بسم الله الرحمن الرحيم

North Lebanon Automotive Systems

ANNUAL REPORT 2024

- **Investments 2022-2024**
- **Production of a Electrical 4-wheel transporter Tuk-tuk with solar system and Lithium Batteries**
- **Building of a Production Facility in Ras Nhache**

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Last Update: 25.12.2024 08:27

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Preface

This report contains details of our implementation of the 2023 NLAS project. The presented project is 4 Wheel E-TRACTUK Electric Tractor based on Tuk-Tuk chassis.

1 Planning&Controlling 2024

From Tuk-tuk Enhancement Oct-Dec 2023:

Planning Tuk-Tuk Enhancement 2 (Dec 23):

Stage 2: Production

Estimated Time: 6 weeks
Estimated Cost: 750$

1. Production Plan

- **Manufacturing Process:**
  manufacture the new chassis with the new solar roof.
- **Request the components:**
  Request and buy the components from the chosen provider
- **Assembly and Quality Control:**
  Assembly procedures and quality control checks.

2. Testing and Quality Assurance

- **Testing Procedures:**
- Testing the alignment of the over all chassis and parts assembled.
- Testing the suspension performance (noise when driving, drifting left or right, spring and shock absorber reaction in rough roads, brake disk friction).
- Driving range with new batteries.
- Solar panels output power.
- **Quality Assurance:**
- Welding quality performed on the chassis (Lack of uniformity, cracks down the middle of the bead, too thin, and/or a lack of discoloration of the parent metal).
- Painting quality (Dried Dips, excessively sprayed, color mismatch, splotchy Stains).
- No sharp angle in all the vehicle chassis and cover.

3. Stage Tasks

Task	Deliverables
Chassis manufacturing	The chassis
Roof manufacturing	The roof
Components assembly	Vehicle on the road
Prepare the official papers needed for the license	Needed papers

4. Stage extra Cost

- Manufacturing Costs: <specified after stage 1>
- Materials: <specified after stage 1>
- Labor: <workers who may be used when needed>

Project Risks and Mitigations

- **Supply chain disruptions**
  Mitigation: maintain the readiness of another supplier and purchase 2 pieces of all components
- **Technical challenges**
  Mitigation: Hire a specialized person
- **Regulatory hurdles**

2 Introduction

We have several positive aspects of this project:

1. Mechanically: The tuk-tuk with solar cells has good driving power and is easy to maintain. They were able to achieve more durability after new mechanical modifications. After changing to 4 Wheel tuktuk we have more safety and grip.
2. Electrically: Simply charge the battery and check the battery acid level and it works without motor, heat and noise.
3. Health: Without any pollution, which provides a clean environment.
4. Practically: The transportation is comfortable with more features for your comfort. You have more space for the driver than a traditional tuk-tuk. The way it rotates makes it easier to control as well.

3 Investments

4 E-Transporter Summary

E-Rapid Report

Completing the journey of development and enhancement of the E-rapid to reach an innovative product.

1. Introduction:

The E-Rapid is an Electric Vehicle that is meant to transport goods within cities. This E-rapid is a rear-wheel-drive vehicle that is fully electric, it is powered by an advanced solar system that assists the vehicle to charge.

1.1. Brief Timeline recap of the development of E-transporter:

- Assembly of E-tuktuk
- Designing and manufacturing of solar panel system
- Installing new front suspension with two wheels

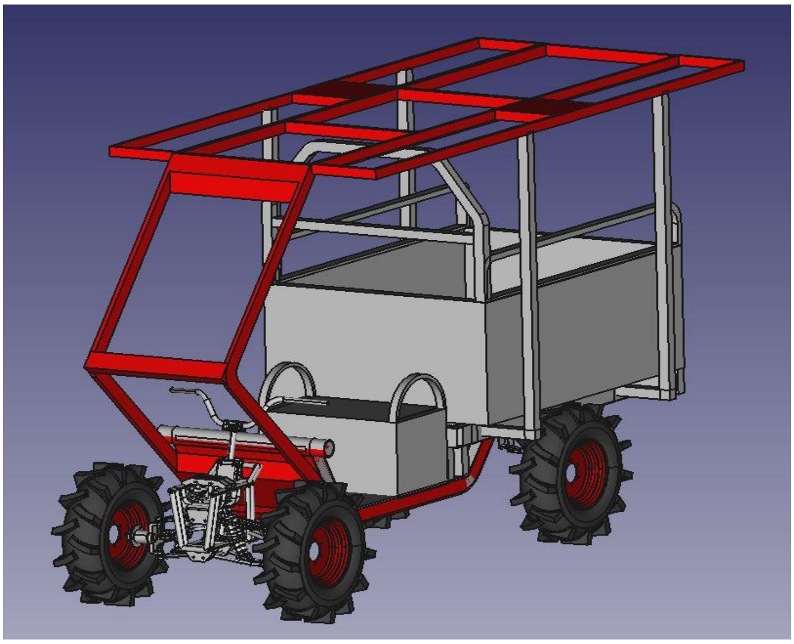


Fig. 1. E-transporter final design [1]

1.2. Current specs of the E-transporter

- Batteries a series of five 12V Gel batteries sums a 60V cell of 45.2 Ah.
- Electric motor a brushless DC motor (BLDC) of rated voltage 60V, power 1000W and 3000 rpm.
- Controller offers reversing, 3 speed shift, over temperature protection.
- Solar system consists of 5 solar panels of 100W with an inverter that is directly connected the charge the batteries when possible.

2. Recommendations for the final E-rapid product:

- Improve front suspension weldments.
- Replace the oil wheels (smoother threads)
- Install Li-ion batteries and increase their capacity
- Improve solar system installation (wires and inverter)

2.1. Improvements descriptions:

1. **Front suspension** that was added to the vehicle to maintain 2 wheels, has loose connections and weldments. To increase its quality and performance, advanced FEM simulations should be drawn out to check its viability, it may need some optimizations in its design.
2. Current **wheels** are the agricultural use, for asphalt use smoother thread wheels to decrease loses.
3. Wires and the inverter of the **solar system** can be packed in a better and safer way.
4. Installing **Li-ion batteries** is a just winning step since the vehicle will be lighter and has batter range.

Mass rough estimation of Li-ion batteries according to its energy density:

Assumption if the lithium batteries will have the same specs the current gel battery of 60 V and 45.2 Ah.

Lithium-ion batteries energy density is between 200-300 Wh/kg [2]. The energy of the battery is its voltage by capacity that implies 2700 Wh. The mass of the battery is its energy over materials energy density, the minimum energy density will be used of 200 Wh/kg. The rough estimated mass is 15 kg, for sure that an error margin depends on the material used.

$$Mass = \frac{Energy\ Density}{Energy} = \frac{200Whkg}{2700Wh} = 15kg \quad (1)$$

According to this mass gain we can increase the capacity/range.

3. conclusion

Optimizing the current E-transporter to reach the ideal stage of performance and quality takes our product to the market-ready status. This includes the enhancements of the key variables like range, battery efficiency, drivetrain performance and overall satisfaction. By doing so, we can confidently introduce to the market our E-Rapid

References

1. NLAS ANNUAL REPORT 2023

2. Energy, T. S. (2023, July 14). Lithium ion batteries: energy density?

5 Technical Issues from Development of E-Transporter Prototype 2022-2023

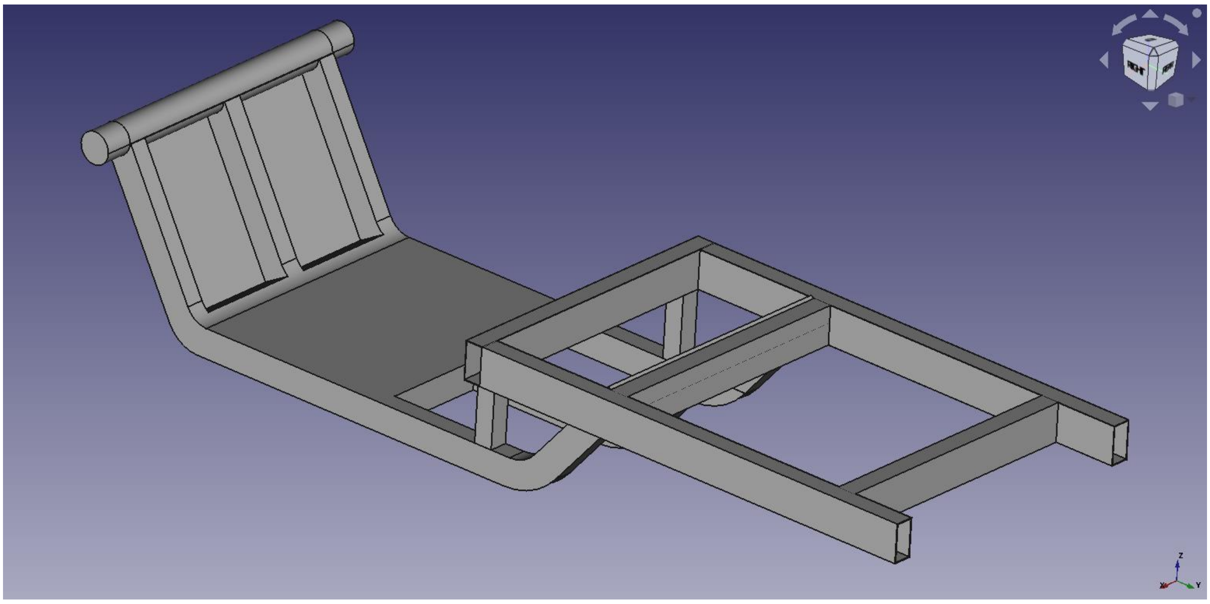
5.1 System Design

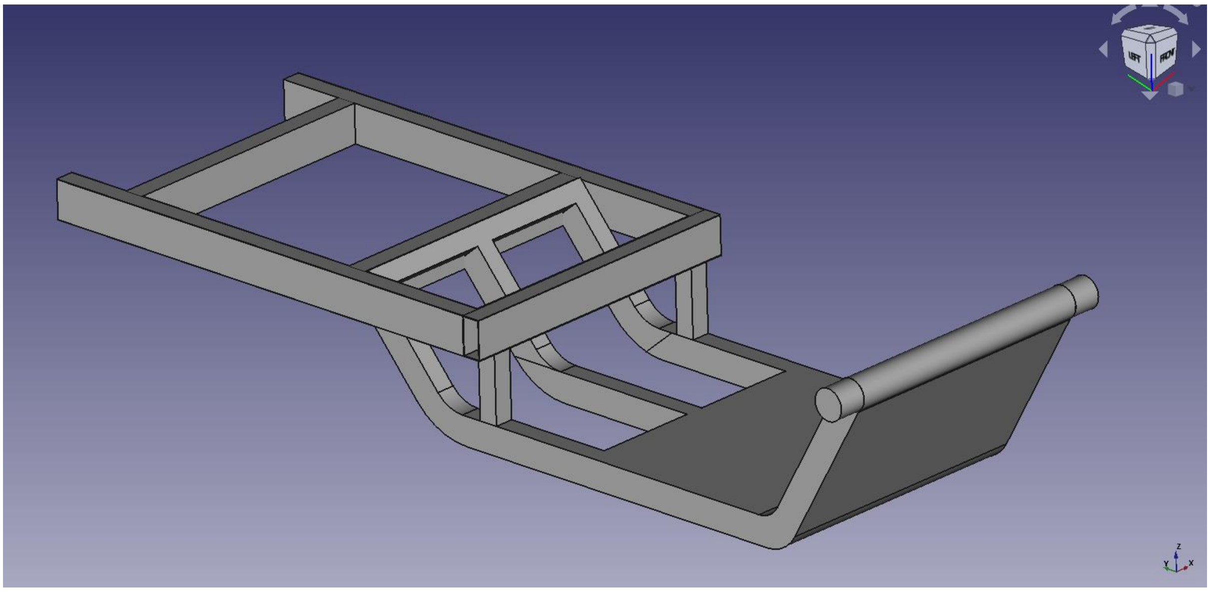
We radically modified the design on the front side, after conducting several experiments on the previous version of Tuk-tuk. We found a problem with balance when driving, and after checking we discovered that it was due to the front wheel. So, we replaced the old one-wheel budget, with a two-wheel budget ATV, with some modifications to fit the Tuk-Tuk chassis.

5.2 E-Tuktuk Mechanical Design

5.2.1 Chassis

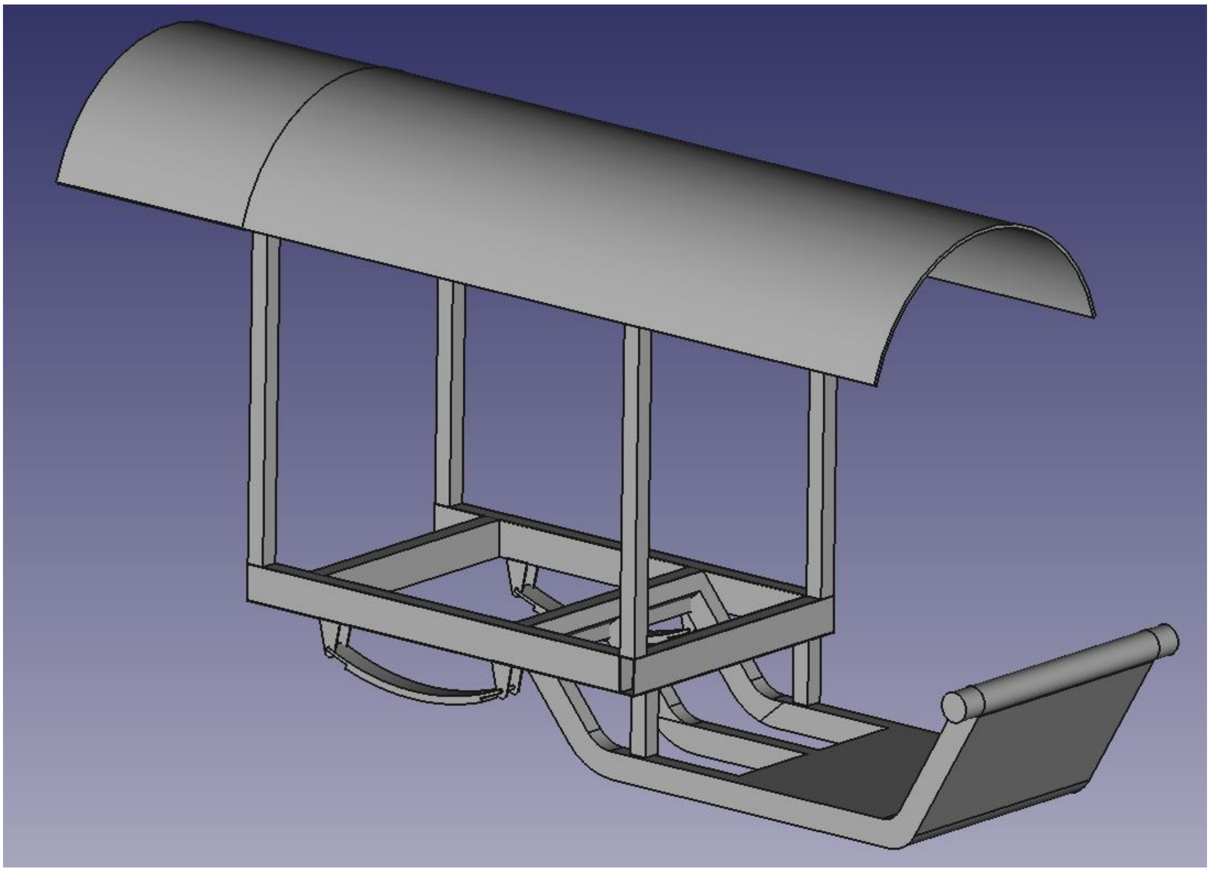
5.2.1.1 E-TukTuk FreeCAD Drawing



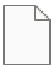


Tbd: Chassis 2D drawings

17-11-2022:



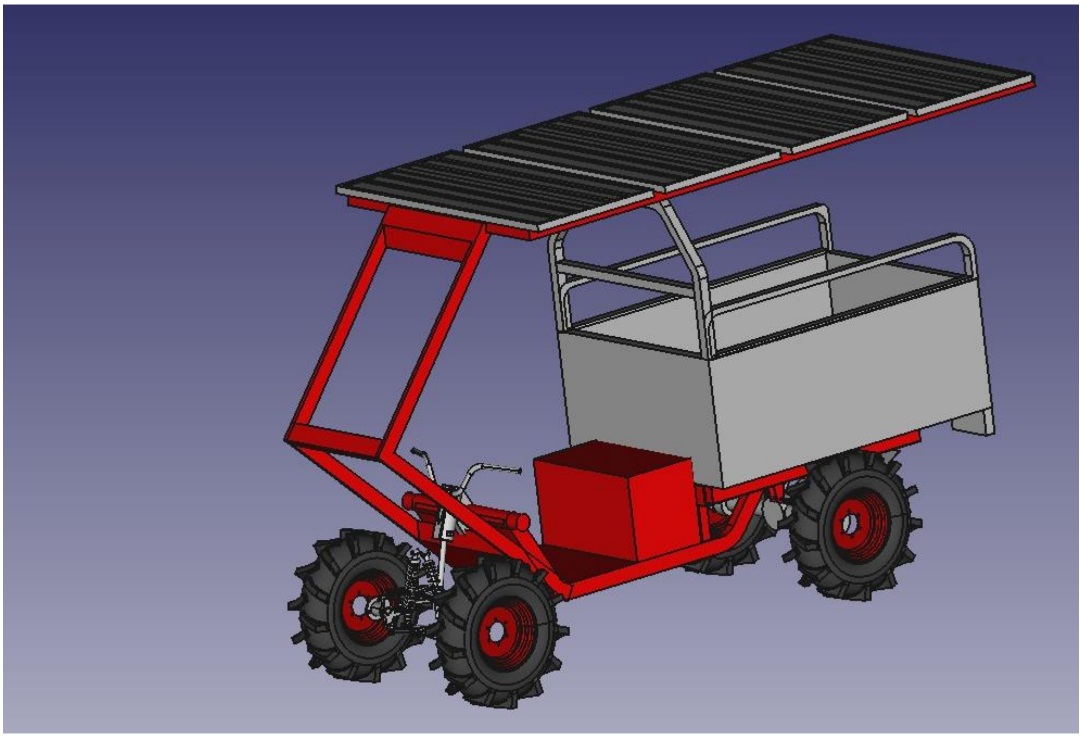
E-TukTuk FreeCAD Drawing
E-TukTuk FreeCAD 24-10-22



17-11-22
E-TukTuk.FCStd

5.2.1.2 Mechanical Realization

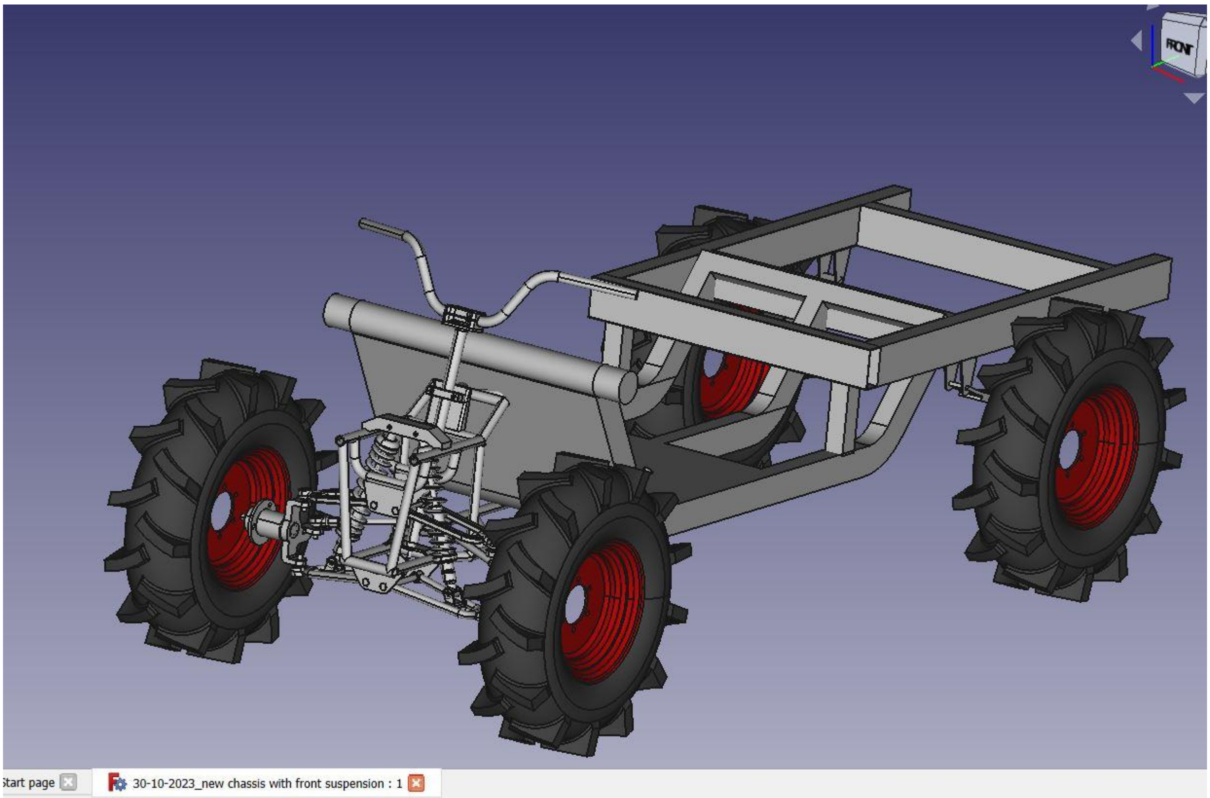
5.2.2 Chassis design (Oct-Dec 2023)

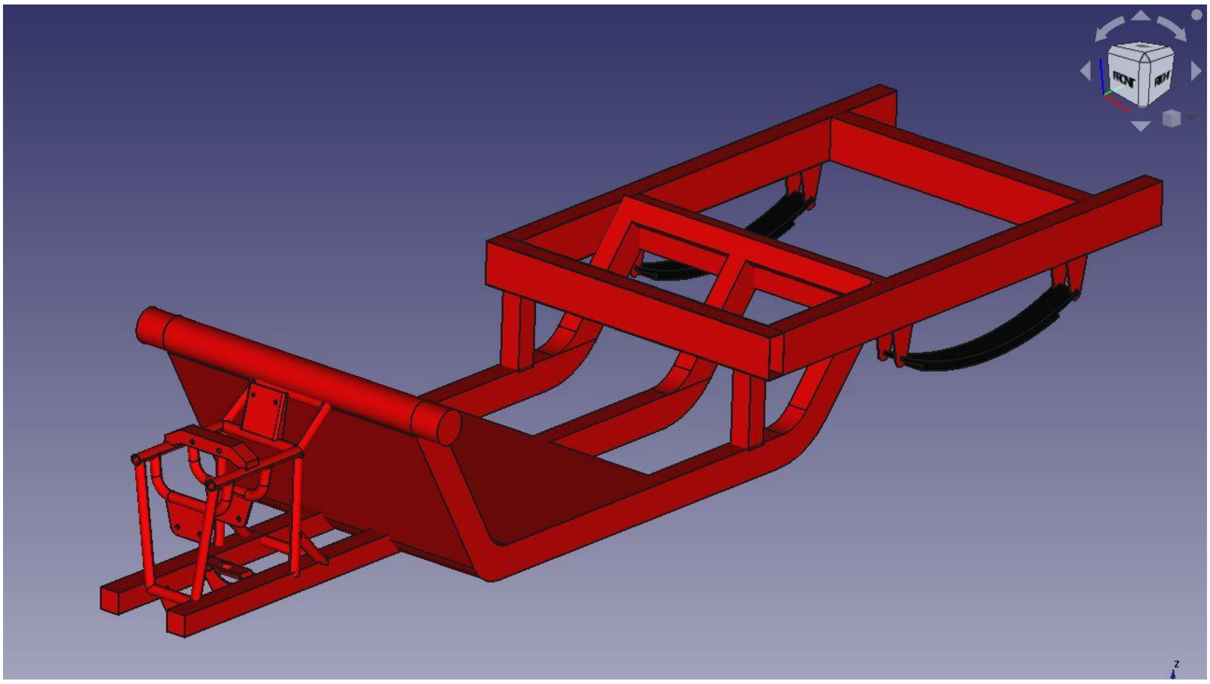


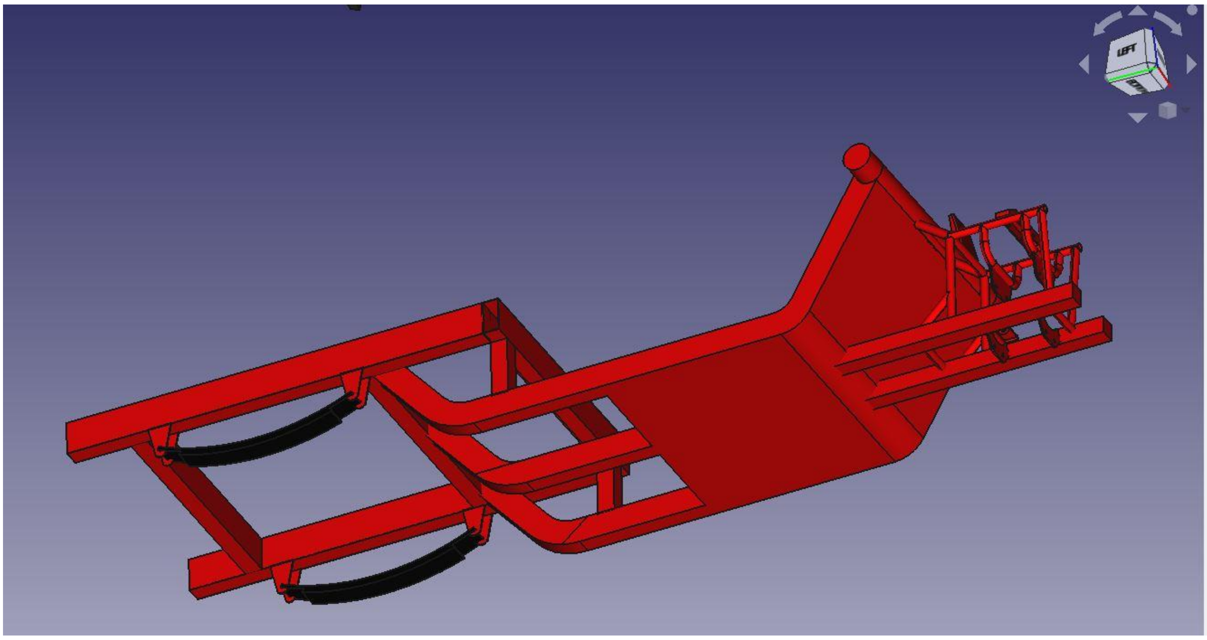
FreeCAD design of new chassis (21.10.23) :

