ČESKÉ
VYSOKÉ
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V PRAZE

Ústav automobilů, spalovacích motorů a kolejových vozidel

Pakage malého městského automobilu

Pakaging of small urban vehicle

BAKALÁŘSKÁ PRÁCE

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Gashnikov Andrei

Studijní program: Teoretický základ strojního inženýrství
Studijní obor: bez oboru
Vedoucí práce: Ing. Michal Vašíček, Ph.D.

ČVUT ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

ZADÁNÍ BAKALÁŘSKÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

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II. ÚDAJE K BAKALÁŘSKÉ PRÁCI

Název bakalářské práce:

Package malého městského automobilu

Název bakalářské práce anglicky:

Packaging of a small urban vehicle

Pokyny pro vypracování:

1) Vytvořte koncept packagingu malého městského vozidla založeného na open source platformě.
2) Navrhněte potřebné konstrukční úpravy platformy.

Seznam doporučené literatury:

Jméno a pracoviště vedoucí(ho) bakalářské práce:

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Jméno a pracoviště druhé(ho) vedoucí(ho) nebo konzultanta(ky) bakalářské práce:

Datum zadání bakalářské práce: **18.04.2018** Termín odevzdání bakalářské práce: **11.07.2018**

Platnost zadání bakalářské práce: ____________

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III. PŘEVZETÍ ZADÁNÍ

Student bere na vědomí, že je povinen vypracovat bakalářskou práci samostatně, bez cizí pomoci, s výjimkou poskytnutých konzultací.
Seznam použité literatury, jiných pramenů a jmen konzultantů je třeba uvést v bakalářské práci.

Datum převzetí zadání

Podpis studenta

CVUT-CZ-ZBP-2015.1

PROHLÁŠENÍ

Prohlašuji, že jsem bakalářskou práci s názvem: „Package malého městského automobilu“ vypracoval samostatně pod vedením Ing. Michala Vašíčka, Ph.D. a s použitím literatury uvedené na konci mé bakalářské práce v seznamu použité literatury.

V Praze 01.06.2018 Andrei Gashnikov

PODĚKOVÁNÍ

Na tomto místě bych velmi rád poděkoval svému vedoucímu mé bakalářské práce Ing. Michalu Vašíčkovi za odborný dohled, konzultace, vedení a čas, který mi věnoval, a které mi značně pomohly k vypracování této bakalářské práce.

ANOTAČNÍ LIST

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Název bakalařské práce: Pakage malého městského automobilu

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Keywords: electric car, mobility, carsharing, battery, aerodynamics, platform, safety of cars, TABBY EVO open source platform, sustainable, green mobility, urban car, electric powertrain, driving position, visibility, CATIA V5, frame of car, manikin builder, battery pack, L7e categhory, L6e category

Anotace: Tato bakalářská práce se zabývá navrhem pakagu malého městského elektrického automobilu kategorie L7e, vhodný pro používání v carsahringu. Automobil je založen na modifikovaném TABBY EVO open source platformě . V této bakalářské práci jsme rozvinuli sazení řidiče, zkontrolovali viditelnost z místa řidiče, udělali změny v platformě v CATIA V5. Kromě toho, my jsme prozkoumali konstrunkci karoserie, aerodinamiku, baterie a trh automobilů kategorie L7e.

Annotation: This thesis reviews development of packaging of a small urban electric vehicle L7e cathegory, apropriate for using in carsharing. Car is based on modified TABBY EVO open source platform. In this thesis we developed driving position, controled visibility of driver, made necessary changes of platform in CATIA V5. Beside this, we discuss body structure of car, aerodynamic, battery pack and market of L7e cathegory cars.

Contents

Motivation

Urbanization rapidly increases in modern world. According to The United Nations, about 68% of the world's population is projected to be urban by 2050 [1]. It will cause a significant increase of city's inhabitants and density of population, which will enhance loading on transport system.

Many modern cities already cannot manage the increased number of people, causing them to spend a lot of time in traffic jams, there is a lack of parking zones, and environment suffers from emissions from the cars. It makes using a car expensive and uncomfortable. Obviously, that mode of transport must change crucially.

We suppose that shared mobility and especially car sharing can be an appropriate solution of transport problems. Car sharing is a type of car rental where people rent cars for short periods and pay per minute for using a car. It can reduce a considerable number of cars on the roads and save a lot of place in parking zones. There are many car sharing companies in most megalopolises. Unfortunately, it is still mostly an unprofitable business, which is supported by governmental grants. We are sure, that the main problem is the absence of suitable cars for this. Car sharing companies use cars, such as Skoda Octavia, which are expensive in maintenance. They are also cumbersome in traffic jams. Another problem, which we want to solve, is ecological situation. Big cities suffer from pollution and governments are trying to support emission free transport such as electric cars. We believe, that electric cars are the future of automotive engineering and we want to participate in this "electric revolution".

In our bachelor work, we tried to develop a concept of electric car of the future, which will meet the requirements of people in modern cities and will be appropriate for using in car sharing. We chose this field, because we think it is very perspective and the competition in the market for small city cars is weak. We hope that our work will turn into a big project or even a startup, which will change automotive engineering profoundly.

Categories of vehicles

M1 category of vehicles is the most popular today and includes many cars from small Smart ForTwo to a huge pickup Ford F-150. However, we believe that a share of M1 vehicle will decrease in the market in the future, but vehicles of L6e and L7e category will become more and more popular.

L7e category includes cars, whose weight is less than 450 kg (without batteries and occupants) and whose power is less than 15 Kw. This car can be driven by a person, who is 16 years of age or older and hold one of the following licenses A, A1, A2, A3, A4, AT, AL, B, C, D. [2]

L6e category includes cars, whose weight is less than 425 kg (without batteries and occupants), maximum power is less than 6 Kw and maximum speed is limited by 45 km/h. A person, who is older than 14 (15 in Czech Republic) and holds AM license can drive this car. [2]

L7e and L6e category vehicle have many advantages over M1 category vehicles. Firstly, these vehicles are not subject to the same legislation as M1 cars, and do not have to be crash tested before they can be sold for road use. Standards for this type of cars are not as strict as for usual passenger cars, which makes development easier and cheaper. Secondly, teenagers can drive vehicles of these categories – hence it expands the target audience. Thirdly, maintenance of these cars is cheaper, than maintenance of conventional cars. Unfortunately, as everything does, vehicles of L7e and L6e categories have some disadvantages. They must weigh a little, which is difficult to achieve. In addition, there are some difficulties to make such a light car safe. We are going to solve this problem by using composite materials and modern technologies.

