SUCCESS STORY

ZUKEN

E^3.series

E^3.series is a Windows-based, scalable, easy-to-learn system for the design of wiring and control systems, hydraulics and pneumatics.

Mecalac (formerly Terex GB) cuts the time taken to develop right-first-time cable harnesses for its heavy plant vehicles.

MECALAC

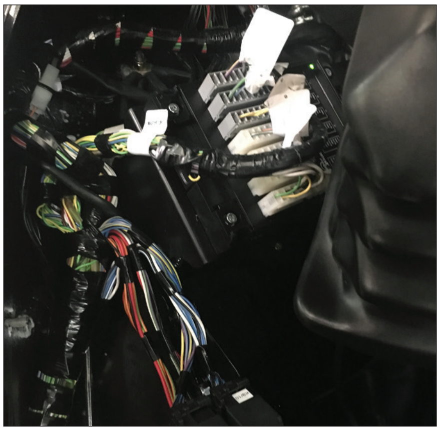
"Switching to E^3.formboard – and using E^3.Routing Bridge and E^3.eCheck – is enabling us to be more productive as engineers and more competitive as an OEM of construction vehicles."

Carl Worthington,
Principal Electrical Engineer,
Mecalac Construction
Equipment UK Ltd

Mecalac (formerly Terex GB) cuts the time taken to develop right-first-time cable harnesses for its heavy plant vehicles.

Mecalac designs and manufactures heavy plant vehicles for use in construction. There are three main vehicle types – backhoe loaders, site dumpers and compaction rollers – of which there are several variants of each. They all need to work in harsh environments. In 2016 the company (then known as Terex GB) decided to give its TLB990, one of the company's most popular backhoe loaders, an engineering makeover. They used a number of Zuken's E³.series tools for the development of the vehicle's four cable harnesses and, in doing so, Mecalac estimated it has halved the amount of time it takes to develop harnesses. The OEM also anticipates making further reductions in the near future.

Mecalac construction equipment vehicles are built to order, and the company's sales team uses a 'configurator' tool to present customers with configuration options; such as engine size and gearbox type, as well as overall vehicle functions and features. In terms of cable harnesses, Mecalac Construction Equipment UK operates a 150% practice, in that all options are present in the schematics but not necessarily implemented on all harnesses. A typical chassis harness would comprise about 150 wires and a cab harness might have around 350 wires, but only about 80% of connections would be utilized in most cases.



Though designed to fit several vehicle derivatives, the vehicle harnesses are regularly updated to accommodate new vehicle features.

That said, when a new feature comes out on one model, it is not uncommon for a customer to request the same feature on a different model.

Principal Electrical Engineer, Carl Worthington, comments: "Modifying cable harnesses is pretty much an ongoing activity for us, and it's important to get the design and build just right. Correcting a schematic pre-production takes just a few seconds; correcting a harness once fitted to a vehicle could be a few hours' work on the shop-floor."

The OEM has been using Zuken's E³.series since 2010, when it received some electrical design support from its German office. Their German colleagues had been using E³.schematic for defining electrical connectivity and E³.cable for design and layout (plus documentation) of cable plans and harnesses. However, this was (in Germany) mainly for the development of harnesses for relatively flat panels; whereas harnesses on vehicles take routes best described in 3D. In addition, on vehicles, there is a far greater need for flexibility.

Results

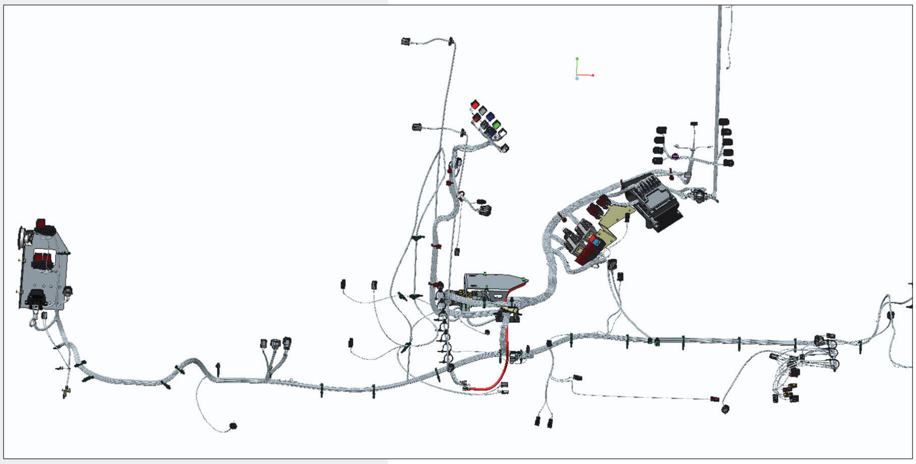
- Greater confidence during the creation or modification of cable harnesses, irrespective of their complexity.
- Impressive ease with which harness designs can be modified in E³.formboard.
- The automation of terminal and connector table selection saves time.
- Fewer and shorter iterative process steps with greatly reduced risk of human errors.
- Better collaboration between electrical and mechanical design engineers.

