



Politecnico di Milano
Facoltà del Design
Corso di L.M in Design & Engineering

LIGHT QUADRICYCLES ELECTRIC FOR HOME DELIVERY

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Abstract

This master thesis aims to design a new product that utilizes existing technology of the electric light quadricycle for the home delivery service.

By the research of the express and logistics market, can understand the requirements of the existing market for home delivery services, and the express companies operation during this service, and thus easy to design the product. Analysis the user(deliveryman) workflow, as well as research the existing products to determine product positioning of the market and know the function of the product and to optimization the concept.

Then at the product concept, will optimize the layout, put forward a new concept of the stored space, make the vehicle convenient for the delivery work. And also can quickly replace the battery. Design the product and make sure that easy install and maintain.

Finally, focus on the vehicle stored space, shell and battery,

consider the production process and how to installation each part. Improve the feasibility of the design.

In conclusoin the light quadricycle electric for the home delivery used with the existing processing techniques and function of electric vehicles, integration and optimization of the cargo space, completing a new product innovations. In this project design can provide a new transport tools of the home delivery market. To improve the efficiency of the user.

PARTE 1. Research

1. The home delivery market research

1.1 Definition

“Home delivery is a service and is the transport of goods directly to the customer's home. Home delivery is offered by many companies to their customers on a policy of customer care, as added benefits, and it may be required a minimum contribution of reimbursement or be offered for free. In the latter case, the fixed costs of the service have already been written off in the price of goods sold.

In many cases, home delivery is the main or the only mode of distribution of the products of a company, and is therefore often associated with mail order. Some companies have specialized as suppliers of services and as an interface between the manufacturers or distributors and end customers, such as public and private postal services.

The sectors of home delivery are virtually all, from the food to the clothing to that of mobile goods of various types.

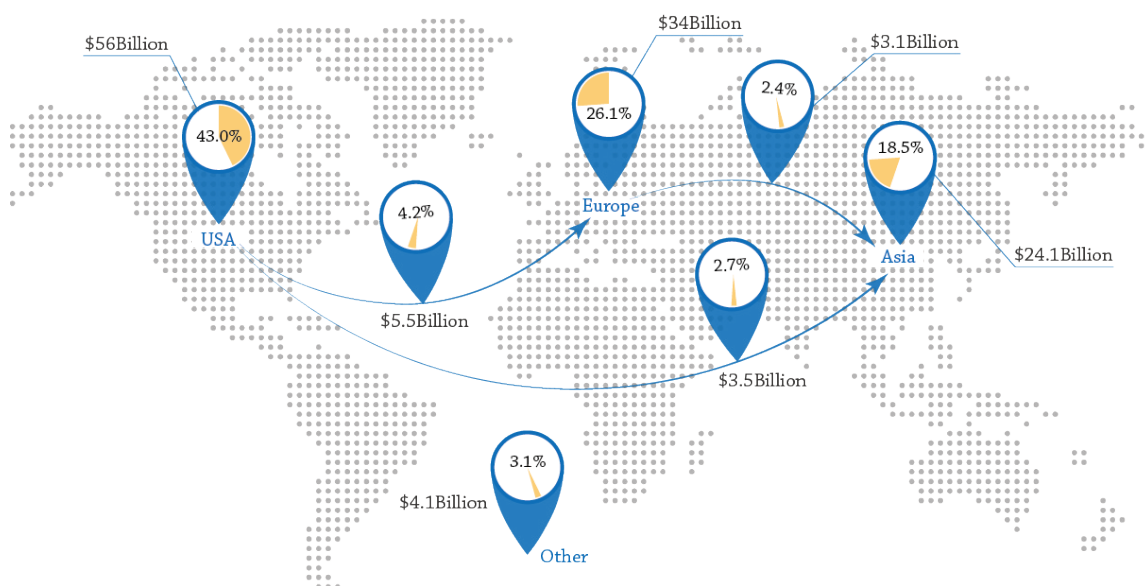
The delivery time will vary depending on the corporate directions, in each case are defined a priori. Some companies operating in vast territories, national or international, allows the customer to control in real time (on the internet, or by telephone) the location of the goods, to understand the state of delivery.”wikipedia

The home delivery is a kind of service, it is relying on, can also say its manifestations is the way through the express and mail to delivery to the people's hands. In the research and analysis, will conduct research the worldwide markets of the express and logistics. Analysis of the existing home delivery market situation, and future potential. Then will analyze the home delivery areas and its characteristics. Finally, understand the shipping method and the parcels specification for the home delivery service.

1.2 Express delivery and logistics business situation

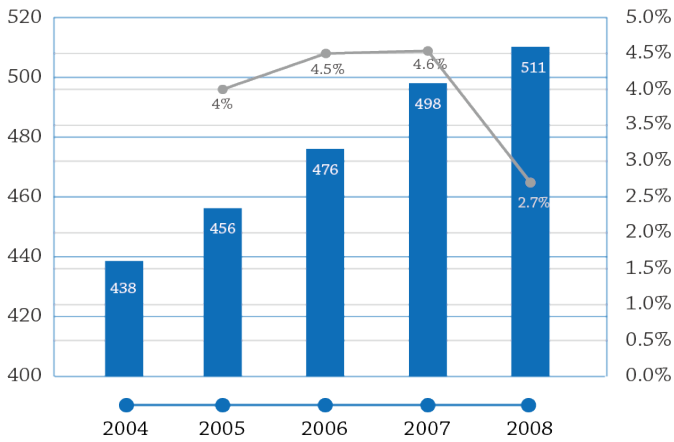
For the consumers, the express is the ultimate performances of the logistics. Because it is the most direct effect on consumers.

graphic1.1 - 2013 the global market share of express



At 2013, according to the Global Express Association data show that the global express industry's contribution to global GDP over 140 billion US dollars, the contribution rate of 0.19%. International express delivery market for nearly five years, the average annual growth rate of around 7%. The EU market is the largest international express service, accounting for nearly half of global international business volume. Will directly create 2.1 million jobs indirectly created and derived 2.4 million jobs, provide a total of 4.5 million jobs.

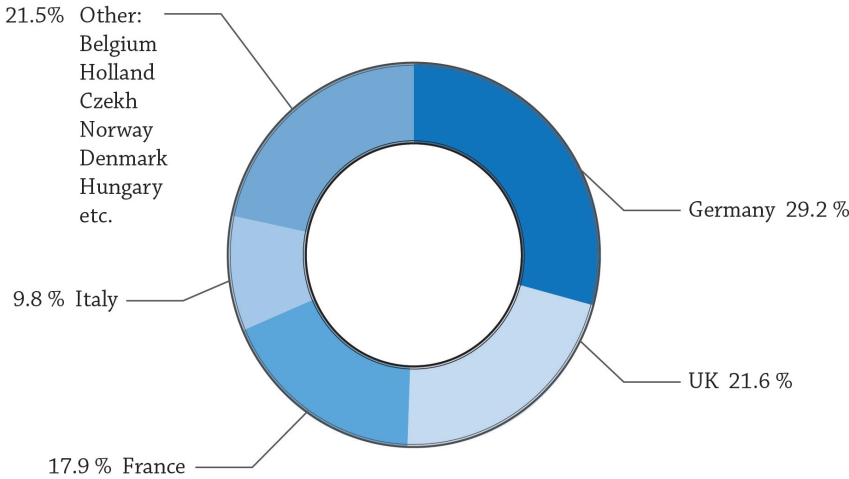
graphic1.2 - 2004 - 2008
European express market,
the growth of amount
and growth of rate



In the distribution of market, the United States accounted for the largest share of 43%, are \$46 billion, the second largest market is Europe accounted for 26.1%, are \$34 billion. According to the Oxford Economic Forecasting Center estimates, the global express industry market growth rate will reach 8%.

Europe is the world's second largest market, 2004-2008, the

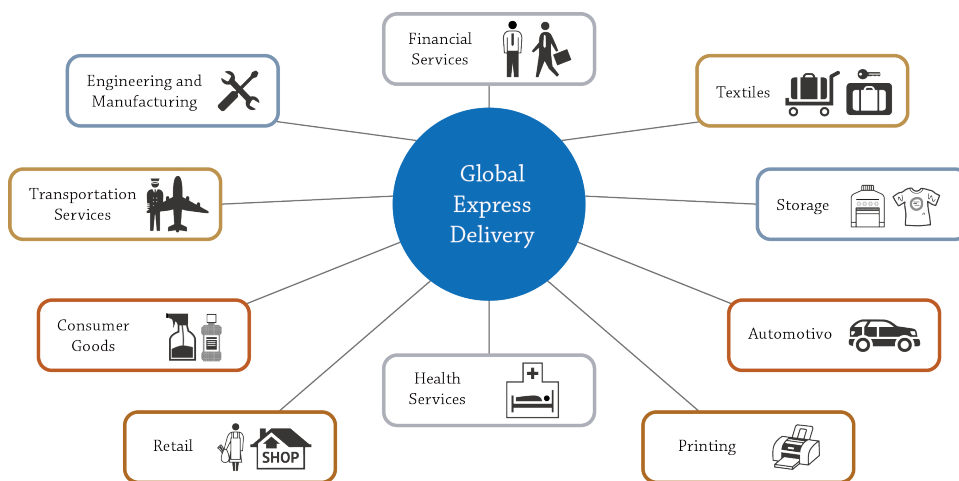
graphic1.3 - 2008
European express market
share



total market grew from \$ 43.8 billion to \$ 51.1 billion, an annual growth rate of 3.9%. Germany, Britain, France, Italy, the main express logistics market in Europe, respectively, accounted for 29.2%, 21.6%, 17.9% and 9.8% market share, 21.5% Other share including Belgium, the Netherlands, Czech Republic, Norway, Denmark, Hungary and so on.

1.3 Main areas of application

The leading premier provider of express delivery is companies, Including small companies that have occasional and regular express demand. Also includes a large volume of business enterprises.



graphic1.4 - Application area of express

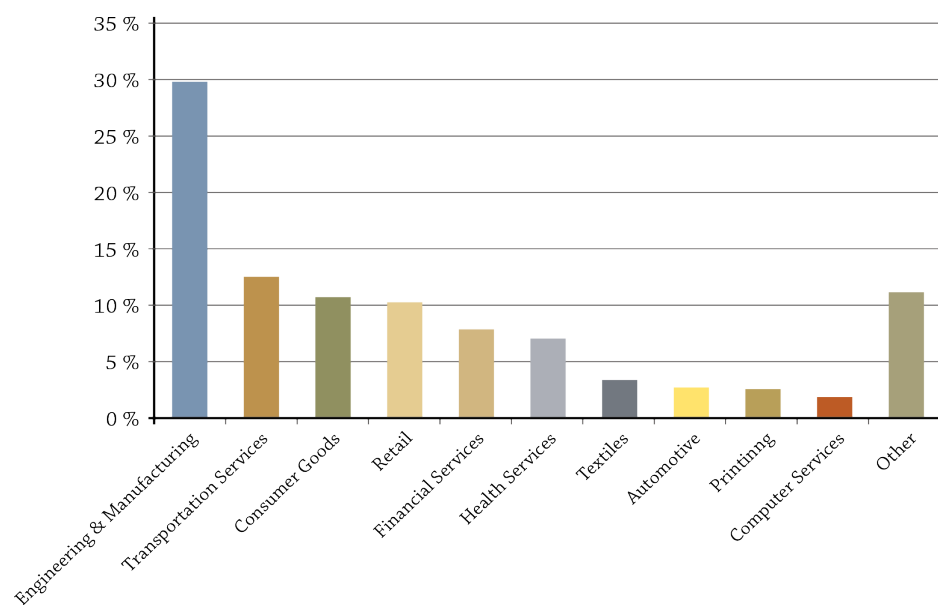
Demand for express services in all sectors of distribution of is not uniform. Engineering and manufacturing companies are the largest user of express service, accounting for 30% of the 2013 business volume. These companies produce electrical products, computer equipment, such as microprocessors, and other high-tech products.

Then the three most important industries, transportation services, retail and consumer products industries, accounting

for 30% of total business courier. After two industry companies usually shipped to consumers rather than businesses. Consumer goods, including the need to quickly reach the retail market of perishable goods and groceries. Engaged in toys, household goods, jewelry and sports and leisure goods retailer will regularly use courier. Demand for transport services industry including aircraft spare parts delivery.

graphic1.5 - Market share of each area

Global breakdown of international express delivery users by sector of activity, 2013



1.4 Demand of retailers for the express delivery

Retail and consumer products industries accounted for demand of express delivery about 30%, accounting for a large proportion in the courier industry, which the E-commerce dominates in the retail and consumer products. In the past decade, with the extensive use of the Internet, the customer's shopping habits have changed dramatically. For example, in recent years, the proportion of consumers use of electronic commerce in Europe increased significantly, rising from 20% in 2004 to 45% in 2012.

Worldwide business-to-consumer (B2C) e-commerce transactions reached \$ 1.4 trillion total. Europe and North America as the largest B2C e-commerce market. But recently, the Asia-Pacific region's fastest growing B2C e-commerce, total consumer e-commerce spending in the region has more than North America.

B2C e-commerce is expected to grow the trend will continue, as shown in Figure 21, 2017, B2C e-commerce sales will reach \$ 2.3 trillion, or average annual growth of about 20%. From the regional perspective, Asia is expected e-commerce growth rate is higher than in North America and Europe will continue to 2017, Asian e-commerce market than North America, 60% larger, than the European large 137%. The smallest e-commerce market in Latin America, the Middle East and Africa, expects its growth rate will be higher than in North America and Europe.

1.5 Research of express logistics company

There are several leading companies occupy the europe express delivery market. Sort by market share are: DHL, TNT, Fedex. But in various country, various enterprises occupied the share of market are not the same order. The main enterprises are as follows :

	<i>leader company</i>
<i>Germany</i>	<i>DHL, Fedex, TNT</i>
<i>U.K</i>	<i>DHL, Royal Mail, TNT</i>
<i>Frenca</i>	<i>La Poste, DHL, Fedex</i>
<i>Italy</i>	<i>DHL, TNT, Poste italiane</i>

table1.1 - the leader express company of germany, U.K, Frenca and italy

Express company charges depends on: at the same served time, according to the increase in package size and weight increased the cost. And most of the express company depending on the size of the delivery goods, there will be several standard packages. This easy to transport, saving space. Is easy to

	Fedex size(cm)	UPS size(cm)
25kg box	54.8 x 42.1 x 33.5	50 x 45 x 34
10kg box	40.1 x 32.8 x 25.8	42 x 34 x 27
large box(<10kg)	45.4 x 31.4 x 7.6	44 x 31.1 x 7.5
Medium box(<10kg)	33.6 x 29.2 x 6.0	44.5 x 31.8 x 7.6
small box(<10kg)	31.1 x 27.7 x 3.8	31.8 x 27.6 x 5.1
tube(<10kg)	96.5 x 15.2 x 15.2 x15.2	96.5 x 15.3 x 15.3
extra large pak(<2.5kg)	44.4 x 52.7	40.3 x 32.3
padded pak(<2.5kg)	29.8 x 38.7	/
large pak(<2.5kg)	30.4 x 39.3	/
envepole(<0.5kg)	23.5 x 33.5	25 x 34

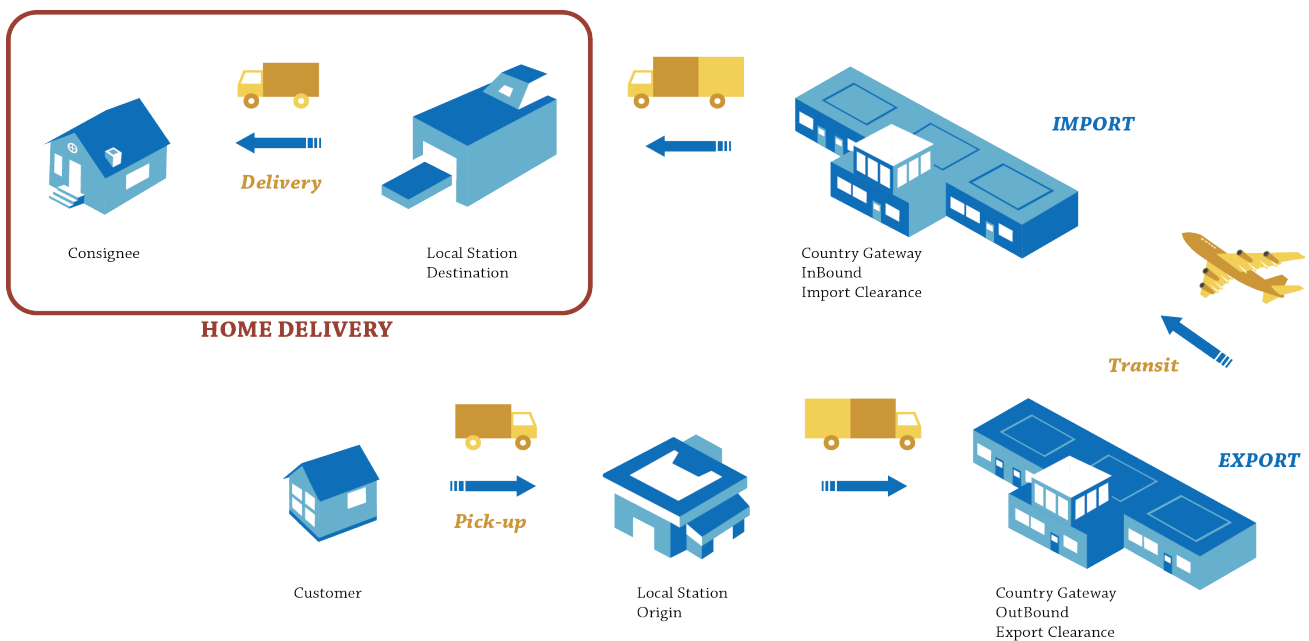
table1.2 - the Standard package of Fedex and UPS

transport and saving the space. If the parcels of different sizes, not standard, when stacked together, easy to caused a lot of gap because of different size of parcels, easy to causing the damage of parcel and goods because of the force discontinuity.

1.6 Existing home delivery of transport

graphic1.6 - the express transport process

Entire transport links of the express services including: express companies receipt the goods, transported to a local express



company transfer centre, transported to the next local transfer centre, delivered to the recipient. If involves international transport, then need to exit and entry the custom.

Home delivery services are delivered to the recipient is the final part of the all process. From the local transfer centre where nearby the recipient address, delivered to the recipient.

Existing vehicles in general are: vans, motorcycles, bicycles, carts, etc.



image1.1 - the express transport tool

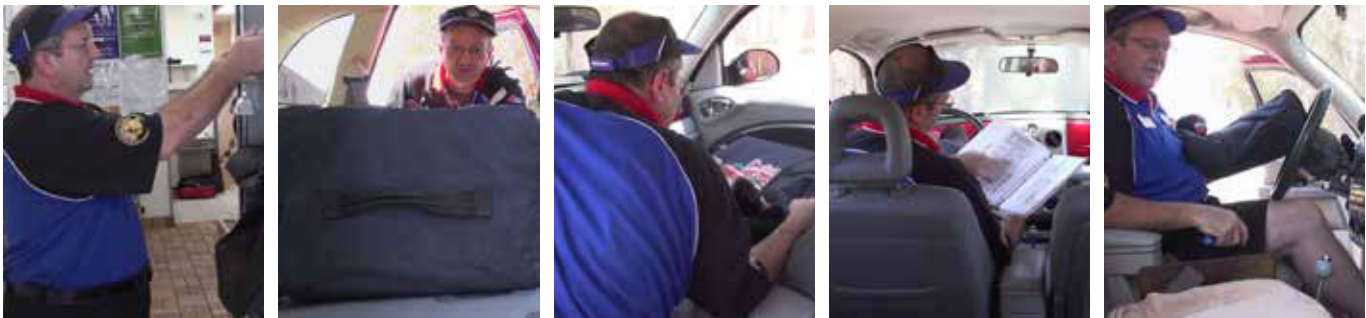
2. User Analysis(deliveryman)

2.1 the ueser process analysis

As a safeguard of the home delivery services, the deliveryman is the whole process--the only participant and the user from the express company transportation centre to the recipient.

image2.1 - the process of home delivery

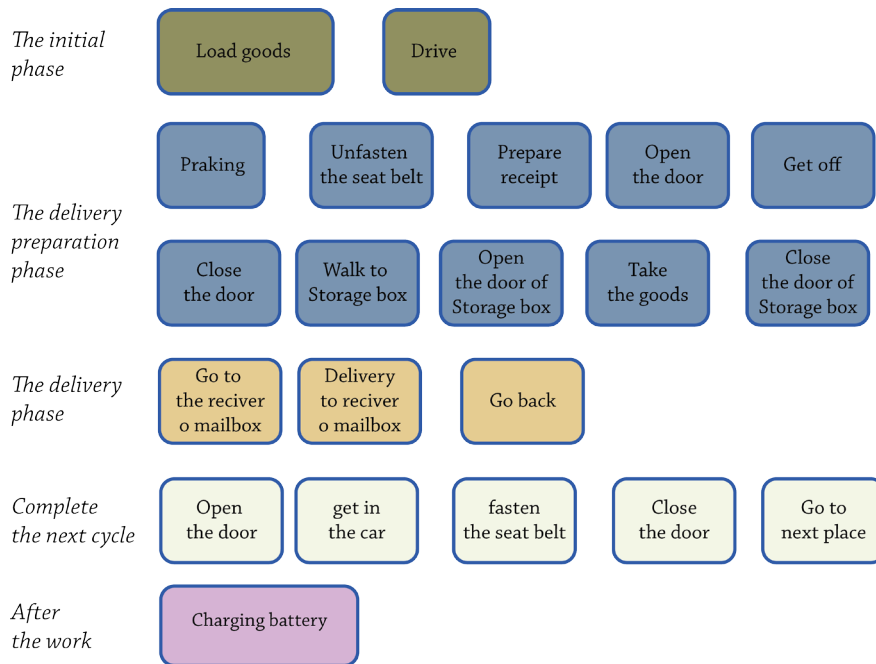
According to the survey obtained general messenger work 8 hours per day on average, with a distance of 30km-60km.



