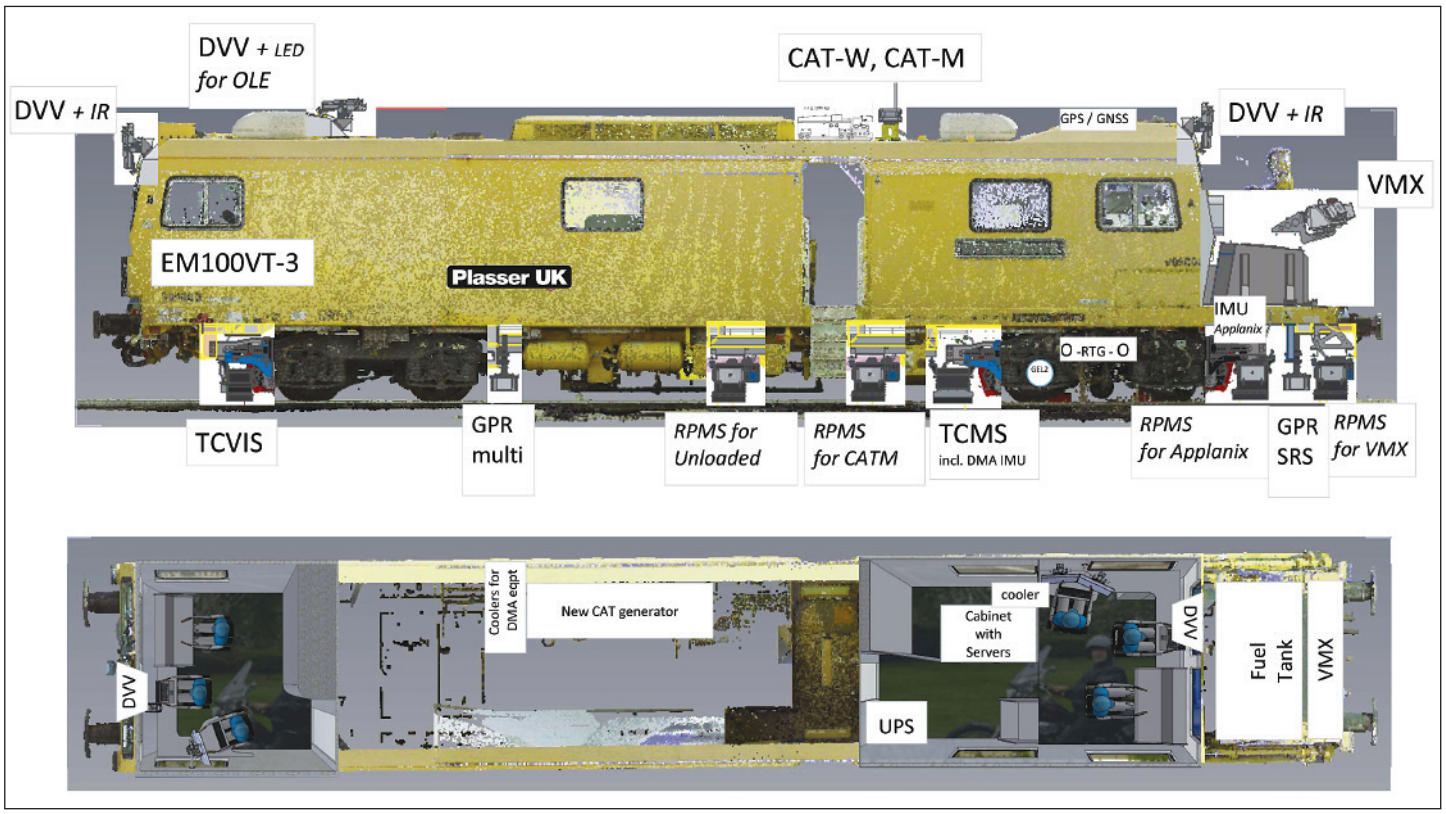
Plasser & Theurer had moved the competence centre for measuring systems and vehicles to Plasser Italiana, which carried out the refurbishment and installation of the measuring equipment. Of even more significance was the acquisition by Plasser & Theurer of Ground Control, a manufacturer and service provider of Ground Penetrating Radar (GPR) equipment and of DMA, a manufacturer of measuring equipment.

DMA, based in Turin, Italy, may already be known to *Rail Infrastructure* readers as it had enjoyed recent success in the UK, including supplying and integrating a number of the measuring systems fitted to the Robel engineering trains that had been delivered for use on the Elizabeth Line.

DMA directly designs and builds precision laser and optical-based measuring equipment, as well as acquisition hardware and software, including a web-based platform Tracksnet for gathering, processing, displaying and reporting on infrastructure measurements.