We believe, that car of L7e category is the most appropriate for exploitation in a big city and for car-sharing.

Market research

We researched modern market to find a product, which satisfies all demands of modern city's inhabitant. The main criteria were that car must be small and have electric propulsion. We listed cars of L7e and L6e category, which you can buy in European market now. Smart ForTwo ED belongs to M1 category and is listed as a reference car.

1. Smart ForTwo ED

Figure 1 Smart ForTwo ED

Smart ForTwo ED is the most popular, safe, good looking and qualitative car in this list. Its main drawback is high price.
Category: M1
Maximum power: 60 kW
Range: 160 km
Capacity of battery: 17,6 kWh
Weight: 1085 kg
Safety: four stars out of five, 89% protection of adult occupants
Price: 21940 € (568 900 Kč in Czech Republic) [3]

2. Aixam City Pack


Figure 2 Aixam City Pack

Category: L6e
Maximum power: 6 kW
Range: -
Capacity of battery: -
Weight: 440 kg
Safety: one star out of five, 25% protection of adult occupants (version Aixam Crossover GTR)
Price: 14399 € (405 900 Kč in Czech Republic) [4]

3. Aixam Coupe Premium

Category: L6e
Maximum power: 6 kW
Range: -
Capacity of battery: -
Weight: 440 kg
Safety: one star out of five, 25% protection of adult occupants (version Aixam Crossover GTR)
Price: 17699 € (495 900 Kč in Czech Republic) [5]

Figure 3 Aixam Coupe Premium

4. Tazzari Zero Junior

Category: L6e
Maximum power: 6 kW
Range: 125 km
Capacity of battery: 9 kWh
Weight: 425 kg
Safety: one star out of five, 31% protection of adult occupants (version Tazzari Zero)
Price: 15600 € [6]

Figure 4 Tazzari Zero Junior

5. Tazzari Zero City

Category: L7e
Maximum power: 15 kW
Range: 200 km
Capacity of battery: 15kWh
Weight: 450 kg
Safety: one star out of five, 31% protection of adult occupants (version Tazzari Zero)
Price: 17800 € [7]

Figure 5 Tazzary Zero City

6. Renault Twizy 80

Category: L6e
Maximum power: 13 kW
Range: 80 km
Capacity of battery: 6.1 kWh
Weight: 400 kg
Safety: two stars out of five, 39% protection of adult occupants (version Tazzari Zero)
Price: 8340 € +50€ per month for battery [8]

Figure 6 Renault Twizy 80

To be competitive with these cars, our project car should have a price of about 14 000 €. We have an advantage over current models listed above: manufacturing in Czech Republic is cheaper than in France (Aixam and Renault Twizi) or Italy (Tazzari).

Safety of L7e vehicles

As I mentioned above, vehicles of L7e category do not have to be crash tested. Otherwise, Euro NCAP has their own protocols (developed in 2014) for testing cars of this category. They do two full-scale crash tests: a full-width frontal impact at 50km/h against a deformable element; and a side impact test, also at 50km/h, in which a deformable barrier is driven into the side of the vehicle. [9]

Euro NCAP has tested eight models of L7e cars since 2014. The leader of its test is Renault Twizy 80, which got only two stars out of five and only 39% protection of adult occupants. The second place belongs to Chatenet CH30, which got only two stars out of five and only 38% protection of adult occupants. [10]

In order to be competitive on the market, we need to be safer than our rivals are. We must to take into account Euro NCAP protocols and develop protection of adult occupants better than 40%.

Beside this, we must ensure safety of battery in case of accident: body of battery must be unbroken after any accident.

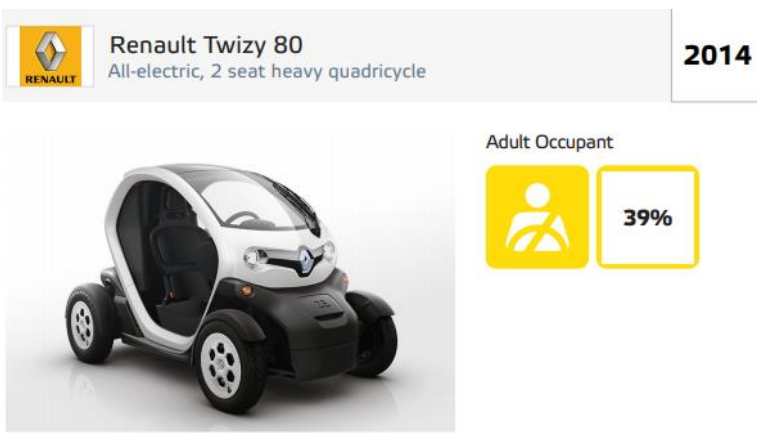
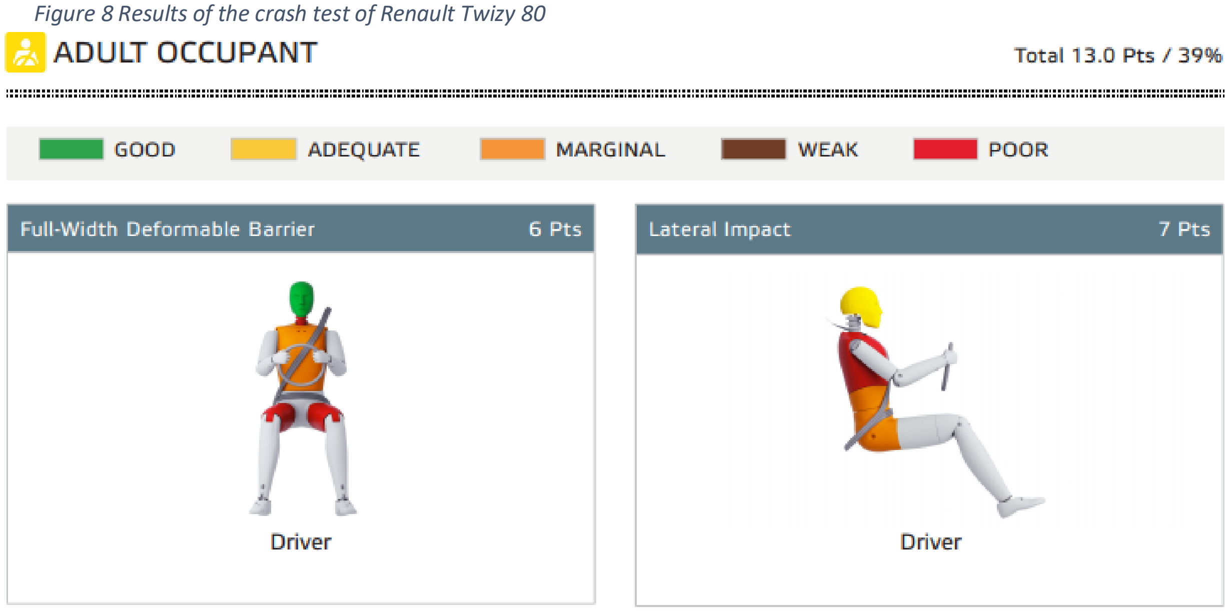


