A Senior Design Project Report on

"Mining Truck Cabin Air Monitoring System"

Bachelor of Engineering in Mechanical Engineering

Submitted by

Team M22_23

Venkatesh Barakol	01FE19BME112
Basavanagowda P N	01FE19BME105
Shashank Deshpande	01FE19BME111
Aniket Joshi	01FE19BME172
Akash Arkasali	01FE19BME087
Abhishek Kulkarni	01FE19BME139

Under the Guidance of

Prof.P.P.Revankar

2022-23

K L E Society's

KLE Technological University HUBLI-31

School of Mechanical Engineering

KLE Technological University
KLE TECH.
Creating Value
Leveraging Knowledge

CERTIFICATE

This is to certify that Senior Design Project entitled **"Mining Truck Cabin Air Monitoring System"** submitted by **Team 23** to the **KLE Technological University**, Hubli-580031; towards partial fulfillment for the award of the degree of Bachelor of Engineering is a bona-fide record of work carried out by him/her under our supervision. The contents of project report, in full or in parts, have not been submitted to any other institute or university for award of any degree or diploma.

Prof.P.P.Revankar	Dr.B.B.Kotturshetter
Guide	**School Head**

Name of the Examiners	**Signature with date**

1.

2.

ACKNOWLEDGEMENT

The successful completion of any task would be incomplete without mentioning the people whomade it possible and whose guidance and encouragement has made our efforts successful.

At the outset, we would like to express our deep sense of gratitude for our guide **Prof. P.P.Revankar** for making this project report successful through their invaluable guidance at every stage of the project report.

We also thank **Dr. B.B.Kottutshettar** for his encouragement in undertaking the task of this project.

We also thankful to all faculty members of the Mechanical Engineering Department of KLE Technological University, for helping us directly or indirectly in different stages of our project work.

Student signature

(Team 23)

Table of Contents:

1. ABSTRACT

The mining region's pollutants reduce the quality of the air and may have an adverse effect on the health of drivers who work in the mines. Cardiovascular and respiratory conditions may result from poor air quality. To prevent workplace accidents, drivers' health and attentiveness are essential. Therefore, it is crucial to control air quality, especially in mining regions. It is possible to measure air parameters to provide vital data for managing air quality and warning drivers and fleet management. The air in the cabins might be monitored with the aid of some sensors. Constructing a system that can receive data from sensors that detect various pollutants such as sulphates, nitrogen oxides, ozone, carbon monoxide, and carbon dioxide. Using data gathered in real time, the air monitoring device can inform drivers about the situation and management. Additional air purifiers could aid in enhancing the air quality.

1.1 PROBLEM STATEMENT

Typically truck drivers operate for long hours and at times in highly polluted environments like mines. Driver health and alertness while driving is key to avoid accidents at work site. Sometimes air quality deteriorates inside the cabin, and this could lead to driver fatigue. So come up with a solution that can detect air quality level inside the cabin, and at the same time alerting the driver as well as fleet management.

2. LITERATURE SURVEY

- In the past several decades, the effects of air pollution exposure on human health have been extensively studied, indicating that air pollution is a vital cause of increased morbidity and mortality.
- 1–3 People spend most of their time in indoor environments, including vehicle cabins.
- The in-cabin micro-environment has become a significant source of exposure to various air pollutants, such as particulate matters (PMs), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), carbon monoxide, nitrogen oxides etc.
- The quality of air in the cabins of Trucks operating in mines is affected by many factors.
- In cabin, pollutants come from the outside environment or they are emitted directly inside the vehicles.
- The main external sources of air pollution are the underground mining operations themselves (exploitation of resources) and diesel engine exhaust; oftentimes, the mine ventilation system is insufficient to remove this pollution.
- Harmful pollutants from these sources may enter the cabin by infiltration, or they may be carried in by the cabin ventilation system.

2.1 POLLUTANTS RELEASED IN AIR DUE TO MINING

- Ozone
- Sulphur dioxide
- Nitrogen dioxide
- Carbon dioxide
- Lead
- Arsenic
- Fluorine
- Mercury

2.2 HEALTH EFFECTS OF MINING

- The mercury used in mining causes a number of different health problems, including neurological disorders and kidney diseases. Besides mercury-poisoning, people living around mines are polluted by lead, zinc and copper.
- The negative consequences of mining for human health include respiratory complications such as pneumoconiosis, asbestosis, and silicosis caused by inhaling fine particles from the large amounts of dust generated by mining activities such as blasting and drilling.

2.3 MINING FATALITIES SINCE PASSAGE OF THE MINE ACT [1]

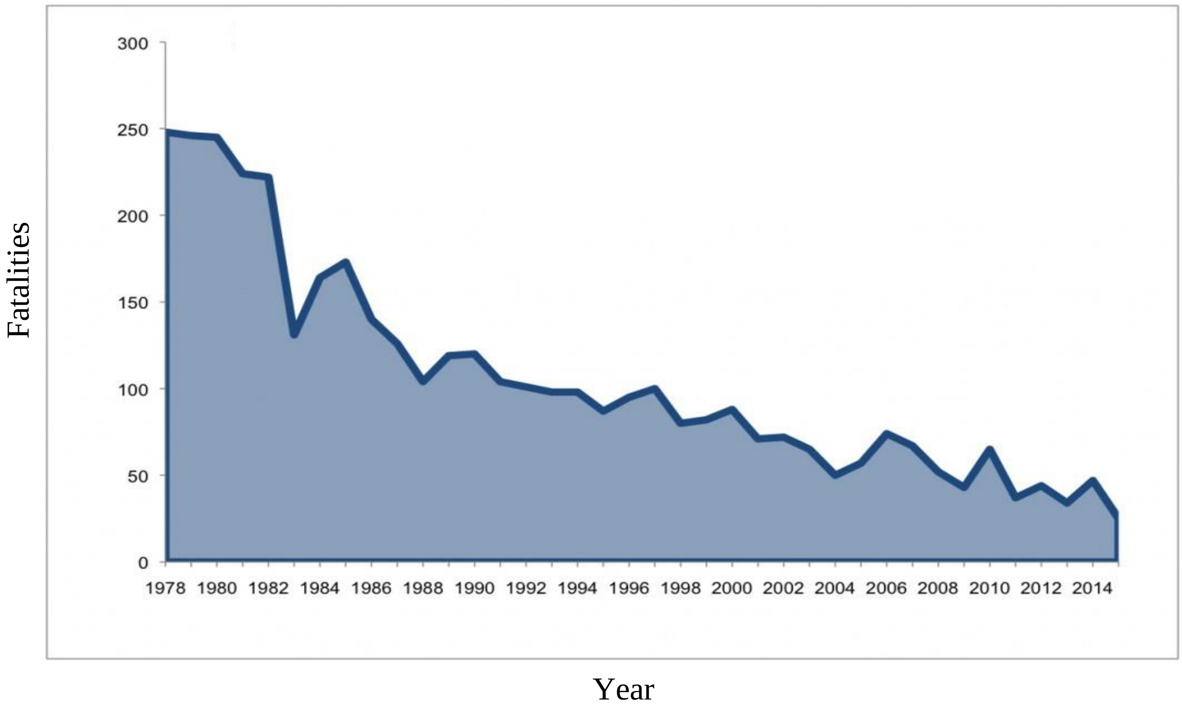

Figure: 2.1

Graph from the year 1978 to 2014 illustrating the number of fatalities in mining zones.