In order to analyze and optimize work process of the deliveryman. Conduct the user tracking surveys to existing car as a reference. Observing the process of user from the transportation centre to delivery locations, the delivery is completed, and then to another place of delivery.

First, when loading goods, the diliveryman usually sort the goods, larges will be placed with the rear of the vehicle, small pieces of goods or mail placed in the zone that can be easy to take. So they can more quickly deliver the small goods. After arriving the destination, parking, unfasten the seat belts, ready to prepare the receipt for the recipient and goods or letter, if it is small items, then take the goods first, then open the door, if it is large cargo, then opened the door and then Open the back door to pick up cargo, lock the doors. Add to the mailbox or give to the recipient. When they are done, open the lock and door, get

on the car, shut the door, fasten seat belts, go to the next place to start the next process.



graphic2.1 - the operation flow optimization of the messenger delivery process

2.2 Process Optimization

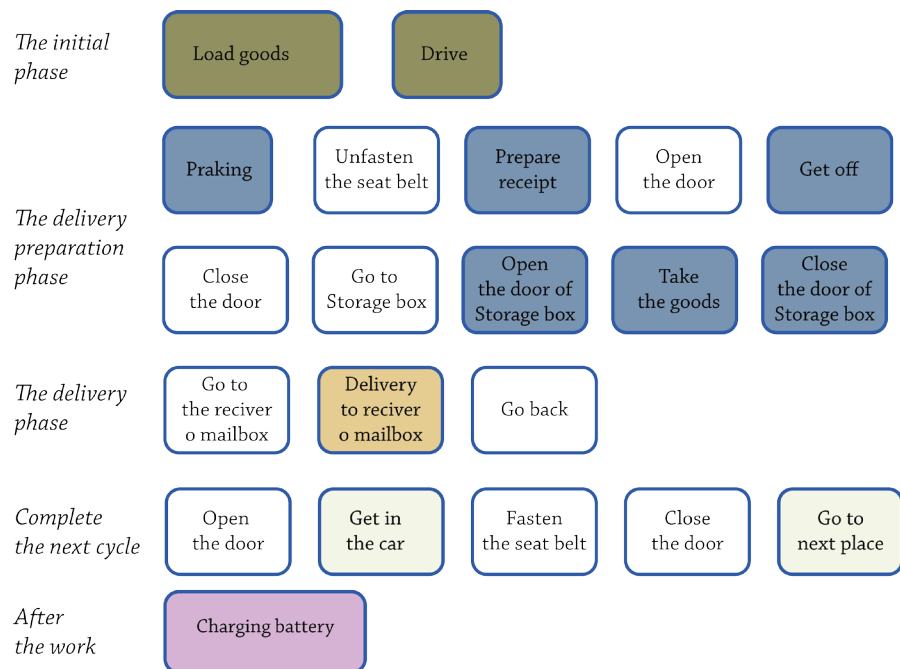
According to the user process, can optimize or reduce the user`s operation in several respects, to give:

- Easier get on and off or even do not need on and off the vehicle, so can direct delivery the goods to the mailbox o the recipient.
- Convenience store and pick up the goods, allowing more cargo or lagger pieces of goods to storage and users can not get off the viechle and to range of contacts.

In the graphic 2.1, can analyze the whole process of the delivery pderocess drawn into four phases. The first phase is the initial preparation, the operation is necessary can not be optimized. The second phase is delivery preparation phase, from parking to take the goods to delivery, in this process, there is a lot of

action. Remove unfasten seat belts, open door, can save four movements, Let storage space closer with deliveryman or within accessible range, can optimize the action: go to the storage box. The third phase is the delivery phase, if allow deliveryman to directly delivery, can be simplified two actions, faster completion the work. The fourth phase is opposite of the second phase of. In the second phase of the operation optimization, can be omitted in there.

graphic2.2 - the operation flow of the messenger delivery process Optimization



In the graphic 2.2, the operation with white squares can be omitted.

2.3 Process problem.

Home delivery service is a dynamic outdoor work process, therefore in this process will be greatly affected by the environmental impact. Such as unexpected weather conditions, traffic conditions, the condition around druning the transport. In order to prevent the parcel damaged and lost in transit. Delivery process problem should also be taken into account.

2.3.1 Cargo security

In the parking delivery process, deliveryman maybe leave transport some time for go to delivery goods, so there is no guarantee for the goods. The thief can use this process to theft the parcel, resulting in losses.

In the process analysis, we can see that in the delivery preparation phase, there are many actions. If the user forget to lock the door of the storage space, directly go to delivery, then when the user leaves along the vehicle, the thief might swoop in and steal the goods when the vehicle does not stay in a locked.

2.3.2 Protection of users and parcel in extreme weather

Since the whole process is conducted outdoors, so when faced with extreme weather, such as wind, rain, snow. User efficiency will decline and no guarantee of the security. Meanwhile, the parcel and letters packaging paper products substantially, when faced with rain or snow, easy to get the parcel wet, causing damage to the internal items.

2.3.3 Stability of goods during transportation

In transit, The transport remain state movement, but also vulnerable to road bumps, brakes and other emergency situations. Thus if the goods are simply stacked together, or place with an open area, parcel will be prone to fall, the impact is easy to make the damage of the delivery goods.

3. Research and analysis of the light quadricycles electric

“In 1992, the European Union published Directive 92/61/EEC which considered that quadricycles fell into the same category as mopeds. Framework Directive 2002/24/EC then refined this definition by distinguishing between light and heavy quadricycles (L6e and L7e categories)

Furthermore, Directive 2006/126 (3rd Driving Licence Directive) establishes a common framework for light quadricycles driving licences. It imposes the same requirements for light quadricycles as for mopeds, including the driving age, for which it recommends 16 years as a minimum. The transposition deadline of the directive is 19 January 2011”wikipedia

Divided into light and heavy two kinds (l6e and l7e), in which the standard of the light quadricycles electric are: the vehicle weight (to remove the battery and the load) no more than: 425kg, the maximum design speed no more than: 45 km/h. Its electric motor power no more than: 4kw.

3.1 Characteristic of the light quadricycle electric

As the name suggests the light quadricycle electric more lightweight than to the car normal, and a transportation using as electricity energy. With respect to the heavy quadricycle electric, light one has the lighter weight and the lower maximum

image3.1 - the vehicle usage scenarios



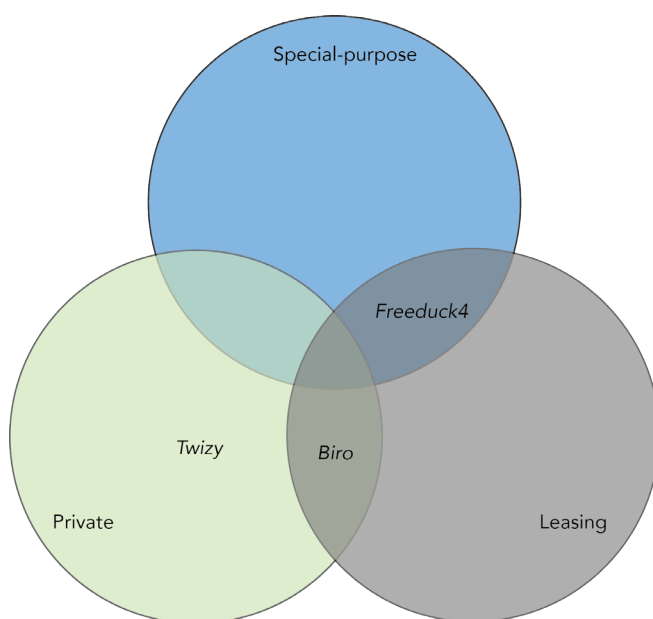
speed.

From here we can be drawn, because of the speed and weight restrictions, while the battery capacity is insufficient to travel over long distances, and the charging time is too long (about 8 hours), so the vehicle only be used with an urban area, or a large relatively closed environment (airports, railway stations, factories, shopping malls, parks, large residential area, etc.). While electricity unlike traditional energy of vehicles (petrol and diesel). It is a kind of zero-emission to the atmosphere, pollution-free clean energy, will not pollution to the environment. Is an ideal transportation of urban or large area.

The use of features like light motorcycles, but driving environment and load characteristics similar to mini cars, is a new energy vehicles between them.

3.2 The purpose of the light quadricycle electric

In the few existing light quadricycles electric application area include: private vehicles, Special-purpose vehicles and Leasing vehicles.



graphic3.1 - the vehicle applications distribution

Private vehicle by definition is similar to the existing private car, is a means of transport of people, the driver is usually himself or relatives and friends. The main purpose is travel, and auxiliary functions to have some space can be positioned cargo. It can provide a certain degree of security and privacy. Wherein two brands of vehicles Twizy and Biro are belonging to this area.

Special-purpose vehicle engaged in exclusive activities vehicles, such as delivery, cleaning, police and medical and so on. Unlike the private vehicle, they are need more to consider the product's functionality. In the space utilization of the vehicle in order to function for the first objective, give up some convenience design for driving. And special-purpose vehicle according to different functional requirements, design carried out is also very different.

Definition and characteristics of leasing vehicle approaching with the private vehicle, but it is different from private vehicles. Leasing vehicles for more consideration to the use of different groups of people with a variety of characteristics and vehicle parking and use situation. For instance, some people want more storage space, and some people want to be able to carry more passengers, or carry the child. freeduck4 in existing products and applied in this area

By the graph it can be seen in the current stage in the private sector for light quadricycles electric is more than others, and there are several brand in the leasing sector, in the sector of special-purpose vehicles, only freeduck4 one brand, mainly used in delivery and police vehicles while the brand's vehicles are used for these two areas are the same models. So use it as a special-purpose vehicle when in operation and function have inconvenient place. For example, storage space is small so can not carry more cargo and so on.

3.3 Analysis of existing brand vehicles

In the existing products, the most common on the market is biro, twizy, freeduck4. Primarily focuses on the above three.

3.3.1 Biro

biro is a light quadricycle electric that design and manufacturing by the Estrima company. It can carry two peoples. biro is a located in the urban green mini vehicle, stylish. Manufacture by a 3mm thick steel tube, you can choose to buy the polycarbonate door. Production at June 2009. It features a detachable on part of the batterys, the part of battery that can detachable is similar to a trolleys, people can be easy to pick up, the weighs is about 26kg. Exterior dimensions are 1740mm x 1030mm x 1560mm, the weight total is 125kg, the maximum speed is 45km/h. A time of charge can travel 40-70 km away. Charging time corresponds to travel distance, essentially 10km needs to be recharged for an



image3.2 - the Dimensions of Biro

hour. Form

table3.1 - the technical parameters of Biro

	<i>data</i>
<i>top speed</i>	45 km/h
<i>battery changing time</i>	4-9 h
<i>weight</i>	245 kg
<i>driving distance</i>	50 km
<i>number of seats</i>	2
<i>engine</i>	n° 2 Brush-less 48 V
<i>rated power</i>	4 kw
<i>whell</i>	R13
<i>frame</i>	tubular steel 3 mm
<i>traction</i>	rear
<i>front/rear brakes</i>	disk/disk
<i>helmet</i>	NO
<i>seat belt</i>	YES
<i>quick-change battery</i>	YES

3.3.2 twizy

twizy is a light quadricycle electric that design and manufacturing by the Renault. It can carry two people before and after in the series, and is an urban green mini vehicles as the biro. There are two types, depending on the volume of the engine for light and heavy quadricycle, light quadricycle for maximum speed 45km/h, while heavy one can reach 80km/h. Exterior dimensions are 2338mm x 1237mm x 1454mm, weight

image3.3 - the Dimensions of Twizy



of 446-474kg. Twizy can define interior decoration and roof according to the user's own preferences. The appearance is more athletic. Form

	data
<i>top speed</i>	45 km/h
<i>battery changing time</i>	3.5 h
<i>weight</i>	450 kg
<i>driving distance</i>	100 km
<i>number of seats</i>	2
<i>engine</i>	n° 2 Brush-less 48 V
<i>rated power</i>	4 kw
<i>whell</i>	R13
<i>frame</i>	
<i>traction</i>	rear
<i>front/rear brakes</i>	disk/disk
<i>helmet</i>	NO
<i>seat belt</i>	YES
<i>quick-change battery</i>	NO

table3.2 - the technical parameters of Twizy

3.3.3 Freeduck4

Freeduck4 is the product prototype, designed and manufactured by the Ducati energia. Can carry two people, there is a rear load space can carry cargo about 30L, each rear wheel equipped with the motor. Exterior dimensions 1760mm x 1630mm x 910mm.



image3.4 - the Dimensions of Freeduck4

The weight is 220kg. Maximum speed 45km/h, can travel 50 kilometers, the charging time is 8 hours. Lead-acid batteries. Frame uses steel bending welding process, shell process is the thermoforming. Freeduck4 rear suspension system is different with biro and twizy, the suspension of biro and twizy are connected to the frame on longitudinal direction, But freeduck4 is lateral connections with the frame.

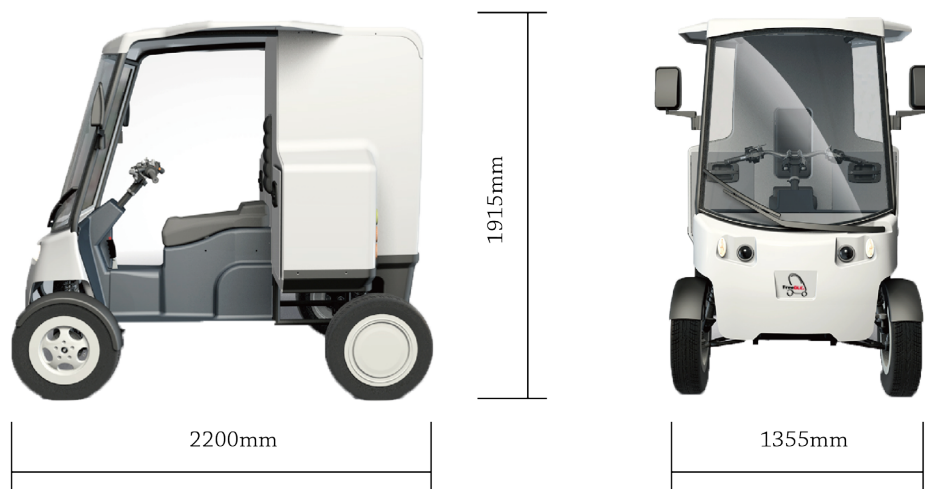
table3.3 - the technical parameters of Freeduck4

	data
<i>top speed</i>	45 km/h
<i>battery changing time</i>	8 h
<i>weight</i>	220 kg
<i>driving distance</i>	45 km
<i>number of seats</i>	2
<i>engine</i>	n° 2 Brush-less 48 V
<i>rated power</i>	4 kw
<i>whell</i>	R10
<i>frame</i>	tubular steel 3 mm
<i>traction</i>	rear
<i>front/rear brakes</i>	disk/disk
<i>helmet</i>	NO
<i>seat belt</i>	YES
<i>quick-change battery</i>	NO

3.4 Preliminary concept oscar

Oscar is the another prototype of this design. In the course "Laboratorio finale sintesi" worked with the group. It applies to home delivery service. In this design, because of the course time, standardized components for the seat, the seat shell, roof and intermediate shell and front panel. Frame is 3mm thick steel welded. The shell process is the thermoforming, the thickness is 3mm. Battery is placed underneath the driver. Applications the motor same as the Freeduck4.

image3.5 - the Dimensions of Oscar



	data
<i>top speed</i>	45 km/h
<i>battery changing time</i>	8 h
<i>weight</i>	330 kg
<i>driving distance</i>	45 km
<i>number of seats</i>	1
<i>engine</i>	n° 2 Brush-less 48 V
<i>rated power</i>	4 kw
<i>whell</i>	R13
<i>frame</i>	tubular steel 3 mm
<i>traction</i>	rear
<i>front/rear brakes</i>	disk/disk
<i>helmet</i>	YES
<i>seat belt</i>	NO
<i>quick-change battery</i>	NO

table3.4 - the technical parameters of Oscar

3.4.1 Advantage

In the preliminary design concept, the vehicle applies a dedicated delivery service, left and right sides can move forward with drawers open, to help the user easy to direct pick up items, without get off the vehicle. While use the motorcycle handlebars and the seat, can quickly get off and go to in the delivery process, reduce demand for the other actions, such as unfasten the seat belts, open the door and other extra action.

3.4.2 Disadvantage

The vehicle in the design process, Underneath of the rear space is not completely closed, easy enter to the surface water and the dust debris in the course of the vehicle travel, There is also a lack of the protection for the tire of the rear wheel, the rear tire directly completely exposed to the general situation on road, Easily lead to damage the rear wheels and tire. It is likely to cause damage and short circuit of the internal electrical components, to impact the effect of the using. At the same time, the depth of the rear intermediate storage space is too large, the hand is difficult to touch the bottom of the storage space, so is not very convenience to taken the goods that in the rear intermediate cargo space.

In the rear of the vehicle, the shap is not enough continuously, less unified modeling language and detail design. Division on the part of the shell, can improve.

PART 2. Project

4. Brief

This product is for the urban home delivery service, each deliveryman has one of it, delivered in a few blocks be delivered work in days. Let the deliveryman to improve productivity in the their work, to better protect the safety and preventing damage of the goods. At the same time according to parcel dimensions to optimization and increased the storage space of goods. Offered a kind of efficiente new energr conveyance for the delivery service.

For the product prototype, can better use of the space limitede of the light quadricycles electric. Reasonable utilize the storage space of goods, at the same time, to be different from the traditional products, think a new usage for the user, content ergonomic requirements. To make the user to better and get higher efficient, easier complete daily delivery work.

And planning to product assembly process, Let technicians

facilitate to debugging and testing the function of the product. Easy maintenance and replacement the part that easily damaged.

Finally, make product parts fit the manufacture, calculate the forces in some parts. Ensure the feasibility of the product.

Can remove battery set, so can replace the new set of battery when the old set is empty, for increase product endurance capacity and reduce or avoid the charging time and improve efficiency.

4.1 Background

From the investigation of the front-end of the market of home delivery, delivery areas, and the delegator -- E-commerce and C2C service, can know, more and more people choose, believe, and dedication to the home delivery services. The business occupy a large market, have a great contribution for developed countries economy. In the ensuing years, it will provide more employment opportunities, and let more people choose this service.

	Van	Bicycle	Motorcycle	Quadricycle light
Autonomy	■ ■ ■	■	■ ■	■ ■
Circulation	■	■ ■ ■	■ ■ ■	■ ■
Safety merchandise	■ ■ ■	■	■	■ ■ ■
Number of deliveries	■ ■ ■	■	■	■ ■
Economic savings	■	■ ■ ■	■ ■	■ ■
Shelter (bad weather)	■ ■ ■	■	■	■ ■ ■
Parking	■	■ ■ ■	■ ■ ■	■ ■

table4.1 - the Compare of transport tools for home delivery

With the development of the Internet, as well as the popularity of computers and smartphones, people can at any time through the terminal, to select and purchase goods online and through online payment. Wait a short time, can get the purchase of goods. People choose home delivery, because of its quality and speed of delivery have a higher guarantee, so for the home delivery the professional, fast transport tools can bring greater convenience to consumers, but also can improve efficiency deliveryman.