Figure 7Renauit Twizy. Full-width frontal impact

Figure 8 Results of the crash test of Renault Twizy 80



Concept of vehicle

Design

Most of small city cars are three or five door hatchbacks. It makes them look very similar. We think that it will be better, if our project car was a small two-seat two-door coupé. This type of body has many advantages. Firstly, coupé has better proportions than a conventional hatchback, so the design of our car will refer to that of a sportcar. Secondly, lower car has lower center of gravity, which will make our small car more stable. In addition, lower cars have less aerodynamic drag, which is good for maximal range and speed.

Coupé has also some disadvantages compared to hatchbacks: getting in and out of the car isn't as comfortable as in a hatchback. Also, the driver in coupé is located lower than in a hatchback, causing worse visibility. We solved these problems in our project.

Our car has close dimensions to Smart Roadster and Honda S660.

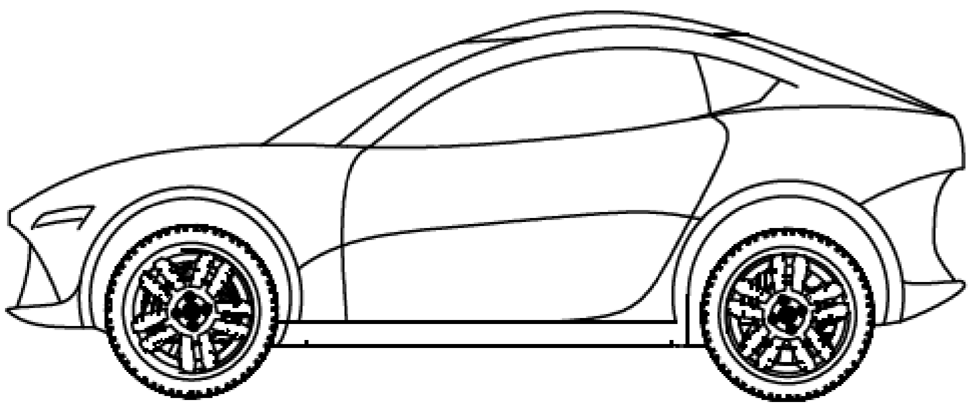


Figure 9 Design of our project

Figure 10 Smart Roadster has close dimensions to our project car

Aerodynamics

Aerodynamics affects a lot of characteristics of modern car. First of all, an aerodynamically effective automobile has longer range and a higher maximum speed than aerodynamically ineffective one. These properties are very important for modern electric vehicles. Beside this, improvement of a car's aerodynamics allows to reduce noise and improve stability of a car at high speed. In addition, we can cool electric motor and electronics by managing the airflows.

Here we will describe the aerodynamic efficiency of our project car. The main goal for us is to reduce drag. There are two important characteristics of a car, affecting drag force: projected frontal area of the car and a coefficient of drag resistance C_x.

$$F_D = \frac{1}{2} * \rho * C_x * A * \upsilon^2 \text{ [11]}$$

Meaning of drag force (F_D [N]), ρ [kg/m^3] – density of air, C_x – coefficient of drag resistance, A [m^2] – frontal area of car, υ [m/s] car's velocity

Drag force is directly proportional to frontal area, so reducing the frontal area is the easiest way to reduce the drag. As our project car has close dimensions to the Smart Roadster Coupe, we can assume that our project car will have a similar frontal area. It means, that frontal area of our vehicle will be about 1,5 – 1,6m^2. It is about 30% less, than the frontal area of a conventional family cars like Toyota Prius (about 2,4 m^2).

Coefficient of drag resistance C_x is another very important characteristic of a vehicle. The car's bodyshape affects it a lot. An example to follow is a Volkswagen XL1, which was in limited produce between 2013-2015. Its C_x is 0,19. [12] Even though it has approximately the same frontal area (about 1,47m^2) as our vehicle, XL1 is longer, has a tapering rear part of body, has cameras instead of rear view mirrors and covered rear wheel arches. All these features make drag coefficient of Volkswagen unreachable for us.

On the other hand, C_x of the Smart Roadster Coupe (with nearly the same dimensions) is 0.38. We can improve this parameter by using a flat floor (our car's construction affords it). Also, we want to make the body shape of our car more aerodynamic, and believe to reach C_x between 0,27-0,32. Low drag coefficient with the little front area will make our project car one of the most aerodynamically efficient in the world.

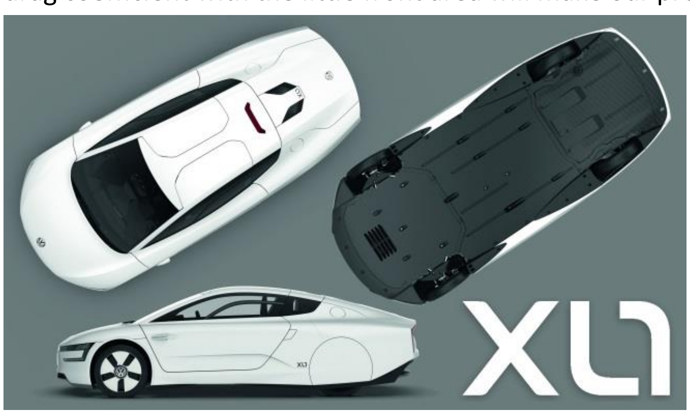


Figure 11 Volkswagen XL1 is one of the mos aerodynamic effisient car in the world. It has tapering rear part, flat floor and cameras instead of rear view mirrors, what provides low air resistance. [12]

Car body

Body is the most important part of every car. Car's body must meet basic requirements:

Protect occupants against wind

Carry elements of passive and active safety

Create comfort temperature inside

Constrain noise

Constrain vibration

Supply good visibility

Supply comfortable seating position for passengers

Be aerodynamically stable

Etc.

