DVN

Automotive lighting, ADAS & Car Interior technologies

50 Years of Lightstyling

A Half-Century of Vehicle Lighting Design

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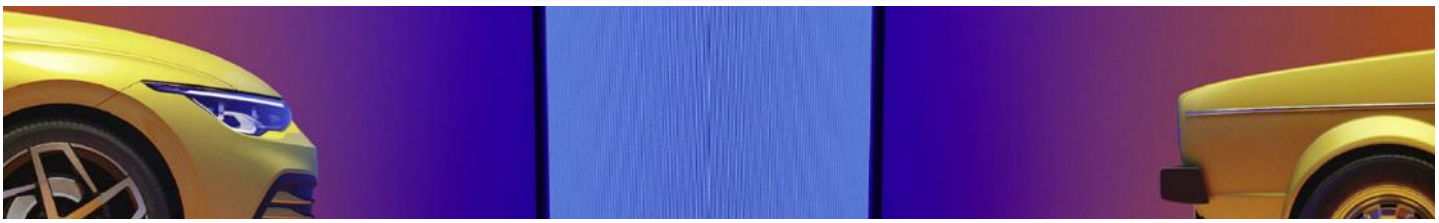


Front and rear lamps have long played a big part in the evolution of car design, influencing and being influenced by the form of the sheetmetal. The shape, contour, and design of the headlamps and rear lamps bring a showcase effect and make a major contribution to perceived quality of the vehicle as a whole.

Here we present significant design innovations, ten in front and ten in rear lighting, which have been particularly impactful on automobile styling evolution. We discuss the specialities involved—optics, thermics, electronics, testing, materials, regulations, light sources, and the like—which were often at the centre of the styling evolution typefied by each innovation we highlight.

Ten vehicle marques from Europe, America, and Asia are analysed, decade over decade, as to the evolution of their lighting components and systems.

In the story of vehicle lightstyling, two periods stand out as particularly important:
- The 1985–'93 timeframe starts just after the American mandate for standard-size-and-shape sealed-beam headlamps was finally dropped after over four decades, and ends just after ECE Regulations began permitting plastic headlight lenses, and technology allowing height reduction of headlamps.
- The 2005–'10 timeframe saw LEDs break out from their former confinment to minor functions (CHMSL, dashboard indicators), first to DRLs and then to the main headlamp functions, allowing vast new design possibilities to radically change the appearance of cars.

We are now at the start of what surely looks like another significant timeframe in this arena. New lighting functions like Welcome and Farewell displays, decoration, dynamic signal lights, digital headlamps, OLED lamps, and light-based displays will once again take a lead role in unprecedented changes to car design.

About the authors

Hector Fratty's entire career has been in vehicle lighting. From 1995 to 2006, he was Valeo Lighting Systems' chief of R&D, managing a staff of 650 engineers and technicians and a budget of over €70m. His level of expertise in lighting gained him recognition as one of Valeo's 5 Master Experts. He headed the Valeo Lighting Expert Committee through March 2008.
Hector Fratty presides over the biennial VISION Congress international vehicle lighting and driver assistance symposium.

The next VISION Congress will be held on the 7th and 8th of October, 2020 in France; more than 600 experts from around the world will attend the congress, and 20 technology demonstration vehicles will be presented.
He is also a member of the ISAL steering committee, which guides and administers the ISAL international symposium on automotive lighting organized by TU Darmstadt.
He founded and is now president of **Driving Vision News**, the vehicle lighting and ADAS industry's journal of record, dedicated to keeping the involved community informed and communicating about the latest progress and developments.

The three targets of DVN are:
Technological watch on new emerging technologies, with weekly electronic newsletters (available in English and in Chinese) bringing news, analysis, and crucial information on innovation in lighting and ADAS; there are also monthly technical reports with sharp focus on cutting edge technologies, company profiles, motor shows, regulatory matters, and other relevant content available only from DVN.

Networking of high-level decisionmakers, researchers, innovators, practitioners, academics, and regulators to make new business connections with two workshops per year in rotating locations throughout America, Europe, China, Japan, India, and Korea. DVN Workshops gather over 300 participants, and include two days of conference, lunch and coffee breaks, sponsored expo booths, and a gala dinner preceded by a cocktail party. These events really bring together the DVN lighting and ADAS community.

Promotion of innovations from DVN's 150 (and counting!) member companies—we facilitate the promulgation of knowledge of innovation, which in turn paves the way for commercialisation, enabling to build new relationships through DVN Community to forge new business worldwide.

The 150 DVN Gold company membership roster includes 30 car makers, 30 lighting & ADAS tier-1 suppliers, 15 light source suppliers, 50 tier-2 & -3, suppliers and 25 universities.
DVN Gold members—a thousand of them at last count—receive all publications and attendance privileges at all DVN Workshops. Basic members (2,500 and counting) receive short Newsletters and can obtain a limited access to other DVN publications and functions.

50 years of technological and styling evolution across the automotive industry

From 1970 to 2020, automotive styling has been highly influenced by lighting innovations, with reciprocal propulsion from the fields of optics, materials, thermics, electronics, simulation, testing, light sources, and regulations.
The ongoing results: Brand and model family design identity, with automakers using light shapes and signature to stand out from their competitors and create coherence in their product ranges.
Here's a side-by-side look at a 1970s and a 2020s headlamp design:

VW Golf MK1


VW Golf MK8

ust a few of the innovations in lighting that have shaped the course of front-end design: projector optisc, complex reflectors with window-clear lens, plastic materials, LEDs, dynamic turn signals, and new lighting functions presently under development.

Now here's a side-by-side of 1970s and 2020s rear lamp design:


VW Golf MK1


VW Golf MK8

Technological and technical advances in lighting that have strongly influenced the evolution of rear-end design include overmoulding, CHMSLs and then other rear lamps with LEDs, 3D appearances, thin and thick 3-dimensional light bar optics, dynamic turn indicators, OLEDs, and now digital lights and displays.

1. CHAPTER

Lighting Innovations

1.1 Front Lighting Innovations Influencing Style

Lighting innovations are important for automakers to offer appearance differentiation and create their own brand signature and model-family identity. Here are twenty advances—ten front, then ten rear—that unlocked new styling possibilities for vehicle designers:

1. Fixed-lens headlamps (1975 Europe, 1993 USA)

Fixing the lens in position, and aiming by moving only the reflector behind the lens, allowed to reduce the gap between headlamp and body and eliminate unsightly rubber fillers—thus improving the perceived quality of the car as a whole. First application: Renault R18.

Renault 18

2. Projector optics (1983 Europe, 1989 USA)

First commercialised as an optional auxiliary «mid beam» headlamp on certain U.S. Dodge models in 1969, polyellipsoidal optics allowed much smaller frontal dimensions for any given level of headlighting performance, though the depth was much greater. The Opel Calibra was the first car with standard-equipment projector low beams, followed by many other models—BMW signed on in a big way, then Audi.

Opel Calibra

3. Plastic reflectors (1985) and lenses (1983 USA, 1993 Europe)

Plastic allows much more intricate and extreme shapes compared to stamped steel reflectors and glass lenses. Ford's Lincoln Mark VII was the first U.S. model with thermoplastic reflectors and polycarbonate lenses, used for reasons of low cost. The Austin Maestro was the first vehicle equipped with Lucas-Carello's innovative BMC «homofocal» reflectors (having parabolic sections of different focal lengths). The Opel Omega was the first car in Europe with polycarbonate headlamp lenses.

Austin (MG) Maestro

4. Free Form/Complex Shape reflectors (1988)

Computing power grew to the level that a reflector with 50,000 individually-calculated points could be designed, then tooled and moulded in plastic with the necessary fidelity. This greatly increased the optical efficiency of the headlamp compared to the simple parabolic reflector, for the low beam cutoff could now be realised by projecting the edge of the filament rather than relying on a shade to block off the lower half of the reflector. This, in turn allowed to reduce the height of a headlamp by 30% for any given performance level. The first generation of these reflectors still used lens optics for final beam formation. The first applications were the Citroën XM in Europe and the Eagle Premier/Dodge Monaco in the USA, both by Valeo.

Citroën Xm

5. Window-clear lenses (1990)

Complex-surface reflectors evolved to be able to fully shape the beam, so corrective optics—flutes and prisms—were no longer needed in the lens. Although the technology was first developed and demonstrated by GM's Guide Lamp Division in 1972, it was first commercialised by Stanley on the 1990 Honda Accord, then by Valeo for the 1993 Chrysler line.
Window-clear headlamp lenses will become a stylistic requirement; optic lenses now appeared old-fashioned regardless of the actual performance of the lamps so equipped.

Honda Accord

6. Showcase effect (1996)

Building on the window-clear style, designers arranged the internal components of the headlamp to deliberately provide a high-tech, high-performance appearance to the headlamps, and thereby to the car as a whole.
First application: the Volkswagen Golf IV.

Golf IV

7. Dynamic bending light (2004)

This was the modern instantiation of the steering-linked high beams on the American 1948 Tucker and a variety of 1960s-'70s Citroëns. Now the showcase headlamp shows movement within it! BMW was an early adopter; the first commercial application was a BMW coupé.

BMW 3-series

8. LEDs and light guides in the headlamp (2004)

At first in clusters and then with all kinds of light guides, when dependable white and amber LEDs came along, stylists eagerly used them to differentiate headlamp designs, model years, trim levels, brand identities, and model family relations.
In the process, they created numerous examples of how stylists leverage safety technology to emphasise styling differentiation. First applications included the Audi A5 and the BMW 7 Series with «Angel Eye» rings—previously with halogen light sources, moved to LED.

Audi A5

9. LED main headlamps (2007)

White LEDs increased in power and dependability, and optical technique evolved to the point where it became technically feasible to use them for road illumination, not just signal lights. With fundamentally different optical structure—non-imaging, rather than the imaging optics used with all previous point-type light sources—designers were freed in all kinds of new directions to make headlamps like none before. Lexus unveiled the first headlamp with an LED low beam—a 3-projector affair made by Koito with Nichia LEDs—in the 2007 LS600H, with halogen high beam. Then came the Audi R8 with the world's first full-LED (high/low beam) headlamp.

Lexus LS 600h

10. Dynamic turn signal (2016)

The natural next step from LEDs all lighting up at once was LEDs lighting up in animated sequence, and the logical first application was to add some movement to the turn signals in an effort to bring both styling differentiation and safety improvment. Audi were first to market modern sweeping LED turn signals.

Audi A8

1.2 Rear Lighting Innovations Influencing Style

Styling innovations are important for OEM in order to offer differentiation and create their own signature.

1. Overmoulding (1972)

This technique puts an additional layer of resin over an existing moulded part to provide a combination of characteristics that no single material can provide. Overmolding can provide excellent adhesion of different materials—like colourless, amber, and red plastics for a combination rear lamp—while eliminating seams and the need to assemble materials by hand.

Mazda MX5

2. LED CHMSL (1986)

Red LEDs led the brightness evolution curve. Once they grew bright enough to make the jump from dashboard indicators to exterior lighting, brake lights were a logical first application—the LED's instantaneous illumination, 250 ms faster than a filament bulb, meant more time for following drivers to see and react to the brake light signal. The first application was the 1986 Chevrolet Corvette.

Chevrolet Corvette

3. LED main rear lamps (1998)

LEDs freed designers from the constraints of reflector bowls and fresnel lenses to pursue virtually any shape and size for the rear lamps and provide new day and night designs. First applications included the Maserati 3200 GT and the BMW E46.

