RAIL INDUSTRY

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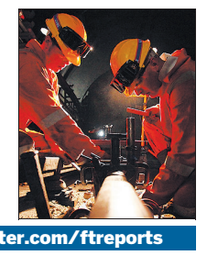
Inside
Metro upgrades are proving an uphill task for suppliers
Page 4



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New entrants roar out of the sidings

On track: the pace of change is picking up faster in the developing world than the developed Alamy

Tensions are rising as the train business goes through big changes, says **Robert Wright**, who wrote this report

When Siemens, one of the world's biggest trainmakers, invited dignitaries and journalists to mark the launch of its latest high-speed train, the outsiders were treated to a rare glimpse of the tensions shaping the industry.

After a few remarks about the Velaro-D train, Volker Kefer, the board member for technology and infrastructure of Deutsche Bahn, Germany's state-owned rail company, digressed to criticise railway suppliers generally. Their products needed to become more reliable, he said.

Hans-Jörg Grundmann, head of Siemens' mobility division, retorted that Siemens had an "antiquated" relationship with DB and was not given a big enough role in maintaining trains after it delivered them.

The incident in April illustrated one of the many big changes under way in the world's railway industry – the once-cosy relationship between Europe's big trainmakers and their big customers has become more adversarial.

New technology is also forcing operators and suppliers to revise their standards and ways of working. Still more importantly, the industry universally expects a large-scale effort by Chinese manufacturers to break into many of the world's most important markets.

The question is what kind of railway industry is likely to emerge from the upheaval.

Peter Ulrich, a partner in Boston Consulting Group who has overseen production of a comprehensive study of the rail supply market for Unife, the European railway industry association, says the industry's immediate fate depends on the world economy.

Growth in the mature economies that have been the industry's main markets is likely to be slow, and public spending limits tight. Emerging economies are likely to enjoy faster growth and their spending on rail equipment is likely to rise.

"Through the crisis, there was not a really severe impact on the rail industry," Mr Ulrich says. "However, we believe that, as infrastructure investment is pretty much linked to public spending, we have to expect this two-speed economy to have a big influence."

Events over the past 20 years, when Europe's big train operators and suppliers have unstitched their once-close partnerships to facilitate greater competition, explain much of the testiness that was on display in April.

Instead of designing and sometimes assembling rolling stock themselves, most railways in recent years have handed over responsibility to Siemens, Alstom of France, and the many European companies now part of Canada's Bombardier.

Having in some cases been only component suppliers, the biggest companies have become global designers, builders and maintainers of trains, modelled on the big automobile or aircraft makers.

Orders are now decided, in theory at least, by open public tenders – even if key projects still tend to go to the companies seen as each country's national champion.

The changes have been accelerated by the emergence of private operators of both passenger and freight services, encouraged by European liberalisation legislation. Such operators demand clarity about costs and design and a standard, reliable product.

The state-owned operators and their suppliers nevertheless still sometimes resemble divorced couples squabbling over the children. Some of Europe's best-known trains – France's TGV (Train à Grande Vitesse) and Germany's ICE (InterCity Express) family – were designed in collaborations between the railways and suppliers. The state-owned operators still take a proprietorial interest in how some of these products develop.

Some believe the relationships between customers and suppliers have still not been properly formalised. Mr Kefer said in April that DB was trying to ensure that suppliers told it much earlier in the design and manufacturing process exactly what type of product, built to what kind of standard, it would receive.

"We're doing this not in an effort to blame somebody later, but to improve quality at a much earlier point," he said. "It would be wrong to say that there is one manufacturer that hasn't had a problem. All manufacturers have had their problems."

Yet, as they grapple with the significant changes within Europe, the large European manufacturers also face the biggest ever challenge to their dominance of the world passenger rail industry.

The European manufacturers were until recently confidently agreeing to export high-speed train technology to China for use on the 25,000km of dedicated high-speed lines the country plans to build by 2020. Few believed Chinese manufacturers were close to mastering the technology to build such trains on their own.

This year, however, Siemens felt forced to pull out of a consortium it had formed to bid for Saudi Ara-

Continued on Page 2

Inside this issue

Sector entrants leave the sidings

Continued from Page 1

bia's planned Mecca to Medina high-speed line and instead join a consortium with China South Locomotive & Rolling Stock Corporation.

The big manufacturers face unexpected Chinese competition in markets such as the US, where China's Ministry of Railways has signed a memorandum of understanding with General Electric over possible joint bids for work on US high-speed rail.

Tom McCarthy, managing director for rail operations for Bechtel, the US civil engineer, says Chinese manufacturers are expanding worldwide.

"I think what's impressive is that their capability has grown exceptionally – their ability to bring in quality; their ability to bring in technology, the rolling stock and signalling, the systems which we would not have thought of five, 10 years ago," he says. "They can compete head-on with the Europeans and the Japanese."

General Electric and Caterpillar's Electro-Motive Diesel division – the two dominant suppliers of freight locomotives in the huge North American market – also face far stiffer competition than before.

Chinese manufacturers are expected to challenge the pair's powerful position in the large international market for locomotives to haul heavy freight, which is growing thanks to Chinese demand for raw materials.