MINING FATALITIES FROM 2000 to 2015 [2]

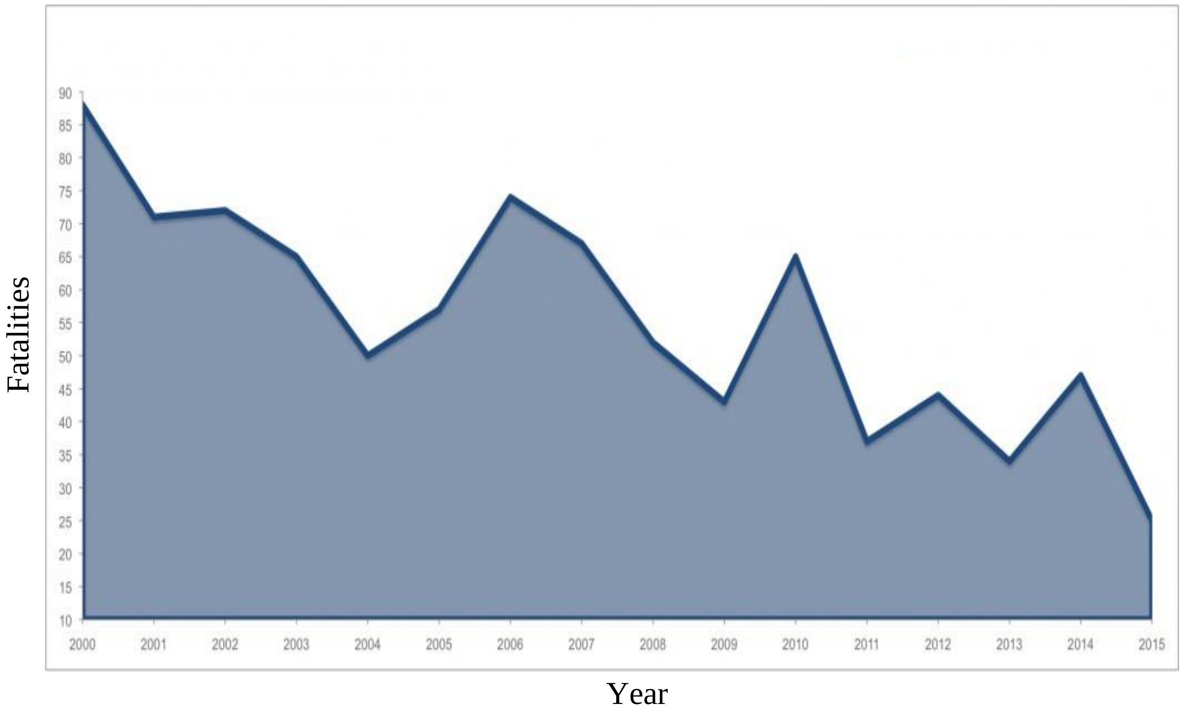

Figure: 2.2

Graph showing the number of fatalities in mining zones from the year 2000 to 2015.

3. RESEARCH ARTICLES

1. Bin Xu et al...(2016) this study summarizes the key findings that have been reported in the literature on the air quality inside passenger cars, including chemical species, sources, measurement techniques, and management methods. Information based on the literature has provided solid backing. There is evidence that pollutants in indoor air are common. Highly exposed cabins could have detrimental effects. Consequences on travellers' health various sources release various air pollutants at varying levels. Depending on the ventilation or driving conditions [3].

2. Ramik Rawal et al... (2019) have reported that MQ135 and MQ7 sensors are used in this study to assess carbon monoxide (CO) and air quality, respectively. Measuring air quality is an important step in educating the public about the importance of ensuring that future generations have healthier lives. The Indian government has already taken some action to ban motorcycles with single- and two-stroke engines, which are quite significant polluters [4].

3. Andrzej Szczurek et al...(2020) the analysis showed that numerous Health & safety requirements cannot be met inside the cabin, even with the best ventilation solutions now available, if the same requirements are not met outside the machine. The recommended method resolves this problem by combining already present elements like ventilation, air conditioning, and filtration with a personal source of pure air. The concept is adaptable and can be changed to fit a variety of specific requirements [5].

4. Ganesh et al... (2017) there is a cooling cycle that uses vapor absorption in the exhaust system. The recommended air conditioning system could be powered by the truck's exhaust heat, it was discovered. By cooling the driver off, it enhances his performance without reducing fuel efficiency. It is environmentally friendly because it doesn't use any refrigerants with a high global warming potential (GWP). Our strategy entails developing the vapor absorption air-conditioning for cars that will be necessary in the future. We designed a refrigeration system that relies on ammonia vapor absorption, and we then simulated it using several parametric settings [6].

5. A.B. Cecela et al...(2009) the enclosed cab of the unidirectional design uses the top-down clean-air flow pattern. In re-circulation systems, the intake and discharge air vents are commonly located on the top of the cab. Two problems exist with this design. Some of the clean air ejected is immediately short-circuited back into the re-circulation vent before entering the enclosed cab (intake). Second, dust from the operator's clothing, the interior cab walls, and the floor is transported up over the operator's breathing zone as air enters the re-circulation duct at the ceiling of the cab [7].

6. Rasmus Parsmo et al...(2019) the project's objective was to understand the primary factors contributing to and the severity of air pollution in car interiors, with a focus on particle pollution. Along with examining how the design of the ventilation system and air purification technology in cars affects the quality of the air inside of them, and developing a trustworthy and effective method for evaluation in traffic conditions. Five complete full-scale measurement projects and a number of smaller, scaled-down measurement sessions were used to test the levels of air pollution inside and outside the vehicle cabin as well as comfort metrics while driving in actual traffic [8].

4. KEYWORDS

Table No: 4.1 Keywords

Portable
Digitalize
Compact
Automatic
Accurate
Precise
Maximum volume
Measuring oxides of Nitrogen (NO_x)
Measuring Carbon Monoxide (CO)
Measuring Ozone (O_3)
Measuring Particulate Matter
Interpret data in readable form
Alerting
Operating Current
Operating Voltage
Air purification
User friendly

5. OBJECTIVES, CONSTRAINTS, FUNCTIONS (OCF)

Table No: 5.1 OCF Chart

Sl. No	Keywords	Objectives	Constraints	Functions
1.	Portable	✔		
2.	Digitalize	✔		
3.	Compact	✔		
4.	Automatic	✔		
5.	Accurate	✔		
6.	Precision	✔		
7.	Maximum volume		✔	
8.	Measuring oxides of Nitrogen (NO_x)			✔
9.	Measuring Carbon Monoxide (CO)			✔
10.	Measuring Ozone (O_3)			✔
11.	Measuring Particulate Matter			✔
12.	Interpret data in readable form	✔		
13.	Alerting	✔		
14.	Operating Current		✔	
15.	Operating Voltage		✔	
16.	Air purification			✔
17.	User friendly	✔		

5.1 OBJECTIVES

Table No: 5.2

1.	Portable
2.	Digitalize
3.	Compact
4.	Automatic
5.	Accurate
6.	Precision
7.	Interpret data in readable form
8.	Alerting
9.	User friendly

5.2 CONSTRAINTS

Table No: 5.3

1.	Maximum Volume(20x10x10)
2.	Maximum Operating Current(15 mA)
3.	Maximum Operating Voltage(5V)

5.3 FUNCTIONS

Table No: 5.4

1.	Measuring oxides of Nitrogen (NO_x)
2.	Measuring Carbon Monoxide (CO)
3.	Measuring Ozone (O_3)
4.	Measuring Particulate Matter
5.	Air purification

