FACULTY OF NATURAL SCIENCES

Cradle to Cradle costing for the Automobile Industry

Rich Knight,

Biodiversity & Conservation Biology

UWC

knight.rich[at]gmail.com

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What is Cradle to Cradle Costing?

- Production that goes beyond efficiency by minimizing all aspects of waste
- Coined by Walter R. Stahel. Popularised in book *Cradle to Cradle: Remaking the Way We Make Things (2002) by* William McDonough and Michael Braungart.
- A Technical-Biological framework analogous to nutrient re-cycling.
- Contrasts to Cradle to Grave framework where production seeks only responsible disposal of goods produced after their operational lifespan.
- Cradle to Cradle ensures the produced goods constituent components are put back into service

A Green Automobile Industry?

- One of the most vital but “ungreen” industries.
- A “green vehicle” is usually interpreted as requiring low energy, especially fossil fuel requirements.
- Vehicles with lowered use of raw materials are preferable.
- A more holistic interpretation looks at the entire process of production, operation and disposal of resources used in the vehicle during its entire life time.

The Automobile Factory

- Process starts with the location of the factory and its footprint. Issues include size of factory, sensitivity of the ecosystem, and its connection with transportation systems.
- Land that is re-used/reclaimed from past (ab)use is preferable to use of new land.
- Negatives are use of high productivity agricultural land, wetlands, land adjacent to rivers, or containing high biodiversity or where ground water is high.
- Manufacturing of a vehicle is a high energy operation. Need to identify the source of energy?
- Renewable Energy such as generation from wind turbines is best followed by nuclear or hydro-generated electricity. (Lotus uses its own wind turbines)
- Energy derived from natural gas is preferable from coal-fired power stations.

Steel in the Automobile Industry

- Steel is processed iron (to which carbon is introduced). Steel often has other elements such as nickel and manganese to increase tensile strength. Other elements introduced include chromium, vanadium and molybdenum to reduce fatigue. Sulphur, nitrogen, and phosphorus are usually removed as the steel will be rather brittle.
- Steel is extensively used in automobile manufacture.
- Steel is derived from mining (incl. open-cast).
- Steel is relatively heavy and mostly has to be “imported” incurring the cost of carbon miles.
- Steel is prone to oxidisation (rust) so it is usually treated with a zinc coating. This is usually applied by immersion in a high temperature (460 °C) bath of zinc (the pure zinc reacts with oxygen to form zinc oxide).
- Many additional elements introduced to steel are heavy metals which are hazardous to ecosystems since they accumulated within the biological organisms.
- Using re-cycled steel/iron has significant environmental benefits including energy conservation.

Aluminium in the Automobile Industry

- Automobiles are increasingly using aluminium – especially for the manufacture of the engine – an all aluminium engines save mass and therefore fuel costs.
- Aluminium is starting to be used for the chassis (Audi and Lotus) and body panels (Daihatsu).
- Aluminium, while a widespread and common element is energy expensive to produce (aluminium smelters need huge energy inputs).
- Aluminium mining very environmental damaging.
- Aluminium is, however, the most cost-effective material to recycle - Recycling 1kg of aluminium saves up to 6kg of bauxite, 4kg of chemical products and 14 kWh of electricity.
- Aluminium is less resistant to oxidisation, has lower mass and extensive use in automobile construction will reduce the fuel costs of operation.
- Aluminium welding is a more specialised skill– so aluminium is bonded (glued) – a Lotus patent.
- Aluminium surfaces need less protection in form of coatings and paint, but unprotected surface can scratch.

Plastics in the Automobile Industry

- Modern automobiles make extensive use of plastics produced from fossil fuels derived from the petro-chemical industry.
- There is virtually a “plastic” for almost all functions in the car including heat resistant forms.
- Most plastics are used in the interior and for containers (radiators, reservoirs etc). They are generally light weight and fairly inexpensive to manufacture.
- One-piece plastic bodies historically associated with low volume productions and are more difficult to repair than steel.
- Using of plastic panels (doors, roof, bonnet, boot etc) is now being introduced (smart cars). Modular body panels are dent-resistant or inexpensive to replace.
- White, black and yellow plastics are most easily re-cycled.
- Recycled plastic may be use for dashboards and even body panels (grey or black)
- Plastic can be colour impregnated (so relatively scratch resistant) not requiring painting and is lightweight.

Plastics in the Automobile Industry

- Glass-fibre impregnated resins are used in low volume production, but use of natural fibre such as hemp is better, especially if the resin is bio-degradable.

- Carbon composites have the highest strength to weight ratio of any manufactured material. However, their manufacture is specialised (requiring autoclaves), energy- expensive and very costly as it needs laboratory like cleanliness.