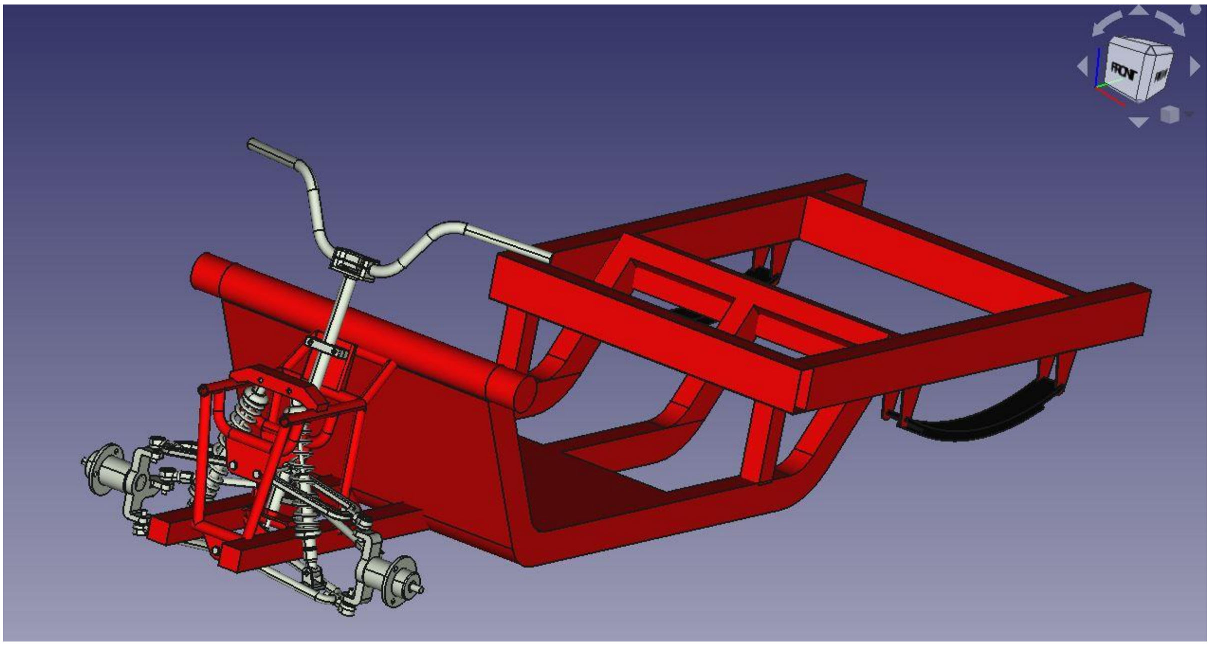
21-10-23
E_TukTuk.FCStd

5.2.2.1 Chassis









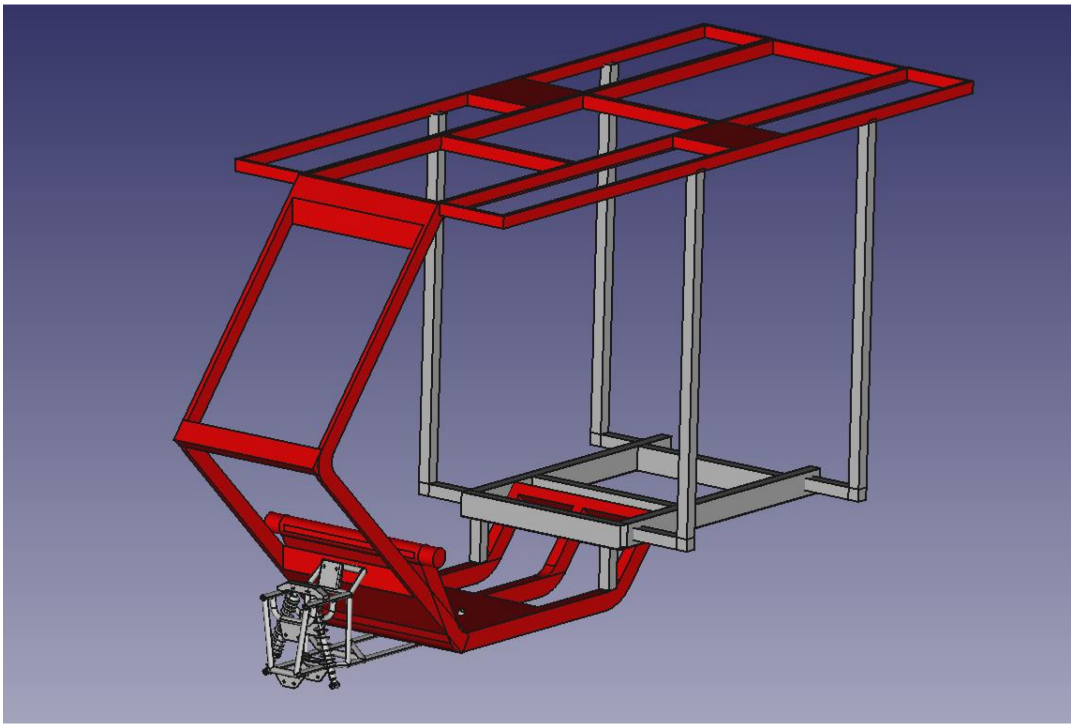
FreeCAD design 7-11-2023_new chassis with front suspension:

7-11-2023_new
chassis with front susp

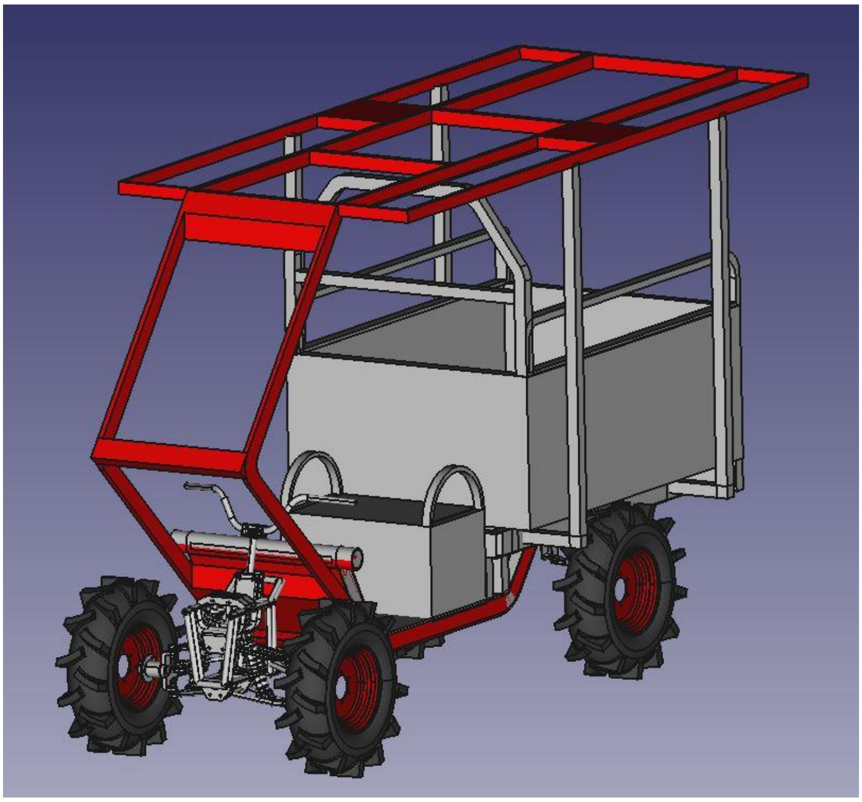
FreeCAD design for solar panels stand:

[31-10-2023_solar panels stand new]:

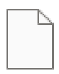
31-10-2023_solar
panels stand new.FCS



5.2.2.2 Assembly of new chassis and solar panels stand (Version Oct 2023)



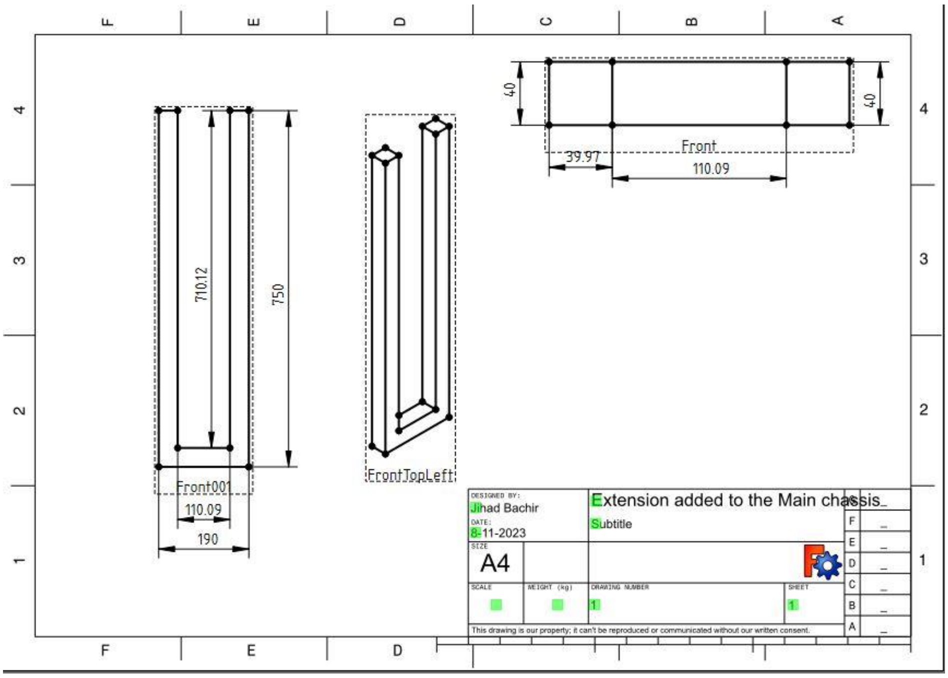
31-10-2023_new assembly chassis with front suspension and solar panels:



31-10-2023_new
assembly chassis with

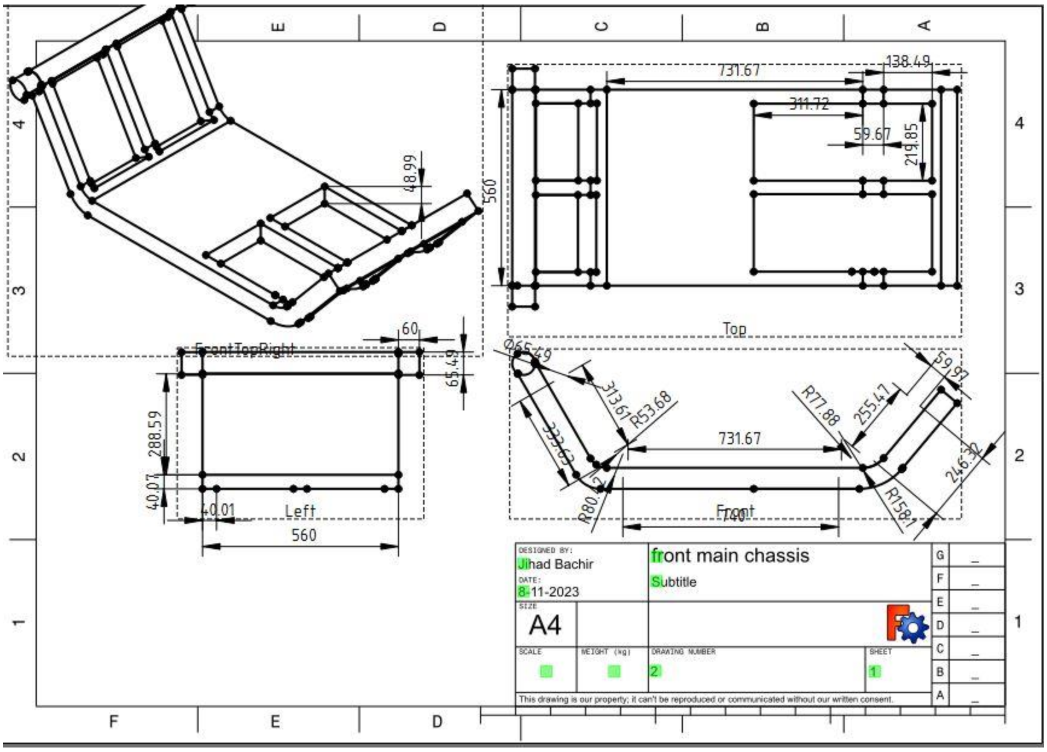
2D Parts Drawings:

Extension link from front suspension to main chassis



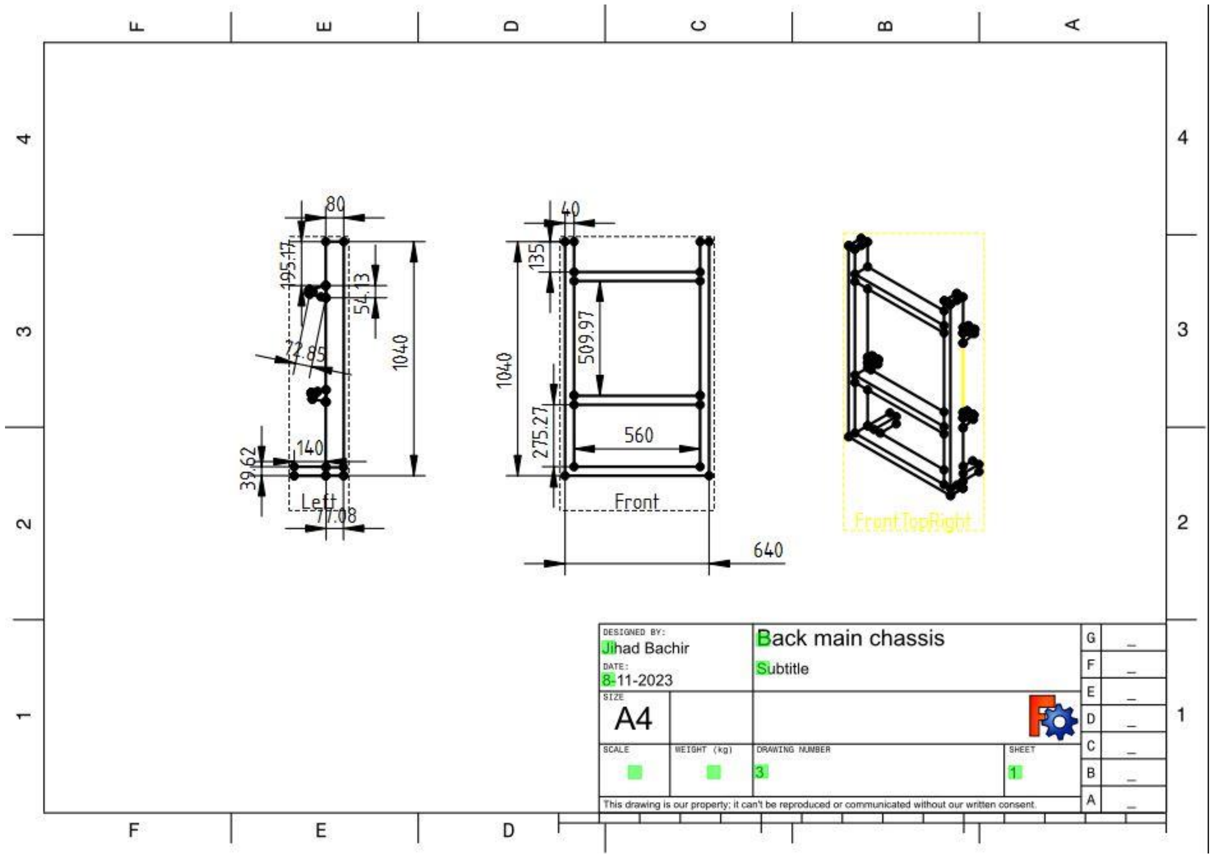
FreeCAD 2d and 3d drawing of the extension link between front suspension and main chassis :	8-11-2023_extension link from front susper

2- Front main chassis:



2D and 3D drawing and techdraw for the front main chassis design :	8-11-2023_front main chassis 3d and 2d.FCS

Back main chassis:



[2d and 3d drawing of the back part of the main chassis]:

8-11-2023_Back main chassis 3d and 2d.FCS

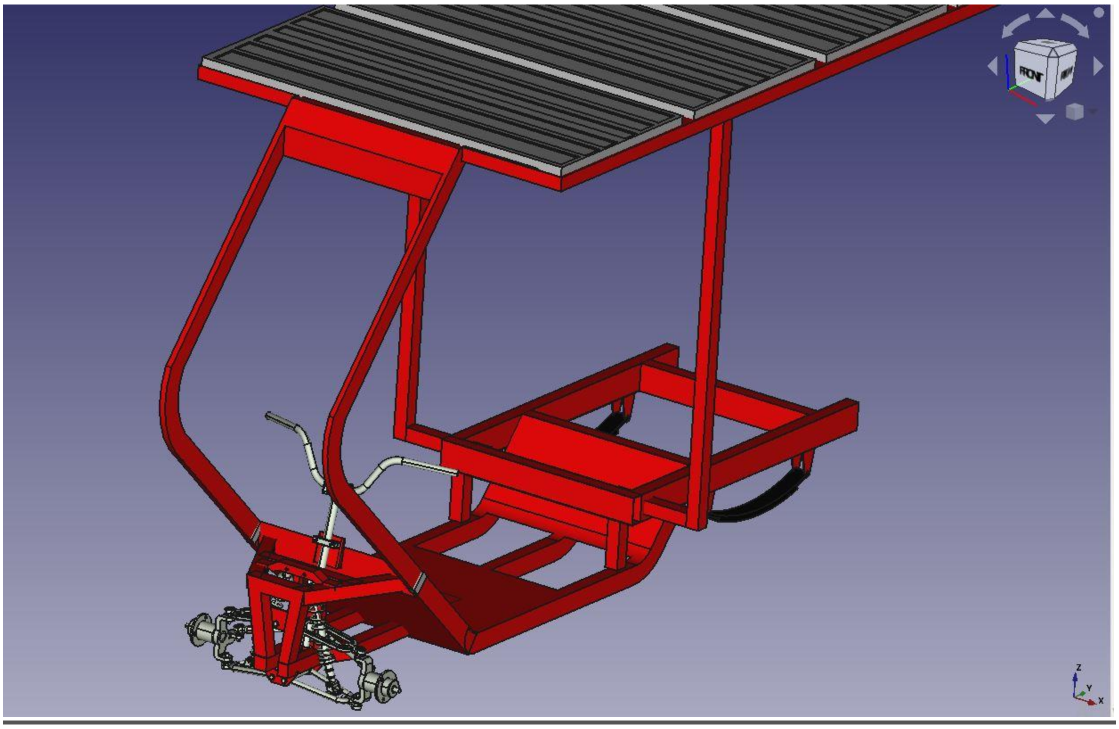
Excel sheet for all vehicle components

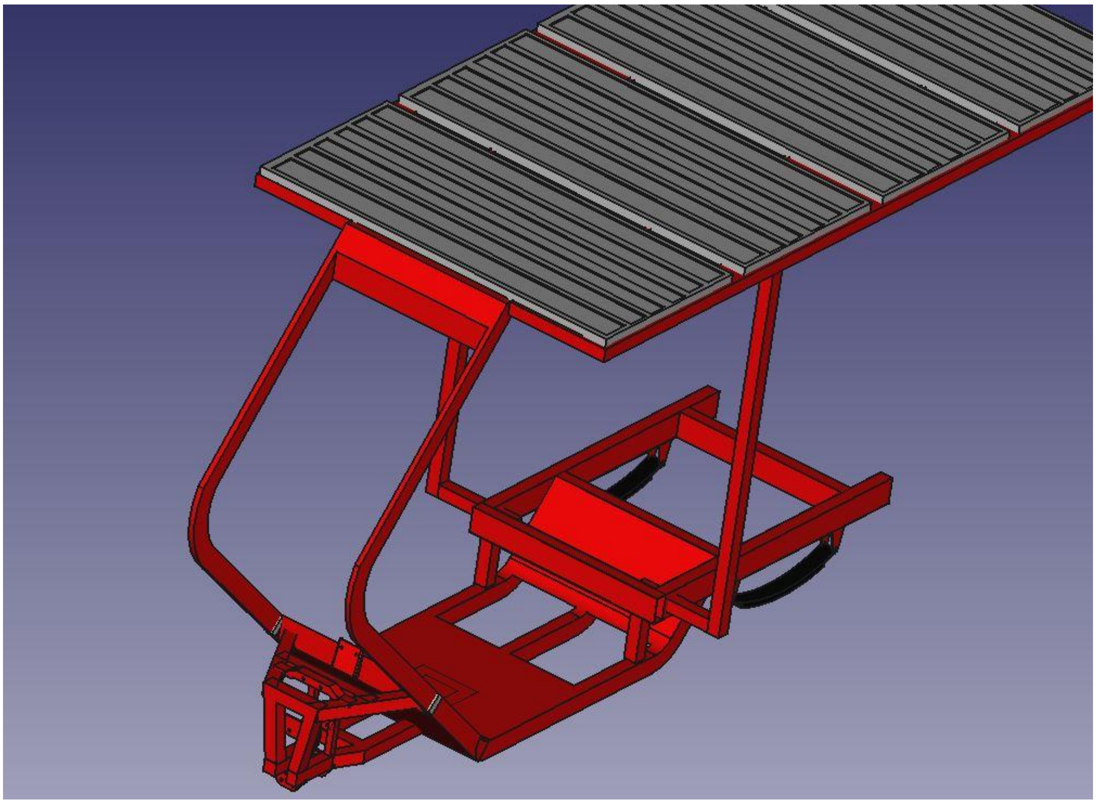
Excel einfügen

[31-10-2023_vehicle components list]

5.2.2.3 Chassis Version 7 Nov 2023

The new chassis and solar panel stand costs 500$ including material and labor work fees

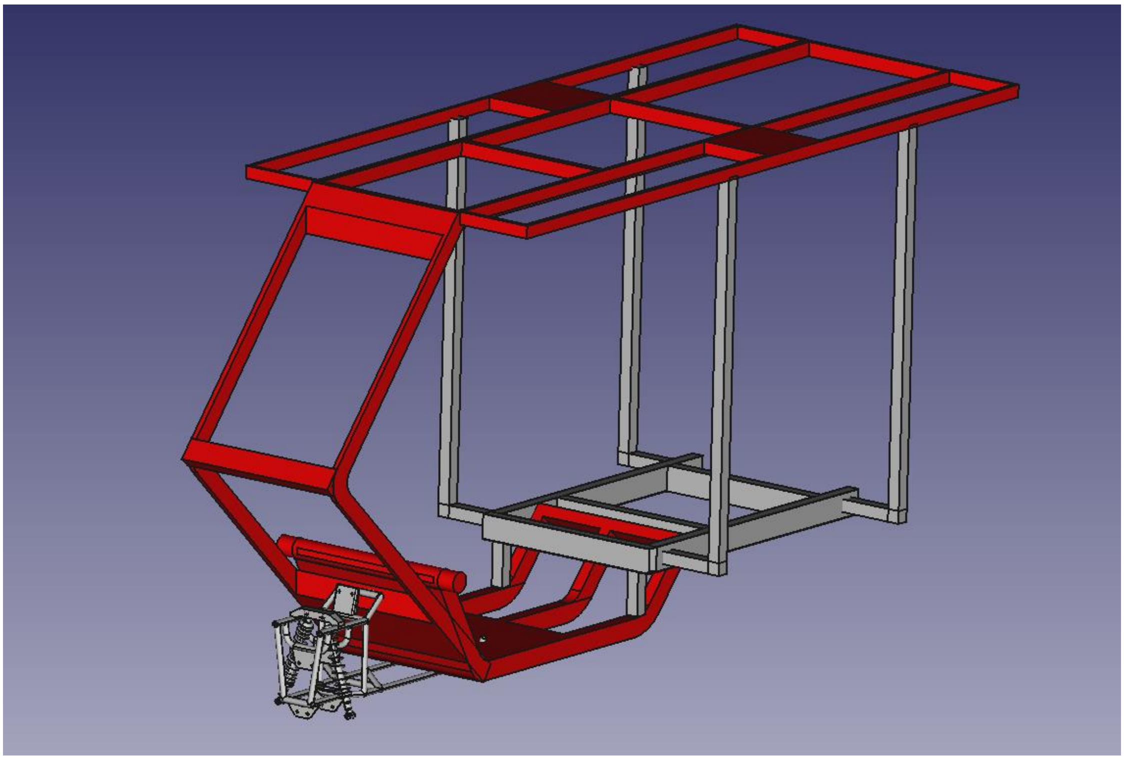




[FreeCAD design 3-1-24_NEW tuktuk chassis with solar panel stand]

FreeCAD design for solar panels stand:

[31-10-2023_solar panels stand new]



