european aluminium association

MOVING UP TO ALUMINIUM

HIGH PAYLOAD, SAFE AND SUSTAINABLE ROAD TRANSPORT

CONTENTS

In 1903, the Wright brothers made aviation history when they achieved the world's first flight powered by a lightweight engine made with aluminium components. Today, aluminium is fundamental to the aviation industry. It accounts for more than 60% of the structural weight of the Airbus A380, and up to 80% of short- and mid-range aircrafts.

It was in the 1920s that aluminium shipping applications started to expand due to new alloys becoming available for marine use.

Today, 1000 high-speed passenger ships are in service, most of which have a structure and superstructure made of aluminium. Cruise ship superstructures are commonly made of aluminium, while over half of all luxury yachts have aluminium hulls.

These ships take full advantage of aluminium's lightness and strength, as well as its corrosion-resistance, an indispensable property for marine environments.

In the 1980s, aluminium emerged as the metal of choice to lower running costs and to improve acceleration of metros, tramways, intercity and high speed trains. In 1996, the TGV Duplex train was introduced, transporting 40% more passengers while weighing 12% less than the single deck version, all thanks to its aluminium structure. Today, aluminium metros and trams operate in many European capitals and aluminium trains are used all over Europe.

In 1899, a small sports car with an aluminium body was unveiled at the Berlin international car exhibition. In 1948, Land Rover started using aluminium outer skin sheets.

Today, besides well-known aluminium-intensive cars like the Audi A8 and the Jaguar XJ, many cars contain significant amounts of aluminium. The average volume of aluminium used in passenger cars was already 140kg in 2012.

In 2012, one car in every four produced in Europe had an aluminium bonnet and around one third of European cars are already equipped with aluminium bumper systems.

110 YEARS

More than a century of aluminium in transport

INTRODUCTION

Having made its debut in Parisian buses in 1910, aluminium was used for a variety of elements in commercial vehicles in the 1930s. The 1950s saw the first aluminium tankers, vans and tipping vehicles. In 1976, the Alusuisse truck prototype was put on the road, maximizing the use of aluminium for every parts where it was possible, including the chassis.

An all aluminium platform semi-trailer is available since the year 2000. Today, most tankers and silo semi-trailers are made entirely of aluminium. It is also frequently used for vans, tipping or self-discharging bodies and a multitude of components. Today's European articulated trucks contain between 500kg and 3000kg of aluminium, depending on the transport segment under consideration, and contain 1000kg on average.

The following pages cover the wide spectrum of aluminium's advantages for use in road transport. It explains, among others, how aluminium helps to cope with rising diesel price, taxation, environmental issues and road safety concerns.

1910 First aluminium parts in Parisian buses | 1930s | 1950s | 1976 | 2000

Aluminium increases your profitability

INCREASED PAYLOAD + HIGHER RESIDUAL VALUE = ADDITIONAL INCOMES

Aluminium reduces dead vehicle weight. When transporting high-density freight, which usually saturates the maximum gross vehicle weight, aluminium allows the loading of more goods. This translates into additional income and/or better competitiveness.

