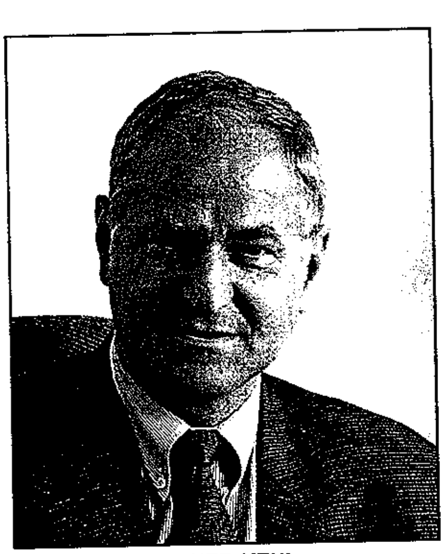
Modular LRV Offers Sa

Major manufacturers are responding to the growing demand for cheaper, lightweight—but also durable—light rail vehicles. Among them is Siemens, which unveiled its Combino modular LRV earlier this year (IRJ August p38). The new 100% low-floor aluminium-bodied vehicle will cost 30% less than previous models.

Rainer Kehl
Executive Director, Siemens Transportation Systems, Mass Transit Rolling Stock Division



RAINER KEHL

PRIVATISATION of public transport services is resulting in more stringent demands being made upon equipment suppliers by customers. The travelling public is demanding greater convenience and improved creature comforts, and the service provider in turn requires better operating economics and a longer service life from rolling stock. In short, everyone wants greater flexibility and better value for money.

As the name implies, the Combino light rail vehicle brings together the key features necessary to meet the demanding requirements of the urban transport operator. Among these is the use of standardised low-floor vehicle modules that are produced using the latest materials and manufacturing techniques.

However, standardisation does not reduce flexibility. Operator-specific requirements are met by combining modules at the planning stage of a particular project or order. In this way the most varied vehicle configurations can be accommodated.

It is no longer acceptable to regard the operator as the proving ground for rolling stock and related equipment. Today's urban light rail systems have to earn revenue the moment they enter service. Consequently, the guiding principle behind the Combino concept is the use of tried-and-tested components and sub-systems to ensure maximum reliability and guaranteed availability.

This principle, of course, does not preclude innovation: new construction techniques using lightweight materials reduce tare weight and take full advantage of the most modern electric drives, while still affording maximum passenger convenience.

Innovative maintenance methods and spare-parts scheduling that were considered at the conceptual design stage ensure the minimum down time (ie maximum availability) at the lowest possible servicing cost. Maintainability is further facilitated by automated fault detection and recording.

In other words, much of the innovation incorporated in the Combino concept is directed at minimising capital cost, improving operating economics, and enhancing serviceability—but not at the expense of passenger convenience or comfort. This adds up to a very attractive price-to-performance ratio which should continue over the projected service life of about 30 years.

To meet what amounts to a design-to-cost specification, Siemens' Transportation Systems Group and its subsidiary Duewag developed the Combino very much with enhanced operating economics in mind: lower purchase price coupled with reduced operating and maintenance costs were the driving forces behind this radically new LRV design.

Passenger comfort and utility have not suffered as a result, though. Anatomical seating and operational flexibility go hand-in-hand with the special requirements of the aged and handicapped, notably ease of access, as well as those of mothers with prams, tourists with rucksacks and, of course, cyclists with their bikes. Furthermore, extensive use of glass promotes a feeling of space and allows passengers to appreciate the journey better.

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A Combino costs less than many comparative vehicles that are currently available. Furthermore, on a one-for-one comparison, operating and maintenance costs are predicted to be lower over the scheduled life cycle.

The most varied vehicles can be implemented by combining modules at the planning stage of an order. Configurations ranging from a short 18m vehicle to a long multi-articulated 40m train can be assembled with widths from 2200 to 2650mm (the diagram shows some possible train configurations). Modularity also permits variations in performance and operational scope (eg uni- or bi-directional running) without changing the basic concept.

Nonetheless, there is considerable scope for operational variation: optional extras include a more detailed passenger information system, air-conditioning and a redundant power supply for enhanced reliability. A notable customer option is the facility to change the vehicle's internal configuration to provide more capacity, for example to change the seating layout to accommodate more passengers attending large events such as football matches.