5.2.3 Front axis

5.2.3.1 FreeCAD Drawing

3D tbd

2D tbd

5.2.3.2 Mechanical Realization

tbd

5.2.4 Front Wheels

5.2.4.1 FreeCAD Drawing

3D tbd

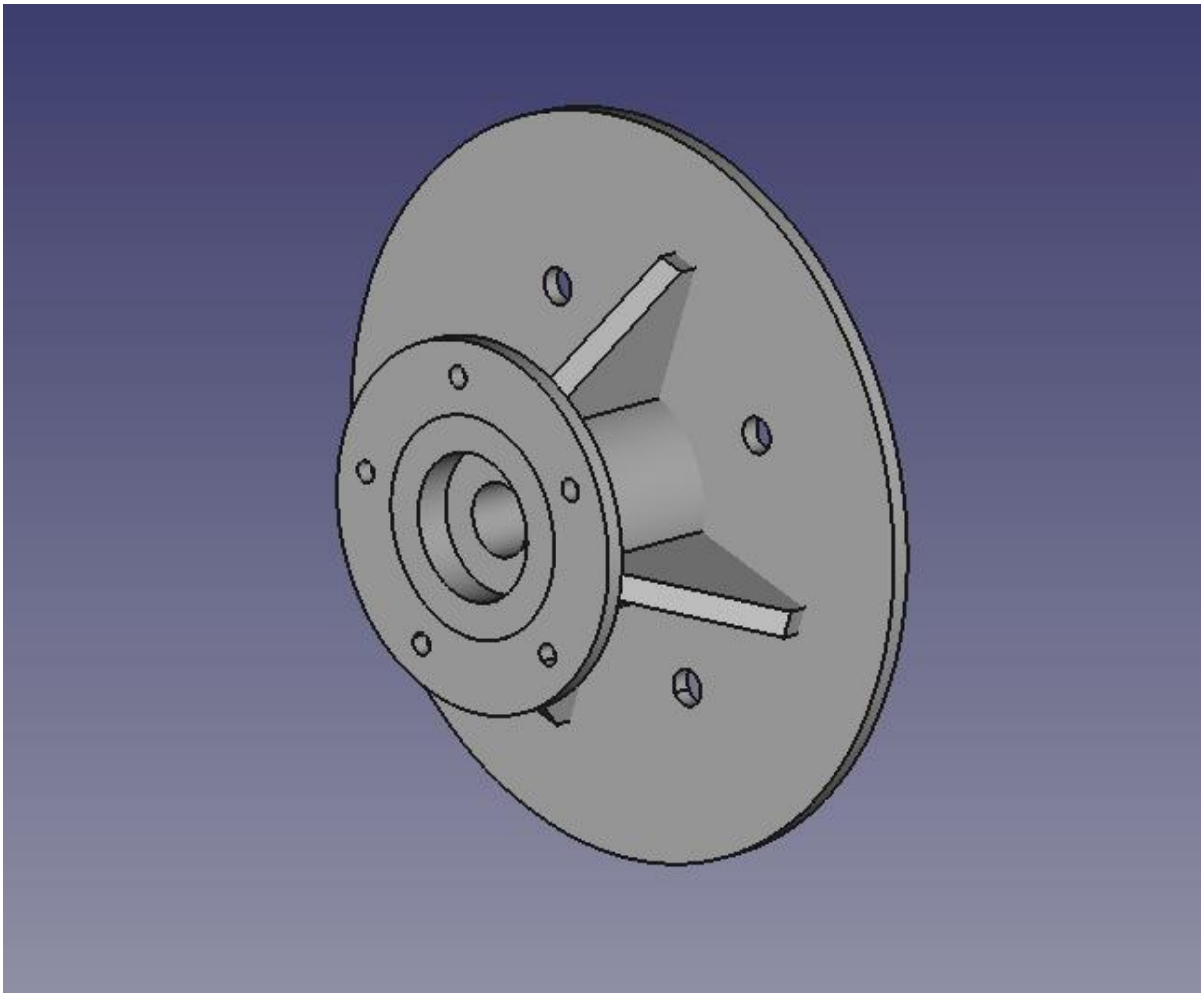
2D tbd

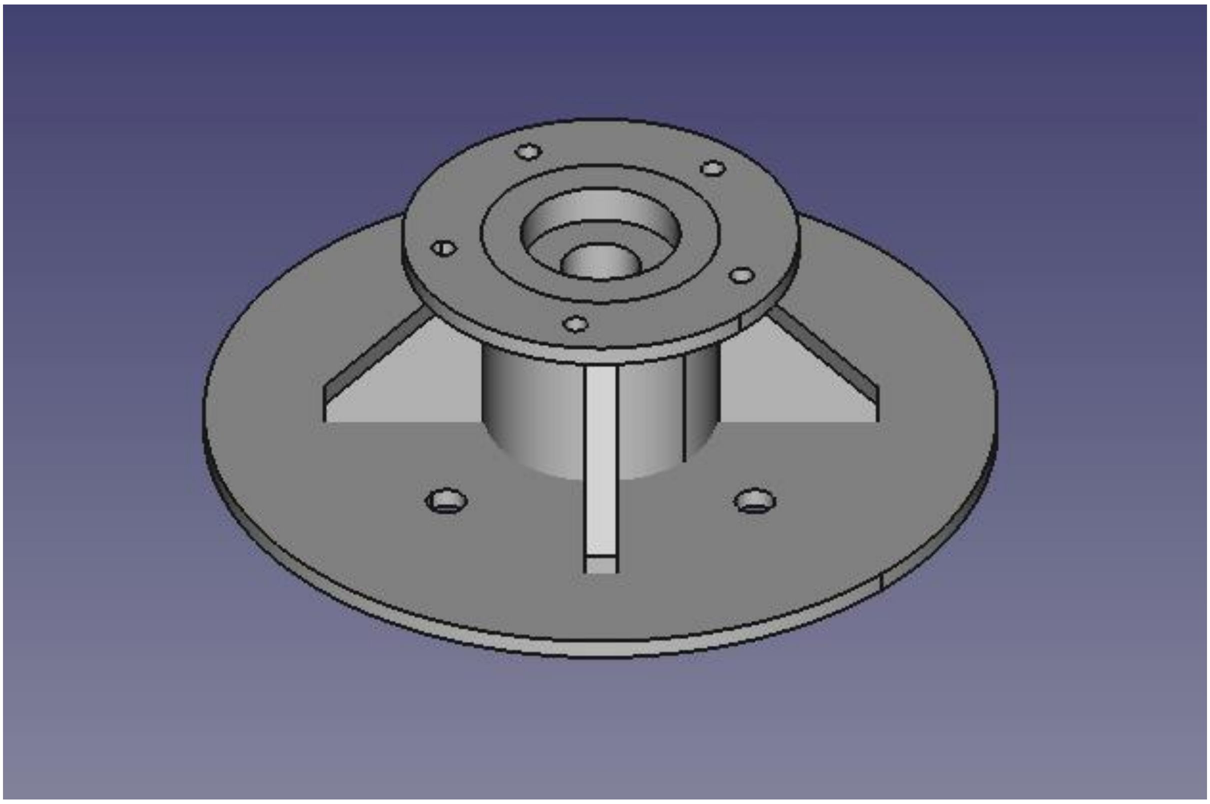
5.2.4.2 Mechanical Realization

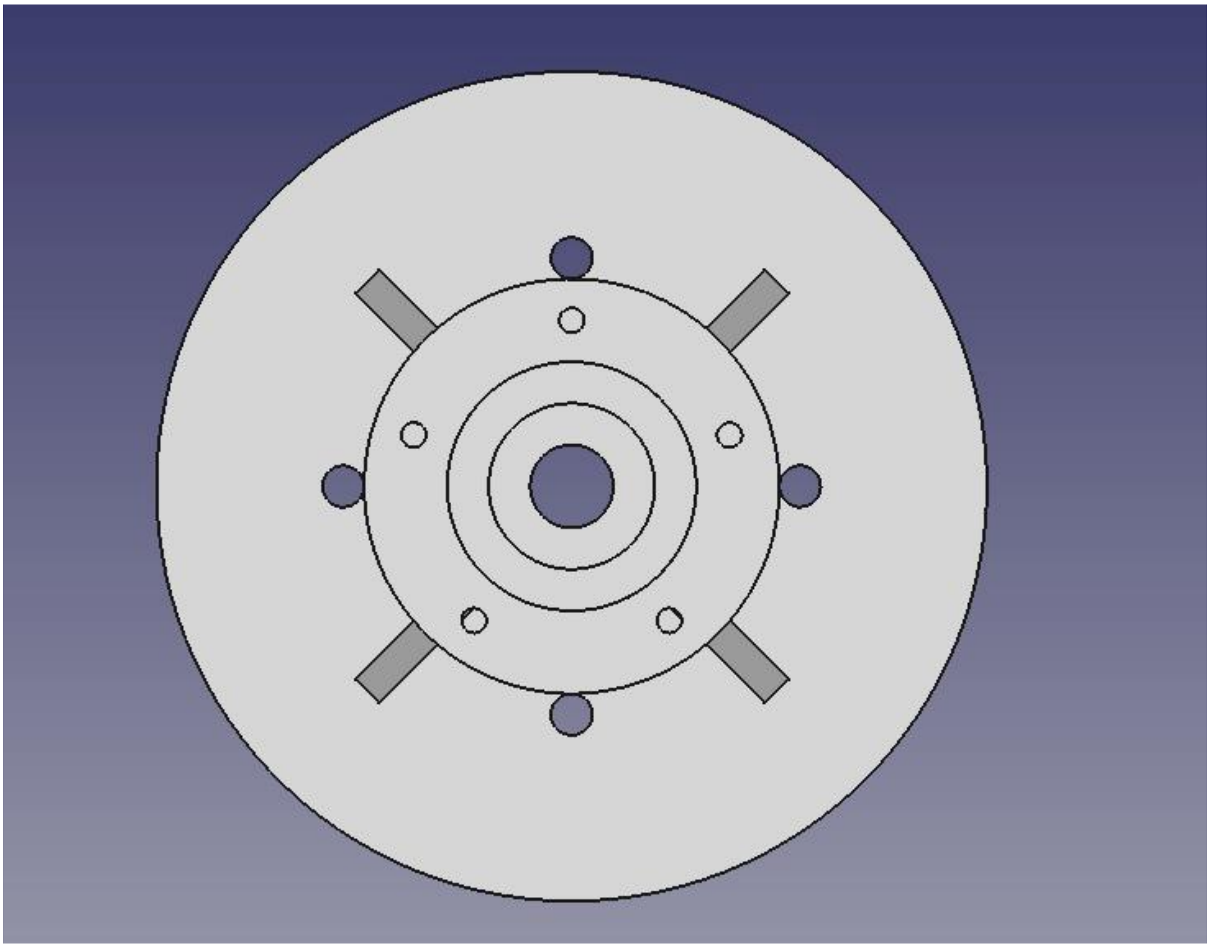
tbd

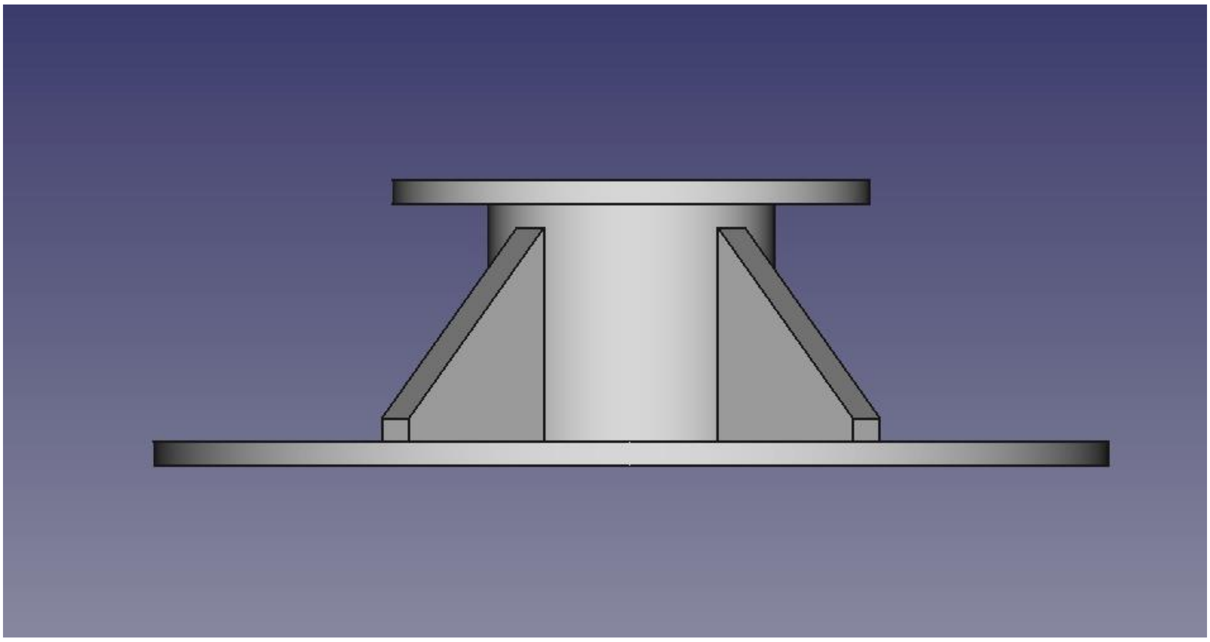
5.2.4.3 Front wheel rim disc

design:

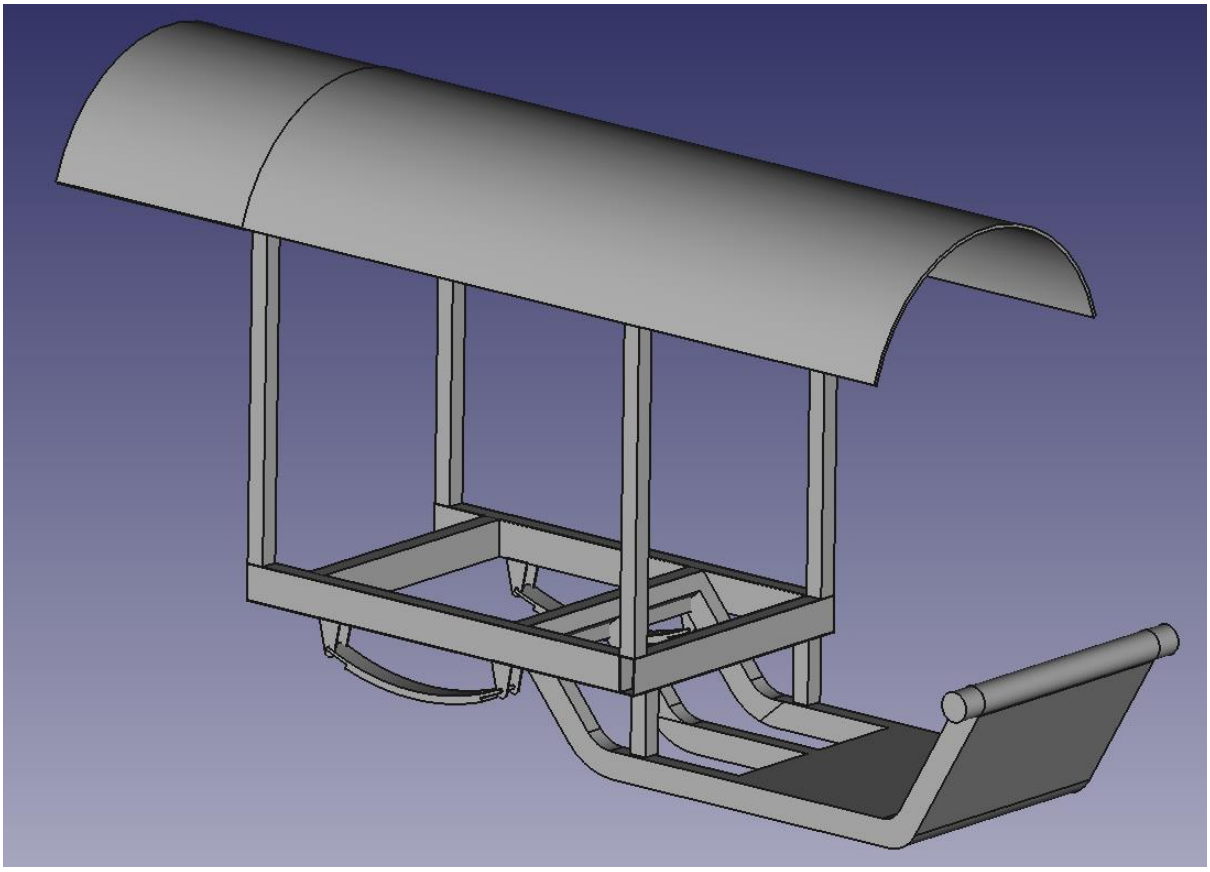




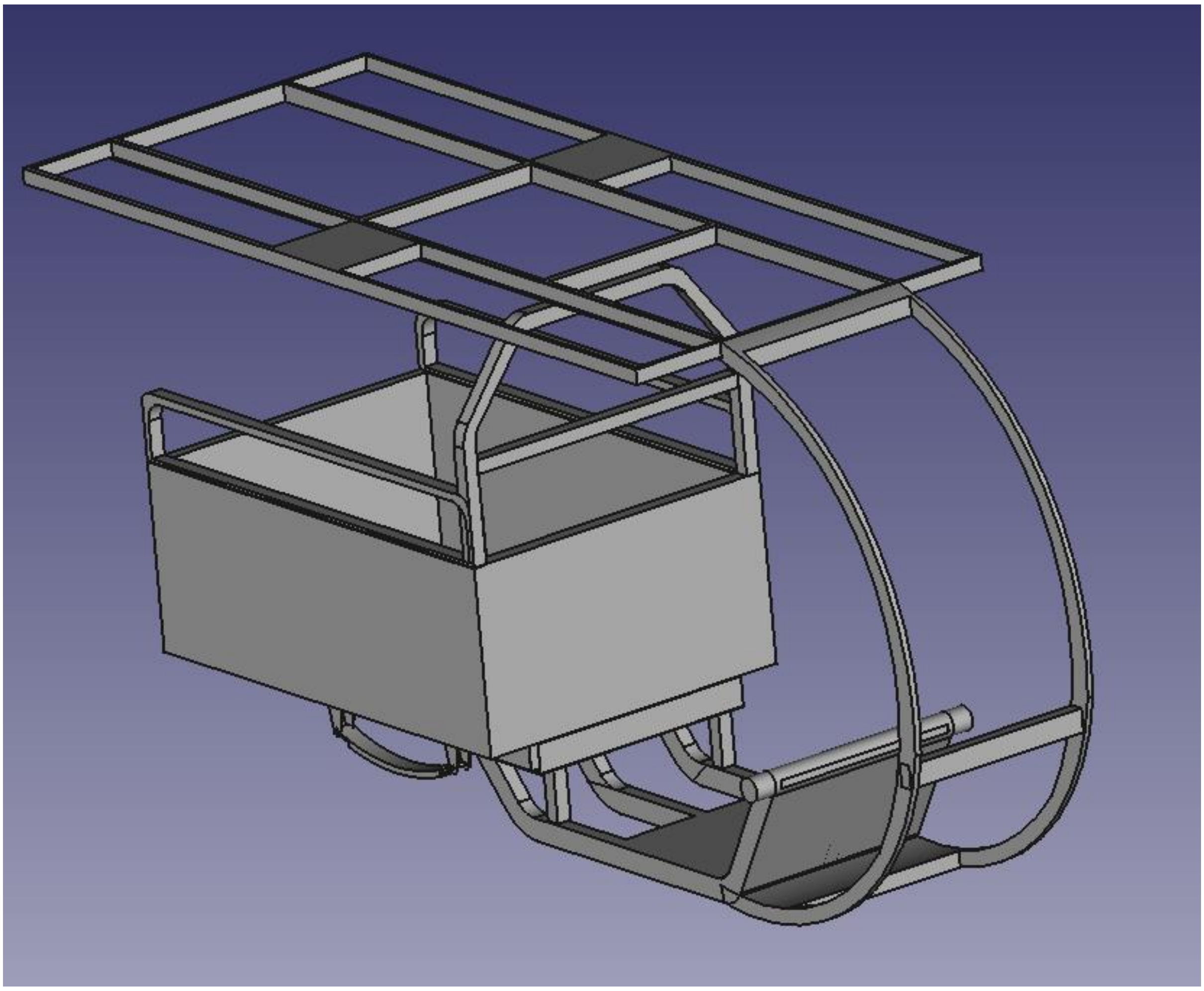


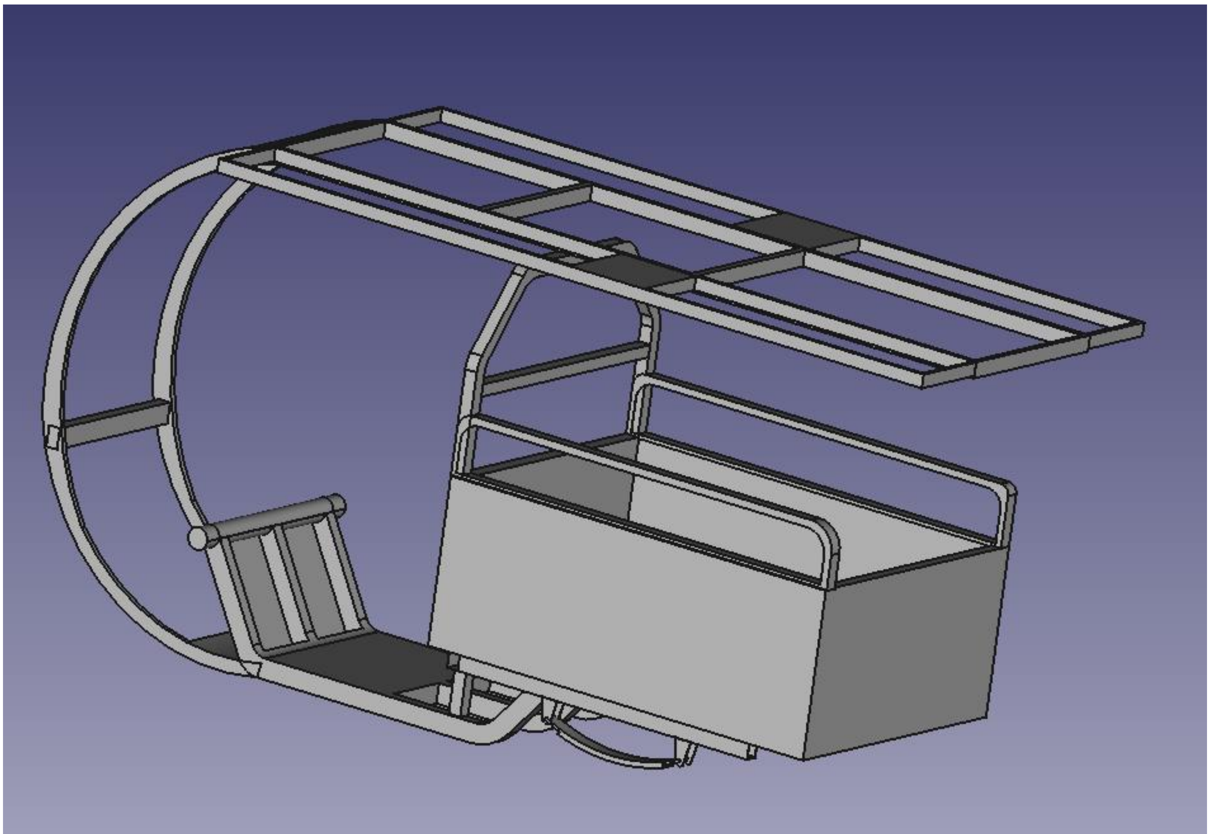


17-22-2022 drawing:

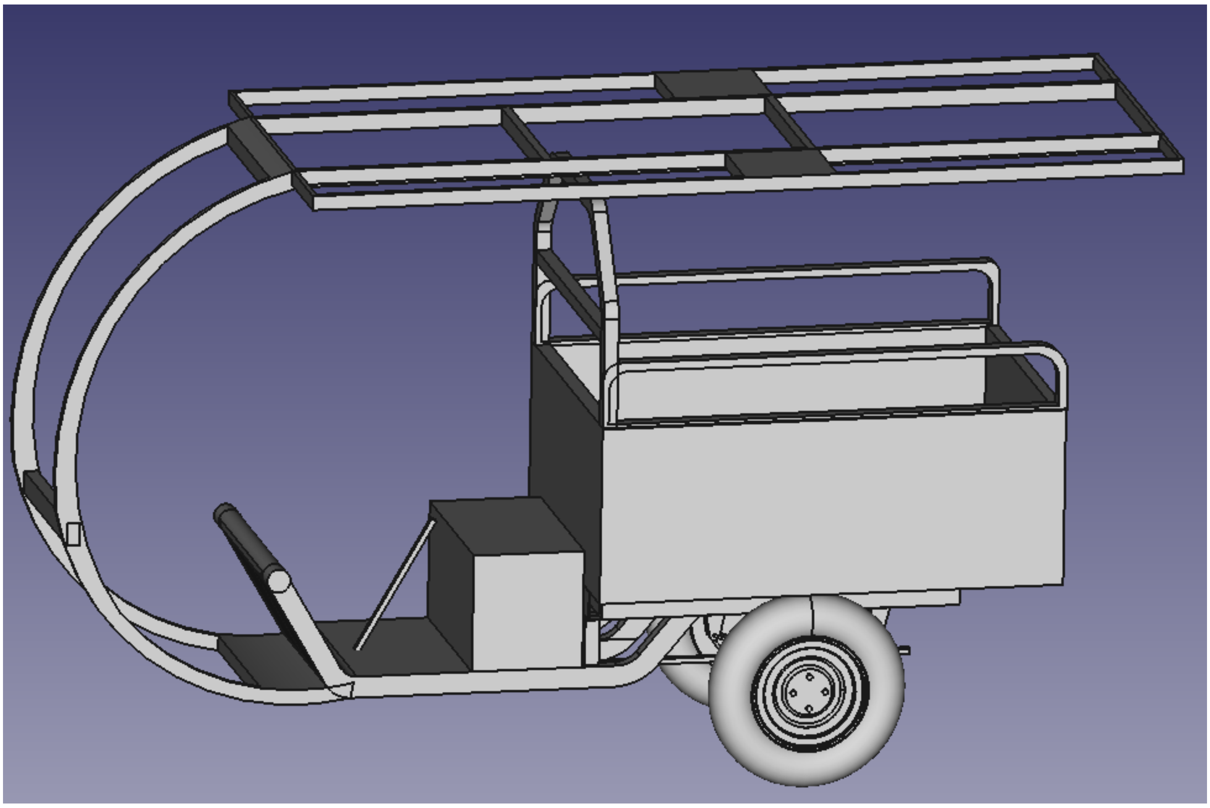


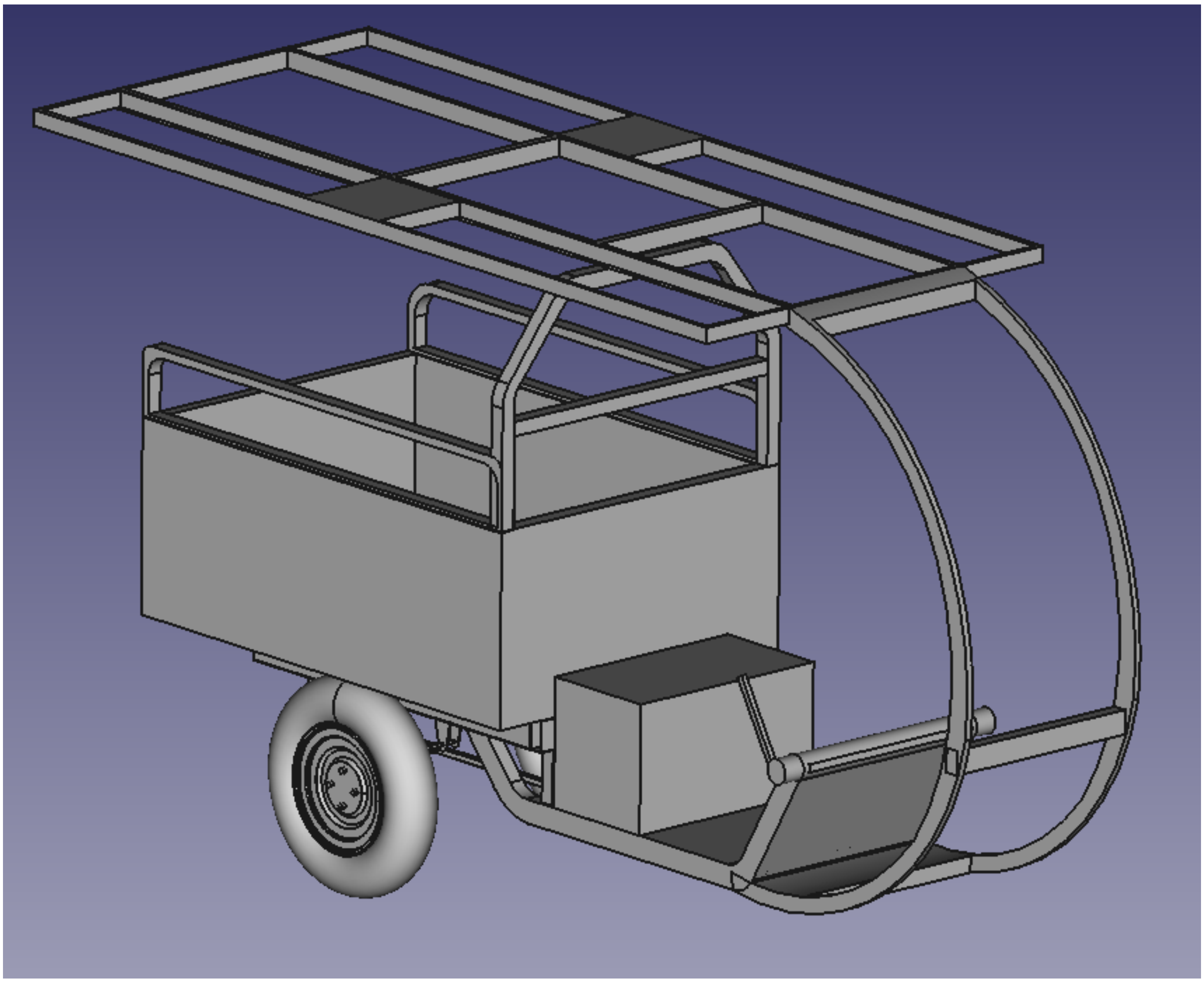
28-11-22 E_TukTuk with solar panel stand:



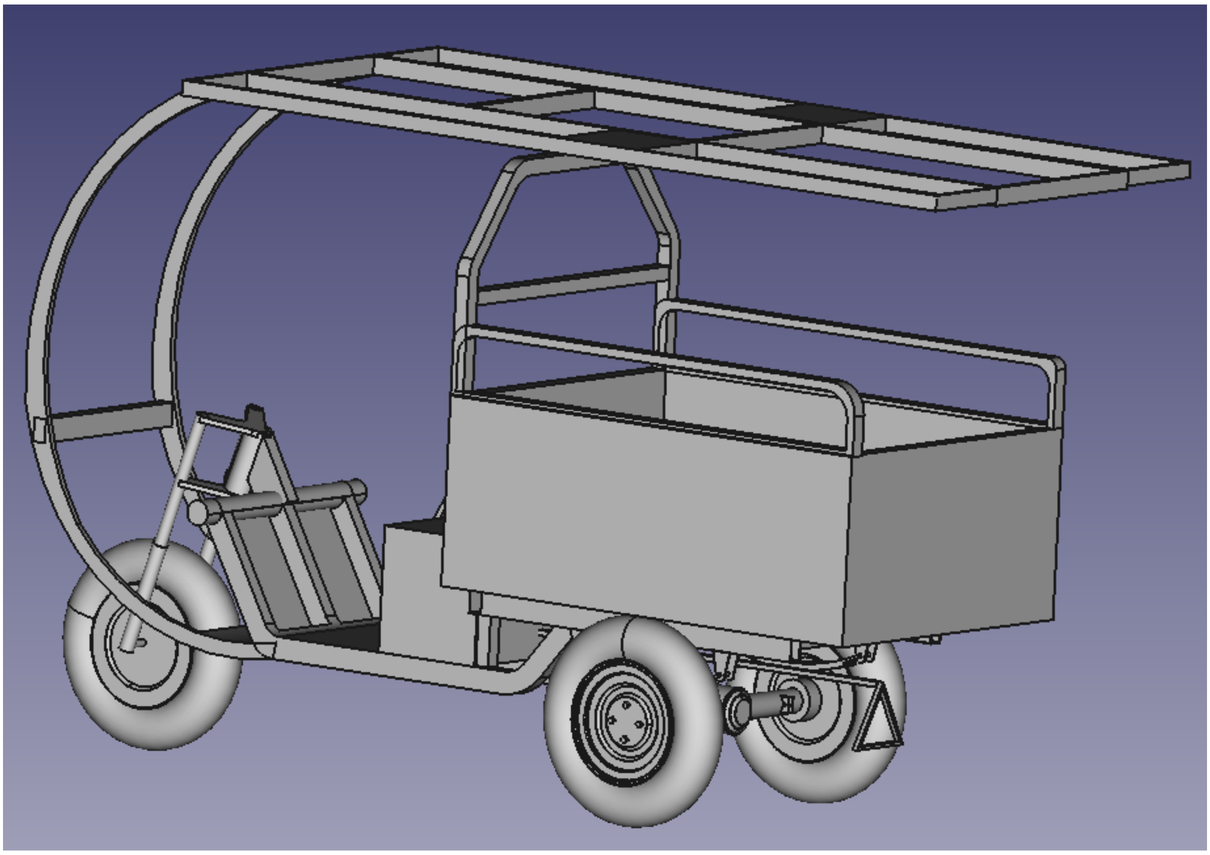


30-11-22 E_TukTuk with solar panel stand and hitch handle:

