LITEBUS

Modular Lightweight Sandwich Bus Concept

**Funding:** European (6th RTD Framework Programme)

**Duration:** Oct 2006 - Sep 2009

**Status:** Complete with results

**Total project cost:** €3,455,074

**EU contribution:** €1,999,998

**Call for proposal:** FP6-2005-TRANSPORT-4

**CORDIS RCN:** 79972

**Background & policy context:**

Bus manufacturing is a niche market compared with the car market. It is estimated that there are more than 500,000 buses in circulation in EU countries alone. The bus industry uses extensively welded fabrication, which is labour intensive in nature. In order to stay competitive and maintain employment, bus/rail manufacturers will have to produce more attractive products and reduce production costs, thus new concept designs, materials and assembly methods will have to be developed and applied.

Currently there are no buses/coaches or rail rolling stock in the market using the design concepts and composite sandwich materials developed within the LITEBUS project.

The project aimed to explore the potential benefits offered by integrated composite sandwich material in passenger buses/coaches as a case study for other potential applications in trains, ships, trucks, cars, vans, etc.

The new vehicle concept was benchmarked with current steel vehicles through a life cycle analysis (LCA) in order to implement the new Integrated Product Policy (IPP) principles, leading to a more environmentally friendly vehicle.

**Objectives:**

The main objectives of the project were:

- to solve the problem of reducing weight and production costs of land transport vehicles through the development of a technology of modular bus/coach construction, using 'all composite' multi-material sandwich panels instead of a steel/aluminium spaceframe lined with sheets of different materials (metallic or non-metallic);
- to devise design methodologies that decrease production lead time through reducing the number of components and functional integration, and allowing for dismantling, easy repair and recycling;
- to develop high quality urban transport;
- to contribute to the shifting of balance between modes of transport;
- to contribute to improved road safety;
- to contribute to improved quality in the road transport sector.

**Methodology:**

The work plan was divided into several tasks that cover the development of a novel modular architecture of a bus structure based on composite sandwich materials.

The following aspects were investigated:

- development of new vehicle architecture, based on modularity guidelines;
- study of concepts of sandwich materials available in the market or produced in other EU-funded projects, comparison of their properties with requirements of stiffness, crashworthiness and
manufacturability for bus and rail, and study of the possible processing methods and select the most applicable processes for large structural components;
• provision of a validated and safe design technology for joining sandwich panels, fibre-reinforced composite sheets and metallic inserts;
• development of numerical models based on FEM to analyse the static, dynamic and modal behaviour of the body of the vehicle in order to guarantee that the 'all composite body-in-white' of the vehicle has the same flexural and torsional stiffness and modal behaviour of state-of-the-art metallic bodies;
• demonstration of the crashworthiness of the concept vehicle and ensure that the bus structure meets the requirements of the European Directives and regulations (rollover, seat and belt anchorages);
• development of lifetime prediction techniques for the sandwich structural concepts developed in the project;
• production of a design which minimises the total whole-life cost of the vehicle;
• validation of the concepts developed experimentally through the testing of a bodywork cell section.

Parent Programmes:
FP6-SUSTDEV-3 - Global Change and Ecosystems
Institute type: Public institution
Institute name: European Commission
Funding type: Public (EU)

Lead Organisation:

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**Technologies:**
- Road vehicle design and manufacturing
- Modular bus interior and exterior design

**Development phase:** Research/Invention

**Key Results:**

During the first year the research effort was placed in the development of the bus body concept, materials to be used and respective production technologies. Aspects related with static and dynamic behaviour of the structure, crashworthiness and durability and life cycle cost analysis, although addressed in the identification of the vehicle attributes and specifications did not play the major role of the research effort during the first year.

During the second year, the research work concentrated on the static and dynamic analysis of the proposed structure and design/production of the die to be used in the manufacturing of the pultruded rail floor section and start of pilot production tests. Initial components were manufactured and tested. Particular attention was devoted to the design and production of the pultruded section. Static and fatigue tests on materials and components were performed. A numerical model was developed for composite-composite bonded joints. The activities were developed with the active collaboration of all partners, both during specific work-package meetings, exchanges through email and during the steering committee meetings. A new clamping system was developed to fix the pillars to the lower steel structure of the bus. This system was used in most of the quasi-static tests of the pillar rings and they were used to clamp short straight pillars to test and study the effect of the lateral panels and pultruded profiles on the stiffness of the cell. Residual (survival) space was preserved during the test. The roll-over test validated the proposed new concept of bus body, as far as crashworthiness is concerned. Flexural and torsional stiffness were also demonstrated to be at least equal to equivalent steel bodies.

**Videos on the roll-over test performed are available at:**
Innovation aspects

This project adopted an innovative holistic approach since:

- a new concept structural sandwich material with FRP reinforcements (pultruded sections) and the technology to produce single modular panels was developed;
- new modular vehicle concept architecture, based on the use of structurally resistant composite sandwich panels to produce the structure (lateral, roof and floor panels), instead of the traditional space-frame concept, either in aluminium alloy or steel hollow sections, lined with metallic or composite sheets;
- design of a new product using principles of extended product responsibility (EPR), which extends responsibility to a life cycle stage, taking into account environmental impacts of the product system and principles of design for manufacturing and recycling (that takes into consideration the constraints imposed by the composite sandwich material);
- the new concept reinforced sandwich material and modular panel architecture and respective connections were validated by experimental work, numerical modelling simulation and a rollover test on a bodywork section;
- design, implement, test and evaluate a new structural health monitoring concept relying on novel optical fibre sensing heads and readout equipment, based on in-fibre gratings and micro-cavities for temperature and strain measurements in the body, for composite damage assessment.

Technical Implications

The main technical achievements were to:

- design, manufacture and validate of a sandwich material concept with high stiffness and energy absorption suitable for surface transport vehicle;
- generate of new concept vehicle architecture, using systematic product development methodologies and integrated product policy for a more environment friendly vehicle;
- develop a new manufacturing technology for the production of large panels with functional integration. The materials, conceptual design methodologies, design philosophy and assembly methods can be applicable to other industry sectors in particular train rolling stock, ship / boats, and trucks and self-supported refrigerated containers.

Documents:
- PUBLISHABLE EXECUTIVE SUMMARY_3.pdf (Other project deliverable)
- Final Report Summary - LITEBUS (Modular lightweight sandwich bus concept)

STRIA Roadmaps: Vehicle design and manufacturing
Transport mode: Road transport
Transport sectors: Passenger transport, Freight transport
Transport policies: Other specified
Geo-spatial type: Other