Through to the survey of the workload for the home delivery deliveryman possible get the light quadricycle electric trip distance, accord to the demand of deliveryman's daily workload distance. Meanwhile contrast with the existing Transport products such as: motorcycles, vans, bicycles, we can see the light quadricycle electric and motorcycle have the same speed, but have the greater the amount of delivery, unnecessary the round trip to pick up the goods. Comparison with the van, although it shipped amount is small, but it has a more convenient to parking, low cost, environmental protection and other features, and less restrictions of the city streets than vans. For the bike, in addition to high prices, there is no disadvantage. By calculating the scores of several tools to compare can be obtained, the light quadricycle electric has 16 point, for home delivery within the urban service has a more unique advantage.

At the same time for the analysis of user processes we can get, optimize storage space, easy pick up parcels and letters, convenience get on and get of the vehicle, or directly delivered in the vehicle, can significantly reduce the user's workload, Improve work efficiency. Make the storage space sealed, and storage space for the carried in parcel size design, can play well protected parcel and the inside goods during transportation and

delivery process.

In the action process increase the wear helmet at the beginning of the every day of delivery, such as the green box. Delete the many extra action. In the process, if the delivery destination can directly drive to, can omit the action get on and off, if not, need to do, as shown in the white box.

In the research of the conventional light quadricycle electric, can



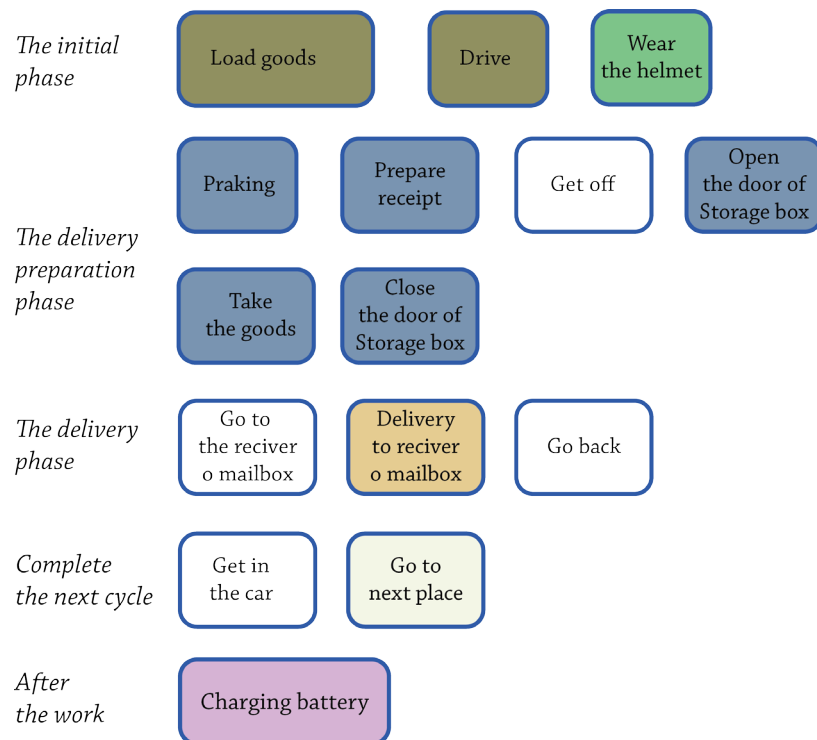
graphic4.1 - delete the action in the operation flow of the messenger delivery process

get a prototype -- Freeduck4, the maximum distance is 50-80km, charging time is required 8 hours. While the average daily user of transport distance of about 50km, the basic situation is that when the work is completed every day, the car charging, at the next morning when work began fully charged battery. However, in order to deal with emergency situations, such as: day needs a larger number of parcels to delivery, delivery a longer distance. Or not filled batteries at night rechargeable time, design the battery to be quickly replaced. When the battery runs out, can go to a nearby express compan to replace a fully charged battery, the empty one is left to there and continue charging. By a simple

operation to complete this series of actions. can avoids situation because the vehicle can not continue to work with the power problem, do not need the professional technical to replace the battery.

4.2 Ergonomics

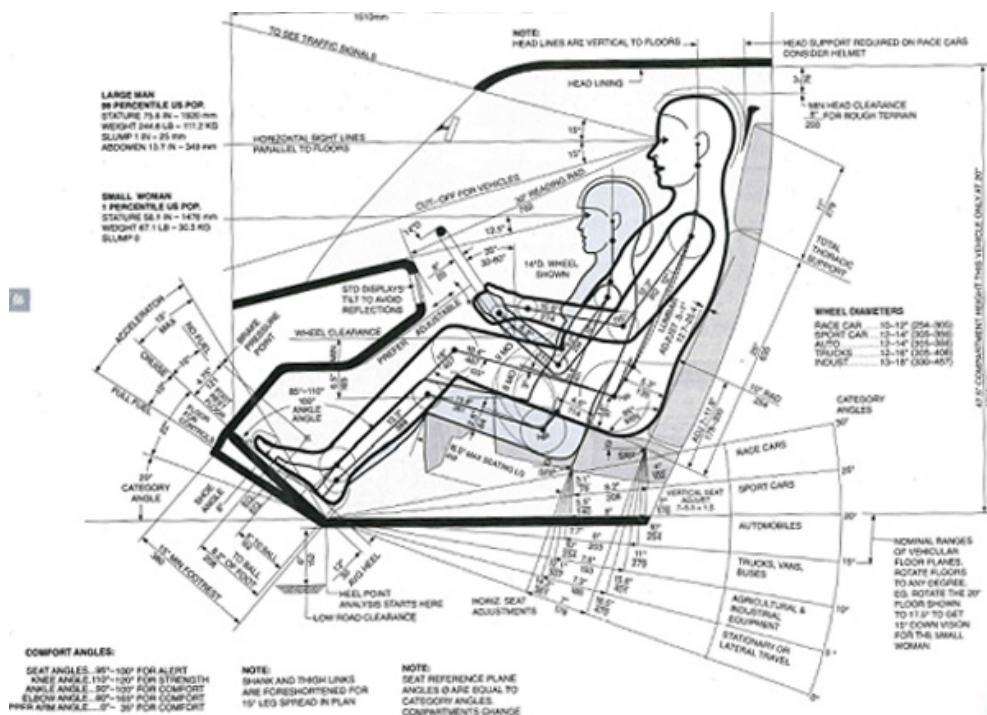
graphic4.2 - the operation flow of the messenger delivery process optimized



Body dimensions within this section are used in the data “Henry Dreyfuss -- Ergonomic”, 99% of adult males.

In the designs applied to the ergonomics into three main parts driving area, at the left and right sides the open forward storage area and rear storage area.

In the driving area, depending on the type of vehicle the driver have a different angle of inclination, such as cycle racong need angle of 30 degrees, while agricultural vehicles will take up to 5 degrees. It is because the car needs a smaller driving area height to get less resistance, but the agricultural vehicles require a



larger down depending on size, so the size from front to back is small. The light quadricycle electric, because the confined of size, also need some storage space, less demanding speed, so choose the angle of 0 degrees. So can get the best results in a small space.

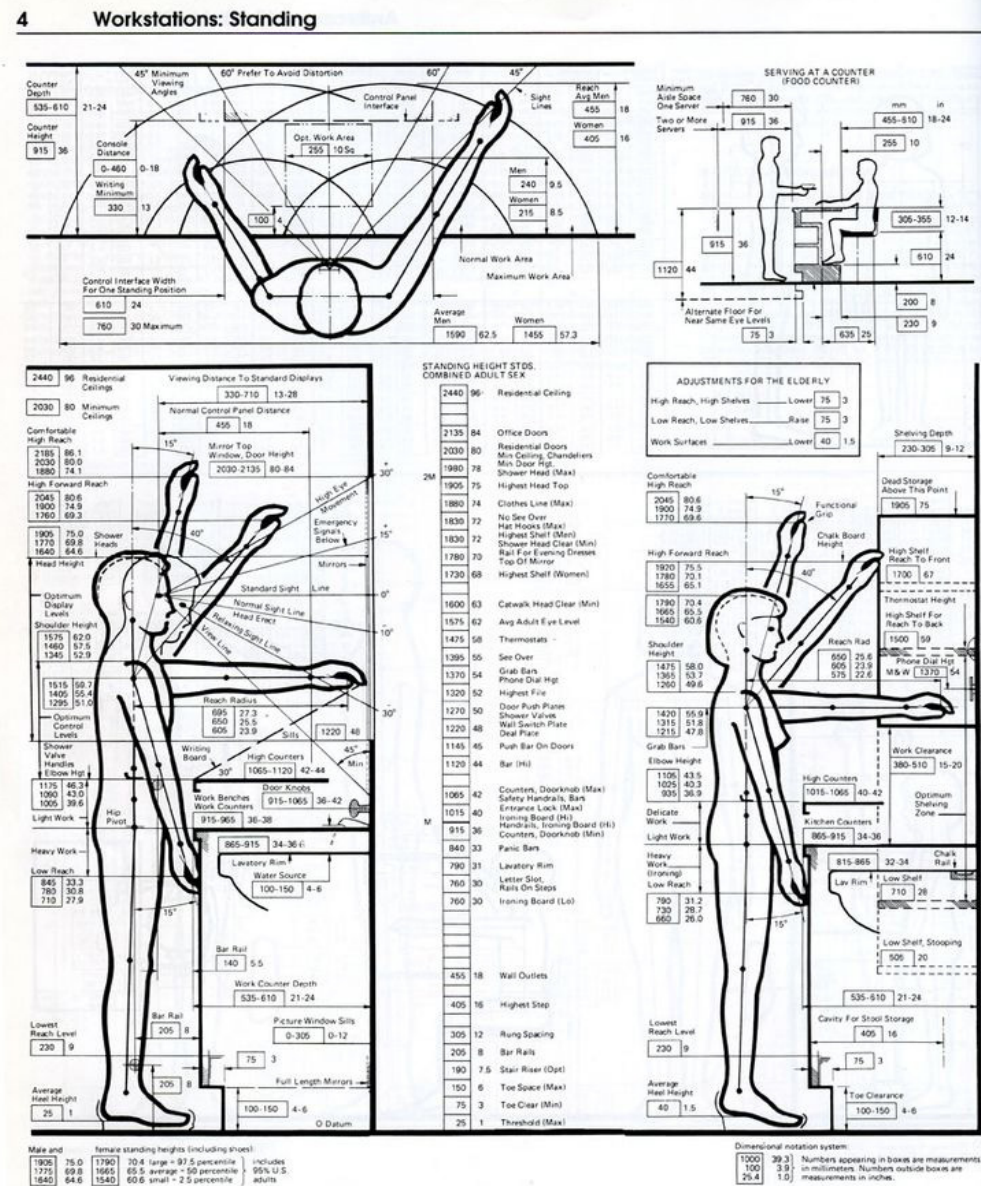
Left and right sides of the storage area can open forward. The most high-end storage area below the man's upper arm, and ensure that when opened, does not affect the user's shoulder area. Open length of 400mm. When fully opened, it is located in the lower-front of the body, to facilitate make the order or pick goods. If the design of the storage space above the lowermost position of the human upper arm, when opening or closing will affect or interfere with the area of the user's shoulder, causing the user's body twisted, affect efficiency.

The upper-center position in the storage area setting handle, the user does not have to turn around, can directly access to the handle, easy to open.

The rear storage area a minimum height of 750mm. Height is

image4.1 - the cockpit ergonomic size

image4.2 - the sitting and standing ergonomic size



1000mm. Its highly satisfied request when the person standing can directly placing goods. The area depth 500mm, compared to the previous product reduced 200mm. Because of the width dimension of the space is 500mm, depth more than width size, and width size smaller than adult males shoulder, so people hands are difficult full access to the back of storage area, change to 500mm, reduce a part of the space, increase the utilization of space. Meanwhile 500mm depth can also guarantee larger than the maximum size of the parcel.

4.3 laws and regulations

4.3.1 general

In order to meet the design can be realized in the design process also follows the relevant statutory provisions regarding light electric vehicles.

The first is to follow the EU definition of four-wheel electric light,

- Design-load vehicle weight of not more than 425kg.
- Design speed is not more than 45 km/h.
- Maximum continuous rated power does not exceed 4 kW in the case of an electric motor.

4.3.2 dimension

Through the study of 93/93/cee provisions dimensions maximum:

- length:4,00mm.
- width:2,00mm.
- height:2,50mm.

4.3.3 license

Car license plate on the car mounting method specified in the 93/94/CEE.

- The licence Size is 100mm x 175mm or 145mm x 125mm.
- Inclined from the vertical by an angle not exceeding 30 ° when the surface bearing the registration number is facing upward; inclined from the vertical by an angle not exceeding 15 ° when the surface bearing the registration number is facing downwards.
- Installation height not exceed 1.5m, not less than 0.2m.
- Mounting edge outward angle of inclination, the up and down are 30° and 5°, the right and left are 30° and 30°.

4.3.4 headlight

In the 93/92/CEE specified installation and technical requirements of front and rear lights.

--As the vehicle is wider over than 1300mm, the lamp needs two and symmetrical.

table4.2 - the vehicle lighting installation and design parameters

	width(mm)	height(mm)	geometric visibility	grouped
beam headlamps	/	/	horizontal : 5°,5° Vertical:5°,5°	dipped headlights Front position lamps
dipped headlights	Edge: $x > 400$ $x > 550$	$500 < x < 1200$	horizontal : 10°,45° Vertical:15°,10°	dipped headlights Front position lamps
Direction indicators	Edge: $x > 400$ $x > 500$	$350 < x < 1500$	horizontal : 45°,80° Vertical:15°,15°	: one or more lamps
Brake lights	$x > 600$	$250 < x < 1500$	horizontal : 45°,45° Vertical:15°,15°	: one or more rear lamps
Front position lamps	Edge: $x > 400$ $x > 550$	$350 < x < 1500$	horizontal : 45°,80° Vertical:15°,15°	: all other front lamp
Tail lights	$x > 600$	$250 < x < 1200$	horizontal : 45°,80° Vertical:15°,15°	: any other rear lamp

5. *design definition*

5.1 Layout

In the light quadricycle electric, it is divided into four parts, storage space, driving space, electrical and mechanical systems and batteries.

5.1.1 Layout size.

From the courier company's research of package size, can get the biggest package area occupied is 450mm x 400mm, so for the storage space, the bottom area should be larger than the size of the package, in order to ensure that the parcel can be placed.

Driving space

Driving space demensions designed according to the illustration of the ergonomically driving area “The measure of man and woman”.

Electrical mechanical systems

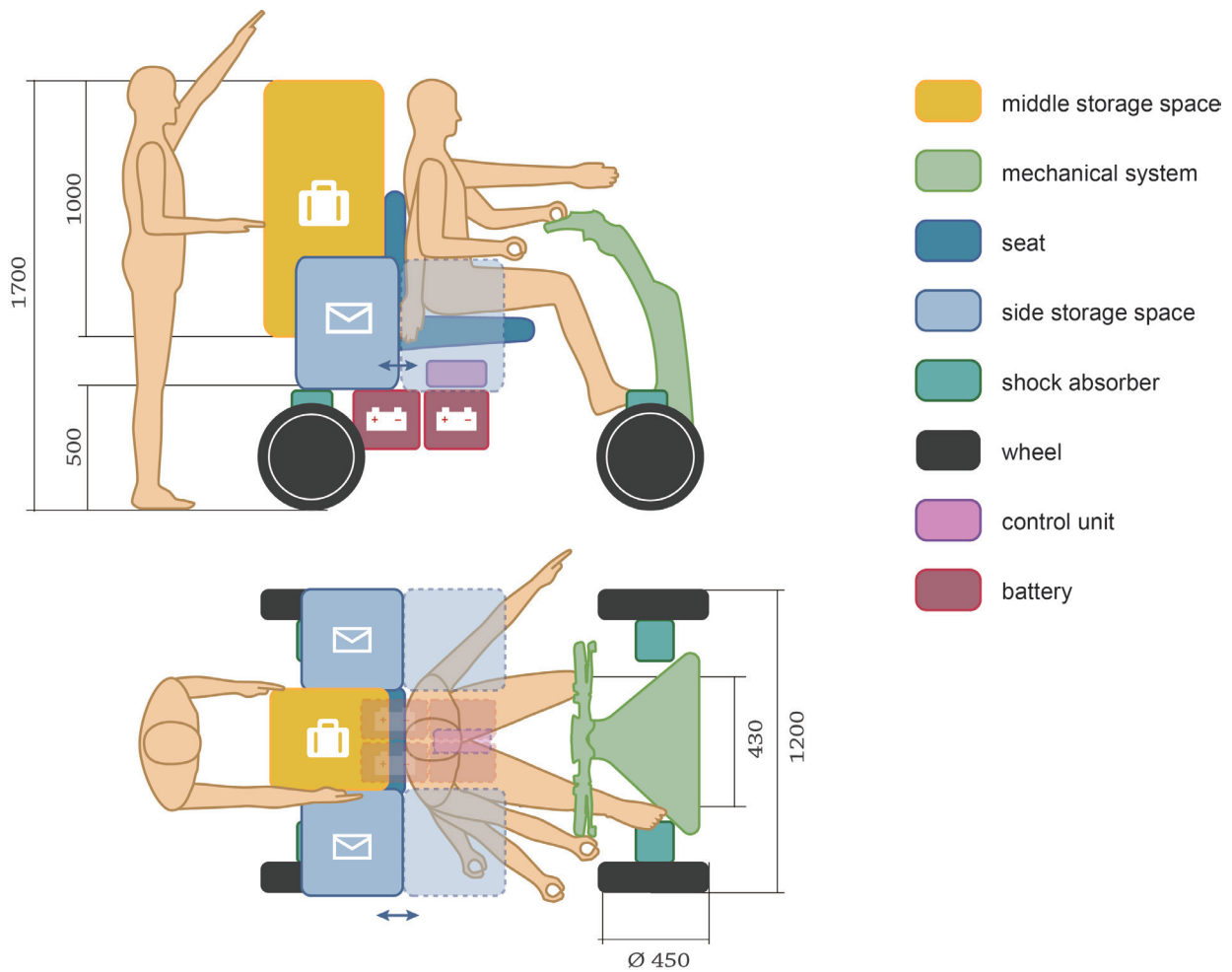
Electrical mechanical systems, we chose 13-inch wheels. Other parts placed substantially between the front wheel and handlebar position.

Battery

A total of four batteries, the external dimensions of 260mm x 172mm x 225mm for one battery.

5.1.2 Optimization

First, can determine the relationship between the mechanical and electrical systems and the driver. The driver is located above the wheel, the positon of foot is in the rear of the front wheel. Thus can be determined the relationship between the steering system and the wheel. The battery can be placed under the



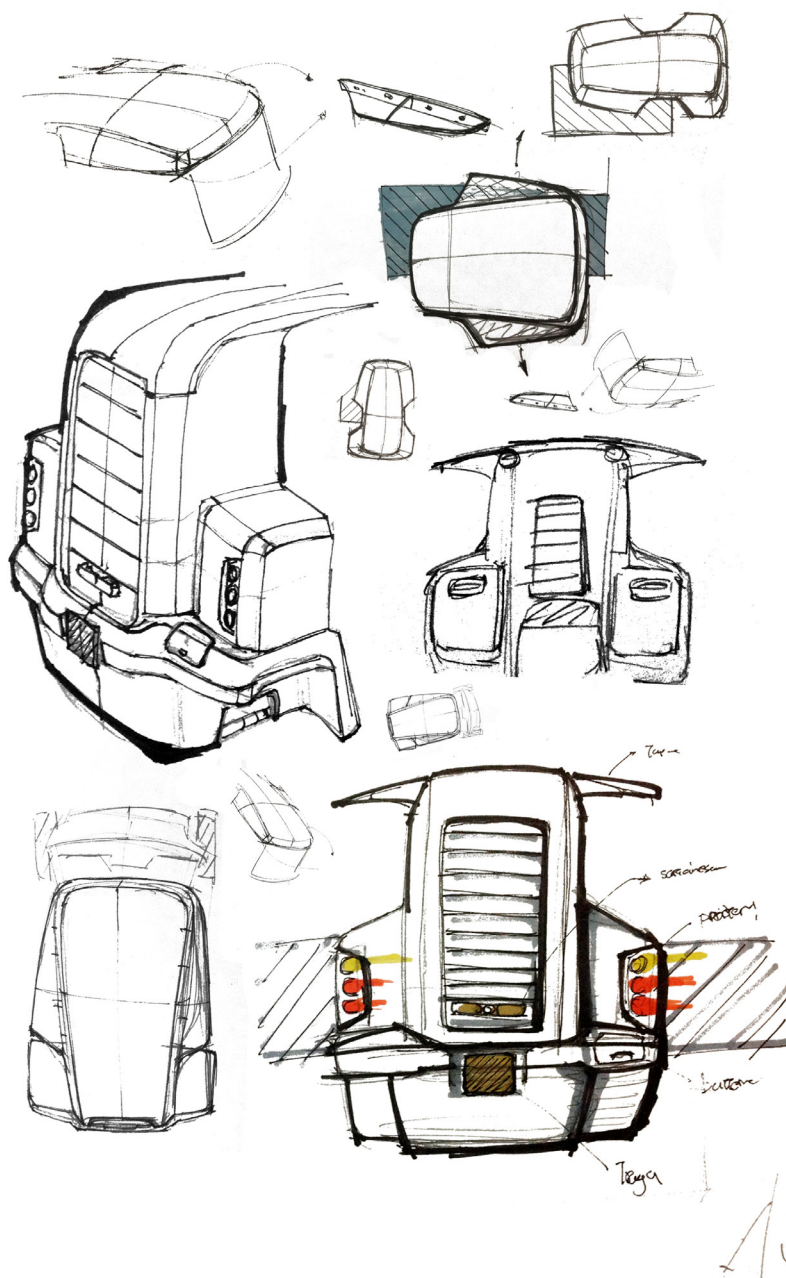
graphic5.1 - the concept final layout and size

seat in the rear of this space, accord with the size requirement. Between the battery and the people there is a few distance, electrical controls can be placed here, Let the electrical system has a short distance, to prevent electromagnetic interference. The whole rear part is for the storage space. Stay out of the area inferior for replace the battery, In order to ensure the center of gravity between the front and rear wheels, the rear wheel center line and the storage space centerline are collinear. In order to facilitate the user does not get off when he can pick up some goods, and make the goods to enclosed unified storage, in the left and right side of the center storage, the lateral storage box can open forward.

