



1:1 LEGO TECHNIC BUGATTI CHIRON PROJECT:

Technical Documentation and Features



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Facts & Numbers:

- Over 1,000,000 LEGO elements in total 339 types of LEGO Technic elements used
- No glue used in the assembly
- Total weight: 1500 kg
- Engine contains 2304 LEGO Power Function Motors
- Engine contains 4032 LEGO Technic gear wheels
- Engine contains 2016 LEGO Technic cross axles
- Theoretical performance of 5.3 HP
 Estimated Torque of 92 Nm
- Functional rear spoiler (using both
- LEGO Power Functions and Pneumatics)
 Functional speedometer built entirely from LEGO Technic elements
 13,438-man hours used on development and construction.



1. Exterior & Skin

- 56 custom made Technic element types (existing shapes in new colors) were made for this project, including custom made transparent Technic beam pieces to create the lights.
- The key design lines were laid first, then the area between them was filled with a "skin" built of interconnected triangular segments, a kind of a LEGO Technic fabric.
- The skin is attached via the Technic linear actuators that can be adjusted in distance to shape the outer form of the car, which is necessary to replicate the complex organic shapes of the original vehicle.
- There was an extra electric screwdriver build to adjust the cylinder pistons. It is made completely out of LEGO Technic pieces. It was needed because an actual screwdriver has too much torque. The LEGO one uses Power Functions motor, simple gearbox and custom-designed switch.
- The carbon fibre sections of the real car were replicated with another type of Technic fabric, woven from 3M black beams clad over the base structure, mimicking the texture and contrast of the original material.
- The front horseshoe mask features replica of the Chiron's trademark grille with a 3D effect.. The same design is used on all the grilles on the car. It was built by layering two hexagonal nets built of propeller hub elements.

- The rear spoiler can move out and tilt. It uses a complex pneumatic system:
- Moving the spoiler out is powered by 4 XL motors, 2 per each pylon, with a worm gear and rack along the length of the pylon
- Additional 4 XL motors powers two custom-designed compressor units with four Technic pneumatic pumps each
- the tilt of the wing is controlled by Technic pneumatics
- in each of the wing's pylons, three LEGO pneumatic large cylinders are arranged in a cascade. The first tilts the wing to normal operating position, the second and third then lift it into the airbrake position
- two LEGO power function servos operate the LEGO valves
- the PLC board gives a signal to the servos to open and close in the right times and sequences
- the air in the system is stored in eight LEGO Technic pneumatic air tanks at the rear
- the pneumatics elements for the spoiler are connected by 15 meters of silicon tubing
- the operating pressure is around 2.8 bars, the driver can read the pressure out of a LEGO manometer built into the instrument cluster.
- For maintenance purposes, some parts of the body are detachable (front and rear hood, rear fenders. These parts are completely selfsupporting (no steel reinforcement whatsoever) and feature custom designed locking mechanism securing them to the rest of the car.
- the pneumatics for the spoiler are powered by 15 meters of silicon tubing
- the operating pressure is around 2.8 bars.



• Blinkers in the side mirrors.



2. Interior

- You and a passenger can sit in the car and it is operated it with:
- working pedal for brake (there is no acceleration/gas pedal as the car is driven by voltage level -> more info under Electronics)
- 11 buttons for the lights and motors
- a gear shift is present but not functional (there is no gear box) paddles on the steering wheel to change the gears (again, not working because there is no gear box)
- replica turning indicator signals/wiper arms
- speed indicator / speedometer to show the actual speed of the car
- also fully made out of Technic elements. It is a speed sensor that is linked to a Power Functions L motor and a gear box that is linked to the speed needle. It goes up to 60 km/h
- a pressure indicator (manometer) in the dashboard for the driver to see the pressure on the original LEGO Pneumatic system that drives the rear spoiler
- two segmented displays for the battery voltage to monitor the power source (two batteries). More info under Electronics
- real seat belts for both passengers to ensure security. They are attached to the roll cage and the steel frame
- a real keyhole and key that unlocks the motor by a relay. The key looks and feels like the original Bugatti one.

- Two keys: one is the Bugatti key replica that slides into the dashboard (though only for efffect). Plus another key to unlock motor operation.
- Custom silver coated Bugatti logo on the steering wheel created out of 72 Technic bricks.
- Detachable steering wheel.
- Working doors and closing opening mechanism made entirely of LEGO Technic bricks.
- Channel between the seats contains the large amounts of cables and pneumatic and hydraulic tubing.
- Interior lighting stripe in the middle between the driver/passenger.
- Interior rear-view mirror, fully adjustable.





3. Main inner construction

There were several types of load-bearing structures developed, each with different strength, torque/bend resistance and weight parameters.