Other Automobile Material

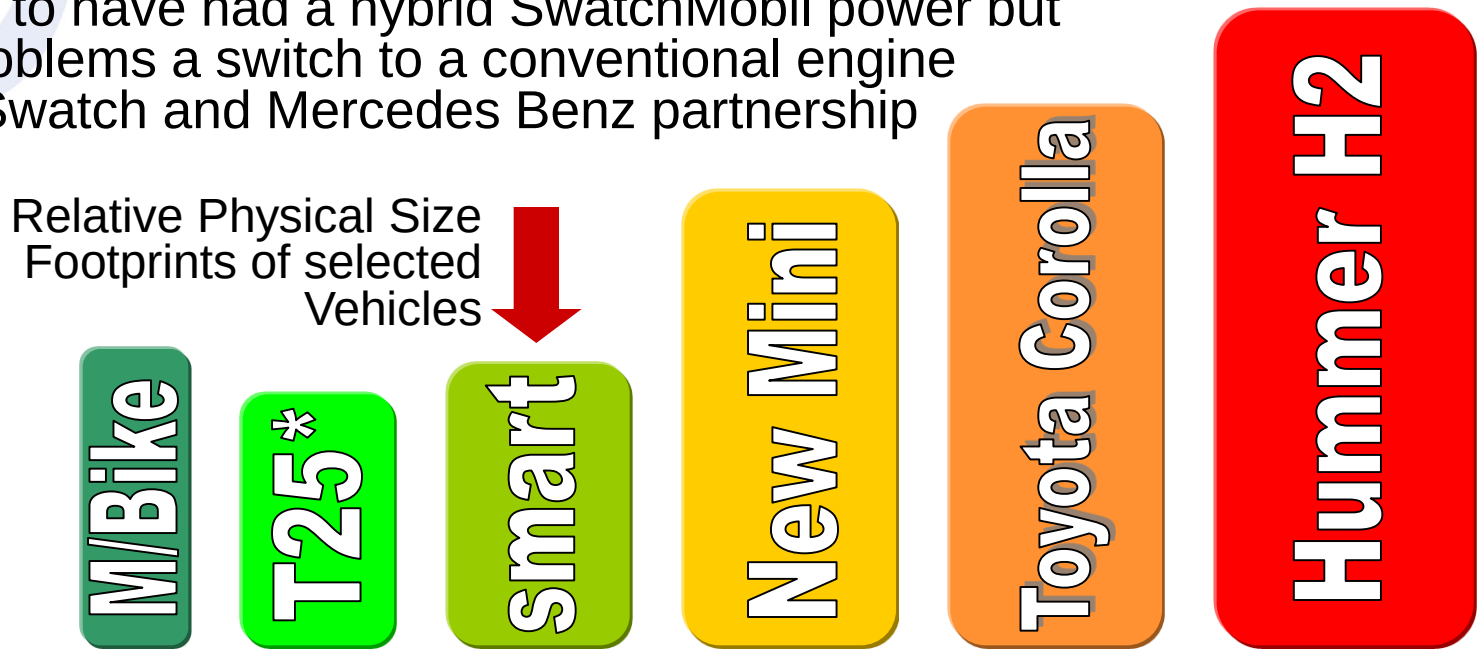
- The manufacture of cars also involves glass for windows – due to the plastic laminate between the glass it is considered not re-cyclable.
- Asbestos can still be found in clutches and brakes of cars this represent health and environmental issues
- Wiring harness most often has PVC coating. Difficult to extract all the wiring so it is burnt and the copper extracted. Release of toxic substances.
- Many auto-parts are nickel plated (electroplating) – difficult to re-cycle.
- Batteries are still lead acid (and will be) – fortunately, although hazardous to the environment and health the lead is recycled. Lead used as weight for wheel balancing has been banned in California but is the most major form of lead pollution.

Other Automobile Material continued

- Upholstery is usually synthetic fabric although there is increasing use of leather in luxury brands. Fabric is usually synthetic material but could be recycled material, natural fibre (hemp) or wool (which has a natural fire retardant).
- Natural material is bio-degradable rather than re-cyclable.
- Leather is not considered very green since in a typical medium to large car eight cow hides are used.
- Carpets could be wool, sisal or coir rather than synthetic material.
- Care in selection of material will reduce carbon miles.

Case study One
smart cars – the concept

- Conceived by CEO of Swatch Nicolas Hayek to be fun, cheap, simple, accessorisable and yet environmentally sound.
- Two-seater, 2.5m long by 1.5m wide
- Two smart cars can fit in one parking space
- Originally to have had a hybrid SwatchMobil power but due to problems a switch to a conventional engine saw the Swatch and Mercedes Benz partnership split.