Henry Posner, an international railway investor with experience of Africa, an important growing market, says Chinese suppliers are likely to compete strongly, even if initial reliability problems with their locomotives have hindered them.

"They have not been able to compete effectively so far, but that's not to say the Chinese are not going to be a third player in the market," Mr Posner says.

It could be issues surrounding reliability and technology that prove decisive in the struggle between established suppliers and the Chinese.

Few in the market doubt that European and North American trainmakers will stay ahead of Chinese manufacturers for the foreseeable future in developing new electronic and computer systems.

The new technology gives operators immediate warnings about potential problems with tracks and trains, and can pack far more trains into a given section of line than had been possible before.

The long-term running costs for operators using such advanced technology should be lower. But the question is how many operators will demand such technology, and how many will be swayed by the lower upfront costs of the new suppliers.

Lorenzo Simonelli, chief executive of General Electric's transportation division, has an optimistic view. The Chinese and the established manufacturers should be able to co-exist, he says. His division has formed some "good partnerships" with Chinese manufacturers building its designs in China.

"At the same time, we focus on technology and making sure we provide what customers say they need," he says.

"There are going to be marketplaces where there's space for all of us."

His company and other established manufacturers can only hope that he will be proved right.

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To the point: network operators aim to replace equipment just before it fails, rather than long before – or just after Charlie Bibby

Engineers learn lessons from aviation industry

Maintenance

Gathering information remotely can provide substantial gains in performance

John Smith is checking a set of points in Scotland. Mr Smith, a programme manager for Network Rail, owner of the British rail network, examines closely how long the points at Newbridge Junction, west of Edinburgh, took to move last time they were switched. A graph shows him how much electricity the motor that pushed the blades required.

For the time being, he concludes, the points, which link two key routes across central Scotland, are working well.

Yet Mr Smith is actually more than 400 miles from Newbridge Junction, working with his laptop computer in Network Rail's London headquarters. He is able to check on the Scottish points thanks to a family of new technologies that promise to reduce train delays and improve the efficiency of railway maintenance work.

Sensors on the point motors record information about each movement and transmit it to a website. Network Rail engineers anywhere with an internet connection can analyse the data.

Many of the points and signalling systems along the main Edinburgh to Glasgow commuter route have been fitted with such test equipment in a trial of the new technology, known as remote condition monitoring.

The goal is to help Network Rail, and other infrastructure owners worldwide, move away from traditional, inefficient maintenance practices. In future, equipment should be replaced just before it breaks down and causes delays – rather than after.

Mr Smith has little doubt of the technology's extraordinary potential. "It has the capability to deliver a transformational level of improvement on assets," he says.

There remains a delicate balance to be struck, however. If installed on equipment not vital to the functioning of a railway, remote condition monitoring could simply increase cost and complexity.

The system must be managed correctly – an area in which David Taylor, business development director of the UK arm of Thales, the French electronics contractor, says the UK is a leader.

The challenge is to make sure the huge quantities of information generated are filtered until only the immediately useful is left. "You can monitor practically anything," Mr Taylor says. "It's a question of what you do with the information once you have it."

There is no doubt that traditional railway monitoring techniques need updating. Track workers normally check the track by walking along it – daily on the busiest UK sections – to spot damaged or deteriorating equipment.

The system is dangerous – track workers are sometimes hit by trains – and poor at picking up early signs of damage.

Because they have so little information about equipment's condition, infrastructure owners have traditionally resorted to replacing equipment according to the time it has been in place.

This approach replaces most equipment prematurely but sometimes misses incipient faults before the equipment breaks down and holds up trains.

While remote monitoring is unlikely to supplant visual inspections in ensuring safety, it is likely in future to play an increasingly important role in spotting reliability problems.

With signalling power supplies, sudden drops in electrical resistance indicate they are no longer properly earthed and likely to fail. Similar monitoring can spot problems with the equipment that passes low-voltage electrical currents through rails to detect when trains are present. The normally smooth flow of electricity through points' electrical motors becomes jagged when parts are worn.

> 'You can monitor practically anything. It's a question of what you do with the information once you have it'

Yet it would be folly, according to Mr Smith, to deploy expensive monitoring devices everywhere. His team has drawn up an analytical programme to decide where installation would prevent enough delays to justify the equipment's cost.

The analysis concluded that 10 per cent of points were worth monitoring.

"It basically looks at an asset category, looks at its prior performance in terms of causing service-affecting delay, and it looks at its criticality to the network," Mr Smith says.

Most efforts now are focused on working out how to improve the software sifting the vast amounts of data flowing in. If alerts for engineers are set off too easily, a spell of cold weather that clogs up or freezes points could trigger scores of alerts about equipment that is responding normally. If alerts are too slow to be set off, impending failures could be missed until it is too late.

The problem is especially difficult to address, Mr Taylor points out, because different manufacturers' point motors or signalling systems will all have different operating characteristics and show different signs of failing.

Network Rail has appointed a "flight engineer" – a job title betraying the monitoring technology's genesis in the aerospace industry – to work at understanding better the patterns of signals returned by the monitoring equipment.