6. CONCEPTUALIZATION

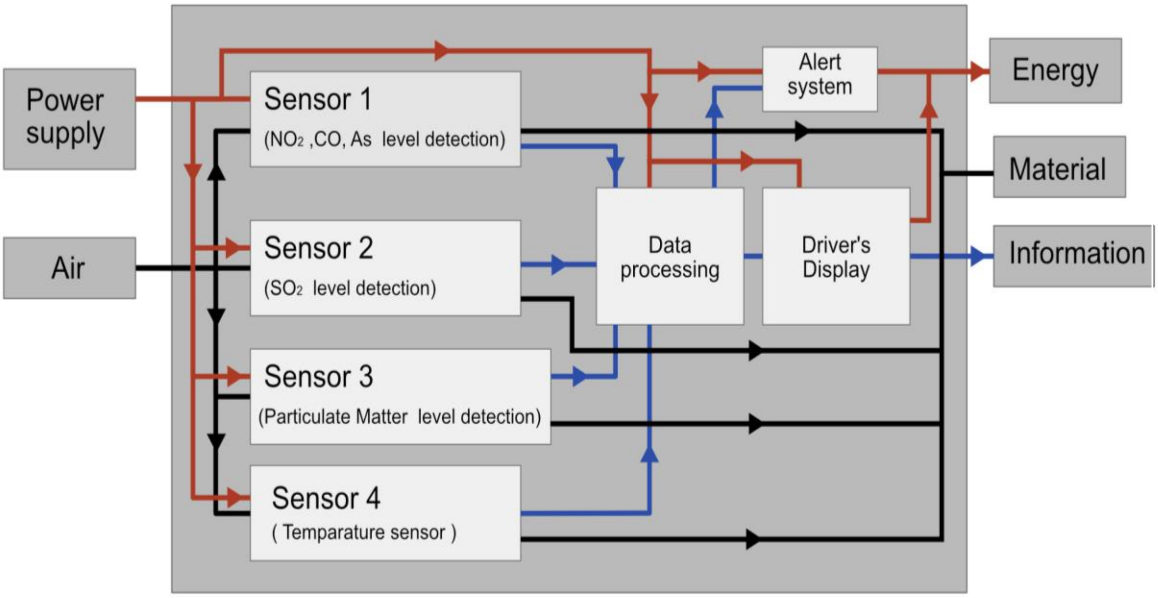

Figure: 6.1

The above figure illustrates the working flow of the device from the sensors to the microcontroller to the alert system and driver's display.

7. ALTERNATE DESIGNS

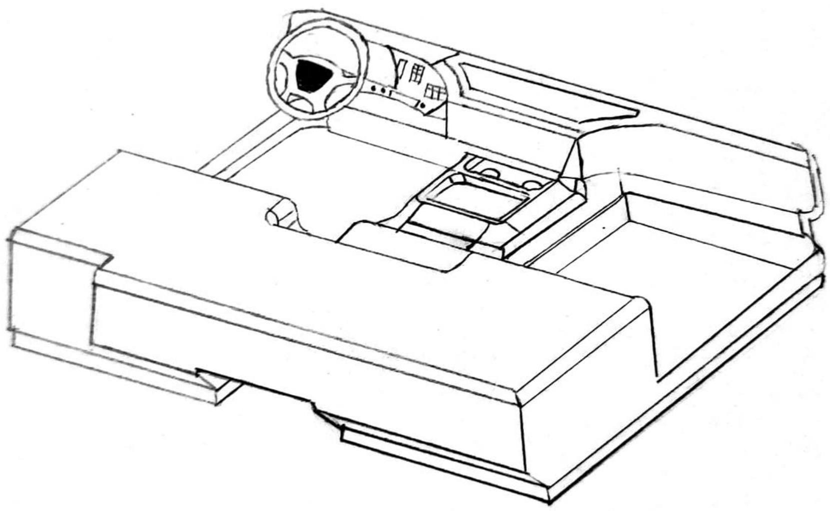

Figure: 7.1

The illustration up top shows an isometric view of the conceptual design for the truck cabins used in the mining regions.

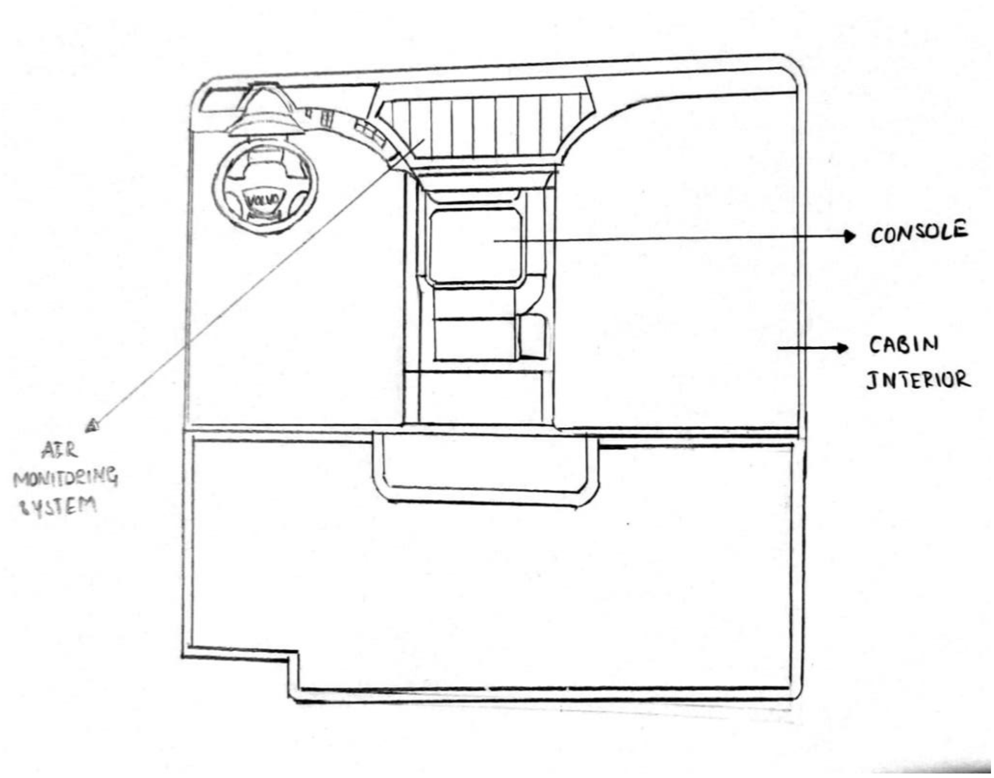

Figure: 7.2

The top view of the conceptually designed cabin of the truck for used in mining regions is depicted in the figure above.

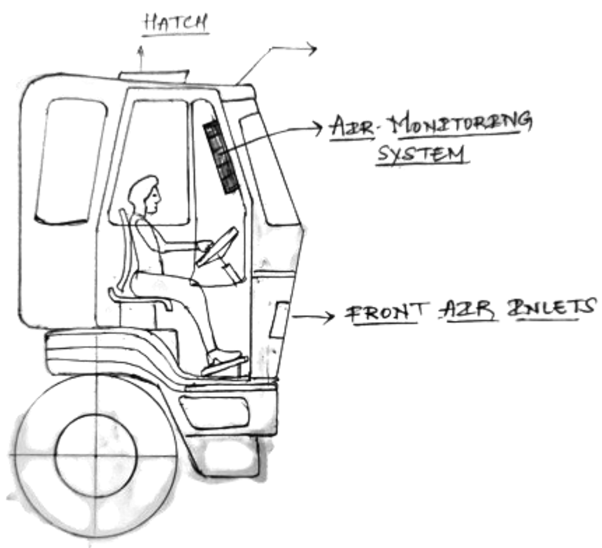

Figure: 7.3

A design alternate shows the truck cabin with an air monitoring system mounted beside the cabin's window.

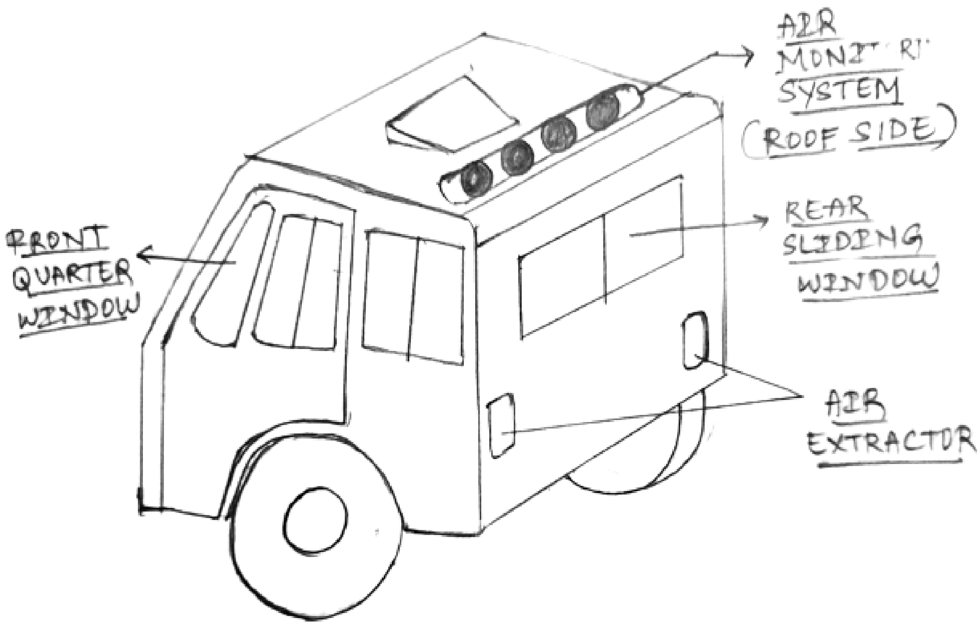

Figure: 7.4

An alternative design depicts the truck cabin's top being mounted with an air monitoring device.