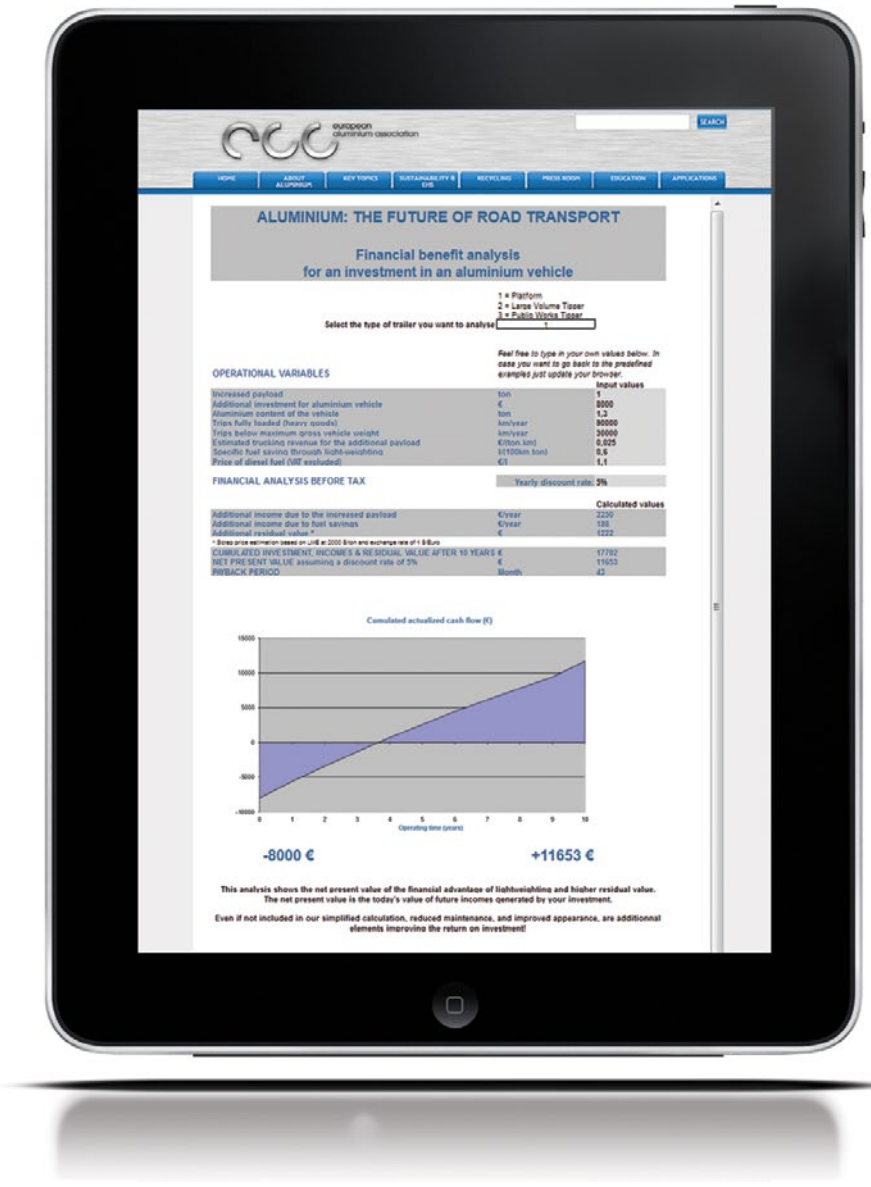
Furthermore, used aluminium vehicles have a lot of success on the second, and even third hand market, where they are usually sold for a very good price. Finally, when they have reached the end of their long service life they still have a high scrap value. This is due to the fact that aluminium is easily recycled, without loosing any of its quality and saving 95% of the primary energy input.

FUEL SAVING + LONG LIFE + REDUCED MAINTENANCE = COST SAVINGS

A study conducted by the IFEU[1] in cooperation with the TU-Graz[2] concluded that 1 ton saved on the total weight of an articulated truck leads to a fuel saving of 0,6 litres per 100 km.

This saving occurs during trips made below the maximum gross vehicle weight, i.e. when transporting low-density goods, for partly loaded or empty trips.

Aluminium's well-known corrosion resistance is an obvious advantage in road transport: It contributes to a long service life, especially in vehicles which work in conditions that can cause serious rust problems. No painting or other surface protection is required and it is easy to clean. Maintenance is therefore kept to a minimum.



MAKE YOUR OWN CALCULATION

http://www.alueurope.eu/financial-benefits-simulator/

[1] Institüte für Energie und Umwelt Forschung, Heidelberg, Germany
[2] Technical University of Graz, Austria

Watching weight becomes increasingly important

According to the "user pays" principle, an increasing number of countries are introducing weight control stations and road tolls that increase cost per kilometre. On the other hand, increasing payload with aluminium allows reducing the risk to be overloaded and spreads toll costs over a bigger tonnage of goods.