The majority of the internal structure was built by chaining multiple layers of technic frames together and interlocking them with pins and beams. That created a very sturdy base to support the skin and the interior. This frame structure was then wrapped with Technic panels to appear solid and also to add extra strength. In places where we didn't need a solid structure, we used more a more open lattice framework built from 3x11 panels or a honeycomb structures built out of these panels as well.

The most challenging part was the interior as most of it is load-bearing and modeled after original design at the same time, which required a lot of experimenting to get achieve the balance between good design and needed strength (for example in the seats).



<u>4. Chassis & Frame</u>

- A Steel frame was defined necessary to support the weight.
- The model rests on the frame just by gravity on its own weight.
- The Steel Frame provides both safety and structural stability, while also ensuring the weight is kept to a minimum.
- The Steel frame is used to:
- attach the front and rear axles that connect the original Bugatti Chiron wheels
- attach the hydraulic brake system from a go-cart
- attach the power steering from an ATV, that's driven by a standard car battery

- support the weight of the LEGO bricks and persons in the vehicle
- support the weight of the Power Functions motor packs
- attach roll cage for security
- provide 4 lifting points as steel plates under the chassis to lift the car for maintenance and transportation
- •1,5 meters (rear fender and rear deck-lid) are the longest selfsupporting lengths of stand-alone Technic elements.
- No suspension on the wheels due to complexity and the amount of space available on the chassis.





5. Motorization

- The car will drive approx. 30 km/h and is powered by original LEGO Power Functions L-Motors.
- The motor block powers the rear axle with:
- 96 Power Functions L-Motor per motor pack
- 24 motor packs in total
- 2304 LEGO Power Functions L-Motor in total
- Each motor pack is made almost entirely out of original LEGO elements (apart from 336 custom made Teflon washers in each pack which serve as bearings)
- Apart from the frame itself that supports the motor packs, the outgoing axle (with a 3D printed carbon fiber gear wheel) chain wheel and chain connecting the packs with the main driving shaft, are the only parts made of steel in the entire motor block.

- Motor packs contain double layers of LEGO gear wheels to connect all the motors in a pack in order to reduce forces in gearing. Quantity of LEGO gear wheels per motor block is 4032 in total.
- Teflon custom made washers serving as bearings to keep friction low on the original LEGO cross axles.
- The 24 motor packs are connected by one steel chain to the main steel. driving shaft that is connected to the rear axle.
- The motor blocks are modular and can be interchanged.



6. Electronics

- Two batteries in the car are the overall power source:
- 1x battery with 80 volts that powers the 1304 Power Function L-motors
- LiFePo4 type, 24 Winston cells, 160Ah, max. current limited to 200A
- Charging time 8 hours max
- Balancing protection circuit that control the charging and discharging process on each cell
- But how to connect a L-motor to 80 volts?

Per motor pack there are always six motors in series and four string motors in parallels. That creates 24 motors in one chain serial parallel combination. And by adding that up to the total amount of motor packs you get 12 volts per single L motor.

- 1x battery with 12 volts (standard car battery) that powers the power steering while also covering the power peaks by the system
- DC/DC 80/12V convertor that powers all the LED lights and other electronic functions
- DC/DC 80/24V convertor that powers the electro-magnetic clutches.
- Acceleration works with a potentiometer that starts the electronic motor blocks and increases the speed of the car. The speed is defined by the provided voltage level of the potentiometer.

- Breaking works with a sensor on the paddle that triggers:
- the breaking lights
- the rear spoiler wing moves into brake position
- the electro-magnetic clutches on the rear axle are disconnected so there is no longer a connection to the motors. The voltage starts to decrease automatically to zero on the Technic Power Function motors
- The clutches will disconnect from the motors to prevent the remaining torque power of the wheels breaking the Power Function motors.
- PLC board as light controller with WiFith atruns a webserver to remotely control with a mobile device the entire lights and electric features.
- All lighting is made with LED stripes, single LEDs and larger bulbs (COB LED) for the front lights.
- Light start-up sequence is exactly the same as on the original Bugatti Chiron (the lights on the real car have an animated start-up sequence that is reconstructed on the Technic version).



The First Time...

- ...we built a fully-functional self-propelled life-size LEGO Technic car
- ...we built such a complex non-glued LEGO Technic model
- ...we have powered a large model using LEGO TECHNIC power function motors
- ...we have built a large-scale moving model using LEGOTECHNIC bricks & elements
- ...we had to create new types of transparent LEGO TECHNIC bricks
- ...we used 58 types of TECHNIC Q elements
- ...we created load bearing parts build purely out of LEGO TECHNIC bricks & elements.

Project timeline overview:

12. June 2017: first brief to make a 1:1 Bugatti.

Mid-August 2017: concept presentation, initial calculations, feasibility study.

End of September 2017: Green Light Project START.

End of March 2018: Finished car => ONLY 6 months for the full concept, build and problem solving.





For Further Information:

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