Factfile - Edition Number 5, Summer 2001

The Electric Vehicle

A publication from Vauxhall's Education Service

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Raising the Standard

EV1 technology

The EV1 is a stylish 2-seat coupe which has all the comfort, safety, and convenience features that the customer expects including. Significantly, the car meets every US crash-safety test.

Safety and Comfort
The EV1's specification includes dual airbags, anti-lock brakes, air-conditioning, a CD player and cruise control. Because the car is extremely quiet it is fitted with special "pedestrian-friendly" chimes, light signals and a reversing horn to warn of its presence.

World records
The EV1 has performance to rival similarly sized petrol-driven cars. In 1997 a prototype EV1 captured the world land-speed record for electric vehicles at 183 mph. With a drag coefficient of 0.19 the EV1 is the world's most aerodynamic production vehicle.

The spread of 'new' technology
Research, conducted in the United States, has revealed some interesting information about the proliferation of new technologies which may give some insight into the future of alternative transport systems. The chart below, originally published in the Wall Street Journal, shows the number of years it took for key technologies to spread to 25 per cent of the population in the United States. The results indicate an increase in the rate of spread, particularly in the case of the mobile phone and video recorder.

The EV1 - not the first electric car
Purpose built for electric propulsion, the EV1 shows the way ahead with state-of-the-art materials and electronics. Perhaps in the first half of the next century, the electric car will be as common in the US as it was at the beginning of the century, when 38 per cent of cars were electric.

Delco Power Electronics System 110
System 110 incorporates a state-of-the-art inverter which converts direct current (DC) from the battery pack into 110 kilowatts of three-phase alternating current (AC) which is used to drive the vehicle's motor.

Electric vehicles do not have the internal combustion engine's continuously rotating shaft for belt driven power, so System 110 provides auxiliary electric modules to drive EV1's power steering, air-conditioning, and provide heating.

The 'brains' of System 110 is the Propulsion Control Module (PCM). The module provides slip and current commands to the drive motor by monitoring the position of the accelerator pedal and the automatic gearbox selection.

Display Steering Chime Module
The Display Steering Chime Module (DSCM) provides audio and visual information on the status of various vehicle functions such as speed, power consumption and the state of charge.

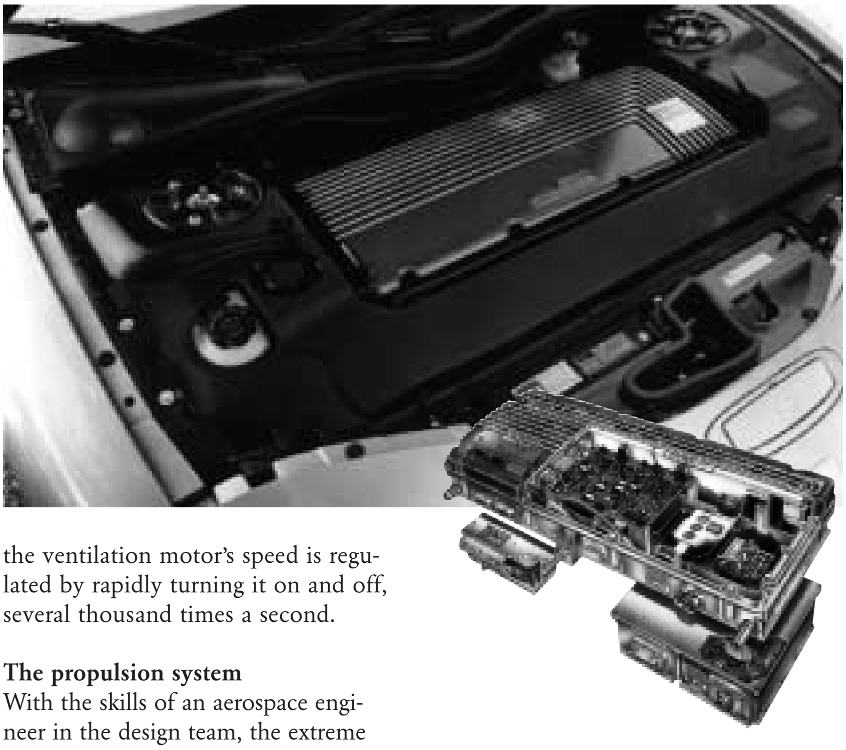
Other functions of the DSCM include gear selection indication, mileometer, time to full charge and the vehicle's range. High beam, park status and passenger compartment environment pre-conditioning are also shown by the DSCM.

Console Control Unit
This Delco Electronics designed unit consolidates most controls in one module situated between the driver and passenger. With this module the driver is able to operate a wide-range of controls, including power windows, heating and air conditioning, automatic gearbox selection and the security keypad used to start the vehicle.

Console Control Unit consolidates most controls in one central module.