In countries where road toll is limited to the heaviest vehicle category, "mini-semi-trailers" are built using a substantial amount of aluminium allowing the operator to keep a good payload while not exceeding the weight limit where a toll is applicable.

Aluminium contributes to the ergonomics of vehicles. Mobile parts that are manipulated at each delivery, like drop-side walls or rear doors, are lighter to move when made out of aluminium. This saves a lot of effort for the drivers and reduces the risk of injuries.

Last but not least, being impossible to quantify, the visual impact of bright shiny aluminium should not be overlooked. Operators often report that drivers take noticeably more care of vehicles they are proud to drive.

Aluminium offers great freedom to designers

DIVERSITY & FUNCTIONALITY OF SEMI-FINISHED PRODUCTS, CASTINGS AND FORGINGS

Vehicle designers and manufacturers have a wide range of aluminium alloy semi-finished products from which to choose:

- Rolled semis: sheets, tread plates (floor plates), pre-painted sheets
- Extruded semis: hollow or solid shapes, standard or customized
- Castings and forgings

This diversity of semi-finished products makes it possible to:

- Design structural elements with special functions such as shapes with grooves for screw heads, hydraulic circuits, inertia shapes, snap-locks, welding flanges etc.
- Save time and cost for assembly and finishing. This can compensate for the added raw material cost of structures made from aluminium alloys compared with equivalent steel structures.
- Reduce stress due to welding by placing castings at assembly intersections or using special extrusions to divert welding stresses into less stressed areas of a fabricated structure.
- Design complex cast or forged shapes.

EASY TO WORK WITH

Aluminium alloys used in the manufacture of commercial vehicles and their accessories are easy to process. They lend themselves to a variety of shaping and joining techniques that are detailed in a separate publication of the European Aluminium Association[3].

In a nutshell, aluminium can easily be

- **cut:** sawing, shearing, water jet, laser or plasma cutting
- **machined:** milling, drilling
- **bent**
- **joined:** welding, adhesive bonding, bolting and riveting

Furthermore, being light, aluminium is easy to handle in the workshop.

[3] To respond to the needs of design and process engineers, the technical manual "ALUMINIUM IN COMMERCIAL VEHICLES" is available on

WWW.ALUEUROPE.EU

Every kg of aluminium in today's trucks saves 26 kg of CO_2

ALUMINIUM AS A COMPLEMENT TO EURO VI ENGINES

The European Environment Directives for trucks date back to 1988, while the first standard limiting emissions of nitrogen oxides (NO_x) and particulates (PM) from heavy-duty diesel engines were introduced at the beginning of the 1990's.

The EURO VI legislation, fully in force since 1st January 2014, represents a dramatic reduction of NO_x and PM emissions, meaning a considerable amount of additional technology. Each manufacturer has his own strategy to meet the new emission standard and, depending on the technologies already applied under the previous EURO V, EURO VI may mean a substantial weight penalty up to 200kg.

Using more aluminium components allows the manufacturer to compensate for this weight penalty.

The payload can therefore be preserved and even increased.

ALUMINIUM REDUCES CO_2 EMISSIONS

To achieve emission reductions, it is not only important to develop low-emission engines, but also to use them in the most rational way possible. Saving weight with aluminium is a good way of achieving this objective as explained below.

Aluminium contributes to the reduction of CO_2 emissions from road transport as follows:

- When carrying heavy goods, it increases the load capacity of vehicles and therefore improves transport performance, allowing more goods to be carried per trip. In this case, one ton saved on the dead weight of an articulated truck saves **1.300 litres of diesel**[4] **over 100.000 km**.
- When carrying voluminous goods, it reduces the overall weight, lowering fuel consumption per kilometre. In this case, one ton saved on the dead weight of an articulated truck saves **600 litres of diesel**[5] **over 100.000 km**
- When carrying passengers, it reduces the overall weight and lowers fuel consumption. One ton saved on an urban bus saves between 1700-1900 litres per 100.000 km.