We chose space frame body for our project. Space frame is very popular among limited produced cars. It is strong, lightweight and easy to develop. Modern technologies allow to develop and produce space frames very fast by using generative design (Autodesk software) and 3d printing technology.

Hinged panels of the car, such as hood, fenders, and doors can be made of composite materials and do not carry any load. We are planning to weld the frame from steel profiles. Some details can be made by 3d printing. Hinged panels are attached to the space frame by bolts and glue.

Figure 13 Space frame of Lamborghini Huracan is made of aluminum and composite materials

Figure 12 Space frame of company Hackord is built by 3d printing

Platform

In order to reduce expenses on development and production, many automotive companies use one car platform for many models. For example, Volkswagen Group use MQB platform in more than 20 different models such as Audi A3 Mk3, Volkswagen Golf Mk7, Skoda Oktavia Mk3, Volkswagen Passat B8 etc.

We decided that the prepared car platform would make development easier and faster. We chose TABBY EVO Platform (two-seat, 15 kW L7e version) from the Open Motors company [13]. TABBY EVO is a hardware open source platform for electric vehicles. It is free to use and available to everyone. You can see main technical characteristics of two seat, 15 kW L7e TABBY EVO platform below:

Dimensions and weight [13]

Dimension: 2330 mm x 1488 mm x 1380 mm
Weight (batteries included): 520 kg
Weight without batteries: 380 kg
Wheelbase: 1650 mm

Chassis

Technology: welded and screwed tubes
Material: steel S235JR – Painted frame
Assembled chassis weight: 105 kg

Steering system

Rack and pinion
Turn radius: 4m
Power steering: optional (surcharge)

Braking system

Front and rear disc brakes
Regenerative braking configured at 10% to prevent abrupt slowdowns
ABS system: optional (surcharge)

Suspension systems

Front and rear McPherson

Wheels

Rims: steel
Tires: 175/55R15 Pirelli P1 "green" tires (low rolling friction)

Figure 14 TABBY EVO platform

Figure 15 TABBY EVO platform

Safety Equipment
Emergency switch
Roll-bar not included (due to impact on final vehicle design)
Battery pack
24 elements LIFePO4, 160Ah, 82V (12, 8 kWh of stored energy)
Single element: 3.4V, 160Ah
Battery life: 5,000 charges at 80% depth of discharge

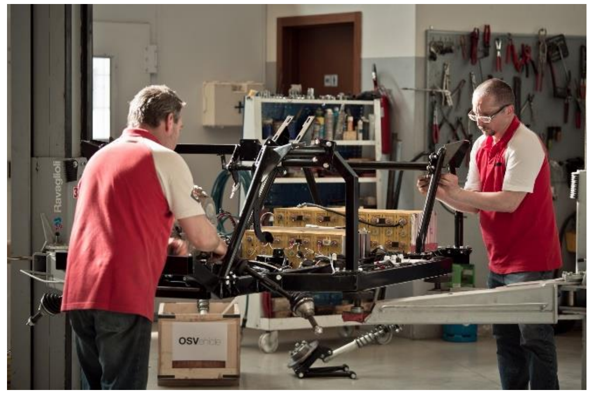


Figure 16 Assembling of TABBY EVO platform lasts one hour and demands only two workers

Company Open Source (Italy, Modena) also has four-seat version of this platform, which is very similar to the two-seat platform. Chassis of four-seat version is made from the same profiles as chassis of two-seat version, but is longer by 700 mm.

Open Motors optimized construction, logistic and components cost. They sell their platform to companies, which develop autonomous cars, military and logistic vehicles. It makes the cost of the platform relatively low.

TABBY EVO Platform will cost $17,980 for a prototype and $8,800 for big-scale production [14]. We can reduce the price by developing and producing our own batteries.

R&D impact	
costs	~~US$ 2 Million~~
time	~~3 years~~
impact	**0** FREE

B2B pricing	R&D / Testing	Small batch	Bigger batch
Quantities	1	+250	+500
Target	Prototype	Startup	Production
Avg. market price	US$ 100,000	US$15,900	US$10,900
Our price*	**US$12,480**	**US$6,900**	**US$3,900**

Lithium batteries			
Quantities	1	+250	+500
Price*	**US$5,500**	**US$5,000**	**US$4,900**

Total price : platform + batteries			
Quantities	1	+250	+500
Total price*	**US$17,980**	**US$11,900**	**US$8,800**