The use of standardised components and sub-assemblies minimises costs and reduces delivery times, but not to the extent of restricting choice. Each operator ordering a Combino set in effect takes delivery of a bespoke vehicle. Such versatility should make the Combino suitable for service in most parts of the world.

Reducing the specific energy consumption (energy consumed per unit of weight) was also high on the list of design priorities. The use of both lightweight materials (aluminium and composites) and weight-saving construction methods (bonded-sandwich techniques) coupled with the extensive use of data-bus wiring to minimise cabling runs helps to save energy. Depending of course on the configuration, the tare weight can be as low as 900kg/m of vehicle length.

Nonetheless, this is only part of the story. The most significant energy savings are in the use of advanced electric drives based on IGBT technology.

Tractive effort is derived from the robust Duewag longitudinal drive comprising two 100kW self-ventilated asynchronous motors,

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each with two bevel-gear drives, the necessary coupling, a disk brake and a spring-loaded brake.

This tried-and-tested drive assembly is fully suspended on the outside of the running-gear frame and, therefore, all component parts are accessible through side covers in the LRV's skirting—an important facility for reducing maintenance costs. Moreover, a drive fully suspended in this way greatly facilitates track guidance, which in turn minimises wear and provides a smoother and quieter run.

The running gear makes use of portal axles to achieve the low-floor access. These are connected to the bodyshell by longitudinal levers in order to restrict the swivel angle. This in turn allows for a passageway up to 830mm wide, even when running on metre-gauge track.

The two parallel traction motors of each running-gear module are driven from a single inverter that uses the pulse-width modulation technique based on IGBT technology to optimise energy use. The drive is regulated by Siemens' Sibas traction control system that is in service in many parts of the world. The motors are fed with 600/750V dc from the usual pantograph arrangement mounted on the roof of one of the modules. The main items of roof-mounted equipment are the centre container, pantograph housing, cable ducts, heating and ventilation unit, terminal boxes, driver's cab heating and ventilation unit, and destination indicator.

Changing patterns of operational management and the need to operate under stricter commercial conditions means that service and maintenance are moving increasingly away from the remit of the operator and more towards that of the equipment supplier. The operator provides the transport service per se and the equipment supplier the means to carry out the service to stipulated standards.

This force majeure means that Siemens needs to consider terotechnology (techniques for dealing with the installation and ongoing maintenance) as an integral part of the design, build, operate and maintain process. The implications of such an all-encompassing philosophy go beyond the drawing board and production factory: they extend the commitment and responsibility of the equipment supplier to the entire working life of the tram. In the case of a typical Combino, this amounts to more than a quarter of a century.

Terotechnology and all it implies is playing an increasingly key role in Siemens' rail technology. Developments in Britain in particular have given the company the opportunity to put its terotechnology ideas and practices to the test: for the past four years it has carried out the day-to-day maintenance of the Sheffield Supertram stock, and is currently building a purpose-built maintenance depot for the Heathrow Express project, located next to the Railtrack maintenance site at Old Oak Common. These and other servicing activities will provide the company with the valuable experience to expand its rail-maintenance facilities around continental Europe and elsewhere.