Maserati 3200 GT

4. Light guides for rear signal lights

New linear themes and designs became possible with light guides lit by hidden LEDs. After unveiling the technology of horizontal light guides extended in all rear lamps, BMW created the light bar technology. First application: BMW 5 Series

BMW 5-series

5. Curtain Light and Microöptics (2004)

The whole lens becomes a light guide, with texturing and surface features for outcoupling.
This allowed newly homogeneous lighting, or shimmering effects. First applications with the Peugeot 308 CC and several Volvo models.

Peugeot 308cc

6. 3D appearance (2005)

To improve the styling differentiation, distinctive 3D-effect LED rear lights were developed. A notable application was on the DS3, which also features a chrome-finish DS logo in a black embossed DS setting.

Citroën DS3

7. 3D light bar (2008)

Three-stripe optics with prominent 3D effect.
First application: BMW 7 Series

BMW 7-series

8. Dynamic turn signal (2016)

Turn signals had remained largely unchanged since being patented in 1938 and subsequently adopted by automotive manufacturers: a light flashing on and off, that's all. The idea of a sequential rear turn signal was much older than in front; certain American and Japanese cars of the mid-1960s to early 1970s were equipped. But those had only three or four compartments, each with its own bulb, and the controllers were bulky and finicky—they used motor-driven cams and rotary-switch sequencers, or early transistorised electronics. Animated LED arrays brought a much greater degree and speed of animation, with much more dependable controllers. As at the front of the car, Audi were an early and first commercialiser.

Audi Q5

9. OLED tail lights (2018)

Organic Light Emitting Diodes are efficient, very thin, lightweight, and their surface illuminates with perfect homogeneity. Though technically challenging to realise in a manner compatible with rough automotive service and long expected lifespan, great strides have been made in those areas. First application: Audi TT RS.

Audi TT

10. Digital lights and displays (2020)

Displays at the rear of the car will offer the possibility to send versatile messages to following drivers, and so to inform more precisely about the status or intent for speed, acceleration or deceleration, and direction as well as to inform by anticipation about a potential danger ahead. Such displays can also be used to show EV charging status, shared-car customer acknowledgement, and other messages. First applications with Audi and Volkswagen.

Volkswagen

1.3 Research lab'

Technical and technological innovation does not spring forth out of nowhere, nor does it jump directly from the human imagination to the production line. Fields related to the one at hand exert pushes and pulls and often present keys to discoveries. Here are some of the fields that are reciprocally pushed and pushing, pulled and pulling the evolution of vehicle lightstylings:

1. Optics

In the 1970s, a headlamp was an assembly of three main parts: a parabolic reflector, a glass lens with optics moulded in, and a tungsten or tungsten-halogen bulb.
Styling demands were minimal, because of the relatively primitive state of optics, and great precision in reflector manufacturing and internal-component assembly wasn't really necessary because it was impossible to see them through the flutes and prisms in the lens.

In 1983, the introduction of projector headlamps—a polyel-lipsoidal reflector, a shield with its upper edge in the desired low beam cutoff shape, and a condensing lens of about 60 diameter was a major departure for optics.

Mercedes-Benz CLS

For the first time, the headlamp's external lens played no role in the light distribution; it served only to protect the lamp and blend it into the car's bodywork. Projector lamps also allowed a major reduction in the frontal dimensions of the headlamp, though depth was increased.
In 1988 the development of complex (or «free form» reflectors allowed the low beam cutoff to be created by the detailed shape of the reflector, rather than by the crude and inefficient previous method of simply blocking the lower half of the reflector from view of the filament. Striations on the lens were still necessary at first, though with greatly reduced workload of just fine-tuning the beam distribution. This greater efficiency resulting from being able to use the whole reflector rather than just half of it to produce the low beam allowed a significant size reduction—the Citroën XM's 70mm-tall headlamps were radically slim at that time.

In 2007, the introduction of compact LEDs with low emission temperature and the regulatory evolution—allowing multiple light sources for the low beam—spurred the development of new types of optics, particularly miniature projector units first seen on the Lexus. Projectors for LEDs began drifting away from the longstanding round form factor; more and more they came with rectangular frontal appearances, or with double reflection as on the first Nissan Leaf, and more recently with light guides used for main beams.
With LEDs, the first non-point-source lighting technology in the history of headlamps, enormously diverse new optical systems are bringing a wide range of new styles, particularly with small rectangular projection lenses presented as jewels.

In parallel, signal functions are significantly changed by the development of light guide systems. A great deal of development was necessary to achieve very good homogeneity while having still an acceptable level of efficiency. Light guides are widely deployed in DRLs and turn signals at the front, and in most lighting functions at the rear.

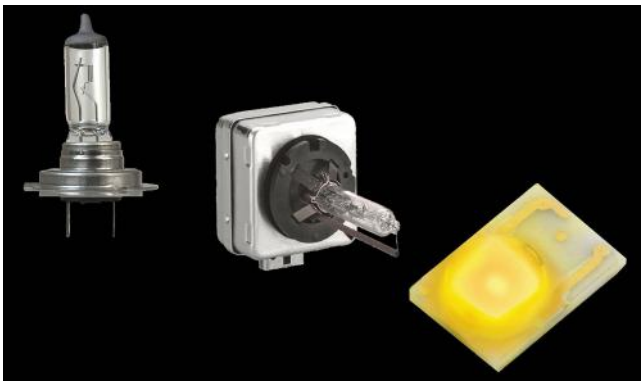
Now in 2020 with high range ADB systems, premium headlamps are no longer constrained to discrete low and high beams (except in the USA). The shape of the headlamp, the interior of the headlamp, and the lights from DRL all play primary roles for the styling of the car as a whole. Today's headlamps are intelligent, high-resolution, and multifunctional.

Modern light modules evolving to high definition systems are mostly based on projection principles, which means only the condenser lens is visible, and that means relatively few styling differentiation prospects by themselves. However, the differentiation is still present thanks to the complementary main beams, for instance, for added beam width, and with DRL and turn signal functions in the front.

In the 2020s light modules will be very thin, and with the arrival of new light functions for communication, signal lights will migrate away from the vehicle body itself—Audi were an early experimenter in this regard, devising a clever laser-projection rear fog lamp that casts a transverse red line a safe distance behind the equipped vehicle to warn following drivers; in fog or heavy rain or snow the projection itself becomes a red triangle in space for added warning effect. Now, road projections for turn signals and reversing lamps are under development to bolster safety for drivers, pedestrians, and bicyclists in traffic.

2. Light sources

Discovering new light sources is always a big step forward in the industry. The improvements of light sources are mainly in four directions: higher flux, better efficacy, smaller size, and longer lifespan. These improvements are mainly used in lighting systems to improve safety by dint of more flux on the road (same size, greater performance than what came before), but in many cases over the years increased output has been used to justify smaller lamps and new shapes (equal performance, smaller size than what came before).



H1 / Xenon / HID

In the 1970s, halogen bulbs were gaining traction. The H1 had been introduced in 1962, H2 in 1964, and H3 in 1966; these were all single-filament sources.

The H4, first commercialised in the United Kingdom in 1968 and permitted in Europe in early 1972, was the world's first two-filament halogen headlight bulb catering for low and high beam from one bulb in one reflector behind one lens. It rapidly came to be the world's most popular headlight bulb, and was eventually (1992) permitted even in the USA. In the halogen era, the main job of light source suppliers were to reduce glare from reflection inside the external glass, to increase lifespan, and to improve filament focus and luminance.

The introduction of HID («Xenon») light sources in 1991 was an important step for the improvement of the flux, rising from the 1500 lumens of a good halogen bulb to 3000 lumens from the new HID. Xenon systems were mainly realised with projection systems, though Mercedes stylists stayed with reflector-type optics for about a decade, and reflector-type HID headlamps were also relatively popular with Japanese automakers. But the primary main appearance differentiation was in their light colour of 4200K, much bluer than halogen. Marketers pounced on the opportunity to present it as «whiter» and to draw comparisons to daylight.

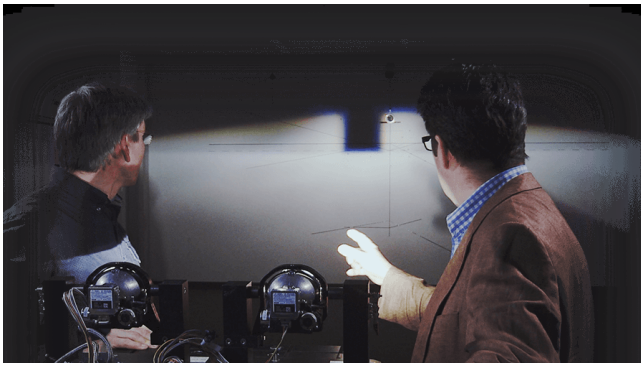
The introduction of LEDs—first in CHMSLs in 1986 and eventually in all signal lamps, then finally in low and high beams in 2007—was a huge breakthrough allowing a profusion of new appearances. For signal functions, the compactness of the source combined with its relatively low temperature emission allowed to reduce the size of all the optical units, and also to introduce light guides impossible with incandescent sources. For the low beam, the possibility to use several LEDs sources allowed many combinations, with often several optical units in a single headlamp for both improved flux and styling differentiation. Now there are also many realisations with several LEDs sources in one optical unit particularly with projection systems.

To this decisive advantages for LEDs, we should add an improved efficacy—five times better than halogen—a lifespan exceeding that of the car, and a colour temperature even bluer than Xenon at up to 6500K.

Today's vehicles are generally designed and engineered with only LED light sources. Xenon is no longer considered in new-vehicle development, and halogen is hanging on only by dint of its very low price, an advantage that is slipping away day by day as LEDs grow less and less expensive. Laser light sources still have a low penetration. The stylist has a big library of light sources and associated optics to play with for appearance differentiation.

3. Testing

Even with high-fidelity simulations, tests are still considered necessary, both to check committed performance and to ensure the maintenance of performance during the car's service life. Specific equipment is used in laboratories to test for resistance to vibration, heat, sun, weather, and so on. For judgment of beams, road tests are done. However, while for many years headlighting tests could be done on short test roads or even with the car stopped, today's ADB systems can't be tested so simply.
A real evaluation can only be done with a lot of driving in many different situations to meet as many scenarios as possible.

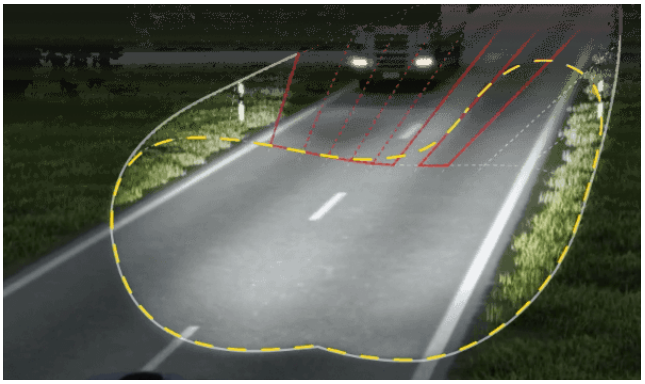


Light testing

This is one of the main sticking points holding up ADB in the USA, where the subjective assessment called for in the UN Regulations is not compatible with the American legal and regulatory system.