Figure 17 Pricing of TABBY EVO platform

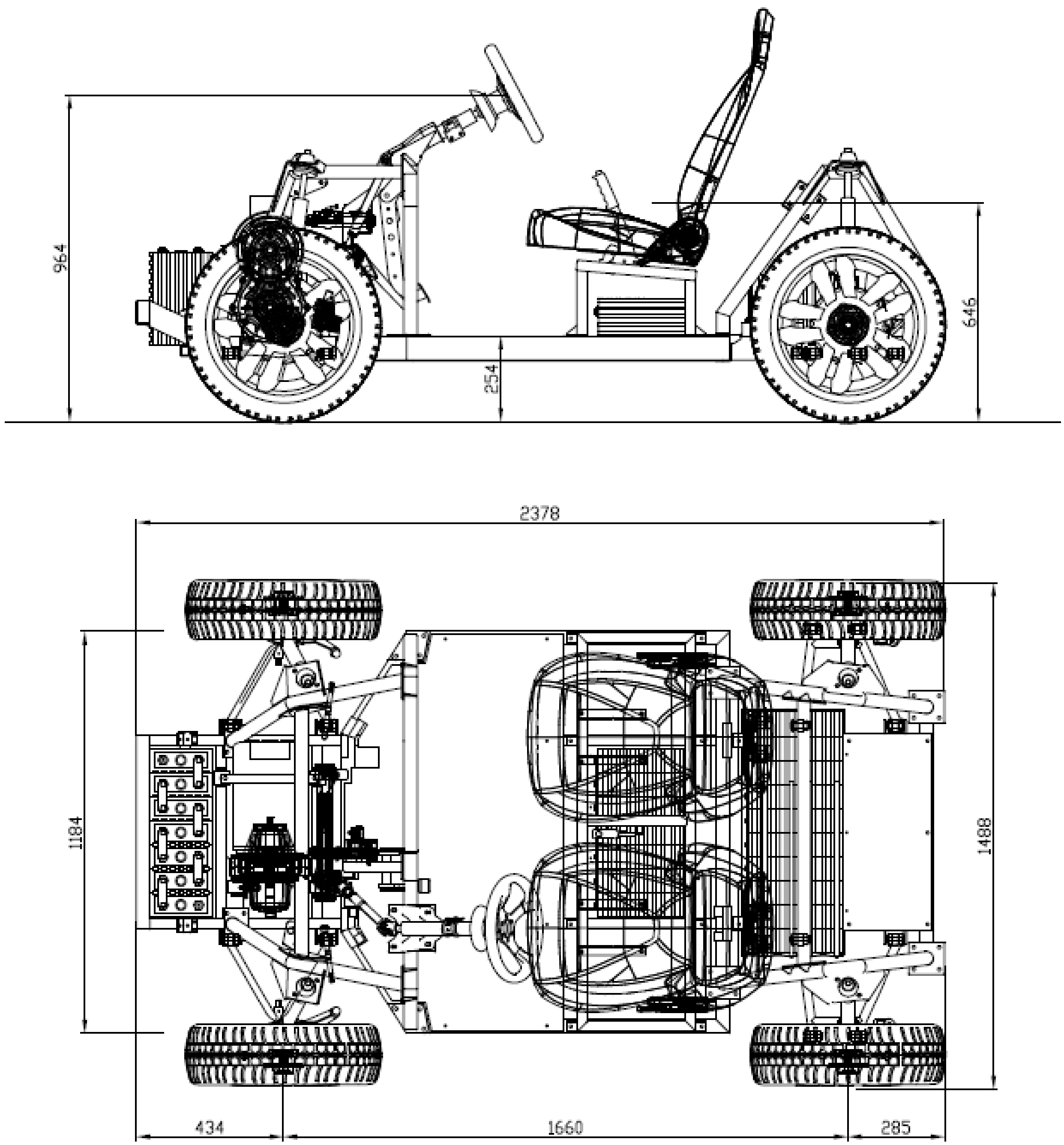


Figure 18 Drawing of two-seat TABBY EVO platform

Required changes of the platform

We took a TABBY EVO two-seat platform and developed some changes. We tried to use as much components of platform as possible and left the suspension system, wheels, braking system, electric motor, reduction gearbox, electronics (AC/DC converter, motor controller and battery charger), front and rear part of frame etc. untouched. Some elements of platform, such as frame between axles, seats, steering column, panels of floor and configuration of battery were changed.

Figure 19 Platform of our project car

Figure 20 Platform of our project car

Seats

Figure 11 BRIDE-CR1BIS CUGA seats

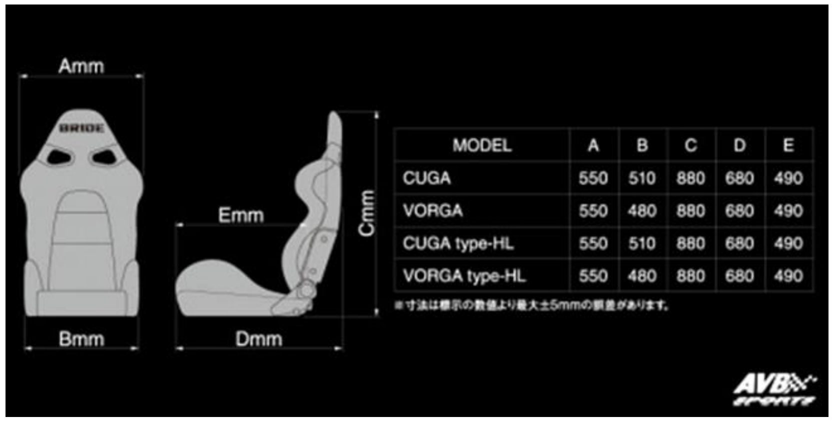


Figure 12 Dimensions of BRIDE CUGA seat

We do not use standard seats of TABBY EVO platform because they are narrow, uncomfortable and do not have a good body and head support. Instead of this we use BRIDE-CR1BIS CUGA seats [15]. They perfectly fit dimensions of our project and are legal to use on the motorways. The seat is placed on Double Locking Seat Slide Rails, that allows driver to adjust seating position within 231 mm in a horizontal direction. It corresponds with standard ČSN 30 0724 article 21, which says, that horizontal movement of driving seat must be bigger than 150 mm.

Technical characteristics of seats:

Weight: 13.6 Kg
Uses seat rails: RO, RB and RK Type
High of Double Locking Seat Slide Rails: 28 mm

Figure 21 Double Locking Seat Slide Rails

Steering column

Driving position of our project car needs a new position of the steering wheel. We developed a position of the steering wheel (white circle in hands of manikin in Figure 23) in Catia V5, which is comfortable for tall and short people alike. Hence, we should create a new steering column for a new position of the steering wheel.

Frame of platform

The distance between AHP (Accelerator Heel Point) and H-Point (Hip Point) in our car is less than in the platform. Hence, we need to modernize middle section of platform's frame in order to attach seats lower and free more legroom.

In order to create more room for elbows and shoulders, we extend distance between seats. Distance between area of symmetry of the driving seat and area of symmetry of the car (W20-1) in TABBY EVO platform is 280 mm, which is less than competitors have. Distance between seat and area of symmetry in our project is 315 mm. That is close to distance in Honda S660.

All these modifications demand changing to the structure of the frame: it must be extended by 350 mm and widened by 236 mm. Of course, it must be strengthened to withstand increased loadings.