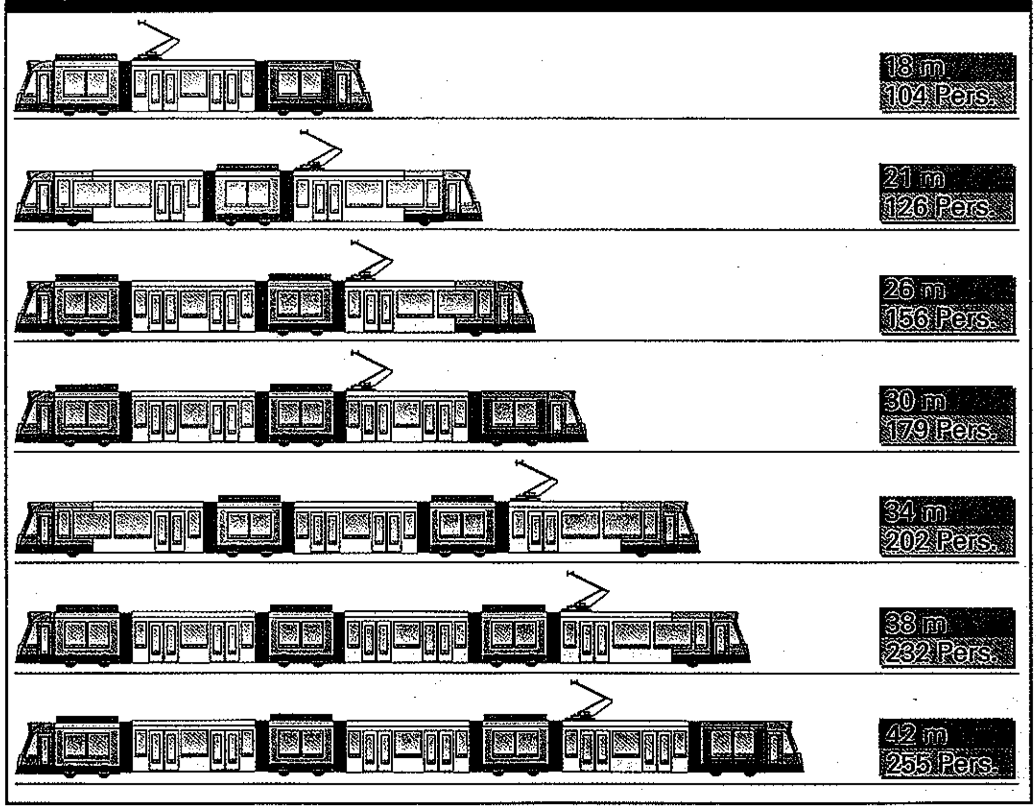
Terotechnology involves far more than just the installation and subsequent servicing of rolling stock as practised in the past. Its techniques bring a whole new philosophy to permanent way operations, as well as servicing and maintenance. This is particularly essential to those operators with short-term franchises if they are to be profitable and at the same time meet demanding safety requirements.

In these days of increasing competition, the target price—the initial capital cost—has always to be kept clearly in sight when the outline specifications are transformed into a design reality. Nowhere is this more necessary than with urban light-rail vehicles. Consequently, this was a practice strictly adhered to during the early stages of Combino's design process.

An analysis of existing urban transport showed that the demanding specifications could not be achieved simply by progressive development; so a novel concept was envisaged that approached the problem more from a general road transport omnibus point of view than from that of a conventional tram. As can be appreciated, such a concept required some radical re-thinking both in terms of design and materials used; so the Combino represents a "new train of thought" for light rail operations.

The growing demand for lightweight mass transit vehicles such as Combino is an encouraging sign of a revival in urban tramways. This revival will, of course, be governed increasingly by environmental considerations as well as economics. The introduction of new technology LRVs is an indication of how the manufacturers are re-orienting themselves to the requirements of not just the private operators, but also to the travelling public, who will be persuaded increasingly in the future to leave their cars at home. **IRJ**

VARIOUS CONFIGURATIONS USING DIFFERENT COMBINO MODULES



Cromweld Steels, Britain. This new-generation material plays a vital role in reducing the overall weight of the vehicle. Its high yield strength, energy absorption properties, and high corrosion resistance—estimated at 200 times that of mild steel—means that reduced-thickness panels can be used in constructing LRVs. Substantial weight savings can be achieved as a result. The manufacturer of 3CR12 says it is not only cheaper to purchase than conventional stainless steel, but its performance ensures greater operational efficiency, reduced maintenance, and longer vehicle life.

The Tram Group—comprising Pullman Transportation Projects, Blackpool Transportation, Blackpool Design Associates, Powergen, and Tram Research—intends to sell its new LRV designs under licence to other manufacturers. Robinson is confident that the group will be able to exploit the growing demand for affordable vehicles worldwide, with the new lightweight range regarded as suitable for operators of existing light rail networks as well as those considering whether to build and equip new lines. Pullman is also likely to be interested in joining consortia bidding for future light rail construction projects.

Meanwhile, development work is continuing on the new LR55 track system, which is the brainchild of Professor Lewis Lesley of Liverpool John Moores University. It was Professor Lesley who developed the lightweight low-cost LRV concept, and he subsequently formed Tram Research, which became an important member of the Tram Group.