5.2 Design Description

In the design shape process, Shell shape using a larger curvature curve as the main style. Because the vehicle belong to the technical vehicles, without excessive curved surface to reduce wind resistance, but too many straight line will make the body too rigid, interactive unfriendly. Since the shell is made of

image5.1 - the design sketches

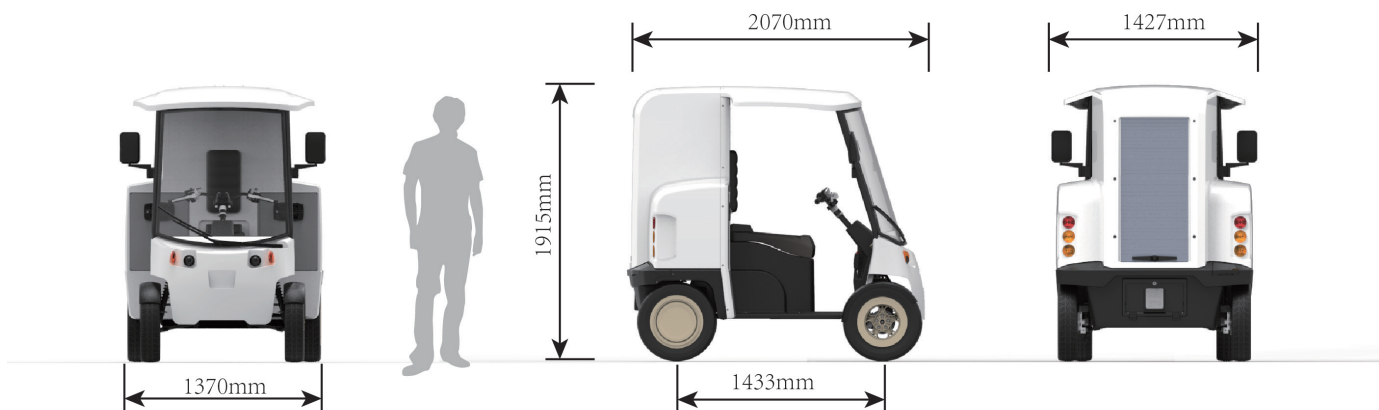


thermoforming, a large area flat easily collapse in the middle, because the process is not a one-time molding the central ribs.

5.2.1 Requirements of the vehicle

Vehicle dimensions are 2070mm x 1370mm x 1915mm, netweight 382kg, the center of gravity is located below the seat. There are three cargo space, the cargo volume of central cargo space are 205L, two sides cargo volume 77L.

image5.2 - the vehicle dimensions



Loading goods

Divided into three main areas loaded. Rear load space, and lateral the loading space. Through the prevent research for the express logistics company standard package dimensions and weight requirements how to get directed to the rear space of the vehicle, the packages can be placed three large and two small packages, including large one weight: 5kg, small one weight : 3kg. The total weight of the rear load space can load as 21kg. The lateral load space are loading small cargo, courier convenient easy to pick up and delivery. Can be placed three small package and one large package. the weighs 14kg.

Package large X 5
400mm X 330mm X 270mm
5kg

Package small X 8
440mm X 310mm X 75mm
3kg



5.2.2 Method of operation

In the driving area, use of motorcycle's handlebar and motorcycle saddle, do not designed doors and seat belts. Because the user get on and off many times in the delivery process, with respect to the steering wheel and seats of the ordinary vehicle, motorcycle system can easilier get on and off. To facilitate the delivery of goods. System of motorcycle does

image5.3 - the volume of load cargo



image5.4 - users pick up the cargo in the drawer

not require seat belts while driving. Can reduce the time to wear the seat belt. Reducing the width of the driving area, the convenient of user to be able to direct step on the ground when take the leg on both sides. The body center of gravity can be easily moved out of the vehicle. Reduce the drastically additional action to because get on and off.

image5.5 - users pick up the cargo in the storage box



Storage area is divided into three parts: storage space for the middle and the left and right side storage space. The middle of storage space can be opening up the shutter doors, the lower end there are the handle and lock, during transportation to ensure product safety, and waterproof. The left and right side of storage space can be opened forward by the handle, After opening the storage space is on the underneath-front on both sides of the user, the user may not need to get off, directly pick up and deposited the packages or letters to delivery. Reducing the large number of walking time. At the same time both sides of drawers are equipped with a handle and locks to ensure the safe of parcels during the transport and delivery process.

image5.6 - the Vehicle in charge

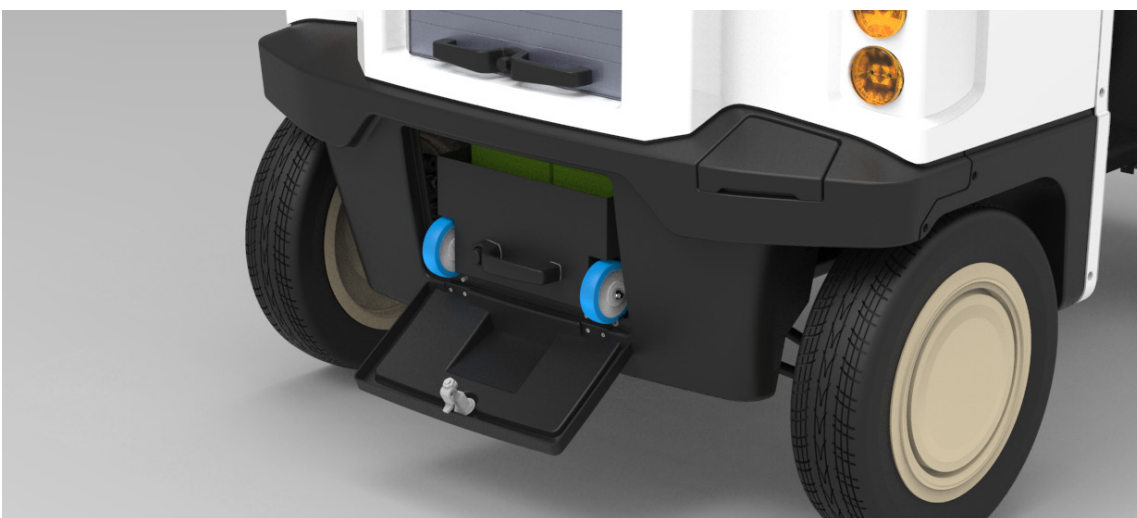


The left front panel with a control system that can control the vehicle start up and can be observed in the vehicle state and the battery power through the screen.

During charging, open right side the cover of charge plug, the cable and charging pile connection, can start charging.

If during operation, the battery is empty. Can replace the battery. Use the key to open the inferior battery compartment

image5.7 - Open the battery compartment, remove the battery



cover. Hold the handle of battery box, press the button, you can remove the battery along the guide. The battery box design with wheels, can easily move on the ground. Replace a new battery. The battery pushed along the guide, to the extreme position, the battery can be automatically fixed. Close the door and lock it.

5.2.3 Center of gravity

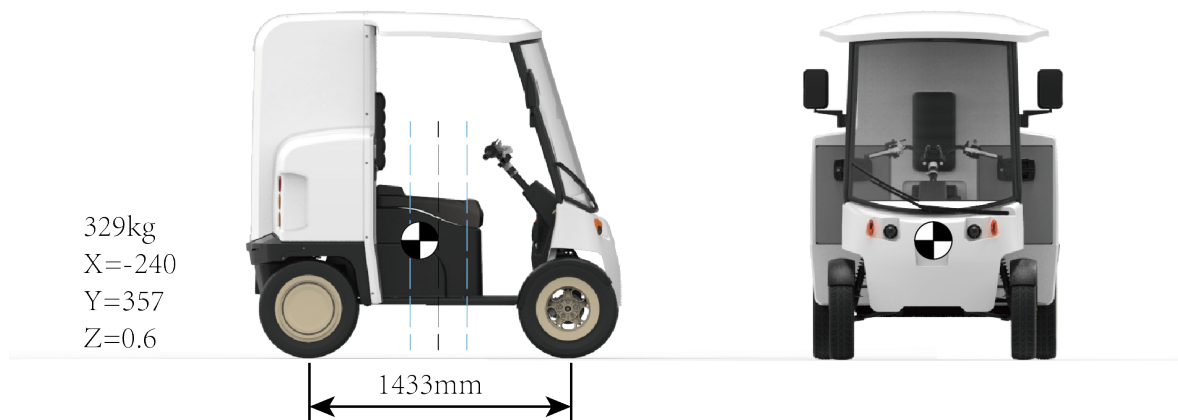
There are three cases of the gravity of the vehicle: The gravity of the vehicle when is net weight, The gravity of the vehicle when is unloading the goods and The gravity of the vehicle when is full load.

In the case of net weight: only the weight of the vehicle, the driver and the cargo goods did not load, according to the 3d modeling software Solidworks calculated the net weight of the vehicle is 329kg. The center gravity of the vehicle when is net weight at coordinates:

X: -240mm, Y: 357mm, Z: 0.6mm.

Its position shown in image 5.8.

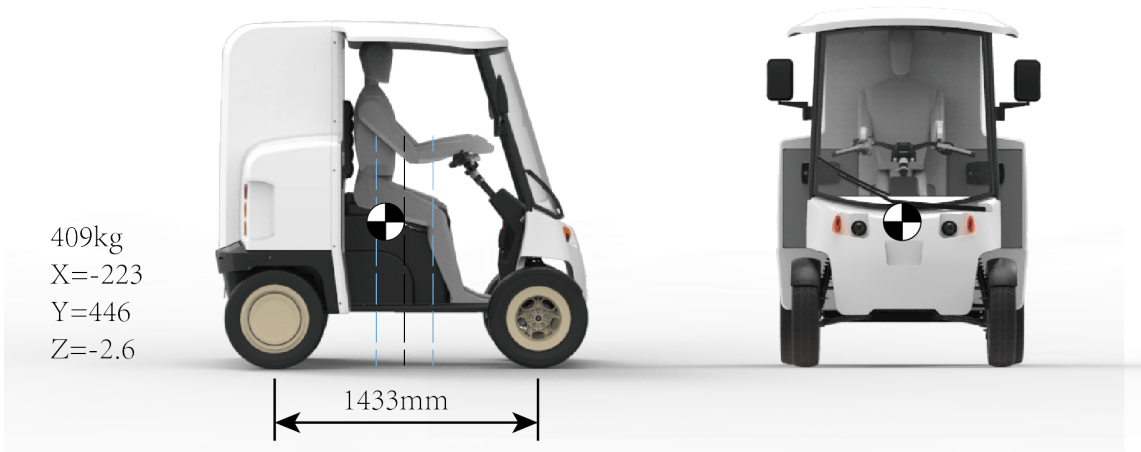
image5.8 - the center gravity of vehicle net weight



In the case when the vehicle is unloading: do not place the cargo in the storage space, just consider the weight and the position of the driver, based on ergonomic data meet 99% of the male

body weight: 80kg. Driver's seat above the seats. weight 409kg.
 Located in the center of gravity at the coordinates :
 X: -223mm, Y: 446mm, Z: -2.6mm.
 Its position shown in image 5.9.

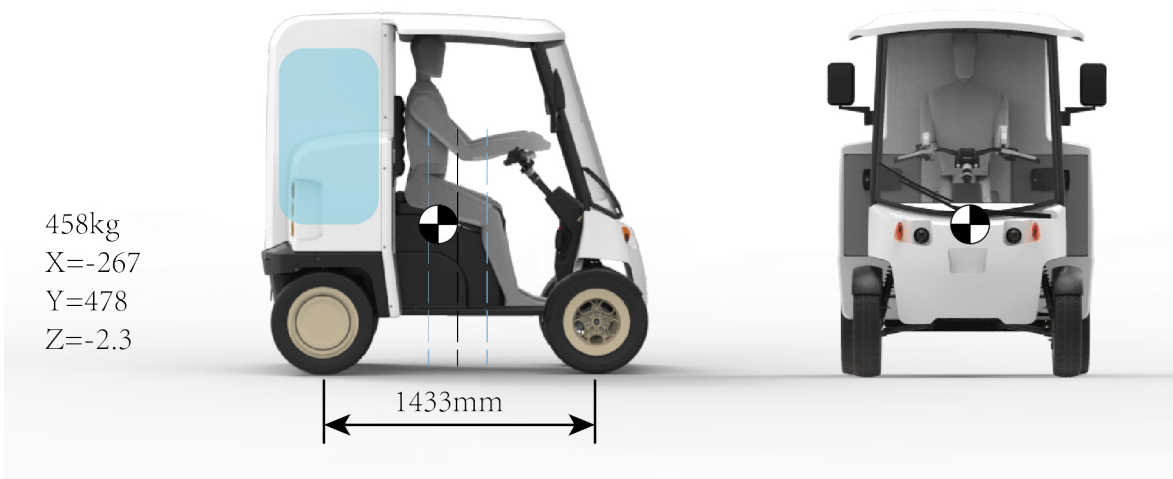
image5.9 - the center gravity of vehicle unloading



When the vehicle is fully loaded: According to the previous full load that cargo weight 458kg, where cargo volume for the central 21kg. Left and right portions, respectively 14kg. The weight of the driver to meet 99% of male weight 80kg according to ergonomics. Located on the seat release. After the weight of the vehicle is fully loaded: 458kg. Located in the center of gravity coordinates:

X: -267mm, Y: 478mm, Z: -2.3mm.
 Its position shown in image 5.10

image5.10 - the center gravity of vehicle fully loaded



Vehicle front and rear track width of 1433mm. Driving mode of the vehicle is rear-wheel drive, it should be more opposite mating wheel. 60% -65% of the total breeding. Therefore, the position of the center of gravity should be located at a distance of 60% -65% of the front and rear wheels for the best.

Located in the center of gravity of the vehicle -240mm net weight. -223mm when the vehicle is located. Located -267mm when the vehicle fully loaded. To accord with the 60% -65% range.

5.3 Component and installation

Assembly process is very important during the whole production process. During the installation of the vehicle, starting from the frame, the installation driving components and electrical components, and then install the various parts of the shell, finally some direct interactive components. The whole idea is: First install functional parts. The idea is: First install the functional parts, then the workers can easily test and repair. If the car shell is installed, and then test. experiencing problems to re-demolition, reduced efficiency and even cause damage to some of the components.

5.4 The system of frame

The system of frame is the most fundamental part of the quadricycle, most of the mechanical parts and the the shell are connected with the system of frame, the system of frame has the frame itself and the connection parts that connect to other parts.

Frame made of carbon steel materials, steel quality: S235JR, The

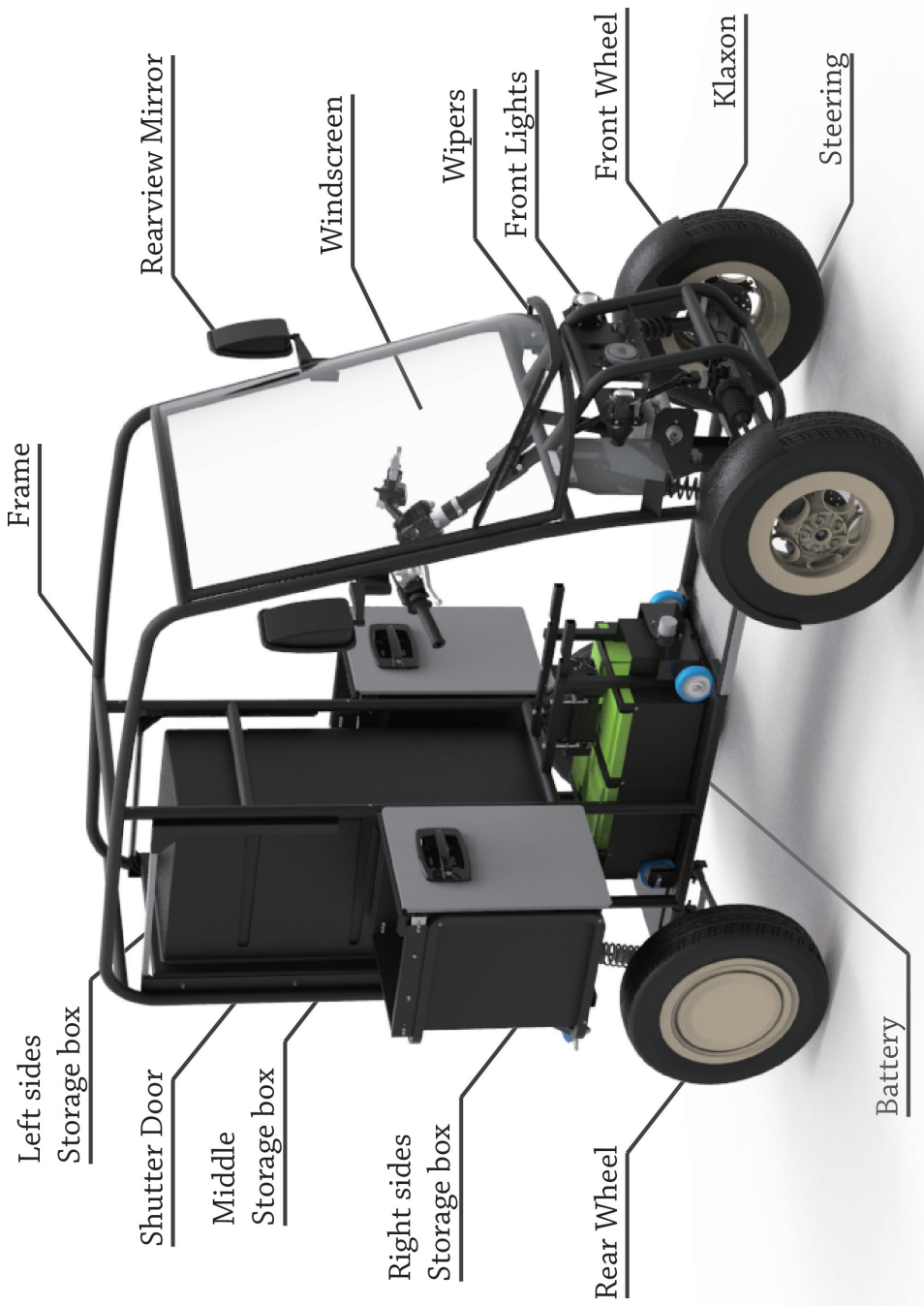
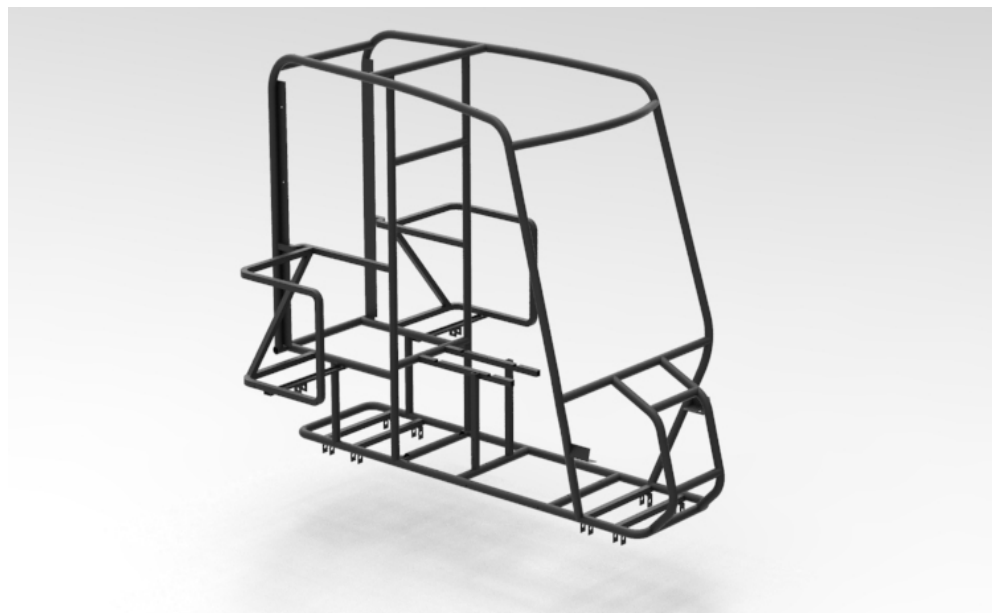


image5.11 - the componet of vehicle

materials used for the circular pipe diameter 35mm thickness : 3mm. The square pipe: 25mm x 25mm wall thickness: 3mm, the sheet thickness: 3mm. Total weight is 82.4kg. Applied to the manufacturing of laser cutting, bending pipes, bending sheet metal, welding, galvanizing and surface paint. It also applied the rivet nut for easy installation with shell . Application process was riveting.

