Low-Floor LRVs Move Into Second Generation

Low-floor LRVs have been in operation for 10 years. Here we take a look at how lessons learned are being incorporated into second-generation low-floor LRVs which are now starting to be introduced.

THE concepts behind today's lightweight low-floor LRVs are both radical and imaginative and are a good example of how the rolling stock industry has broken new ground in terms of operating flexibility, running costs and passenger convenience, and in many instances at a price not much more than the traditional high-floor tram. Nonetheless, some of the first-generation designs have had—and some still have—their problems.

The old adage "necessity is the mother of invention" was particularly apt when the first purpose-built low-floor LRVs were being designed more than 10 years ago—the first low-floor LRVs became operational in Geneva, Switzerland, in the autumn of 1987. Most of the more traditional trams were more than 20 years old both in design and operating concept and, therefore, were not really suitable for the requirements of the next 20 or 30 years. Something new was required for the post-automobile city centre of the next century.

Various transport authorities, town planners and, indeed, many rolling stock manufacturers, took the opportunity to take a radical look at the tram and come up with something that was better for both the passenger and operator and would overcome many of the attendant problems of transporting people in densely-populated cities: truly a case were necessity drove both design and operating requirements.

In these days of increasing cost sensitivity within the transport industry, the target price—the initial capital cost—must always be kept clearly in sight when outline specifications are transformed into design realities. This was a view strictly adhered to at the earliest stages of low-floor LRVs for both the first and second generation. Continuing analyses of existing and future urban transport requirements showed, and continue to show, that this cannot not be achieved simply by progressive development; so novel concepts were and are continually being envisaged that approach the problems more from the point of view of bus design than from that of a conventional tram or light-rail vehicle. Such concepts necessitate radical re-thinking both in terms of design and materials used.

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The most apparent advantages of today's low-floor LRVs is that they make life easier for passengers, particularly the handicapped and parents with pushchairs for example. Moreover, in most cases boarding times have been significantly reduced, an important consideration during peak-hour travel.

But passengers have not been the sole benefactors. Operators in many cases have benefited from improved operating economics. For example, ac traction motors are very robust indeed and as a result do not require the same levels of maintenance and servicing as their dc predecessors. Also, self-ventilated asynchronous motors are far less prone to overloading and the efficiency of the slip/slide protection is much better, allowing the operator to improve services. The latter improvement is, of course, largely the result of using regenerative braking. Another operator advantage is that the use of solid-state traction control makes wheel flats almost a thing of the past.

However, as with most radically new and innovative technology, many first-generation designs of low-floor LRV have had their problems. For example, interior noise has been higher than expected because the running wheels are much closer to the vehicle floor and, therefore, the passenger. The propulsion electronics, surprisingly, and rheostatic braking have also proved to be noisier than expected. Another point of contention has been the weight of the first generation of low-floor LRVs, which is more than conventional designs. As a result, electricity consumption is about the same as traditional designs. However, it should always be borne in mind that low-floor designs do offer significant savings in other areas such as maintenance and servicing.

The effects of running conditions, especially on those components surrounding the wheel/rail environment, have given rise to high vertical *g* values leading to excessive wear resulting in some cars being derailed. Some single-wheel drives have proved to be noisy. Furthermore, independent wheels have not prevented the annoying shrieks associated with past generations of trams or noticeably reduced track wear and tear.