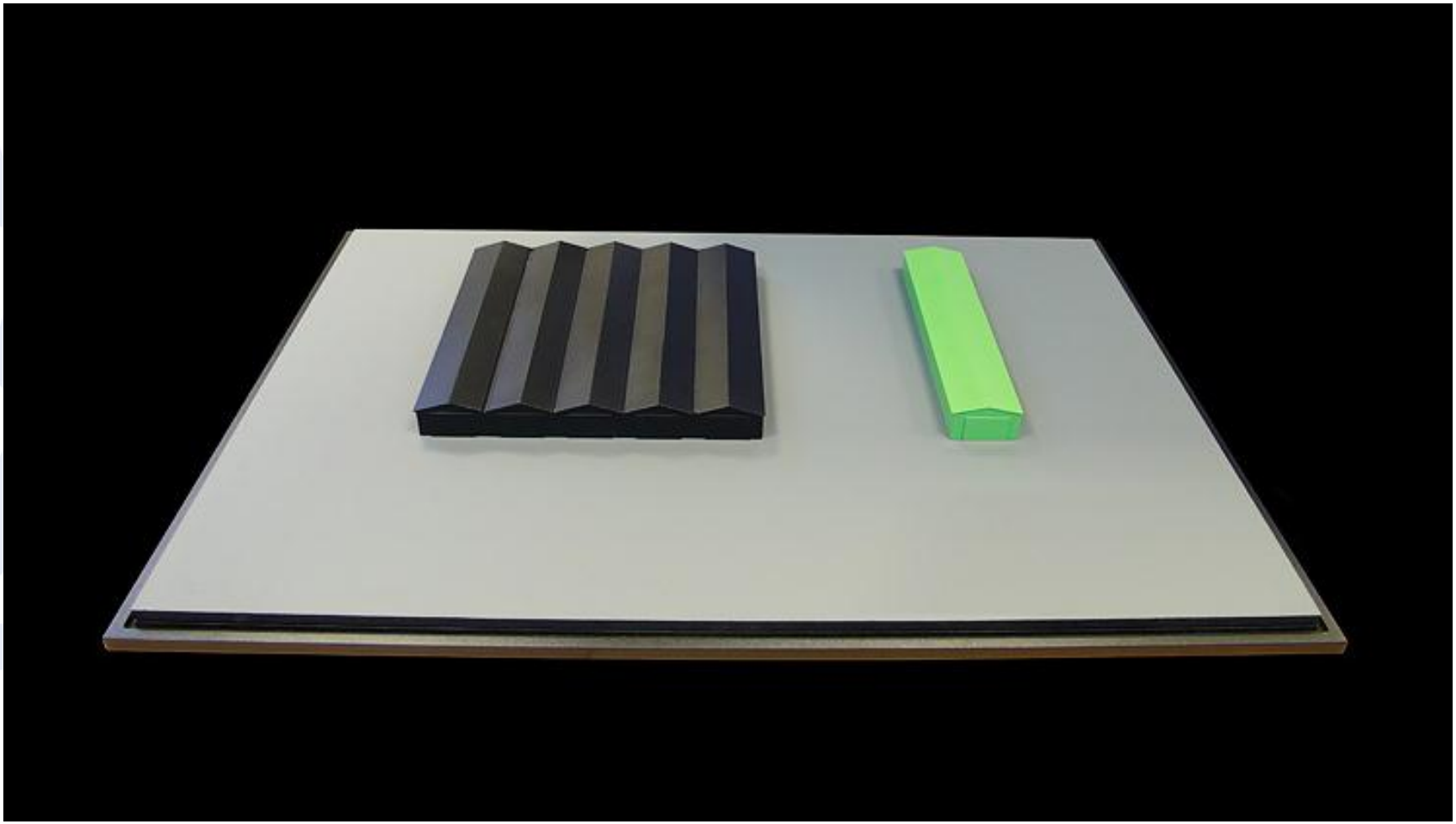


Case study One
Mercedes smart cars – the factory

- A new, modern factory called Smartville was built at Hambach in Lorraine, France.
- Intentionally sited in an economically depressed area with high unemployment. Used French government tax incentives.
- Used industrial waste lands and now includes a nature reserve, with rare plant species.
- Minimal formal landscaping using mostly indigenous species. Plentiful use of grass-blocks in parking areas.
- Factory built from re-cycled and naturally renewable materials.
- Rain water collected for tempering steel.
- Wastewater draining off roads is directed into the oil separation plants, treated and re-used.

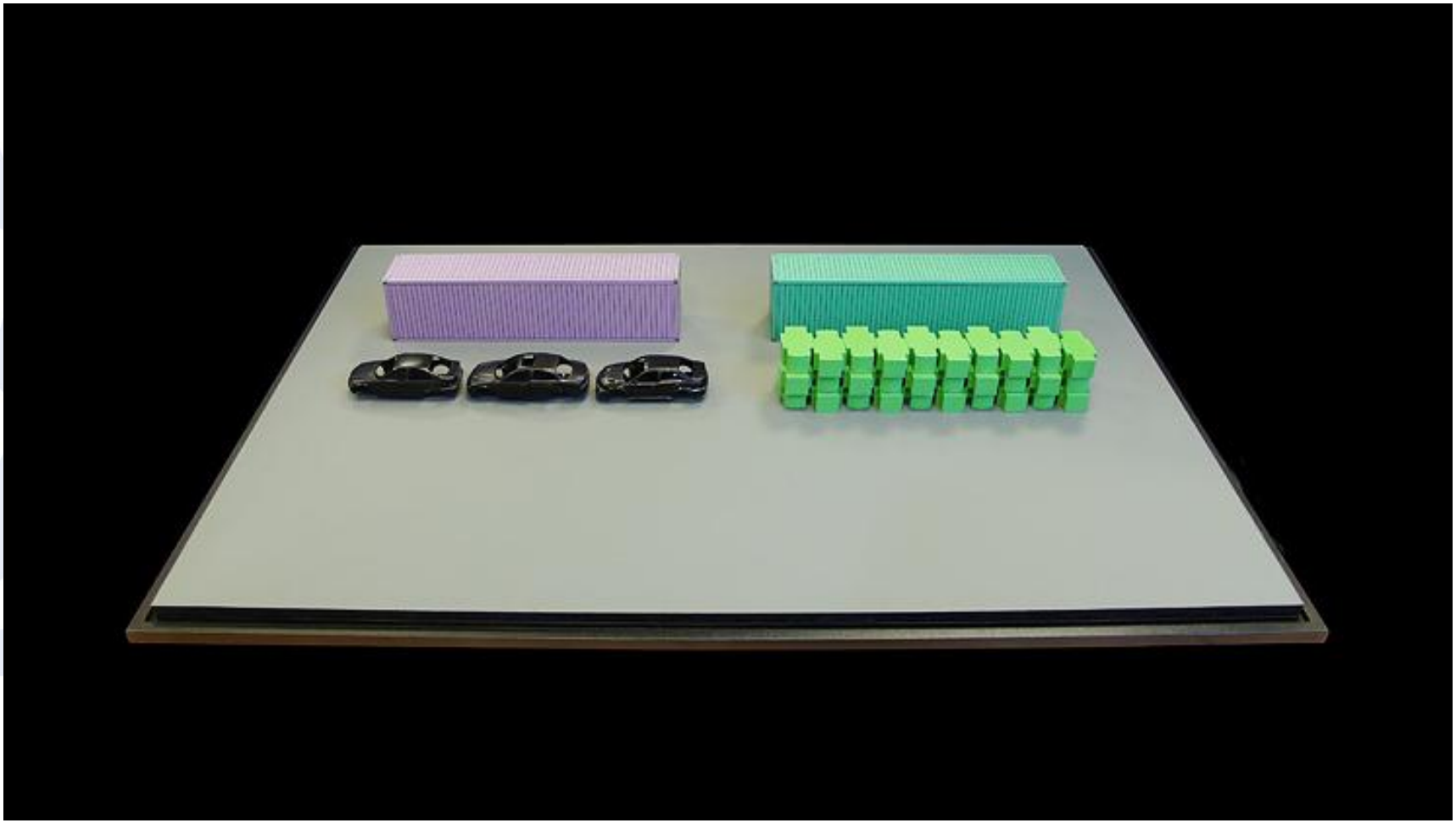
Case study One
smart cars – the factory cont…

- Sanitary and industrial wastewater is purified and used in the gardens or as a coolant in the production process.
- Buildings thermally insulated to reduce heat loss and utilizes no air-conditioning (just ciculates the air).
- Plant uses a low CO2 emitting gas power station to supply hot water and certain electricity needs.
- Surplus heat from the injection moulding equipment is employed to heat the paint booths. The Plant has no cooling towers.
- The Environmental Management System is certified to DIN EN ISO14001 standards
- All potentially hazardous substance are audited and where possible e.g. formaldehyde, CFC and asbestos or eliminated e.g. cadmium.
- Painting uses powder-coating processes or water-soluble paint paint. Aerosols and pollutions are reduced.



1. Factory Area

- 20% of average car factory footprint.
- Drastically reducing capital investment and environmental damage.

