

# Lightweight solutions strengthen Swedish competitiveness and growth

– for a sustainable society 🌍

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Strategic research and innovation agenda for lightweight

2013-2033



## Roadmap now ready

Our cross-industry lightweight agenda presents ways in which Sweden can develop new technologies and innovations to drive growth and tackle the most important challenges facing society. We identify the basic requirements that are needed and the areas Sweden should focus on to ensure that our investments result in lightweight, sustainable products.

Our national vision is "Lightweight solutions strengthen Swedish competitiveness and growth for a sustainable society". By this, we mean that our technologies and solutions shall make a decisive impact on Swedish competitiveness and contribute to a sustainable society.

To demonstrate the need for a long-term approach, the lightweight agenda will span two decades, from 2013 to 2033. A large number of companies, universities, colleges, institutes and other organisations have been involved in promoting the agenda and have formally expressed their support for it. Together we have a unique and powerful opportunity to promote future cooperation in lightweight solutions that is boundary-crossing, focused and effective.

During 2013, the lightweight project will be planned in greater detail. We are also seeking to collaborate with several innovation agendas and roadmaps that

have lightweight as an intermediate target or are directed at a specific industry. Industries such as the automotive, aviation and marine sectors are obvious partners, as are the agendas for production, metallic materials, moulded products, etc.

We extend a warm welcome to any organisation that would like to contribute and benefit from this work. The first lightweight projects are already being implemented through LIGHTer, our national cross-industry lightweight arena. For the latest news on the agenda work, current projects, and everything else, go to [www.lighterarena.se](http://www.lighterarena.se)

## Our recommendations in brief

The lightweight agenda recommends measures within seven innovation mechanisms that we consider absolutely critical to success. Read more on pages 16–26.

1. Three selected strategic research areas
2. More cross-industry, industrial-based development projects
3. Development of existing test and demonstration facilities
4. Exchange between small and large companies for growth
5. Broad competence development and enhanced expertise chains
6. Coordination at all levels: regional, national and international
7. Sustainable and cohesive management and financing structure

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# LIGHT MUST BE LIGHT

The need for lighter products is governed by the major global challenges facing us today. The world's growing population must learn to share our planet's finite resources while agreeing on effective environmental measures. Designing lighter products is an obvious and quick way to reduce demands on resources and increase energy efficiency, especially within the transport industry.

Similarly, the benefits of lightweight are evident in products within energy generation and energy transport, such as wind turbines and insulators; within the construction and infrastructure sector with prefabricated building components and reinforcement materials; within the engineering industry with hand tools and robots; within the materials industry with all types of special materials and within healthcare with prostheses and aids.

In other words, Sweden's ability to develop world leading expertise within lightweight technologies will be crucial for maintaining our future industrial competitiveness. Countries such as Germany, UK, France, USA, Korea and Japan are now undertaking major national research and development initiatives. So we can see that it is absolutely essential for Sweden to make a national concerted effort to promote lightweight solutions if we are to continue to see growth in our key strengths!

## A 40% lighter agenda

This is the third edition of the lightweight agenda. We practice what we preach and have reduced the paper weight – from 119 to 72 g.

# Swedish lightweight solutions carry **weight**

Despite its size, Sweden is a strong industrial nation with several leading international companies producing cars, trucks, buses, aircraft, marine vessels, energy and engineering. Swedish industry also depends on major players in the supply chain, for example, in materials fabrication, processing, production equipment and automation as well as within the service sector. In all of these sectors, the demand for lighter products is constantly growing. Lightweight solutions provide competitive advantages for our major materials producers as well as companies manufacturing the final products. The field is therefore of vital importance for Swedish jobs and exports.

In order to strengthen the competitiveness of Swedish manufacturing companies, a rewarding customer and supplier relationship is required that can generate the right challenges. Large influential companies work in an international environment and inevitably choose the subcontractors and research partners that best meet their needs from an international perspective. A strong Swedish network of expertise and services creates strong national ties, regardless of the ownership of the companies concerned, and promotes the development of small and large businesses alike.

**“Lightweight solutions provide competitive advantages for our major materials producers as well as companies manufacturing the final products. The field is therefore of vital importance for Swedish jobs and exports.”**

## ACROSS DISCIPLINES AND SECTORS

In order to develop lighter products, and not merely reduce the weight of conventional products, the industrial and academic worlds need to think things through from scratch. We need to create a new structure for the way in which technologies are developed and amass skills that cut across various industries and disciplines. A new generation of lightweight solutions will need to combine the development of materials, processes and design in an integrated way. Research groups need to work with a common focus and chains of collaboration need to be strengthened at all levels – between companies producing finished products and their suppliers, between institutions and academia, and between authorities and stakeholders within the field.

# THE VALUE OF LIGHTWEIGHT

The potential of lightweight technology is enormous. We estimate that at least half of Sweden's exports<sup>1)</sup> depend on the development of lightweight solutions as sectors such as transport, electronics, machinery, iron and steel, metal, forestry and furniture already use lightweight technologies to gain a competitive edge or have niches with growth potential. Similarly, if we look at the largest export companies in Sweden<sup>2)</sup>, we can conclude that at least eight of the ten leading firms compete in markets that require lighter products.

Another measure of the significance of lightweight development is described by the Swedish Welding Commission (Svetskommissionen). They estimate that one third of Sweden's overall GNP<sup>3)</sup> has content associated with welding. Welding and other joining methods are key technologies for Swedish industry and new joining expertise is one of the prerequisites for the introduction of new lightweight materials and designs.

**“At least half of Sweden's exports depend on the development of lightweight solutions”**



1) Source: Statistics Sweden (SCB), commodity areas share of total exports Jan-June 2012.

2) Facts about the Swedish Economy (the Confederation of Swedish Enterprise [Svenskt Näringsliv]), the ten largest export companies in 2011.