Extra sophistication will come, according to Mr Taylor, once analysts consider factors such as the outside temperature at the time a reading was taken alongside the raw signal.

The significant improvements in performance already being achieved in Scotland suggest, nevertheless, that Mr Smith's talk about remote monitoring's "transformational" potential is not hyperbole.

So sharp have been the improvements on the Edinburgh-Glasgow line that Mr Smith is reluctant to quantify them, for fear of whipping up excitement about the programme that might not be justified in other locations.

"The timetabling and geographic variations mean I would not like to suggest what we're seeing in Scotland is 100 per cent repeatable," he says. "But Scotland is demonstrating some significant improvements."

Heavy haulage giants join in fresh battle

Freight

US locomotives are cleaner and more efficient. But that may not be enough

The small town of Erie, by the lake of the same name in north-western Pennsylania, has no obvious links with the mining businesses currently hacking huge quanties of commodities out of Australia, Brazil and South Africa for export to China. However, many of the high-powered diesel locomotives that move coal, iron ore and other bulk commodities from producing countries' mines to ports start life in a vast brick building on the town's eastern side, the main production plant of the US's General Electric.

Producing the power of more than 400 standard family cars, the latest diesel-electric machines rolling off the long Erie production line allow mining companies and train operators worldwide to carry far more than ever before on each train leaving a mine or quarry for a port or power station.

Yet many involved believe GE's transportation division now faces some of the toughest challenges in the 20 years since it took over market leadership from Electro-Motive Diesel. Route electrifications and Chinese competitors are both potential threats. More immediately, Caterpillar, the earthmoving equipment manufacturer, bought Illinois-based EMD, GE's only serious competitor, in June and is expected to invest heavily.

Henry Posner, chairman of Pittsburgh-based Railroad Development Corporation, an international railway investment company, says General Motors, EMD's owner until 2005, let the company fall behind.

"EMD lost the market to GE," Mr Posner says. "EMD is now playing catch-up and, with its new owner, it should have a bigger budget for innovation."

Lorenzo Simonelli, chief executive of GE's Transportation division, points to two key areas of technical improvement in the past decade. One is in the diesel engines that are at the heart of both GE's and EMD's locomotives, driving the electric generators that power the electric motors.

GE says its latest engine, in use on its Evolution model, saves fuel by generating as much power from 12 cylinders as its predecessor did from 16. EMD has also achieved fuel savings, but from a less comprehensive engine redesign.

The other main improvement is in the software controlling the locomotives' electronics. Control over each wheel's grip on the track, the power delivered to motors, and many other important functions is now much more sophisticated.

The improvements have made a noticeable impact on the efficiency statistics by which the big Class I North American railroads – GE's largest customers – are judged, says Mr Simonelli. "We're willing to invest," he says. "That's where we stay ahead."

The 1,300km network run by Rio Tinto, the mining company, in Western Australia's Pilbara region provides GE's products with some of their toughest tests, with locomotives having to start and stop trains of 33,000 tonnes.

Sid Hay, Rio Tinto's manager for rail development, says the Evolution, which it has been using since 2008, has continued improvements under way since 1995, when it introduced GE's then-new Dash 9 model.

The Dash 9 allowed Rio Tinto to make its trains longer than the 210 cars it was then running. The extra power also allowed Rio Tinto to cut back the number of locomotives per train from three to two – though it has since reverted to three to ensure reliability.

"When we went back to two locomotives, we actually pushed the train length to upwards of 230 cars," Mr Hay says. "We also increased the total weight of the cars."

The Evolution's main benefit has been reduced fuel consumption, Mr Cohen says. "The Evolution series locomotive has slightly more power than the Dash 9, with significantly lower emissions," he says.

The next technical step is likely to be into hybrid power. Much of a modern locomotive's braking effort is produced by turning its traction motors into generators and dissipating the energy in large banks of electrical resistors.

GE is investing $150m in developing sodium battery technology that would instead allow braking energy to be stored to power the train on restarting.

> 'EMD is now playing catch-up and, with its new owner, it should have a bigger budget for innovation'

Yet GE could be less well-placed if many operators decided to switch to picking up remotely generated electric power from overhead power lines – as happens on South Africa's main coal export line to the Port of Richards Bay.

Mr Simonelli says GE will switch to building purely electric locomotives if the industry is interested. But it most recently built them in 1991.

Chinese manufacturers, meanwhile, have already supplied some of the many African railways being built or refurbished by Chinese companies.

Mr Simonelli insists that the cost benefits of GE locomotives' fuel-efficiency and reliability more than outweigh the lower initial cost of buying a locomotive from a Chinese manufacturer.

Mr Posner says the experience of the Iowa Interstate Railroad, owned by Railroad Development Corporation, bears out Mr Simonelli's point.

The Iowa Interstate recently took delivery of 12 GE Evolution locomotives. It had calculated that the GE product's flexibility would allow each one to replace three existing locomotives, while also letting the company run longer trains and thus save fuel.

"It's transformed the way we operate," Mr Posner says.

Diesel-hydraulic maker moves into mainstream

Profile
Vossloh

A German group has high hopes for its green, flexible locomotive

In 2005, when Veolia Transport started running France's first privately operated freight train in 70 years, the locomotives hauling the train attracted far less attention than a group of demonstrating workers from France's state railway.