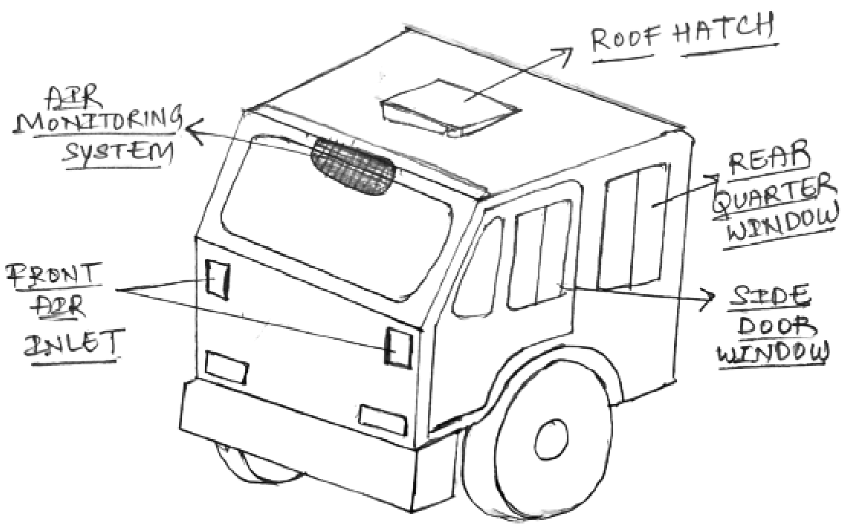

Figure: 7.5

In an alternate design, the truck cabin is shown with an air monitoring device positioned on its front side.

8. 3D MODELS

8.1 PART MODELS

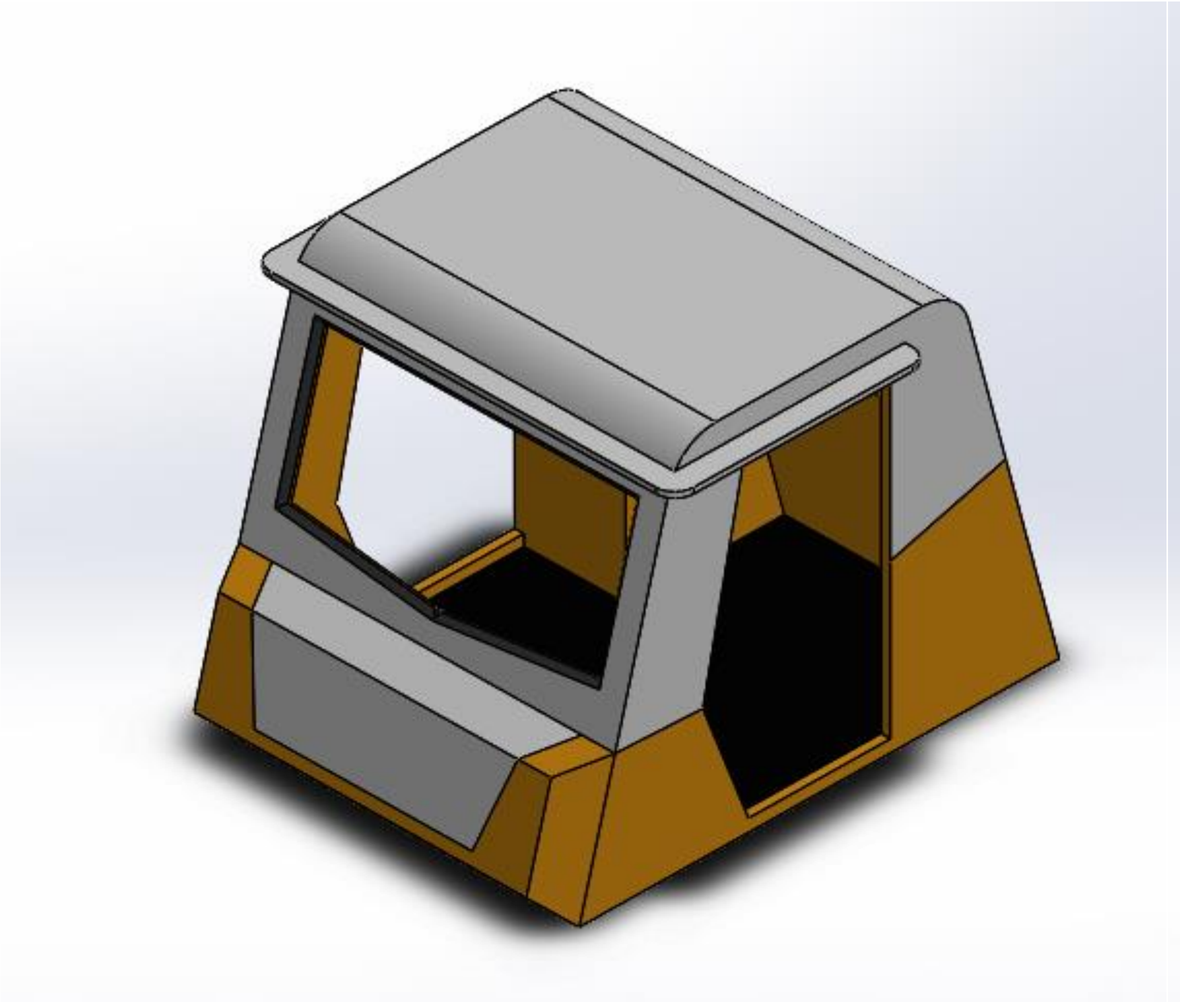

Figure: 8.1

3D model of cabin shell of mining truck.

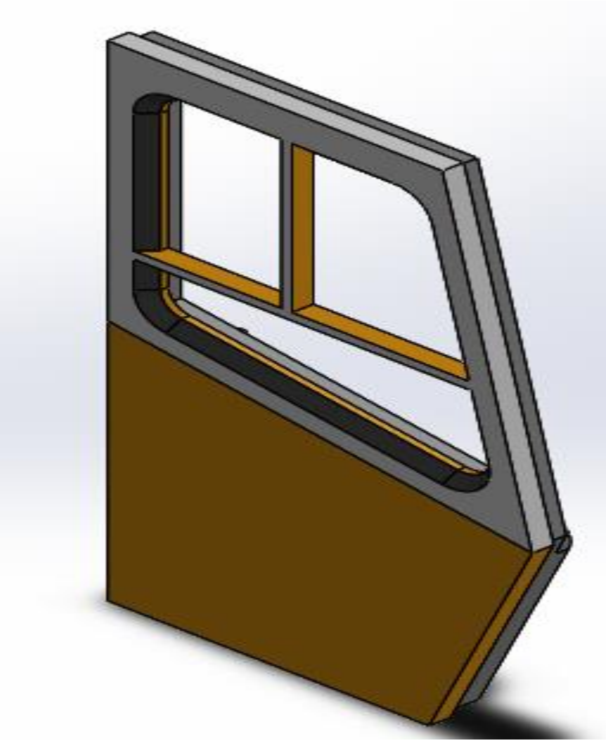

Figure: 8.2

3D model of the mining truck's cabin door.