3) The Swedish Welding Commission (Svetskommissionen), Roadmap 2015.

# FUTURE DEMANDS FOR LIGHTWEIGHT

The transport industry, which accounts for almost a fifth of global emissions of greenhouse gases, has a central role in worldwide efforts to improve the environment. Each mode of transport has its own national and international requirements and visions, all of which require lighter vehicles and marine vessels. Many other sectors have lightweight requirements within environment and health, economics or technology.

## LIGHT AND HEAVY VEHICLES

Europe has launched the world's toughest emission limits for passenger cars. EU law requires car manufacturers to ensure that, by 2020, their car fleets emit no more than 95 grams of CO<sub>2</sub> per kilometre. For truck journeys, ERTRAC (the European Road Transport Research Advisory Council) has set targets for 2030 that represent a 40% reduction in CO<sub>2</sub> emissions per tonne of cargo, per kilometre.

“Energy efficiency is now a functional requirement for new bridges and roads.”

## AVIATION

Through ACARE (Advisory Council for Aeronautics Research in Europe), the aviation industry has set targets for 2020 that require CO<sub>2</sub> emissions to be halved and NOx to be reduced by 80%. And by 2050, CO<sub>2</sub> emissions must be reduced by 75% and NOx by 90%, compared with levels in 2000. In practice, weight targets for the aviation industry will result in a minimum 10% reduction in the weight of aircraft and aircraft engine components every 10 years.

## MARINE VESSELS

For the marine vessels sector, this means that the use of heavy oil in the Baltic Sea, North Sea and English Channel will be banned from 2015. The UN agency IMO, International Maritime Organisation, categorizes these areas as SECA (Sulphur Emission Control Area). The transition to fuels with low sulphur content means higher fuel costs, which in turn will accelerate the trend for lighter vessel construction with reduced fuel requirements and increased payloads.

## INFRASTRUCTURE

The long-term strategies of the Swedish Transport Administration (Trafikverket) include energy consumption as a functional requirement in the procurement of infrastructure. For the construction industry, this now involves competing with lightweight designs that reduce the environmental impact, construction time and life-cycle costs.

## MORE SECTORS

The development of lightweight technologies is also being boosted by major economic and technological incentives as well as working environment requirements. Lightweight solutions are being used to create products that are easier to use and cheaper to transport, handle and repair. These driving forces are clearly evident within energy, engineering, construction, automation, etc.

## LIGHTWEIGHT CASE STUDIES

### Volvo Cars

#### 150 KG LIGHTER CAR BODY



To meet EU emission standards in 2020 – so far the toughest in the world – the fleets of the entire automotive industry must be made lighter. Volvo Cars estimates that the body of a standard size family car must be made about 150 kg lighter. This requires, for example, the development of applications for new composite materials that are inexpensive to manufacture.

### Gestamp HardTech

#### 20% LIGHTER WITH A STEEL SANDWICH



Gestamp HardTech has developed press hardening of high-strength boron steel to a rational process that has already reduced the weight of car bumpers by 20-25%. The next step in this development is to save a further 20% by using this unique process to produce sandwich structures.

### Kockums

#### 50% LIGHTER VESSEL SUPERSTRUCTURES



Requirements for low-sulphur marine fuels in, e.g. the Baltic Sea are accelerating the development of light vessels with lower fuel consumption. Kockums aims to reduce the structural weight of vessel superstructures by 50% and use lightweight materials to construct the entire hulls of small vessels.

### WSP

#### 50% LOWER ENERGY CONSUMPTION FOR LIGHTWEIGHT BRIDGES



The expansion of roads and bridges can be achieved more efficiently using lighter products. The environmental benefits can be gained in everything from lighter transport to shorter installation times with fewer traffic disruptions. An international survey shows that the energy consumption of a footbridge made of lightweight materials can be reduced by more than 50%\* during the bridge's life cycle.

## MORE EXAMPLES OF LIGHTWEIGHT CASE STUDIES

### Saab

Impact goal: 75% lower CO<sub>2</sub> emissions by 2050

Weight target: 10% lighter wing structure by 2020



### GKN Aerospace Sweden

Impact goal: 75% lower CO<sub>2</sub> emissions by 2050

Weight target: 10% lighter aircraft engine structures every 10 years



### Volvo Construction Equipment

Impact goal: Higher loading capacity

Weight target: Lighter welded structures in construction machinery



### Bombardier

Impact goal: Energy savings, 400m train < 1,000 tonnes

Weight target: 30% lighter carriage body structure

More lightweight case studies can be found at [www.lighterarena.se](http://www.lighterarena.se)

\* Daniel, R.A., A composite bridge is favoured by quantifying ecological impact, IABSE 2010.

# Lightweight trends throughout the world

The development of lightweight structures in Europe is largely driven by major manufacturers within the transport sector. Here, joint ventures in both metals and composites have contributed to strong growth in the supply chain. The current trend is for car manufacturers to form alliances with materials companies and other key suppliers. The aviation industry also employs a risk sharing model.

Similar developments in lightweight technology have been taking place in Japan and the USA, where work has been conducted for decades on the development of high-tensile steel and light metals. In recent years, China and Korea have also made important strides in this area. Press hardening of high-strength steel is an example of methods that are spreading across the world, as it reduces weight and increases motor vehicle safety. Another example is the development of high entropy materials, with stable properties in tough environments. Taiwan is among the leading countries in this field.

Europe also has a head start on Sweden in terms of lightweight solutions in mixed materials. German manufacturers of heavy vehicles already use several different joining methods in series production to reduce weight by using the right materials in the right place.

At present, the strongest lightweight trend in the European automotive industry is in the introduction of composite materials in cars. Manufacturers such as Audi and Mercedes have chosen to follow this route in the premium segment, while BMW is investing in electric cars in which the entire chassis, bar the crumple zone, are made of composites. There is a pressing need for lightweight electric vehicles in urban traffic, as halving the weight of a vehicle generally leads to halving energy consumption and doubling the distance between charges.