Taking primary production, use stage and end-of-life recycling into account, life-cycle savings have been estimated as follows[6].

- **1kg** of aluminium in today's average articulated truck saves **26kg of CO_2**
- Every additional kg of aluminium in tomorrow's average articulated truck would save a minimum of **19kg of CO_2**
- **1kg** of aluminium in an urban bus typically saves **40kg of CO_2**

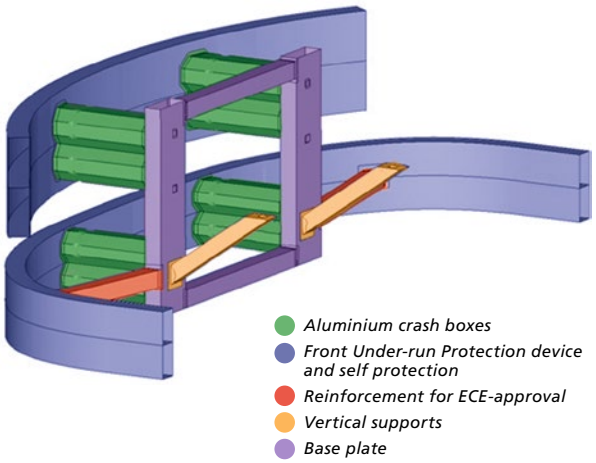
[4] To move the same amount of goods over the same distance, a standard vehicle would need 3.800 more vehicle-km, representing more than 1.300 litres of diesel.
[5] Energy savings by light-weighting for European articulated trucks - IFEU - Institüt für Energie- und Umweltforschung Heidelberg GmbH, 2005
[6] CO_2 reduction potential of aluminium for articulated trucks - EAA - European Aluminium Association, 2014

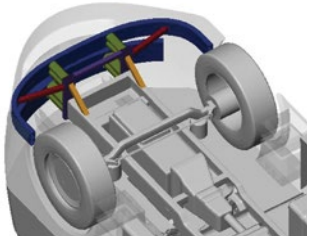
Aluminium improves road safety

Road safety is a major priority for EU policy makers. One way to improve road safety is to reduce the severity of accidents between large trucks, smaller personal vehicles and vulnerable road users. A study[7] was conducted to investigate if a tractor optimized for better aerodynamics and pedestrian safety could be equipped with an energy-absorbing crash management system (CMS). The aerodynamic design led to an extra space in the front of the tractor, and this space was identified as a good place to mount this energy absorbing structure. A state-of-the-art aluminium CMS was developed, and the study demonstrated that the severity of car to truck accidents can be significantly reduced, while at the same time the self-protection for truck drivers can be improved.

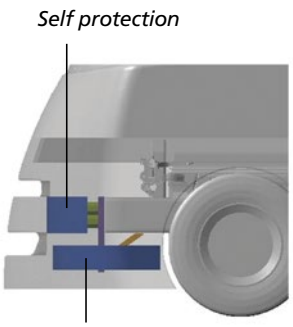
The safety improvements that this brings involve a very low weight increase of less than 10 kg compared to a CMS from a conventional tractor. To introduce this type of passive safety devices into trucks, the tractor would have to be extended in the forward section by 500-1000 mm. The European Directive on the weight and dimensions of trucks (96/53/EC) is currently being revised in that direction.