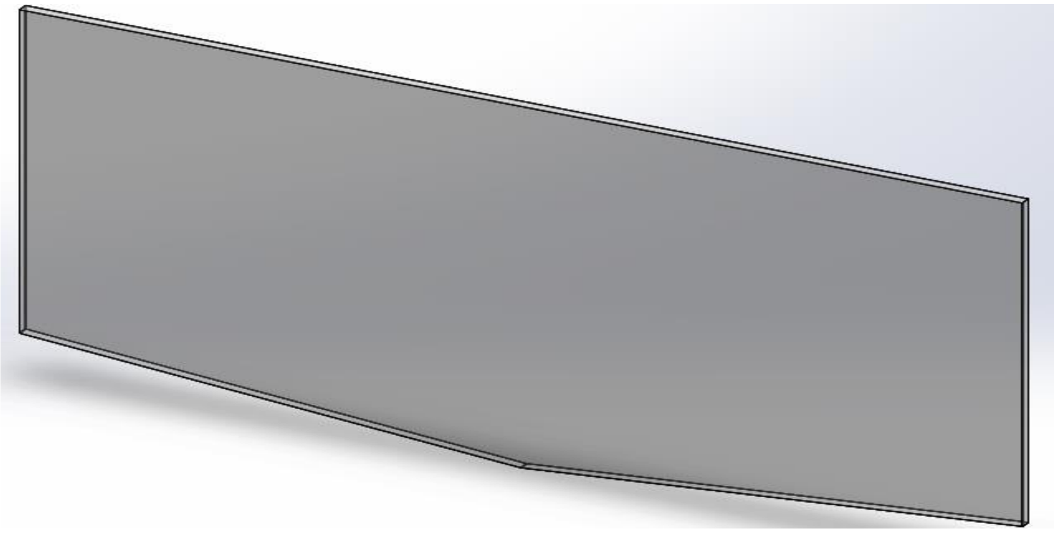

Figure: 8.33D model of the front window glass of the mining truck.

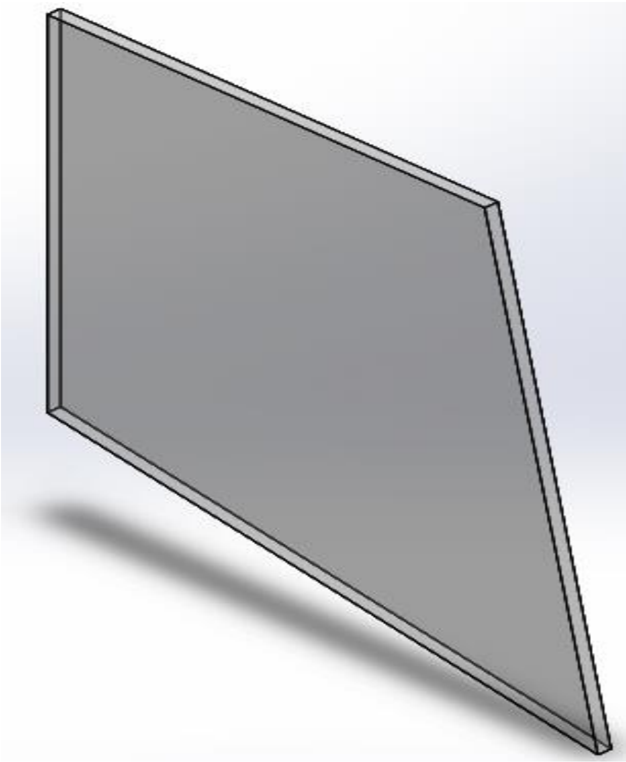

Figure: 8.4

3D model of the window glass of the cabin door.

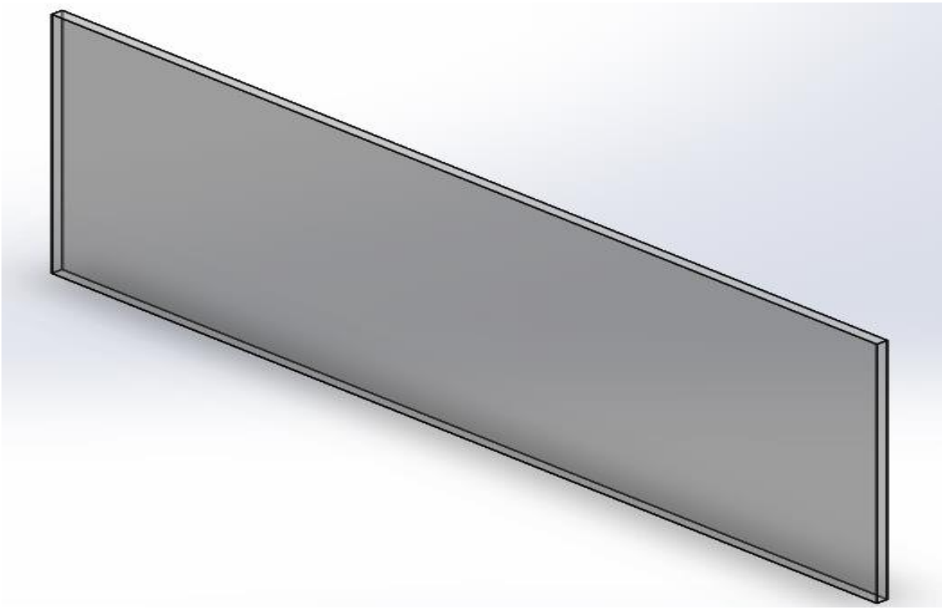

Figure: 8.5

3D model of the rear window glass of the truck's cabin.

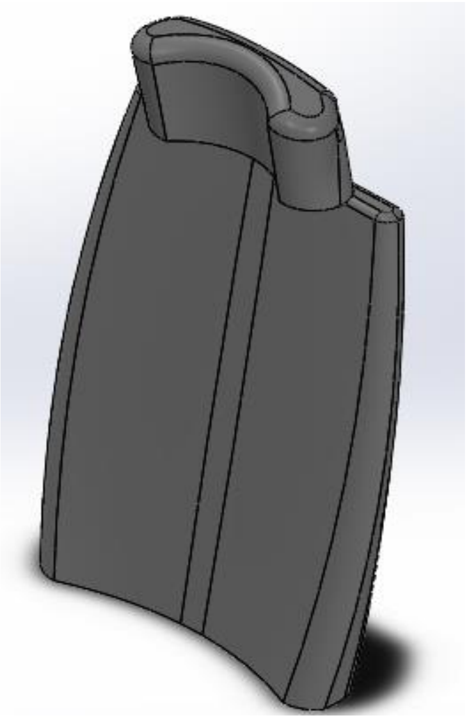

Figure: 8.6

3D model of the seat back rest.

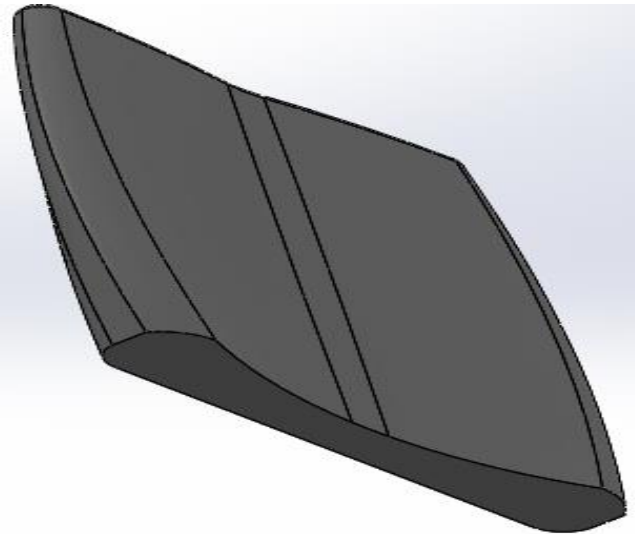

Figure: 8.7

3D model of the bottom seat rest.