Compared with the automotive industry, the world's major aircraft manufacturers have made significantly more progress in the composites field. Boeing and



**“A weight reduction of 1kg for a commercial aircraft results in a fuel saving of SEK 10,000 during its life cycle.”**

Airbus have gradually increased the proportion of composite materials in their products to the point where half the structural weight is now made up of composites. The interweaving of environmental and economic requirements forms an extremely strong incentive. In addition to the environmental benefits, a weight reduction of 1kg for a commercial aircraft results in a saving of SEK 10,000 during its life cycle.<sup>1)</sup>

Even the marine vessel and wind power industries are making more of their products using composites. Analyses of the payback period for composites in marine vessels shows that this can be as little as three years. This has led to a major boost for composites in ships in Northern Europe.

Significant research initiatives in the area of composites are being conducted in several countries around the world. The USA and Japan are focusing, for example, on the development of high-performance

composites that use significantly cheaper raw materials and processes. A national strategy for the composite field has been prepared in the UK, resulting notably in a government investment of £25 m in a new industrial centre in addition to the industrial centres already established in the UK. Similarly, Germany is investing in the construction of industrial research centres in composite materials. Germany and the UK are also among the leading countries in research on mixed materials and joining.

Lightweight development initiatives in Europe are, naturally, creating demand for skilled engineers within composites and other lightweight areas. Major training initiatives are therefore taking place in a number of countries. For example, some 40 universities in the UK are currently conducting research and training in composite materials.

1) Zenkert D, Kaufmann M. "The cost of weight – and how that affects the design," Swerea SICOMP Mölndal tenth anniversary workshop, Swerea SICOMP, 2010.



# THE CURRENT SITUATION IN SWEDEN

Our analysis of lightweight development in Sweden is based on three materials development areas – metals, mixed/innovative materials and composites. Drawing up an inventory of the size of the industry, supplier structures, lightweight technologies, research and skills provision, has helped us to create a picture of the current situation.

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## LOW THRESHOLD FOR SOLUTIONS IN METAL

Sweden has a strong metal-based industry that includes many globally successful materials, tools and equipment manufacturers. The threshold for new conceptual solutions in metal is therefore relatively low. For example, Sweden was among the first to manufacture high tensile steel and press-hardened products.

Among system suppliers, metallic lightweight solutions are primarily found in the transport industry. Companies in the automotive, truck, bus, aviation and marine vessel sectors are internationally competitive when it comes to saving weight in bodywork, superstructures, aerospace structures and engine com-

ponents, which in turn have helped develop subcontractors' metalworking skills. The majority of Swedish suppliers are working with ferrous metals, and our strengths also include aluminium extrusions, moulded components and powder technology.

Sweden conducts extensive research into metallic materials, resulting in successful niche materials and processes. Today, the majority of the advanced metal products developed in Sweden are exported.

## MIXED MATERIALS STILL IN THEIR INFANCY

The need for lightweight solutions that involve combining several different materials is affecting large parts of Swedish industry. Mixed and innovative materials represent huge areas of development, where joining technologies and many other skills are essential for Swedish industry to be part of the international elite.

At present, the development of processes for the construction of mixed materials is largely being pursued in national and international research projects linked to the Swedish aerospace industry. The technology needs to be more cost-effective for it to be used in other manufacturing industries. Research and training in mixed materials are also limited and spread across several smaller initiatives. Swedish industry simply lacks the knowledge required to convert these new materials into products through moulding, finishing, joining, etc.

## MANY INDUSTRIES WANT TO INTRODUCE COMPOSITES

Sweden's aerospace industry has used composite materials in its products for more than fifty years and has therefore built up a great deal of expertise within the field. The Swedish marine industry also leads the way with vessels made using carbon-fibre composite.

Both sectors use high quality materials and processes, but these are not sufficiently cost-effective or modified for use in industries with different pricing. Swedish industry, including the automotive sector, needs to concentrate its efforts significantly in the area of com-

posite materials and thereby raise its competitive edge. New skills are required at all levels for companies to be able to design, dimension and manufacture composite components. Major producers are also dependent on having a larger supply of subcontractors near them. With the exception of a few innovation-driven companies, the Swedish subcontractor structure in composites is weak.

Swedish research is competitive in certain composite areas and could be strengthened further through

national coordination. We lack research programmes directed at composite materials and their applications, as well as large testing facilities for demonstrating new manufacturing technologies and properties on a system level. Sweden is also educating too few engineers with expertise in composites and other lightweight technologies, and needs to provide more vocational training and further education in this field.

## CONCLUSIONS FROM ANALYSIS AND LIGHTWEIGHT CASE STUDIES

- Welding, moulding and simulation of steel and metal products and their processes are Swedish strengths that can be safeguarded for the future through a cross-industry focus on lightweight technology.
- Designs in which different materials e.g. metals and composites, are joined together, are a field of development with great potential.
- Composites are of great interest to a large number of sectors, yet Swedish industry suffers from a shortage of professionals capable of developing and manufacturing with new composite materials.
- A greater understanding of the material properties of composites is required, and materials and processes need to be made more cost-effective.
- Sweden has a wide network of suppliers within the field of metals, but companies are restricted by uncertain future requirements, lack of industry certification and insufficient external competence networks.
- Sweden has a weak supplier structure in composites, with only a small number of exceptions (innovation-driven companies).

# VISION & IMPACT GOALS

The lightweight agenda faces up to society's main challenges by steering towards challenging goals regarding the environment, growth and innovation efficiency. In the next step, our goals will be refined further by the lightweight agenda's management. This work will also include a plan for how we can best follow up the goals and thereby increase our understanding about which initiatives actually yield long-term effects.