The latter point is perhaps the biggest grouse coming

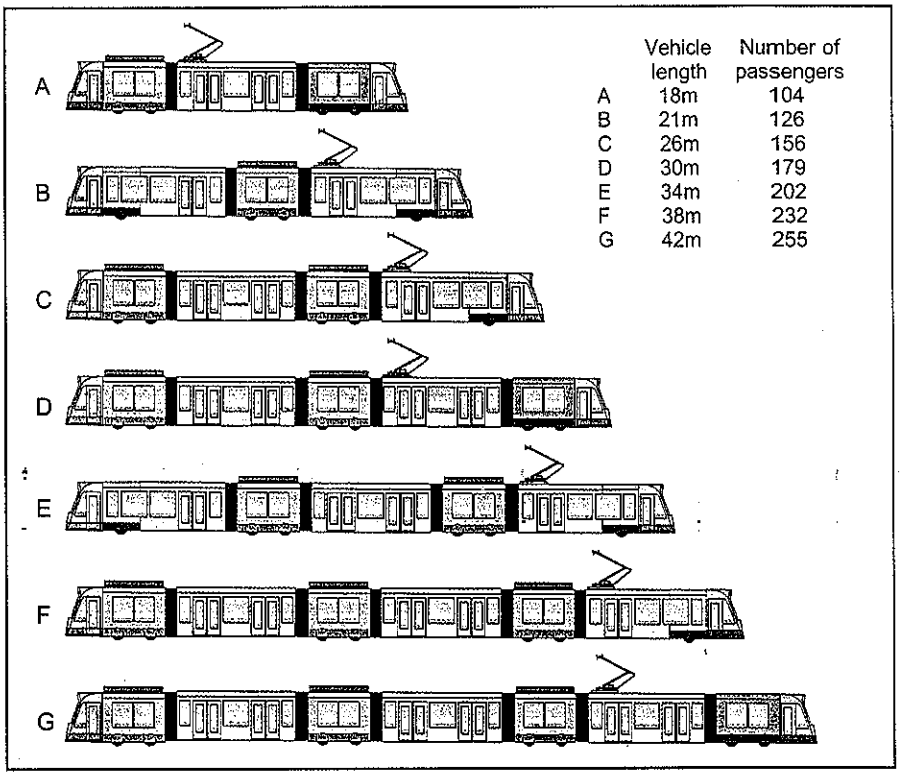
Geneva was the first city to introduce low-floor light rail vehicles.

from the operators, for the ride of low-floor LRVs, particularly those with single axles carrying individual wheels, has proved to be particularly sensitive to the quality of the track. Generally, poorly-maintained track has shown to significantly increase running noise and wear and tear to both LRV and track. Clearly there is an incentive for an operator to increase the frequency of track maintenance.

The length of commissioning times has also given rise to concern on the part of some operators. In some cases it has been many months before the new design of vehicle is working to specification.

One can perhaps infer from this that too many new designs have been introduced over too short a time, and as a result the situation overloaded the capacity of many rolling stock suppliers and operators. The situation has been compounded by too much relatively untried innovation that has imposed high remedial costs on some manufacturers. Initially one can also come to the conclusion that trying to produce a generic type of low-floor LRV to suit all situations exacerbates the situation.

Many of these problems should be resolved by the second-generation of low-floor LRVs that are shortly to be commissioned. Most manufacturers have successfully incorporated new and innovative technology and are concentrating on improving the breed. The Siemens Combino is an example of this. To date 73 Combino LRVs have been ordered with options for a further 20. The first will enter service in October in Potsdam, Germany. The design incorporates many years' experience derived from operating under a variety of conditions in various parts of the world.



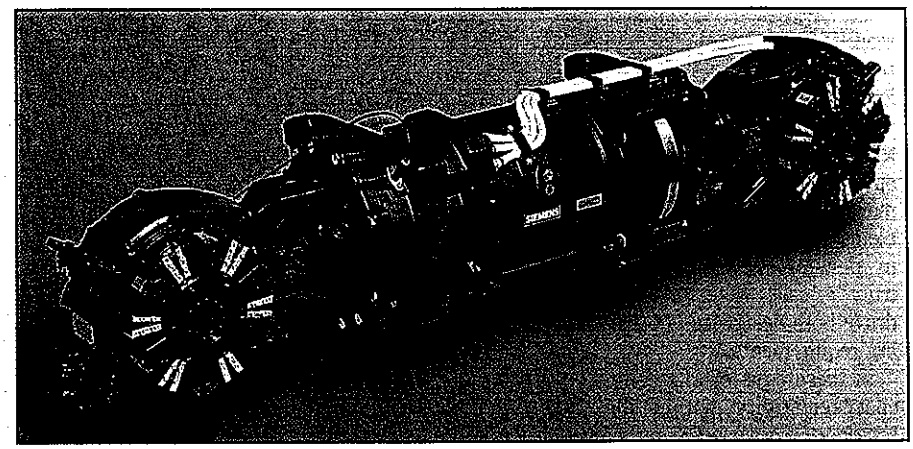
	Vehicle length	Number of passengers
A	18m	104
B	21m	126
C	26m	156
D	30m	179
E	34m	202
F	38m	232
G	42m	255

Combino uses a variety of modules to produce several types of vehicle.