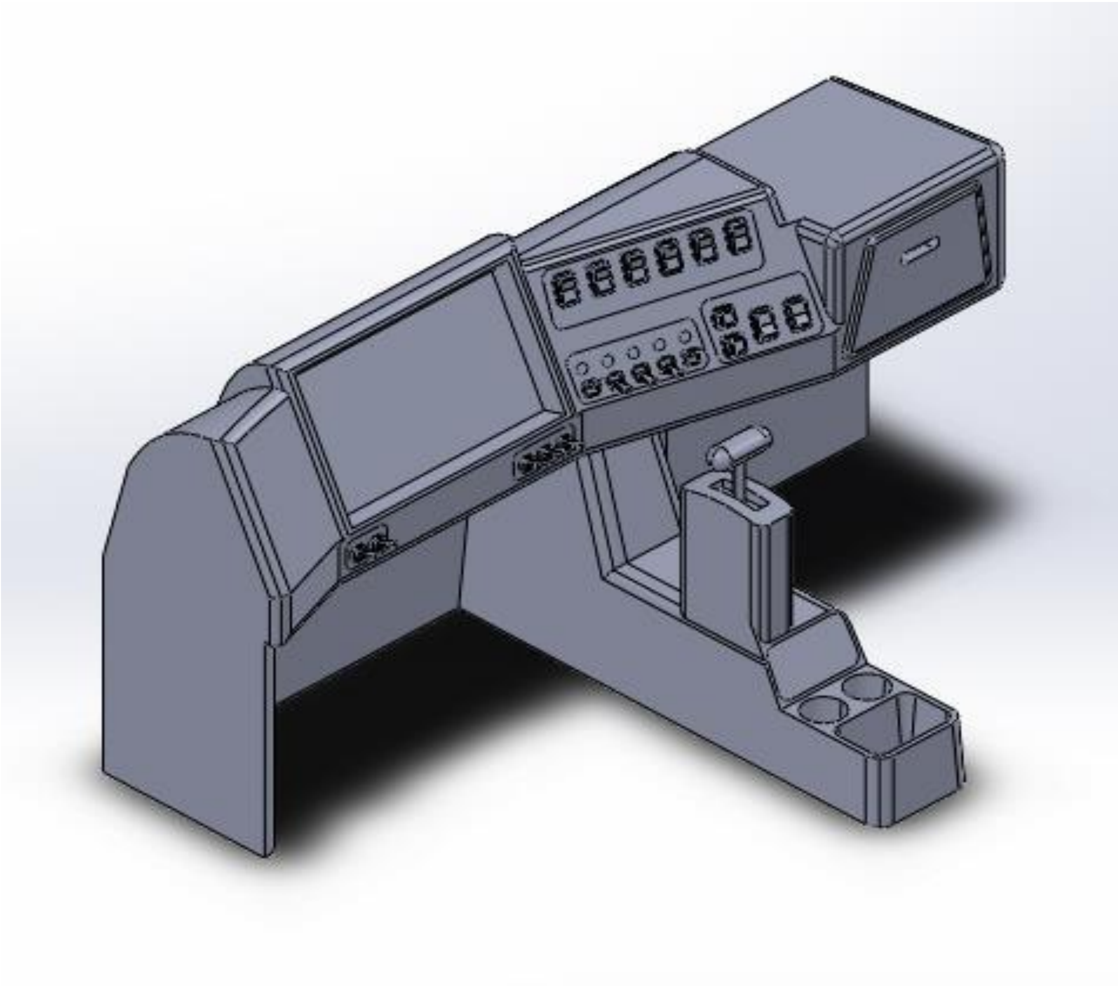

Figure: 8.8

3D model of the cabin's console of the mining truck.

8.2 ASSEMBLY MODEL

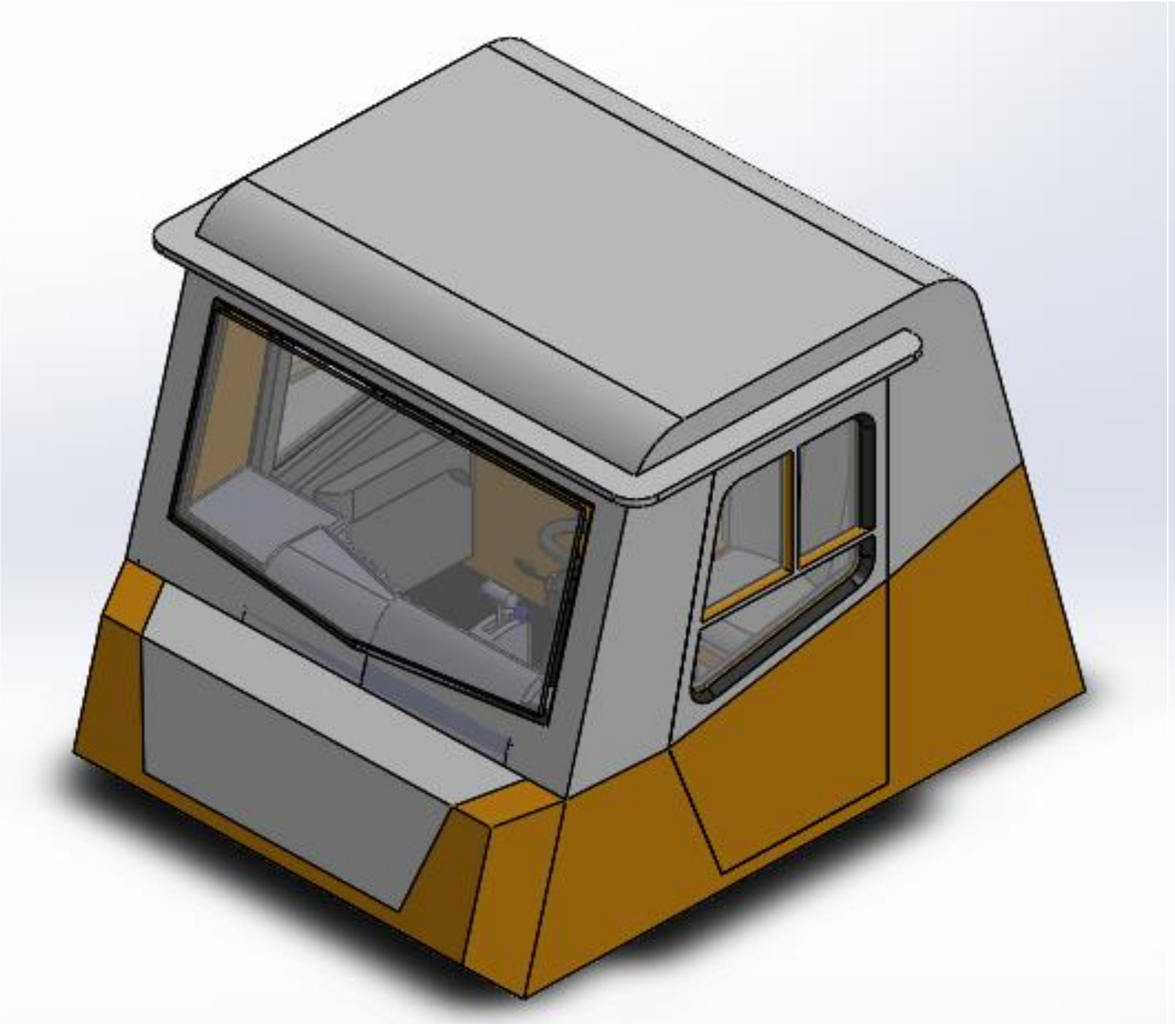

Figure: 8.9

3D assembly model of mining truck's cabin.