The spread of key technologies to 25 per cent of the US population

46 years	Household Electricity..................1873
35 years	Telephone.....................................1875
55 years	Automobile..................................1885
54 years	Airplane..1903
22 years	Radio..1906
26 years	Television.....................................1925
34 years	Video recorder..............................1952
30 years	Microwave oven............................1953
15 years	Personal computer........................1975
13 years	Mobile phone................................1983



The Power Electronic Bay houses the PCM unit which manages the use of electric energy and the power inverter which converts direct current from the batteries into alternating current for the motor. The unit is capable of handling the same power that would be needed to run a 100,000 watt radio station. The cutaway shows some of the sophisticated electronics.

Heating and ventilation

The EV1 needed a totally different approach to cabin heating and cooling. The principle of the heat pump, in common household use in the US, was applied to this problem. This was also the first time a heat pump had been used in an automobile. A Thermal Control Module, which consists of a electrically-driven reversible heat pump and an electronic unit, controls the passenger compartment environment and drive system cooling. The pump uses the environmentally sound refrigerant R-134a. The system can also pre-condition the cabin environment whilst the vehicle is charging. Power is taken from the recharge station and not the vehicle's batteries.

Pulse Width Modulation (PWM) control modules conserve energy in DC motor applications. With PWM, the ventilation motor's speed is regulated by rapidly turning it on and off, several thousand times a second.

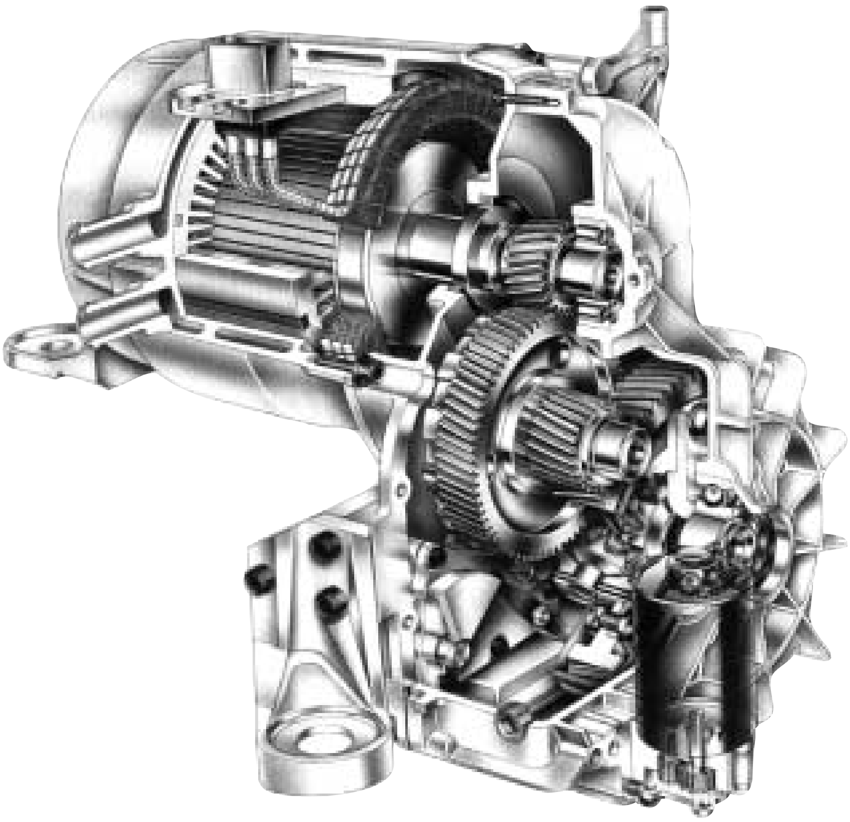
The propulsion system

With the skills of an aerospace engineer in the design team, the extreme requirements of EV1's propulsion system were met and exceeded. The unit had to be compact, light, highly efficient and able to deliver power levels comparable to other road vehicles. The result of the considerable efforts of the design team was the Delphi Drive Unit, a three-phase AC induction motor with integrated gear reduction. The drive unit motor is capable of than 13,000 RPM and only requires routine maintenance when it has covered more than 160,000 km. Rated at 103 kW peak, the unit features regenerative braking which extends the vehicle's range by up to 20 per cent.

Weight was the most vital factor in the design of every EV1 component especially the drive unit which weighs a mere 150 pounds - one third the weight of an equivalent four-cylinder petrol engine.

The drive unit has liquid cooling, oil lubrication and built-in temperature sensors and a gear mode switch. The parking brake can be applied by simply pressing a button in the cabin which operates a park/lock device in the unit. The unit is also very simple to use as forward, reverse and park are the only gear selections needed.

GM is already moving to production of the 2nd generation propulsion system which is lighter and has fewer moving parts. A third generation system, currently under development, sees the contents of the Power Electronics Bay reduced to the size of a shoe box.