But the manufacturer of the distinctive-looking engines, with cabs three-quarters of the way down their bodies, has played a key role in opening many of Europe's rail markets to competition.

Germany's Vossloh has become supplier of choice of diesel locomotives to many small private operators set up in recent years to challenge state-owned incumbents.

Vossloh is also technically distinctive. Its locomotive division was for many years virtually Europe's only champion of diesel-hydraulic transmission. This transfers power from the engine to the wheels by pumping hydraulic fluid, rather than – like most modern diesels – generating electricity to power electric motors.

However, the company, which besides its locomotive business supplies track equipment, points, trams and electrical controls, is now seeking to move into the mainstream diesel-electric market.

The question is whether it can find a profitable niche.

Tim Jackson, former head of the European business of Angel Trains, the train-leasing company, says operators of shorter-haul freight trains tend to favour Vossloh's diesel-hydraulics.

The company was set up in 1872 by Eduard Vossloh after his return from the Franco-Prussian war.

The company, based around the family blacksmith's forge in Werdohl, in North Rhine-Westphalia, started supplying rail fastenings to the then German Imperial Railways.

It eventually became an industrial conglomerate but after German reunification refocused as a railway supplier.

It entered the locomotive-building business in 1998, buying a factory in Kiel from Siemens. In 2005, it bought another factory in Valencia, Spain, from France's Alstom.

Norbert Schiedeck, Vossloh's chief operating officer, says the Kiel factory's traditional mainstay was supplying diesel-hydraulic locomotives to the hundreds of German industrial complexes with small rail networks.

When competition for the state railways was introduced, it was natural for Vossloh to start servicing small new entrants' needs as well.

"Diesel-hydraulic is a very simple, reliable technology," Mr Schiedeck says. "Some operators like that. They want to have a reliable system, and maybe their volume of traffic or the distances are not so high that its poorer fuel consumption is a real issue for them."

But steady improvements in diesel-electric technology, along with its greater flexibility, have persuaded Vossloh to develop new diesel-electric locomotives.

The high-powered Euro 4000 brings Vossloh into competition with two of the leading forces in the European rail market – Bombardier and Siemens – as well as the US's Electro-Motive Diesel and General Electric.

That makes for a crowded marketplace when most busy European freight routes are electrified.

The market for large, powerful diesels is largely confined to Scandinavia,

High-power: Euro 4000

the UK and Spain, where there are long, non-electrified lines in hilly areas.

EMD's Class 66 is by far the most popular freight locomotive in the UK and has been sold to a number of continental European private operators.

The UK's Freightliner last year started taking delivery of the first of General Electric's new Powerhaul locomotive, designed for the European market.

However, the Euro 4000 is more powerful than its competitors.

"We have our advantages in engineering and our experience of fulfilling even very specific customer requirements," says Mr Schiedeck.

He concedes that parts of Vossloh's market have grown tougher. Voith, which supplies Vossloh's hydraulic drives, now produces full-scale diesel-hydraulic locomotives itself.

The locomotive operation has also suffered from the economic downturn. At €483m, sales at Vossloh's motive power and components division in 2009 were 4.3 per cent down on the previous year.

Mr Schiedeck says: "We serve two types of private operators: those who earn their revenues through logistics; and those who earn their profits by other industrial activities. Both were heavily affected by the crisis."

Mr Schiedeck insists, however, that both types of operator are ordering again and that his company's nimble use of innovative technology will enable it to compete against larger companies.

One important initiative is Vossloh's planned introduction of a diesel-electric locomotive which, like a hybrid car, charges batteries while braking. It can also obtain power from overhead wires on electrified lines.

Many operators currently buy diesels and run them on largely electrified routes simply because short sections at either end lack electric power.

According to Mr Schiedeck, the new model should appeal to private operators who, like Veolia Transport in France in 2005, lack large locomotive pools.

"They don't have the capacity to say 'OK – I'll cover this distance with an electric locomotive and then I have a diesel locomotive close by for the rest,'" Mr Schiedeck says. "They only have one."

First project is fast route to more work

US

Florida's high-speed line in the centre of the I-4 corridor has captured the public's imagination

Ripe for rail: the broad area between the carriageways of I-4 in Florida could, as soon as 2015, host trains travelling at three times the speed of the automobiles

As highway engineers have worked over the past decade to widen Florida's I-4 highway, they have left a broad, grassy strip between the carriageways. One day, it was intended, the grass would be dug up and the strip would become a high-speed rail line.

Yet, far more quickly than most anticipated, the idea of turning the I-4 corridor into the US's first dedicated, high-speed line has caught the imagination of both state and federal politicians, from President Barack Obama down.

Trains could be flashing past traffic on I-4 at about 200mph as early as 2015, the scheme's promoters hope.

The question for train manufacturers all over the world is what kind of technology the new trains are likely to use and which manufacturers will be best-placed to supply it. Successful suppliers to pioneering Florida could shape the development of high-speed rail across the US.