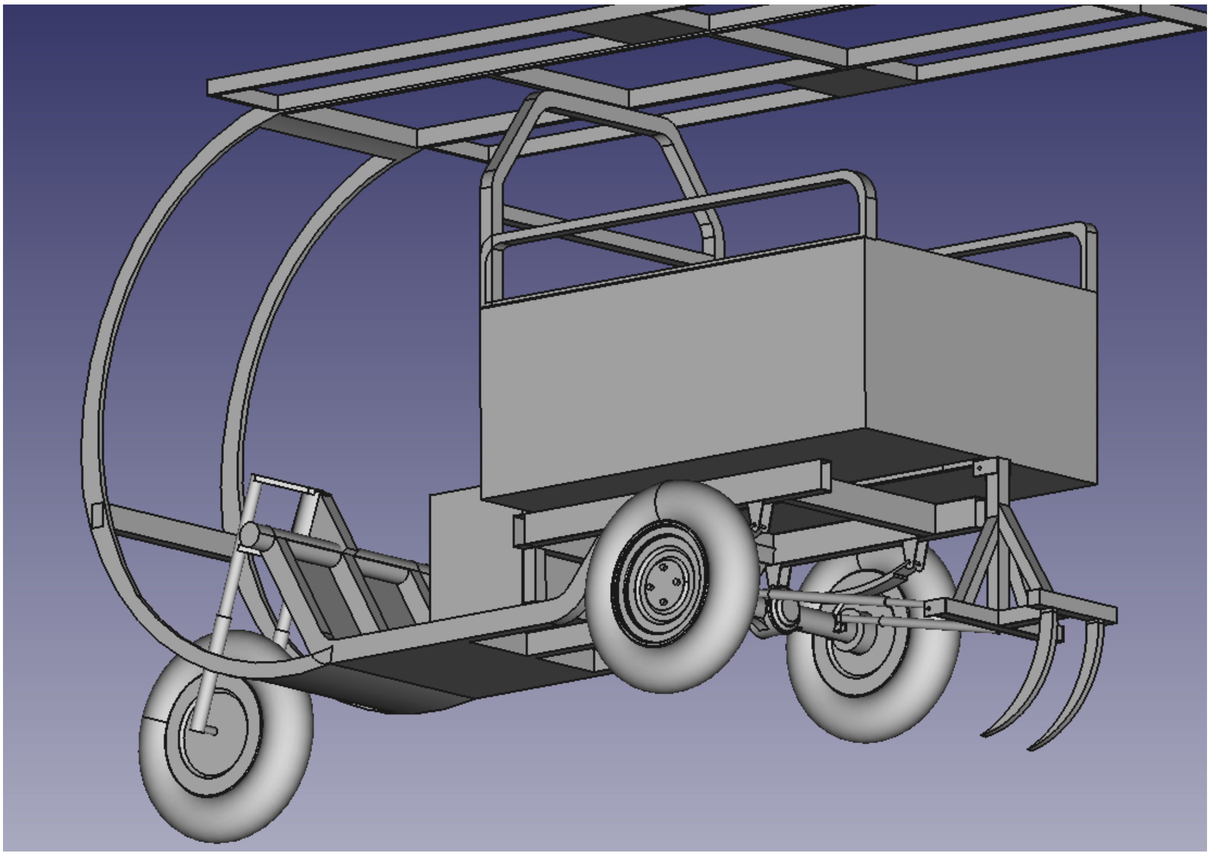


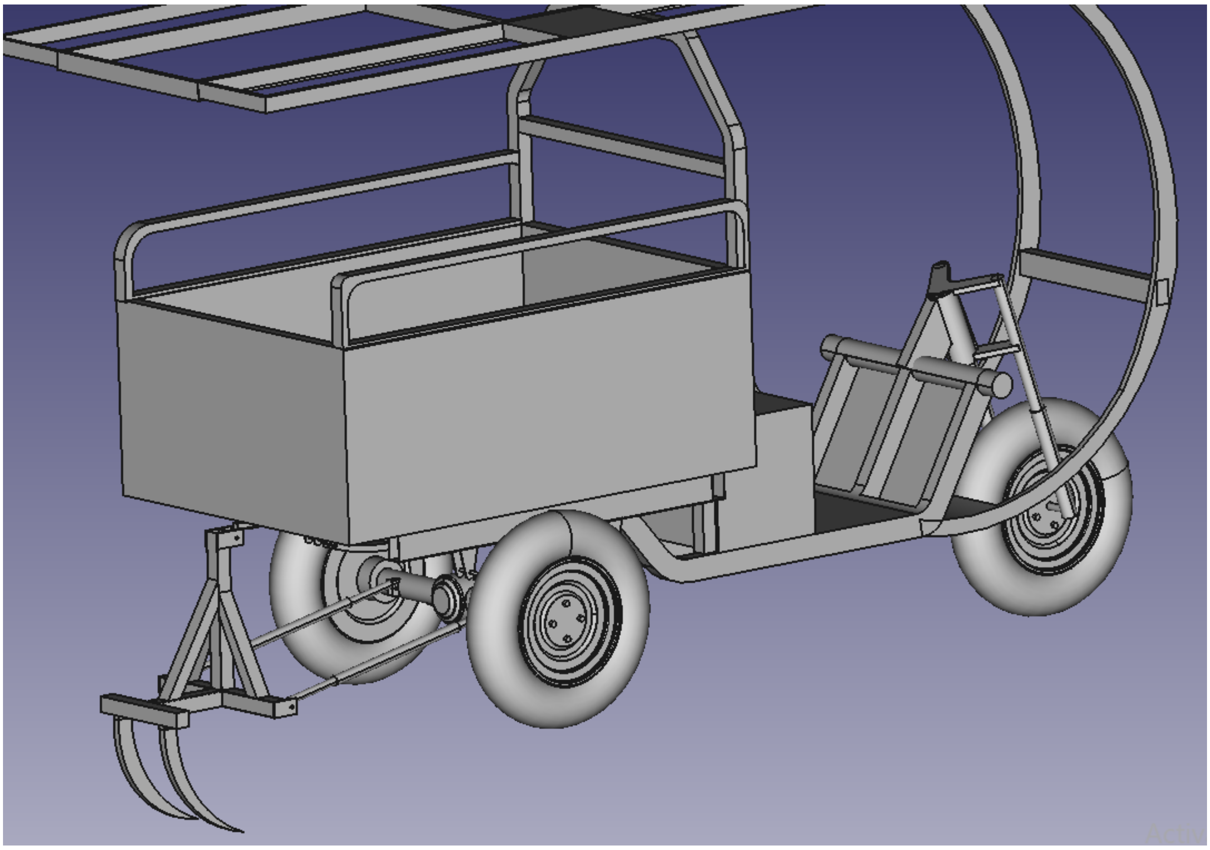


5-12-22 E_TukTuk:

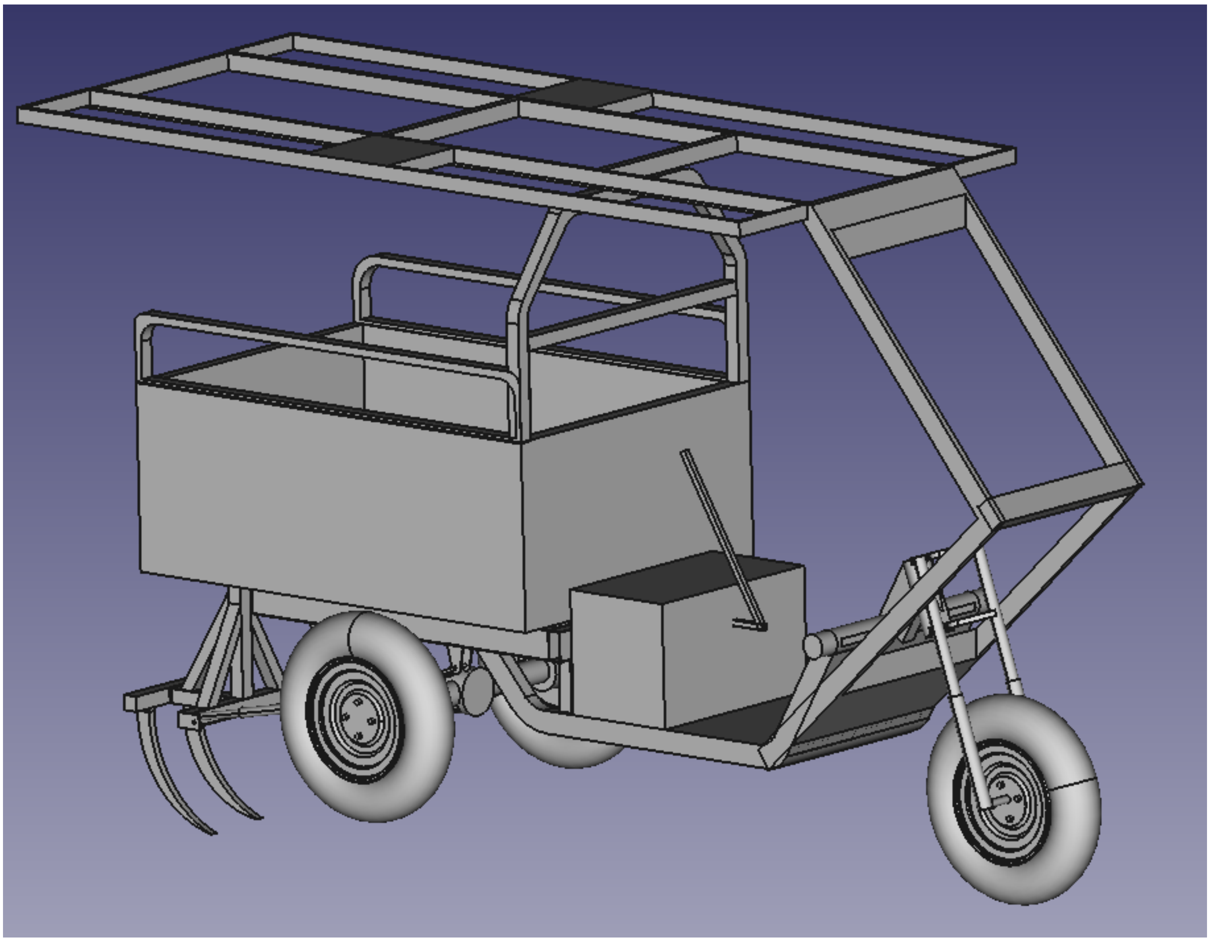


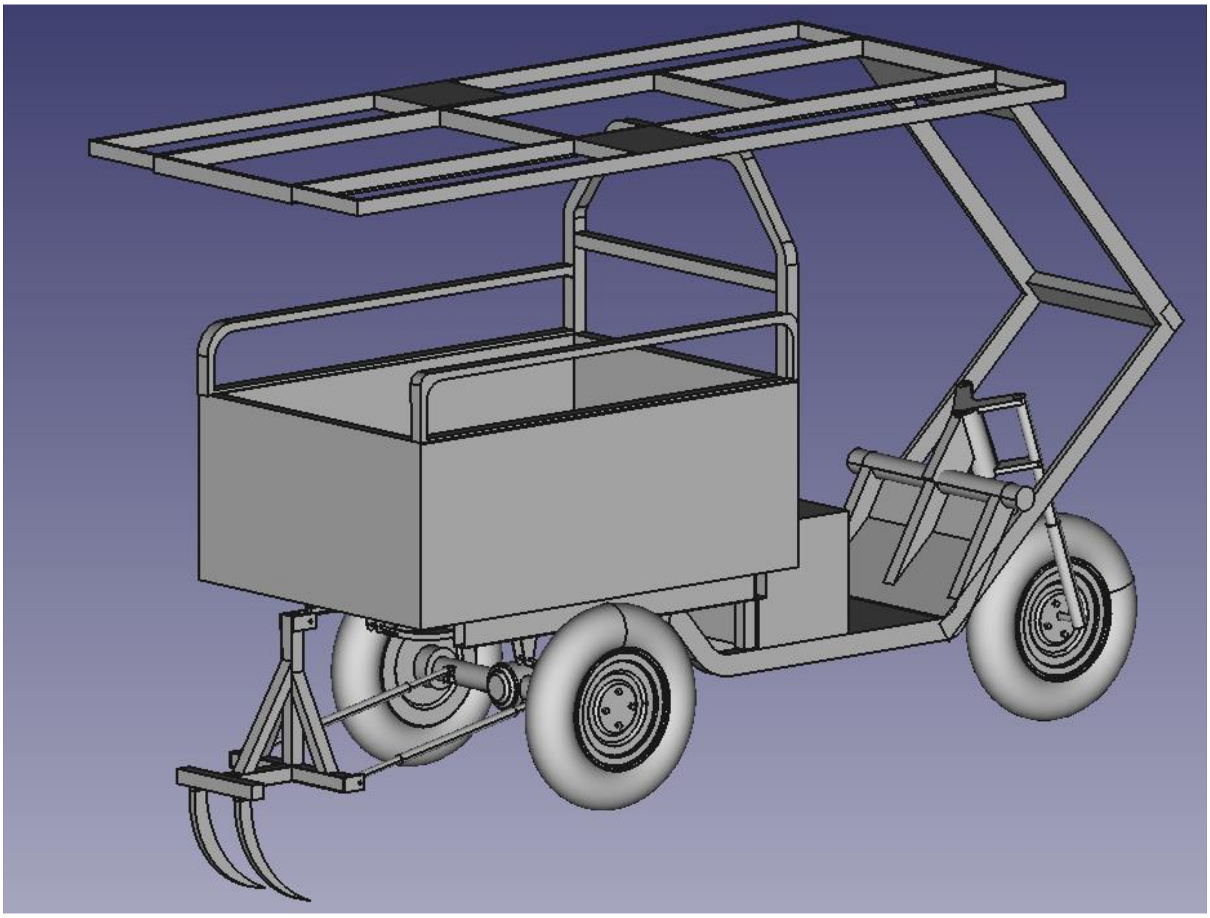
17-12-22 :

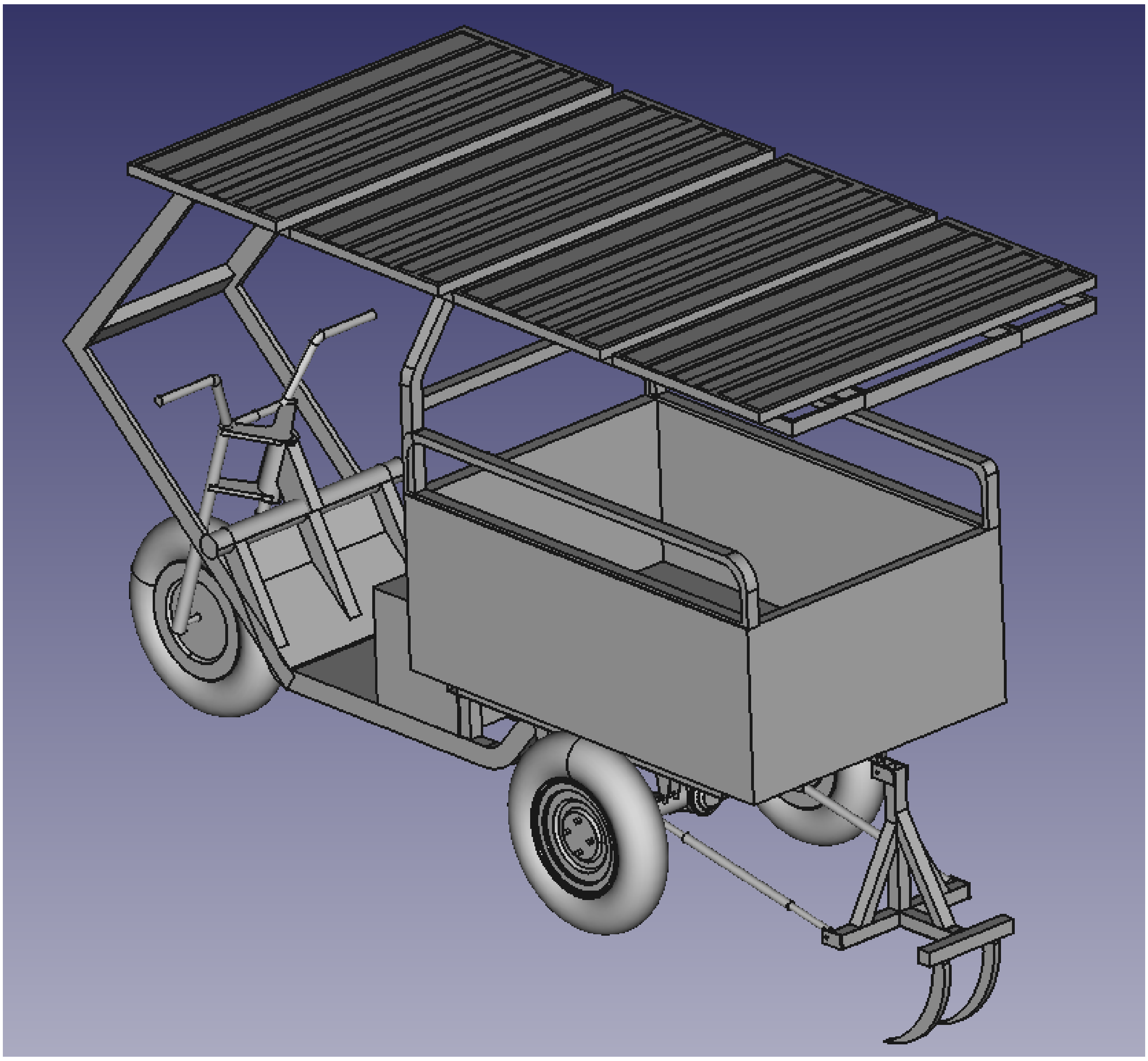


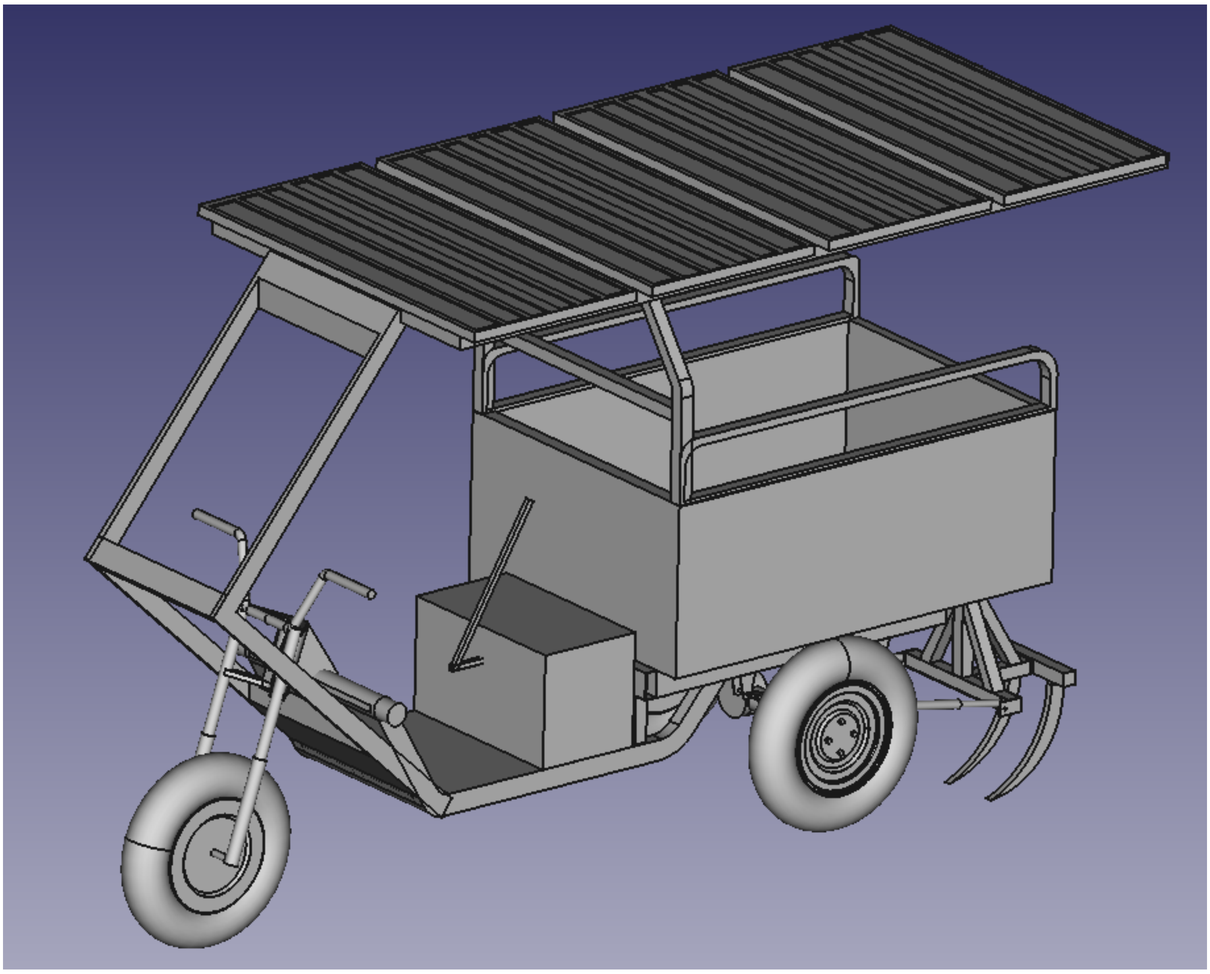


19-12-22 E_TukTuk with solar panel stand:









28-11-22 E_TukTuk with solar panel stand: [5-12-22 E_TukTuk]

19-12-22 E_TukTuk with solar panel stand

17-12-2022 New Solar Panels stand [17-12-2022 E-tukTuk]

19-12-22 E_TukTuk with solar panel stand

Hitch Design [19-12-22 New Hitch design]

19-12-22 E_TukTuk with solar panel stand

5.2.5 Rear Wheels

5.2.5.1 FreeCAD Drawing

3D tbd

2D tbd

5.2.5.2 Mechanical Realization

tbd

5.2.6 Excel sheet for all vehicle components:

31-10-2023_vehicle components list:

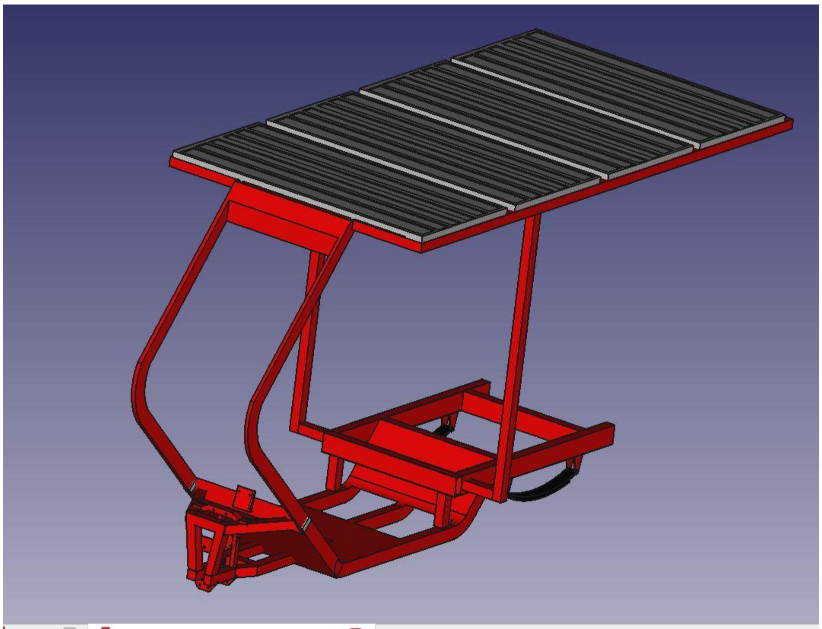
31-10-2023_vehicle components list.xlsx

5.3 Enhancement Report (Oct-Dec 2023)

Task	Deliverables
Design new chassis	CAD design
Design & enhance the vehicle roof with the solar panel	CAD design
Find a manufactory for the chassis and solar roof	Quotations and contacts
Specify all vehicle components list	Excel sheet
Find provider for each component	Quotations and contacts
Fully check the battery requirement and solar charging	Electrical study
Start preparing for the license agreement	Official Lebanese answers
Documentation (Always UpToDate)	Word file and Website
Weekly meeting	Online/onsite weekly meeting

<u>The assembled design of the chassis and solar panel roof design</u>:

3-1-24_NEW tuktuk chassis with solar pan



5.3.1 New chassis design

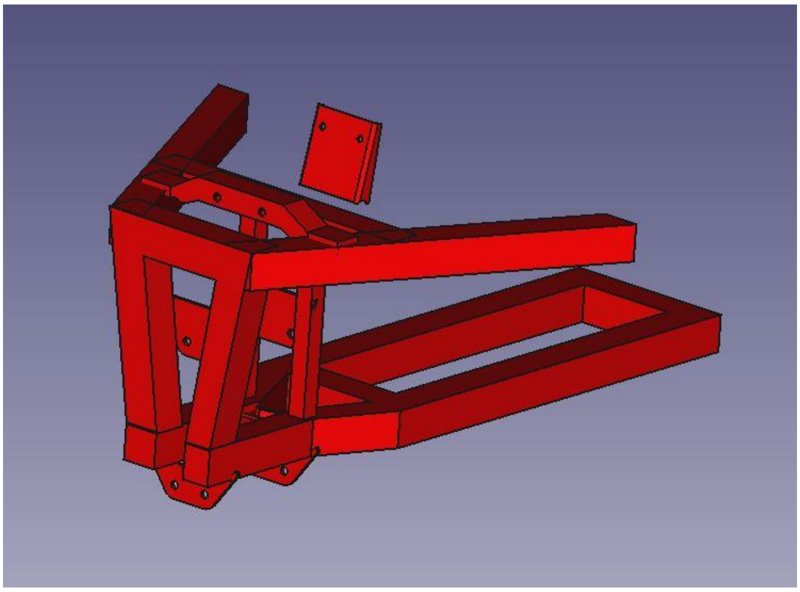
5.3.1.1 Chassis CAD file:

front suspension.FCStd

accessories.FCStd1

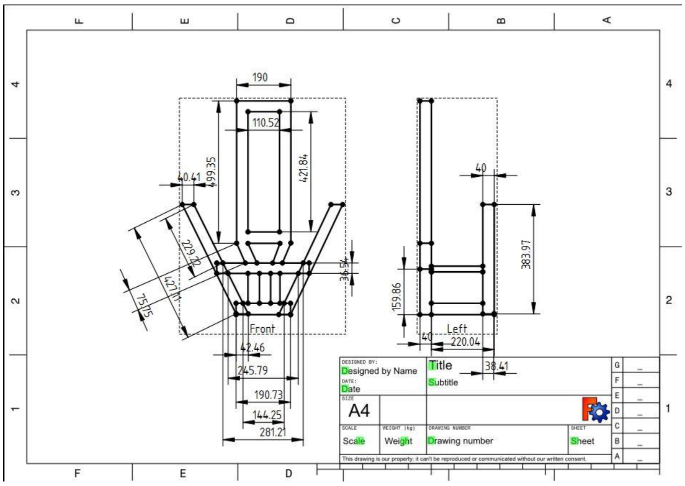
main front suspension 2d.FCStd

5.3.1.2 Chassis design screenshot:

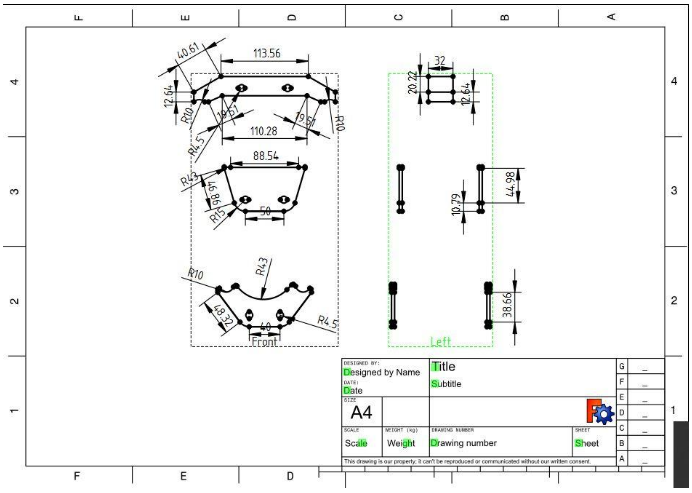


5.3.1.3 Needed 2D detailed designs:

main front suspension 2d.FCStd



accessories.FCStd1

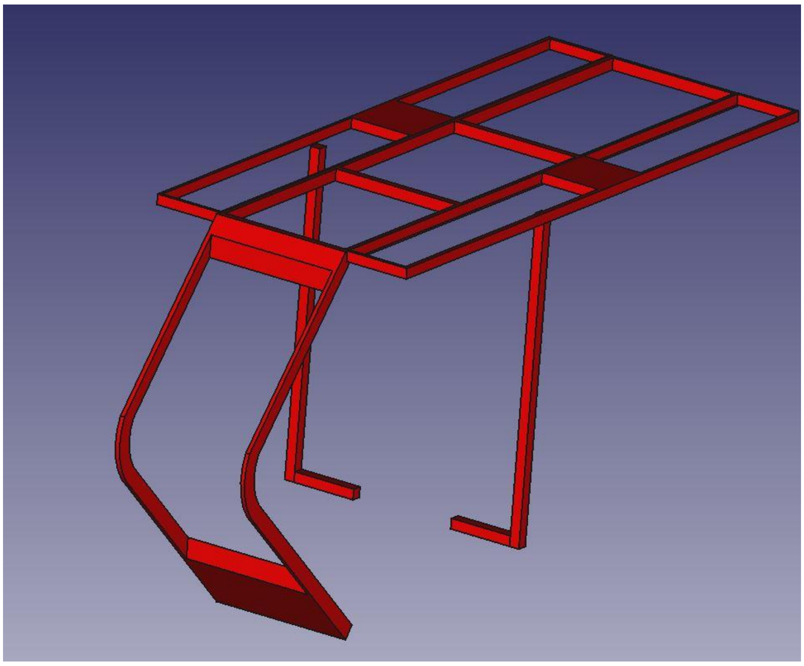


5.3.2 New roof design

5.3.2.1 roof CAD file

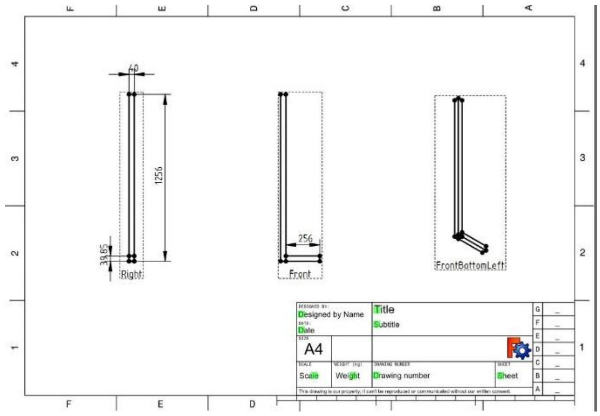
solar panels stand
and panels new versic