The Delphi Drive Unit

Electrical systems

The power and signal distribution system, designed and built by Delphi Packard Electric Systems, was a unique challenge for the designers. The system's extreme high voltage requirements brought added safety and engineering considerations.

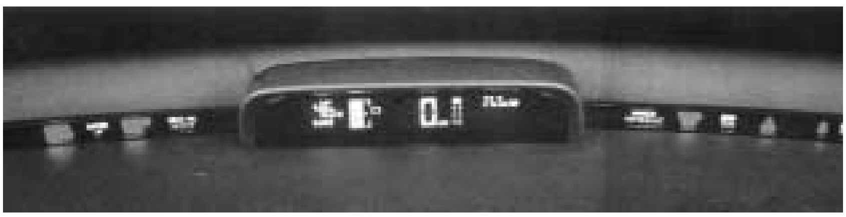
The EV1 has a variety of multi-voltage sub-systems which differ greatly from standard 12-volt systems. The use of high-current military-grade connection systems along with special electromagnetic shielding has made the EV1 a safe reliable alternative form of transport. Amazingly, the EV1's electrical system has more than 4.2 miles of wire, 460 plastic components, 1,110 metal parts and 103 cable splices.

Delphi Battery Pack

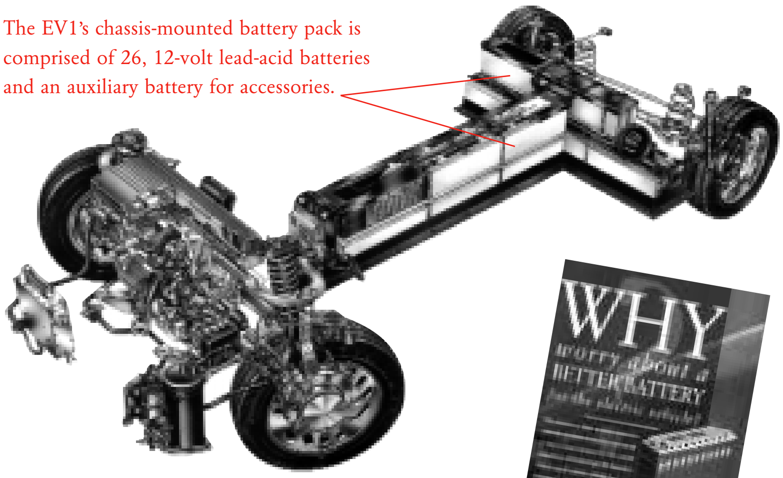
Invented more than a century ago, the lead-acid battery still has a place in modern applications. Because of the high demands of weight, performance and duty cycle (how energy is put in and taken out of the battery), these batteries have to be engineered to very higher standards.

The batteries used to start a conventional vehicle rarely use more than 5 per cent of their energy, whereas an EV battery uses over 85 per cent of its charge without damage. The advanced battery pack designed by Delphi is able to meet EV performance, durability and safety requirements. Features include an electronic module to control charging, automatic and manual disconnection for safety, thermal management, a vent system and battery temperature/voltage sensors.

The Display Steering Chime module has a centrally-mounted display which contains a digital speedometer, as well as range and power consumption information. Other readouts include direction indicators, tyre pressure low warning lights and gearbox selection information. Information is presented in the driver's forward field of view - a key safety feature.



The EV1's chassis-mounted battery pack is comprised of 26, 12-volt lead-acid batteries and an auxiliary battery for accessories.



The pack consists of 26 valve-regulated batteries which are maintenance free and able to deliver more than 450 deep discharge cycles. An ordinary battery would only survive around 50 cycles. Significantly the EV1's batteries are completely recyclable within the existing infrastructure.

The Delphi battery pack weighs 1,175 pounds and can store 16,200 watt-hours of energy or the equivalent to a little less than 5 litres of petrol. This simple fact demonstrates the supreme energy efficiency of the EV1 which has a range of up to 145km.

NiMH - the next generation

The EV1 was designed to make the most of existing lead-acid battery technology. This was not enough for the designers who have been looking closely at alternative electrical power sources for the EV1's motor. GM's designers identified the nickel metal hydride battery as showing the most potential.

The NiMH battery was invented in 1983 and is in common use in many domestic applications such as video cameras and laptop computers. A NiMH battery can store more than twice the amount of electrical energy than its lead-acid counterpart.

In 1998, GM introduced the NiMH battery on the EV1 and set another benchmark for electric vehicle performance. Although the NiMH battery delivers power at a slightly reduced rate (90 per cent) it is unlikely to affect the performance-appeal of the EV1. A major motor magazine in the U.S recorded a 7.7 second, 0-60 acceleration time on a lead-acid equipped EV1 during a road test. During the development of the EV1 NiMH battery an experimental car covered 373 miles on a single charge.