Kevin Thibault, executive director of the state's Florida Rail Enterprise, says the Florida line's opening could represent a change for the US as profound as the building of the highway system, inspired by President Eisenhower.

"The interstate system's success was starting from the top down," Mr Thibault says. "The president said, 'I have this vision'. This project is starting from the president, going down to our governor, to our leadership here."

One of the few certainties is that dedicated high-speed rail lines of the kind being discussed for Florida will be rare in the US at first. Most of a series of planned projects described as high-speed rail – including new services around Chicago and in the Pacific north-west – involve trains running at up to 125mph along existing tracks.

Such lower-speed, lower-cost projects could do a great deal to improve rail's share of journeys between some clusters of US cities.

But only the Florida project and one in California linking San Diego to San Francisco and Sacramento are likely to resemble European and Asian high-speed rail lines, where journeys are mostly undertaken on segregated, electrified tracks allowing speeds of up to about 200mph.

Such high-speed services are so new a concept in the US that Joseph Szabo, administrator of the Federal Railroad Association, says he will be open to discussions with bidders about how signalling and other safety questions should be handled.

"It's a question of 'Come in and show how your system is going to perform'," Mr Szabo says. "We're flexible."

A key decision will be whether to segregate the new lines entirely from the rest of the rail system. Such a position would open the US to adopting the Shinkansen – or bullet-train – technology developed in Japan and exported to Taiwan and mainland China. The system relies on advanced signalling systems and physical barriers to ensure the light, energy-efficient trains never suffer a crash they would be ill-equipped to withstand.

Train operators in France and Germany use strengthened trains that are heavier than their Japanese counterparts but are able to withstand head-on crashes. This means they can safely use existing, conventional-speed tracks to reach cities not yet connected to the high-speed network or share commuter lines for the last stretch into existing, city-centre railway stations.

Pierre Gauthier, US country president for France's Alstom, maker of the TGV high-speed train and its successor, the AGV (Automotrice à Grande Vitesse), says the ability to run through dense urban areas on existing rail lines is a "big benefit" of his company's technology.

> The emerging US market is presenting trainmakers with dilemmas as well as opportunities

"The Japanese have to transfer people on to the destination or have other types of transportation modes to feed into the high-speed rail system," he says. "The European system does have a big advantage in that regard."

Florida, where there is less suitable existing rail infrastructure to use, could take a different approach from California, where trains may serve existing city centre stations, such as the beautiful, art deco Union Station in Los Angeles. "We believe that it's important that the service serves the city centre," Mr Szabo says.

However, the emerging US market is presenting trainmakers with dilemmas as well as opportunities. The initial Florida order – for a line linking Tampa and Orlando along the I-4 – could require only seven or even fewer trains. To supply those, the successful bidder will probably need to redesign its existing models to meet specific US requirements and will be obliged to set up a suitable US manufacturing plant.

Mr Thibault says the successful bidder – likely to be a consortium including construction and maintenance contractors, as well as a trainmaker – will have first refusal on supplying a more lucrative extension from Orlando to Miami. It will also put itself in a uniquely strong position to supply other US high-speed rail projects as they are developed.

Mr Gauthier nevertheless warns that, even for a project as prestigious and high-profile as building the US's first modern high-speed trains, greater certainty about long-term prospects may be required.

"For any manufacturer to produce a new design, you need a substantial value [of order] and you need certainty on that market over time," Mr Gauthier says. "That's something that we don't have up to this point."

Rivals must trim their prices in race for sales

Europe

High costs may harm prospects in emerging markets

Switching tracks: the Velaro-D represents a change of direction for its maker, Siemens Alamy

In a spacious, modern factory in Uerdingen, on the outskirts of Düsseldorf, a shiny, streamlined carriage sits on trestles, awaiting the time when it will be united with its wheels. Some time next year, it should be at the head of a train whisking passengers from Frankfurt to Paris at speeds of up to 320kph.

Almost 1,000km away at La Rochelle in western France, engineers are developing an even sleeker high-speed train, ready to enter service next September between northern and southern Italy.

The German train – one of the first of a model dubbed the Velaro-D by Siemens, its manufacturer – represents the first comprehensive rethink of Siemens' flagship high-speed train design in a decade.

The train being built in La Rochelle, the AGV (Automotrice à Grande Vitesse), represents a still more sweeping rethink of the high-speed train technology of France's Alstom, builder of the TGV (Train à Grande Vitesse).

The imminent launch of the two new models will put high-speed rail's most bitter rivals head-to-head for the first time as they offer comparable technology to international buyers.

But the two dominant forces in the world high-speed train market will soon find out whether technology designed with Europe's train operators in mind will meet the needs of poorer countries now eager to buy high-speed trains.

René Rambusch, project leader for a recent survey of the world rail equipment market for the Boston Consulting Group, says emerging economies have different needs.

"These countries want low-cost, no-frills equipment," Mr Rambusch says.

The carriage in Uerdingen is a descendant of the Inter City Express (ICE) trains first introduced in the late 1980s by the federal railways of the then West Germany.

The early generations were hauled by power cars packed with electrical equipment at either or both ends of the trains.

The system, still used for all France's high-speed trains, is simple but has disadvantages. The power car is heavy, increasing wear on the track. The intermediate coaches contribute nothing to powering the train.