The inferior part of the frame is rectangular, the centre of the frame is welding the cross member to ensure the overall stability, prevent distorted. It is mainly used to connect the frame superior and the inferior portion of the wheels. The part superior of the frame has been extended from the front end to the back end. In the centre of them there are two pillars for increasing the strength and divided driving area and the cargo area. The forefront framework in order to protect machinery, electrical components of the whole front. The rear of the frame is divided into three areas, the middle area is the main storage space, and the left and right areas are open forward drawer storage space. In order to facilitate fixed drawer guide, use the left and right frame part of the square tube welded.

image5.12 - the frame



Connectors, the connector is to make the function parts that better and more easily installed on the frame. If all the functional parts connected to the frame, then the frame structure can be very complex, increasing the difficulty of production can or not even production, while the overall weight of the frame will increase. All connectors are the steel that are bending welding after the laser cutting. And the frame is connections by welding. During the welding process, how to more accurate positioning is focused on design considerations.



image5.13 - the frame and the part weld on the frame

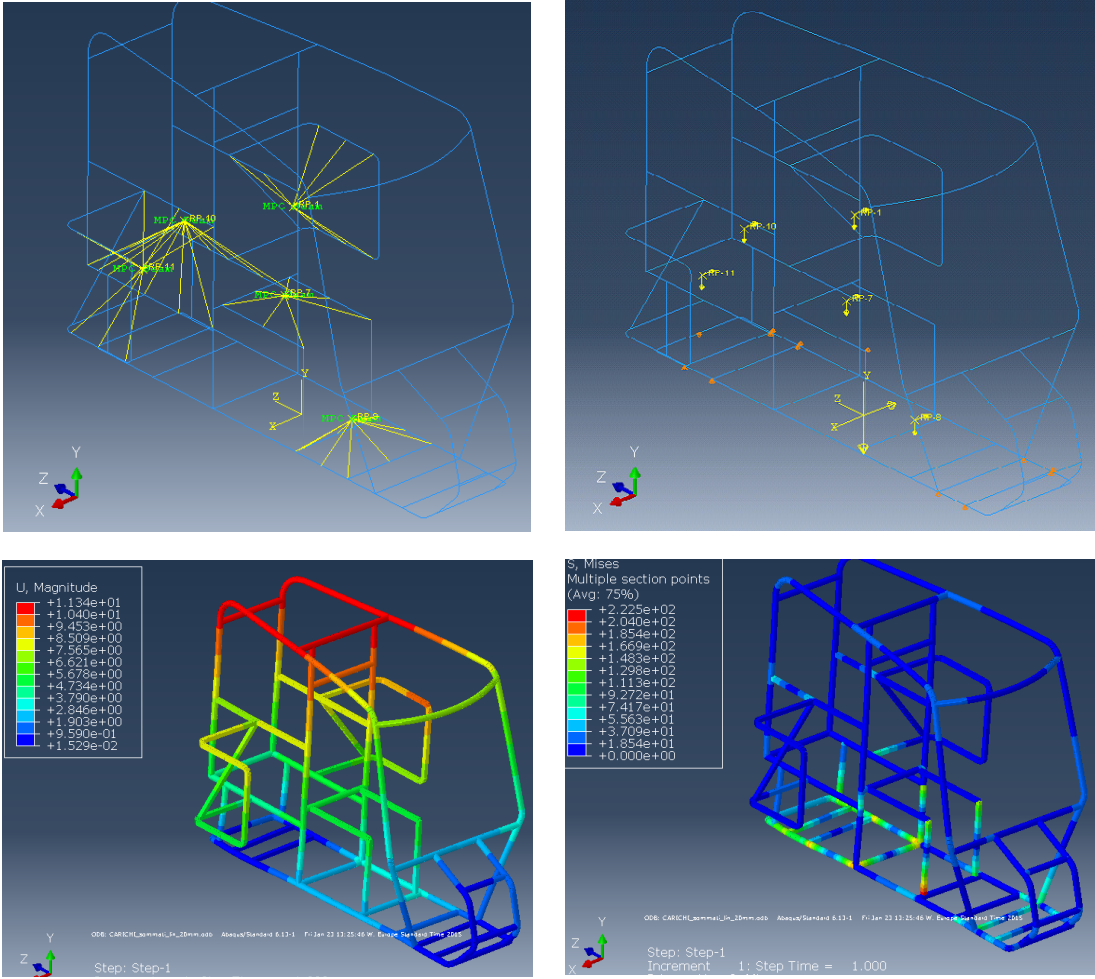
The basic design rule is that if the direction of the plate vertical of the frame pipe, using the the laser cutting mode, directly cut out the shape of the outside diameter of the steel pipe, bending welding the connector shape and overlapped on the frame to welding thougher. If steel direction is tangent direction with the frame pipe, then try to design a shape with two bends, overlap

on the frame pipe, to ensure the positioning dimensions X-axis and Y-axis. Only need to measure the horizontal angles and dimensions of the Z-axis, can avoid the problem of difficult positioning during welding.

The main load frame for the driver and cargo. In which cargo is divided into left and right sides and rear. Driver's weight is 80Kg, the total weight of cargo 35kg, rear of 21kg, left and right respectively 14kg. Fixed to the bottom section of the vehicle frame suspended position attached to the wheel. Because the wheel and the bottom connection. We can assume, with respect to the frame, the wheels of the fixed part.

After the analysis can be learned:

image5.14 - the finite element analysis of frame



5.5 Functional components

The functional components including wheels, handlebars, steering, brakes, wiper systems, speakers and power switch, battery pack, controllers, charging plug, lights. Wherein the power switch, battery pack, controllers, charging plug and motor vehicles constitute the entire power system. The wheels, steering, brakes constitute the entire car's travel system.

power system

The vehicle power source is a set of four rechargeable lithium batteries. Connected to the motor through the controller to the motor to provide power sources, other electronic control components such as: wipers, lights set, speakers and other sources of electricity also from the battery pack, switch to the anterior panel to control the supply of electricity. Addition charging plug for external power supply, used to charge the battery.

Wherein the switch and charging plug have direct contact with user (users often used) parts, mounted on the vehicle's

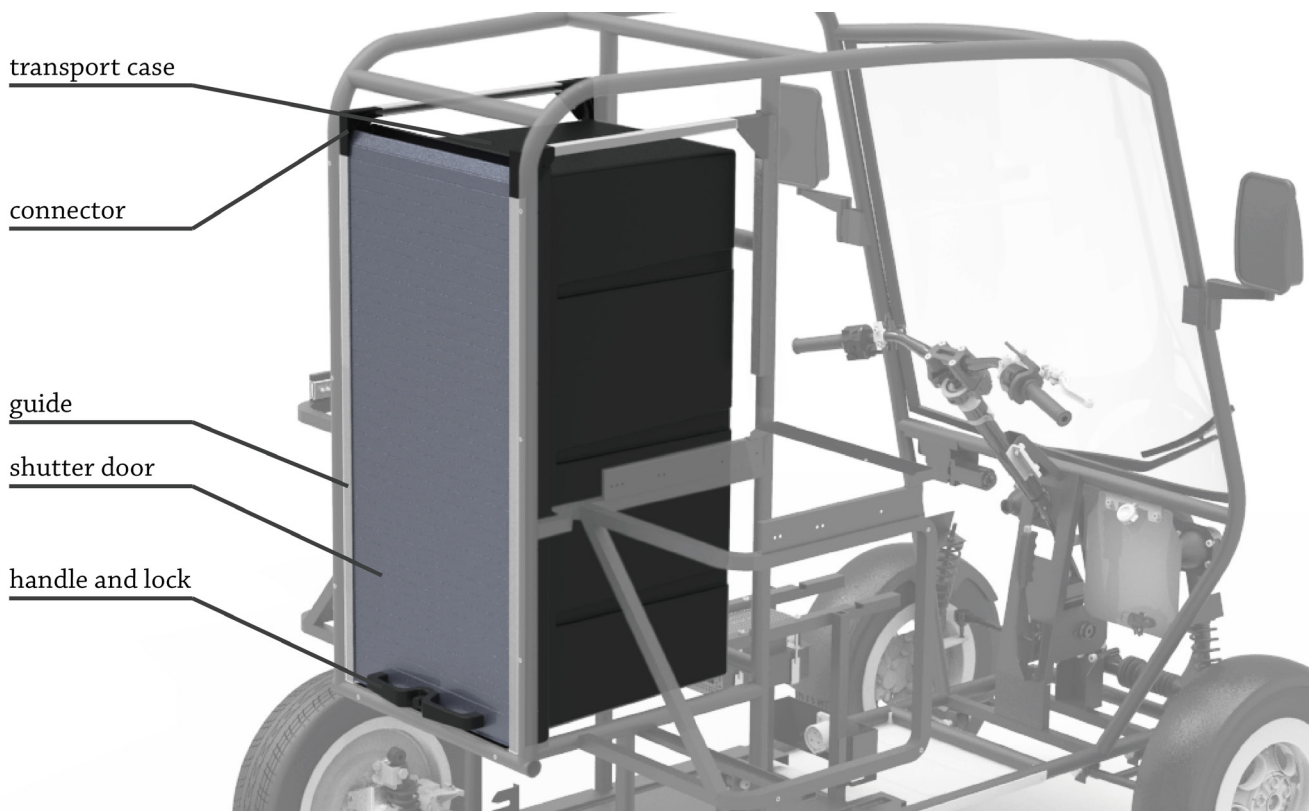


image5.15 - the functional component Installation on the frame

shell, which is more convenient for people's daily use. Other components are functional components, not often contact with user, so direct installation on the frame. With shell to protect them. At the same time because the vehicle is outdoor work products, for the electrical system needs to have a waterproof protection. In the design, except the frame and the shell to protect the electrical components. The parts buy also choose to waterproof rating.

image5.16 - the transport system

5.6 The transport system



5.6.1 The transport case

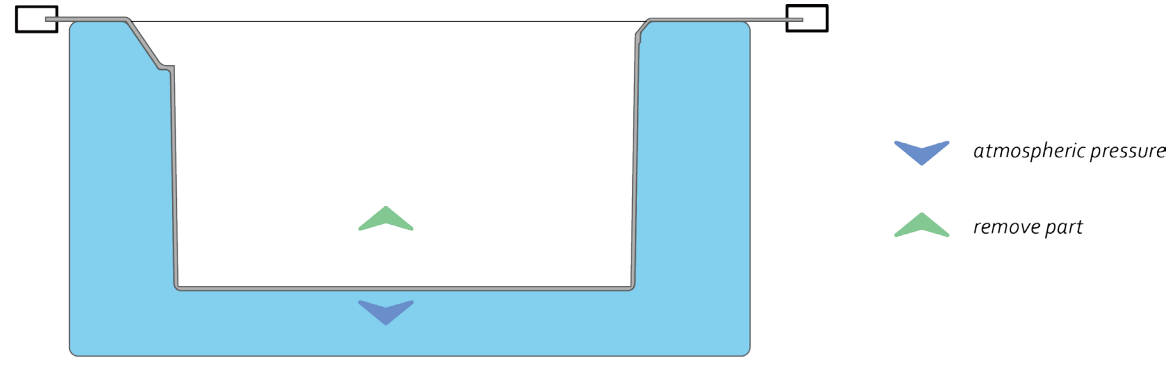
Intermediate storage case size is 480mm x 1020mm x 420mm, volume is 205L. ABS sheet materials, the manufacture is thermoforming, reserved 1 degree draft angle. Because this

image5.17 - the transport case

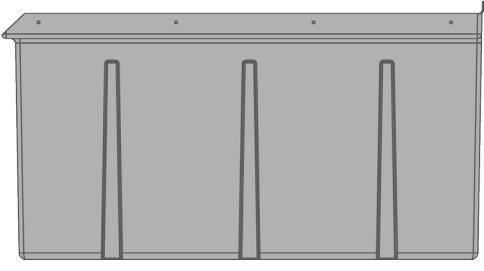


case need to bear the weight of the goods, so we must to add the ribs structure on the shell, maintaining the strength of the shell. Throughout the open side of the case fixed with the frame, while the load center of the gravity at the center of the case, so the design of the transverse ribs. Taking into account the car is

image5.18 - the manufacturing process of transport case



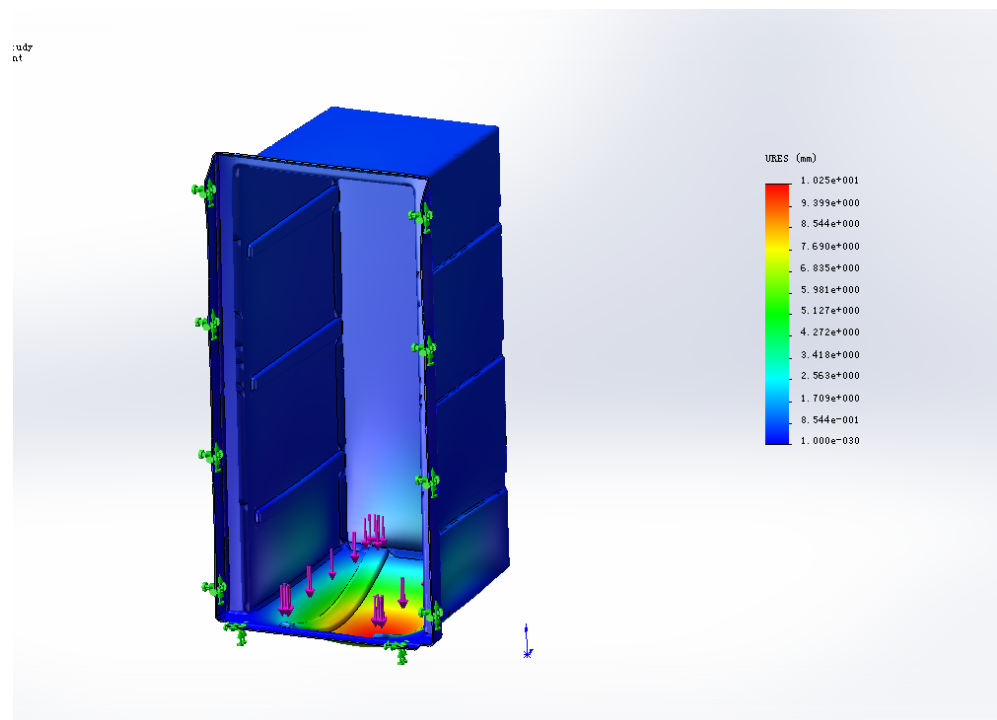
cut off edge



dynamic object, the hole of connection between two parts will be crack because of the vibration, especially the plastic shell. so the addition of a kind of gasket that can sleeve into the hole, to prevent vibration, it called the mounting hole grommets, can also avoid the tapered gap that caused by draft between the parts.

For the finite element analysis middle of the cargo space for loading large goods, located directly at the rear of the vehicle. Use material ABS. Process for the hot plastic process plastics. The shell fixed with the frmae though the left and right sides and the underneath part, it is possible to load cargo 21kg. In finite element analysis, the left and right sides and the underneath part to a fixed end. Goods by force of gravity is 205.8N. Loaded at the bottom surface. After the analysis can be obtained, the overall deformation is 8mm. The forces and deformation of the case as shown.

image5.19 - the finite element analysis of transport case



5.6.2 Shutter doors

On vehicle application shutter doors in order to save the open door space. Compared to ordinary storage box door, shutter doors open to an external space requirements when smaller, the need for external open and closed space. For Freeduck urban delivery that can park in a more confined space, giving the user more possibilities operate in complex situations. such as the fire truck are also using shutter doors to meet the narrow space to start work. Meanwhile the end of shutter door with a handle and lock, can guarantee security during transport and deliver goods within storage reservoirs and ensure commodity is not contaminated external environment such as rain, and so on.

In existing products primarily through select shutter door track, door panels, handles and sealing strip to determine the type. In accordance with the exterior and the available interior space to calculate the exterior and installation dimensions.

According to the search of package size inferred to the width of the centre part is 500mm, in order to join the mounting structure of the shutter door, so the frame width is 600mm, as shown in the figure, the door width is 530mm ensure that the goods can be successfully loaded.

Shutter doors length calculation.

Determining: L1 length 1000mm, L2 is 420mm, L3 unknown, two connector arc radius R is 65mm. The connector circumference C

$$C = 3.14 \times 2 \times R = 3.14 \times 2 \times 65 = 100\text{mm}$$

When the shutter doors are closed, the length:

$$L = L1 + C = 1100\text{mm}$$

can guarantee independent the inside and outside the space.

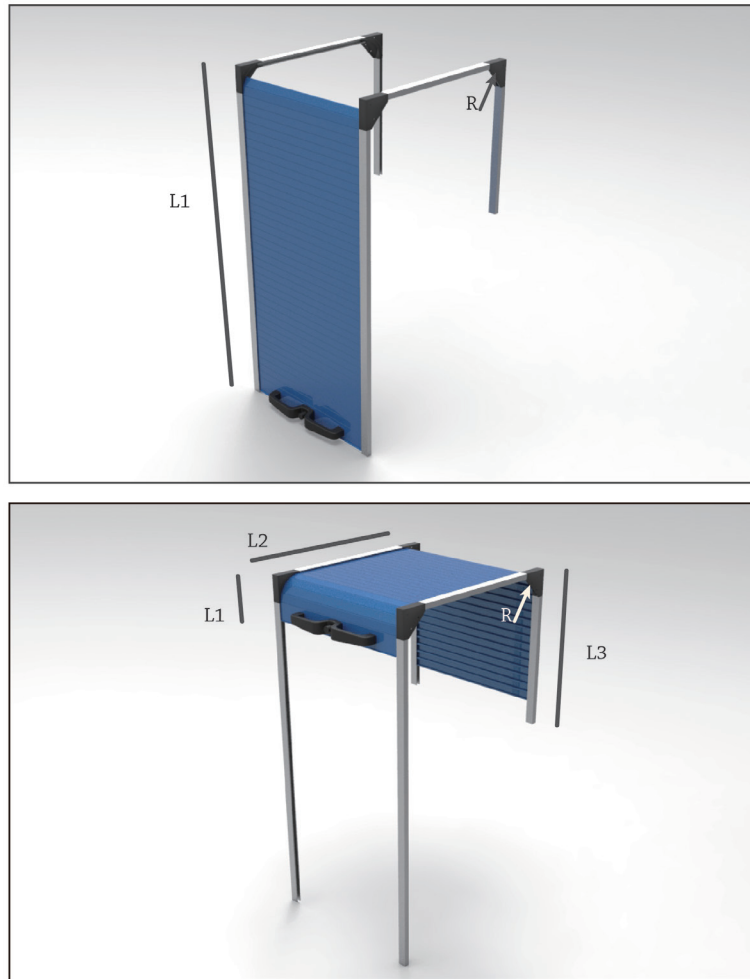
When the shutter doors all open, reaching the last section of L3, the length :

$$L = 1100 = 420 + 100 + 100 + l3 + 100.$$

Keeping the handle in the track L1 lenhth: 100mm

$$L3 = 380\text{mm}.$$

image5.20 - the size of shutter door



Wherein the marerial of track and the door panel is aluminum , the connector material is nylon. Shutter doors can ensure strength and durability (corrosion resistance in outdoor environments), and reduce weight.