In 1994, GM formed the Ovonic Battery venture to develop NiMH battery technology.

Although the NiMH battery is considerably more expensive to manufacture, it has a service life four-times longer than lead-acid and will probably last the life of the vehicle. The new battery also exhibits better cold-climate performance and and are more robust and able to withstand overcharging. Importantly for the future, these batteries can accept high charging rates and may, in the very near future, be able to absorb an 80 per cent recharge in under 20 minutes.

Delco Battery Pack Monitor

This solid state electronic controller tracks critical parameters of the battery pack such as current, voltages, and temperatures to safely and efficiently control usage and charging of the battery pack. This monitoring and control ensures maximum vehicle range and battery life.

The Magne-Charge plastic 'paddle' is seen here in cutaway showing the magnetic induction coils.

Magne-Charge

From the start GM's engineers knew that the recharging of the EV1 would need to be simple, convenient and safe if the car was to gain acceptance with potential customers. The Magne-Charge charging system, developed for maximum electrical safety and convenience, meets these requirements. There are no conventional 'live' plugs and sockets. Instead, a weatherproof 'paddle' is inserted, transferring power by magnetic induction.

Magne-Charge makes it possible to recharge the EV1's batteries from the domestic electric supply. Connected to a purpose-designed 220 volt 30 amp power outlet, full charge is obtained in about three hours. Using the on-board 110v unit (shown in the foreground above right) full charge is obtained in 15 hours.

Magne-Charge can transfer up to 120 kW of power and conforms to the industry's first accepted standard for electric vehicle charging. Magne-Charge was used successfully by 700 PrEView Impact drivers who logged over 450,000 miles.

With an 85 per cent charge, the range varies from 65 miles in city traffic to 85 miles on the highway. Interestingly, US government figures show that the average round-trip commuter journey is about 22 miles. The key to the successful implementation of any new transport system relies on the infrastructure and for this reason, public charging stations are being planned for strategic locations around the US.

The spaceframe

Weight considerations were paramount in the design of the EV1 where every 22kg equates to a mile of urban driving.

The EV1 is constructed around a bonded and welded aluminium spaceframe which, at 290 pounds, is 40 per cent lighter than the steel equivalent.

The aluminium spaceframe is joined by an aerospace-grade structural adhesive - the first application of this technology in a production automobile. The 500 linear feet of adhesive weighing just 6 pounds has reduced the number of spot welds which would normally have been needed and doubled the spaceframe's torsional stiffness (resistance to twisting). Spot welds and rivets were used only where appropriate to join the 165 pieces of the spaceframe.

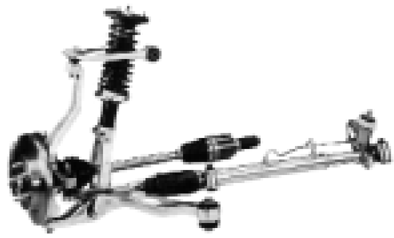
GM's structural engineers used a computer system called Finite Element Analysis to determine whether sheet, extruded or cast aluminium should be used and how the elements should be joined to give the spaceframe the best strength to weight ratio.

The body panels also required careful consideration. Composite material was chosen as it offered the lowest mass and the styling flexibility important for aerodynamics. Composites also offer excellent resistance to dents and corrosion.

Three types of composite are used in the EV1. The first, a fibreglass reinforced moulding was used for the roof, doors, and bonnet. Where more flexibility was needed, such as the bumpers and interior facias, reaction injection-moulded (RIM) polyurathane was used. To improve aerodynamics under the car, a structural reinforced injection moulding (SRIM) was used to form the bellypan.

A key design feature was the use of hollow glass beads in the filler of the moulded panels which made weight savings of up to 30 percent possible. The 13 body panels that make up the EV1 weigh just 90 pound, that is 50 pounds lighter than steel.

Inside the car, fibreglass-reinforced urethane was used to make the dashboard and centre console because of it is so rigid it needs no additional support. This was the first time this material had been used in an automobile.



The EV1's suspension has exceeded all design expectations in handling, ride and comfort.