5.3.2.2 roof design screenshot:

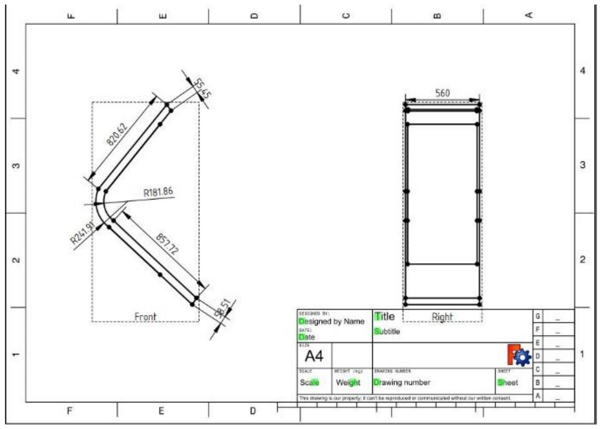


5.3.2.3 Needed 2D detailed designs:

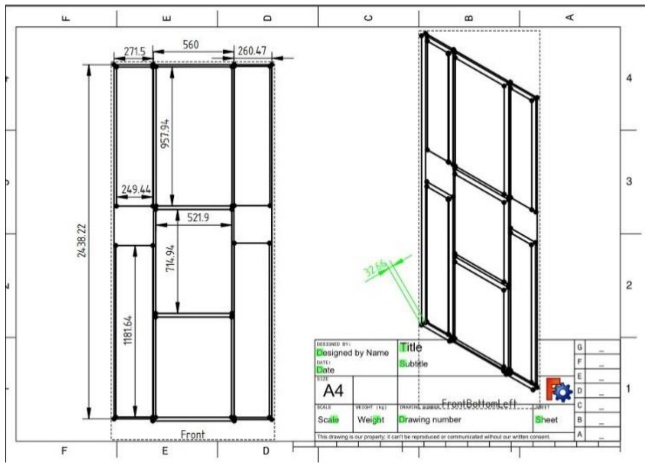
L shape.FCStd1



solar panel front side.FCStd



solar panel roof.FCStd1



5.3.3 Chassis and roof quotations (2 quotations min)

No official quotation sheet,

1- Abo Al Abeds quotation : 500$
2- Khaled Saleh CNC : 750$ if we order one peace, another price for a 5 plus chassis order.

5.3.4 Vehicle components list (with an image notes each component on the vehicle)

31-10-2023_vehicle components list.xlsx

5.3.5 Components quotations (2 quotations min)

Al halabi is the only local supplier of electric tuktuk parts with best prices and prices less then AliBaBa in the term of small orders

Invoice from al Halabi.pdf

Bicycle And E.Bike
Bicycle and Parts - Gen.Traid

TRIPOLI
North Lebanon

31/10/23 تاريخ

13393 فاتورة رقم

0000	زحل	المطلوب من السيد: تدريب

المجموع	السعر	العدد	الوحدة	الشرح
5.00	2.50	2	1	اشارات-تكتك-امامي-جنب
8.00	8.00	1	جوز	اشارات-تكتك-خلفي
7.00	3.50	2		اكس-عيار ديفرانسال-تكتك
9.00	3.00	3		اكس-فريم-تكتك
2.50	2.50	1		بوبين اشارة-60V-
18.00	1.50	12		بوغ-مقص-تكتك
10.00	10.00	1		تابلو-تكتك-60V-ديجيتال
18.00	18.00	1		تي-ملقط-تكتك
32.00	16.00	2		جنط-12"-تكتك-خلفي-فارغ
3.00	3.00	1		جوزة كونتاك-تكتك-
200.00	200.00	1		ديفرانسي-تكتك-كامل
7.00	7.00	1		رولمون-تكتك-ك
28.00	28.00	1		سرسيون تكتك-موديل جديد-كامل
5.00	5.00	1		سلك تكتك-GEAR-1M
2.50	2.50	1		سنسر-فريم-تكتك
2.50	2.50	1		علبة توصيل-6 برغي-
10.00	10.00	1		فقسات-تكتك-طلم
8.00	4.00	2		قاعدة-تثبيت-مقص
95.00	95.00	1		كف كهربا-BRSH-60/72V 1500W
10.00	10.00	1		كيدون-تكتك-حديد
7.00	7.00	1		مسكة تكتك-GEAR-
8.00	8.00	1		مسكة تكتك-فريم ايد-
6.00	6.00	1		مسكة سرعة-FR-3S
40.00	40.00	1	2	مقص-تكتك-جوز
120.00	120.00	1		موتير تكتك-72V 1500W-
661.50				**المجموع :**

0.00 رصيد حسابكم الكامل

5.3.6 Electrical study

Abdallah Kassem

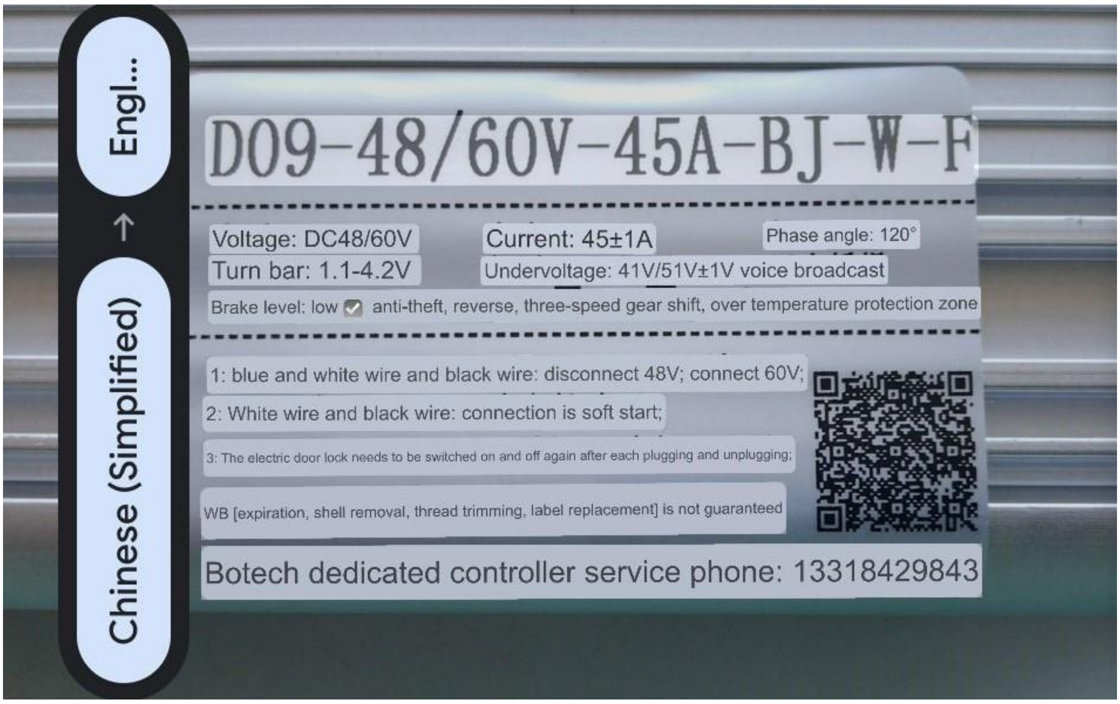
5.3.7 Official answers

محمد الصعيدي مخلص معاملات
+961 70 113 677

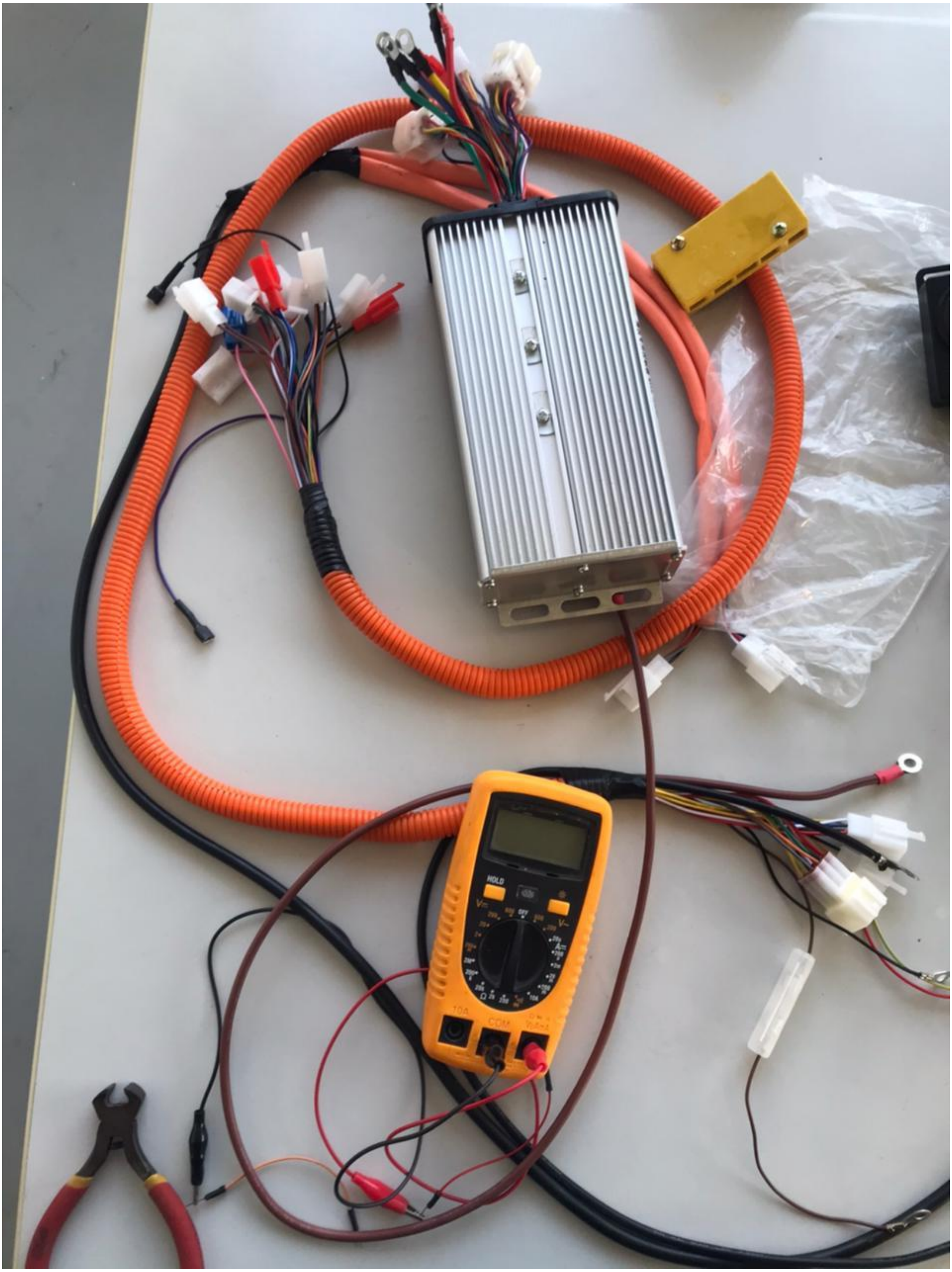
5.4 Electric/Electronic of E-Tuktuk[1]

5.4.1 Parts

5.4.1.1 Controller



[1] https://aecenar.com/index.php/companies/nl-automotive-systems-nlas/e-tuktuk/e-tuktuk-mechanical-realization

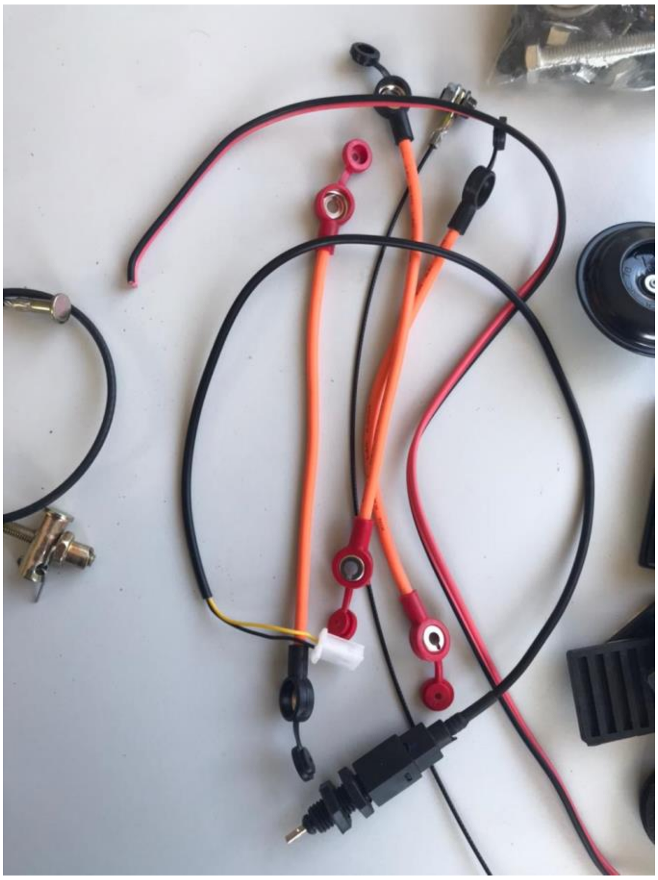


5.4.1.2 1000w Electric Motor:

5.4.1.3 The Throttle Handlebar and lighting/Flasher controller:

5.4.1.4 Lighting and flashers

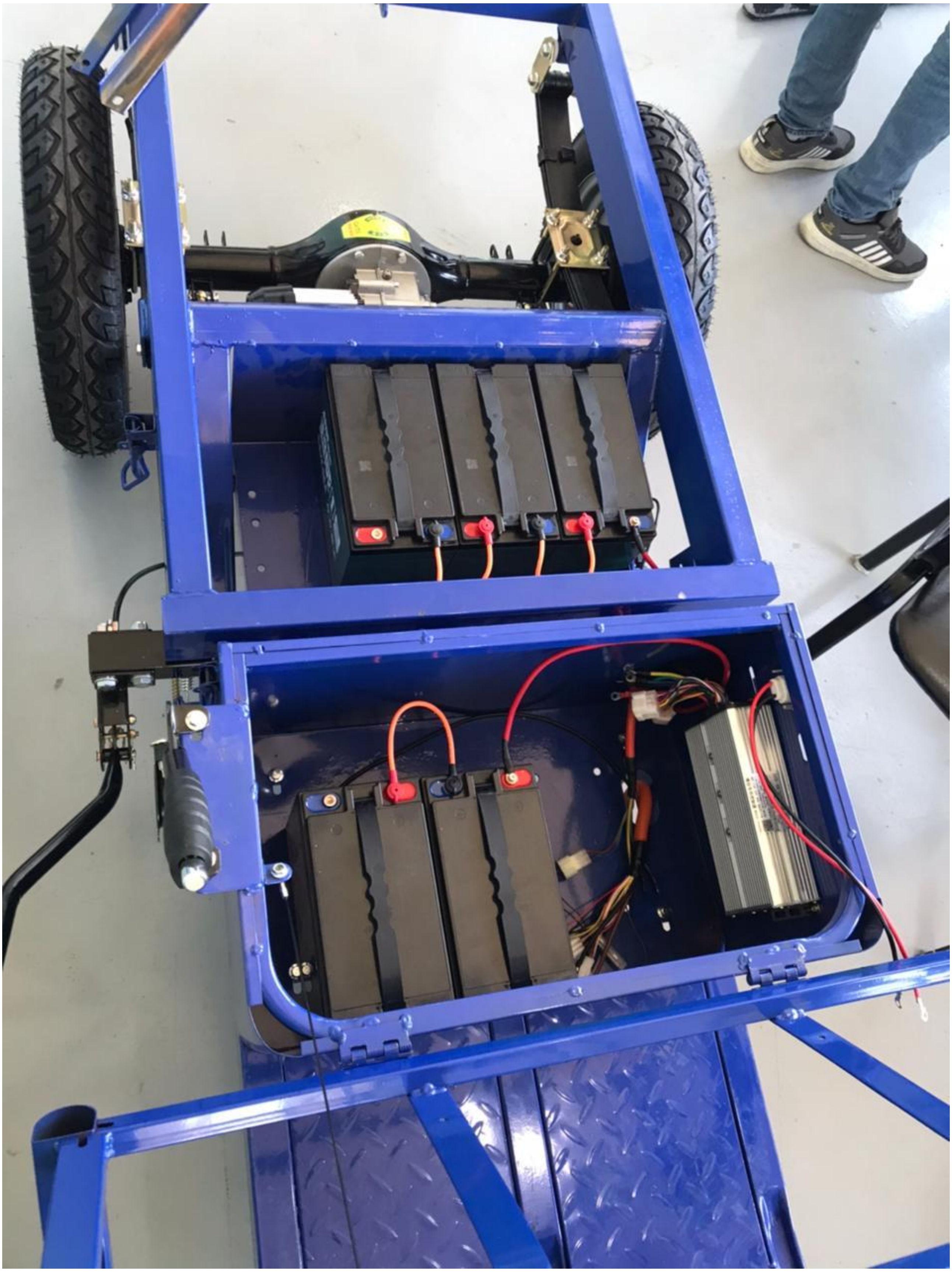
5.4.1.5 5 Batteries 12V , 45.2 Ah

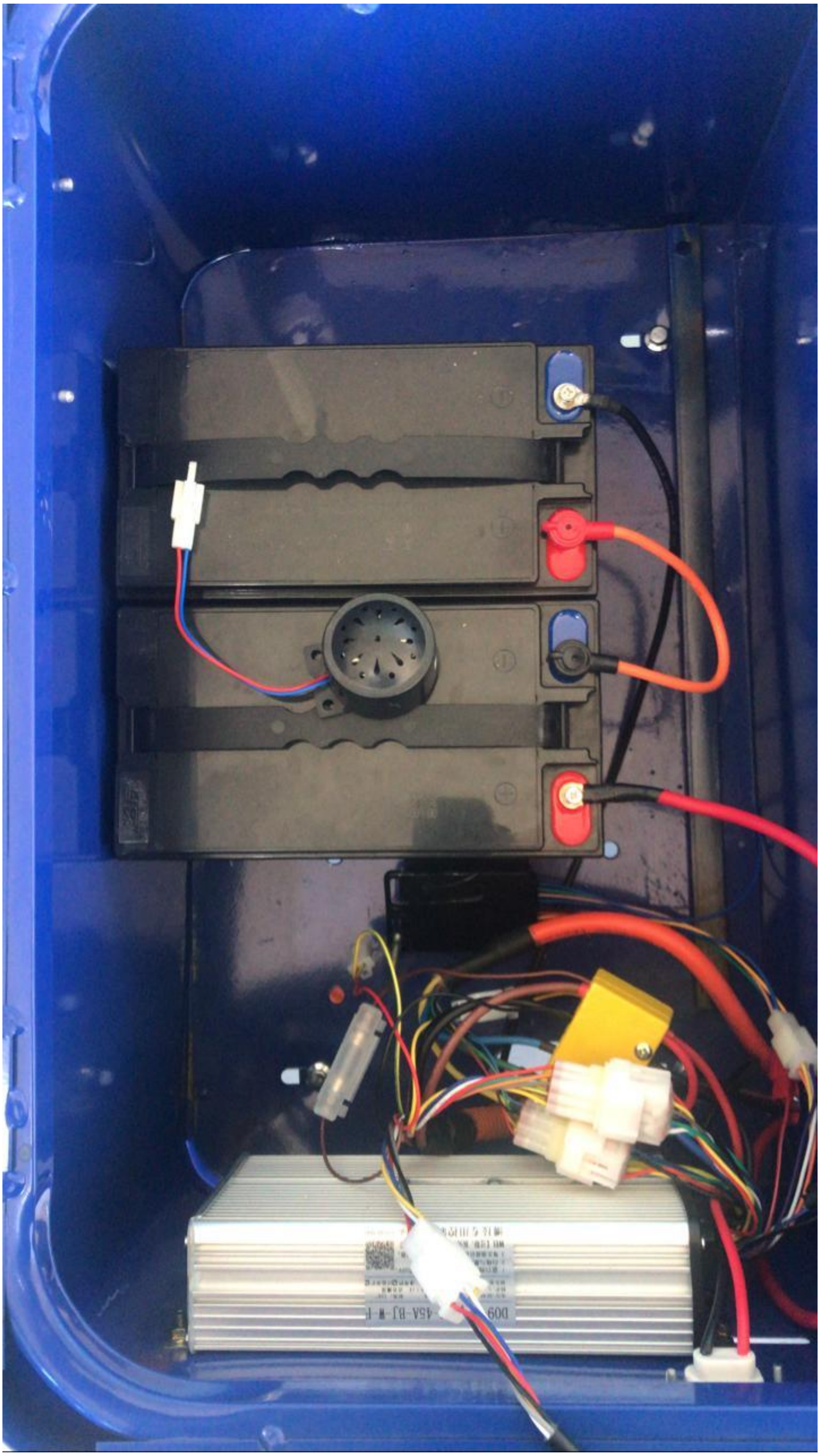


5.4.1.6 Batteries charger


电动车充电器
产品型号: 60V 45Ah
生产日期:
输入功率: ≈360W
直流输出电压: 60-74.4V
直流输出电流: 5.5A±0.2A
输入电压: 220V～50Hz
执行标准: T/ TCDZ 0001-2019
注意事项
使用前应充分阅读使用说明书。
本充电器仅适用于铅酸电池充电。
用于户内使用，谨防雨淋。
禁止给不可再充电的电池充电。
严禁充电器放在电动车内或电动车上充电。
内有高压，非专业人员请勿打开。
如电源软线损坏，须由专业人员更换。
警告

5.4.1.7 All electric parts installation with batteries and controller





5.5 Lithium-Ion Batteries Manufactoring Concept and Battery Management System (BMS) Design

5.5.1 Overview

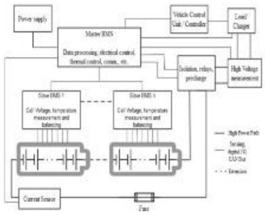
AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

NLAS AUTOMOTIVE SYSTEMS

Lithium-Ion Battery Charger (18650)

Battery Management System(BMS)



1 Theory of Operation — Theoretical and mathematical aspects of Li-Ion battery charging

2 Hardware — Hardware design aspects of Li-Ion chargers

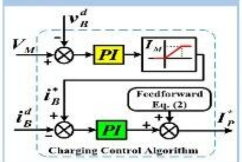
3 Circuit Diagram — Li-Ion charger circuit diagram

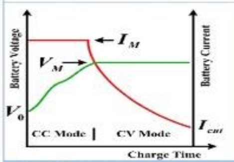
4 PCB Layout — PCB Layout for Li-Ion Charger

5 User Interface — Lithium-ion charger user interface

1.1 CC-CV Charging

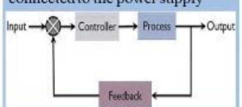
Li-Ion batteries are charged using the constant current charging (CC-CV) method at a constant current to reach a certain voltage Vmax = 4.2Vcell.





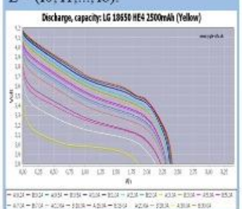
1.2 Control Loop

The "–" battery connected to the positive power supply (by MOSFET) The "-" battery connected to the power supply



1.3 State-of-Charge Estimation

The state of charge of the SOC is read through the battery voltage V and compared with the values stored in the lookup table L = (l0, l1,…, l8).



1.4 Safety

The charger implements many safety features, such as under-voltage, over-voltage, short circuit, and open circuit detection.

1.5 Trickle Charging

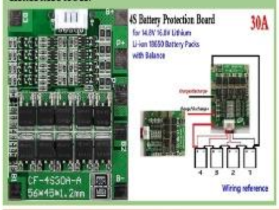
Once the end-of-charge (EOC) criteria are met, the charger cuts off the charging current, switches to idle mode, and continuously monitors the battery voltage.

2.1 Mechanical Design

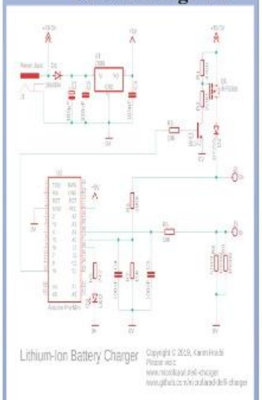
We used four LG 18650 HE4 Li-Ion cells and a battery protection board (or battery management system also known as BMS). Modern lithium-ion cells use much less space.

2.2 Battery Protection Board

It is necessary to use a dedicated battery protection board for each battery pack. This provides additional protection to prevent over-charging or over-discharging due to software or hardware malfunction.



3.1 Li-Ion Charger Circuit Diagram

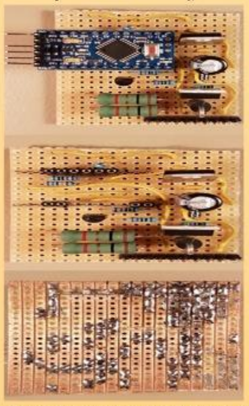


3.2 Different Number of Cells

The following values for R2, R4 and the power supply voltage need to be chosen in order to charge different numbers of Cells:

N_{cells}	Power Supply	R_2	R_4
1	5V-6V	220Ω	39KΩ
2	10V-15V	100Ω	82KΩ
3	14V-20V	220Ω	120KΩ
4	18.5V-20V	220Ω	180KΩ

All components are of the punch-hole type and are mounted on a PCB board. The Figure below shows the PCB layout of a Li-Ion charger.