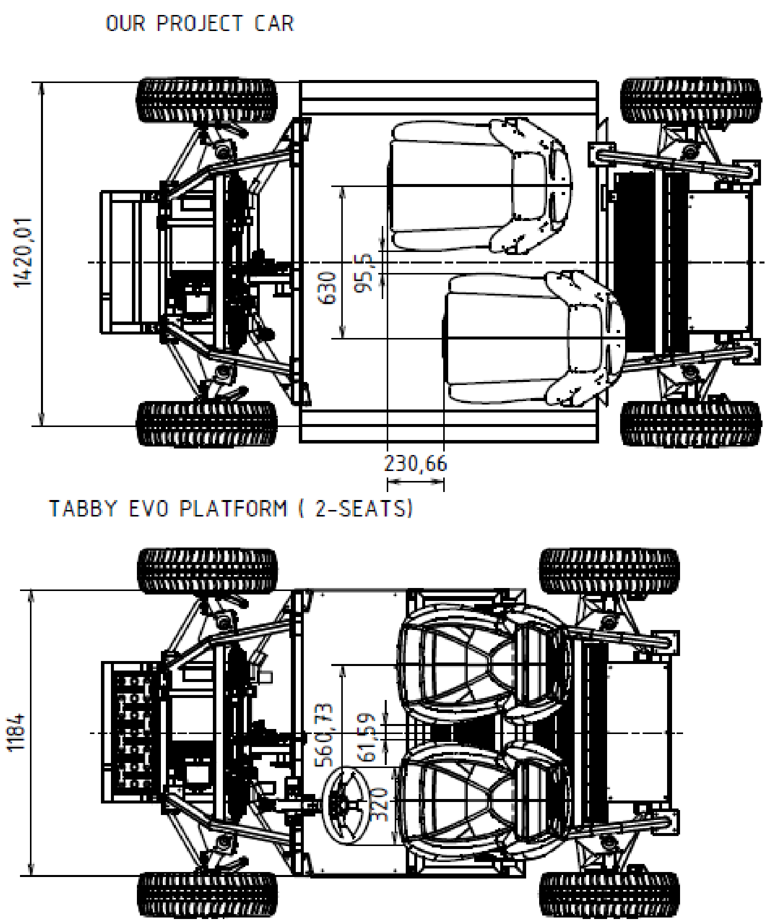


Figure 22 Comparison of our project car platform and TABBY EVO platform

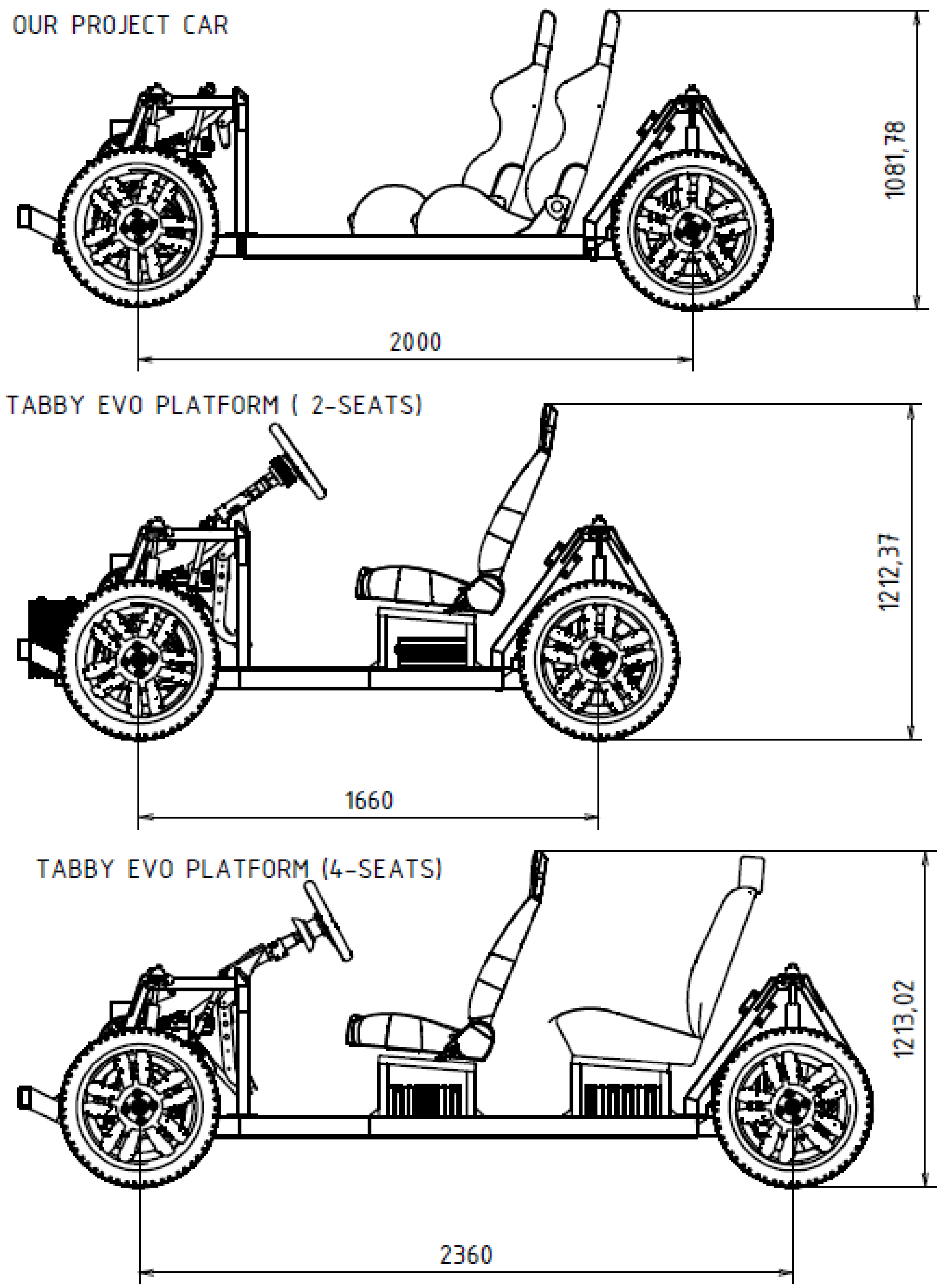


Figure 23 Comparison of our project car platform, TABBY EVO 2-seat platform and TABBY EVO 4-seat platform

Driving position

Comfortable driving position is one of the most important qualities of the car. Driving position is defined by ČSN 30 0724 standard [16]. This standard specifies the process of developing the interior of the car with respect to conditions for comfortable seating of driver and passenger.

According to this standard, we developed two extreme positions of the driving seat. First position is the closest to the steering wheel. This position of the seat is defined for comfortable seating of a short person, whose height is 1500 mm. Second position is the farthest from the steering wheel. This position of seat is defined for comfortable seating of a tall person, whose height is 1900 mm.