4. Simulation

At the beginning of the 1970s, simulation technology did not exist. All optical calculations were done by hand. In the middle of that decade, the first optical simulation tools arrived with the possibility to get the first calculation of intensity distributions. Initially, many set makers developed their own tools for these optical simulations, but now more and more specific companies are proposing standard simulation tools with both better accuracy and covering all the optical realisations including complex light guides. These simulation tools are helping enormously for development, as their appearance rendering is now very good, and engineers can rely on their results for the lit and unlit appearance of headlamps and rearlamps, and for the view of the main beams.



Automotive Lighting Glare Free high beam segmented simulation

Dynamic tools are now routinely used to simulate the view of the driver through the windscreen with multiple high definition video projectors and beamers.

The challenge for the future of these simulation tools is to develop simulators for the new ADB and high definition systems combined with ADAS functionalities anticipating the many different scenarios that could be met on the roads with the lighting system interaction. Artificial intelligence will be more and more important for these simulations.

Besides optics, all the traditional domains of lighting now have their own simulation tools allowing quicker and safer developments in thermics, condensation, electronics, and mechanics both static and dynamic.
With the proliferation of electronics and software, their corresponding simulations are now becoming crucial as these fields are now much more important in automotive lighting.

5. Materials

In the automotive industry, materials have changed decade after decade. Before 1985, virtually all reflectors stamped steel in Europe and pressed glass in the US, while most all lenses all over the world were pressed glass. Then came reflectors in different kinds of plastic—initially cheap thermoplastic in the US where there was no concern for focus shift as the lamp would heat up with use, and more dimensionally-stable thermoset phenolics and polyesters in Europe where there was a low beam cutoff to maintain across all lamp operating temperatures. Meanwhile, polycarbonate lenses came to the USA in 1983, and Europe in 1992.

Micro-patterned polycarbonate

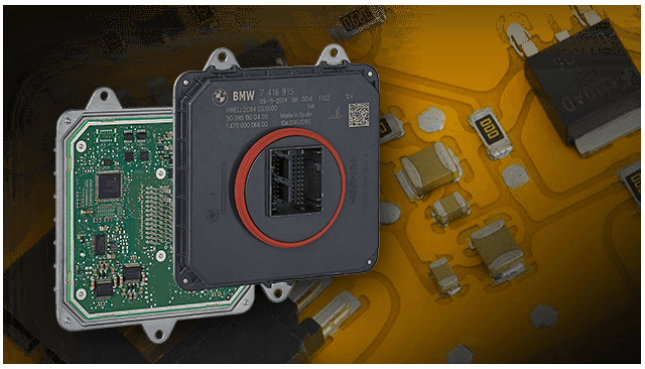
6. Light tunnel

The light tunnel is a traditional tool for beam evaluation. Some have a length of up to 150 metres for a good evaluation of the low beam and the high beam.
These tools are interesting for a first control of the beam, particularly in the mock up phase. But they're limited in their ability to evaluate the dynamic beam patterns from modern headlighting systems.

Wolfsburg light tunnel

7. Electronics

Electronics appeared first with the levellers used for headlamp aiming adjustment. The introduction of HID bulbs drove the development of ballasts as the three stages of HID operation are first the establishment of the arc with very high voltage like that of a gasoline engine's ignition system, then the evaporation/warmup stage with 80 W power, and finally the steady-state stage with 35W. This requires complex electronics. There was an impressive dimensional shrinkage of these ballasts—at the beginning they were roughly the size of a shoe box; at the end, smaller than a deck of cards.



BMW electronics developped by AL

The introduction of AFS in 1995 was the opportunity for have a real global system with several sensors and actuators with their software control. In parallel during that period of the nineties, perhaps one of the more important evolution for the electronics was the development of network architecture with LIN and CAN buses, with the development of their software.

The introduction of LEDs needed also electronics for their current control. At the beginning with CHMSLs and rear lamps, often very simple resistive electronic circuits were used. Now, more and more due to the precision needed and the necessity to have communications with the car system network, nearly all LEDs are controlled by much more complex electronics units using microprocessors.

ADB, starting from 2010, was also a step ahead for electronics complexity with communication with a new important sensor: the camera. And naturally, the future high-definition systems will need significantly increased complexity of hardware and above all software. For instance, in 1995 AFS needed roughly 1 to 3 kilobytes for software. In 2020, new headlamps systems need about a megabyte, and surely future systems will be much more demanding.

8. Regulations

Regulations normally are introduced only for safety improvements, and for each new regulation introduced, specific studies are done to demonstrate to the administrations that there is a benefit for accident reduction and life savings.
But in the domain of vehicle lighting, many new regulations have also an effect—sometimes a benefit—for styling.
We have already seen the advantages of new light sources, halogen then HID and finally LEDs and laser—for styling, but their introduction needed adaptation of the UN Regulations.
Naturally the introduction of new functions like the CHMSL and the DRL was also justified by safety, but we have seen all the new styling possibilities offered by such devices.

Legislation helps improving the safety

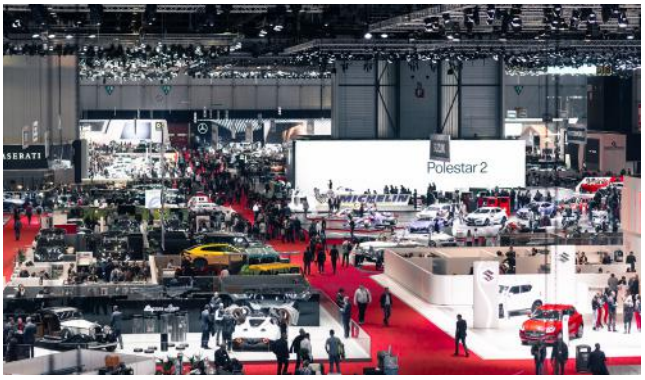
Now the industry has many ideas for guidance lines, new projections for communication, or new information through displays. All these new technologies are currently developped with high definition systems, microlens arrays, or microLED displays. But their final adoption will only be effective after adaptation of the regulation and the definition of standards understandable by everybody, and so after realisation of studies that have mostly not yet been done to demonstrate their safety benefits (or at least their safety-neutrality).

1.4 Who promoted the lighting innovations

Technologies and styling improvements are promoted via a variety of channels, including:

1. Motorshows

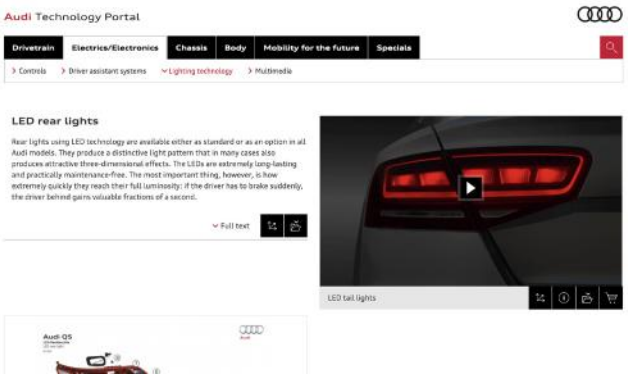
For the community of lighting, motorshows are very interesting to see the styling trends.
They can be observed in production cars, but perhaps with more interest in concept cars that are the expression of stylists' and designers' dreams. From these can be derived a sketch of future needs for styling and technology.
tCurrently, for instance, there is a trend to have slimmer and larger lights sometimes occupying all the front or rear of the car, with the development of signals in new positions all around the car.



Geneva motorshow 2019

2. Automaker communication

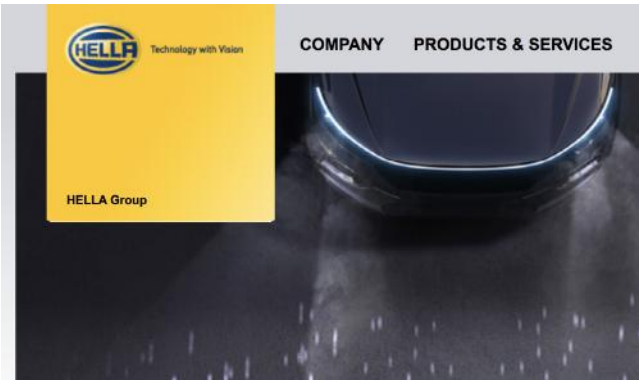
Automakers often use lighting as a marketing «billboard» of sorts, to create a story around the brand signature and to promote new technologies. This is due to the fact that lighting features of a car are by their nature very visible.
In the showroom they are the first equipment meeting the observer's gaze, and headlamps are considered the eyes of the car. In parallel, they can show through their clear lens a high level of technology that provides a sort of «halo» effect: buyers see a high-technology appearance to the lights, and perceive a high-tech nature to the whole car, even its parts that are not visible.



Audi website

3. Lighting suppliers communication

Lighting suppliers are essentially orientated to their automaker customers, so their communication strives to demonstrate their technical abilities. As new technologies appear, lighting suppliers make tremendous effort to develop and demonstrate them in hopes of winning a contract to commercialise them. It will be interesting to see how this line of promotion develops as the wall between lighting suppliers and high-tech suppliers dissolves.



Hella website

4. Magazines

Car magazines often promote car lighting, using close-up photos of car lights on the cover and on first pages of articles. Here again, the lights are the eyes of the car.
In some markets, magazines do technical comparisons and tests about the performance and perceptions of various cars' lights. This kind of analysis responds to strong interest on the part of drivers, who rank lighting high in their wish lists.

Various car magazine front covers

5. Racing

«The race will test endurance and strength of all car bodies, but also both lights and the engines». When he announced the creation of the 24 Hours of Le Mans in 1922, Georges Durand already aspired to experience and drive evolution of lighting. At that time, the acetylene lamp (or carbide lamp) which lit the first cars had been replaced by the electric light bulb, but this was only the beginning.
Fog lamps were first developed for le Mans!
Racing is also a strong lever for communication and the halogen bulbs wre strongly promoted by the Rally of Monte Carlo in 1962.

In 90 years, visibility has increased from 100 to nearly 1,000

2.
CHAPTER

Front End Styling
1970s to 2020s

Audi

Audi is the one of the world's leading brands for vehicle lighting technology and is driving progress at a fast tempo, with new solutions such as matrix laser headlights. The lighting of Audi models is also of central importance as a design element; it embodies the brand's core values: progressiveness, sportiness and sophistication to a great extent. Since 2000, most of the new technologies concerning styling were initiated by Audi thanks the involvment of the top management transmitted by the lighting team led by Dr Huhn, and a strong link between engineering and styling.

1970s With the 80, Audi introduced lightweight vehicle equipped with four round headlamps for low beams and high beams, echoing the 4-ring logo of the brand with good effect

Audi 80

1980s The round lamps were replaced by rectangular ones with the same dimensions of American sealed beams. The car was technically a breakthrough, the lighting system perhaps less remarkable.

Audi Quattro

1990s

The headlamps are enclosed in a housing, but until the 1998 facelift, the turn signal was still a separate piece with its own reflector and acrylic lens.

Audi A4

2000s

In 2008, the R8 was the first car with full-LED headlamps. All lighting functions were realised by using only LEDs.

Audi R8

2010s

The high-performance LEDs for the low- and high-beam headlights produce striking graphics. The DRL and the turn signal, comprising a multitude of LEDs, appear as a homogeneous strip at the bottom edge of the headlight, with a sequantial turn signal which makes an appearance differentiation and, Audi say, improves their safety performance.