9. 2D DRAWINGS

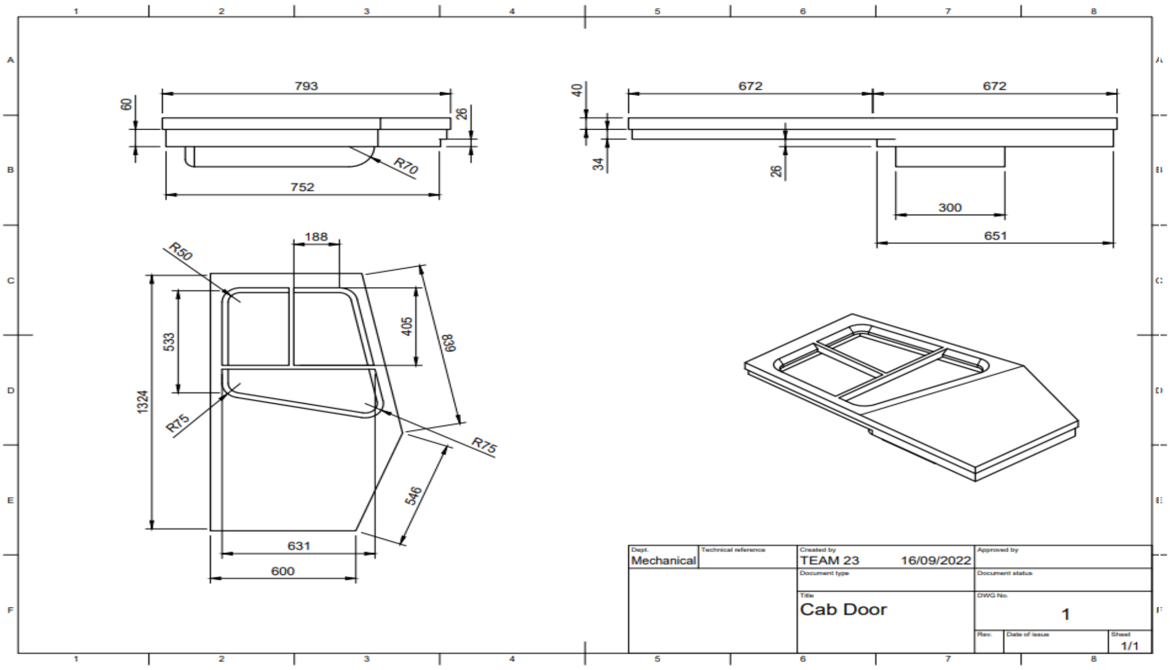

Figure: 9.1

2D drawing of the cabin door.

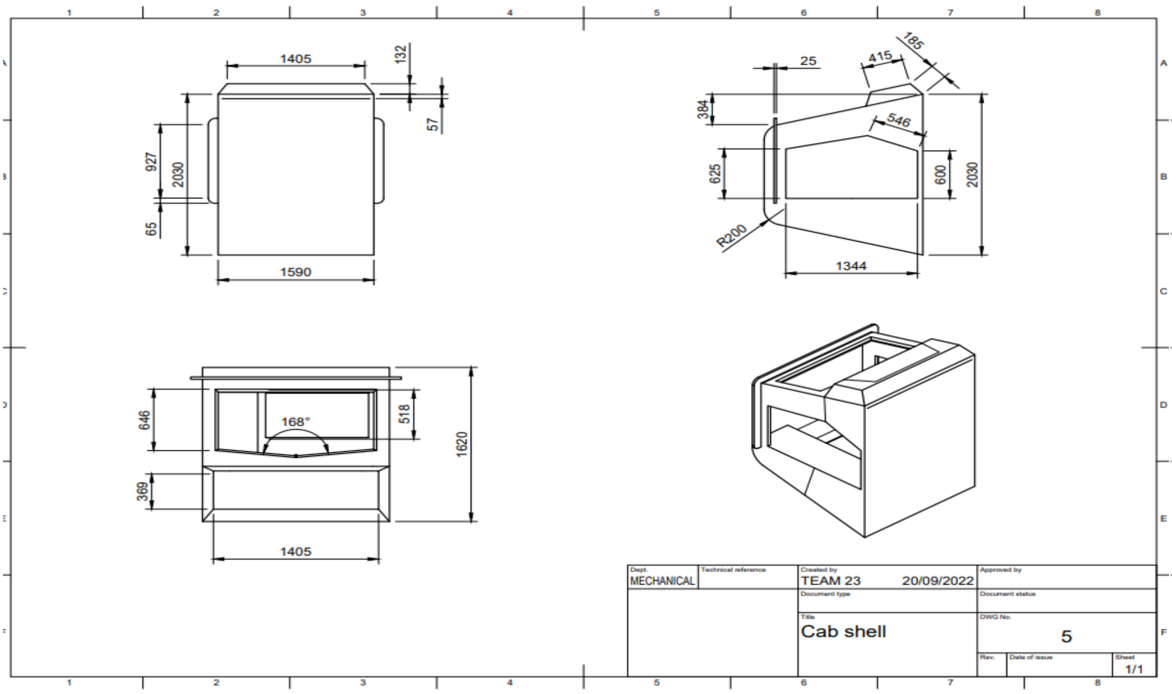

Figure: 9.2

2D drawing of the cabin shell of the mining truck.

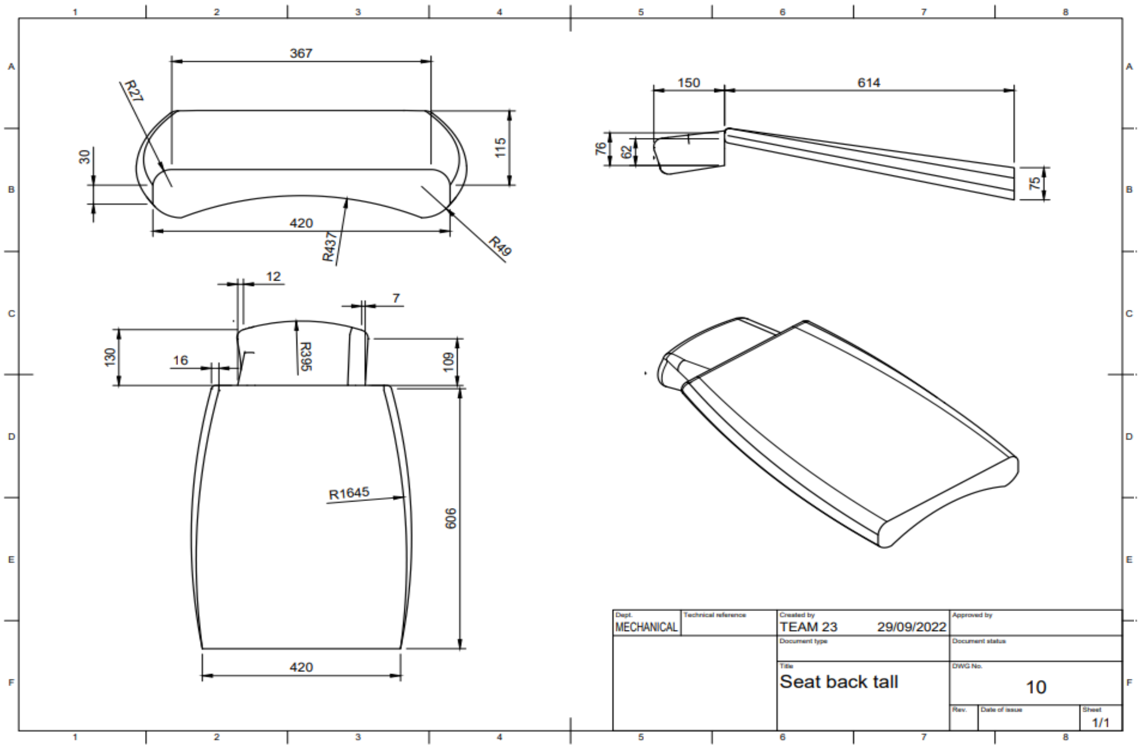

Figure: 9.3

2D drawing of the seat back rest.