For visualization, we developed a 3D model of interior space in CATIA V5 [17], using Manikin Posture. This program allows to develop driving position for people of different height and weight. We developed a driving position for a German woman of five percentile (her height is about 1557 mm), and for a man of 95 percentile (his height is about 1912 mm). We placed the man on the left side and woman on the right side of car for comparison. As you can see in the picture, they have enough room. All characteristics of both positions correspond with following standards:

ČSN 30 0723 Interior dimensions of passenger car [18]

ČSN 30 0724 Seating positions by means of three-dimensional manikin for passenger cars

ČSN 30 0725 Road vehicles. Three and two-dimensional manikin [19]

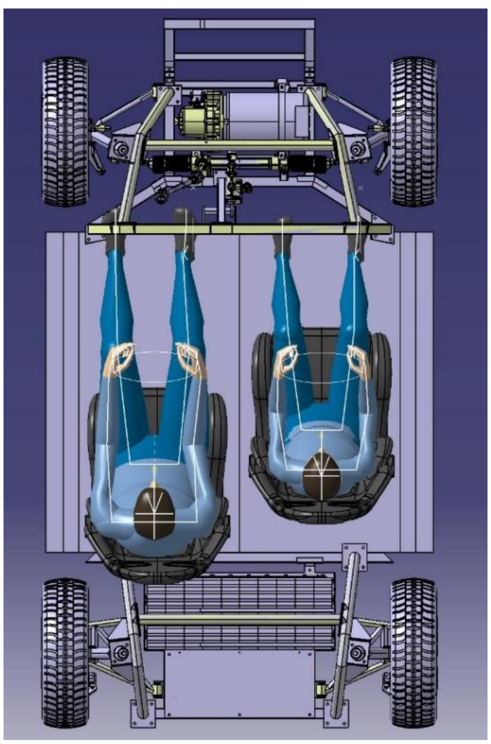


Figure 26 Comparison of driving position of a man of 95 percentile and a woman of 5 percentile

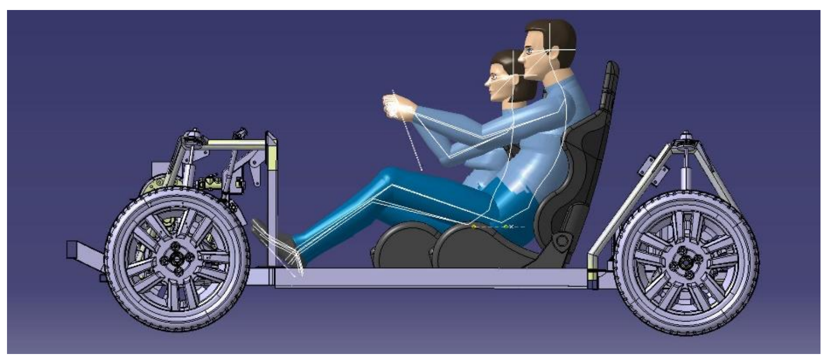


Figure 24 Driving position of man of 95 percentile

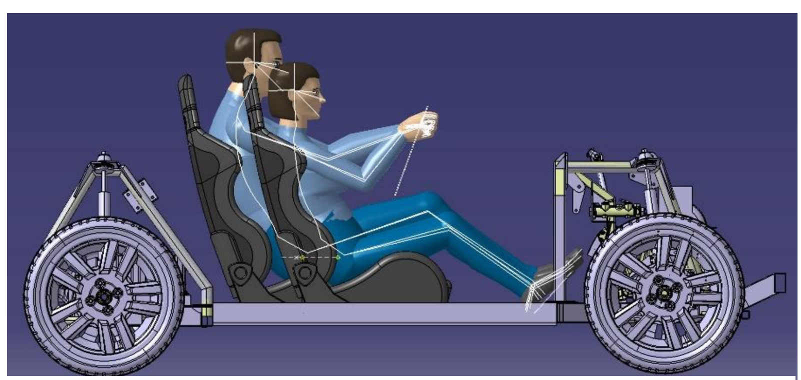


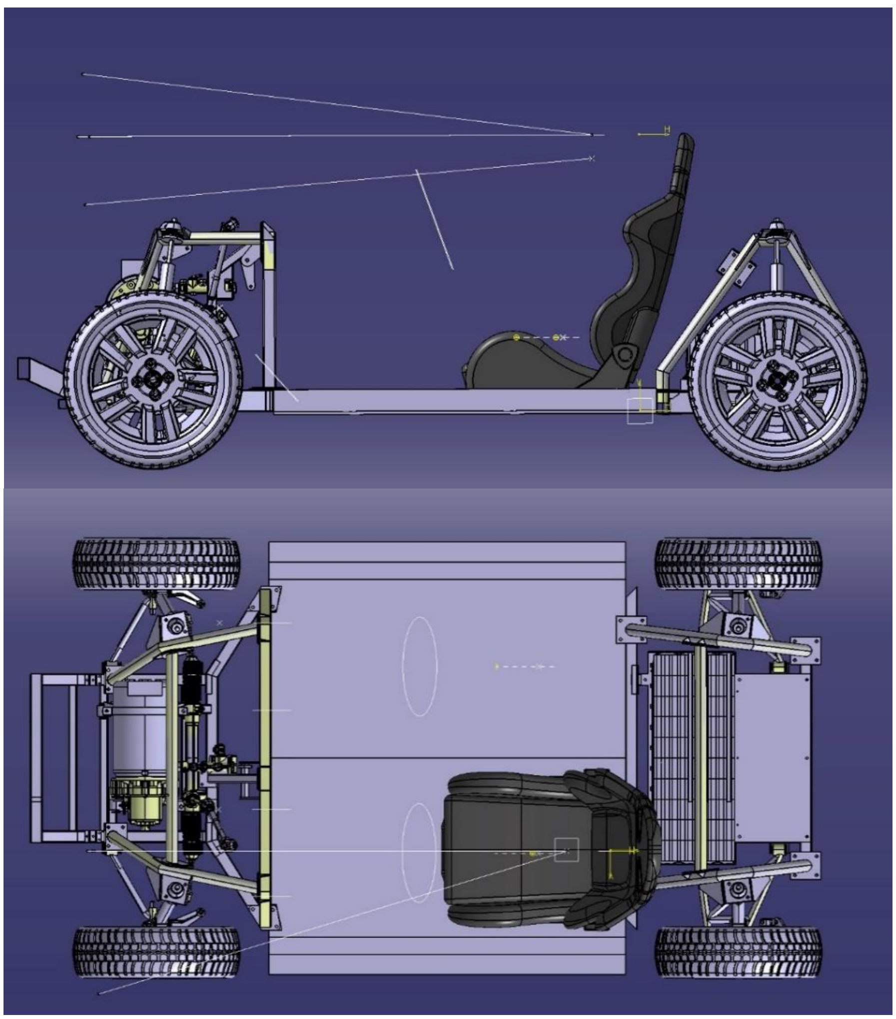
Figure 25 Driving position of a woman of 5 percentile

Visibility

Good visibility is another important quality of a car. Visibility of our project was controlled by "Testing methodology of road vehicles. View from the place of a driver" (Czech: Zkušební metodika silničních vozidel. Výhled z místa řidiče) [20].