Professor Lesley's track system—promoted by the Track Group—uses a new profile of rail and exploits the strength of existing highway pavements by transmitting the static and dynamic loads from the upper surface rather than the foot of the rail.

This means that the load on the railhead distributed on to the highway sub-base has a stress sufficiently low so that a separate foundation is not normally required and the depth of excavation is minimised. This should obviate the need to relocate under-street services such as pipes and cables.

The ambitious project is taking much longer than expected to reach fruition, however. Initially, it was planned to install an 18m test section in Blackpool in March 1994, but the city authority ruled out the proposal. Eventually, a short test section was installed in March this year on the South Yorkshire Supertram light rail network.

"The track can be installed economically, and it is capable of carrying mainline axleloads of 25 tonnes as well as LRVs and lorries. It promises to make street-running light rail systems as economic as bus services."
—Prof Lewis Lesley

Results so far have proved encouraging—with no signs yet of failure—according to Professor Lesley, who told IRJ: "We have come across scepticism and a reluctance in some cases to accept the system, but this hasn't surprised me. When the first iron ships were proposed, people said they would sink. This is the sort of problem we are faced with at moment, but people will soon appreciate that this system is going to work and that it will reduce costs tremendously.

"Obviously, we are going to target planned new light rail systems, including those proposed for Croydon in Britain, and Dublin in the Republic of Ireland. But first we must find sufficient finance to build a 300m-long test section of track to enable further tests to take place. This will have to be done before a realistic bid can be made to install the LR55 track system on an entire new line."

In his latest paper, produced jointly with university colleague Dr Hassan Al-Nageim, Professor Lesley confirmed that testing so far has been highly successful, and he argued that the new LR55 track will make light rail systems as economic to operate as bus services in the future.

Professor Lesley presented the paper to the Institution of Civil Engineers' metro and rapid transit conference, held recently in Manchester, Britain, in conjunction with the Infrarail 96 exhibition (IRJ November p35).

The paper stated: "Installing tracks in city streets is extremely expensive. Part of this cost involves relocating underground services and utilities outside the swept path of LRVs. This diversion in city centres can be physically difficult. For the Manchester Metrolink, the diversion of underground services cost nearly £8 million, compared with only £6 million for the track construction.

"Traditional light rail track systems are based on a reinforced concrete slab about 6m wide and up to half a metre thick, on which rails up to 180mm-deep are mounted. In order to enjoy continued access for maintenance, underground utility plant has to be moved.

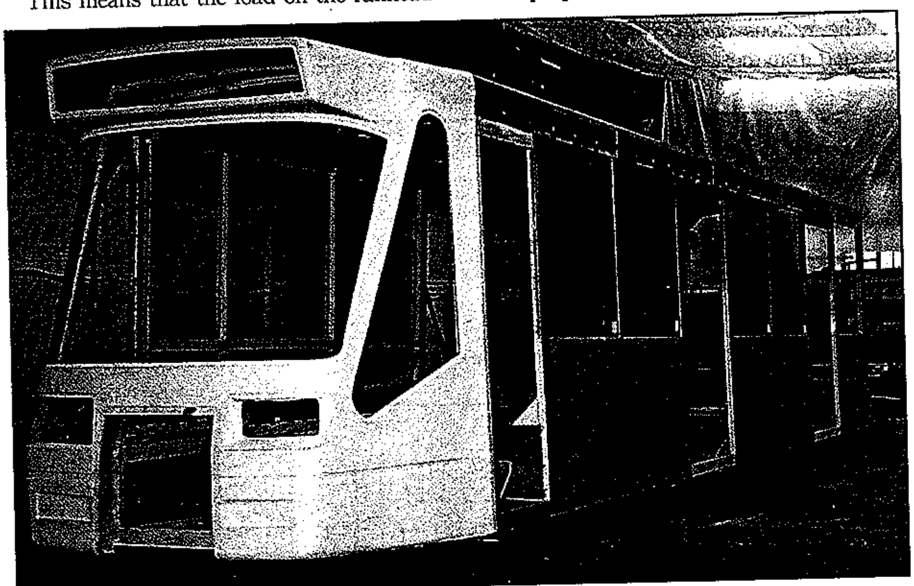
"A light rail track system will need to be less than 180mm deep if it is not to interfere with underground plant which remains in place. In order to retain access to the plant, the carriageway sub-strata should be accessible around the running rails, and the track should be self-supporting.