Audi A6

2020s

Light is used as a core design feature. Each matrix LED headlamp includes 55 diodes, ten of which are for the high beam.

Audi e-Tron

2020+

Audi have introduced a visionary mobility concept for the megacities of the future: The show car, known as the AI:ME, offers compact dimensions, a spacious, futuristic interior, and the ability to drive autonomously at level 4. This allows the occupants to do what they like with their time on board.
Lighting design for autonomous cars is more about being seen and understood.

Audi AI-ME

The special thing is that the lights communicate with the surrounding environment. For this reason, the lights are more prominently placed to make them easily visible to those outside the car, such as pedestrians. The higher positioning on the grill and at the front and rear let the car better communicate with its surroundings. The many individual LEDs in the structure of the grill make it possible to display different light animations in different colours and intensities.

BMW

BMW made their first innovation in lighting in 1981 when they replaced highly conventional parabolic H1 low beam headlamps with new «BiFocus» H1 low beams: the reflector was stamped with a stepped lower section having a different focal length, so it could be used to augment the low beam pattern rather than being shadowed out. BMW's innovation took a giant stride in 1985 with projector optics, which combined a small aperture and high efficiency. The second innovation arrived in 2004 with the «Angel Eye» rings providing front position light function and strong brand identity. By and by, the «Angel Eye» rings also took on daytime running light function, and were eventually switched from halogen to LED illumination. The third BMW innovation is the laser technology.

1970s Four round lamps, same 5.75-inch diameter as American sealed beams.

BMW 3 series (E21)

1980s Same four-round lamp appearance. Initially there is a low level of lighting performance on low beam because of the small diameter of the reflector combined with the early technology allowing the use of only the upper half of the already-small reflector; this is improved in 1981 with the BiFocus low beam, and greatly improved in 1985 with projector lamps.

BMW 3 series (E30)

1990s

As with the Audi A4, BMW put forth a great change of styling with reflectors inside a common housing, but still with the brand-identifying appearance of four round lamps.

BMW 3-series (E36)

2000s

Arrival of the «Angel Eye» rings, continuing the four-round-eyes look.

BMW 3-series (E92)

2010s

LED accent lights positioned like eyebrows above the striking twin headlights with corona rings lend an extra intensity to the classic BMW focused look. Arrival of laser technology.

BMW 3-series (F30)

2020s

Full-LED headlights come as standard; extended features and U-shaped daytime running lights are available. Adaptive LED headlights with laser high beam booster face the world with hexagonal Angel Eye rings and blue decorative surface lights.

BMW 3-series (G20)

2020+

The BMW Group unveil a pure-electric gran coupe, the concept i4. The headlamps provide a bridge between the past and the future; the classic BMW four-eyed front end is reprised here with a very modern interpretation.

BMW i4 concept

Two intricate, freestanding LED elements on either side integrate all of the requisite light functions.

Cadillac

Cadillac, the top marque from General Motors, was named after Antoine de la Mothe Cadillac, who founded Detroit, Michigan. With this American brand, it must be remembered that until 1983, only four headlamp systems were permitted on all vehicles in the United States: round or rectangular sealed beams, one large or two small per side.

1970s

Four small round sealed beams, two on each side.

Cadillac Eldorado

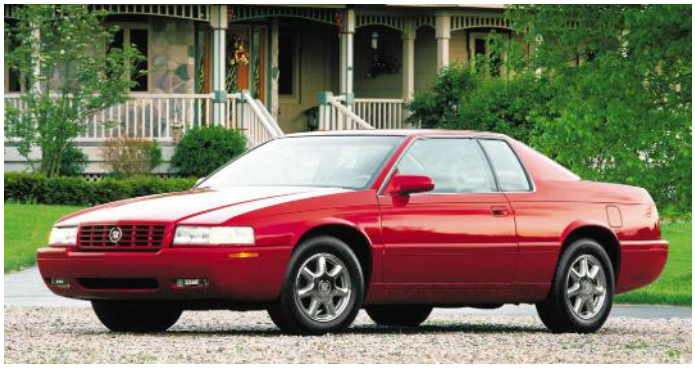
1980s

Four small rectangular sealed beams, two on each side.

Cadillac Eldorado

1990s

Composite replaceable-bulb headlamps, still with a basic rectangular appearance as though sealed beams had been removed and composite lamps had been put in the same space.



Cadillac Eldorado

2000s

Evolution to vertical headlamps

Cadillac XLR

2010s

Vertical headlamps equipped with full LED, for the first time in America.

Cadillac CTS

2020s

LED headlamps with limited adaptivity (ADB is still not permitted in USA).

Cadillac ATS

2020+

This concept car uses brand-signature vertical lights.

Cadillac Elmiraj concept

Jaguar

Jaguar, the fabled English luxury marque, style headlamps as the window to the «soul» of the car. Thus, Jaguars are instantly recognisable by looking at the lamps.

1970s This oval headlamp was very difficult even for Cibié's very talented engineers. The body shape the lens had to match made it so. A double internal lens was used in the first version with twin H1 bulbs; later versions used a single H4 bulb with simpler single lens optics.

Jaguar XJ-S

1980s Double round headlamps on each side, one large and one small (US models have two small rounds on each side, as mixed sizes were not permitted).

Jaguar XJ III

1990s

Some car makers wanted at this time to hide the headlamps; mainly when great slope.

Jaguar XJ 220

2000s

First Jaguar headlamp with a housing containing all the lighting components.

Jaguar XKR

2010s

The headlamps run vertically rather than horizontally. The compact Xenon unit requires just one projector, and there's a J-Blade LED running light.

Jaguar F-TYPE

2020s

Matrix LED technology makes for compact headlamps that incorporate Jaguar's double-J graphic with sweeping indicators.

Jaguar I-PACE

Mercedes-Benz

In comparison with their big rival BMW, Mercedes has sometimes used similar and sometimes used different lightstyles.

1970s Vertical rounded-rectangle frontal shape. One glass lens covers the main headlamp reflector (H4 light source), the front turn signal and position lamp, and the fog lamp.

Mercedes-Benz E-Class (W123)

1980s Large rectangular reflector for H4 high/low beam headlamp. H3 fog lamp inboard.

Mercedes-Benz E-Class (W124)

1990s

H7 halogen or D2R Xenon reflector low beam outboard with turn signal at the top, H7 halogen high beam inboard. A classic twin-round theme with a modern interpretation.

Mercedes-Benz E-Class (W210)

2000s

Iterative design with a leap in technology: projector optics whether halogen or Xenon light sources are specified. World's first car with adaptive headlights that adjust to driving and weather conditions to improve safety.

Mercedes-Benz E-Class (W211)

2010s

The round lamps become rectangles, presenting as precision-cut gems.

Mercedes-Benz E-Class (W212)

2020s

Full-LED headlamps as standard. Multibeam LED headlamps including Ultra Range high beam are optional.

Mercedes-Benz E-Class (W213)

2020+

This concept EV bristles with LEDs inside and out. Where the grille would be on a combustion-engine car is a giant array of colour-changing LEDs ready to communicate a variety of messages.

Mercedes-Benz EQS Vision

Headlamps are conceived with two projector eyes and three white lines apiece. Technologically futuristic features include Digital Light headlamps, each with two holographic lens modules, integrated into the continuous 360-degree exterior lightbelt. These allow an almost unlimited light distribution. 229 illuminated, individual stars form the seamlessly integrated lightbelt at the rear, causing the brand's trademark to shine out in a previously unknown way.

Peugeot

Peugeot is a brand with strong French heritage. It made several innovations related to styling like complex shape reflector allowing a remarkable decrease of the height of headlamps since 604.

1970s The Peugeot 104 has very traditional technology: the entire lamp assembly moves when aimed, the glass lenses are rectangular and vertical, and the bulbs are either tungsten R2 or halogen H4.

Peugeot 104

1980s This very successful Peugeot model was still equipped with lamps that moved entire when aimed, but now the shape is trapezoidal and there's some rake angle to the lens.

Peugeot 205

1990s

Aerodynamic plastic window-clear lenses with integrated turn signal, a big departure from past practice. H4 for low trim cars, and complex reflectors with H7 bulbs for high trim cars.

Peugeot 206

2000s

Slimmer and longer headlamps, still with a simple H4 version and a complex shape high range version.

Peugeot 207

2010s

LEDs and a light guide, component showcasing, and blackout walls emphasise the expression of the headlamp unit, both day and night.

Peugeot 208

2020s

The front end is a clever blend echoing the visual signature of the lower section of new Peugeot and the full-LED 3-claw headlight signature.

Peugeot e-208

2020+

Modernity meets classicism. The car is identifiable as a Peugeot by its visual signature with three claws and two double modules. The technical area is located under the projectors, and includes all the functions of driving assistants.

Peugeot e-Legend

Renault

Until the last decade, Renault didn't have a clear styling strategy. Now the company puts money on rear lights and present innovative rear lights.

1970s Traditional rectangular shape with each function with its distinctive colour visible

Renault 9

1980s Traditional rectangular shape with each function with its distinctive colour visible

Renault 19

1990s

This Sport version of the Megane I has two round lamps, one for the turn signal and the second one for the other functions. The basic version of the car had a rear lamp with functions distributed behind a grey and red lens.

Renault Megane I

2000s

The advanced but controversial style of the Megane II shows evolution towards a two-colour rear lamp appearance, with red for stop, tail, and fog, and colourless plastic for reverse and turn indicator, in a single unit on the quarter panel.

Renault Megane II

2010s

Innovative rectangular projector modules which will be used in all the new models of the brand.

Renault Megane III

2020s

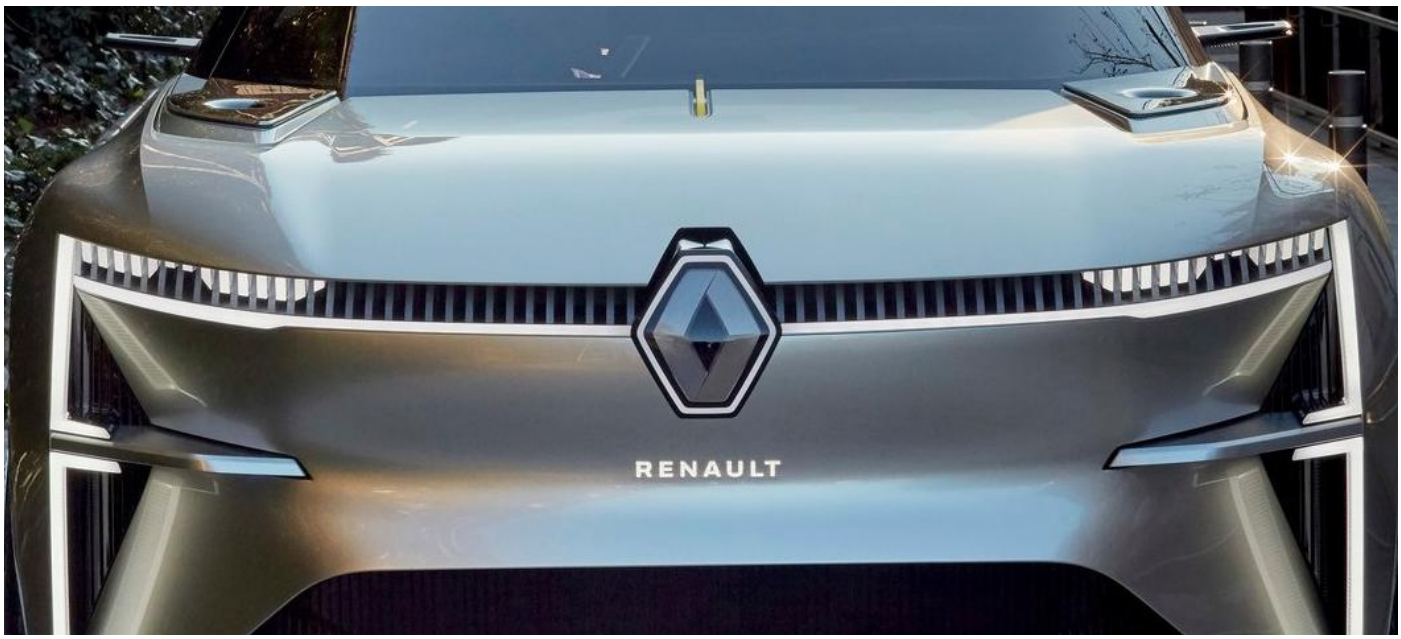
Pure Vision LED headlamps to improve visibility and comfort during journeys, added with innovative DRLs.