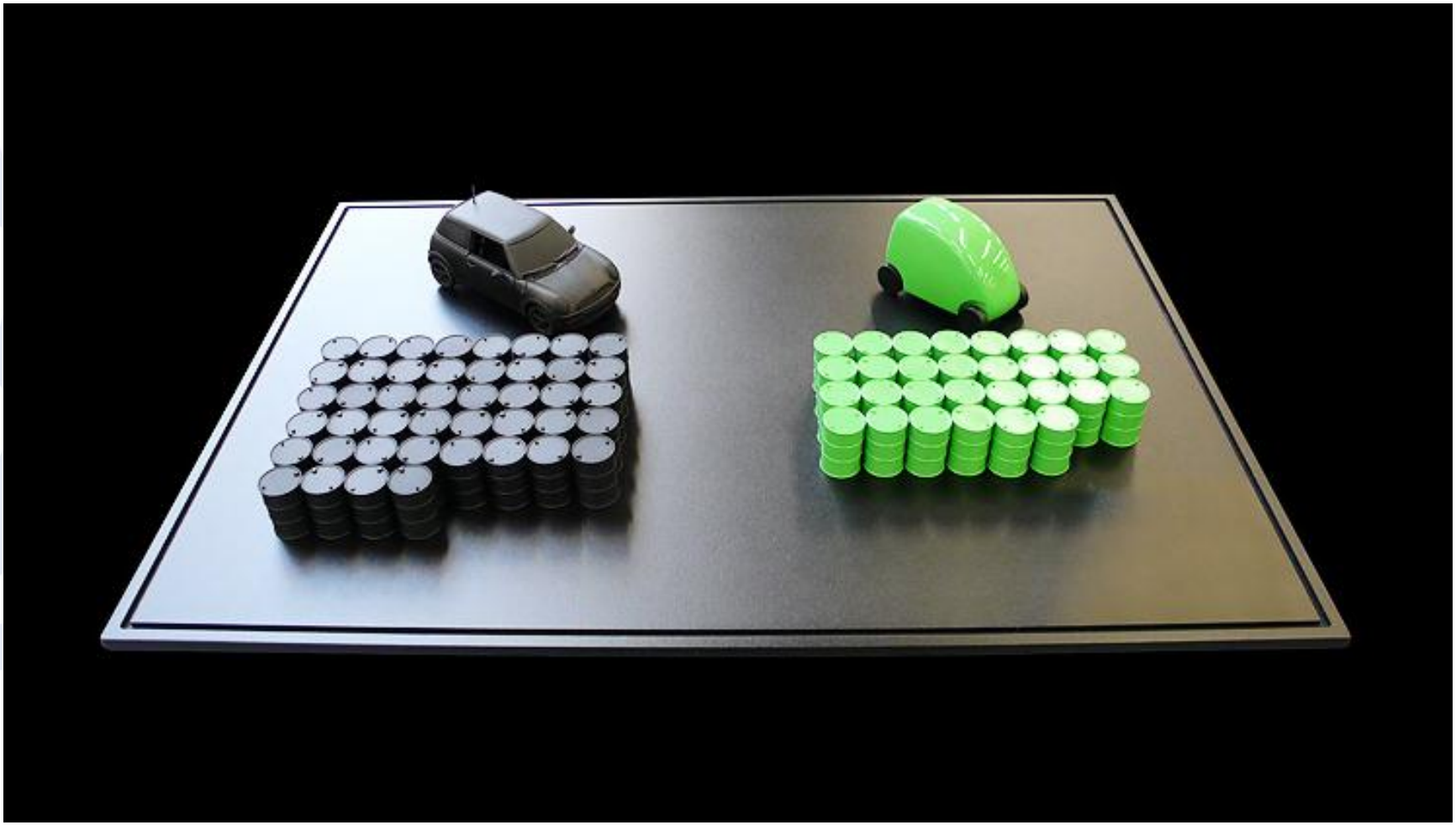


2. Shipping Volume

- 12 times as many T25 ‘body in white’s’ in a standard shipping container as compared to a average car body in white.

3. A new class of vehicle

- Setting new standards in vehicle packaging.