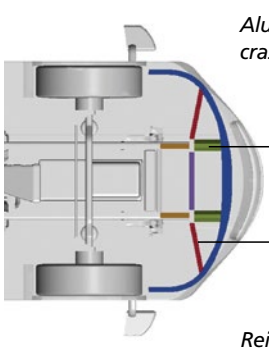
Tractor optimized for better aerodynamics and safety





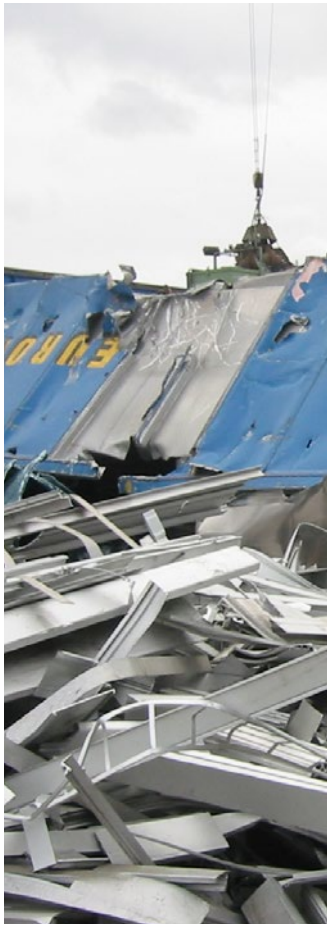
Design of the aluminium CMS for a truck with extended front.





[7] Concept Design of a Crash Management System for Heavy Goods - Forschungsgesellschaft Kraftfahrwesen mbH Aachen - 2011

Aluminium is easily and economically recycled



Two studies demonstrated that, unlike traditional vehicles that are often exported to end their life a long way from Europe, aluminium-intensive trailers generally stay on our continent because they allow a profitable use over a very long lifespan. Finally, at the end of their service life, recycling them in Europe is also profitable, resulting in very high recycling rates.

The first study[8] explored the fate, the present and future end-of-life treatment of aluminium parts from trucks and trailers used in EU-25. The main output of that project has been a European mass flow model of the aluminium scraps coming from end-of-life commercial vehicles.

In a second project[9], the current end-of-life processing practices were analyzed through four actual case studies: one road tractor, one flatbed semi-trailer, one silo semi-trailer and a tipping body.

A minimum recycling rate of 95% of the aluminium content was demonstrated.

As the energy required to recycle aluminium is about 5% of that needed for primary production, the environmental benefits of recycling are obvious. The energy required to produce primary aluminium is not lost: it is "stored in the metal".

[8] The fate of aluminium from end-of-life commercial vehicles - Université de Technologie de Troyes - 2006
[9] Recycling rates of aluminium from end-of-life commercial vehicles, four case studies – Université de Technologie de Troyes - 2009

High « strength-to-weight » and high « stiffness-to-weight » ratio

Aluminium alloys used in commercial vehicles have strength-to-weight and stiffness-to-weight ratio comparable with the most advanced metals like high strength steel and titanium.

These properties, among many others, are taken into account when designing a vehicle. No weight saving can be obtained with aluminium if design principles are copied from steel.

Designs optimised for aluminium, are based on specific sections, smooth transitions and clever joints, which normally give 40-60% weight saving over competing materials when designed for:

1) equivalent or superior strength

2) equivalent stiffness

3) equivalent lifespan.

In order to meet weight reduction targets experienced by using aluminium, competing materials often sacrifice one of the three criteria so that weight comparisons make no sense.

Comparison of weight-optimised beams made with 3 different materials and 2 design criteria[10]

DEFINITIONS

	Traditional material	High strength material	Aluminium alloy
Yield strength (MPa)	350	760	250
E-Modulus (MPa)	210000	210000	70000
Density (kg/m³)	7800	7800	2700

EQUAL STRENGTH

	Traditional material		High strength material		Aluminium alloy
Strength	1	=	1	=	1
Stiffness	1	>	0,3	<	0,6
Weight	1	>	0,7	>	0,4
Section height	1	>	0,6	<	1,2

EQUAL STIFFNESS

	Traditional material		High strength material		Aluminium alloy
Strength	1	<	2,2	>	1,5
Stiffness	1	=	1	=	1
Weight	1	=	1	>	0,6
Section height	1	=	1	<	1,4

Calculations are based on standard beam design, the so called "double T". Further weight optimisation is possible with aluminium because:

- Finite element modeling allows precise definition of most favorable section's geometry;
- These sections, even if very complex, can easily be produced with the aluminium extrusion process

[10] Calculation based on finite element modelling. Results are typical values and not contractual.