Suspension

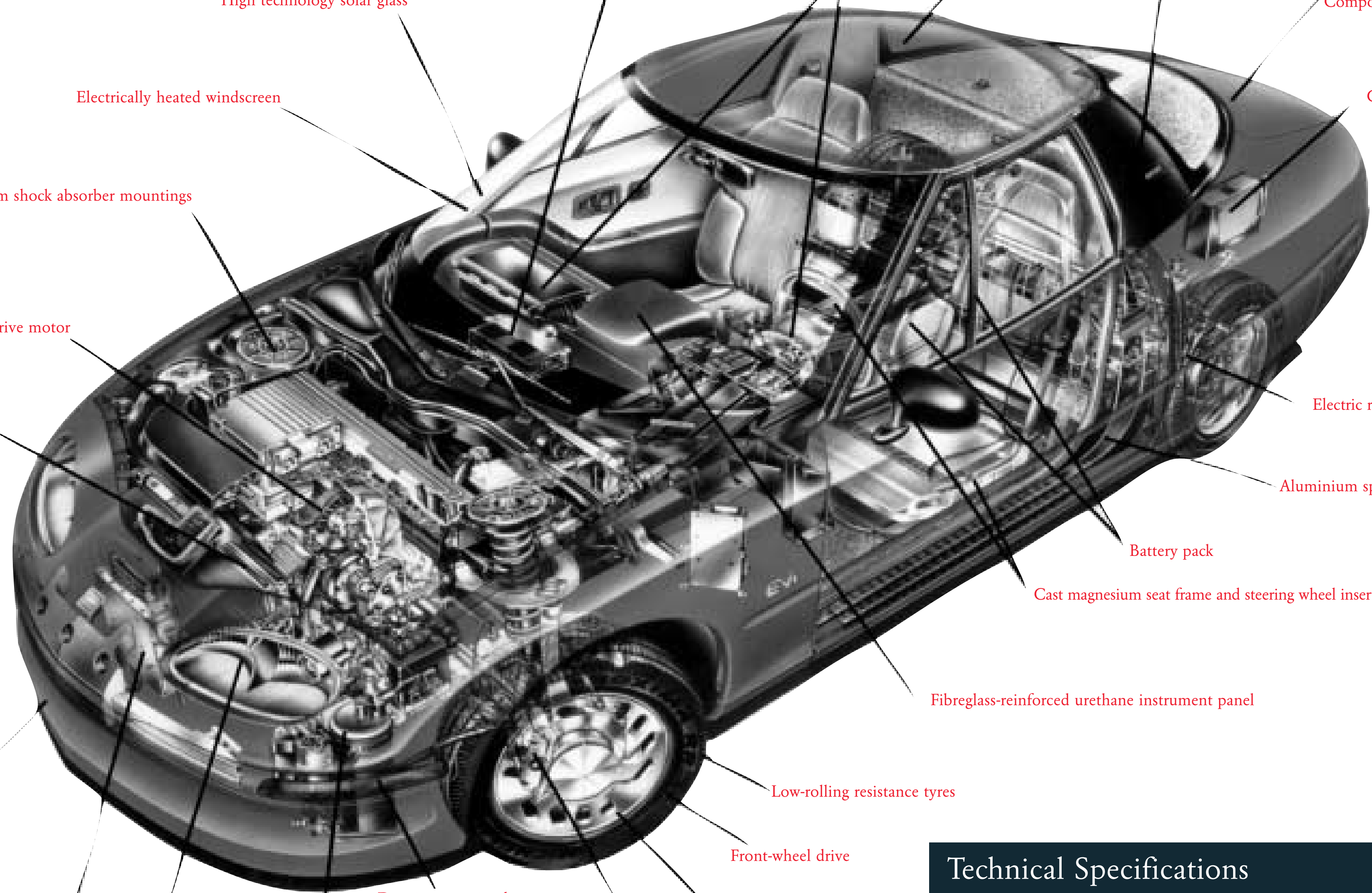
The Virtuoso lightweight suspension developed with expertise from Lotus Engineering has exceeded all design expectations in handling, ride and comfort. Whilst the suspension has a conventional layout it has some radical design details.

Designed in close cooperation with the EV1 platform engineers, Virtuoso combines a unique 5-link rear suspension with extensive use of metal and polymer composites such the Panhard rods. These are normally made from steel but in the EV1 are fibreglass with bonded aluminium end fixings.

Squeeze-cast, forged and extruded aluminium materials and micro-alloy springs are used in both the front and rear units. The resulting 25-40 per cent weight saving contributes significantly to the vehicles range.

The EV1's bonded and welded aluminium spaceframe.

Inside the EV1



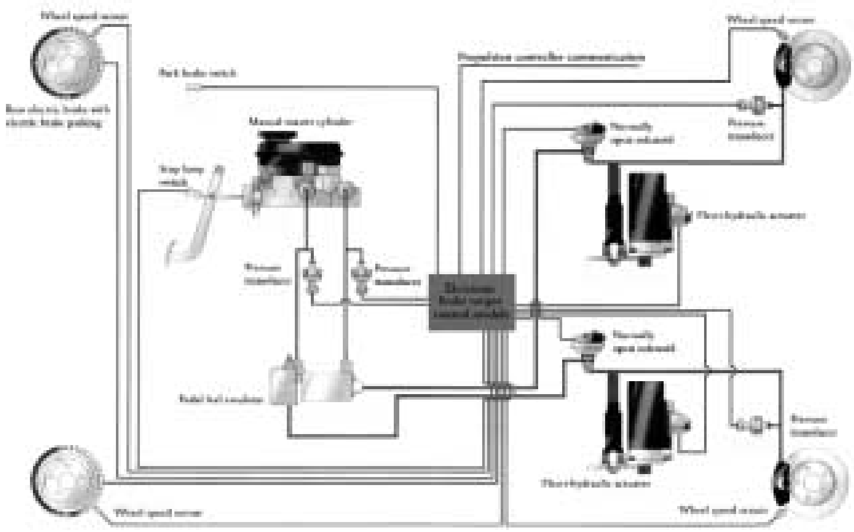
An EV1 at a public charging station.