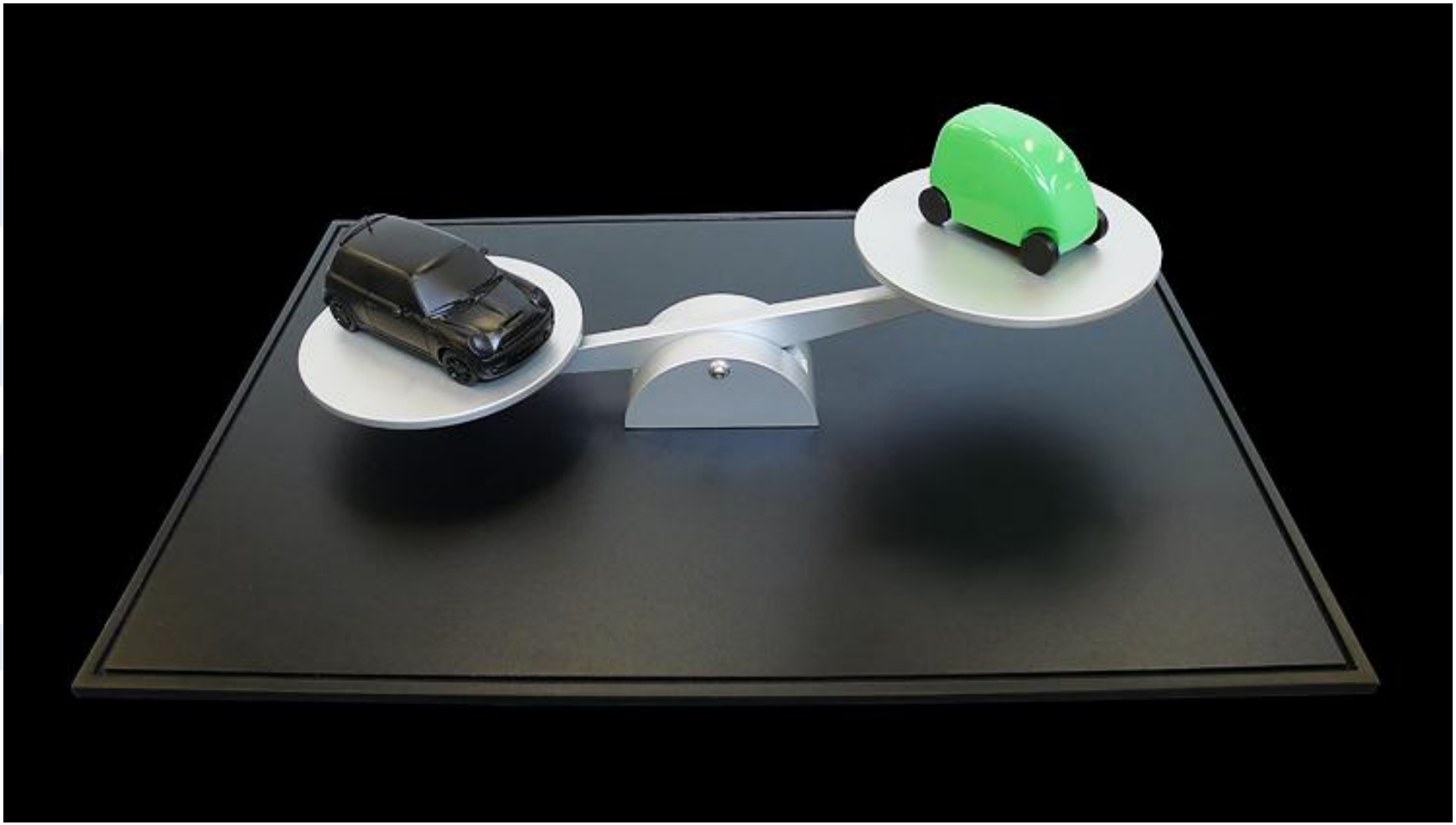


4. Life cycle-CO2 damage

- Lifetime CO^2 emissions from ‘cradle to grave’ will be at least 40% less compared with the average car.

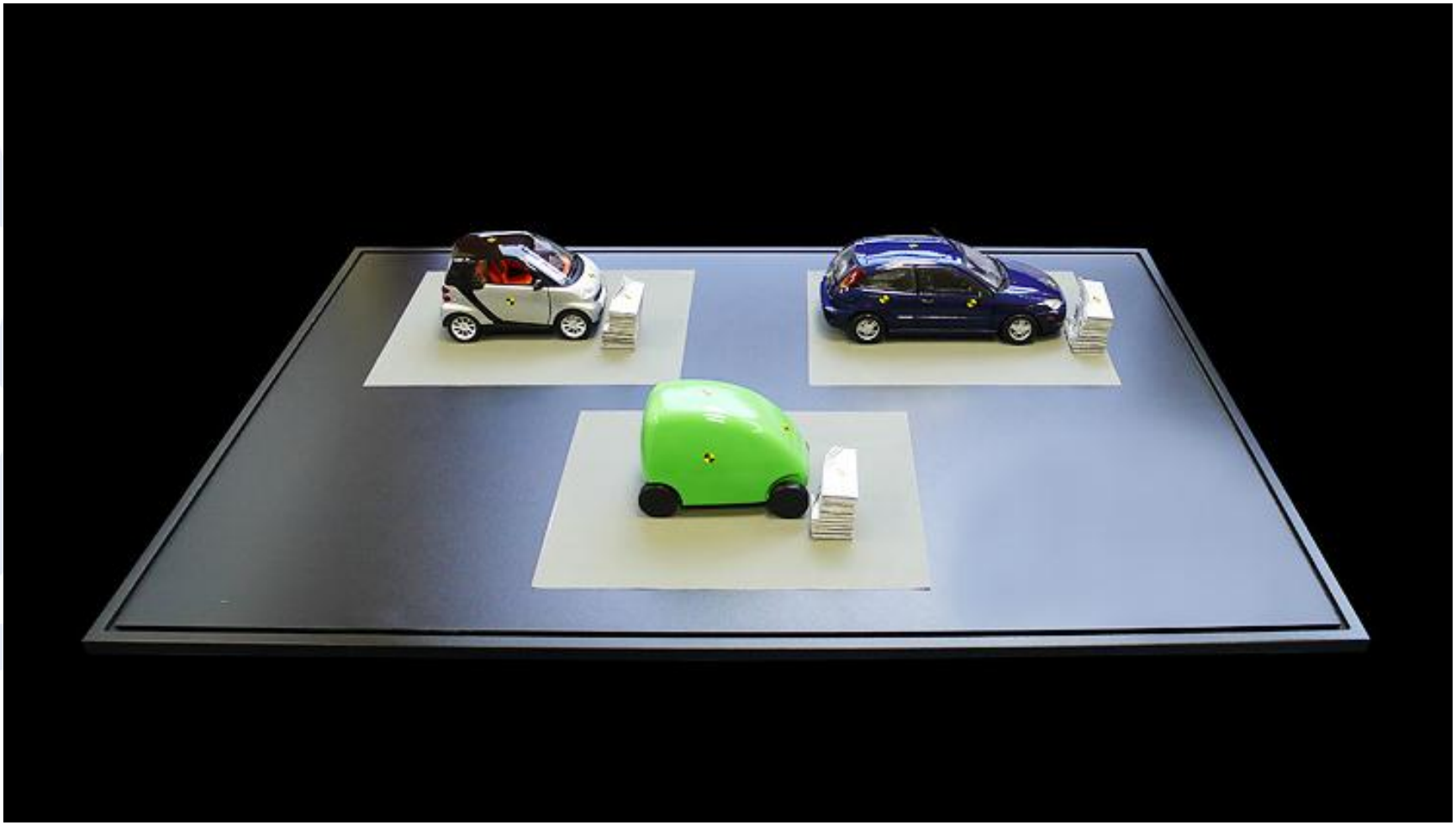
5. Carbon foot print

- Saves over a tonne of CO^2 emissions every year compared to an average car.



6. Weight

- Reversing the trend towards larger, heavier cars.