Aluminium only requires low maintenance

HIGH DURABILITY

Some operators still fear problems with aluminium trailer chassis in heavy duty applications, but they should know that the lifespan is not material related if properly designed.

Experienced manufacturers optimise their design for the material they use and are able to produce aluminium chassis offering an equivalent or longer lifespan but at a much lower weight than conventional models.

It is also important to underline that aluminium vehicles operate in transport segments where the load factors are the highest (solid and liquid bulk, public works etc…). In other words, they are much more intensively used than conventional ones, and this fact is taken into account in the design of aluminium vehicles.

HIGH STABILITY

It has often been claimed that achieving IRTE[11] Class A[12] tipping stability standard for an aluminium tipper chassis would be difficult simply because "it flexes too much" or that, to provide the equivalent rigidity of a steel chassis "the lightness benefit would be practically eliminated", but tests run during the summer of 2002 confirmed that both statements were totally unfounded.

Indeed, a full-aluminium vehicle, significantly lighter than others, passed the IRTE Class A test at 44 tonnes with its standard chassis, reminding everyone that an appropriate design leads to both lightness and torsional stiffness.

ALUMINIUM IS A NON-COMBUSTIBLE MATERIAL

Aluminium and its alloys are, under atmospheric conditions, totally non-combustible and do not contribute to the spread of fire. Aluminium alloys will, however, melt at around 650°C, but without releasing harmful gases.

CORROSION RESISTANCE

Correctly used, aluminium alloys have been developed to offer optimum corrosion resistance in all environments. Just one example: the widespread use of unpainted aluminium in marine applications.

ALUMINIUM IS EASY TO REPAIR

Few people know that Land Rovers have had an aluminium body since 1948, and a repair network has been operating for the last 60 years.

This illustrates the fact that repair is possible, but aluminium repair techniques are definitely different from those of steel. Leading chassis manufacturers have set up a European dealer network where an efficient repair service is offered.

[11] Institute of Road Transport Engineers, UK
[12] "Class A" standard states that a trailer should be able to tilt sideways 7° without falling with a fully loaded and raised body.

Cost-efficient aluminium solutions offer significant additional weight reduction potential

Components for tractors & rigid trucks

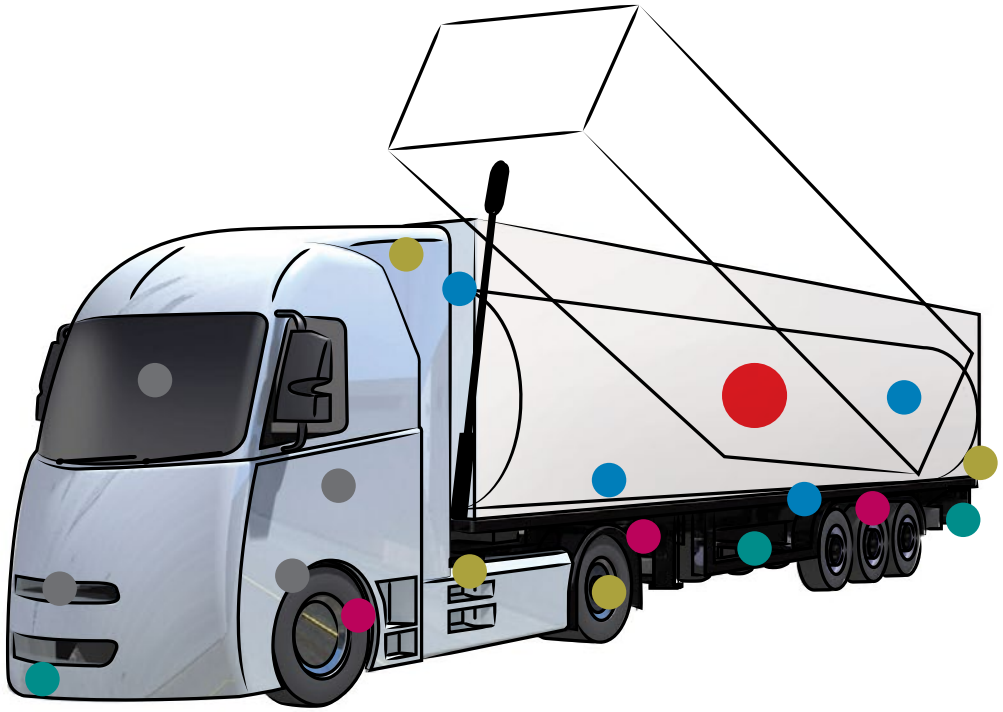
- cabin & doors: -200kg
- chassis: -350kg
- powertrain parts: -125kg
- suspension parts: -110kg
- fifth wheel: - 33kg