In the late 1990s, after Deutsche Bahn, as it is now called, realised that existing designs would struggle with the steep gradients of the new Frankfurt to Cologne high-speed line it was constructing, it commissioned a new design.

The new train, called the ICE3 and introduced in 2000, had the motors and electrical equipment hidden beneath the floor and distributed all along the train – a system known as distributed traction.

The design improved the trains' climbing power and freed the front and rear cars for passengers.

Edzard Lübben, vice-president for high-speed rail at Siemens' transport division, says that 80 per cent of components on the Velaro-D have been updated compared with the ICE3.

The new design's nose shape is more aerodynamic, while other technologies that were previously too immature to use are being included.

"Combining the old train concept – proven over 10 years' experience – together with those stepwise evolutionary improvements was really a key advantage," Mr Lübben says.

SNCF, Alstom's main customer, has pursued some of the same goals as DB via a different route.

To increase the number of passengers on each train while conserving energy, it has ordered scores of double-deck TGV Duplex trains.

> 'The AGV is Alstom's first train to be designed and developed without SNCF'

The trains, which rely on traditional power cars, carry 45 per cent more passengers than a single-deck TGV using only 30 per cent more energy.

For several years, Siemens won orders virtually unchallenged from train operators demanding single-deck trains with distributed traction, while Alstom built the Duplex only for SNCF, the only operator that needed it. Siemens has sold the Velaro in Spain, Russia and China.

François Lacôte, Alstom Transport's senior technical vice-president, says he is proud of how Alstom has now developed the AGV unaided to counter the Velaro.

He also expresses satisfaction that it won its first order from another operator – Italy's NTV, Europe's first wholly-private high-speed train operator.

"The AGV is Alstom's first train to be designed and developed without SNCF," he says.

Mr Lacôte says the AGV is technically superior, weighing the same when loaded with passengers as the Velaro does empty.

Heavier trains are slower and more energy-hungry when accelerating.

Mr Lübben argues it is to Siemens' advantage that its new product is less revolutionary than either the AGV or the Zefiro being developed by Bombardier of Canada, the world's largest trainmaker.

"We feel absolutely confident that we are better placed than our competition," he says.

Yet, further dangers lie in store for Siemens and Alstom.

As India, Brazil, South Africa and other emerging economies start to invest in high-speed rail, they could shy away from the high costs of the Velaro-D or the AGV.

The products' energy efficiency, light weight and durability should certainly make them more cost-effective over their lifetimes than cheaper but less efficient rivals.

But such calculations may be of limited interest to countries desperate to start high-speed rail services with minimal upfront costs.

The threat could grow more intense, Mr Rambusch points out, as China slows construction of its high-speed network.

Alstom and Siemens could find themselves fighting each other less – and underemployed Chinese factories more.

"The capacity that has been built in China will have to be filled in the future somehow," he says.

High-speed commuter trains Packing in new passengers

At Hitachi Europe's maintenance depot in Ashford, in the south-eastern English county of Kent, the trains sit on tracks well above the sunken floor, giving excellent, all-round access to the vehicles' undersides.

The elevated tracks also give visitors an eye line view of one of the key design features of these trains, designed to carry commuters at up to 225kph on the dedicated high-speed line linking London to Ashford and to run on Kent's battered conventional lines. The bogie – the swivelling metal frame to which the wheels are attached – is made of thick beams far heavier and more robust than on the Japanese Shinkansen trains from which the British trains were developed.

Many train operators worldwide see high-speed commuter services – of which the London to Kent services are among the few current examples – as one of the strongest potential growth areas for high-speed rail.

The services are likely to have an especially important role in densely populated countries such as the UK and the Netherlands. Introduction of high-speed commuter services can bring extra traffic to dedicated high-speed lines that might otherwise be only lightly used by long-distance traffic.

However, the bogie on the Japanese-built trains used in Kent – known as Class 395s – is a reminder that the equipment required complex design compromises to fit the specific circumstances of each service.

Ronald Stevens, a spokesman for Nederlandse Spoorwegen, the Dutch state-owned train operator, says it expects about half the passengers on the country's high-speed rail services to be travelling relatively short distances on domestic trains when it launches its range of high-speed services, probably in 2011.

"We expect that passengers who are ready and willing to pay the difference will transfer from conventional to high-speed trains," Mr Stevens says.

The key challenge in designing such trains is that they are required to play two often contradictory roles, usually on the same journey.

In Kent, the Class 395 bogie had to be light and firm enough to handle high-speed running on dedicated track without inflicting excessive damage.

It had to be robust and springy enough, meanwhile, to handle the sharp curves and uneven track of the Victorian-era routes around Canterbury, Margate and other Kent towns.

One of the Japanese engineers involved likens it to finding a compromise between the suspension of a Formula One racing car and a cross-country sport utility vehicle.

The 395 also has to understand three signalling systems – two on the high-speed line and the conventional British system on the older lines. It is equipped to draw power from the high-speed line's 25,000 volt alternating current overhead wires and the 750V direct current third rail elsewhere.