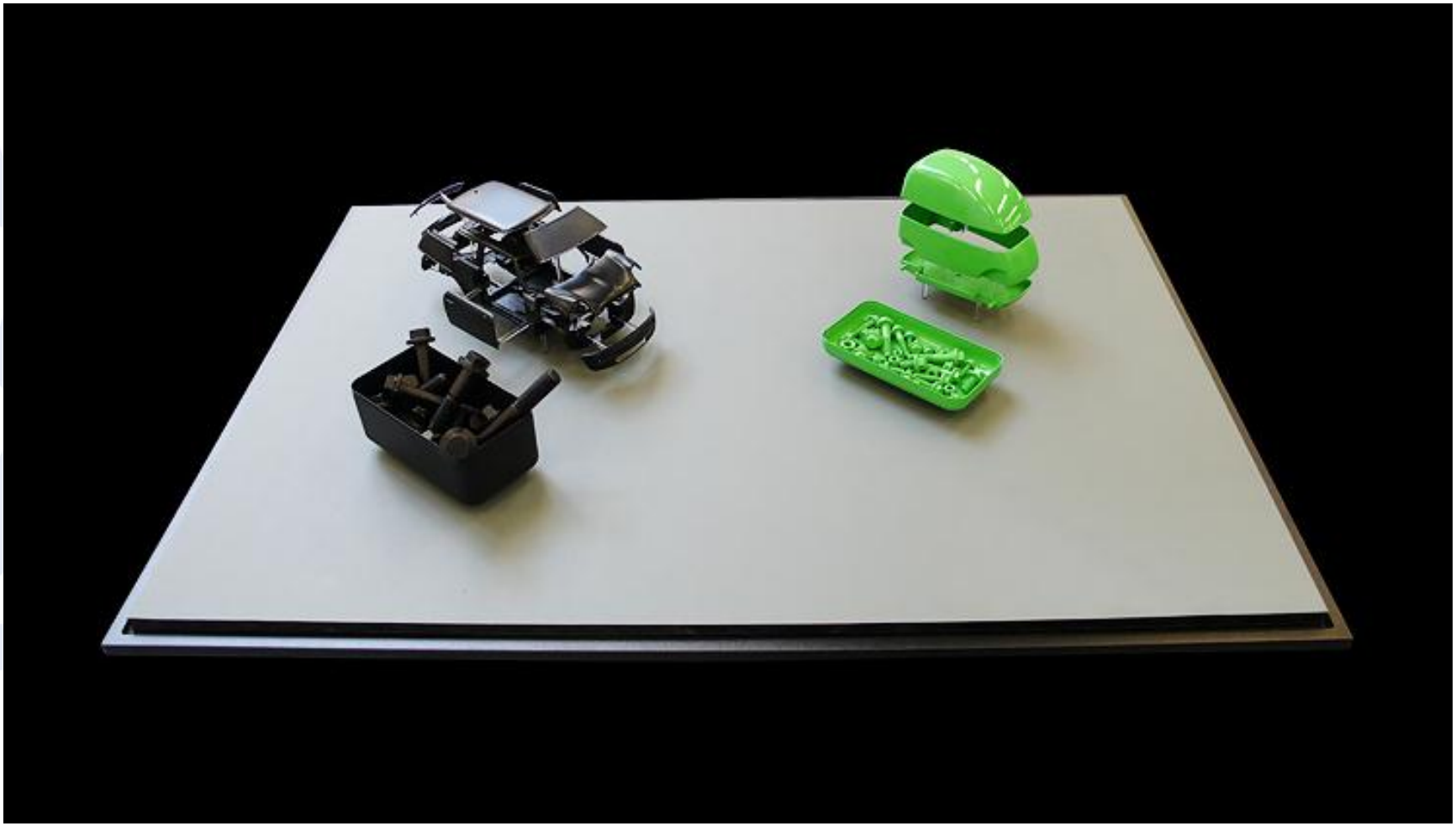


7. Safety

- Half the size of an average car but just as safe.

8. Separate chassis/body system

- Multiple body designs on the same rolling chassis.

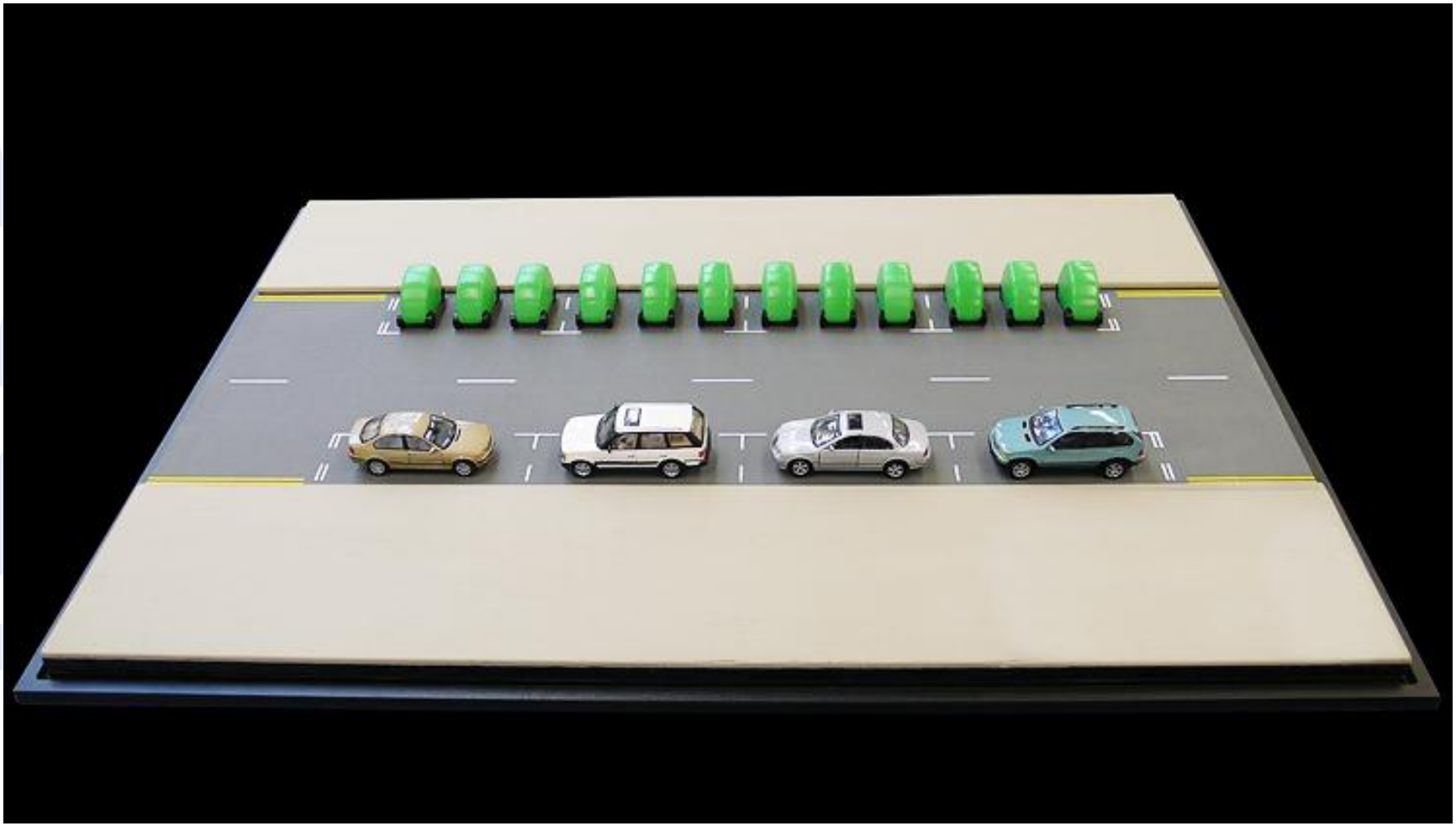


9. Low parts count

- Low parts count by design.