75% lower CO<sub>2</sub> emissions by 2050  
ACARE



< 95 g CO<sub>2</sub> per km by 2020  
EU requirement

Vision  
2015

Doubling of Swedish exports  
Minister for Trade, Ewa Björling

Government  
TARGETS

A nation conducting  
outstanding research  
Research bill 2012

## Environment

Swedish lightweight products & services reach end customers.

- More than 75% of lightweight technologies (materials, products, and services) that are developed as part of the lightweight agenda are industrialised.

- Swedish industrial firms meet or exceed national and international environmental targets linked to lightweight solutions.
- Thanks to its expertise within lightweight solutions, Sweden has a strong international profile regarding energy and the environment.

## Growth

Swedish lightweight solutions create growth in the economy.

- Swedish lightweight exports are increasing by more than 10% annually.
- 5–10 Swedish start-up companies within lightweight technology have developed into established global companies.
- 100% increase in the number of engineers and researchers with degrees in lightweight technologies.

## Innovation efficiency

Creative structures for research and innovation give a greater return per krona invested.

- More than 50% of Sweden's lightweight innovations are based on cross-industry technological development.
- Doubled staff mobility within lightweight between industry and academy/institutes (every 10 years).



“Lightweight solutions strengthen Swedish competitiveness and growth for a sustainable society.”












# THE LIGHTWEIGHT AGENDA

Our national lightweight agenda is based on the practical needs expressed in lightweight case studies produced by industries in many different sectors. The analysis has resulted in four distinct innovation themes. With these themes, we are able to link and define projects and areas of research enabling us to work towards our goals. Naturally, a project can lead to development within several themes.

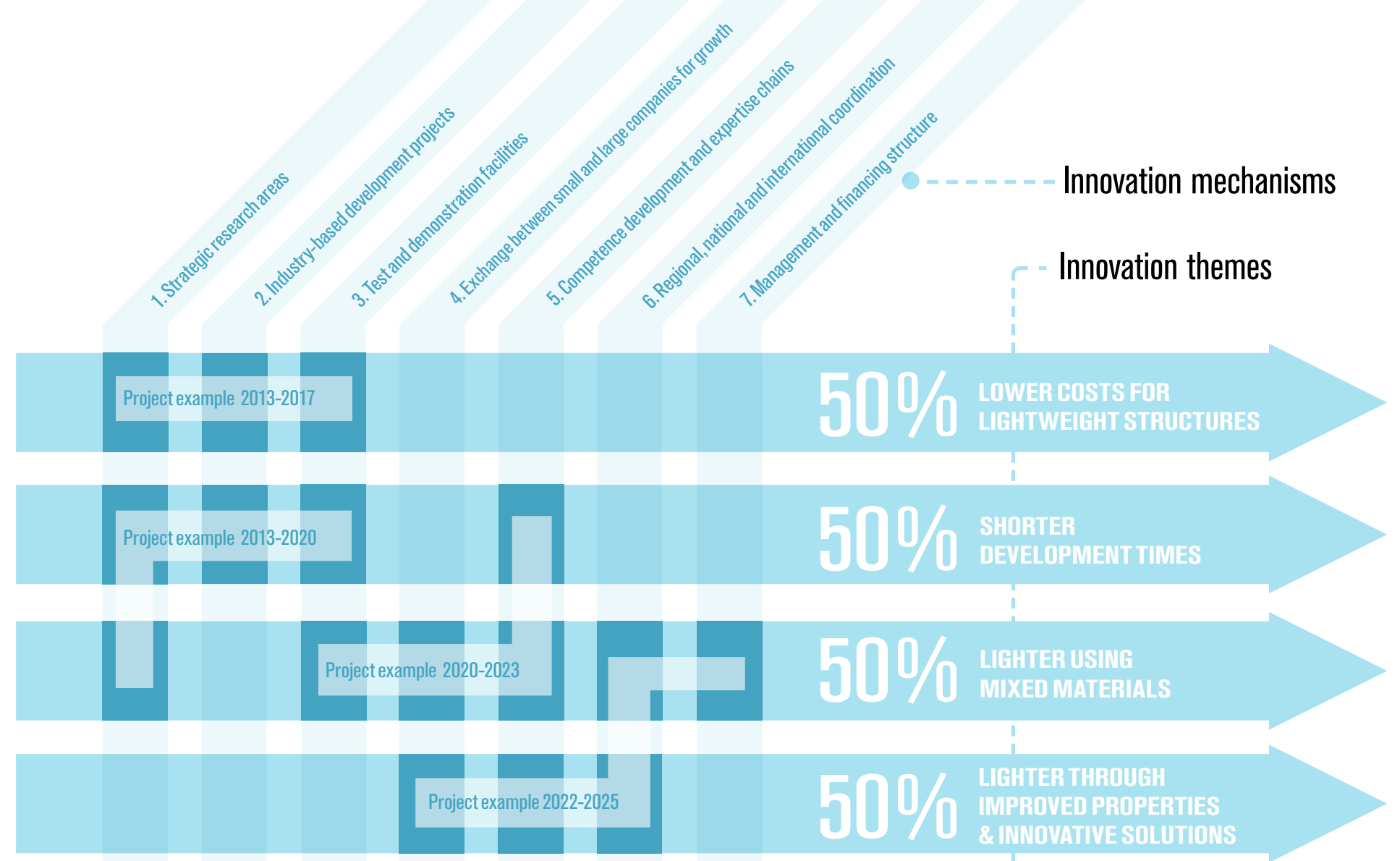
Each innovation theme is also a comprehensive objective that challenges and gets us to make use of the innovation potential in each project. (Percentages are used to show levels and should not be taken as exact figures.)

So what needs to be done and how do we want to work? This can be described in seven innovation mechanisms that we consider absolutely critical to success. Together they boost lightweight Sweden and create a better environment, competitiveness and growth.