The Dutch commuter trains – being built by Italy's Ansaldo Breda – have to handle separate Dutch and Belgian electrification and signalling systems, as well as yet another set of systems for the high-speed line linking Antwerp to Amsterdam.

Commuter trains using the high-speed lines north of Madrid in Spain, such as the Talgo 250, even have to be equipped to handle the different track gauges of Spain's high-speed and conventional networks.

The complexity imposes undeniable costs. The Dutch trains' delivery has been delayed by the complexity of making the advanced signalling equipment for the high-speed line speak to the units on the trains. The multiple sets of equipment also impose a substantial weight disadvantage.

Despite their manufacturers' efforts to make them as light as possible, the Class 395s weigh an average 44.75 tonnes per vehicle – against 40.3 tonnes for the conventional-speed Bombardier Electrostar trains that run on some of the same lines.

The weight disadvantages also mean the trains consume more energy. As a result, none can run at the full 300kph standard on Europe's high-speed rail lines. They would consume too much expensive power when on conventional tracks if equipped to do so.

Yet the rewards of coping with the trains' extra cost and complexity can be substantial, according to Keith Ludeman, chief executive of Go-Ahead, the majority owner of Southeastern Trains, the Class 395s' operator.

"It's a definite stimulus to rail travel in areas where it's introduced," Mr Ludeman says, pointing out that the new service has cut commuting times from Canterbury, Kent's county town, to London by 40 minutes to around an hour. Effectively, you shrink Kent into London by considerably reducing journey times," he says.

Mr Stevens expects a similar effect in the Netherlands. Many travellers drive on the congested roads between Amsterdam and Rotterdam rather than taking a train journey of more than an hour that feels longer because of frequent stops.

When the journey time drops to 36 minutes with a single stop at Schipol Airport, travellers' calculation is likely to change. "We expect new markets to develop," Mr Stevens says.

On target: Hitachi's 395 bullet train

Rail Industry

Going underground: workers prepare to improve London Underground infrastructure while minimising disruption to services

Peter Macdiarmid/Getty Images

Metro upgrades prove an uphill task

City transit systems

Integrating new with ancient technology is the toughest challenge

Only the most observant passengers will spot the difference when upgrade work on London Underground's Jubilee Line is completed this year or early next.

Some inconspicuous wires and antennas apart, trains and stations on the line should look unchanged. However, the work will allow trains to complete journeys 20 per cent faster and, since it will also let trains run closer together, overall capacity will improve 30 per cent.

Engineers work beneath city streets all around the world on similar projects every night.

Leading transit systems including the New York subway and Paris metro are seeking to harness the power of new signalling technology to put more capacity on to track that, under existing technology, is carrying all the passengers it can.

Work on such projects could be one of the biggest sources of business for railway signalling suppliers in coming years.

But the risks for suppliers trying to integrate brand-new systems with sometimes decades-old equipment on constantly operating metros are substantial.

David Waboso, head of line upgrades for the London Underground, says passengers should not be fooled by the lack of visual cues into missing the work's scale. "It's like having the foundations of your house, the roof and the internal cavity walls all renewed; you don't see it," he says.

The New York City subway, which had until recently been slower than other large metros to adapt new train-control systems, faces the biggest challenge.

It currently relies on systems that treat the track as a series of blocks – designed to be long enough for a train travelling at the maximum line speed to stop – and keep one clear behind each occupied one. The trains' speed, acceleration and braking are almost entirely left to the discretion of the driver.

Such systems waste space by blocking more track than necessary behind each train. Mismatches between individuals' driving styles can also create bunching of trains or overlong gaps between them.

The Metropolitan Transit Authority, the body in charge of the subway, decided in 2000 to make the short, self-contained Canarsie Line the first to be converted to communications-based train control (CBTC), as the family of new technologies being installed worldwide is known. CBTC systems use track space more efficiently because they constantly monitor trains' location, calculating how much distance they need to stop at their current speed.

This year, France's Thales was awarded the contract to carry out a similar upgrade of a second line, the Flushing Line.

Both the Flushing project and the Canarsie project, carried out by Germany's Siemens, have had the same aim, according to John Brohm, chief executive of Thales' US transport unit.

"It has been to modernise the signalling and infrastructure on those rights of way and bring them to an acceptable modern standard," Mr Brohm says.

Yet the starting point has to be understanding existing systems, according to Frank Gerken, head of the mass transit segment of Siemens' rail automation business.

New systems that breach existing safety rules are unlikely to be approved, while the new system generally has to mimic the old system's workings during a period of parallel operation.

It may be a challenge for operators to explain the full detail of how a decades-old signalling set-up works. "It's up to us to us as outsiders to ask the right questions," Mr Gerken says.

Mr Brohm predicts that there will also be "interface issues" between Thales' CBTC technology and existing systems on the Flushing Line, but says he is more concerned about the problems of keeping the line operating.

"The fact that it's a live, operating railway drives most of the considerations that have to go into the installation and integration plan," he says.

Mr Waboso says lines could be kept open more during upgrade work if contractors invested more in off-site simulation, .

He is also impressed with how other metros, including Madrid, have weeded out problems during periods of "shadow running", when new technology ran alongside old systems but controlled nothing.