Technical Specifications

Overall length	4309mm	Battery capacity	16.2kW/h
Overall width	1766mm	Battery pack weight	533kg
Overall height	1281mm	Battery module weight	489kg
Wheelbase	2512mm	Recharge 15% to 95%...	
Track front	1470mm	220 volt/6.6 kW supply	3hours
Track rear	1244mm	110 volt/1.2 kW supply	15hours
Kerb weight	1350kg	Range with 85% discharge...	
Frontal area	1.89sq m	Urban cycle	112km
Drag Coefficient	0.19	Motorway	145km
Tyre size	175/65R14	Acceleration 0-100 km/h	under 9seconds
Motor rating	137 hp/102kW	Top speed (regulated)	129 km/h

Wheels
Similar to the wheel hubs and suspension components the road wheels are constructed from squeeze-cast aluminium. The wheel weighs just 8.5 pounds and is probably the lightest wheel on a production car.

Tyres
The self-sealing, puncture resistant Michelin 175/65R14 tyres were especially developed for the EV1. Designed specifically to have low rolling resistance and excellent road adhesion, handling and ride quality, these tyres operate at 50 psi. Because low tyre pressure could adversely affect the range of the vehicle a warning system on the EV1 detects the change in rotational speed that occurs if a tyre is deflating or below pressure. A warning light on the control panel shows if the pressure changes by as little as 5psi.



The EV1's braking system.

Brakes
Hydraulic brake systems, in use for over 75 years, were too heavy and did not contribute to the energy efficiency of the car. The EV1 has three distinct types of braking, all blended seamlessly for maximum efficiency by a highly-sophisticated computer system - The Brake Torque Control Module (BTCM). The result is Galileo, the world's most efficient and intelligent stopping system ever fitted to a production automobile.

Brake systems are energy converters, vehicle motion or kinetic energy is converted into heat which is released into the air. This energy is harnessed by the EV1's regenerative braking system which, under the control of the BTCM, temporarily transforms the drive motor into a generator. The energy thus generated is returned to the battery pack when the driver brakes or releases the accelerator pedal, and is particularly effective in stop-and-go driving situations. At low speeds, regenerative braking does around 90 per cent of the work, extending the range by over 10 miles.

The EV1 has electro-hydraulic front disc brakes. When the brake pedal is depressed, a conventional hydraulic line transfers the instruction to hydraulic actuators which provide the hydraulic pressure to operate the brakes. The car also has state-of-the-art electric rear brakes which are also under the control of the BTCM.

Electrically operating these brakes means that no hydraulic or cable lines are needed, saving 8 pounds in weight. In an industry first, the parking brake is also applied electrically. When the driver operates a switch in the cabin a latch mechanism applies the rear brakes. Electric brake technology will feature on conventional vehicles in the future.

Variable Effort Steering Controllers
The Power Steering Control Module (PSCM) provides power instantaneously to the power steering motor only when it is required. In conventional cars, power steering draws constant energy from the engine. Steering in the EV1 requires 80 per cent less energy, and a system based on this technology is fitted to the new Vauxhall Astra.

Air Bag Electronics
The Delco Electronics single point sensing and diagnostic modules (SDM) employ a silicon micro-machined accelerometer to detect the deceleration from a crash. Information is processed through state-of-the-art sensing algorithms to provide correct deployment of the air bags as well as the seat belt pre-tensioners.

Performance and economy
Production EV1s are electronically limited to 80 mph, and have a 0-60 time under 9 seconds. Compared with petrol, the low-tax cost of domestic electricity makes the operating cost extremely low - around 4p per mile at UK prices.

In the USA, GM announced the car with a price of $33,995 (£22,000), however this can be reduced in California, through local incentives and concessions, to about $25,595 (£16,000). This compares favourably with the US price of around $15,000 (£9,500) for a regular US compact, petrol-driven car. GM is launching an alternative scheme to lease the car from about $480 (£300) per month over 3 years to meet consumer preferences.

Home of the EV1

The EV1 is built at the Lansing Craft Centre in Michigan. The centre is embedded deep within a traditional assembly complex known mainly for building convertibles.

Hand crafted
The Lansing Craft Centre is far from conventional. Here, craftsmen hand-build the EV1 in flexible work stations and that are decoupled from the production line so that problems can be resolved without creating a 'domino effect'.