## Lightweight case studies

-  Aviation
-  Marine vessels
-  Automotive vehicles
-  Trains
-  Engineering
-  Construction
-  Etc.

2013



2033

Competitiveness

## INNOVATION THEMES:

50% LOWER COSTS FOR LIGHTWEIGHT STRUCTURES

50% SHORTER DEVELOPMENT TIMES

50% LIGHTER USING MIXED MATERIALS

50% LIGHTER THROUGH IMPROVED PROPERTIES & INNOVATIVE SOLUTIONS

### 50% LOWER COSTS FOR LIGHTWEIGHT STRUCTURES

Creating new lightweight solutions nearly always involves a cost due to adjustments in production and higher material costs. Therefore, creating competitive products requires substantial cost savings. Today, many companies are striving to streamline their processes in order to compensate for higher material costs, for instance when replacing carbon steel with aluminium. In the case of composite materials, the manufacturing processes and raw materials are both more expensive than the corresponding shell



*AP&T has launched compact production lines for press hardening that reduces costs for customers through faster processes, fewer quality related costs and reduced space requirements.*

products made from steel. One of the objectives here is to develop efficient high-volume production of composite structures, another is to reduce material costs through new manufacturing processes, raw materials and recycling technologies. The objective of our development efforts in this respect is to halve the cost of lightweight structures.

### 50% SHORTER DEVELOPMENT TIMES

There is strong demand for short, predetermined product development times in all global markets. Technologies and development methods must therefore be verified before the real development work gets under way, ensuring that business projects can be conducted without loops in the design process or development tests. This is done by developing and using virtual methods wherever possible.

New design solutions, construction materials or manufacturing processes can only therefore be introduced in a business project when there are already reliable simulation methods available, help us to stick to the schedule. One clear example is the car industry, where it must be possible to test tomorrow's composite cars through simulation as effectively as for today's cars. Replacing virtual verification with more extensive physical testing than today is not possible due to increased costs and development times.

Another example is the ability to simulate the effect of production processes and tools types on a product's final geometry, for example in sheet metal forming, moulding or hardening of a polymer composite component. The objective of the innovation theme is to halve the development time, which in practice means that the virtual tool box must be developed in parallel with the physical one.

### 50% LIGHTER USING MIXED MATERIAL

Products are subjected to a variety of functional requirements, which often leads to materials being chosen based on a local limitation, such as high operating temperatures. The ability to use the right material in the right place in a design without losing weight potential of the joints is therefore an obvious innovation theme for weight reduction. The challenge is to find structural joining methods that can handle materials' different thermal expansions, galvanic corrosion, etc. The problems become apparent with so many different materials such as steel and polymer composite, or when two steel alloys with different characteristics must be joined together. Properties must not be lost in the joining process (e.g. welding) or in subsequent heat treatment. The objective of our innovation theme is to halve the weight by managing



to combine different materials while achieving optimum performance.

*GKN Aerospace has developed a design in which titanium parts of an aircraft engine have been replaced with polymer composites. The structure, which also contains aluminium, glass fibre and silicone rubber, became 20% lighter and will save fuel in every future flight.*

### LIGHTER THROUGH IMPROVED PROPERTIES & INNOVATIVE SOLUTIONS

There are many approaches for creating lighter components, which makes it important to work at an overall system level. Through improved material properties, the wall thickness of a component can be reduced or the material be moved to the right place. There are also other non-mechanical properties that can help to lower weight, such as corrosion resistance.

Metallic materials such as steel, cast iron and aluminium as well as polymer composites such as carbon and glass fibre have tremendous potential as lightweight materials. It is about improving properties locally and globally, but it is also about developing innovative materials or processes. One example is Lamerax Hybrix™, which is a hybrid material from steel and polymer composite.



*In Scania's new truck engine, the product developers have managed to improve the output and lower the weight using high-strength cast iron, CGI, to an extent that would not have been possible without the new material.*

## INNOVATION MECHANISMS: STRATEGIC RESEARCH AREAS

In order to continuously renew our competitiveness, Sweden must conduct world-leading research within a small number of selected areas. We know that the key to major technological breakthroughs is cooperation and sustainability. Successful research groups must therefore be coordinated and have the opportunity to conduct cutting-edge research within the selected areas for the next 20-years at least. Management by objectives and continuity are created by connecting the strategic research areas to LIGHTer's innovation themes no to short-term needs.

To achieve excellence in lightweight requires interdisciplinary research projects, with a sizeable proportion of active research by senior researchers. We

need to build partnerships with leading international research groups, in other words, leading researchers must be welcomed into Swedish research and our researchers must be given the opportunity to periodically work in prominent groups abroad. In parallel with this, we want to boost the recruitment of young researchers through graduate schools. Altogether, this will build a sustainable national network of researchers in lightweight technology of the highest international standard.

Our strategic research is focused on fundamental issues and methods that can be used across industry and be refined in our industry-driven projects, before subsequently being verified in test and demonstration facilities. Here, senior researchers at research institutes have a special responsibility to transfer mature technology to industry.

### Our three selected strategic research areas:

- 1 Modelling the links between materials microstructure, the manufacturing process and final properties for minimal weight

New lightweight materials require new understanding, models and verified methods. We need to understand and describe the relationship between a material's composition and microstructure and the manufacturing process, and explain how this will affect the final product's processability, properties and uses.

## INDUSTRY-BASED DEVELOPMENT PROJECTS

All of our development projects are rooted in tangible industrial needs to create flexibility, market adjustment and power in Swedish lightweight development. The projects will form a bridge to quicker product development and commercialisation, both for companies with end products and companies focused on materials, manufacturing processes or services. The content of the projects is directed towards our four innovation themes and findings in the form of solutions, methods and skills should be introduced into commercial projects within five years. In order to do this, we need to demonstrate new

technologies in relevant manufacturing or operating environments, i.e. project results moving from TRL4 to reach TRL5-6. This requires a multidisciplinary approach and sophisticated test environments. Development projects have a duration of 1-3 years and involve a number of industries and supplier levels. Projects may also be required to learn generic lessons from their activities and communicate them to stakeholders within the lightweight agenda.