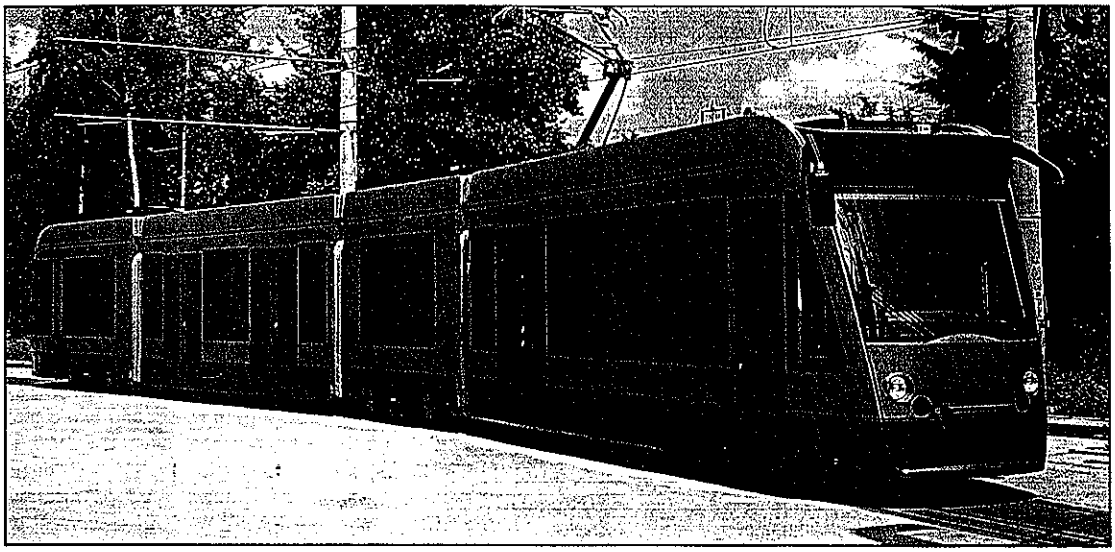
Reducing the specific energy consumption (energy consumed *per* unit of weight) is high on the list of design priorities of most manufacturers. Many second-generation designs use both lightweight materials (aluminium and composites) and weight-saving construction methods (bonded-sandwich techniques) coupled with the extensive use of data-bus wiring to minimise cabling runs. All this goes some way to save energy. If the Combino is typical of this approach, the tare weight of such an LRV can be as low as 1 tonne/m of vehicle length.

Nevertheless, this is only part of the story. The most significant energy savings are in the use of advanced electric drives based on IGBT (Insulated-Gate Bipolar Transistors) technology which makes much more efficient use of electrical energy and is considered to be quieter in operation.

Specific operator requirements are being met by modular design and by combining modules at the planning stage of an order. In this way the most varied vehicles can be implemented and operator requirements met at the cost of a series-produced vehicle. Modularity also permits variations in performance and operational scope, for example uni- or bi-directional running, without changing the basic concept. The use of standardised components and sub-assemblies also obviously minimises costs and reduces



Second-generation traction: a Siemens two-wheel longitudinal drive unit.



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delivery times, but not to the extent of restricting choice. Each operator ordering an LRV based on such a modular design concept in effect takes delivery of a bespoke vehicle at an off-the-peg price. Clearly, such versatility makes this kind of LRV suitable for service in most parts of the world.

Many of the second-generation low-floor LRVs will incorporate improved drive technology. In the opinion of many, compact two-wheel longitudinal drives, comprising self-ventilated asynchronous motors, bevel-gear drives, the necessary coupling, a brake disk and a spring-loaded brake, is likely to prove a better configuration. This has all the benefits of the traditional two-axle longitudinal drive.

This tried and tested method of traction 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. Moreover, a drive fully suspended in this way greatly facilitates track guidance, which in turn minimises wear, provides a smoother run and reduces ambient noise and, of course, is much harder to derail.

It is no longer acceptable to expect the operator to act as the proving ground for the supplier's equipment. Complaints about the excessively long commissioning times of first-generation low-floor LRVs bear this out. Rail vehicles, irrespective of type or mode, have to earn revenue the moment they enter service—this is just one of the results of privatisation.

Consequently, one of the guiding principles of the more enlightened manufacturers is to use in future more tried and tested components and sub-systems to ensure improved reliability and to test fully the completed LRV on their own test facilities. Such measures will go a long way to reduce commissioning times. **IRJ**