These new updated measuring systems installed onto the EM120VT-2 have been very successful and formed the basis for the final equipment list for the UK project, which was fixed in late 2022. Spoiler alert - the basic idea was everything that the first vehicle has and everything the VT-2 has all in one machine. Oh and keep it within W6a gauge - in fact, keep it within the original envelope of the UK EM-SAT machines!

EM120VT-2 at the 2022 iaf exhibition in Münster, Germany. *Photograph: Alex Hall.*



UK specification

So, the EM100VT-3 (UK) will be fitted with:

The Plasser & Theurer RTG stereoscopic camera system for measuring the rail distance and height from a fixed point (e.g. on an OLE mast).

The POS-TG relative track geometry measuring system from TMC, making use of a highly accurate Applanix Inertial Measuring Unit (IMU) able to provide precise results also at low speeds.

These two systems combine with the 10,000 pulse axle encoder and GPS/GNSS positioning aerials to provide precise track geometry, positionally located with high accuracy to the original survey for the fixed points.

The RIEGL VMX-RAIL mobile laser scanning system for track mapping and clearance surveying, equipped with three VUX-1HA high accuracy laser scanners and two RIEGL cameras with its own integrated IMU and GNSS antenna. This enables the capture of the complete rail corridor, including catenary systems, railheads and the complete periphery, even signs orthogonal to running direction, and high-end system performance supports rapid data acquisition of dense point clouds.

The EM-SAT being stripped down in the Plasser UK workshops at West Ealing. *Photograph: Mark Simmons.*

The DMA non-contact Track and Crossing Measurement System (TCMS), based on high-definition laser camera technology, includes an inertial measurement unit that provides a highly detailed condition assessment of switches and turnouts and highly accurate measurement of main track geometry and rail profile parameters under load providing:

- Full track geometry.
- Rail profiles and wear.
- Tongue and frog wear.
- Stock-rail/tongue interaction.
- Gaps and gauges.
- Running clearance and free wheel passage.
- Check rail depth and height.
- Wing rails.

The DMA non-contact Track Component Video Inspection System (TCVIS), which provides high-quality, high-resolution imaging of the trackbed, rails and other trackbed infrastructure with automated defect recognition for a wide range of rail, fastener and other defects, for example:

- Top of the rail.
- Joint bars.

Equipment layout superimposed over a laser scan of the EM-SAT.

- Fasteners and clips.
- Sleepers.
- Surface defects.

The DMA Driver's View Video (DVV) - a video inspection system that collects digital images of the track for visual review and analysis of safety conditions, detected exceptions and inspection planning. As an integrated component to the track geometry and video systems, the DVV allows the association of visual location information to the measurement data, providing the user immediate access to visual location information on sites of interest, such as a defect location. This reduces the need for on-site visits and helps in maintenance planning.

Two DMA non-contacting catenary monitoring systems to record overhead wire position, geometry and wear.

The Ground Control Safe Rail System (SRS) Ground Penetrating Radar (GPR), which uses three sets of three 400MHz antennae (polarisation HH) for mapping the trackbed. The electromagnetic waves seamlessly measure layer thicknesses, material properties and changes in structure along the

Stripping down continues with the satellite removed and the machine's superstructure standing on accommodation bogies. *Photograph: Mark Simmons.*

line. It also detects defects such as ballast pockets, fouled ballast, poor drainage, subsoil settlements, or problems with transitions, depending on their extent.

A further Ground Control system - the multi-channel GPR based on an array of antennae tuned to different frequencies arranged closely together across the whole four-foot, which combines to provide a high-density detailed inspection of the near surface trackbed for identifying any obstacle buried within the ballast and other information relevant to a ballast cleaning or undercutting shift.

Four DMA Rail Profile Measurement Systems (RPMS) are additionally deployed on the bogie and machine frames to locate all the instruments' measured values to the rail, without the need to mount them on inertial measurement frames fixed to the axles and subject to extreme accelerations.

In addition, the server systems mounted in the machine server room provide common location and timing markers for all the instruments and their processing servers - allowing all measured values to be accurately located in relation to each other, the track and the fixed-point markers. This accurate and common location of all the measured parameters will make handling processing and managing the measurements significantly easier and open new avenues for monitoring analysis. For example, analysis of repeated combined measurements over time could help to model the impact of a poor quality trackbed on the geometry degradation and wear on the rails and OLE.

Work commences

Of course, these modern technologically advanced instruments cannot simply be fitted to a 20-year-old machine that has not operated for 10 years without also overhauling the machine. That is happening at the moment in the Plasser UK workshops in West Ealing.

In future articles, we will detail the overhaul, the installation of the instruments and then the commissioning, testing and bringing into full service of the individual measuring systems and the machine as a whole.