Mecalac Construction Equipment UK is a global manufacturer of compact plant machinery, providing market-leading solutions that maximize return on investment.

E³.series is a Windows-based, scalable, easy-to-learn system for the design of wiring and control systems, hydraulics and pneumatics. Its object-oriented system architecture, built on a central database, ensures the continuous synchronization of all engineering stages.

For example, during assembly and servicing there is often a need to move a harness to one side without undoing too many clips in order to reach certain vehicle parts/components. Worthington adds: "We found ourselves redrawing almost everything using E³.cable, mainly lengthening harness sections, to compensate for our 3D environment."

Mecalac worked with High Peak Systems, a leading UK-based reseller and support partner of mechanical and electrical computer aided design software solutions, for its purchase and ongoing support of E³.series.



A view of the dashboard and chassis harnesses, emphasizing its complexity as a 3D object.

Next Generation

In late 2015, Mecalac became aware of a new steering system that would be ideal for use on its vehicles. Worthington: "We'd also been noting other technical developments that could be applied to future vehicles – as well as trends in ergonomics – so the availability of a new steering system was the catalyst we needed to completely revamp our TLB990 backhoe loader. We then sought a wealth of feedback and views from our current customers, which enabled us to create a detailed specification for the revamped vehicle."

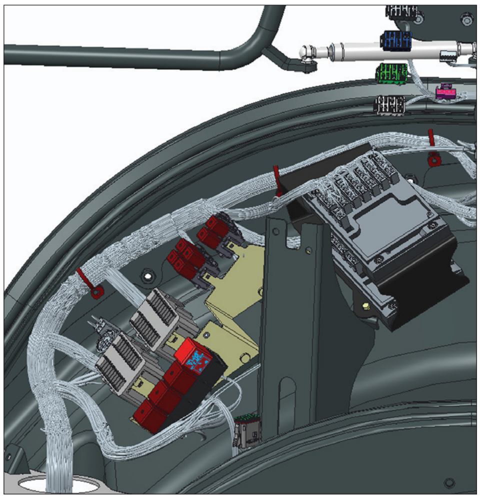
The company also saw the development of the TLB990 as an ideal opportunity to evaluate a number of other products from Zuken's E³.series with a view to improving overall productivity and right-first-time design confidence.

E³.schematic would be (and is) used, as before, and a number of new tools were introduced:

- E³.formboard, a complete solution for harness drawing and manufacturing, is now being instead of E³.cable;
- E³.3D Routing Bridge, which allows for better collaboration between Mecalac's electrical and mechanical design engineers; and
- E³.eCheck, which enables Mecalac to analyze its schematics.

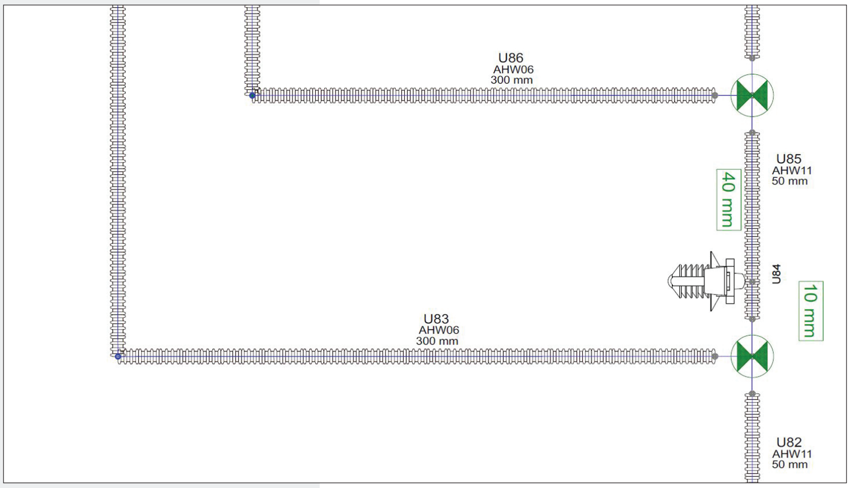
The TLB990 has four main harnesses – for the chassis, dashboard, roof and engine – plus a number of smaller harnesses, and began its next-generation project by first defining the electrical connectivity of all harnesses in E³.schematic.

The from-to connectivity and the names of connectors were then imported, via E³.3D Routing Bridge, into the mechanical engineer's CAD system. Worthington offers: "Advice I'd give to anyone doing the same is to adopt a consistent naming convention. In our case, we use the manufacturer's part numbers, so our electrical engineers, our mechanical engineers and our suppliers know they're all talking about the same connectors."



Above, a screenshot of part of the cab harness in the mechanical designers CAD environment. From-to connectivity data (along with connector names) is imported from E³.schematic, and the engineer defines routes for the cables to follow. It is in this 3D environment that the cables have mechanical properties (e.g. wire diameters) and that the harness is dressed with clips.

In the mechanical engineer's 3D design environment routes are outlined for the harnesses (which now have mechanical properties such as individual wire and bundle diameters) to take in order to reach the mating halves of the connectors. It is also at this stage that the harnesses are dressed with clips.