Research institutes and industry will have leading roles in the project implementation, while universities participate selectively. Projects must have an economic

scope covering the needs of multiple industries, inputs from multiple disciplines plus comprehensive experimental verification and demonstration.

Efforts within this mechanism require strong leadership at two levels. The first level is the focused management of individual projects while they are being conducted. The second level is to lead and develop the project portfolio so that the projects implemented during the period 2013 to 2033 meet the agenda's goals as fully as possible with regard to the environment, growth and innovation efficiency.

- 2 Innovative methods for effective production of lightweight components

The challenge is to create efficient manufacturing and material processing of complex geometries with high material utilisation and enable customised development of the material's microstructure and residual stress state. The research has strong links to Swedish strengths, such as welding, casting, sheet metal forming, powder technology and additive manufacturing. It also requires extensive research in order to shorten cycle durations for the manufacture of high-performance composite materials.

- 3 Development of new material systems with new properties for lighter structures and systems

Sweden must develop new materials with radically improved lightweight properties. These new materials allow comprehensive weight reduction with significantly improved mechanical properties relative to density and increased functionality. The research includes Swedish strengths, such as steel, powder technology, metal and multifunctional polymer fibre composites and nanocomposites.

### Examples of industry-based development projects

LIGHTer is currently pursuing two projects: "UfoH – Development of joining methods for the combination of different materials for hybrid solutions" and "Triple Use – Rapid and low cost manufacturing of high performance composite components".

The projects meet our description above and are on a scale of SEK 10–15 m per year including industry funding. Experiences from these projects form the basis for a number of our recommendations.

### TEST AND DEMONSTRATION FACILITIES

New lightweight technologies and solutions need to be mature and verified in order to be considered for commercial projects. The global trend is that more and more technology development and verification takes place before product development begins in order to minimise business risks. Sweden's ability to compete requires work that is cross-industry, with shared resources, right up to demo level.

By systematically focusing on TRL5-6-verification (testing in relevant environments) in our industry-based development projects, we create completely new opportunities for the commercialisation of new technologies. We can dramatically streamline the Swedish flow of innovation.

We therefore want to strengthen Sweden's existing test and demonstration facilities in a cost-effective way. Facilities must uphold the relevant industry standards and have the right testing environments in order to attract many businesses and industries. Our innovative themes create the framework to determine which facilities need to be complemented. It then becomes important to guide as much testing and verification as possible toward these facilities to make them economically viable.

Project drivers in LIGHTer are given responsibility and resources to staff the test and demo facilities so that companies can receive qualified and rapid help with production tests, material and component testing, etc. Here we will create shared resources that strengthen the cooperation between small and large

companies as well as research institutes. It is also important that graduate students and students in higher education and industrial training have access to resources for training purposes.

Examples of demonstration requirements that strengthen our innovation themes:

#### Improved material properties

- Pilot scale material production
- Material analysis

#### Mixed material

- Production equipment for the entire chain: moulding/casting, machining, joining, painting/heat treatment and automation

#### More efficient development

- Modelling clusters: computing power, methods, material data and software

#### Reduced costs

- High volume production and assembly of composite parts

#### Testing

- Component tests in relevant operating environments

### EXCHANGE BETWEEN SMALL AND LARGE COMPANIES FOR GROWTH

Sweden must take advantage of the innovation potential of our small business and create synergies with larger companies, so that we benefit from our combined expertise. While the lightweight agenda has been under development, a large number of stakeholders have discussed how best to do this. One of the conclusions is that the growth-limiting factors for small and medium-sized businesses is different for innovation-driven businesses compared to manufacturing companies and service companies. We have taken this into account in our proposals.



### COMPETENCE DEVELOPMENT AND EXPERTISE CHAINS

Swedish industry has huge skills gaps in the lightweight field, especially within composites, and there is a lack of structure regarding how these gaps will be filled.

LIGHTer therefore wishes to create industry-adapted training in composite structure that is tailored for professional engineers at different levels. Even our industrial and research projects will generate training courses for a variety of lightweight themes. Projects are required to summarise generic knowledge from their activities and communicate this to all stakeholders.

Equally, Sweden must increase the number of researchers within lightweight. We estimate that at least 100 new doctors will be required within a 10-year period in order to seriously lift Swedish innovation.

LIGHTer has already initiated a research school that we intend to develop further. The research school, which is run by a "host university" along with several collaborating institutions, provides a sound training structure and generates more researchers with lightweight expertise.

We also need to strengthen the expertise chains within the lightweight field area using so-called frontier crossers. There are people who operate in more than one organisation, thus spreading expertise, utilising results and building networks. Frontier crossers can operate between small and large companies, SMEs and institutes, and between universities and institutes. It must also be an appealing career choice to become a frontier crosser.

We have identified four initiatives to increase the ability of Sweden to take advantage of the power of innovation and growth in small and medium-sized enterprises (SMEs).

- Shorter development efforts are directed toward SMEs without extensive administration. Targeted use of "prototype and process checks" for lightweight can help companies take the first step into the development project.
- Large companies become "prime customers" by procuring SME solutions (materials, processes or services) in higher system level development projects. The smaller companies have the opportunity to showcase their technology, while relevant delivery requirements are also set. (The level of funding is high.)
- A frontier crossing model is developed between research institutes and SMEs in order to boost skills and provide access to the institutions' development resources.
- The proper resources are allocated so that more SMEs can receive support during quality certification for specific industries such as the automotive or aerospace industries.