5.8 Shell of vehicle

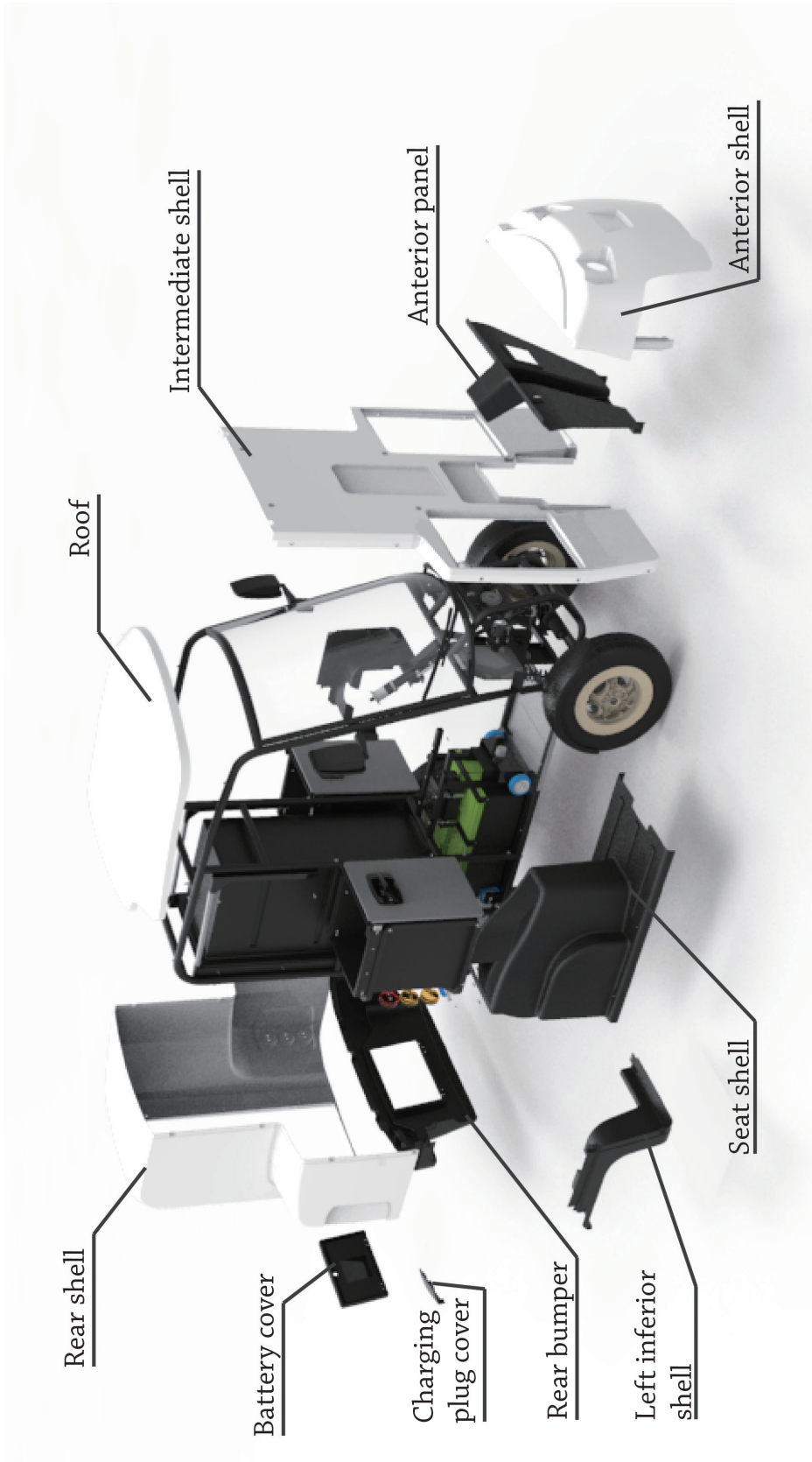


image5.21 - the vehicle shell exploded view

The shell of vehicle used to coverage the frame, allowing users to avoid contact to the internal structure. Play a role in protecting the frame, internal electrical components, users and passenger, and because the quadricycle is a tool used outdoors, the shell also play the role in isolated of the external environment, such as dust, rain, and other small animals. The last shell also has the characteristic of the surface and the ergonomics, user-friendly, to protect the internal transport of goods.

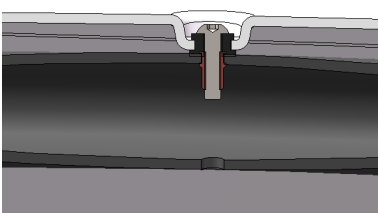
In order to ensure the feasibility of the production process, the convenience of installation, the product aesthetics and other aspects requirements, the whole shell of the quadricycle is divided into 10 parts. All using the thermoforming to fabrication, divided into: the roof, the rear bumper, left and right inferior shell, the rear shell, the intermediate shell, the anterior panel, the anterior shell, the seat shell, the battery cover and the charging plug cover. Depending on the purpose there are two types of material, one is the ABS + PMMA, Mainly used in surface aesthetics of the shell.

Another is ABS, applied on the shell that not to the aesthetics of the main purpose. After thermoforming a whole wall thickness of 3mm. However, prior to processing, a wall thickness of 5mm or 6mm, depending on the size and shape is determined.

image5.22 - the section of roof installation on the frame

5.8.1 Roof

The main function of the roof is to prevent rain water get wet the user and the internal cargo of the lateral drawers when they are open. And it fixed with the frame by screws. The roof using curved shape, in order to reduce the air resistance and guide the flow of rainwater on the roof, while can also provide the structural strength than the shape of the plane. On connection, the roof design the 4 grooves to connection the frame, in the



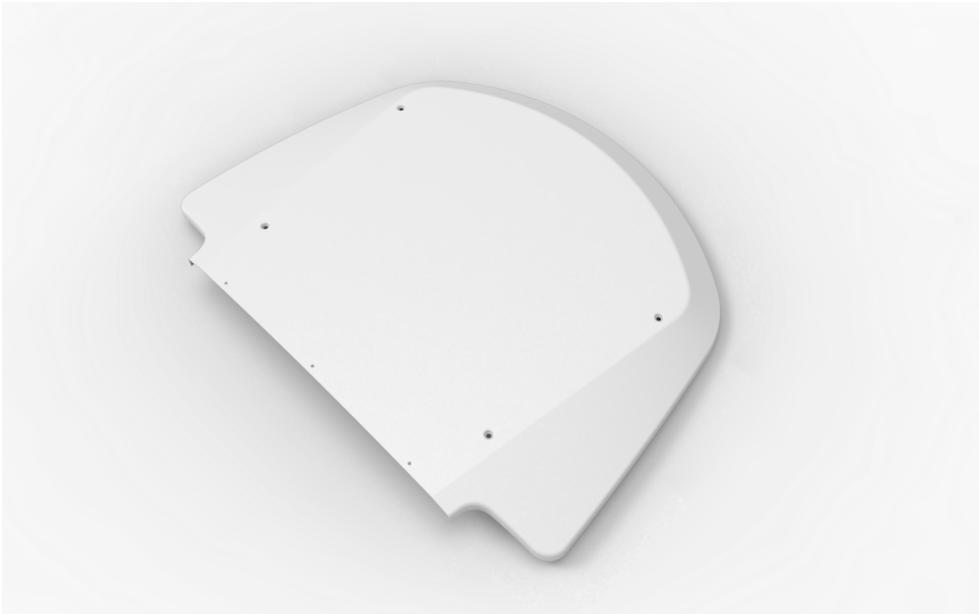
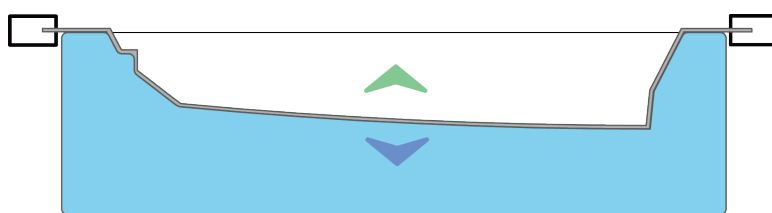




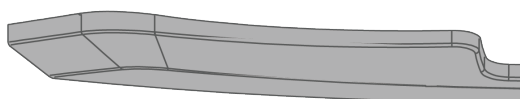
image5.23 - the roof

centre of the grooves is the hole what fitted the mounting hole grommets. They contact directly with the frame to avoid vibrations caused by tear opening on the hole. Only four mounting holes connected with the frame not all the roof, is for decreasing installation contact area to reducing unnecessary precision of the manufacture. Design a flange on the outside, the equivalent adding ribs, ensure the strength of the entire shell, not distortion. Overall draft angle of 1 degree. Prevent the undercut. Application manufacture are the thermoforming, cutting, drilling. Because the part is aesthetic, so the choice of materials ABS + PMMA. Can reach the surface of the bright and beautiful effect.

image5.24 - the manufacturing process of roof



-  atmospheric pressure
-  remove part



cut off edge

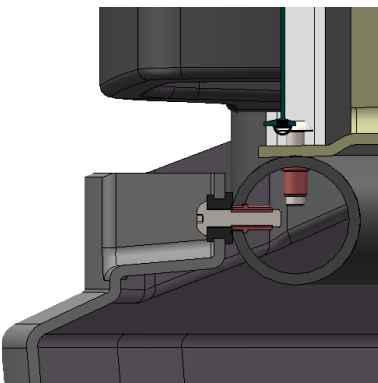
5.8.2 Rear bumper

image5.25 - the rear bumper

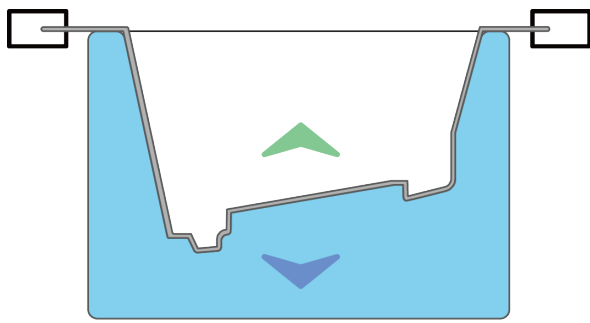


The function of the rear bumper is to protect the rear Internal parts and the rear wheel, to prevent the direct collision on the frame. The rear bumper and the frame is connected by screws, connecting the frame with a mounting hole grommets and the vehicle shell separated by. Among them, there are two gaskets, left and right ends due to limitations of size and installation method using conventional gaskets, the thickness 2mm, compared with other sets of hole. At the ends of the lift and right shell there are two rivet threaded, in order to facilitate installation the inferior shells. In connection with the left and right of the inferior shells, due to the installation of small size, but do not meet the release requirements, the need for plastic welding process.

image5.26 - the section of rear bumper installation on the frame

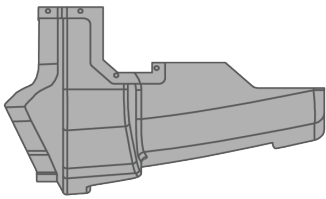


In the welding process, finished first overall details of the housing and welding the two shell butt welding plastic welding gun. Plastic shell of the main advantages of ultrasonic welding.

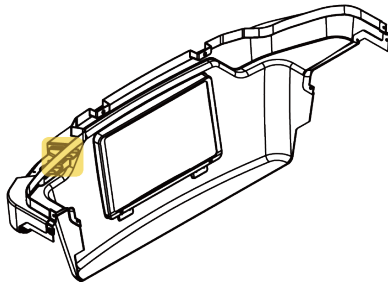


atmospheric pressure

remove part



cut off edge



plastic welding

5.8.3 Lateral rear shell

The shells are two symmetrical parts, the main function is to protect the rear wheel and internal structure, while giving the front of the intermediate shell the fixed position. This shell are

image5.27 - the manufacturing process of rear bumper

image5.28 - the lateral rear shell



fixed to the rear bumper and frame by screws.

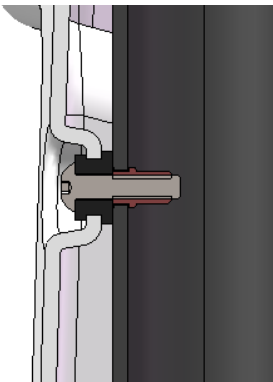
Due to the basic functions coincide with the rear bumper, so consider to becoming single shell. But in the design definition process taking into account the convenience installation and the rule of manufacture, the rear-inferior part is divided into three parts, facilitate after the wheel mounting further the shell installation. Is to convenient technical debugging the inside function parts. Using the same ABS plastic plate as the rear bumper. The draft angle for the thermoforming is 1 degree. Draft direction is perpendicular to the outer side.

5.8.4 Rear shell

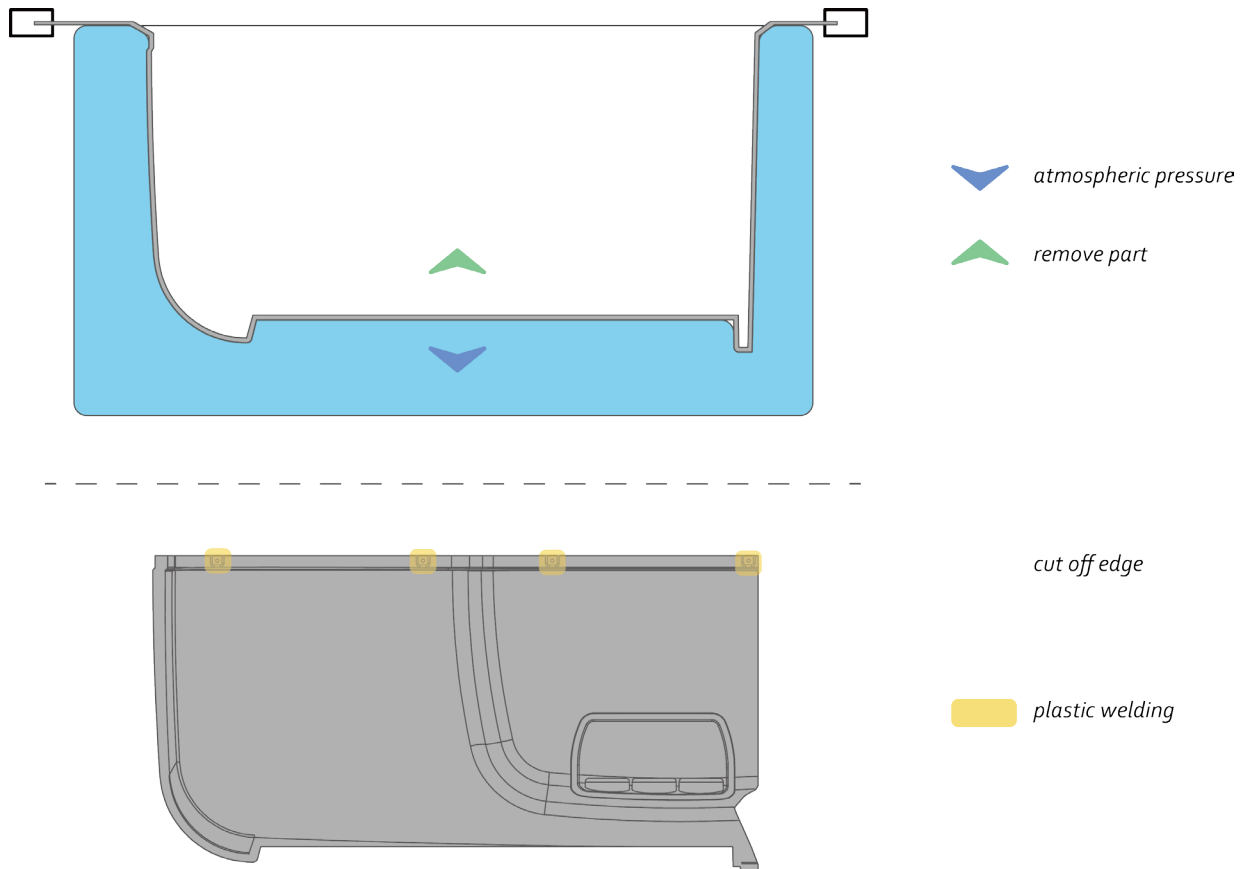
image5.29 - the rear shell



image5.30 - the section of rear shell installation on the frame



The rear shell is design to protect the three storage space. Prevent rain, dust entering and ensure the safety of goods. And connected the frame by screws, between them join mounting hole grommets and also connected to the roof by screws. In order to maintain the overall aesthetic, there is no direct connection between the rear shell and the rear bumper, just overlapping relationship, it is connected with the frame. Due to the need



to install light on the left and right of the rear shell, in order to enhance its strength, designed a shape to achieve a effect as ribs. Rear opening is to be able to overlap with the shutter doors. The material of rear shell is ABS + PMMA, the same material as the roof, play a beautiful effect. Draft direction is perpendicular to rear surface. Draft anglo is 1 degree. Due to the need to design the groove of the upper of shell to connected with the frame, can not be applied disposable for the thermoforming, the shape of junction require subsequent hot gas welding process.

image5.31 - the manufacturing process of rear shell

5.8.5 Intermediate shell

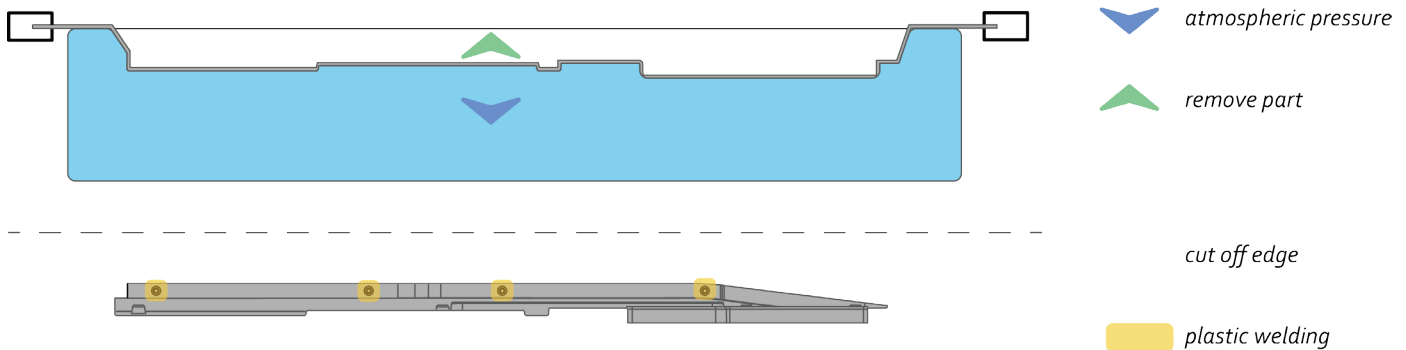
The intermediate shell and the rear shell are made a complete space, in order to protect both Left and right storage space. It is also connected to Left and right of the inferior shell. Protect the internal mechanical and electrical parts inferior. Designed a

image5.32 - the intermediate shell



hollow shape to facilitate overlapping with the door of the left and right storage drawers. Let drawer door is extrude. While adding seal between the shell and the door of drawer, to prevent rainwater from entering. The hollow shape of the centre is to be placed the seat cushions, the inferior opening can step aside of the frame and the electrical structure, to ensure the cable and the battery can pass through the shell.

image5.33 - the manufacturing process of intermediate shell



Connection mode is connection with the frame in the middle of the shell, at around connections with the left and right inferior shell and the rear shell.

The complex shape of shell in addition to design needs, also can play the effect of ribs to ensure the overall strength of the shell. Materials used ABS + PMMA, ensure beautiful and smooth effect.

5.8.6 Other shell

The anterior panel

The function is protect the front of the frame, and internal mechanical and electrical components with the anterior shell together, and internal mechanical and electrical components. On the anterior panel as well as a large number of operating parts. Allows users to intuitively understand the use of the operating parts, and these parts do not interfere with each other but also a effect of the anterior panel. Anterior panel has simple shapes, connected to the frame. The functions of opening as to be able to make the components exposed what interact with user such as switch of quadricycle, hand brake, handlebars, and brush glass water inlet. At the same time isolating these components, to avoid misuse or affect operation.

image5.34 - the section of intermediate shell installation on the frame

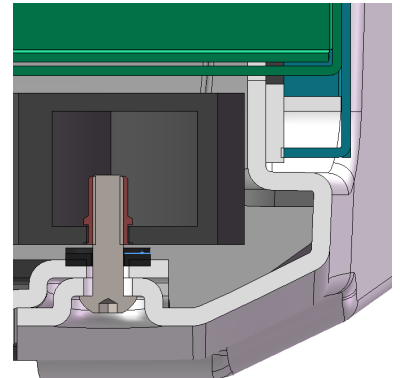


image5.35 - the anterior panel

The anterior shell

image5.36 - the anterior shell



The anterior shell is connected with the frame. There are lights and turn signals, wipers and other components on the shell. In order to increase the recognition of the product, can be placed the product logo in the center location. To design the left and right lights, comply with the statutory provisions, to ensure that the location and geometry of the headlight provisions.