The Jubilee Line illustrates what can go wrong. Bad relations between Tube Lines, the private consortium that started the work, and London Underground led to misunderstandings about the nature of London Underground's safety standards. Changes to match the system to the rules led to long delays.

Tube Lines had also installed the new system so that it was incapable of working alongside the old, in an effort to circumvent the complexities of integrating them. Engineers take hours to switch over between systems at the start and finish of testing, with the line closed all the time.

Delays on the Jubilee Line played a role in persuading Tube Lines' owners to pull out of their underground contract, selling the company to London Underground. "It's fair to say that the implications of how long [the switch-over] was going to take were never really fully appreciated," Mr Waboso says.

Yet Mr Waboso's challenges in rescuing the Jubilee Line upgrade look minor compared with the task facing the New York subway bosses.

Because so many lines interconnect and use a common pool of trains, the next big upgrade project after the Flushing Line will have to start addressing the challenge of switching over nearly every other route on the system to CBTC.

That, according to one person involved, could be one of the most complex rail engineering projects of all time.

Customised systems on the right lines

Trams

Manufacturers will increasingly have to adapt to buyers' specific needs

Blackpool-bound: Bombardier's Flexity 2

Visitors to the north-western English town of Blackpool have for decades regarded the old-fashioned trams as part of the traditional seaside resort's charm, along with donkey rides and its junior version of the Eiffel Tower.

But from the middle of next year, sleek, low-floor trams will hum along the town's wind-blown promenade. Blackpool's 125-year old tramway is serving as the worldwide launch customer for the latest model from the world's biggest tram maker.

The launch of Montreal-based Bombardier Transportation's Flexity 2 tram design in Blackpool underlines the idiosyncrasies of the world market for light rail vehicles.

Although based on a standard design that will have many elements in common with other Flexity 2 orders, the 16 trams will inevitably need some tailoring to Blackpool.

The modern, sophisticated vehicles will have to run along track designed for, and battered by, the rest of the municipal transport company's fleet, nearly all dating from before the second world war.

The world's leading tram makers – which include several European manufacturers and Japan's Kinki Sharyo – have battled for years to create basic designs, or platforms, flexible enough to be adapted to each customer's needs without the expense of a sweeping redesign.

Many, like Bombardier, are overhauling their offerings by using carbon-composite materials to reduce the vehicles' weight and energy consumption.

Some sceptics say the large manufacturers still struggle to meet the range of customer requirements properly. But Colin Walton, Bombardier Transportation's chairman for the UK and Ireland, insists the Flexity 2 is easily adapted to relatively small orders.

"If you have a standard design and you build in hundreds and somebody wants five bespoke vehicles, you can't put that in the middle of your construction line," he says.

> Alstom designed a special bogie whose wheels flex slightly to cope with poor-quality track

"With Flexity 2, we have the option of giving them a bespoke vehicle and doing orders of 15 to 20."

The nature of the challenge is clear to Pierre Gosset, platform director for the Citadis family of trams built by France's Alstom, one of Bombardier's main competitors.

Nearly all Citadis orders have come from customers building new tramways, such as Athens' municipal transport company, which bought striking, silver-coloured Citadis trams for new lines before the 2004 Olympic Games.

The Citadis and other makers' standard products have lower, more accessible interiors than traditional trams. Older trams needed high floors to allow the bogies – the frames that carried their swivelling wheels – to move around underneath. The new designs' flexible bodies take them round corners while the wheels stay rigid.

There has been a buoyant market for such low-floor trams in Alstom's native France, where nearly all municipalities closed their tram systems after the second world war but recent years have seen scores of modern systems built.

The differences between Citadis trams built for such modern systems are mainly cosmetic, Mr Gosset says.

On existing tramways, however, other adjustments are often required. Alstom is currently delivering 37 Citadis vehicles to Istanbul, where some will be deployed on the older Zeytinburnu-Bagcilar line. Alstom has had to design a special bogie whose wheels flex slightly to cope with the poor-quality track.

Some big networks – including Zagreb, in Croatia, and Helsinki, in Finland – use tracks only a metre apart, instead of the 1,435mm standard.

In Germany, many areas retained trams but built platforms at stations, so insist on high-floor trams. Adapting designs to this demand is "a much bigger issue" than the problem of the rough track in Istanbul, Mr Gosset says.

Yet, according to Norbert Schiedeck, chief operating officer of Germany's Vossloh, one of Europe's smallest tram manufacturers, small, idiosyncratic tram orders are a natural feature of the market, not the exception. Trams tend to operate in medium-sized cities too small to have metros.

There remains a niche in the market to build individually tailored designs for cities which, if they were restricted to the big manufacturers' standard trams, could be forced to make expensive changes to their track to fit them.

"We offer 15 to 20 vehicles and customers are happy about that because they otherwise would not get individual vehicles," Mr Schiedeck says.

He may have history on his side. Since many of the cities best suited to building new tram systems have already done so, Mr Gosset accepts that future tenders are likely increasingly to resemble that from Blackpool rather than Athens.

"We have to be able to adapt our standard product to fit with the environmental constraints of our customers," he says.