Renault Megane IV

2020+

The concept car boasts a futuristic full-width front lighting belt which zags downward to define the outboard edges of the front of the car. All lighting functions are in white LED technology.

Renault Morphoz Concept



Toyota

A key element in Toyota's success is its commitment to designing, engineering and building cars in the world regions where they will be sold. The innovations in headlamps are not used in Toyota brand but in Lexus brand, even styling differenciations are appearing.

1970s One 7-inch round headlamp on each side: sealed beam in the US and Japan, tungsten R2 or halogen H4 in Europe and elsewhere in the world.

Toyota Corolla (E30)

1980s Rectangular glass lens with small rake angle, halogen bulb.

Toyota Corolla (E80)

1990s

Very limited appearance evolution compared to the previous model with a slightly stretched lens.

Toyota Corolla (E90)

2000s

This eighth version of the Corolla has plastic lenses, which are still striated rather than window-clear. The shape of the lens varies; in some markets the lamps are round, in others they're rectangular, and in still others they're teardrop-shaped.

Toyota Corolla (E120)

2010s

The 2014 Corolla is the first popular-price car sold in North America with standard-equipment LED low beams.

Toyota Corolla (E140)

2020s

The slim, J-shaped Bi- LED headlamps are set deeply into angular housings for a high-tech appearance.

Toyota Corolla (E170)

2020+

Lighting is a focal point of the design in, on, and all around the I Concept, which greets drivers and passengers with lights and lighted messages as they approach the vehicle.

Toyota i Concept

Volvo

Volvo's signature issue has long been safety. Headlamp terget is focussed to safety because safety on the roads is a Swedish culture.

1970s Round headlamps, as on all Volvo models, with round fog lamps inboard.

Volvo 164

1980s Enormous rectangular H4 headlamps, the largest on the market. H4 bulb, glass striated lens. Very basic technology, but the large size allows excellent performance.

Volvo 240

1990s

Initially with H4 headlamps, then with more advanced complex-shape reflectors so the height of the reflector could decrease without decreasing the lighting performance and so the safety.

Volvo 850

2000s

Minor evolutionary change from the 800 series.

Volvo V70

2010s

The headlamps become sleeker, more aerodynamic, and more technological with more advanced reflectors for the halogen version and projectors for the Xenon version.

Volvo V70

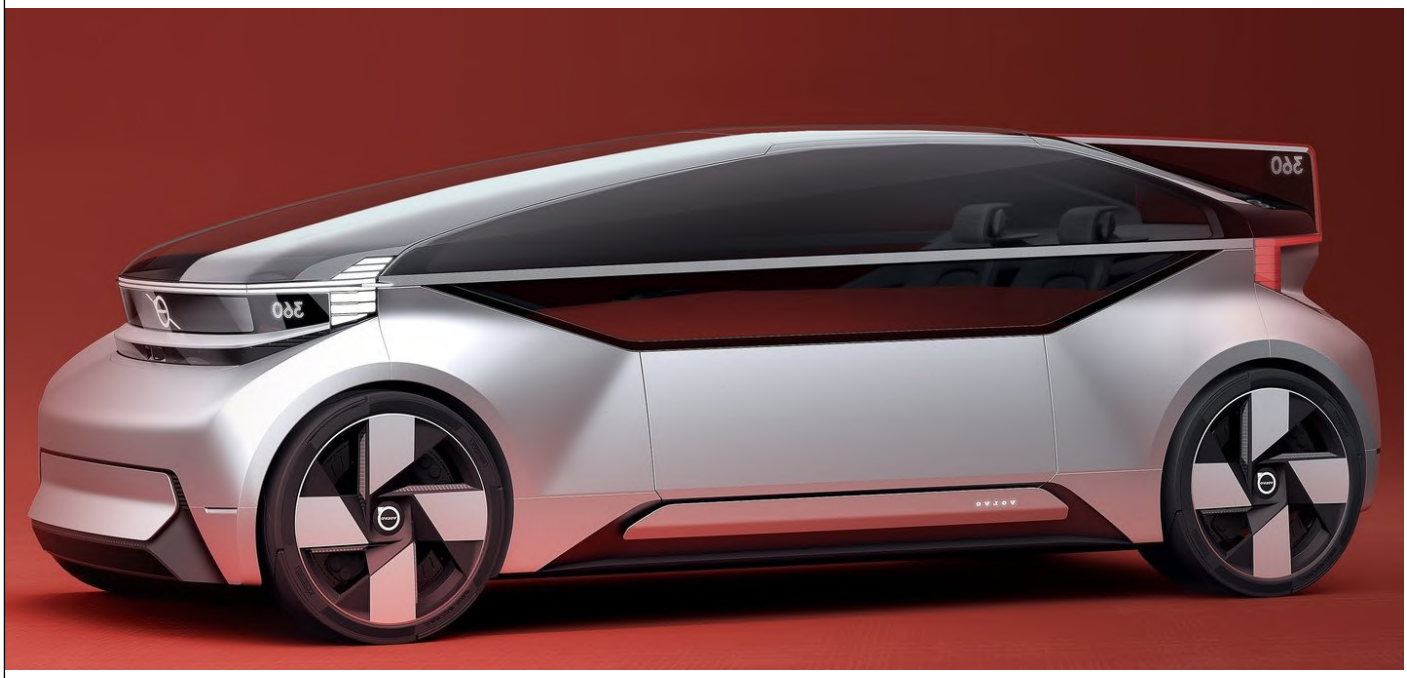
2020s

Prominent «Thor's Hammer» DRL design with high-tech LED optics hidden in the dark bars above and below the hammer handle.

Volvo V60

2020+

With its new 360c autonomous concept, Volvo Cars tackles one of the main challenges around the introduction of autonomous technology and calls for a new, global standard in how autonomous vehicles can safely communicate with all other road users.



Volvo 360c

Autonomous drive and safety are closely linked and the technology has the potential to deliver the most significant improvement in traffic safety since Volvo Cars invented the three-point safety belt in 1959. However, autonomous technology will be introduced gradually rather than overnight.

Volkswagen

Volkswagen, the major high-profile German automobile manufacturer, was founded by the German government in 1937 to mass-produce a low-priced «people's car». This generalist brand is continuing to present endless innovations in front lighting, particularely in the different models of the Golf.

1970s One 7-inch round headlamp with vertical glass lens and steel reflector. H4 on the high-spec versions, tungsten R2 on the basic models.

VW Golf I

1980s Almost change at first, with 7-inch round headlamps, but over this model's run a great deal of new technology arrives in the headlamps: large trapezoidal headlamps with plastic homofocal reflectors. H4 bulb (HB1 in USA). A great deal of lighting R&D is commercialised as optional new lights for the Golf II, including freeform-reflector units.

VW GOLF II

1990s

Very little change on the basic model: multifocal reflector with H4 or HB1 bulb. High-spec cars get new free-form reflectors, separate for low and high beam behind a common glass striated lens, with H1/H1 bulbs for Europe and HB3/HB4 for USA.

VW GOLF IV

Then, in the same decade, with the Golf IV, comes the first window-clear plastic cover lens on a VW. H7 for low beam, H1 for high beam (H7 in USA). Xenon projector is also available for high range versions.

2000s

H7 for both low beam and high beam. Very high level of flux thanks to very large reflectors. Xenon projectors on the high-spec cars. Weak evolution of the contour but shoxcase effect desapeared.

VW GOLF V

2010s

Optional Xenon headlamp with dynamic bending light and masked high beam.

VW GOLF VII

2020s

LED headlamps with cornering light and all-weather light. Projector modules are emphasizing by an innovative bezel.

VW GOLF VIII

2020+

The lighting at the front is a definitive design feature. A slender white light strip extends out to the left and right of the illuminated white VW logo, reaching across the front end and into the fenders and side body. The IQ.LIGHT LED matrix headlamps are interactive, and feature lamp modules that are seamlessly integrated into the bumper.

VW ID. SPACE VIZZION

Additional honeycomb-style LED daytime running lights that are an ID. family design cue are located in the sides of the headlamp modules and in the bumper. On the outer side of the bumper, they also act as X-shaped turn signals.

3. CHAPTER

Rear End Styling
1970s to 2020s

Audi

Audi has done a clever strategy using rear-lights to differentiate, at the rear end, the entry-model and the option combined with headlamp.

1970s Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

Audi 80

1980s With this hatchback version, the main rear functions are installed on the upper quarter panels. The reflex function on the hatchback joins the two rear lamps.

Audi Quattro

1990s

The rear lamp is much more elegant with wraparound to the front and an attempt to have an all-red lens (pink outer lens with green inner lens for the amber turn signal, tiny hidden reversing lamp).

Audi A4

2000s

The rear lights feature LED technology and the third brake light strip runs across virtually the full width of the roof, forming the termination of the transparent hood.

Audi R8

2010s

Audi also offers tail lights with LED technology, and a sequential turn indicator, followed by several premium brands and now some generalist brands..

Audi A6

2020s

At the sculpted rear end, a typical feature of Audi's top models - connects the LED rear lights. Strong differentiation of the option vs entry model with dynamics using OLEDs.

Audi e-Tron

2020+

The AI:ME can interpret signals from other vehicles and use its own lighting technology to amplify them if this benefits the surroundings. Example: A vehicle driving in front indicates danger with faint hazard war- ning flashers.

Audi AI-ME

The AI:ME can detect this signal and amplify it with projections and the LED units on the body so that it is clearly visible to all road users.

BMW

Great signature thanks the homogeneous red L bands

1970s Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

BMW 3 series (E21)

1980s Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

BMW 3 series (E30)

1990s

The world's first high-volume production car with all main rear lighting functions (stop/tail/turn) done in LED technology on the high-spec models.

BMW 3-series (E36)

2000s

Evolutionary shape change from the previous model. Stop lights are incandescent; turn signals are incandescent or LED depending on vehicle trim. BMW's first high-volume use of red rear turn signals in the USA since 1968.

BMW 3-series (E92)

2010s

Evolutionary shape change from the previous model. LED and light guide technology introduced to prominent design effect in the tail lights.

BMW 3-series (F30)

2020s

L-shaped taillights. All of the light functions use LEDs as standard.