The seat shell

image5.37 - the seat shell

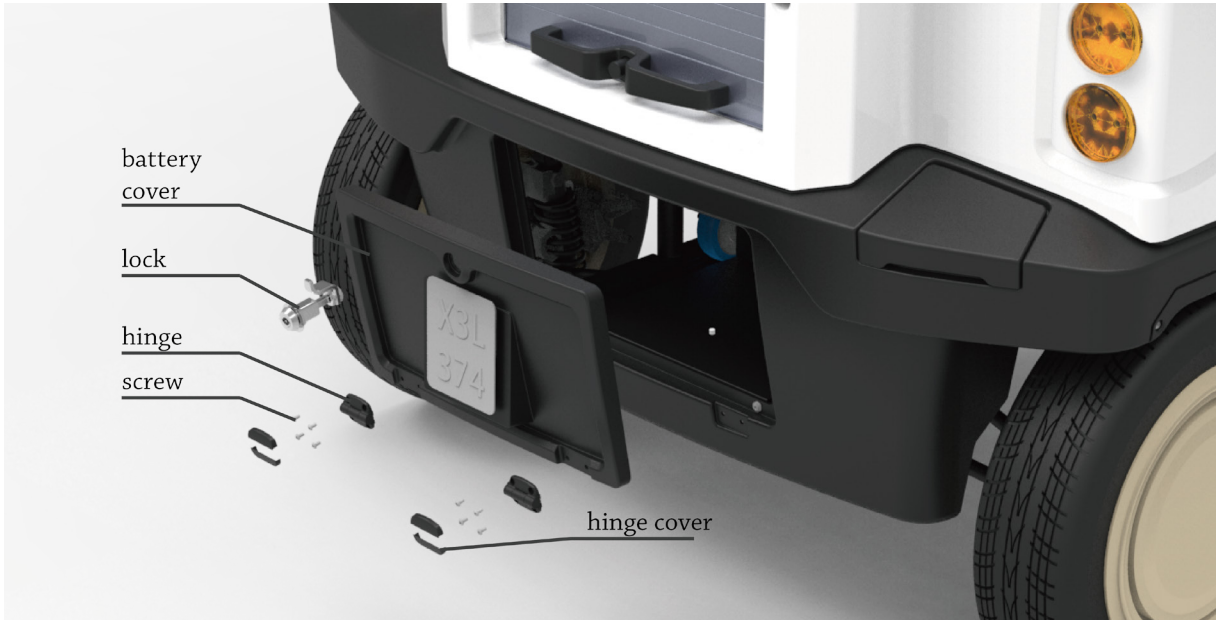


The seat shell is the final parts of shell to installation. Mainly to protect the internal electrical components, prevent rainwater and surface water into the electrical components and cause short circuits and other damage. While ergonomic, to ensure that size is easy to use. Connected by screws with the frame,

while overlapping relationship with the anterior panel and the intermediate shell, can better ensure that the internal seal.

The battery cover and the charging plug cover.

The battery cover



The battery compartment cover in the middle of the rear bumper, connection by the concealed hinges with rear bumper, can rotate. Also connected to the upper end of the rear bumper through the locks. It can be fixed cover. Ensure that the internal battery safety. Designs a protruding part, in order to install the license plate. Its mounting angle compliance with the law. It's easy to identify.

The lock is a rotation lock, rotated 90 degrees with a key, you can open, remove the battery pack.

Charging plug cover

Charging plug cover in the upper-right portion of the rear bumper. According to rule of the left-hand cars, generally parked in the right side of the road, the right side of the car is edge of the road, the edge of road can easily set up the charging device, so the charging head design on the right of the car, the

image5.38 - the battery cover exploded view

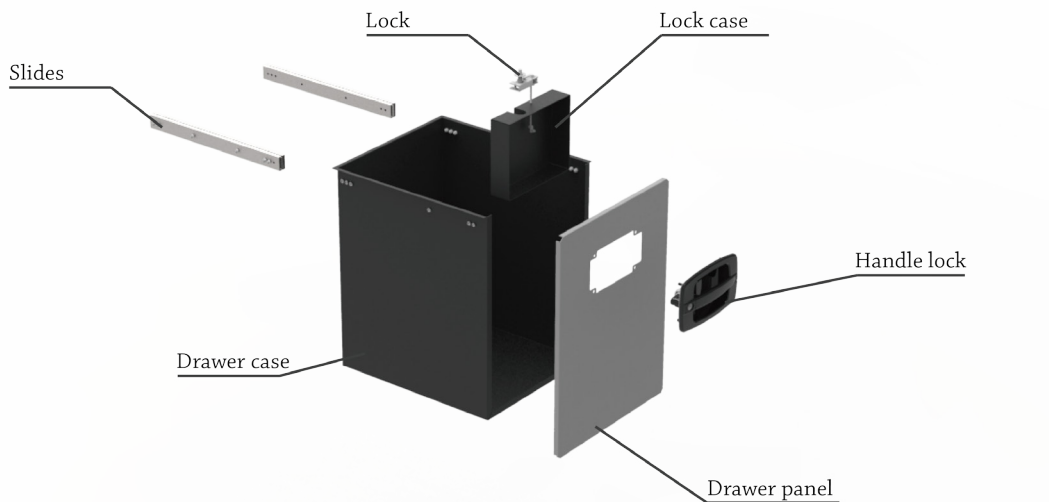


image5.39 - the charging plug cover exploded view

distance is nearest of the charging device. The charge plug cover is connected by the rear shell with the concealed hinges. Use this type of hinges in order to ensure they are internal, It can be integrated with the rear bumper. The charging plug cover fixed by screws with rear bumper. Because the charging plug fixed on the shell, can not be easily disassembled, therefore not designed a lock. Use the magnet to positioning. When the cover is closed, to maintain the closed state by a magnetic force. In order to prevent water from entering was added the sealing strip. Addition the fixed charge plug plane is higher than the opening plane to prevent water from splashing into.

5.9 Drawer

There are two drawers, left one and right one are the same. function is storage of goods. The drawer is connected by slides with the frame. When opened, the drawer can be fully extended to the vehicle body. Pick up the goods user-friendly. Drawer equipped with a handle lock, works like a car door. After opening the lock, pull the knob, opened the drawer, the drawer is pushed back into place directly after the locked position, unless the pull handle. Drawer dimensions 369mmx412mmx500mm.



Application material is carbon steel: S235JR. Manufacture for the laser cutting, bending, welding, galvanizing, painting.

image5.40 - the drawer exploded view

Install seal between the drawer and the car shell, when drawer closed the interior goods are isolated from the outside, to prevent wet package. In addition, both sides of the roof to the extension, prevent rain water when the drawer open.

Right-left sides of the loading space material is carbon steel, processing of bending and welding. The maximum cargo capacity of 14kg. Goods placed on the bottom surface, the force of 137.2N. After the analysis can be obtained, the overall

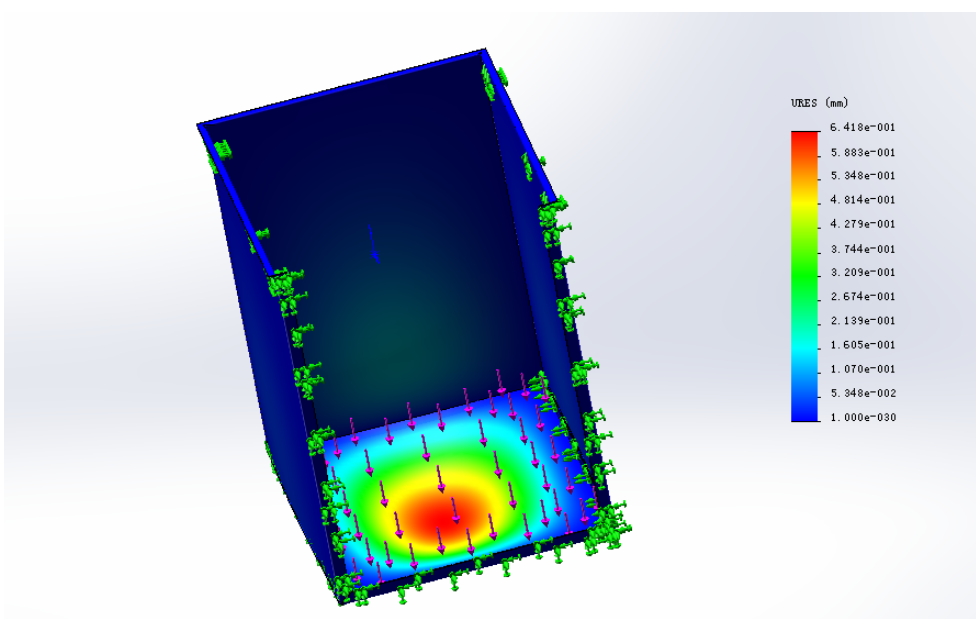


image5.41 - the finite element analysis of drawer

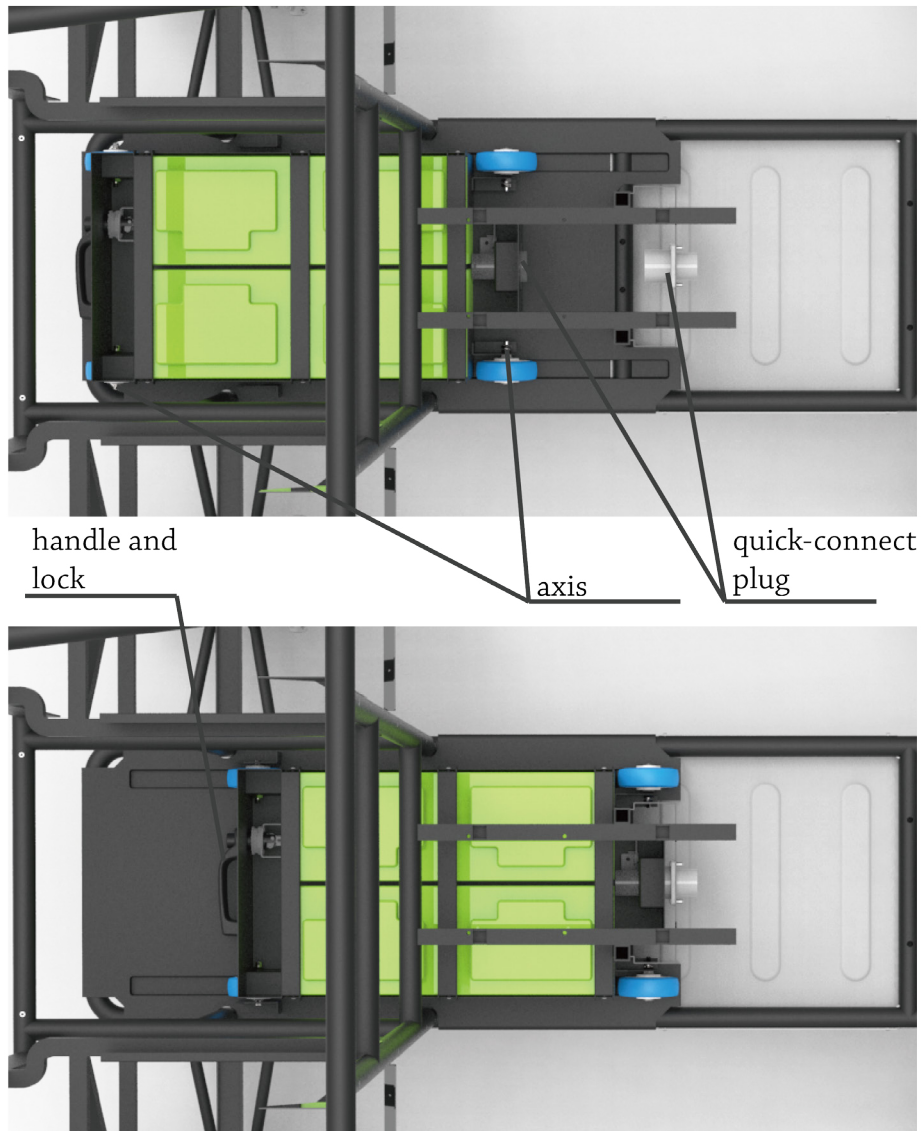
deformation of 0.6mm, as shown in FIG case the forces and deformation.

5.10 Battery

The battery with brand valence, the model is U24-12XP, its external dimensions: 260mm x 172mm x 225mm. Weight: 15.8kg. voltage: 12.8v. current: 110Ah. Composed using four in series battery pack.

Battery pack through quick-connect plug to connect with the vehicle, in order to fix the battery pack has the following steps:

image5.42 - the battery group



X direction by the handle and switch links, because each battery weighs 15.8kg battery packs weighing 63.2kg, in emergency braking situations acceleration is 3.7m/s^2 , $f = ma$ is drawn $f = ma = 63.2 \times 3.7 = 233\text{N}$.

So the battery pack in the case of emergency braking, by the force of 233N, handle switching system purchase from MISUMI, in the catalog, the authorized force load is 1000N, so can respond to emergency braking situations.

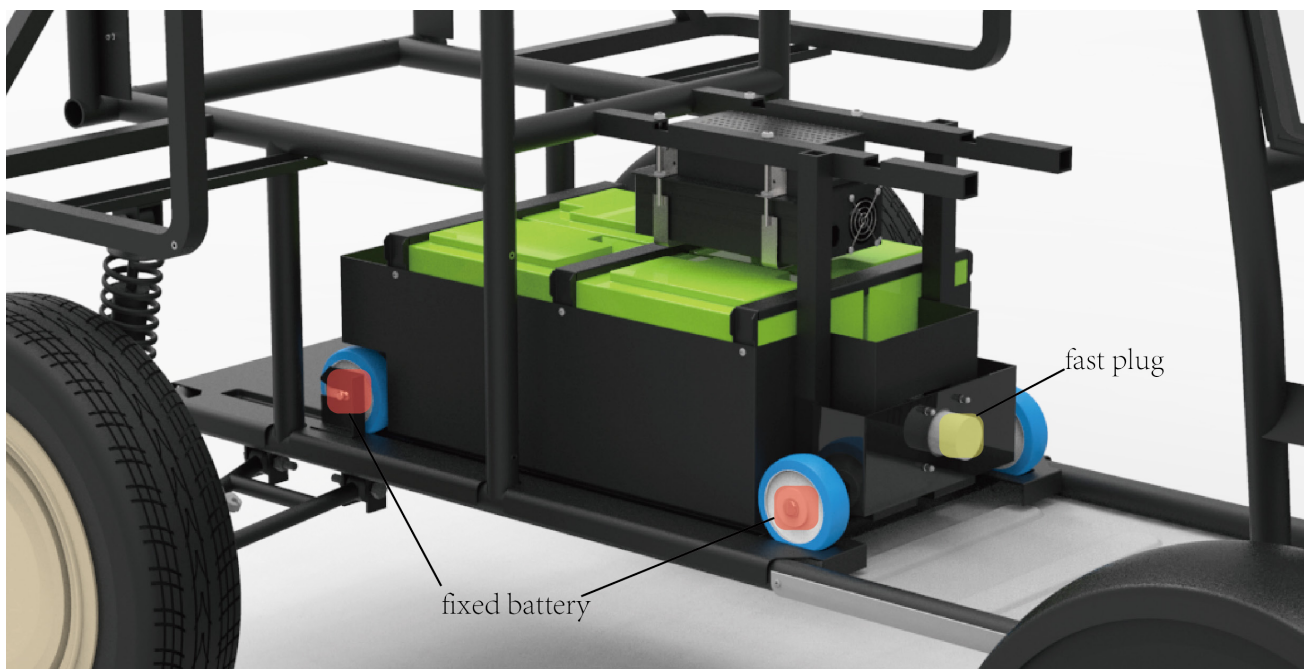
The Y direction is the vertical direction. Respectively four axes extend the battery box, the inside of the two front wheels extend, the rear end of the outer two wheels extended. When the battery reaches the position box, four axes respectively extend into the four opening slot. When the car encounters bumps up and down vibration during driving, each wheel shaft extension slots respectively receive a fixed role to keep the y direction. Calculate the force is: $f = mg$, y direction of the acceleration of gravity.

$$f = mg = 63.2 \times 9.8 = 619\text{N}.$$

There are four fixtures. Each of:

$$f = f/4 = 619/4 = 155\text{N}$$

image5.43 - the battery fixed



For fixing, the Z direction, That the positioning of the left and right directions. Also through to the extend of the wheel axis. Design a projecting part of the root of the axis, having a diameter larger than the diameter of the axis that inserted to the slot to fixed. At the same time, the end face of the fixing part connect with the protruding portion. When the vehicle is truning, through this part to control the stability of the battery box.

5.11 Repair

Repair is an important step of the product design. Throughout the all vehicle, there are shell and the internal structure two parts, the reason of damage is not the same. The main causes of damage for the shell generally is during the driving and parking get the collision and extrusion to caused the shell rupture and deform and the abrasion of daily use. After the shell damaged, it can be replaced again, because all the shell fixation with the frame for the screw connection, so can be repeated disassembly.

Causes of damage of for internal structure is more complex, in addition above to the damage caused by the collision, aging or

image5.44 - the vehicle repair case



short circuit of the electric internal components. In the repair process of internal structure needs to be removed to the protect shell, making repairs or replacement. As the image 5.44. The seat shell, the panel and seat are removed, then we can rapalce or fixed the part of internal.

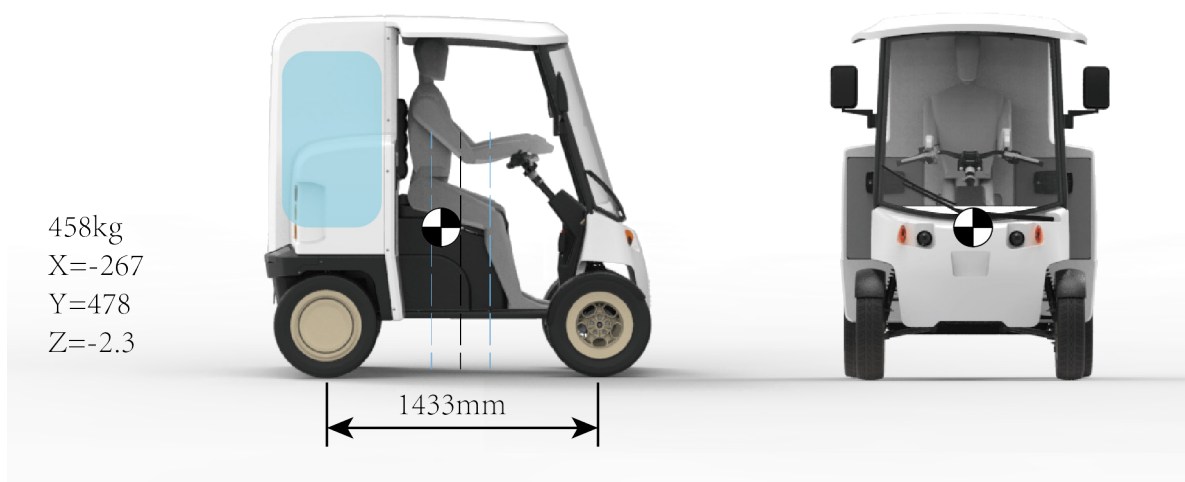
6. Force Analysis

In this process, the main analysis is the force on the wheel of the vehicle during the static and dynamic situation, already know the location of the center gravity, the overall weight and the wheel tread, though the formula the whole force summation equal zero and the whole moment summation equal zero to calculate the vehicle static and dynamic situation of the volume of the force.

Through the center gravity analysis can know that there are three kinds of vehicle load cases, in the case where the main analysis of the most extreme demanding: the full load.