Complete superstructures

- rigid body: 90m² = -800kg
- tipping body: -800 to -2000kg
- ADR fuel tank: 43000l = -1100kg
- self-discharging body
- silo

Components for superstructures

- curtain rails: 2x13.5m = -100kg
- front wall: -85kg
- rear door: -85kg
- side boards: 600mm = -240kg
- stanchions: 10x600mm= -50kg
- reefer floor



Safety parts

Present

- front bumpers: -15kg
- rear bumpers: -15kg
- side bumpers: -20kg
- front and rear under-run protections

Future

- front crash management system

Trailers sub-structures

- chassis: 13.5m = -700kg
- chassis: 6m = -300kg
- chassis+floor: 13.5m = -1100kg
- legs: -35kg

Accessories

- air pressure vessels: 6x60l = -54kg
- diesel tank: 600l = -35kg
- toolbox: -15kg
- tail lift: -150kg
- wheels: 14 rims = -300kg

Aluminium, your best hauling partner

CONCLUSION

Because empty vehicle weight directly impacts fuel consumption and payload, light-weighting is necessary now more than ever to reduce CO_2 emissions and to maintain the competitiveness of road haulage companies.

Aluminium is the ideal light-weighting material, as it allows a weight saving of up to 50% over competing materials in most applications without compromising safety.

Today's European articulated trucks contain between 500kg and 3000kg of aluminium, depending on the transport segment under consideration, and contain 1000kg on average.

It is in weight-sensitive transport segments, i.e. solid and liquid bulk transport, that aluminium is mostly used. However, aluminium use is also growing in other segments, not only because of its low weight but also because of reduced maintenance and improved ergonomics.

Aluminium may also contribute to the improvement of the passive safety of trucks through the incorporation of crash management systems.

Last but not least, when they reach the end of their long service life, aluminium-intensive trailers are mostly recycled in Europe, closing the cradle-to-cradle material loop.

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The European Aluminium Association (EAA), founded in 1981, represents the whole value chain of the aluminium industry in Europe. We actively engage with decision-makers and the wider stakeholder community to promote the outstanding properties of aluminium, secure growth and optimise the contribution our metal can make to meeting Europe's sustainability challenges. Through environmental and technical expertise, economic and statistical analysis, scientific research, education and sharing of best practices, public affairs and communication activities, EAA promotes the use of aluminium as a permanent material that is part of the solution to achieving sustainable goals.

The main advantages of aluminium in transport:

- Increased revenue
- Reduced emissions
- Reduced energy consumption
- Completely non-toxic
- Strong
- Lightweight
- Corrosion resistant
- Easy to repair
- Easy to handle
- Design flexibility
- Recyclable
- Safe
- Weldable
- High residual value

European Aluminium Association
Avenue de Broqueville, 12 - 1150 Brussels - Belgium
Phone: +32 2 775 63 63 Fax: +32 2 779 05 31
eaa@eaa.be - www.alueurope.eu