To simplify the assembly task craftsmen use of a single torque wrench at each station. These wrenches have multiple head sizes, so the appropriate head for the task is selected and a computer applies the proper torque setting for the fastener.

Just 75 people build the EV1. Interestingly, GMs' most advanced vehicle is not built using robots and has more in common with the very earliest days of assembly line operation. An article in a US magazine suggested that the EV1 is so high-tech that the assembly process doesn't have to be. The Craft Centre is also a learning place for other GM plants and those of the future.

Building the car
The Craft Centre consists of six work stations in the body shop and eight in general assembly. Stations have two operators who assist each other through the process. Stations are designed to make the tasks easy and comfortable for the assemblers. Parts are presented in flexible creform racks (modular units made out of plastic tubing with special joints). The wheeled racks are easily refilled and re-configured to hold varying sizes of parts.

To begin with, EVls are transported on wheeled steel dollies which are much simpler than those in conventional automated assembly lines. One person can push a dolly with a car on it because the spaceframe is so light.

Assembly jigs are removed as the spaceframe approaches the two-stage oven where the adhesive will be cured.

Glue
Early in the assembly process, the aluminium spaceframe is constructed using traditional assembly processes, but with the EV1 some parts are glued together. The gluing process provides a continuous bond that is considerably stiffer and more durable than in a traditional welded structure. Once the frames are glued and assembled, they go into a two-stage oven where the adhesive is cured. Other GM divisions are looking at this process to see how it could be used on future platforms.

EV1s move with their own power
Raising of the battery pack from underneath the vehicle is a strictly mechanical operation so as to avoid any worker sustaining an electric shock. Once the batteries and drive unit are installed, the EV1 is driven from station to station on the line.

Finaly, the pre-painted body panels are simply be bolted onto the aluminium substructure. An eight-minute-cycle water leak test, squeak-and-rattle track test drive, and thorough visual audit are the final stages before an EV1 can be released from the plant.

Learning laboratory
The Craft Centre is much more than just the home of the EV1. It is also a laboratory of learning, that has been tasked to look for ways to speed up new model launches and provide information to other vehicle platforms.

Craftsman skills are needed to apply the continuous strip of structural adhesive.

Great care is taken in the installation of the battery pack.

Suspension and underbody components are fitted to the EV1.

The electric truck

Alongside the EV1, General Motors unveiled a new compact electric pick-up at the Los Angeles Show.

Outwardly a "normal" truck
The electric truck, which was available to fleet buyers early in 1997, outwardly looks like any other Chevy S-Series Pickup. However the truck uses the same technologies as the EV1 and is powered by a Delco Propulsion System 85kW AC induction motor and the Delco valve-regulated lead-acid battery. The battery pack, located under the truck, is recharged using the Magne-Charge system.

Usable performance
The truck has a front-wheel-drive, and is available in regular cab configuration with a short box.

The effective range of the S10 is 64 to 96 km, dependant on driving variables such as temperature, terrain accessory and driver usage. The S10 has a governed top speed of 112 km/h and a payload of 385 kg including driver and passenger.

Purpose designed
The electric Chevy is designed for companies and agencies such as: electric utility companies, urban delivery services and large industrial complexes with on-site vehicle fleets. Electric S10 customers qualify for various federal and state purchase incentives in the U.S. Chevrolet, emphasised that far from being a 'stripped down' design the vehicle has a high level of standard features:

- Propulsion battery thermal management system keeps the battery warm in cold climates and cool in hot areas.
- Power Steering
- Regenerative braking
- Drivers' air bag
- Daytime running lamps
- Aerodynamic pack includes a front spoiler and a load area cover.
- Air conditioning
- Supplementary fuel fired heater
- Cruise control

The Chevrolet S-Series truck announced at the Los Angeles and Detroit Motor Shows.

The high-power Magne-Charge fast charger has been developed for the commercial electric vehicle user. With charge rates as high as 50kW per hour, it can significantly reduce off-road time.

The evolution of GMs' electric vehicles

1912-16
682 electric trucks were built by GM Truck Company. Lead-acid and Edison nickel-iron batteries as well as 3 chassis lengths and 9 load ranges were offered.

1964
Electrovair I, (a Corvair conversion) with pioneering 90-hp AC induction motor, silicon-controlled rectifier inverter and 450-volt silver-zinc battery pack.

1965
Electrovan, a GMC van conversion where 32 hydrogen-liquid oxygen fuel cells powered a 125-hp AC induction motor that drove the rear wheels through a gearbox.