"The track system will have to support LRVs—with axleloads usually under 10 tonnes—and lorries with axleloads under 10.5 tonnes. Indeed, the impact of highway vehicles is more damaging to light rail track than LRVs, as the compression and extension effect of rolling rubber tyres can disturb the track and damage the surrounding carriageway structure.

"The LR55 track system comprises two independent troughs, approximately 300mm wide and 160mm deep, set onto a bedding layer at the bottom of a shallow trench. The trench sides are cut with disc, pizza, or water jet cutters, and the troughs are sealed in with suitable mastics.

"The rails, aligned for gauge and horizontal and vertical profiles, are bonded into the troughs using a specially formulated PU grout, which was developed originally to seal leaking high-pressure underground steel gas pipes.

"In testing, a beam model was prepared to predict track behaviour under loading for



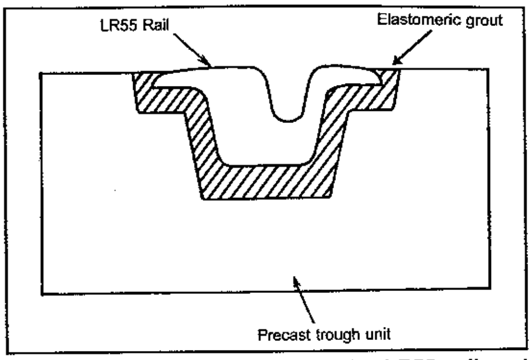
Bodyshell of the new lightweight low-cost LRV at Pullman Transportation's factory.

foundation strength of 5000MPa, predicting shear stress, deflection, and base pressure. This model showed that a foundation of dry sand would provide a strength 30 times greater than the trough base pressure. Laboratory tests confirmed the efficacy of sand foundations.

"Static testing with 80-tonne axleloads, and dynamic testing with 20-tonne axleloads—simulating 30 years of endurance at passing speeds of 100km/h—have been completed.

"Tests with rail samples underwater confirm PU band integrity. Tests pulling a rail from its trough failed at a load of 35kN. Compression tests failed to damage a normally supported rail sample at loads of up to 400kN (80-tonne axleload), and a metre-length sample, simply supported at each end, failed with a central vertical load of 290kN. Climatic testing up to 60°C and down to –10°C produced no failures.

"In March 1993, a 10m length of LR55 track was installed at Rotherham bus station. During a period of two-and-a-half years, more than 3 million buses passed over, along, or across the installation, with each bus entering the station with an axleload of up to 13 tonnes. No failure occurred during this period, which would be equivalent to 30 years on a typical urban bus route.



The precast rail trough holding the LR55 rail and grout is about 160mm deep and 300mm wide.

"In March 1996, an 18m length of LR55 track was laid in an operating light rail system in Sheffield where it was subjected to impact by lorries and LRVs. Since then, the track has been exposed to about 400 daily movements of lorries and LRVs. The installation continues to provide a satisfactory service.

"Agreement has been reached in principle with the statutory undertakers for one proposed light rail system to leave underground plant in place with modified access points. On a 7km route, this has reduced the estimated cost of utility accommodation works to less than £6 million, compared with total diversion costs which would amount to more than £15 million. The cost of installing the LR55 track system has been determined at less than £500 per single track metre.

"The LR55 track system has been proven in field trials, and the mathematical models and laboratory tests have been validated. The track can be installed economically, and it is capable of carrying mainline axleloads of 25 tonnes as well as LRVs and lorries. It promises to make street-running light rail systems as economic as bus services."

During his presentation, Professor Lesley agreed that the wider railhead required for the LR55 system could pose a potential skidding problem for highway vehicles—including bicycles—particularly in wet conditions. However, he claimed there was "no reason why the rails could not meet the normal criteria for highways," and he revealed that tests using anti-skid materials were now being carried out at some locations.

Professor Lesley said that testing is also underway to measure the flexibility and adaptability of the track, and to establish the minimum curve radius which could be achieved in the design and construction of a commercial light rail line. He added: "We could do it to a 15m radius—and maybe even a 12m radius will be possible." **IRJ**