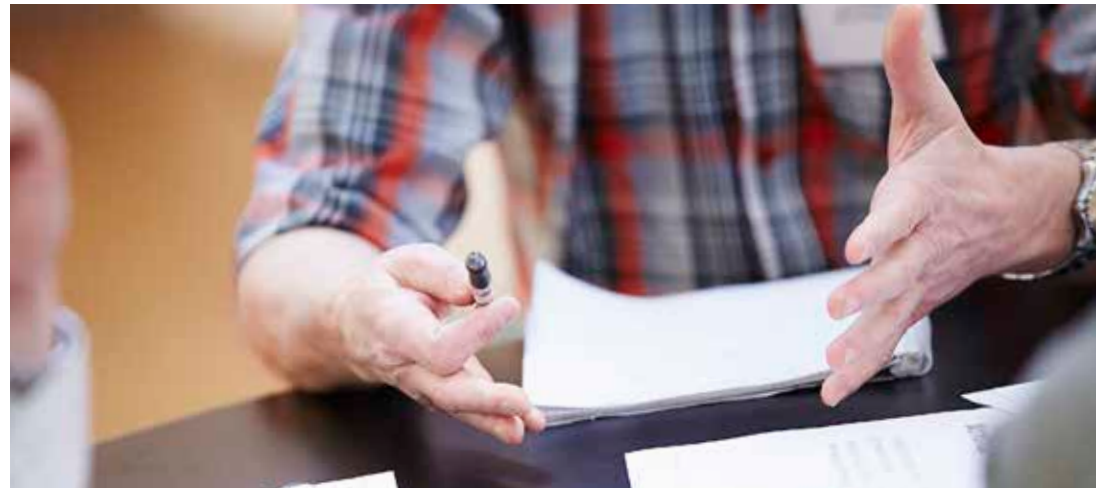
## INNOVATION MECHANISMS:

### REGIONAL, NATIONAL AND INTERNATIONAL COORDINATION

Cross industry collaboration is one of LIGHTer's strengths and we can utilise this in all ways in order to create Swedish excellence in lightweight. For example, we want to develop existing institutions and testing facilities for nodes in order to strengthen cooperation in regions with particular focus on lightweight.

Some non-exclusive examples are: Swerea IVF, PTC and SP in Region Västra Götaland, Swerea SWECAST in Jönköping, COMPRASER in Linköping and Swerea MEFOS in Luleå. Similarly, we need to work with several industry specific organisations, such as Jernkontoret (Swedish Steel Producers' Association), Teknikföretagen (engineering industry association), FKG (the Scandinavian automotive supplier association) etc.

Researchers from academia, institutes and companies are already active in several EU programmes and networks, which we shall develop more. LIGHTer's cross-industry network increases, for example, the ability to tackle the societal challenges identified in the forthcoming Horizon 2020 European Framework Programme. The EU support for SMEs initiated within the RISE group can also be used, ensuring that more companies participate in EU projects with lightweight focus. Another example is the aluminium area, where a Norwegian-Swedish cooperation will be expanded. Equally important is the creation of international exchanges between researchers in academia and business. VINNMER Marie Curie is an international initiative that allows researchers to perform guest research at other companies.



### MANAGEMENT AND FINANCING STRUCTURE

A sustainable and cohesive management with powerful resources is a prerequisite for generating success within lightweight. Government agencies, industry, academia and institutes must together invest heavily in time and money to genuinely leave an industrial footprint.

Our assessment is that coordinated investments are required totalling at least SEK 200 million per year, of which at least 50% is required from the authorities in

order to achieve the goals we have set.

One of the management's most important tasks is to take responsibility for managing the portfolio of development projects and the growth-promoting initiatives within lightweight. Assess needs and opportunities, coordinate, monitor synergies and identify opportunities around us. Individual projects and initiatives, however, are driven by project managers from industry, academia and institutes.

LIGHTer has the organisation to lead this work. We are a national cross-industry lightweight arena commanding great trust and with broad support from many industrial branches, system suppliers and subcontractors, academia, institutions, trade associations and more. We will work effectively in close cooperation with the authorities and our main task is to create growth and competitiveness on behalf of Swedish industry through cross-industry collaboration.

## LIGHTer

LIGHTer has a management, structure and organisation that satisfies industry's needs and future challenges. We have the models to create forums and coordinate national research, development and qualification initiatives.

LIGHTer aims to develop technologies, people and more efficient innovation systems for lightweight solutions.

LIGHTer is operated as a membership programme, but it is also an open forum for all organisations with an interest in lightweight. Networking and exchanges take place through reference groups where concrete actions and activities are discussed.

LIGHTer has an effective operational management, while the overall business responsibility resides with LIGHTer's Board, comprising representatives from industry, academia and research institutes. The research institute Swerea is the host organisation for LIGHTer and the legal entity that manages the finance.