BMW 3-series (G20)

2020+

Long, slim L-shaped rear lights with inner lit elements reminding of a racetrack corner.

BMW i4 concept

Cadillac

Verticality has been a theme of Cadillac taillamps for far longer than it's been a theme of Cadillac headlamps.

1970s

Vestigial tailfins terminated by full-height taillights. Reversing lamps set into chrome bumper.

Cadillac Eldorado

1980s

Vestigial tailfins terminated by full-height taillights. Reversing lamps on either side of licence plate.

Cadillac Eldorado

1990s

Vestigial tailfins terminated by full-height taillights. Reversing lamps on either side of licence plate.

Cadillac Eldorado

2000s

Homage to tailfins, terminated by full-height taillights faired into quarter panels. Prominent full-width CHMSL.

Cadillac XLR

2010s

Homage to tailfins, terminated by full-height taillights faired into quarter panels. Prominent but not full-width CHMSL. Domestic US models have all-red taillights; export models have clear-lens taillights.

Cadillac CTS

2020s

Homage to tailfins, terminated by full-height taillights faired into quarter panels. Prominent but not full-width CHMSL. Domestic US models have all-red taillights; export models have clear-lens taillights.

Cadillac ATS

2020+

Homage to tailfins, terminated by slim, sassy, full-height taillights faired into quarter panels. Prominent but not full-width CHMSL is no longer on the deck lid, but at the base of the backglass.

Cadillac Elmiraj concept

Jaguar

The Jaguar DNA is instantly recognisable across their range – there is an unmistakable purity of line that runs through all of our models. Agile and powerful; sleek and seductive; confident and instinctive: all these qualities are reflected in their cars.

1970s Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

Jaguar XJ-S

1980s Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

Jaguar XJ III

1990s

Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

Jaguar XJ 220

2000s

New LED rear light clusters incorporating fog lamps plus twin reversing lamps (rather than the previous one-of-each). LEDs also light the side repeaters.

Jaguar XKR

2010s

Full LED rear lamps recollect classic E-type light styling, wrapping the lights around to the trailing edge of the rear wheel arch.

Jaguar F-TYPE

2020s

The I-Pace full LED rear light uses a chicane signature, increasingly Jaguar's brand signature for rear lights.

Jaguar I-PACE

Mercedes-Benz

Mercedes-Benz always used big rear lights, most of the time two parts per side. However the last models show an evolution with thinner rear lights.

1970s Dawn of the Mercedes «corrugated» taillight, designed to allow the lights to remain visible even when dirty. Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

Mercedes-Benz E-Class (W123)

1980s Incandescent bulbs in a corrugated multicolour combination rear lamp unit gathering all functions.

Mercedes-Benz E-Class (W124)

1990s

Faint scalloping is all that remains of the corrugations. Incandescent bulbs in a multicolour combination rear lamp unit gathering all functions.

Mercedes-Benz E-Class (W210)

2000s

LEDs for stop/tail on high-spec models, incandescent bulbs for all other functions in a two-colour combination rear lamp unit gathering all functions.

Mercedes-Benz E-Class (W211)

2010s

LEDs for all functions. Mercedes' first red rear turn signals in the USA since 1968.

Mercedes-Benz E-Class (W212)

2020s

LEDs for all functions. Brake lights are flashed to provide the turn signal on the US model, because the colourless-lens amber turn signal section is too small to meet US lit-area requirements.

Mercedes-Benz E-Class (W213)

2020+

A field of red 3-pointed stars spans the whole rear and well into the quarter panels of Mercedes' idea of the car of tomorrow.

Mercedes-Benz EQS Vision

Peugeot

During decades, the styling strategy of Peugeot is to have rear lights with monocolor red appearance when lit off, before shifting to the 3 vertical claws.

1970s Simple rear lamp with traditional bulbs and relatively large functions.

Peugeot 104

1980s The hatch opening is maximised, so the size of the rearlamps is reduced to the degree allowed by regulations and thermal considerations. The fog function is moved down into the bumper.

Peugeot 205

1990s

Important evolution of style with an elongation of the rearlamp wrapping around to the front. All- red lens colour to the maximum degree still allowing white reverse light and amber indicator. New techniques were developed by set makers with subtractive techniques (pink outer lens + green inner lens = amber light with dark red unlit appearance) to achieve this styling goal.

Peugeot 206

2000s

Still with the all-red rear lamp appearance. Effort to have a look of multi-dot LED even with traditional bulbs.

Peugeot 207

2010s

The rear lamps, true technological adornments, also incorporate a light signature with three illuminated boomerang-shaped claws. In a technical feat, they appear unitised with the body.

Peugeot 208

2020s

The rear of the new e-208 stands out with its black band running over the width of the boot lid, linking the 3-claw lights (which are also day-running).

Peugeot e-208

2020+

The three-claw brand signature is expressed in a very technological way. The third brake light, located at the top of the rear window, covers its full width with a multi-blade assembly that reflects itself.

Peugeot e-Legend

Renault

Until the last decade, Renault didn't have a clear styling strategy. Now the company puts money on rear lights and present innovative rear lights.

1970s

Traditional rectangular shape with each function with its distinctive colour visible

Renault 9

1980s

Traditional rectangular shape with each function with its distinctive colour visible

Renault 19

1990s

This Sport version of the Megane I has two round lamps, one for the turn signal and the second one for the other functions. The basic version of the car had a rear lamp with functions distributed behind a grey and red lens.

Renault Megane I

2000s

The advanced but controversial style of the Megane II shows evolution towards a two-colour rear lamp appearance, with red for stop, tail, and fog, and colourless plastic for reverse and turn indicator, in a single unit on the quarter panel.

Renault Megane II

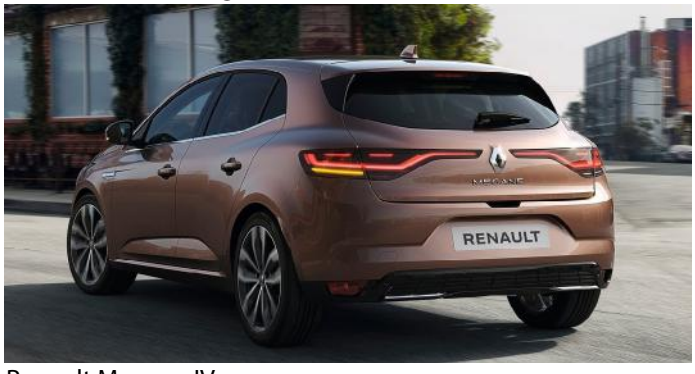
2010s

The Megane III coupé used LEDs for the tail function. The two-colour appearance was maintained with red and clear,, but here with red above and clear below. On the basic version of Megane III, the same principle was chosen but with the colour positions inverted allowing to better distinguish the two versions.

Renault Megane III

2020s

Strong presence of LEDs with exceptionally long light guides for all functions except reverse.
The tail function spans from one side all the way to the other through a complementary element on the hatchback. With this car and others during the same period, Renault was beginning to give a strong lighted signature both at the front and the rear with light guides.

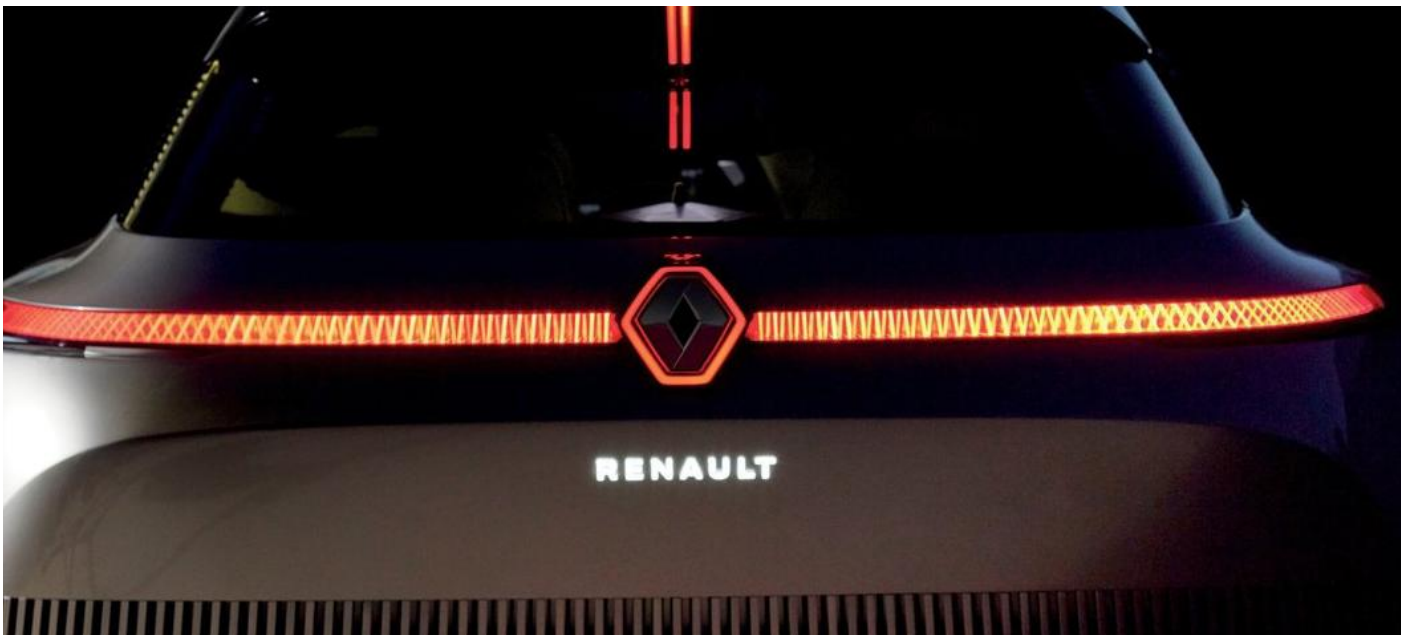


Renault Megane IV

2020+

The slimline rear lights create a shimmering effect and form an unbroken strip. Like the 2017 Symbioz concept, the vertical high-level brake light is suspended from the blade of the roof spoiler where its graphic finish is repeated on the rear fog light beneath the bumper.

Renault Morphoz Concept



Toyota

There is not a clear strategy of Totota on rear lights. Like in the front, the innovations starts with Lexus cars. The unique target is to avoid confusion in the lights. .

1970s Traditional rear lamp with rectangular shape for the complete unit and a compartment for each function. Chrome is used around the unit to embellish the appearance.

Toyota Corolla (E30)

1980s Rectangular/square design theme. Slight wraparound to the quarter panel.

Toyota Corolla (E80)

1990s

Chrome rod between the two parts of the lamp. Two parts for the rear lamp: one on the quarter panel, and one on the hatchback.

Toyota Corolla (E90)

2000s

Similar conception with slimmer functions and more elongation on the wings

Toyota Corolla (E120)

2010s

Incandescent bulbs in a bird wing-shaped lamp with applique flowing into the deck lid.