The pin header located at the top right corner is used for connecting all the external wires. Following is the pinout assuming that pin 1 is at the top right corner and pin 10 is towards the middle of the board.

Pin	Purpose
1 *	LED +
2 *	LED -
3,4 ⏚	Power supply +
5,6 ⏚	Battery +
7,8 ⏚	Power supply -
9,10 ⏚	Battery -

5.1 LED Indicator

The charger status is displayed by turning on or flashing a single LED

Blinking Pattern	Meaning
On for half a second every 2 seconds	Ready, waiting for the battery to be connected
Solid on	Battery charging
On For 0.1 second every 2 seconds	Battery fully charged
Blinking fast (0.4 s period)	Error
Blinking very fast (0.2 s period)	Calibration mode

5.2 Command-Line Interface

This simple lithium-ion battery charger features a CLI that can be accessed via the Arduino's RS232.
Once turned on, the charger will display the current firmware version and present with a list of commands.
Some of these CLI commands must be supplied with arguments.

Command	Description
h	Help- show the list of available commands
[illegible]	Display the real-time parameters, including the charge duration T, charge capacity C, battery voltage V, charging current I, maximum charge duration T_{max}, maximum charge capacity C_{max}, maximum charging voltage V_{max}, maximum charging current I_{max}, PWM duty cycle, voltages V_1, V_2 and their raw ADC values $V_{1,raw}$ and $V_{2,raw}$
r	Show the list of calibration constants that are stored within EEPROM
t	Show the contents of the trace circular buffer
ncells <integer>	Set the total number of cells within the battery pack N_{cells}, the value provided as an argument will be validated and stored in EEPROM
cfull <integer>	Set the battery design capacity C_{full} in mAh, the value provided as an argument will be validated and stored in EEPROM
ichrg <integer>	Set the battery charging current I_{charge}, the value provided as an argument will be validated and stored in EEPROM
ifull <integer>	Set the end of charge current I_{full} in mA, the value provided as an argument will be validated and stored in EEPROM
lut <index> <voltage>	Configure the state-of-charge lookup table (LUT). This command takes and index i = 0, 1, 2, …, 8 and the reference voltage l_i in mV as arguments. Each time this command is called, a new reference voltage value l_i is populated into the LUT and stored into EEPROM, more on this in the following section
rshunt <integer>	Set the shunt resistor value R_{shunt} in mΩ, the value provided as an argument will be validated and stored in EEPROM
cal <start|stop|v1|v2> <mv>	The voltage calibration mode is entered by calling cal start and exited by calling cal stop. V_1 is calibrated using cal v1 <mv>, V_2 is calibrated using cal v2 <mv>, <mv> is the measured voltage level in millivolts. Please refer to the next section for more details about the calibration procedure.

5.3 Calibration Procedure

This section provides an example on how to perform the first-time calibration of the Lithium-Ion battery charger using the CLI over the serial monitor.

5.3.1 Initial ranking

Initial configuration parameters must be loaded into the EEPROM by executing a command sequence.

ncells 4	lut 0 3200	lut 5 3710
cfull 2500	lut 1 3450	lut 6 3825
ichrg 1500	lut 2 3530	lut 7 3920
ifull 150	lut 3 3610	lut 8 4020
rshunt 500	lut 4 3650	

5.3.2 Voltage calibration

After performing the initial step please proceed to calibrate the ADC readings for voltages V1, V2:

1. Enter the Cal start command in the serial monitor.
2. Connect a constant voltage source between terminal B and ground.
3. Enter the command cal-v2 into the serial monitor
4. Connect a constant voltage source between terminal B+ and the ground of the power supply.
5. Enter the command cal v1 <value> into the serial monitor
6. Check the voltage calibration by applying a known voltage to both B+ and B-.
7. Repeat steps 2, 3,… and 6 until the voltage V readings are correct.
8. Enter the command cal stop in order to exit the voltage calibration mode.

5.3.3 Current calibration

Please proceed with calibrating the reading of the current I by following the steps below:

1. Connect a discharged lithium-ion battery in series using a digital ampere meter (set to the 10 A range) to terminals B+ and B-.
2. 2. The Charging message should appear and the current value should begin to increase gradually to approximately 1.5 A.
3. 3. Enter the command [.] and check the displayed value of I.
4. If output of the[.] command is higher than amper meter reading: Increase the Rshunt by 10 mΩ.
5. If output of the[.] command is lower than amper meter reading: decrease the Rshunt by 10 mΩ.
6. Repeat steps 3,4,5 until the current I readings are correct.

5.4 Trace Buffer

A lithium-ion battery charger records events that occur during the charging process in a circular buffer within the available EEPROM space. The contents of the trace buffer are dumped using the t command.

```
0: * 16760     6: i 1495      106: i 241
0: % 0         8: v 14137     108: v 16759
0: v 7820      8: i 1503      108: i 231
0: T 135       10: v 14206    110: v 16764
0: C 3263      (skipped...)   110: i 221
0: S 150       100: v 16767   112: v 16761
0: I 1500      100: i 638     112: i 150
2: v 13222     102: v 16764   113: F 1
2: i 1495      102: i 529     113: t 113
4: v 13719     104: v 16761   113: c 2508
4: i 1499      104: i 381     113: v 16767
6: v 13982     106: v 16754   113: i 139
```

Event	Description	Event	Description
*	Beginning of the charging cycle, indicates the maximum battery voltage V_{max} in V	i	Instantaneous battery current I in mA
%	Initial charge state %	F	Battery full, indicates the end-of-charge condition (1 = I_{full} reached, 2 = C_{max} reached, 3 = T_{max} reached)
T	Maximum permissible charging time T_{max} in minutes	t	Actual charging time T in minutes
C	Maximum permissible charging capacity C_{max} in mAh	c	Actual charged capacity C in mA
S	Safety charging in progress, I_{safe} is indicated in mA	E	Error (1 = over-volt, 2 = under-volt, 3 = open-circuit, 99 = CRC fail)
I	Normal charge in progress, indicates I_{charge} in mA		
v	Instantaneous battery voltage $V=V_1-V_2$ in mV		

Ahmad Dannawi @AECENAR/20-9-2023

5.5.2 Lithium Battery Prototype Manufactoring[2]

5.5.3 Lithium-Ion Battery Charger[3]

This is **Lithium-Ion battery charger** implemented on **Arduino**. Has more advanced features like:

- State of charge estimation.
- **EEPROM** logging.
- Command-Line interface.

It uses the **constant current constant voltage (CC-CV).**

The rationale behind this project was to upgrade the depleted battery pack and charger of an old cordless drill from **Nickel-Cadmium (Ni-Cd)** to **Lithium-Ion (Li-Ion)** technology.

Warning: Lithium-ion batteries are dangerous devices. Overcharging, short circuiting, or misuse of lithium-ion batteries may result in fire and/or violent explosion. It is necessary to equip each lithium-ion battery with its own dedicated battery protection board (or battery management system also known as BMS).

5.5.3.1 Theory of Operation

The following subsections cover the theoretical and mathematical aspects of charging a **Li-Ion battery**.

CC-CV Charging

Li-Ion batteries must be charged using the **Constant Current Constant Voltage (CC-CV)** charging method. This method consists of charging the battery at a constant current $\mathbf{I_{charge}}$ until a certain voltage threshold $\mathbf{V_{max}=4.2V_{cell}}$ is reached, then gradually reducing the charging such that the constant cell voltage $\mathbf{V_{max}}$ is not exceeded. Charging is terminated once the current reaches a certain minimum threshold $\mathbf{I_{full}}$ of typically **50-150 mA**.

Additional End of Charge (EOC) standards have been implemented for safety reasons. These include time-based and capacity-based **EOC** detection. When the battery is connected, the charger measures the voltage at its terminals. The **SOC** value is used to calculate the remaining capacity $\mathbf{C_{max}}$ and charging duration $\mathbf{T_{max}}$. Charging is terminated if any of these values are reached.

[2] https://aecenar.com/index.php/downloads/send/7-association-for-alternative-energy-research-vaef/263-lithiumbat-spec

[3] From Build a Lithium-Ion Battery Charger on Arduino | µF (microfarad.de) (https://www.microfarad.de/li-charger/)

Control Loop

The battery **"+"** terminal is connected to the positive power supply through a power **MOSFET** (field-effect transistor). The battery **"-"** terminal is connected to the power supply ground through a low-value **shunt resistor R_{shunt}.**

The charging current is regulated by **pulse width modulation (PWM)**, where the **MOSFET** is periodically turned on and off by the **Arduino** at a frequency of **31,250 kHz**. The charging current is controlled by gradually adjusting the **PWM** duty cycle which is the ratio between the **ON** and **OFF** duration of the **MOSFET**.

V_1 is the voltage measured at the **"+"** terminal of the battery and **V_2** is the voltage measured at the **"-"** terminal of the battery. Both voltages are measured relative to the power supply ground and are used to calculate the **voltage V** across the battery pack and the charging **current I** as follows:

$$\mathbf{V(Volt) = V1 - V2}$$

$$\boldsymbol{I(Ampere) = \frac{V2}{R_{\mathbf{shunt}}}}$$

Two separate **ADC** channels on the **Arduino** are used for measuring the above voltages. The **Arduino** continuously monitors **V** and **I** and adjusts the **PWM** duty cycle in order to achieve the desired constant current or constant voltage regulation.

State-of-Charge Estimation

The **state of charge SOC** is estimated by reading the battery **voltage V** and comparing it to a series of values stored in a lookup table **L = (l0, l1, l2, l3, l4, l5, l6, l7, l8).** The threshold voltages are derived from the particular discharge curve shown below for the **LG 18650 HE4** cells used in this project. ***(Source:* https://lygte-info.dk/review/batteries2012/LG%2018650%20HE4%202500mAh%20%28Yellow%29%20UK.html*).***

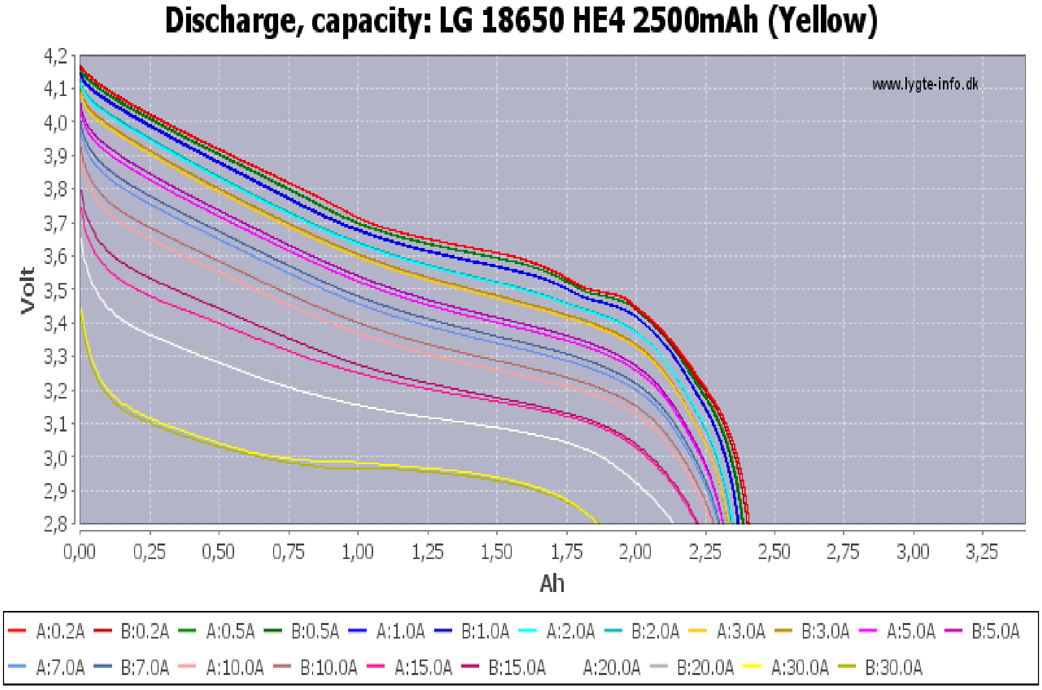


Figure 2: Statistic of Discharge, capacity (LG-18650-HE4-2500mAh)

The red discharge curve corresponding to **0.2A** discharge current has been used, whereas the values of **L** were assigned such that:

- **l_0= V~2.25Ah**
- **l_1= V~2.00Ah**
- **l_2= V~1.75Ah**

  .

  .
- **l_8= V~0.25Ah**

SOC is calculated as follows:

- V< **l_0: SOC= 0%**
- **l_0<V< l_1: SOC= 10%**
- **l_1<V< l_2: SOC= 20%**

  .

  .
- **l_8<V: SOC= 90%**

The remaining capacity **C_{max}** and charge duration **T_{max}** are derived as follows:

$$\boldsymbol{C_{\mathbf{max}}\,(\mathbf{mAh}) = C_{\mathbf{full}} \times (100 - \mathbf{SOC}) \times 1.3}$$

$$\boldsymbol{T_{max} = 3600 \times \frac{C_{\mathbf{full}}}{I_{\mathbf{charge}}} \times (90 - \mathbf{SOC}) + 45.6}$$

Where **C** full is the design capacity of the battery and **C** is the nominal charging current. Note that **C_{max}** is increased by **30%** and **T_{max}** is increased by **45 min** in order to account for resistance losses and inaccuracy of **SOC** estimation.

Safety

The charger implements several safety features. These include:

- **Undervoltage.**
- **Overvoltage.**
- **Short circuit.**
- **Open circuit detection**.

The typical voltage range where a **Li-Ion battery** can safely operate is between $\boldsymbol{V_{\mathrm{min}} = \mathrm{SI}(2.5)V_{\mathrm{cell}}}$ and $\boldsymbol{V_{\mathrm{max}} = \mathrm{SI}(4.2)V_{\mathrm{cell}}}$. Operating outside this range is likely to cause permanent damage to the **Li-Ion** cells and may even result in a catastrophic failure such as an explosion or fire. In addition, the battery pack is protected by a battery protection board (or battery management system also known as **BMS**). The **BMS** measures the voltages of individual battery cells as well as the charging and discharging current flowing through the battery. The **BMS** uses a **solid-state switch** to disconnect the battery once the voltage or current values become outside the specified limits. For the most part, the **BMS** is completely transparent and does not interfere with the charging process, except for the case where the **BMS** disconnects the depleted battery in order to prevent **over-discharge**. In this case, the voltage of the depleted battery is still present across the **BMS** terminals through a high value resistor placed in series with the battery. This high value resistor causes a much lower voltage value to be measured at the charger terminals. Consequently, the charger must ignore the $\mathbf{V_{min}}$ lower limit and start charging at a much lower value of as low as $\boldsymbol{V_{\mathrm{start}} = \mathrm{SI}(0.5)V_{\mathrm{cell}}}$. When served with a depleted battery, the charger will start charging at a low safety current $\boldsymbol{I_{\mathrm{safe}} = \frac{I_{\mathrm{charge}}}{10}}$ until the battery voltage reaches $\boldsymbol{V_{\mathrm{safe}} = \mathrm{SI}(2.8)V_{\mathrm{cell}}}$, after which full charging current $\mathbf{I_{charge}}$ will be applied. Once the voltage reaches this threshold, it is no longer allowed to drop below $\mathbf{V_{min}}$. A voltage lower than $\mathbf{V_{min}}$ may cause an **"under voltage fault"** which may be caused by either a short circuit or open circuit of the battery. Open circuit is also detected if the charging current stays equal to zero while the **PWM** duty cycle increases beyond a specific threshold. This condition would raise an ***"open circuit error"***. Overvoltage is detected whenever the battery pack voltage momentarily exceeds $\boldsymbol{V_{\mathrm{surge}} = \mathrm{SI}(4.25)V_{\mathrm{cell}}}$. Exceeding this value would raise an **"overvolt error".**

Trickle Charging

Once the **end-of-charge (EOC)** criteria has been met, the charger would **cut-off** the charging current and switch to an idle mode where it will continuously monitor the battery voltage. Once the voltage drops below a specific threshold of $\boldsymbol{V_{\mathrm{trickel/start}} = \mathrm{SI}(4.10)V_{\mathrm{cell}}}$, a new charging cycle will be initiated using the following parameters:

$$\mathbf{V_{max}}\,(\boldsymbol{V_{\mathrm{cell}}}) = \boldsymbol{V_{\mathrm{trickel\_max}} = (4.15)V_{\mathrm{cell}}}$$

$$\boldsymbol{C_{max}(\mathrm{mAh}) = C_{full} \times 0.3 + \mathrm{C}}$$

$$\boldsymbol{T_{max}(s) = 20 \times 60 + \mathrm{T}}$$

Where $\mathbf{C_{full}}$ is the battery design capacity. **C** and **T** are the accumulated charge capacity and charge time since the battery has been connected, including the initial charge and all of the subsequent trickle charge cycles. Given the above formulas, the trickle charge cycle uses a reduced $\mathbf{V_{max}}$ and allows for charging up to a maximum of **3%** of the battery design capacity during a maximum duration of **20 minutes**.

5.5.3.2 Hardware

The following **sub-sections** describe the hardware design aspects of the **Li-Ion charger.**

Mechanical Design

We used **four LG 18650 HE4 Li-Ion cells** and a battery protection board (or **battery management system** also known as **BMS**). Modern **lithium-ion cells** use much less space.

Battery Protection Board

It is necessary to use a dedicated battery protection plate for each battery pack. This provides an extra layer of protection to prevent **over charging** or **over discharging** due to software or hardware malfunction. In **figure 2** below, it shows the **4S/30A (4S means 4 cells in series)** battery protection board (or **BMS**).

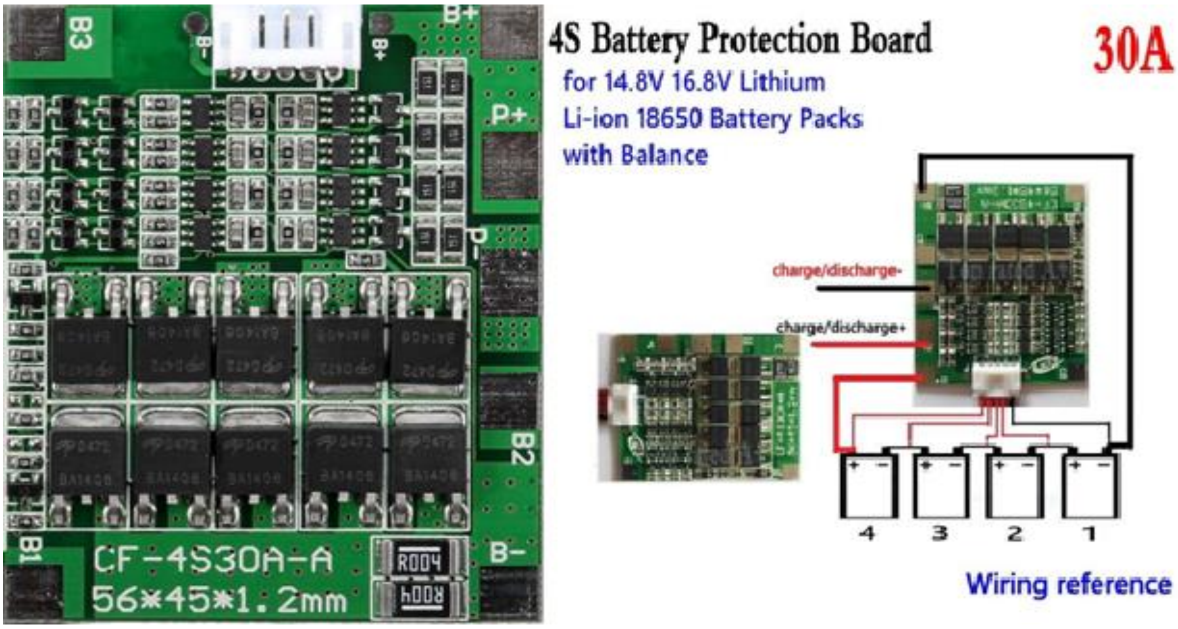


Figure 3: 4S Battery Protection Board

In **figure 2** can see the wiring diagram for connection the **4 Li-Ion cells** with the **BMS**.

This particular **BMS** includes the cell balancer feature. If the voltage of one or more cells becomes higher than the rest of the pack, the **BMS** would actively discharge those cells to ensure that all the cells of the battery pack share the exact same voltage.

Circuit Diagram

In **figure 3** below, it shows the **Li-Ion charger circuit diagram**.

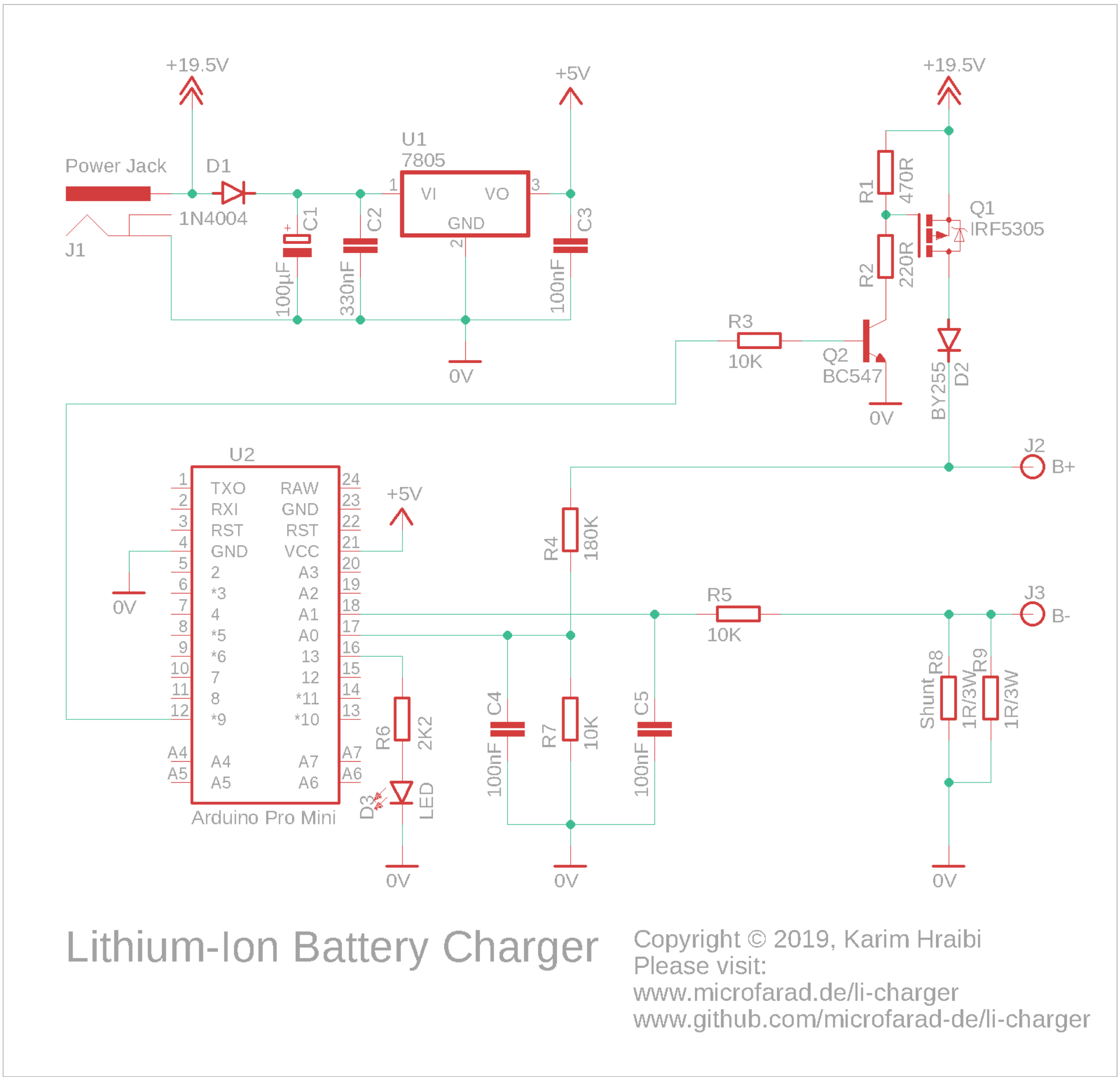


Figure 4: Li-Ion charger circuit diagram

In **figure 3** above schematic, the **19.5 V** of the power supply are stepped-down to **5 V** by the **7805-voltage regulator** U$_1$. The **5 V** is used for powering the **Arduino board**.

The **Arduino Pro Mini** compatible board **U**$_2$ hosts an **AT-mega 328P** microcontroller running at **16 MHz** clock frequency and is used as the main processing unit for the device.

The **Lithium-Ion battery** is connected across the **B+** and **B-** terminals. The battery charging current is regulated by switching **P-Channel MOSFET (field-effect transistor) Q**$_1$ via **pulse-width modulation (PWM).**

The **PWM-enabled digital output pin 9** on the **Arduino** generates a **PWM** signal which drives the gate of the **MOSFET Q**$_1$ through the **NPN transistor Q**$_2$. The **voltage divider** formed by **R**$_1$ and **R**$_2$ ensures that the **gate-source voltage** of the **MOSFET** stays within the specified limits.

A **current-sensing** shunt resistor connects the **B-** terminal with **ground**. It consists of **two 1 Ω / 3 W resistors R**$_8$ and **R**$_9$ connected in **parallel**. This results in a **total resistance** of **0.5 Ω**. At a **charging current** of $I_{charge} = 2A$, the voltage across the shunt will be exactly **1 V**; which is slightly below the **1.1 V** internal voltage reference of the **Arduino** thus corresponds to the full range of the **Arduino**'s **analog-to-digital converter (ADC).**

The **analog pin A_0** on the **Arduino** is used for measuring the **voltage V_1** between **B+** and **0 V**. and the **Analog pin A_1** is used for measuring **V_2** between **B-** and **0V**.

B+ is connected to **pin A_0** through a **voltage divider** consisting of **R_4** and **R_7**, the ratio has been chosen such that the **maximum battery** pack voltage of **16.8 V** would result in slightly less than the **Arduino**'s internal reference voltage of **1.1 V** at **A_0**. Please note that the value of **R_4** needs to be adapted to the number of cells in use. For example, using a **1 cell** setup would require reducing the value of **R_4** to **39 KΩ**.

B- is connected to **A_1** through a **current-limiting resistor R_5**; A **voltage divider** is not required for measuring **V_2** as its value stays below the **Arduino**'s **ADC** internal reference voltage.

Two 100 nF capacitors C_4 and **C_5** are used for blocking the **high-frequency** noise caused by the **PWM** from reaching the **analog inputs**, an essential measure for smooth ADC readings.

The **Diode D_1** protects the **7805** regulator from a reverse power supply polarity. The **diode D_2** protects the battery from a reverse polarity. it also prevents the battery from feeding power back into the **Arduino** in case the main power supply has been disconnected.

A **LED indicator D_3** and its dropper **resistor R_6** are connected to **Arduino**'s **digital pin13.**

Important: The battery terminals in the circuit diagram are labeled as B+ and B-. It is important to connect these terminals to the P+ and P- terminals of the Battery Management System (BMS) depicted in the figure 3. The BMS has its own set of B+ and B- terminals that must be connected directly to the battery terminals. It is crucial to avoid connecting the charger's B+ and B- terminals to the B+ and B- terminals of the BMS, as this would bypass the BMS and prevent it from safeguarding the battery against overcharging.

Different Number of Cells

The following values for **R_2**, **R_4** and the power supply voltage need to be chosen in order to charge different numbers of Cells:

N_{cells}	Power Supply	R_2	R_4
1	5V-6V	220Ω	39KΩ
2	10V-15V	100Ω	82KΩ
3	14V-20V	220Ω	120KΩ
4	18.5V-20V	220Ω	180KΩ

Table 1: N_{cell} with Power Supply, R_2, R_4

When charging **1 cell**, the following circuit modifications must be performed:

- Remove the **voltage regulator U_1** and **capacitor C_3** and power the **Arduino** directly from the output of **D_1.**
- Replace **Q_1** with a **IRLML2244 MOSFET**.
- Increase **R_1** to **10 KΩ.**

- Remove **Q_2** and **R_3.**
- Connect **R_2** directly to **Arduino digital pin 9**.
- Modify the code in **li-charger.ino** to invert the **PWM** signal by subtracting the **PWM** duty cycle from **255** within all instances of **analogWrite ()** using one of the following statements in the figure below:

```
analogWrite (MOSFET_PIN, 255 - G.dutyCycle);  // Replaces analogWrite (MOSFET_PIN, G.dutyCycle)
analogWrite (MOSFET_PIN, 255);                // Replaces analogWrite (MOSFET_PIN, 0)
```

Figure 5: code of analogWrite () in li-charger.ino

5.5.3.3 PCB Layout

All components are of the **punch-hole type** and are mounted on a **PCB board**. The **Figure 4** shows the **PCB layout** of a **Li-Ion charger**.