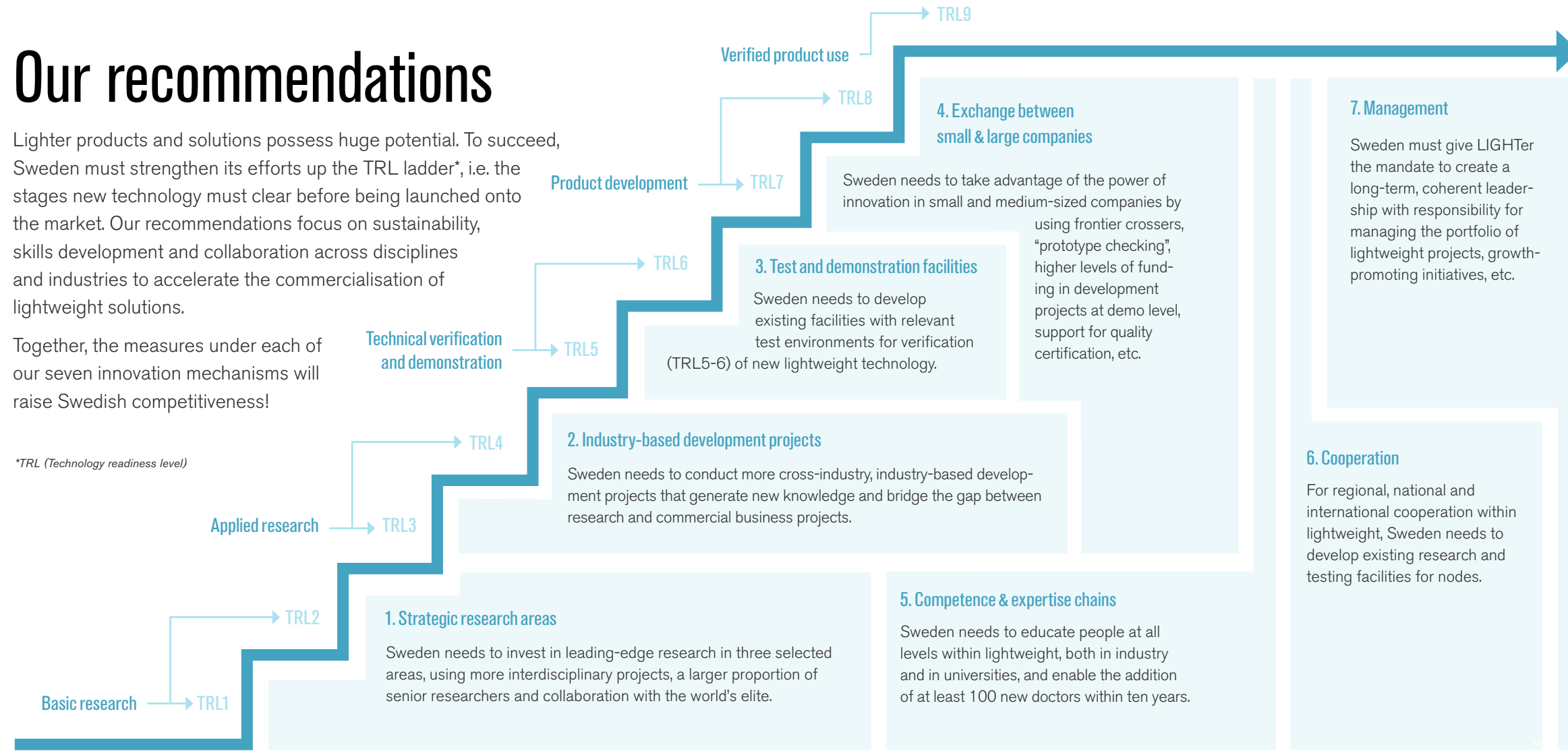
LIGHTer commands great trust and has broad support from Swedish industry, academia and institutes. The lightweight agenda is formally supported by a large number of stakeholders.

# Our recommendations

Lighter products and solutions possess huge potential. To succeed, Sweden must strengthen its efforts up the TRL ladder\*, i.e. the stages new technology must clear before being launched onto the market. Our recommendations focus on sustainability, skills development and collaboration across disciplines and industries to accelerate the commercialisation of lightweight solutions.

Together, the measures under each of our seven innovation mechanisms will raise Swedish competitiveness!

\*TRL (Technology readiness level)



## HUGE SUPPORT FOR THE LIGHTWEIGHT AGENDA

The process of developing the lightweight agenda took place in the autumn of 2012 and spring 2013. More than 100 organisations – companies, universities, colleges, institutes, government agencies and other organisations – took part in intensive workshops and meetings. At the time this document was printed, the following organisations had formally expressed their support for then lightweight agenda. However, efforts to establish the agenda are continuing, and if your organisation wishes to declare its support, you are welcome to contact us so we can update the list on [www.lightterarena.se](http://www.lightterarena.se)

ABB Robotics	HBG Teknopress	SAPA Technology
ADC of Sweden	Husqvarna	Scania CV
Altair Engineering	Höganäs	Semcon
Arsizio	IKEA	SP (Technical Research Institute of Sweden)
Autokaross i Floby	Indexator	SparQs
Benteler Engineering Services	Innovatum	SSAB
Biteam	Innventia	Stena Recycling International
Bulten Sweden	IUC Olofström	Svenska Gjuteriföreningen (Swedish Foundry Association)
Business Region Göteborg	Jernkontoret	Svensk Kompositförening (Swedish Composite Association)
CCG/DIAB Group	Kockums Industrier	Svenskt Aluminium (Swedish Aluminium)
Chalmers University of Technology	Konsult AB Trifol	Svenskt Marintekniskt Forum (Swedish Marine Technology Forum)
Compraser	KTH Royal Institute of Technology	Svetskommissionen (Swedish Welding Commission)
Design Limit Sweden	Lamera	Swedish Waterjet Lab
Devex Mekatronik	LEB Casting Technology	Swerea
DYNAmore Nordic	Lightness by Design	Talent Plastics Göteborg
EELCEE	Linköpings University	The School of Engineering, Jönköping University
Elitkomposit	Ljunghäll Group	University of Borås
Engel Sverige	Luleå University of Technology	University of Skövde
EnginSoft Nordic	Macromould Modell & Form	University West
Envirotainer Engineering	Nolato Göta	Volvo
ESI-Scandinavia/Efield	Nordic Aircraft	Volvo Cars
Exova	N. Sundin Dockstavarvet	WSP Sverige
Faculty of Engineering, LTH	Oxeon	Örebro University
FKG (Fordonskomponentgruppen)	Polymercentrum	
Flexprop	ProfilGruppen	
FS Dynamics Sweden	Region Västra Götaland	
Gestamp HardTech	Rukki	
GKN Aerospace Sweden	Saab	
Halmstad University	Sandvik Coromant	

**LIGHTer**

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A national cross-industry lightweight arena, [www.lighterarena.se](http://www.lighterarena.se)