Toyota Corolla (E140)

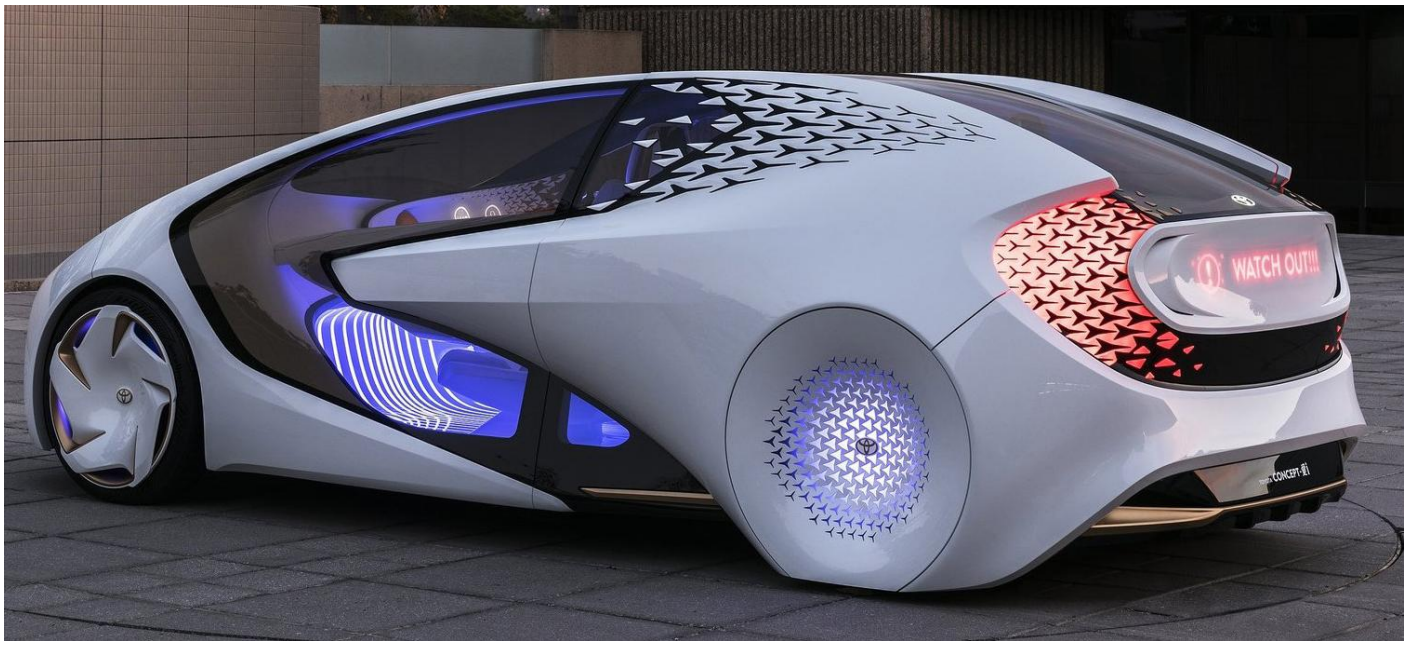
2020s

Replaceable standardised modular «LED bulbs» (LR1, LY1, LW1, etc) used in many models. Others get light guides combined with longer wraparound to the quarter panels.

Toyota Corolla (E170)

2020+

A swarm of lighting elements illuminates in different ways to provide different messages. The rear of the vehicle shows messages to communicate about upcoming turns or warn about a potential hazard.



Toyota i Concept

Volvo

Like with headlamps, Volvo searches safety with great rear lights and clear color.

1970s A vertical cluster of fresnel lenses covering a vertical column of incandescent bulbs.

Volvo 164

1980s Great big rear lamps with six square compartments.

Volvo 240

1990s

Still a large rectangular lamp, but now with horizontal strip-shaped compartments.

Volvo 850

2000s

The wagon version has tall, full-height 2-colour tail lamps.

Volvo V70

2010s

Some style and flair is added to the lamps. LED technology comes in for the stop/tail lights on later-production models, with microoptics technology which provides an homogeneous aspect in all the lit area.

Volvo V70

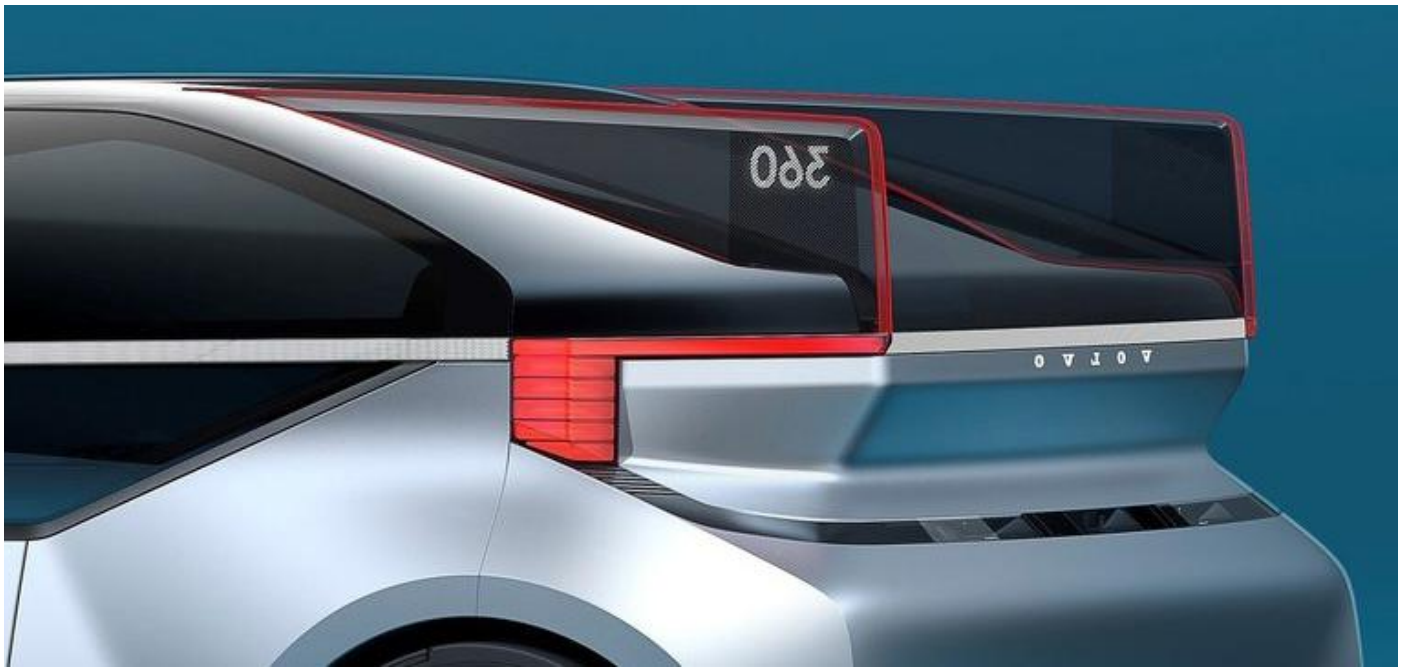
2020s

Intricate, technological design with slim LED light guides providing the tail function and character lines.

Volvo V60

2020+

Stairsteps and right angles from any observation direction.



Volvo 360c

Volkswagen

In these two decdes, Volkswagen searches to have innovative rear lights about the contour, the interior and the dynamics.

1970s Typical rear lamp of this period with rectangular shape for the unit and for each function.

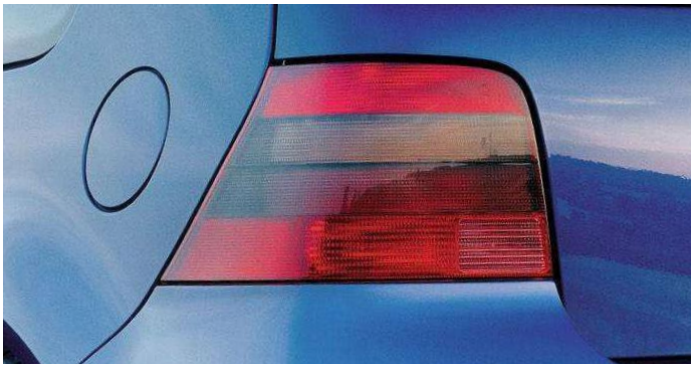
VW Golf I

1980s Introduction of trapezoidal shape, each function is still with its traditional colour. Hella offer aftermarket color-design rear lamps with an all-blue, all-green, all-yellow, all-black, or all-red appearance and subtractive filtration technology to provide the correct light colours, although at reduced efficiency.

VW GOLF II

1990s

Fine horizontal opaque red lines on the surface help nudge the lamp toward an all-red appearance even for the reverse function where light is crossing through small crystal lines, then evolution of colour with use of a grey horizontal area surrounded by two red colour areas for the Golf IV.



VW GOLF IV

2000s

Golf V introduced the use of LEDs in an original way with the combination of turn indicator, stop and tail in round areas. This very compact solution using bicolour LEDs, however, is no longer allowed by regulations.

VW GOLF V

2010s

Wraparound to the quarter panel and on the hatchback, with LEDs for all functions. Very slim reverse function under the main red area of other functions.

VW GOLF VII

2020s

The tail light gives a nice appearance with massive and homogeneous segments illuminated. The more demanding stop, turn, and rear fog functions are produced with small-dot appearance segments.

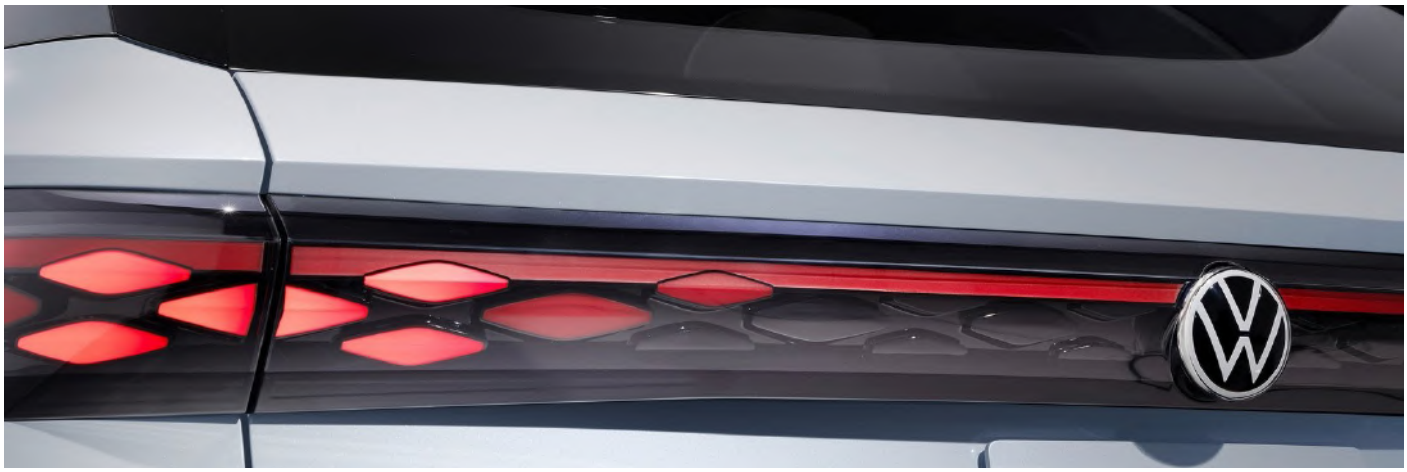
VW GOLF VIII

2020+

The transparent red light strip extends around the entire rear section and through the LED taillight clusters, which also double as X-shaped turn signals. In the upper part of the light strip, an illuminated red line to the left and right of the illuminated white VW logo continues the circumferential lighting. All of the exterior lighting elements are activated when the driver opens the car.