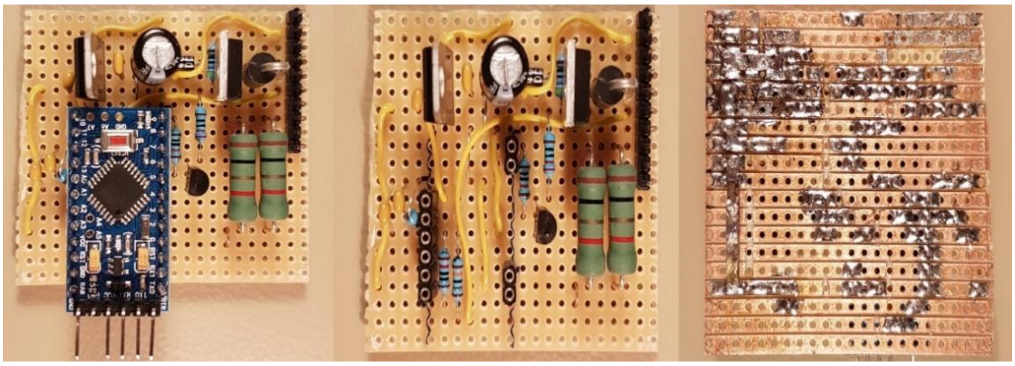


Figure 6:PCB layout of the Li-Ion charger

The **MOSFET Q_1 (TO-220 device in the top right corner)** and large **green-colored shunt resistors** will get pretty hot so adequate ventilation needs to be assured. The following measures has been taken to avoid overheating:

- The **shunt resistors R_8** and **R_9** are raised by around **5mm** from the **PCB** in order to assure adequate cooling.
- A series of holes has been drilled in the bottom of the enclosure in order to allow for a better air flow.
- The charging current **I_{charge}** has been limited to **1.5 A**.

The **electrolytic capacitor C_1** towards the top center of the board is in a **sub-optimal** position due to its location between two hot components, the **7805 regulator** and the **MOSFET**. High temperatures reduce the lifespan of **electrolytic capacitors** thus the must be kept away from heat sources.

The **pin header** located at the top right corner is used for connecting all the external wires. Following is the pinout assuming that **pin 1** is at the top right corner and **pin 10** is towards the middle of the board.

Pin	Purpose
1 *	**LED +**

2 *	LED -
3,4 ⏚	**Power supply +**
5,6 ⏚	**Battery +**
7,8 ⏚	**Power supply -**
9,10 ⏚	**Battery -**

Table 2: All pinhead work

* The LED dropper resistor is located on a separate PCB together with the LED itself.

⏚ Two pins are connected in parallel in order to increase their current capacity.

5.5.3.4 User Interface

The following sections describe the user interface of the **Lithium-Ion charger**. It consists of a **LED indicator** and **a Command-Line Interface (CLI).**

LED Indicator

The charger status is displayed by turning on or flashing a single **LED** as shown

in **Table 3.**

Blinking Pattern	Meaning
On for half a second every 2 seconds	Ready, waiting for the battery to be connected
Solid on	Battery charging
On For 0.1 second every 2 seconds	Battery fully charged
Blinking fast (0.4 s period)	Error
Blinking very fast (0.2 s period)	Calibration mode

Table 3: The meaning of what is displayed via the LED

Command-Line Interface

This **Lithium-Ion battery charger** features a **Command-Line Interface (CLI)** that can be accessed via the **Arduino**'s **RS232 serial port**. The easiest way to connect to the **CLI** is to open the serial monitor of the **Arduino IDE** while connected to the charger using a **FTDI USB** to **Serial converter**. Please ensure that the **Baud rate** is set to **115200**.

Once up and running, the charger will display a welcome message on the serial monitor, show the current firmware version and present with the list of available commands shown in the following list.

Some of these **CLI commands** need to be provided with arguments. Thus, one needs to enter the command followed by **one** or **two** arguments separated by a **white space**. SSS

Command	Description
h	Help- show the list of available commands
.	Display the real-time parameters, including the charge duration T, charge capacity C, battery voltage V, charging current I, maximum charge duration T_{max}, maximum charge capacity C_{max}, maximum charging voltage V_{max}, maximum charging current I_{max}, PWM duty cycle, voltages V_1, V_2 and their raw ADC values $V_{1, raw}$ and $V_{2, raw}$
r	Show the list of calibration constants that are stored within EEPROM
t	Show the contents of the trace circular buffer
ncells <integer>	Set the total number of cells within the battery pack N_{cells}, the value provided as an argument will be validated and stored in EEPROM
cfull <integer>	Set the battery design capacity C_{full} in mAh, the value provided as an argument will be validated and stored in EEPROM
ichrg <integer>	Set the battery charging current I_{charge}, the value provided as an argument will be validated and stored in EEPROM
ifull <integer>	Set the end-of-charge current I_{full} in mA, the value provided as an argument will be validated and stored in EEPROM
iut <index>	Configure the state-of-charge lookup table (LUT). This command takes and index $\boldsymbol{i} = \mathbf{0}, \mathbf{1}, \mathbf{2}, \dots, \mathbf{8}$ and the reference voltage l_i in mV as arguments. Each time this command is called, a new reference voltage value l_i is populated into the LUT and stored into

<voltage>	EEPROM, more on this in the following section
rshunt <integer>	Set the shunt resistor value R_{shunt} in mΩ, the value provided as an argument will be validated and stored in EEPROM
cal <start|stop|v_1|v_2> <mv>	The voltage calibration mode is entered by calling cal start and exited by calling cal stop.V_1 is calibrated using cal v_1 <mv>.V_2 is calibrated using cal v_2 <mv>.<mv> is the measured voltage level in millivolts. Please refer to the next section for more details about the calibration procedure.

Table 4: command followed by one or two arguments separated

Calibration Procedure

This section provides an example on how to perform the **first-time** calibration of the **Lithium-Ion battery charger** using the **CLI** over the serial monitor.

The calibration values are stored into the **Arduino**'s **electrically erasable programmable read-only memory (EEPROM).** A **cyclic redundancy check (CRC)** checksum is appended to the configuration parameters set and stored into **EEPROM** as well. All configuration parameters are validated and **out-of-range values** are automatically replaced with the corresponding failsafe values.

The current example assumes a system consisting of **N_{cells}= 4** connected in series having a design capacity of **C_{max}= 2500mAh** charged using a current of **I_{charge} = 1500mA**.

Important:

- **Do not connect the battery** during the calibration procedure unless instructed otherwise.
- Ensure that the voltage calibration procedure has been properly executed and verified prior to attempting to connect a **Lithium-Ion battery**. It is mandatory to connect a good quality battery protection board between the charger and battery. Failing to observe these precautions may lead to permanent damage or even explosion of the **Lithium-Ion cells**.

Initial ranking

A first step, the initial configuration parameters need to be loaded into **EEPROM** by executing the command sequence as shown in **figure 6** below:

ncells 4	**lut 0 3200**	**lut 5 3710**
cfull 2500	**lut 1 3450**	**lut 6 3825**
ichrg 1500	**lut 2 3530**	**lut 7 3920**
ifull 150	**lut 3 3610**	**lut 8 4020**
rshunt 500	**lut 4 3650**	

Figure 7: command sequence

A confirmation message will be printed on the serial monitor following each value entry.

Voltage calibration

Having performed the above initial step, please proceed for calibrating the **ADC** readings for the voltages **V_1, V_2** as shown below:

1. Enter the **Cal start** command in the serial monitor, this will activate calibration mode. The **Start Calibration** message should appear on the serial monitor.
2. Connect a constant voltage source of approximately **750 mV** between the **B-** terminal and the power supply **ground**, and measure its exact value using a digital multimeter. Note that **750 mV** corresponds to **1.5 A** flowing through the **shunt resistors R_8** and **R_9**.
3. Enter the command **cal v_2 <value>** into the serial monitor, where **<value>** is the value in **mV** of the voltage measured in the previous step. The value of the calibration constant **$V_{2,cal}$** will be displayed upon the successful calibration of **V_2**. If the calibration fails, the message Out of range will appear in the serial monitor.
4. Connect a **constant voltage source** of approximately **16800 mV (4200 mV per cell)** between the **B+** terminal and the **power supply ground**, and measure its exact voltage using a **digital multimeter**.
5. Enter the command **cal v_1 <value>** into the serial monitor, where **<value>** is the value in **mV** of the voltage measured in the previous step. The value of the calibration constant **$V_{1,cal}$** will be displayed upon the successful calibration of **V_1**. If the calibration fails, the message Out of range will appear in the serial monitor.
6. Verify the voltage calibration by applying a known voltage to each of **B+** and **B- (relative to 0 V)**, then enter the **[.](dot)** command and check the displayed values for **V_1** and **V_2** which must match the measured voltages at **B+** and **B-** as closely as possible.
7. Repeat **steps 2, 3, 4, 5 and 6** until the **voltage V** readings are correct.
8. Enter the command **cal stop** in order to exit the voltage **calibration mode**. The message **Calibration stop** should appear on the serial monitor.

Current calibration

Please proceed with calibrating the reading of the **current I** by following the steps below:

1. Connect a discharged **lithium-ion battery** in series using a **digital ampere meter (set to the 10 A range)** to terminals **B+** and **B-.**

2. The message Charging should appear in the serial monitor and the measured current value should start to gradually increase until it reaches a maximum of approximately **1.5 A.**

3. Enter the **[.] (dot)** command and check the displayed value for **I** which must match the measured current as closely as possible.
4. If the output of the **[.]** command is **higher** than the ampere meter reading: **Increase** the **R_{shunt}** value by **10 mΩ** by calling the **r_{shunt}** command.
5. If the output of the **[.]** command is **lower** than the ampere meter reading: **decrease** the **R_{shunt}** value by **10 mΩ** by calling the **r_{shunt}** command.
6. Repeat **steps 3, 4, and 5** until the **current I** readings are correct.

Trace Buffer

A **lithium-ion battery charger** records events that occur during the charging process in a circular buffer within the available **EEPROM** space. The contents of the trace buffer are dumped using the **t command**. Here is a sample trace log output for a complete shipping cycle as shown in **figure 7** below:

```
0: * 16760      6: i 1495       106: i 241
0: % 0          8: v 14137      108: v 16759
0: v 7820       8: i 1503       108: i 231
0: T 135        10: v 14206     110: v 16764
0: C 3263       (skipped...)    110: i 221
0: S 150        100: v 16767    112: v 16761
0: I 1500       100: i 638      112: i 150
2: v 13222      102: v 16764    113: F 1
2: i 1495       102: i 529      113: t 113
4: v 13719      104: v 16761    113: c 2508
4: i 1499       104: i 381      113: v 16767
6: v 13982      106: v 16754    113: i 139
```

Figure 8: t command

Trace messages have the format **<timestamp>: <event> <value>.** While the timestamp counts the minutes that have passed since the beginning of the charging process. The following table shows the available events and their descriptions:

Event	Description
*	**Beginning of the charging cycle, indicates the maximum battery voltage V_{max} in V**
%	**Initial charge state %**
T	**Maximum permissible charging time T_{max} in minutes**

C	Maximum permissible charging capacity C_{max} in mAh
S	**Safety charging in progress, I_{safe} is indicated in mA**
I	Normal charge in progress, indicates I_{charge} in mA
v	**Instantaneous battery voltage $V=V_1-V_2$ in mV**
i	Instantaneous battery current I in mA
F	**Battery full, indicates the end-of-charge condition (1 = I_{full} reached, 2 = C_{max} reached, 3 = T_{max} reached)**
t	Actual charging time T in minutes
c	**Actual charged capacity C in mA**
E	Error (1 = over-volt, 2 = under-volt, 3 = open-circuit, 99 = CRC fail)

Table 5: Available events and descriptions

5.5.3.5 Download:

Below you can find **GitHub download links** for the **Arduino firmware source code**, **Eagle schematic source files** and bill of material. All of the source code is distributed under the **GNU General Public License v3.0**.

Please note that the current implementation uses the watchdog timer functionality which requires the customized **Arduino** bootloader found under the **link** below. For more details, please follow the installation instructions found within the **README file** on **GitHub**.

Customized Arduino Bootloader

Lithium-Ion Charger Firmware

Eagle Schematic Source Files

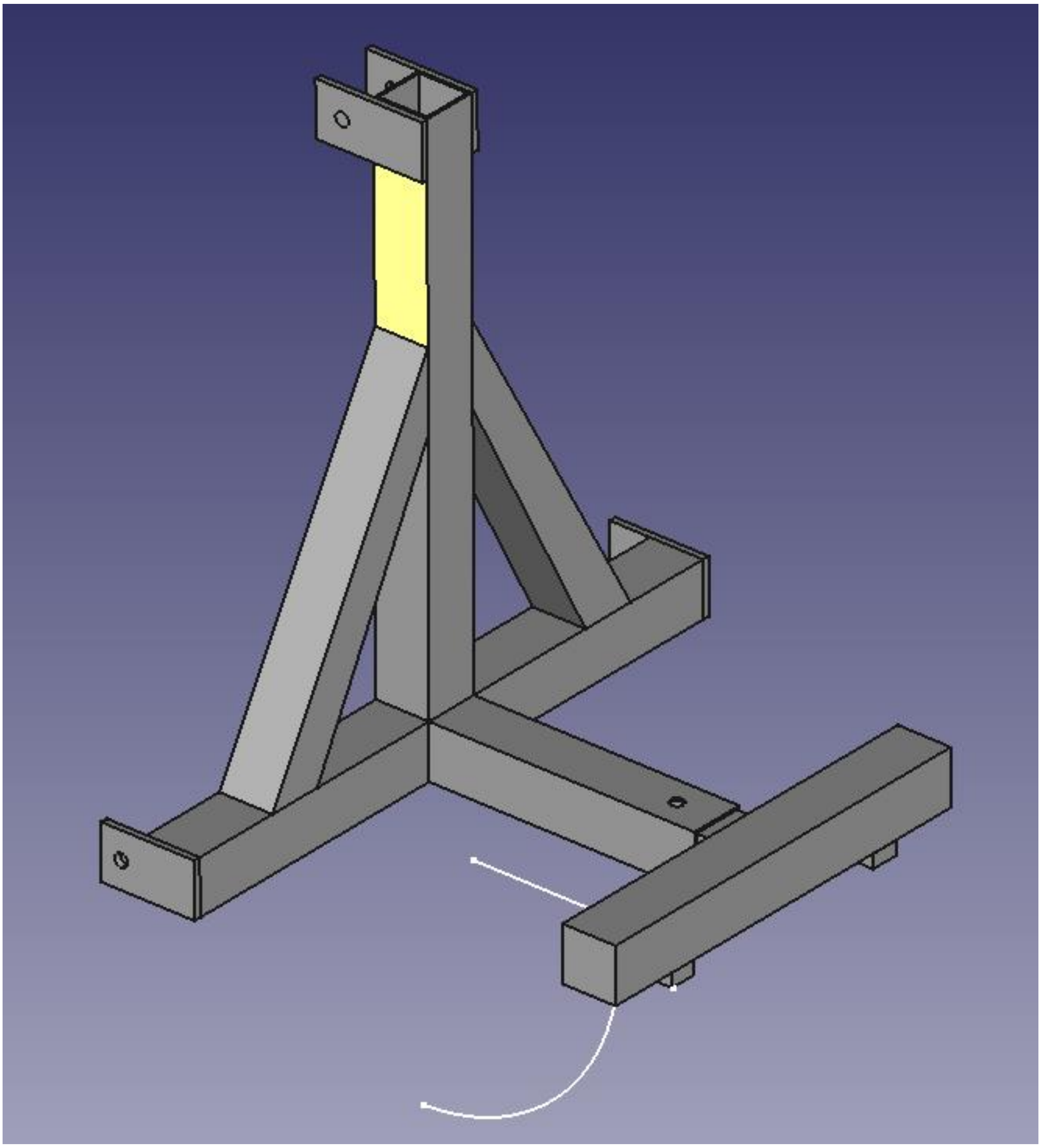
Bill of Material

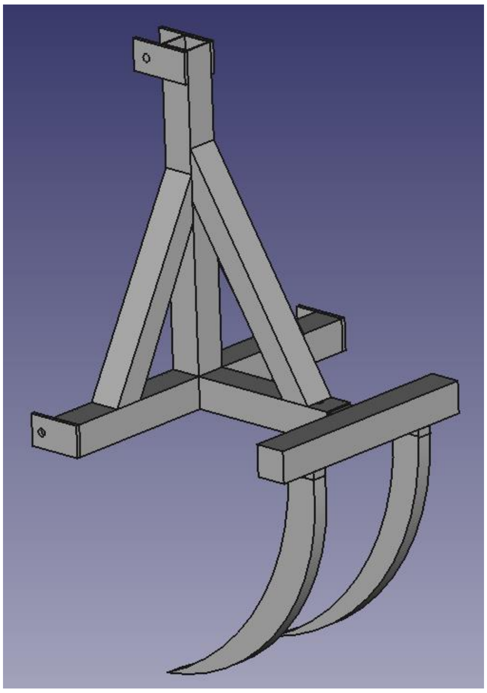
5.6 Agricultural Accessories

5.6.1 Mechanics of Agricultural Acessories

5.6.1.1 Hitch

FreeCad Design



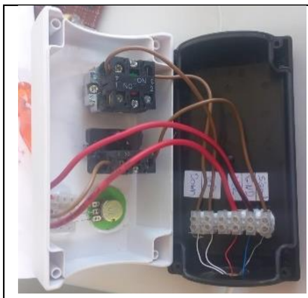
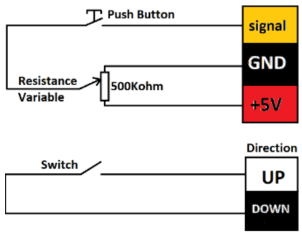


Mechanical Realization

Off-the-shelf device

5.6.2 E/E of Agricultural Acessories

5.6.2.1 Working on controlling the crane (25/6/2023)

5.7 Steps of work

5.7.1 Assemblage the Tuk-Tuk (10/1/2023)

5.7.2 Installing a new structure for solar panels (25/1/2023)

After modifying it from the shape of the blue Tuk-Tuk's structure.

5.7.3 Small Adjustments (1/2/2023)

Raise the box level by 4 cm.

Changing the type of tire rubber

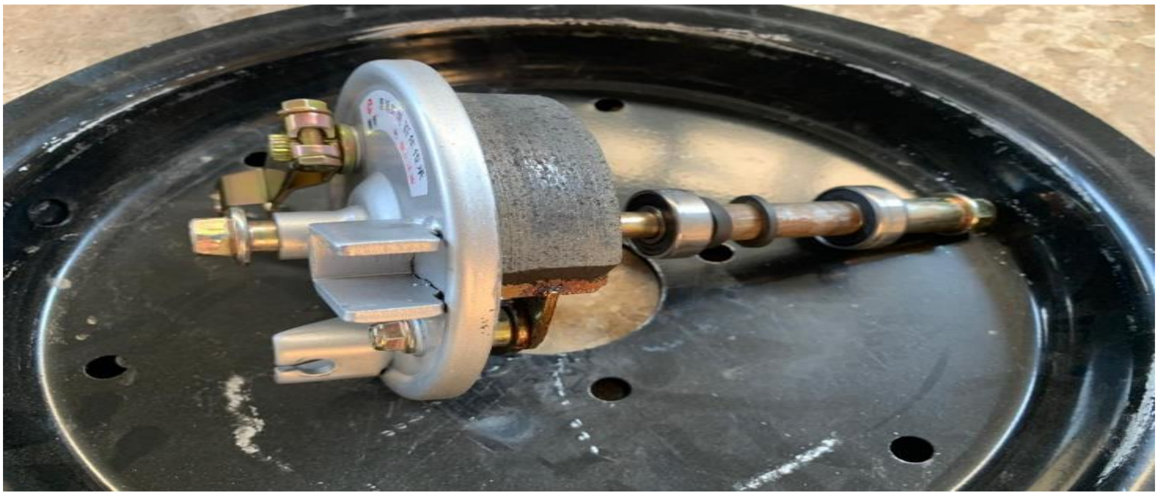
	
Figure 1: Before	Figure 2: After

5.7.4 Modified basic mechanics: (8/2/2023)

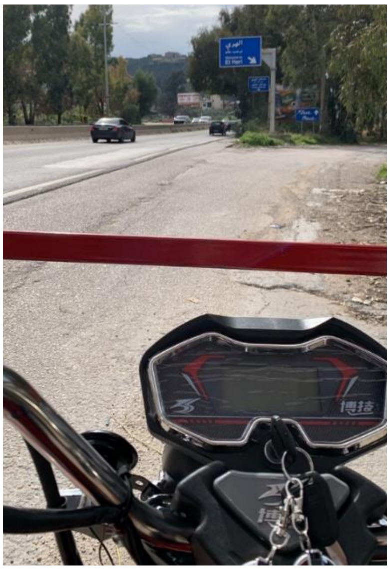
5.7.4.1 Add 2 springs to the front wheel

5.7.4.2 Adjust the springs.

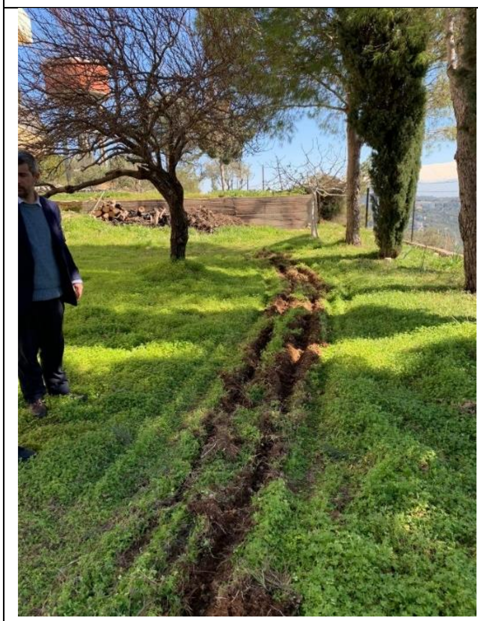
5.7.4.3 Changing the brake system (From the wire to the disc and the oil)



5.7.5 Transfer the red tuk-tuk to Ras Nhache (25/2/2023)



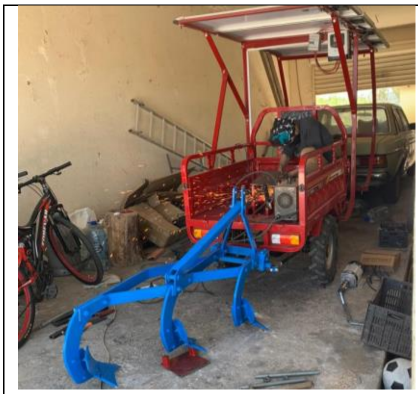
5.7.6 Trying the little blue dibble on the red tuk-tuk (12/3/2023)



5.7.7 Work on the crane of the dibble for red and blue tuk-tuk's (25/3/2023)

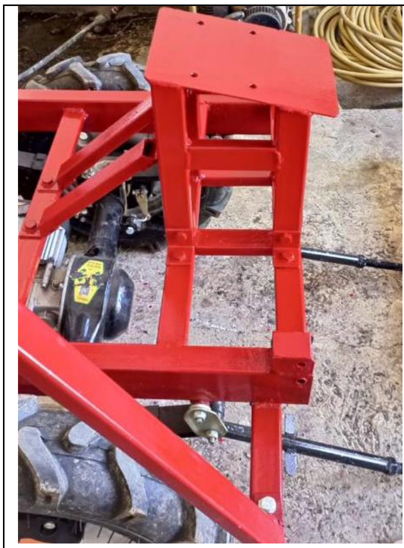
5.7.8 Installing the big red Dibble on the blue Tuk-tuk. (15/4/2023)

5.7.9 Installing the big red Dibble on the red Tuk-tuk. With modification to the crane base (17/4/2023)



5.7.10 Testing the big Dibble (23/5/2023)

5.7.11 Adjusting the crane base on the red tuktuk (30/5/202)

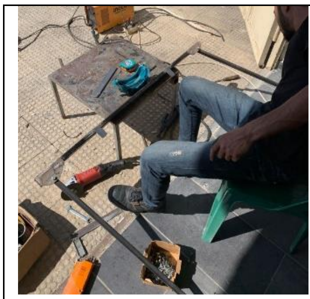


5.7.12 Paint the Tuk-tuk red (1/6/2023)

5.7.13 Testing the Tuk-tuk (6/6/2023)

5.7.14 Receiving the store next to the center and transporting the Tuk-tuk to it from Ras Nhach.(10/6/2023)


5.7.15 Design and installation of an irrigation system on a red Tuk-tuk. With some modifications from the old system in the blue Tuk-tuk (22/6/2023)






5.7.16 Grass shredder installation. (3/7/2023)



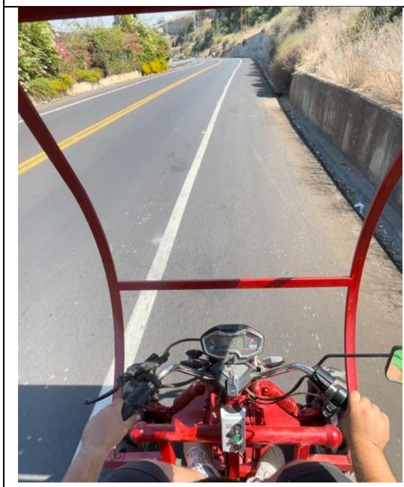
5.7.17 Installing a 12V water pump on the red Tuk-tuk (7/7/2023)

5.7.18 Irrigation test (10/7/2023)

5.7.19 20- Installing two front tires instead of one tire on the red tuk-tuk. (16/8/2023)

5.7.20 Testing and Marketing the red Tuk-tuk (20/8/2023)

5.7.21 The new Tuktuk's front budget is painted red (31/8/2023)

5.7.22 Used the red tuk-tuk by AECENAR team(Power plan) (20/8/2023 to present)

TBD : 3D and 2D designs fort he following parts :

Motor
The heart and soul of your vehicle is the internal electrical motor

Transmission
The transmission is a gearbox filled with gears and gear trains that makes effective use of the motor’s torque to change the gears and power the vehicle.

Battery
The battery delivers the electricity needed to run your vehicle’s electrical components. Without a battery, your car won’t work.

Charger
Part of the electrical system, the charger charges the battery.

Front Axle
Part of the suspension system, the front axle is where the front wheel hubs are attached.

Front Steering and Suspension
Helps improve the ride and handling of the vehicle. Though systems vary in makeup, they typically include shocks/struts, **ball joints**, **tie rod ends**, rack and pinion steering system and **idler**/**pitman arms**.

Brakes
Found on all four wheels, your brakes are one of the most important safety systems on your vehicle. Disc brakes can be found on the front and back wheels and feature brake pads and calipers. Drum brakes with brake

shoes and wheel cylinders may be found on the back wheels of some vehicles.

Rear Axle
Key part of the suspension system to which the rear wheels are mounted.

Rear Suspension
As with the front suspension, the rear suspension contributes to the handling and ride quality of the vehicle. Systems can vary, but they usually are made up of shocks, **coil springs**, **ball joints**, **control arms** and CV joints

6 To be improved

6.1 Power of DC motor

Gasoline Tuk-Tuks on market have about 7-8 kW

The NLAS E-Transporter should have about 3-5 kW

6.2 More own parts (except of chassis with number)

Supplier (2022):

3 wheels tuktuk 1,2 kW , 5 batteries

1600$

To be done in 2025: Concepting for whole parts manufactured in Lebanon with ALU.

6.3 Pricing Goal

The price of the parts for a 4-wheel, 3kW vehicle with solar plates must be 2500$

7 Proposal for Investment in Sustainable Electric Car Project

From: MMJZ and ZM , NLAS Local Factory (100 vehicles per year), Businessplan for Investor Zakariyya (UBSA), March 2024

7.1 Executive Summary

We are pleased to present our proposal for your consideration to invest in our sustainable electric car project. This initiative aims to introduce cutting-edge electric vehicles into the market, addressing the increasing demand for eco-friendly transportation solutions. There are 2 different models presented in our proposal namely Cargo and Passenger Electric Vehicle

The initial stage focuses on a cargo vehicle. This approach allows for a strategic market entry, establishing reliability and functionality. The subsequent phase will transition to passenger transport.