1966
Electrovair II, (a Corvair conversion) with 115 hp induction motor and 530-volt silver-zinc batteries.

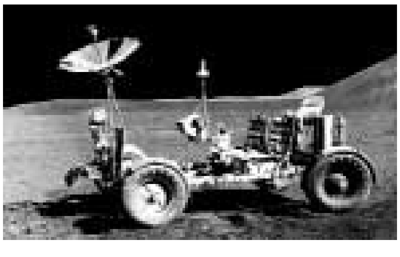
1969
Three XP-512, two-seat urban concept vehicles demonstrated electric and hybrid propulsion systems. The electric vehicle used an 8-hp DC motor to drive the rear wheels and power came from an 84-volt lead-acid battery pack. Top speed was 48 km/h.

1969-72
The Lunar Rover vehicles were built for the Apollo Programme with Boeing as the prime contractor. These electric vehicles had a motor at each wheel, four-wheel steering and a non-rechargeable battery. Three vehicles were left on the moon by the Apollo 15, 16 and 17 astronauts.

1970
The XEP Opel Kadett conversion had a hybrid zinc-air/lead-acid battery pack which supplied the power for two DC motors which drove the rear axle. The vehicle had a 145 km range and a top speed of 84.5 km/h.

1977
The Electrovette - a Chevette conversion with its nickel-zinc batteries, began a programme to design and develop a production electric vehicle.

On December 11, 1972, American astronauts cruised for 22 miles through the Valley of Taurus-Littrow on the Moon. The GM engineers who helped build it are still working to make electric vehicles a realistic alternative form of transport for everyone.



1979
Thirty five model G-vans were converted to electric propulsion for the US telephone company AT&T. A 216-volt power pack of thirty-six 12-volt lead-acid batteries was used to drive a 50hp DC motor. These vehicles had a range of 65 km.

1980
Twelve Chevette conversions were built by GM's EV Project Centre to evaluate nickel-zinc batteries. Each vehicle had a 33 hp DC motor and a 120-volt battery-pack with of 72 cells. These vehicles had a 96.5 km urban driving range.

1980-82
An all-new electric vehicle being designed by GM's Electric Vehicle Project Centre was terminated when the nickel-zinc battery was not able to meet the required specifications.

1985
In the UK, the conversion of 32 vans to electric propulsion completed nearly 10 years of design, development and prototype builds using Bedford vans as the base vehicle.

1987
Sunraycer, a solar-powered electric vehicle, won the 1987 Solar Challenge in Australia by 2-1/2 days. The efficiency lessons learned established the direction for the Impact project.

1986-89
100 GMC G-van conversions were built by Magna for an Electric Power Research Institute Programme. These vehicles used the experience of the earlier G-van and Bedford van programmes. Many of these vehicles are still in operation today.

1990
The Impact electric vehicle was announced at the Los Angeles Auto Show on the 3rd January. The response was phenomenal. This first generation vehicle is presently on display at the EPCOT centre in Orlando, Florida.
On April 18, GM announced that it was forming a group to develop a production version of the Impact show car.
An Impact became the first car ever to be displayed at the House of Commons in 1990.

1990-91
Several Geo Storms and Lumina APVs were converted to electric propulsion using Impact car systems to develop propulsion and braking systems. A Storm EV demonstrator provided many people with their first EV experience.

1991
The HX-3 hybrid-electric car was shown at the Detroit Auto Show in January. The HX-3 used the same electric propulsion system as the Impact show car.

1991
Two Opel Astra estate cars were converted to electric propulsion using the Impact technology. One was shown at the Frankfurt Auto Show in September.

1992
Built in just 99 days and driven on May 1, the "Fast-Build" Impact was the first POC (point-of-concept) vehicle that integrated all of the systems being designed and developed. This was the second-generation vehicle.

1992-93
Twelve additional third-generation POC Impacts were built as test and development vehicles. One of these vehicles was dedicated to consumer marketing and communications projects.

1993-94
Fifty Impacts were built at the GM Tech Centre. These fourth-generation vehicles were used in the PrEView Drive programme. Eighteen Astra estate cars were converted to electric propulsion and named Impulse II. Ten were involved in a test programme on Rugen Island.

1994
A specially-prepared Impact established new EV world speed record of 295.77 km/h. at the Fort Stockton, Texas, test track on March 11.

1994-96
PrEView Drive Programme launched in June. Several hundred drivers in 11 cities used an Impact EV for up to two weeks.

1995
In March, production of the fifth-generation Impact vehicles began at the Lansing Craft Centre. During the first year, manufacturing processes were refined and thirty-four vehicles were built. An electric S-Series truck was shown at the Electric Utilities Fleet Managers' Conference in Troy, Michigan.

1996
On January 4th and 5th, the EV1 and S-Series electric truck were announced at the Los Angeles and Detroit Auto Shows.

1998
Nickel metal hydride batteries were introduced on the EV1 and S10.

The EV1 includes ideas from GM's innovative Sunraycer solar-powered prototype, which won a 3,000 mile race across Australia in 1987.

Published Summer 2001

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VM0102653

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