VW ID. SPACE VIZZION

The VW logos at the front and rear light up white, followed by the light strips on the front section and silhouette which create a 360-degree flow in conjunction with the honeycomb lighting motifs. At the same time, additional honeycomb-style LEDs in the bumper generate a lighting effect. While this is going on, the illuminated red horizontal panel at the back is activated. Finally, a digital effect makes it look like the matrix headlights are opening like eyes. Conversely, a goodbye sequence is initiated as soon as the car is locked.



4.
CHAPTER
FUTURE OF LIGHTING

A bright future for the Automotive Lighting

During this review of five decades' worth of lightstyles, we have seen many remarkable technical evolutions marrying astonishing style novelties. From simple vertical striated lenses with steel reflectors to LED ADB systems with slim headlamps treated as jewels, from simple rectangular rear lamps with bulbs to LEDs or OLEDs in stylish designs incorporating audacious light guides or very homogeneous 3D appearance, the way was always paved with more safety and more style attractiveness.

Now we are in a particular period with a huge challenge for the automotive community to succeed in the electrification of vehicles and to overcome the economic shock of the coronavirus crisis.
Surely lighting will continue to be a crucial focal point for creative and important design and style innovations.
We foresee its evolution flowing in these directions:

1. New communication functions

Communication to the driver, communication to other drivers, communication to VRUs, communication to systems of our own car or to the systems of other cars or even to the environment will offer large possibilities for the stylists as road projections, and new lights, with the condition to be standardised and approved by regulators before adoption. These road projections will be available all around the car, there is an interest in safety to use them. For instance, laterally to inform cyclists about our intent to open a door, or at the rear to inform following drivers about our deceleration. For these different communications, these road projections systems could in some cases be in competition with other technologies, for instance displays.

Mercedes-Benz F015 concept

We'll find displays at the front to inform pedestrians about the intent of the car, particularly useful for future automatic driving vehicles, and at the rear to inform following drivers or following ADAS systems about our speed or our intent for move and many other kinds of information.

2. «Welcome» and «Farewell» displays

Light around the car to welcome the occupants and to see them off with good wishes, with short range projection, will increase thanks to new available technologies like micro-lens arrays.

Toyota Concept-i

3. Decoration

The latest version of BMW's X6 'Sport Activity Coupe' has illuminated kidney grilles available as an option, combined with decorative illuminated Logos front and rear.
Car manufacturers will start to create more and more decorative lighting around the vehicles.

Illuminated kidney grilles on the X6

4. Endless appearance differentiation

Appearance differentiation by dint of light will continue to expand thanks to the imagination of stylists but also due to additional space opened up, creatively speakign, by new kinds of lights on the car and on the roads. All these different new functions will propose a styling content.
For instance, new projections signs will have to be both clearly understandable and nice; the new signals functions that will better welcome the drivers or communicate with pedestrians will certainly be the opportunity to find new styling differentiation as well as displays will need to be as attractive for the eyes as readable.


Mercedes-Benz EQS Concept

These marvelous technologies currently so expensive at the beginning will find their economic way to be installed intensively on cars, as always, decreasing with the quantities produced. For instance, LEDs that are now the standard equipment for all new cars were at their beginning in 2007 many times more expensive than a standard Xenon system. In fact, every technology bringing safety through better performance, better information to other and perhaps above all bringing styling novelty has a chance to succeed. The cost decrease is naturally the other important condition. And for the new technologies explained before, a lot of them are using microprocessors techniques or are incorporating in their cost a lot of software, both being very sensitive to cost decrease with quantities.

The lighting world of tomorrow will be as thrilling as it was in the past after a consolidation period. And as it was in the past, these new functions mainly studied and justified for safety reasons will have a strong styling content.

With six senior lighting experts through the best worldwide experts, DVN is working in a study analysing the evolutions to come and particularly the new functions that will be the future of lighting. This study will be published soon.

5.
CHAPTER
MAIN TAKEAWAY

50 Years Of Automotive Lighting

Here are the five main takeaway points we retain from our DVN analysis of the lighting history

LIGHTING2020

1.

Styling and Lighting are strongly linked
Lighting innovations allow styling differentiations Styling differentiation needs lighting innovations

2.

First breakthrough in styling vs lighting was in 1985-1990 with
Plastic reflectors and lenses Reduced height of headlamps

3.

Second breakthrough in styling vs lighting was in 2005-2010 with
Arrival of LEDs in the main lighting functions DRL as a lever of styling differentiation

4.

Third breakthrough is coming with
New communication functions
Welcome» and «Farewell» display
Decoration
Dynamic light animation

List of DVN Gold Members

Car makers

Aston Martin, UK
Audi, Germany
Bentley, UK
BMW, Germany
Daimler, Germany
FCA, USA
Ford, Germany
Geely, Germany
GM, USA
Honda, Japan, USA
Hyundai Motor, Korea, Europe
Jaguar-Land Rover, UK
Mitsubishi Motor, Japan
Nio, China
Nissan, Japan, Europe, USA
Opel, Germany
Porsche, Germany
PSA, France
Renault, France
Shanghai-Volkswagen, China
Seat, Spain
Skoda, Czech Republic
Toyota, Japan, Europe, USA
Volkswagen, Germany
Volvo Cars, Sweden

DVN-Interior

Faurecia, France
Coindu, Portugal
Honda, Japan
Marelli, Japan
Mitsubishi Motor, Japan
NBHX Trim, Germany
Novem, Germany
Osram, Germany
Preh, Germany
Recticel, Germany
Texs Insruments, USA
Sensata, UK, France
Valeo, France, Spain, China
ZKW, Austria

Set makers and Tier 1s

Bee Lighing, UK
Elba, Romania
Farba, Turkey
Flex'N'gate, USA
Grakon, USA,
Grote, USA
Hascovision, China
Hella, Germany
Ichikoh, Japan
J.W. Speaker, USA
Koito, Japan, Europe, USA
Lear, USA, Europe
Magna, USA, Austria, Italy
Marelli, Germany, USA
Mind Optoelectronics, China
Mobis, Korea
NAL, USA
Neolite ZKW, India
Nordic Lights, Finland
Odelo, Germany
Plastic Omnium, France
Peterson, USA
Rebo Lighting, China, Germany
SL Corporation, Korea
Stanley, Japan
Valeo, France, Spain, China
Varroc, Germany, Czech R.
Xingyu, China
ZKW, Austria
Zodiac, France

Light Source Suppliers

Anrui Opto, China
Cree, USA
Diodes Dynamics, USA
Dominant Opto Tech., Malaysia
Everlight Electronic, Taiwan, Germ.
Excellence Opto Inc., USA, Taiwan
LG Innotek, South Korea
Lumileds, Nederlands
Nichia, Japan
Osram, Germany
Samsung Electronics, Korea
Seoul Semiconductor, Korea
Soraa Laser Diode, USA
Tungsram, Hungary

Lighting Suppliers

3M, USA
A2Mac1, France
AML Systems, France
Aspöck Systems, Germany
ASYST Technologies, USA
Auer-Lighting, Germany
Bicomoptics, China
Bühler Alzenau, Germany
Covestro, US, China, Europe
Dajac, USA
DBM Reflex, Canada
Delvis, Germany
DesignLED, UK
Docter Optics, Germany
EcoGlass, Czech Republic
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GXC Coatings, Germany
Holophane, France
IMS, Netherland
Infineon, Germany
Inova Semiconductors, Germany
Instrument Systems, Germany
Jenoptik, Germany
Keboda, China
Less, Switzerland
LMT, Germany, China
Luminit, USA
Luminus, USA
Lumitex, USA
Maxell Joei Tech, Japan
Mentor Graphics, Europe, USA
Mitsubishi Electric, Germany, Jap.
Myotek Industries, USA
Nalux, Japan
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ON Semiconductor, Europe, Asia, US
Optoflux, Germany
Panasonic, Japan
Proper Group, USA
Red Spot, USA
Sabic, USA
Sapphire, USA
Sea Link International, USA
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TQ Technology, Taiwan
Weidplas CH, Switzerland
WL Gore, USA
Zollner, Germany

Univ., labs, Consultants

Andaltec, Spain
CEA Leti, France
Darmstadt university, Germany
DEKRA laboratory, Nederland
FEP, Franhaufer, Germany
Fudan university, China
GranStudio, Italy
Hannover Leibniz Univ.(HOT), Germ.
Institut d'Optique, Fr.
Karlsruhe Lighting Institute, Germany
LAB, France
Light Sight Safety, Belgium
Nuremberg university, Germany
Pacific Insight, USA
Parma university, Italy
Rensselaer university, USA
SLD Laser—formerly SoraaLaser
UMTRI, USA
University of California, Santa Barbara
YoungNam University, South Korea
Mr Shunxing Wang, China

DVN Reports

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2008-2016 Reports

Hella company profile
Audi company profile
AL company profile
DRL, brand signature
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Koito company profile
China lighting market
The Wonderful World of Passenger Car lighting Regulations
Tier 2and3 contribution on automotive lighting
ZKW company profile
Simulations in automotive lighting
Mercedes-Benz profile
LED technologies in Automotive Head lighting
LEDs Thermo-Electrics
Interior Lighting
BMW and lighting
Lighting and Driver Assistance
OLED technology
Materials in lighting
Laser Head lighting
Korea Lighting Market
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ADAS and Lighting
India Car Industry and Lighting Market
Advanced Motorcycle Lighting
IAA Auto Show 2015
ISAL 2015
Peterson Manufacturing
NAIAS Auto Show
Delhi Auto Expo 2016
DVN Delhi workshop
Geneva Auto Show 2016
Vision of lighting 2025-2030
DVN Tokyo workshop
Automotive lighting Regulations worldwide
New ADB technologies
Mondial Paris Auto Show
VISION Congress Vehicle Lighting in USA
Peterson Manufacturing
NAIAS Auto Show
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DVN Delhi workshop
Geneva Auto Show 2016
Vision of lighting 2025-2030
DVN Tokyo workshop
Vehicle lighting Regulations worldwide
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Mondial Paris Auto Show
VISION Congress Vehicle Lighting in USA

2017 Reports

NAIAS autoshow
DVN Rochester workshop
Geneva autoshow
Simulation Tools
Shanghai autoshow
DVN Shanghai workshop
Interior Lighting
Israeli Startups
IAA Frankfort autoshow
ISAL symposium
Jaguar Land Rover and lighting

2018 Reports

NAIAS and CES Auto Shows
DVN Munich Workshop
Geneva Auto Show
Engineering companies in lighting
Japanese lighting market
DVN Tokyo Workshop
Camera technologies
Varroc profile
Mondial Paris Auto Show
Vision congress
Volkswagen profile

2019 Reports

LA and CES
Geneva Motor Show
Volkswagen profile
Shanghai Auto Show
Materials in vehicle lighting
Status of Regulations
Integration of ADAS in Lights
IAA Frankfurt Auto Show
ISAL
Vehicle lighting in America
Interior lighting

2020 Reports

21 January - CES,
11 February - DVN Munich workshop,
17 March - Geneva autoshow,
22 April - US automotive lighting industry,
9 June - Marelli profile,
30 June - 50 years LightStyling
21 July - ADAS and Lighting,
15 September - Lighting in developing countries
13 October - VISION congress,
20 October – Mondial Paris autoshow,
15 December - Audi profile