10. T.25 Versions

- Four versions of the T.25 and six interior layouts cover the six targeted marketing.

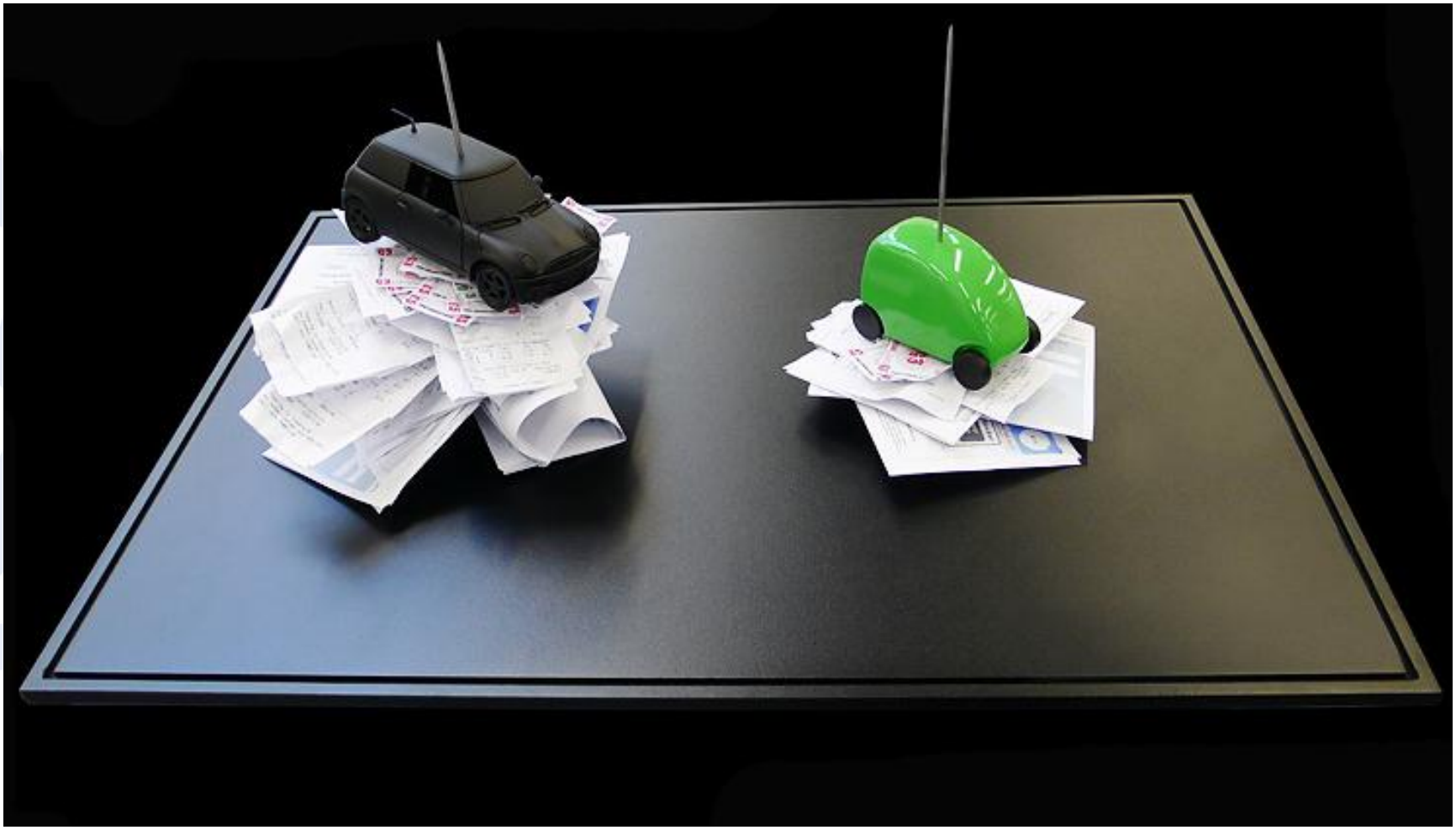


11. Parking

- Trebling UK standard parallel parking spaces (3 to 1).