Above, part of cable diagram from E³.formboard, showing lengths of conduit (U83, for example), two covered joints (the two green triangles in circles) and the location of fir-tree clips. Full scale (1:1) drawings, which include keys and manufacturer notes, are currently sent to Mecalac's supplier as PDFs for quoting purposes. However, the process will soon become digital to greatly reduce the time taken to receive quotes and, by extension, harnesses back from the supplier.

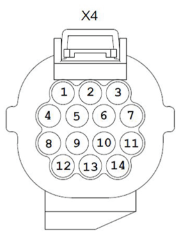
The harnesses – now with wire lengths known – were then imported into E³.formboad (again via E³.3D Routing Bridge) for the creation of 2D harness drawings. Worthington adds: "We estimate this part of the process takes less than a quarter of the time it did when we used E³.cable."

E³.eCheck was used throughout the process to simulate and verify the design.

"As you'd expect, it's an iterative processes," continues Worthington. "Sometimes the shortest route for a harness to take is not the most practical.

X4
TO ENGINE SUB HARNESS

Pin	Signal	Destination	Colour	Cross-section	Cable	Terminal
1	15	SP10.SB:X	White	1.00 mm²	W58	
2	CAN 1 H	SP11.SB:X	Yellow	0.50 mm²	CAN2	
3	CAN 1 L	SP12.SB:X	Green	0.50 mm²	CAN2	
4	Air Con Compressor	X2:25	Purple-Green	1.00 mm²	W89	
5	Alternator W/L	SP26.SB:X	Blue	1.00 mm²	W137	
6	CAN2 H	SP22.SB:X	Yellow	0.50 mm²	CAN9	
7	CAN2 L	SP21.SB:X	Green	0.50 mm²	CAN9	
8	Sensor Common 12VDC	XK94:29	Red-Grey	1.00 mm²	W86	
9	Coolant Level Signal	XK94:13	Green-Brown	0.75 mm²	W50	
10	Sensor Common 0VDC	XK94:87	Yellow-Green	0.75 mm²	W51	
11	Air Filter Switch	XK94:86	Grey-White	0.75 mm²	W52	
12	GND-MACHINE	X31.h:7	Black	1.00 mm²	W104	
Connector : 6189-0136						
Anti-Backout :						



Above, connector information shown in E³.formboard. Connectors are all to scale and terminal selection is automatic.

There may be heat sources to avoid, and it's always worth steering clear of fuel injectors because of EMI. You also need some degree of flex at various sections of any harness just to be able to fit it. Seeing the harnesses in 3D, along with the bend profiles of cables, is a great help, as is knowing that any changes you make are then reflected in E³.formboard."

Mecalac Construction Equipment UK outsources the manufacture of its cable harnesses, providing its supplier with PDFs and BOMs.

The supplier then typically comes back with any concerns or suggestions; for example a specified connector might have a long lead-time but an electrically equivalent connector in, say, a different color may be available as a stock item.

The Build

Cable harnesses were delivered to Mecalac in August 2016. Between them the harnesses contain more than 700 wires and the connector count for the TLB990 is about 200.

The production engineering department then took the lead to determine the most practical order for assembling the vehicle, and the stages at which the harness would be fitted and connected (not always the same time). Worthington says: "In some cases we found that some of the harness parts could do with being longer to simplify fitting on the production models."

The prototype was then supplied to a customer in October 2016 and put through its paces, clocking up several hundred hours in the field. That customer provided feedback in January 2017, confirming the revamped TLB990 is fit-for-purpose. This good news triggered the build of a pre-production machine – for which new harnesses were made. These harnesses respected all of Production Engineering's requests for changes (made against the prototype).

The pre-production machine is currently being put through its paces, and the assembly processes are being fine-tuned; with the caveat that harness changes can still accommodated if necessary.

"As mentioned, it's an iterative process. At virtually any stage, it's all too easy to delete a wire accidentally or to disconnect but not reconnect it within a connector. In the past, we've had to rely heavily on checking each other's work – a laborious process with printouts and highlighter pens. By simulating the design using E^3.eCheck we're spared all of that. Also, the BOM is always reflecting the current design."

The company estimates it has at least halved the amount of time it takes to develop a cable harness; from first editing a schematic (as an existing schematic will serve as a starting point) through to taking delivery of the harness. However, further time reductions are possible, as the harness manufacturer currently has to redraw the 2D plan in their system just to quote for the work. "And that can take weeks," says Worthington. "Our next step is to seek digital continuity. It will remove yet another stage at which human errors could be introduced – meaning no need for checks – and we'll be able to get quotes with reliable lead times back within days."

On to production

Mecalac's TLB990 backhoe loader is expected to enter full production in September 2017. Other backhoe loaders in the OEM's range will then most likely receive similar makeovers.

"It has been a learning exercise," concludes Worthington, "but well worth it. The new E^3.series tools we've adopted have improved the way we work and shortened the time it takes to make a modification to cable harnesses. It's also increased our confidence that it's 100% correct. And the bottom line is that if a customer orders a vehicle with features that require a harness modification, we can deliver much faster than before - enabling us to compete on not just price and quality but also delivery dates."

The TLB900 backhoe loader.

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