We measured the view from the place of the driver in the forward direction. Measurements were done on a driving seat, which was moved to the farthest possible position. We found R-point from these seats, after that we found points V1 and V2, which are used for verifying conditions of view through the windshield. Beams, which go from points V1 and V2 must be inside the transparent square of the windshield. We must take this into account during developing the location of A-pilars, lower and upper edges of windshield.

After we will have developed the body, we must control the effect of the left and right A-pillars on the view.



Battery pack

Developing of the battery is not the main topic of this bachelor work. However, we have some thoughts about battery pack's development.

We assume two ways of battery pack development. The first way is to use standard battery of the TABBY EVO platform. This battery pack consists of 24 elements LIFePO4 cells. Total capacity of this pack is 160Ah (12, 8 kWh of stored energy), the voltage is 82V. A battery is divided into 3 packs: first is above rear axle, second is under the seats, and the third is in front of the overhang. The total weight of battery is 215 kg. Standard LIFePO4 batteries of the platform have many advantages. They can function 5,000 charges at 80% Depth of Discharge. To prevent fire in case of a frontal accident, we decided to remove third battery pack from the front overhang. Moreover, we changed the configuration of the second battery pack and placed it between seats.

A second way of developing the battery pack is to use a battery, made of 18650 lithium elements [22]. For comparison, we used a battery of formula student car FSE.06 (Formula student team eForce, Czech technical university) [21]. Their battery is made of 768 elements US18650VTC5. Total capacity of battery is 7,1 kWh, total weight is 48 kg. Voltage is 345 V. Of course, this battery need to be changed to fit in our project. We just want to compare the basic characteristics of LIFePO4 and Li-ion batteries and discuss their advantages and disadvantages. You can see a comparison between the batteries in Tab.1.

We incline towards the use of a standard TABBY EVO battery. However, if we need to build a removable battery, we will develop a battery consisting of li-ion elements. They are lighter and take up less place.

Figure 27 LiFePO4 cell used in TABBY EVO platforms battery

Figure 28 US18650VTC5 Li-Ion cell used in a battery of FSE.06 formula car

Table 1 Comparison of batteries

	TABBY EVO battery	FSE.06 battery
Type of cells	LIFePO4	US18650VTC5 Li-Ion
Amount of cells	24	768
Total capacity [kWh]	12,8	7,1
Total weight [kg]	215	48
Cycle Performance	5 000	300 [22]
Cost [$]	4 900 - 5 500	-
Advantages	+ We can save a lot of money and time by using ready-made battery + It offers a longer life cycle than other lithium-ion approaches + It is more thermally and chemically stable, than lithium-ion battery, which makes it safer[23]	+ It is lighter than LIFePO4 battery + It takes less place, than LIFePO4 battery + It has lower center of gravity, than LIFePO4 battery
Drawbacks	- It is heavy and big in size - Because of its huge weight, we need to have a stronger frame.	- We need to change the construction of this battery to make it fit to our project. -In order to extend cycle of life, we cannot discharge this battery to 0%. For example, if we want to have 10 kWh available, we need the battery with capacity of about 12 kWh.

Figure 29 Battery of FSE.06 [21]

Conclusion

In our bachelor work, we developed the concept of a small city car of L7e category. Our project car is front-wheel drive two-seat electric coupe; electric motor is located in front compartment of the car. The car is built on open source TABBY EVO platform.

Car is perfectly adapted for city exploitation: it has small size, small turning radius, cheap and easy in exploitation. It can compete with products of other carmakers, and excel most of them. We believe, that our product will be popular among car sharing companies, big cities dwellers, young people and all adepts of green mobility.

We are planning to develop our project in future. We need to develop body frame, hinged panels, interior, multimedia, etc. Development and building of prototype will take a lot of time and will cost a lot of money, so, first of all, we need to gather a good team and find founding. We have a lot of work to do, but we will cope with all difficulties and believe, that our project will change the industry profoundly.

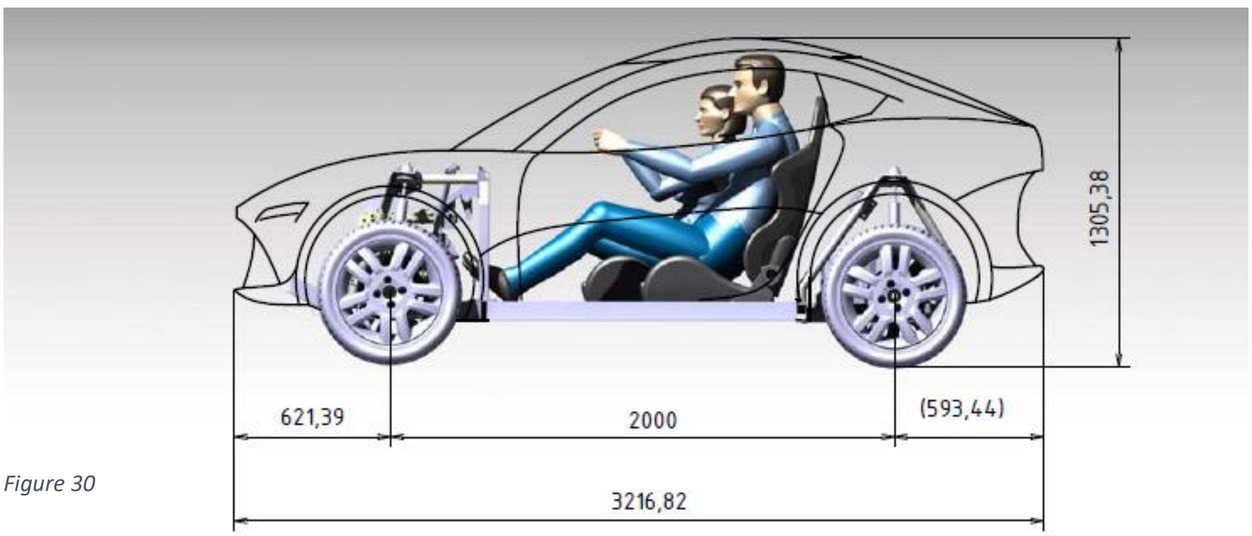


Figure 30

Table 2 Final technical characteristics

Dimensions [mm]	Length 3217, width 1488, height 1306,wheelbase 2000
Weight (with battery, without occupants) [kg]	665
Power [kW]	15
Capacity of battery [kWh]	12,8
Range [km]	About 120
Turn radius [m]	4,8
Body	Welded steel space frame, composite hinged panels
C_x	0,27-0,32
Safety	3/5 stars Euro NCAP
Start price	14 000 €

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List of illustration

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