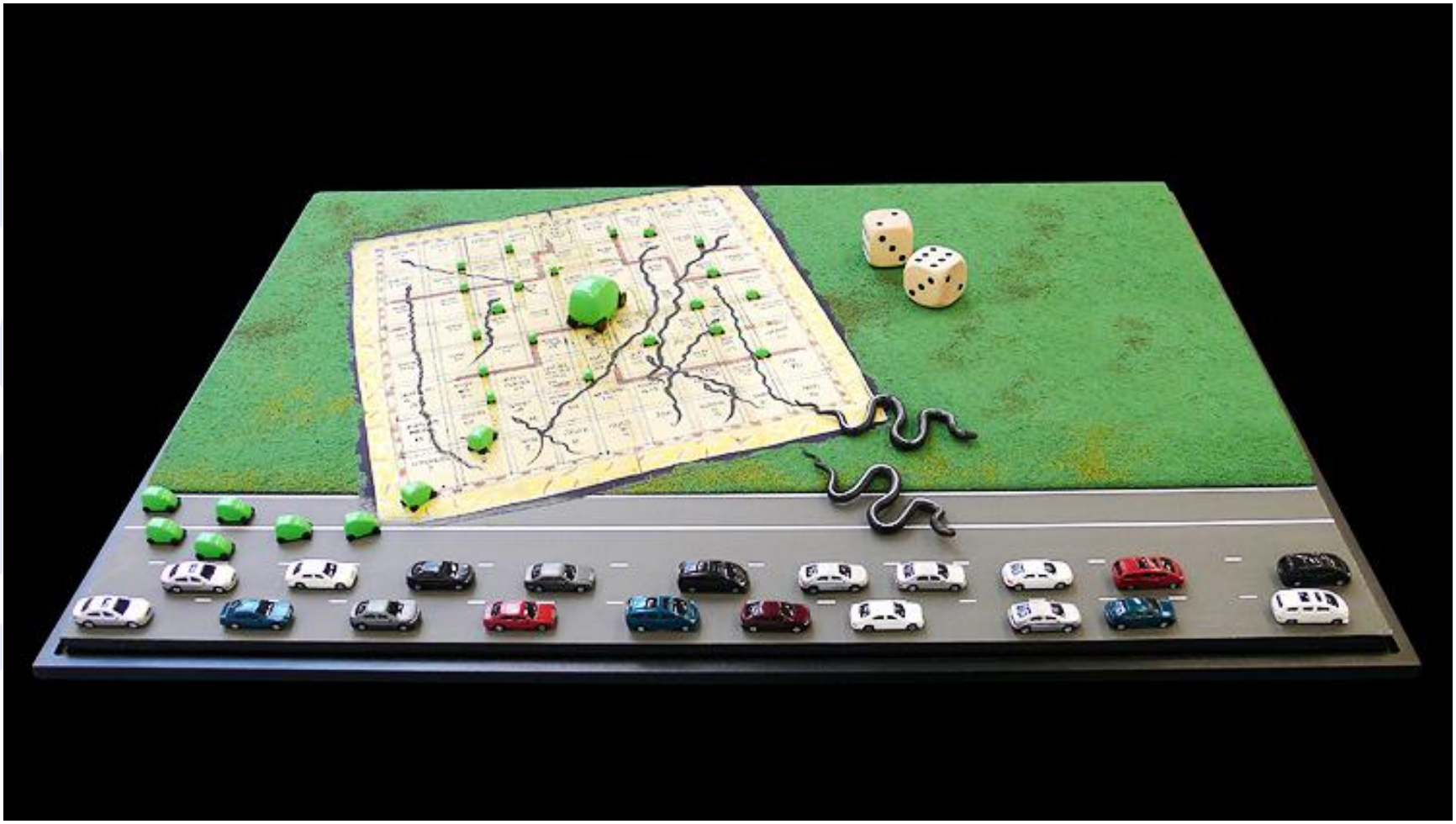
12. Congestion

- Trebling the capacity of motorway lanes reducing congestion



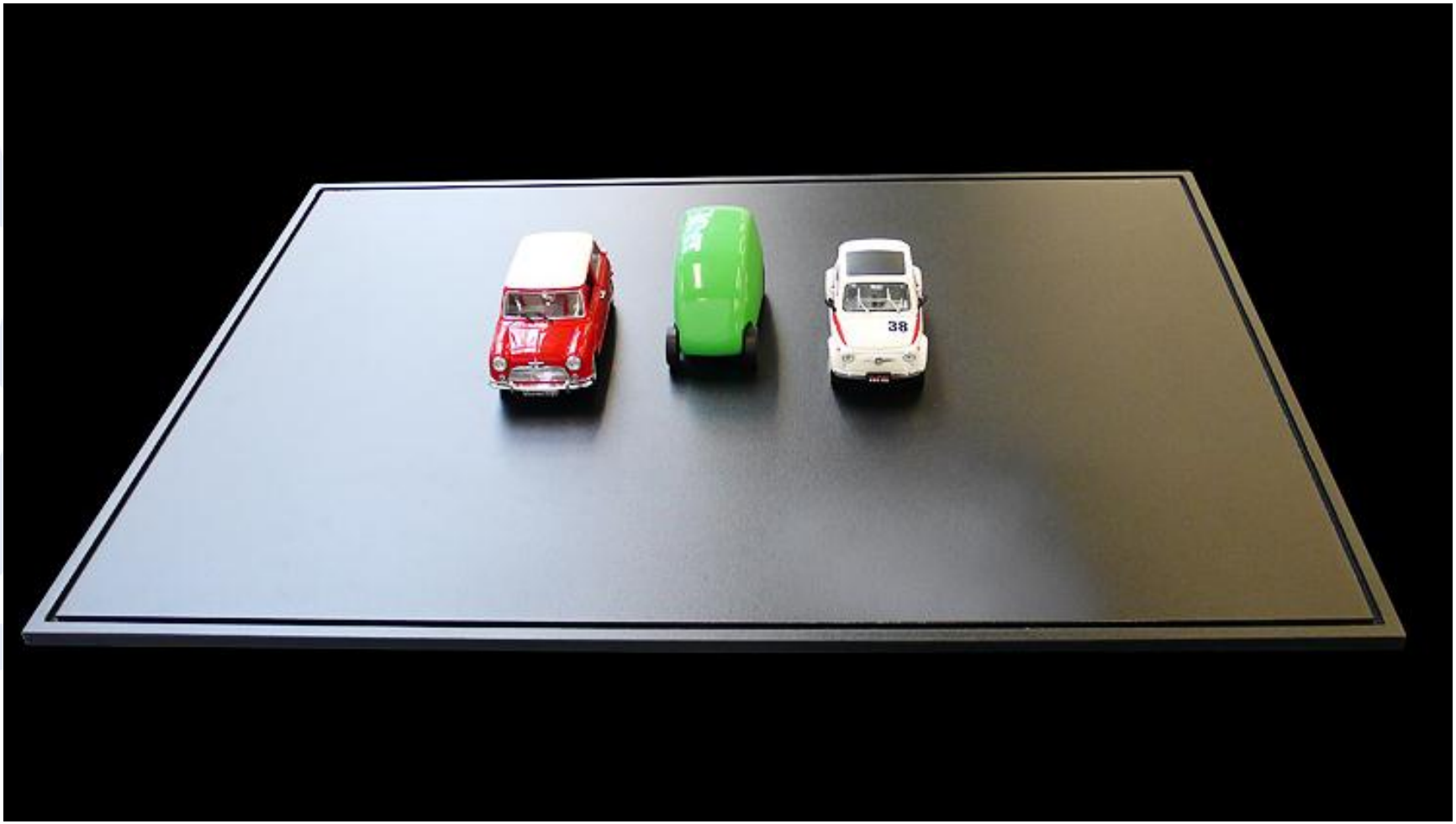
13. Protecting our personal mobility

- Designed to protect our mobility and personal freedom.



14. Putting the fun back into driving

- Lightweight and advanced vehicle dynamics, project driving fun.



15. T.25

- A New British Icon for the 21st Century