7.2 Project Overview

Our project involves the development of electric vehicles powered by solar energy and lithium-ion batteries (further detailed description is clearly defined in **Annex I**).

Based on our market research and following our latest agricultural vehicle prototype (See Figure 1) that has garnered positive feedback from potential customers who expressed enthusiasm for its use, we realized that there is a keen interest in cargo transport rather than agricultural applications, indicating a shift in market demand towards versatile electric vehicles.

The target market for electric vehicles is substantial, with potential growth projections indicating a lucrative opportunity. Regulatory trends favoring sustainable transportation further enhance the market landscape.

Our study has shown that electric vehicles do have advantages over traditional cars especially in maintenance and daily operation (Fuel consumption). According to our business plan analysis (detailed in **ANNEX II**), electric cars save around 75% on Maintenance and 67% on normal operations.

Figure 1: Cargo Electric Car Sample

7.3 Business plan

We are looking to setup a factory to deliver the forecasted cargo and passenger EV. A land is required for this matter (approx. 4000m2) where we need to install a metal structure container that serves the factory vicinity and production plant.

We are forecasting to produce 50 cars each year (25 per each model)

7.3.1 Partnership Duration

We are forecasting a 3-year business plan. The project duration is extendable as the need arise and based on the performance of the first 3 years

7.3.2 Business Model Partnership:

We propose a profit-sharing model as follows:

- First phase (cargo vehicle), with a distribution of 60% for NLAS and 40% for the investor. (R&D already covered by NLAS)
- Second phase (passenger vehicle), the profit-sharing ratio becomes 50% for NLAS and 50% for the investor.

7.3.3 Pricing Strategy:

Our pricing strategy is crafted to ensure competitiveness in the electric vehicle market, taking into account the unique features of our electric cars. Given the limited presence of such vehicles in the region or the absence of strong competitors, our strategic position allows us to address a market need.

Considering the niche nature of the market, we recognize the potential for establishing favorable pricing. The absence of strong competition positions us as pioneers, and we aim to capitalize on this advantage.

We are looking forward to put initial target market price in as follows:

- **Cargo EV**: 3500$ (Lithium as optional with additional 500$)
- **Passenger EV**: 5500$ (Lithium as optional with additional 500$)

Details on pricing strategy will be explained under financial sections

7.3.4 Responsibility Matrix

NLAS will be responsible for R&D, operations, and implementation of the project. Should the investor like to get involved, it is welcomed based on a defined criteria and strategy in order to clarify all roles. As for the marketing and sales, the investor public relation and experience in local market will be added value in the sale channels and business development of the company (Detailed RM in Annex III)

Furthermore, the investor will play a pivotal role in sales and marketing functions. The investor's involvement will extend to overseeing sales strategies, marketing campaigns, and establishing partnerships. This collaborative approach ensures that the investor actively contributes to the success of our pricing strategy in a market where our presence is particularly vital.

As for the funds required for the execution of the project, it is the responsibility of the investor to make sure to avail the required cash at the startup of the project upfront

7.4 4. Financials

7.4.1 Budget estimation

The following breakdown of cost estimation to derive the budget for delivering 1 cargo and passenger EV

7.4.1.1 Factory Setup

Description	Unit	Price	Duration	Total
Land lease	Yearly	$ 15,000	3	$ 45,000
factory garage	Lum	$ 25,000	-	$ 25,000
Power BKP	Lum	$ 5,000	-	$ 5,000
				$ 75,000

7.4.1.2 HR, Operations and integrations

Desc	Y1	Y2	Y3
CARGO			

operation/int	$ 6,000	$ 6,000	$ 6,000
PASSENGER operation/int	$ 15,000.00	$ 15,000.00	$ 15,000.00

7.4.1.3 R&D

Desc	UNIT	Price	Y1	Y2	Y3
R&D Cargo	LS	$ 5,000	$ 5,000	$ 5,000	$ 5,000
R&D Passenger	LS	$ 6,000	$ 6,000	$ 6,000	$ 6,000

The R&D and Operation cost are leveraged over a period of 3 years and based on production of 25 EV per year for each type. We can improve the cost of EV production by increasing the capacity of production which requires more capital. Depend on the investor strategy, we can work another exercise for targeting 100 EV per year thus improve margin cost by 23% per EV

7.4.1.4 Summary

Accordingly Budgetary estimation for the cost of:

CARGO EV :

Desc	Yeary	Per car
Qty	25	
Factory setup	$ 12,500	$ 500
operation/int	$ 6,000	$ 240
R&D	$ 5,000	$ 200
Material	$ 37,500	$ 1,500
TOTAL		$ 2,440

PASSENGER EV

Desc		Y1	Y2	Y3
Qty		25	25	25
PASSENGER Cost		$ 96,000	$ 96,000	$ 96,000
PASSENGER Revenue		$ 137,500	$ 137,500	$ 137,500
Profit		$ 41,500	$ 41,500	$ 41,500
Capital Invest		$ 96,000	$ 96,000	$ 96,000
Investor Profit share	50%		$ 14,500	$ 14,500

NLAS Profit Share	50%	$ 14,500	$ 14,500

In Summary the investor is required to provide capital invest of 56k$ for CARGO and/or 96k$ for PASSENGER EV with respective profit shares of 40/60 for Cargo (since R&D already covered) and 50/50 for PASSENGER

7.5 5. Conclusion and Call to Action

In conclusion, our electric car project presents an exciting opportunity to revolutionize sustainable transportation in the region. With innovative features such as solar energy integration, lithium-ion batteries, and a strategic phased approach from cargo to passenger transport, our project is poised to make a significant impact.

By seeking your investment, we aim to accelerate the development and deployment of our electric cars, addressing the market's growing need for eco-friendly, reliable transportation solutions. Your expertise in marketing and sales, coupled with your strategic vision, will play a crucial role in the success of our venture.

We invite you to further discuss the details of our proposal and explore how your collaboration can propel our electric car project to new heights. Together, let's embark on a journey to shape the future of sustainable mobility.

6. Investment Terms:

The partnership continues as long as the investor fulfills their duties and responsibilities.

The investor is a production partner only and is not allowed to use or sell the sources, layouts, study during or after the contract.

We look forward to the opportunity to meet and discuss the exciting possibilities that lie ahead.

Thank you for considering our proposal.

Dr. Samir Mourad, CEO

7.6 ANNEX I : Product Description

7.6.1 Vehicle Specification

- General:
    1. **Motor Power**: 1500 W
    2. **Battery**: 60 V, 50 Ah
    3. **Max Speed**: 60 km/h
    4. **Distance on a single charge**: 60 km
    5. **Charging time**: on power: 6 hours, on solar: 4 hours
        - Capacity: Cargo version: Max: 600 kg
        - Passenger version: 4 passengers (total: 500 kg)

- Optional Feature:
    1. Solar integration
    2. Lithium battery

7.6.2 Solar Integration:

Solar energy, captured by photovoltaic cells on the vehicle's roof, directly supplements the vehicle's power source, typically batteries. This additional energy input extends the battery life and enhances overall vehicle efficiency. By harnessing solar power, the vehicle's reliance on external charging is reduced, leading to increased sustainability and improved range.

7.6.3 Lithium Battery:

Lithium-ion batteries, commonly used in electric vehicles for their high energy density and long cycle life, are available as an optional feature due to their additional cost. Advances in technology aim to boost energy density, reduce charging times, and enhance safety. Despite their benefits, the optional nature of lithium-ion batteries acknowledges the additional expense they incur, allowing consumers to make choices based on their preferences and budget.

7.6.4 Safety Measures:

Our extensive experience in this field will be leveraged through our involvement in various projects with the majority of German companies (One of our recent collaborations was with JOPP). This car will design and manufacture to the high practice safety and quality standards.

We are committed to providing a safe and reliable transportation environment, considering safety as a non-negotiable aspect in the design and production of our electric vehicles.

7.6.5 Customization Options:

We have the capability and willingness to make changes and customizations to the vehicle based on specific customer needs. Whether it involves modifications to meet particular market requirements, additional features, or design adjustments, our team is flexible and responsive to ensure that the electric car aligns perfectly with the unique preferences and demands of our customers.

7.7 ANNEX II : Market study - Maintenance and operations comparison and cost saving

7.7.1 Maintenance Expenses:

Traditional Cars: Internal combustion engine vehicles have a complex mechanical structure that often requires frequent maintenance, such as oil changes, exhaust system repairs, and transmission adjustments.

Electric Cars: Electric vehicles have fewer moving parts, leading to significantly lower maintenance requirements. The absence of traditional components like oil filters, spark plugs, and complex exhaust systems translates to reduced servicing needs.

7.7.2 Fuel Expenses

Traditional Cars: Reliance on gasoline or diesel can be a significant ongoing expense, especially with fluctuating fuel prices.

Electric Cars: Charging an electric vehicle is generally more cost-effective than filling up a traditional vehicle with gas.

	$ Cost per year		Saving	%
	Traditional Car	Electric Car		
Maintenance	800	200	600$	75%
Fuel/Charge	1500	500	1000$	67%

By transitioning to our electric car, users can potentially save a total of $1,600 per year. These estimations provide a tangible demonstration of the economic advantages and long-term cost savings associated with adopting our sustainable electric vehicle.

7.8 ANNEX III : Responsibility Matrix table

Task	Investor	NLAS
Research and Design	-	R
Budget Estimation	A	R
Component Procurement	-	R
Production	-	R
Testing and Quality Assurance	A	R
Marketing and Promotion	R	-
After Sales	A	R
Capital Funds	R	-

Legend:

R = Responsible (Person or entity responsible for completing the task)

A = Accountable (Person or entity ultimately accountable for the task's success)

- = Not Applicable

7.9 Annex IV : Phase Budget Estimation

7.9.1 Phase 1: Cargo Vehicle

1. Research and Design:

R&D Costs: None already done by NLAS

2. Vehicle Production:

Body Factory Cost: 800 $/vehicle

Materials Procurement: 400 $/vehicle

Solar system: 300 $/vehicle (Optional)

Lithium battery: 400 $/vehicle (Optional)

Assembly Cost: 200 $/vehicle

Total Vehicle production cost: 2100 $

7.9.2 Phase 2: Passenger Vehicle

1. Design Changes:

Duration: 3 months

Engineers Costs: 2000 $/month

Total R&D estimated cost: 6000 $

2. Vehicle Production:

Body Factory cost: 800 $/vehicle

Vehicle Interior cost: 500 $/vehicle

Materials Procurement: 500 $/vehicle

Solar system: 300 $/vehicle (Optional)

Lithium battery: 400 $/vehicle (Optional)

Assembly Cost: 300 $/vehicle

Total Vehicle production cost: 2800 $

3. Additional Tasks for Passenger Vehicle:

Safety Standard Compliance: 2000 $ consulting cost

Formal Registration and Agreements: 1000 $

Testing and Enhancements: 1000 $/month

Total Estimated Cost for Additional Tasks: 4000$

***Note**: all costs and prices are estimated and subject to change based on current market conditions.

7.9.3 ANNEX V : Ready to Market Time Plan

7.9.3.1 Phase 1: Cargo Vehicle

1. Research and Design:

Duration: None

2. Cargo Vehicle Production:

Chassis Production:

Factory Agreement for body: 1 month

Materials Procurement quotation: 1/2 month

Assembly Duration: 1/2 month

Grand Total Time for Cargo vehicles: 2 months

7.9.3.2 Phase 2: Passenger Vehicle

1. Design Changes:

Duration: 3 months

2. Vehicle Production:

Chassis Production:

Duration: 1 month

3. Car Interior Upholstery:

Duration: 1 month

4. Additional Tasks for Passenger Vehicle:

Safety Standard Compliance, Formal Registration, and Agreements, Testing, and Enhancements:

Duration: 2 months

Grand Total Time for passengers vehicle: 7 months

8 Production Facility

8.1 Production Line

Development: Ras Maska, Integration: Ras Nhache, Sales: Tripoli

بسم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

ONLAS AUTOMOTIVE SYSTEMS

E-tuktuk Production Line

Virtual production plan:

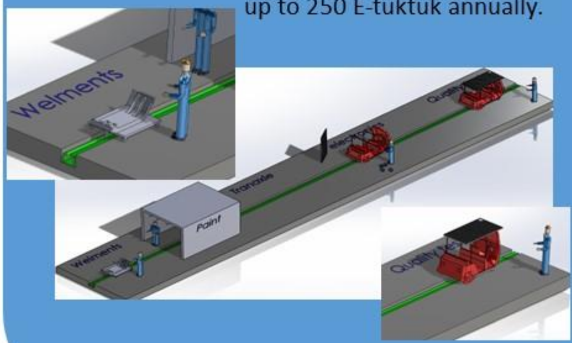
Weldments → Paint → Transaxle assembly → Electronics assembly → Quality test

The assembly line stations will be assigned according to the scheme above to ensure the most efficient assembly of the E-TukTuk.

Assembly line mechanism:

The chosen mechanism for the assembly is the Towline conveyers, such conveyer perfectly fit to this application since it's cheap, easy to maintain and needs less space since it can be embedded in the ground.

Design: A classic assembly line for the E-tuktuk production process, this assembly line can maintain up to 250 E-tuktuk annually.



According to our current vision, we plan to produce 50 vehicles annually. This translates to completing a vehicle every 5 working days. To achieve this, each station in the production line will operate independently, ensuring a streamlined and efficient workflow.

Costs:

The costs of the production line are divided into four parts:

1. Industry costs, which cover machines and tools.
2. Safety systems and equipment.
3. Labor costs for the staff needed to manufacture 50 cars annually.
4. Costs for the facility building and land.

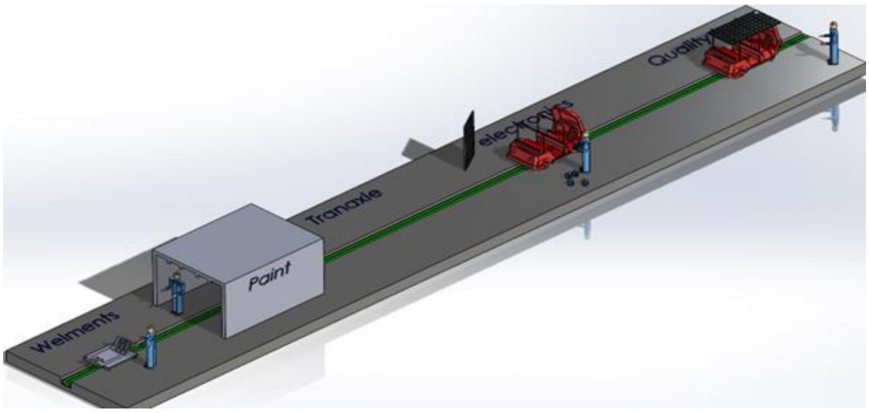
The total estimated cost is approximately **162,000$**.

Industry		
Items	quanity	price ($)
Conveyors	25 m	35000
crane	2	4000
carts	5	1250
tools	-	2500
welders	2	1000
safety		
Items	quanity	price
safety equipments	-	3000
firefighting system	-	6500
labor		
Items	quanity	price
Skilled labor	3	9000
Engineer	1	4500
facility		
Items	quanity	price
building	-	50000
land	400 m squared	45000

@AECENAR/Aug2024

Author: Anas Hamzeh

Solidworks STEP file shows the production line 3D model.



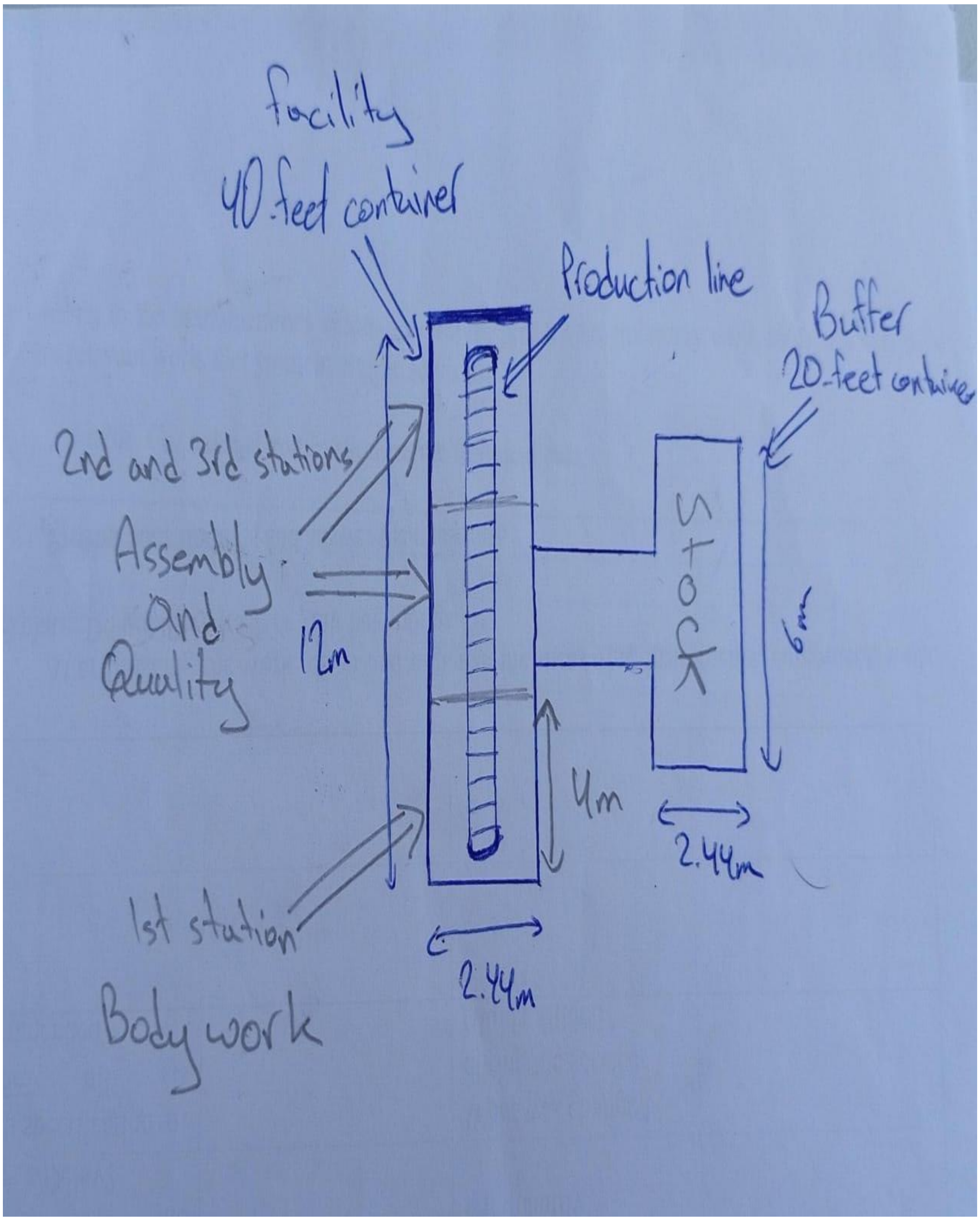
8.1.1 Costs Excel table:

Industry		
Items	quanity	price ($)
Conveyors	25 m	35000
crane	2	4000
carts	5	1250
tools	-	2500
welders	2	1000
safety		
Items	quanity	price
safety equipments	-	3000
firefighting system	-	6500
labor		
Items	quanity	price
Skilled labor	3	9000
Engineer	1	4500
facility		
Items	quanity	price
building	-	50000
land	400 m squared	45000

8.1.2 Production Line (PL) development:

After completing the first version of the production line, we identified that some stations will not be crucial during the initial stages of production since the main chassis parts will be imported.

The production line will be constructed within a 40-foot (approximately 12 meters) container, divided into three stations, each 4 meters long. The first station will be designated for bodywork, where weldments and painting will be performed if necessary. The second and third stations will be used for all assembly tasks (including electrical, electronics, and mechanical assembly), with quality tests conducted throughout the assembly operations. Given the limited space, a buffer storage area is essential to hold the stock of parts required for the production line.



8.1.3 Manufactoring Manual & Production Timeline

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Timeline NLAS production 2024

Task		Timeline	Pieces Prices	Sum open costs	Responsible
Repairing red NLAS E-Transporter		Oct24			Ali, A Kassem
	5x100Ah Gelbats (1y garantee)		$500		
				$500	
Upgrading blue E-Transporter	Lithium Bat (70d delivery): I_max=40A, 100Ah, 20 cells (45$ per cell), ECU: 100$, structure: 50$	Nov 24	$1.050		A Kassem, Supplier: in Tripoli
	2 front wheels		$400		
				$1.450	
SOP (Start of Production)					
Producing 1 E-Transporter		1 week (for 1 vehicle, 2 workers)		**$2.900**	
	Parts for 3-wheels TukTuk		$1.200		
	Solar Structure + Panels		$400		
	Batteries Upgrade		$900		
	Integration (HR) (4 d mech, 2d E/E)		$300		
	Renting Place		$100		

Sum QIV24	**$4.850**

8.1.3.1 NLAS E-Transporter Prototype BOM

NLAS E-Transporter23

1. Using red Transportation Tuk-Tuk for delivery issues						
2. Production Business Plan:						
https://aecenar.com/index.php/downloads/send/7-association-for-alternative-energy-research-vaef/1579-nlas-business-plan-2024-docx						

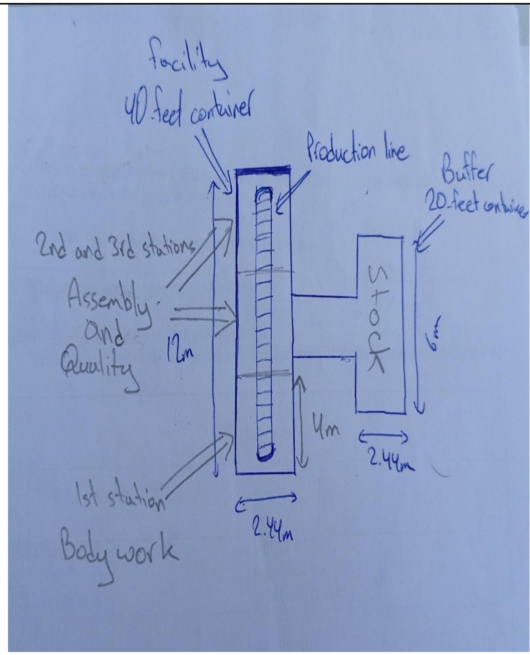
Products

	Main Materials		Used Systems	Develop-ment	Develop-ment	SOP
Transportation E-Tuktuk				Oct 22-Oct24	Oct 22-Oct24	Nov 24
NLAS E-Transporter23 Parts						
Part	**quantity**	**picture**	**description**	**Supplier1**	**Supplier2**	**Price per item**
Basic (originally Tuk-Tuk) parts except of chassis						$200
Front sides flashers	1		the two are connected to each other			
Rear flashers	2					

differartial regulation axe	2					
rear brake axe	3					
flasher coil 60V	1					
pins for rear dampers	12					
digital 60V dashboard	1					
T shape front suspension axe	1					
12 inch rear rims	2		without standard tires			
start switch	1					
rear differatial axe	1		with gear and fising pins			
~~front steering wheel bearing~~	1					
control circuit for all electric parts	1					
Gear shifter rod	1					
brake sensor	1					
6 pins connector box	1		for power distribution			
steering wheels switches and buttons	1 set					
supports for rear damper	2					
controller 1500w 72v BRSH-60	1					
~~steering wheel~~	1					
Gear shifter handle	1					
hand brake handle	1					
speed controller FR-3S	1					
rear dampers	2					
electric motor 1500w 72v	1					
Solar panels parts						$400
MPPT	1					
solar panels 100w	5					
solar system connectror and wires	1 set					
front suspension parts						$400
Front shock absorber	2		350mm for 200cc ATV			

Upper swing arm	2					
Lower swing arm	2					
steering strut knuckle spindle and wheel hub	2					
Bolts	4					
chassis and body						$1.000
long chassis with front suspesion chassis	1					
battery container and driver seat	1					
cabin	1					
solar panels stand	1					
Batteries						
Lithium Bat Block (70d delivery)	1		I_max=40A, 100Ah, 20 cells (45$ per cell), ECU: 100$, structure: 50$			$1.050
Integration (4 d mech, 2d E/E)						$300
					Sum	**$3.350**

8.2 Container/Hangar Facility in Ras Nhache



8.3 Costs

8.3.1 Surface leveling of ground + Cleaning Beton Surface (10cm)

About 2500$

8.3.2 Radier (about 192qm)

About 18000$

Phase	Item	Qty	Unit	Unit Price $	Price $
	Water Tank	1	-	300	300
	15 cm Blocks	300	-	0.6	180
Slab On Grade	Concrete	33	m3	70	2310
Slab On Grade	Labors	15.5	m3	37	573.5
Spacers	Concrete	0.5	m3	70	35
Spacers	Labors	-	-	130	130
Raft	Concrete	77	m3	75	5775
Raft	Rebars	8.5	Ton	750	6375
Raft	Labors	77	m3	33	2541
					18219.5

Dia.	No.	Length	W	Unit Price	Price
mm		m	ton	$/ton	$
14	80	6	0.580	750	435
12	128	7.5	0.852	750	639
12	42	7	0.261	750	196
12	354	6	1.885	750	1414
12	632	5.5	3.084	750	2313
12	282	5	1.251	750	938
12	22	4.5	0.088	750	66
8	200	5	0.394	800	316
Total			8.395		6316

8.3.3 Walls and Ceiling Estimation

	Radier		**Walls**		Ceiling	
	thickness [m]	qm	thickness [	qm		
	0,4	192	0,15	210		
Costs		$ 18.000,00		$ 5.906,25	$ 9.000,00	
					Total Cost	$ 32.906,25

9 Mafrak – Ras Nhache line

9.1 Business Specifications

Price: 50.000 L.L. (about 0,5 cent)

Only for females

Stations: Masjid or Madrasa

9.2 Design of Persons Transport

Transporter: 2 opposite banks for 2x2 persons

10 Next steps

10.1 Moving devices from Ras Maska facility

4 Hangar pieces for welding, 4 x 4-point flanges

10.2 Development issues

10.2.1 Front axis

10.2.1.1 FreeCAD Drawing

3D tbd

2D tbd

10.2.1.2 Mechanical Realization

tbd

10.2.2 Front Wheels

10.2.2.1 FreeCAD Drawing

3D tbd

2D tbd

10.2.2.2 Mechanical Realization

tbd

10.3 To be improved

10.3.1 Power of DC motor

Gasoline Tuk-Tuks on market have about 7-8 kW

The NLAS E-Transporter should have about 3-5 kW

10.3.2 More own parts (except of chassis with number)

Supplier (2022):

3 wheels tuktuk 1,2 kW , 5 batteries

1600$

To be done in 2025: Concepting for whole parts manufactured in Lebanon with ALU.

10.3.3 Pricing Goal

The price of the parts for a 4-wheel, 3kW vehicle with solar plates must be 2500$

10.4 Production facility issues

10.4.1 Surface leveling of ground + Cleaning Surface (10 cm Beton)

About 2500$

10.4.2 Radier (about 250qm)

About 18000$

10.4.3 Walls and Ceiling

	Radier		**Walls**		Ceiling	
	thickness [m]	qm	thickness [	qm		
	0,3	240	0,15	210		
Costs		$ 18.000,00		$ 7.875,00	$ 9.000,00	
					Total Cost	$ 34.875,00

10.5 Team building

10.5.1 Mechanical Engineering

AZ

10.5.2 Electrical Engineering and Installation

AQ

10.5.3 Mechanical Realization and Assembly

Could be outsourced

Staff Requirements: Welding

10.6 Timeplan

	December 24	Jan 25	Feb 25	Mar 25
Moving devices from Ras Maska facility, installing hangar	150$			
Surface leveling	2300$			
نظافة	2300$			

Reference

NLAS 2022 Annual Report (Word File)

NLAS 2022 Annual Report (PDF File)

NLAS 2023 Annual Report (Word File)

NLAS 2023 Annual Report (Pdf File)

https://aecenar.com/jdownloads/NLAS/251224NLAS_Report2024_Administration_and_Production.PDF