Automatic container transport by electric monorail

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Introduction
This article looks at an innovative continuous system of inland container shipping – an all electric and fully automated steel monorail.

A state of the art system
The system is capable of transporting goods in all weather conditions, 24 hours a day, 365 days a year. Travelling in silent procession, without the need to pass through our already overcrowded cities, goods could be moved a distance of 1,200 kilometres per day, whilst consuming less energy and emitting lower levels of pollution than more conventional modes of transport. Early estimates suggest that commercial costs (tonnes-kilometres) could be reduced to nearly half that of the current cost of transporting containers by road, taking into account driver absence and the relatively low cost of both infrastructure and required maintenance.

Control status of goods
With the potential to move 40 million tonnes per year, each line would serve intermediate stations for the loading and unloading of containers, with the stoppage used to conserve energy and absorb speed. The containers would be loaded onto individual platforms, capable of carrying up to 40 tonnes each, which would travel 100 metres apart. Each platform will contain a mini onboard computer that manages its acceleration and constant 50 km/h speed, stopping only at its final destination. The computer is also programmed to follow a freight route map, which is activated upon receiving its cargo. Depending on the logistics of the line, empty containers can also be transferred to other stations if required. Platforms can be identified with an electronic code, which will be read by electronic readers located at a number of points along the line. This will enable customers to track the exact position and status of their goods in real time.

Current state of the sector
Railroad system
Sharing the same infrastructure for passengers and freight is not a sustainable solution for the future. The concept of the ‘Roman road’ is a design of the past and too costly today. The required reform of present infrastructures and maintaining bridges, viaducts and tunnels are the biggest obstacles in developing a sustainable future for rail freight, and could be as costly or more than this innovative model.

In addition, the conventional freight railroad is not an adequate alternative to confront the challenge of both environmental and economic objectives. It presents many limitations. The main problem is that the current system is far from complying with the efficiency required by the market. The diesel weight of locomotives requires high resistance from its supporting infrastructure and emits high levels of CO2. It is also unable to operate on slopes with a gradient above 1.5 percent, while passenger trains are an all too common service disruption. The track gauge is not international, at least in some countries. All these factors explain why conventional rail is struggling to deliver its target of a 40-50 percent share of the total freight market. In Spain this is as low as four percent, while the rest of Europe averages just a 20 percent share.

Road truck system
At 90 kilometres per hour (km/h), 90 percent of the engine power of trucks is consumed by the rolling resistance of both the road surface and aerodynamic drag – 90 kilowatts (kW) and 71 kW respectively. This energy consumption and the incidence of driver cost means that the total cost of a road transport system is about twice that of the monorail concept. Fourteen percent of motorway accidents are related to the presence of trucks and members of this profession have one of the poorest levels of workforce health.

Transport capacity
The estimated capacity on each line could be over 40 million tonnes per year, which over a 1,000 km route would generate 600 million of saved costs, whilst saving up to two million tonnes of CO2 emissions against the classic road traffic model.

<table>
<thead>
<tr>
<th>THEORETICAL CONDITIONS</th>
<th>Results</th>
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<tbody>
<tr>
<td>Travelling speed</td>
<td>50 km/h</td>
</tr>
<tr>
<td>Average load per container</td>
<td>18 tonnes*</td>
</tr>
<tr>
<td>Distance between platforms</td>
<td>100 meters</td>
</tr>
<tr>
<td>Time between platforms</td>
<td>100 / 14</td>
</tr>
<tr>
<td>Container per hour</td>
<td>3,600 / 7.1</td>
</tr>
<tr>
<td>Theoretical capacity**</td>
<td>500 containers/hour</td>
</tr>
</tbody>
</table>

* Average load. Maximum total load per platform is 40 tonnes (10 tonnes per wheel)
** Expected current conditions with operative efficiency 0.55 are: 500 x 0.55 x 24 x 340 x 18 (tonnes/unit) = 40,000,000 tonnes per year
Energy comparisons

Aerodynamic drag resistance
 Accredited tests reveal that at 85 km/h a truck with an 8.7 square metre (m²) frontal area consumes 71 kW (95HP). In comparison, a platform with a 7m² frontal area at 50 km/h would consume 19kW (25HP).

Rolling resistance
 The rolling coefficient of steel wheels on the steel monorail compared to tyres on asphalt is 1:9. A 10-wheel trailer at 85 km/h absorbs 90kw (120 HP), compared to 15kw (19HP) by a railroad platform.

Emissions analysis and required power
Using updated analysis of the technological advantages of the monorail concept against the road truck system we get the following comparative results:

<table>
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<tr>
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<th>Track on road (gas-oil)</th>
<th>Monorail (electricity)</th>
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</thead>
<tbody>
<tr>
<td>Power</td>
<td>175 Kw</td>
<td>35 Kw</td>
</tr>
<tr>
<td>Load per unit</td>
<td>20 Tn</td>
<td>20 Tn</td>
</tr>
<tr>
<td>Emissions CO2</td>
<td>3 Kg / Kg (gas-oil)</td>
<td>0.3 Kg / Kw-h (1)</td>
</tr>
<tr>
<td>Speed</td>
<td>85 Km/h</td>
<td>50 Km/h</td>
</tr>
<tr>
<td>Consumption</td>
<td>400 Kg / 1000 Km</td>
<td>700 Kw-h / 1000 Km</td>
</tr>
</tbody>
</table>

(1) The monorail concept is a zero emission system. The only emissions come from the electricity generation process which the system consumes.
Economic considerations

Calculations of cost per tonne-kilometre suggest that the savings over current road transport could be as much as 50 percent. The main reasons for this huge difference are that the monorail system uses around 60 percent less energy. It is a driverless operation. The system is easier to adapt to the landscape as it only requires one rail per direction. There are major savings on maintenance, labour and loading operations. There is an immediate availability to operate, even for just one container. It is a truly 24-hour service, while there is a vast cost benefit to having thousands of platforms travelling non-stop from departure to destination without the need for locomotive and catenary.

The result is a saving of about €600 million on a 1,000 km route. Part of these savings could provide the foundations for a significant return on investment. This innovation could also be a very attractive solution for container handling in ports and in the hinterland. The concept has already been granted patents in the USA, Russia, China and the European Union.

ABOUT THE AUTHOR

Aeronautical engineer Gregorio Márquez Murillo has over thirty years experience in the transportation sector, power generation and in the design and manufacture of electromechanical auxiliary equipment. After receiving a PhD in engine technologies from Madrid's Polytechnic University, Gregorio worked as an industrial manager at Femsa-Bosch and Poclain in Spain. Today, he is an independent private investigator for the electromechanical industry, and has recently worked with Walthon Weir Pacific and Eurotunnel.

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