At full load case of the vehicle weight is 458kg. The center of gravity position is X:-276mm, Y:478mm, Z: -2.3mm. As shown in image6.1. Front and rear tread width is 1433mm. The center of gravity to the ground height is 790mm. The center of gravity away from the front wheel center is 918mm away from the rear wheel center is 515mm. The rear wheel by the force F1 the front wheel by force F2.

image6.1 - the full load case



6.1 Static case

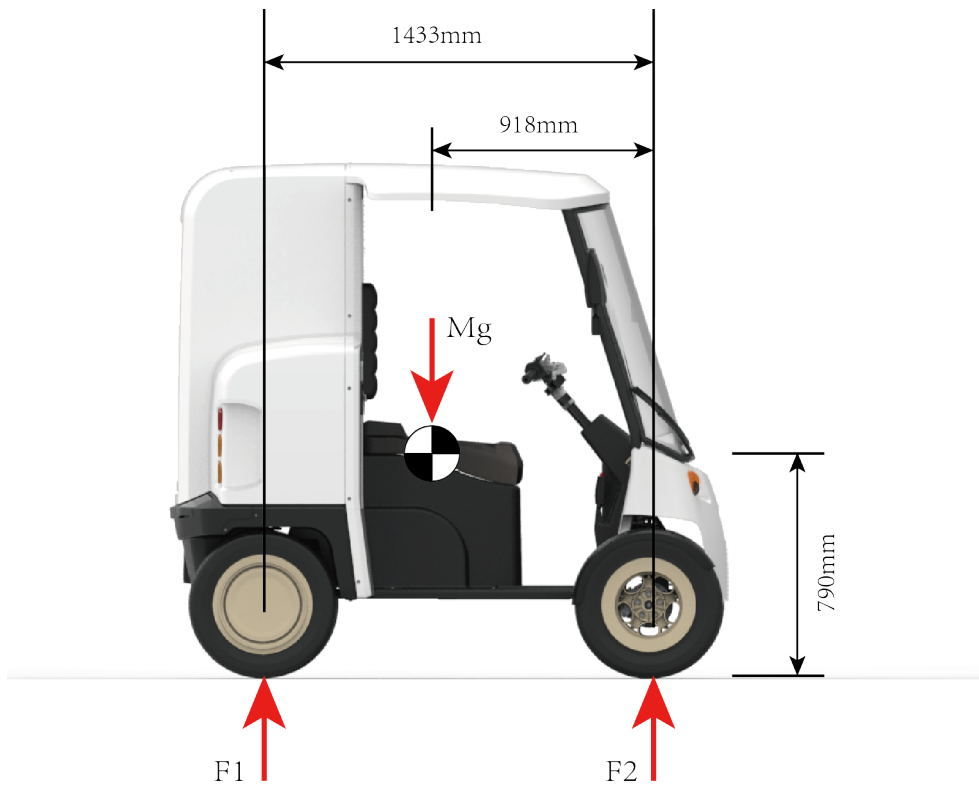


image6.2 - the force analysis of static case

In static state, the rear and the front wheels supportive force and the gravity summation equal to zero. Make the point of the front wheel contact with the ground as the point of origin, the moment summation equal to zero. and so:

$$F1 + F2 = Mg$$

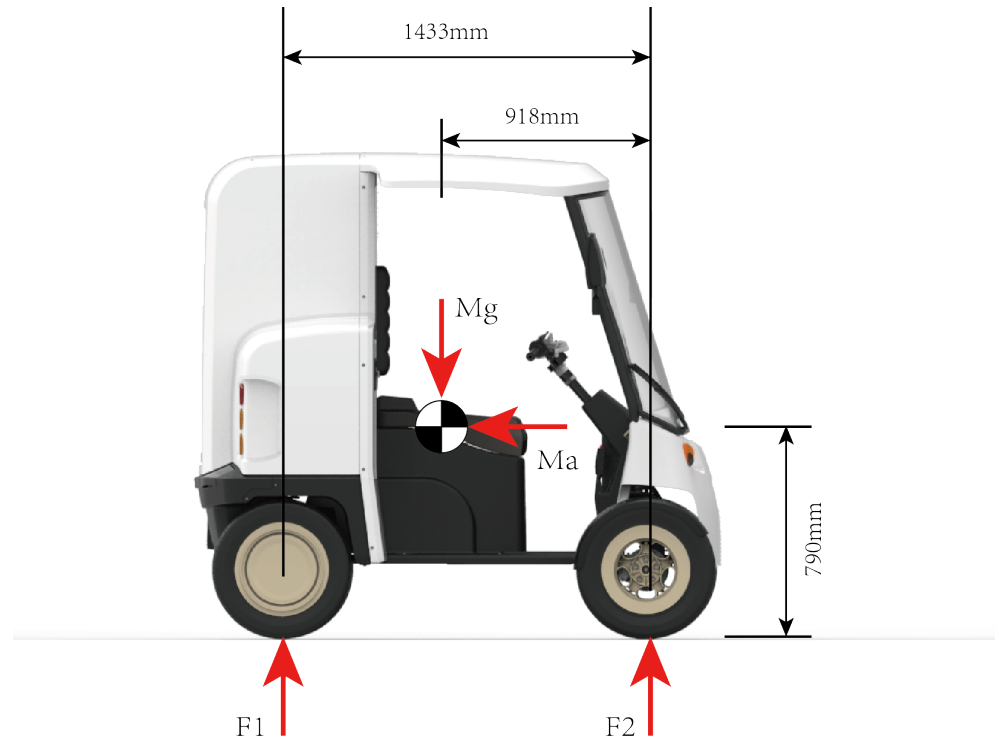
$$F1 \times 1.433 = Mg \times 0.918$$

Can get $F1 = 2875\text{N}$. $F2 = 1613\text{N}$

$F1$ and $F2$ more than 0

6.2 Acceleration case

image6.3 - the force analysis of acceleration case



In the case of acceleration, the force of the rear wheel is F_1 , the force of the front wheel is F_2 , the gravity is Mg , the direction of acceleration is forward, so the another force Ma direction is backward. as the image6.3 shows.

During acceleration condition tire friction with the ground situation as rolling friction. Sliding friction coefficient $\mu = 0.018$,
 $Mg \times 0.4 - 0.018 = Ma = 1714N$

$$a = 3.7m/s$$

According forces and moments summation equal zero :

$$F_1 + F_2 = Mg$$

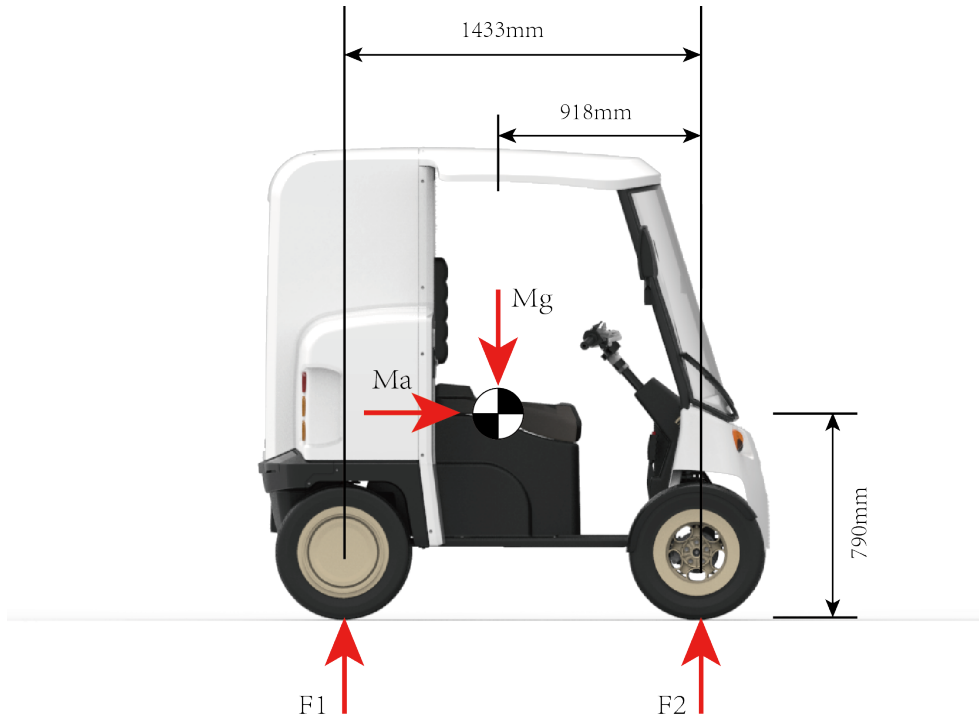
$$F_1 \times 1.433 = Mg \times 0.918 + Ma \times 0.79$$

Then get $F_1 = 3820N$, $F_2 = 668N$

F_1 and F_2 more than 0

6.3 Breaking case

image6.4 - the force analysis of breaking case



In the case of braking, the force of the rear wheel is F_1 , the force of the front wheel is F_2 , the gravity is Mg , the direction of acceleration is backward, so the force Ma direction is forward.

During braking, sudden death due to the tires, stationary, so the tire and the ground is sliding friction, wherein the rubber and the ground friction coefficient $\mu = 0.9$. Shows

$$Ma = Mg \times \mu = 458 \times 9.8 \times 0.9 = 4039\text{N}$$

According forces and moments summation equal zero:

$$F_1 + F_2 = Mg$$

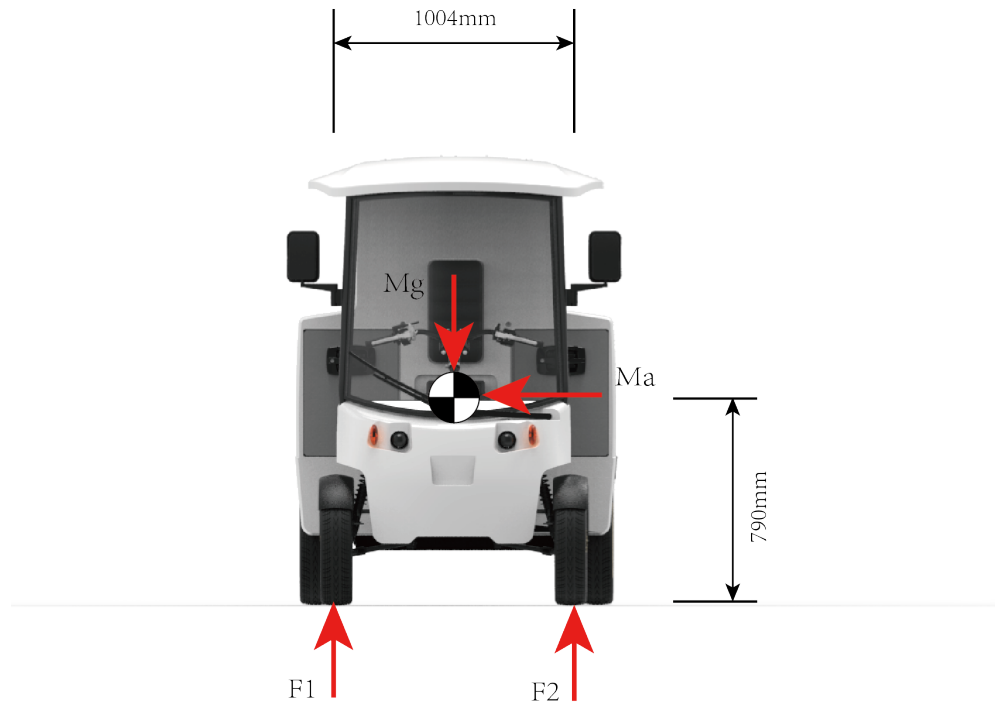
$$F_1 \times 1.433 = Mg \times 0.918 - Ma \times 0.79$$

get the $F_1 = 648\text{N}$. $F_2 = 3840\text{N}$

F_1 and F_2 more than 0

6.4 Turn a corner case

image6.5 - the force analysis of turn a corner case



When at the turn a corner situation. Since the vehicle received the force at the z-direction. So consider the case in the z-direction forces. The force of wheel on the left side is F1, on the right wheels is F2, the gravitation is Mg. On the situation of turn a corner there has a centripetal acceleration of the vehicle, so there are the force Ma, the forces are shown in Fig.,

Where two tire`s distance is 1004mm. Where the centripetal force is $Ma = Mv^2/r$.

At the highest speed situation, through turning at the minimum radius, to give the vehicle a top speed is $v = 40\text{km/h}$, the turning radius $R = 5\text{m}$. It can be converted out $v = 40\text{km/h} = 11\text{m/s}$. So the force $Ma = 11083\text{N}$.

According forces and moments summation equal zero:

$$F1 + F2 = Mg$$

$$F2 \times 1.004 = Mg \times 0.502 + Ma \times 0.79$$

$$\text{got the } F1 = -6509\text{N } F2 = 10998\text{N}$$

In this case, the force at one side of the wheel is negative, causing the rollover at the steering process, this maximum speed to turning the minimum radius of curvature of non-compliance.

Taking into account the limiting case, are set as follows: know the highest speed is 40km/h, obtaining a minimum turning radius, and known the minimum turning radius is 5m, obtaining the maximum allowable cornering speed.

$$F1 = 0N, F2 = Mg = 4488N$$

$$F2 \times 1.004 = Mg \times 0.502 + Ma \times 0.79 \text{ so } Ma = 2840N$$

$$\text{Case1: } v = 11\text{m/s}$$

$$Ma = Mv^2/R$$

$$R = Mv^2/Ma$$

$$\text{so get the } R = 19.5\text{m}$$

$$\text{Case2: } R = 5\text{m}$$

$$Ma = Mv^2/R$$

$$v^2 = Ma \times R/M$$

$$\text{so get the } v = 5.6 \text{ m/s} = 20.16\text{km/h}$$

These are just two limiting cases, and do not represent the general situation of the turning. But as long as the inequality:

$$\mathbf{v^2 < 6.2 \times R}$$

Ps: Wherein the unit of speed v is m/s

7. Conclusion

At the end of the project design development process, for this product starting from fundamental of the functionality and the usability to influences the aesthetics of the whole project. from this in-depth product design optimization that is after the “Laboratorio Di Sintesi Finale”, to make the light quadricycles electric accord with the characteristic of the home delivery services. Optimized the internal structure, realize the new idea to repale the battery quickly, to ensure the vehicle can continuous work and development the transport space. Redesign the vehicle shell exerior for protect the function parts to make sure the water can not into che vehicle. and accede to the design detail to play a greater effect of care for the user.

Now the home delivey service has a great demand of the market. In the future, the volume will be increase. In this design development process, propose one new concept that use the product -- the light quadricycles electric, to act on the home delivery service. It can get rid of the traditional energy for the urban environmental pollution, and excessive demand for conventional vehicles of urban parking systems. Thus can make some help and advance for the delivery industry.

Attachments

Applied materials characteristics

S235JR

s235jr lower carbon content of carbon structural steel, for welding, bolting, riveting structure more,

Material no. 1.0038

according to DIN EN 10025-2

Tensile strength class A

Usage

Suitability for coldforming such as bending, folding, bordering and flanging etc. can be ordered separately.

The user of these steel grades must make sure that his calculation, design and processing methods are appropriate for the material. The welding technique used must be suitable for the intended application and comply with the state-of-the-art. With distinctly closer chemical composition values and mechanical properties, the steel grades of the S235-S355 series are used as material for wheels of passenger cars, lorries and other vehicles.

- Chemical composition
- Mechanical properties
- Notch impact energy
- Available dimensions
- Welding

The steel grades JR, JO, J2 and K2 categories are in general suitable for all welding techniques.

ABS+PMMA

ABS+PMMA is a super high impact ABS with a top layer of high gloss PMMA (acrylic).

- Super high gloss surface finish
- Different stages of weathering performance solutions
- Easy to thermoform
- High impact strength
- Good thermal qualities

Suitable for demanding external automotive component parts which are exposed to UV light, and other tough industrial applications where a high gloss finish is required.

Physical properties:

Density 1.07

Mechanical properties:

Tensile strength at yield: 33 mpa

Tensile elongation at yield: >2%

Tensile elongation at break: 45%

Elastic modulus in tension: 2000Mpa

Flexural strength:55Mpa

Flexural modulus:2000Mpa

Izod impact, notched +23 °C: 23kj/M

Izod impact, unnotched -18 °C:20kj/m

Izod impact, unnotched -35 °C:10kj/m

Ball indentation hardness:77Mpa

Thermal properties:

Linear coefficient of thermal expansion (20-70 °C)

Vicat softening temperature B120:97°c

Heat deflection temperature HDT-A:86°c

Mould shrinkage:0.6-0.7%

ABS

ABS is a super high impact ABS with a semigloss surface that thermoforms quickly and effectively.

- Easy to thermoform
- High impact strength
- Good thermal qualities

In general where a high impact strength material is needed like machine covers, high demanding general purpose & indoor applications.

Physical properties

density:1.05

Mechanical properties

Tensile strength at yield: 33

Tensile elongation at yield:>2%

Tensile elongation at break:55

Elastic modulus in tension:1900

Flexural strength:55

Flexural modulus:2000

Izod impact, notched +23 °C:30

Izod impact, unnotched -18 °C:20

Izod impact, unnotched -35 °C:10

Ball indentation hardness:77

Thermal properties

Linear coefficient of thermal expansion (20-70 °C): 65×10^{-6}

Vicat softening temperature B120:97

Heat deflection temperature HDT-A:86

Mould shrinkage:0.6-0.7%

Hot gas welding

Hot gas welding, also known as hot air welding, is a plastic welding technique using heat. A specially designed heat gun, called a hot air welder, produces a jet of hot air that softens both the parts to be joined and a plastic filler rod, all of which must be of the same or a very similar plastic. (Welding PVC to acrylic is an exception to this rule.)

Hot air/gas welding is a common fabrication technique for manufacturing smaller items such as chemical tanks, water tanks, heat exchangers, and plumbing fittings.

In the case of webs and films a filler rod may not be used. Two sheets of plastic are heated via a hot gas (or a heating element) and then rolled together. This is a quick welding process and can be performed continuously.

Welding materials

There are two groups of plastic materials; thermoplastics and thermosets. The hot gas welding technique is only applicable to those plastic materials that can be heated and melted repeatedly, namely thermoplastics.

When a thermoplastic is heated, the molecular chains become mobile within the material and allow it to melt and flow.

Thermosets are a group of plastic materials in which the molecular chains form cross-links. These cross-links, formed by a chemical reaction, prevent the molecular chains becoming mobile when heat is applied.

Although many thermoplastics can be welded by this process, the most common are polypropylene, polyethylene, PVC and some fluoropolymers such as PVDF, FEP and PFA.

Extruded rod and sheet are the most commonly used raw materials for the manufacture of fabricated plastic products. It is of utmost importance when fabricating plastics that the welding rod and the sheet are of identical material and chemical type.

For example, although it is possible to weld polypropylene homopolymer to polypropylene random block copolymer, the strength of the weld will be reduced significantly. It is also important to check the quality of the welding rod prior to use, since air bubbles within the rod can form during the extrusion process. These will lead to voids in the weld. Welding rods will typically be either three or four millimetres in diameter.

Welding equipment

The equipment used for hot gas welding consists of an air supply, a handle with sturdy grip, a heating chamber with temperature control to produce the hot gas and a nozzle where the heated gas leaves the welding gun in order to heat the plastic rod and substrate.

A fan, either incorporated into the welding gun handle or positioned remotely and connected to the gun, provides the air supply. It is also possible to use compressed gas from bottles, for example, air or nitrogen.

Whichever gas supply is used, it is important that it is clean and dry, since dirt and moisture will contaminate the weld.

The gun temperature is set via a dial on the handle, with some welding guns showing the temperature of the air stream on a digital read-out also on the handle. It is good practice to measure the gas temperature consistently using a digital thermometer, for example, with the thermocouple tip placed 5mm inside the welding gun nozzle.

The front end of the welding gun allows interchangeable welding nozzles to be fitted depending on the type of welding needed.

Three nozzle types are most commonly used, the tacking nozzle, the round nozzle and the high-speed nozzle.

The tacking nozzle, as the name suggests, is used to tack the materials together before welding. The round nozzle allows the welder to heat the rod and substrate without physical contact

with either and is useful for welding in areas with difficult access.

This is less commonly used than the high-speed welding nozzle where the toe of the nozzle contacts the welding rod and allows the welder to put pressure on both the rod and the substrate material whilst welding.

Along with correct temperature, the pressure ensures that there is adequate fusion between the welding rod and the substrate material.

In addition to the welding gun, several tools are needed. These are a coarse tooth file, router and hand grinder for edge preparation, a scraper for removal of the material surface around the weld and a wire brush for cleaning the nozzle. Also, wire cutters are required for cutting the welding rod and a jigsaw for cutting the substrate materials.

Welding parameters

There are four main welding parameters in the hot gas welding process: temperature, pressure, welding speed and gun position. Since the process is manual, it is important that the welder has a good understanding of the need to ensure that all four of these parameters are correct and controlled during the welding operation.

Temperature is the most important of the four parameters, since the temperature at the interface between the rod and the substrate is not only controlled by the setting on the gun, but also by the gun travel speed and the gun position with respect to the substrate.

Typically, the temperature for welding is set between 80 and 100°C above the melting point of the material being welded. The gun travel speed is normally between 0.1 and 0.3m/min, again, depending upon the material being welded.

The welding pressure is applied via the toe of the welding nozzle

and is achieved by holding the welding gun grip firmly and pushing down into the weld. For round nozzle welding, pressure is applied manually from the welding rod.

The correct welding pressure is easier to achieve using welding guns with the fan separate to the gun since a firmer grip around the handle can be achieved. The force applied to the welding rod would typically be between 15 and 30N.

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