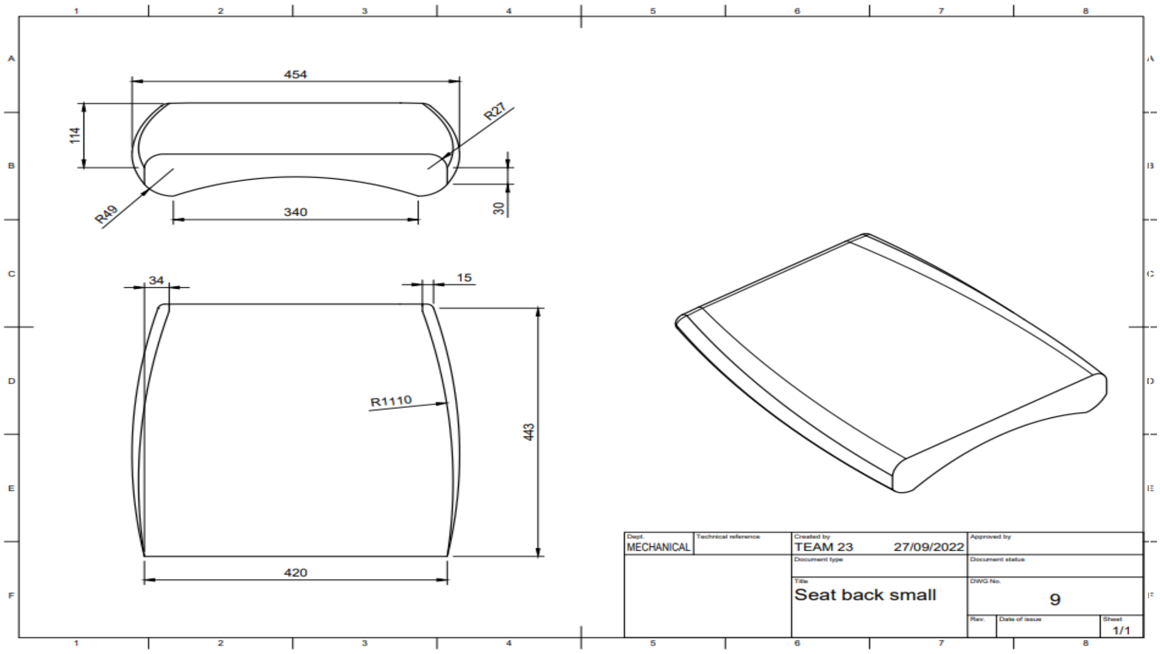

Figure: 9.4

2D drawing of the bottom seat rest.

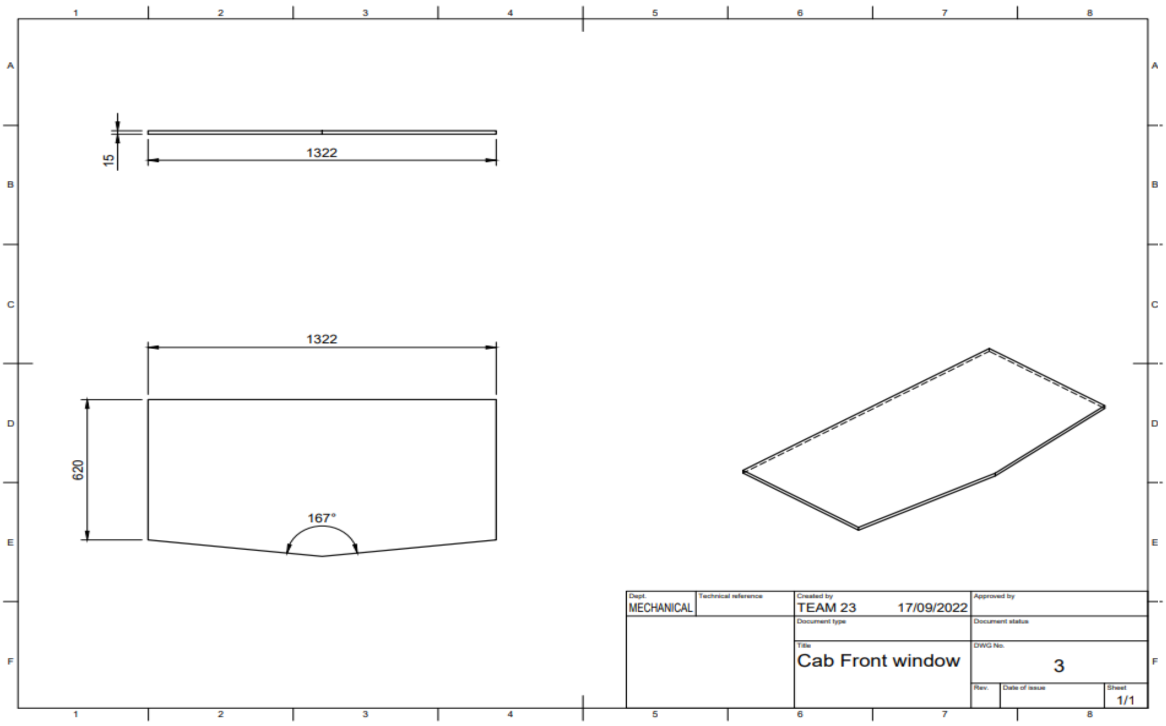

Figure: 9.5

2D drawing of the front window glass of the cabin.

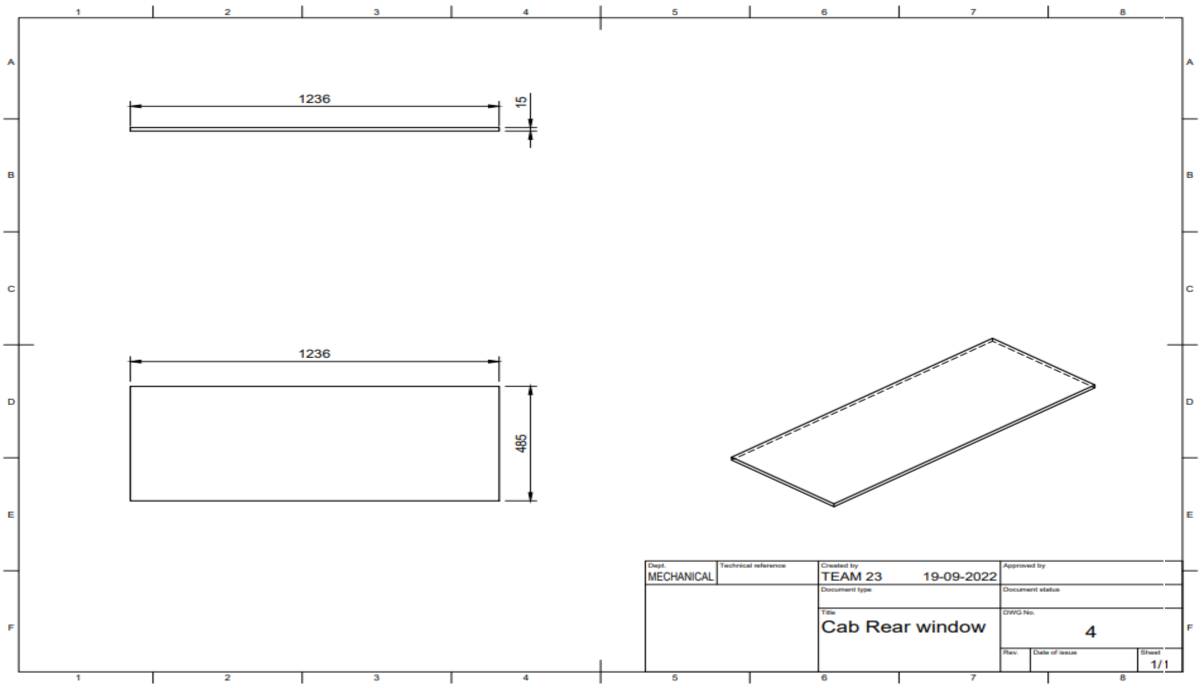

Figure: 9.6

2D drawing of the rear window of the cabin.

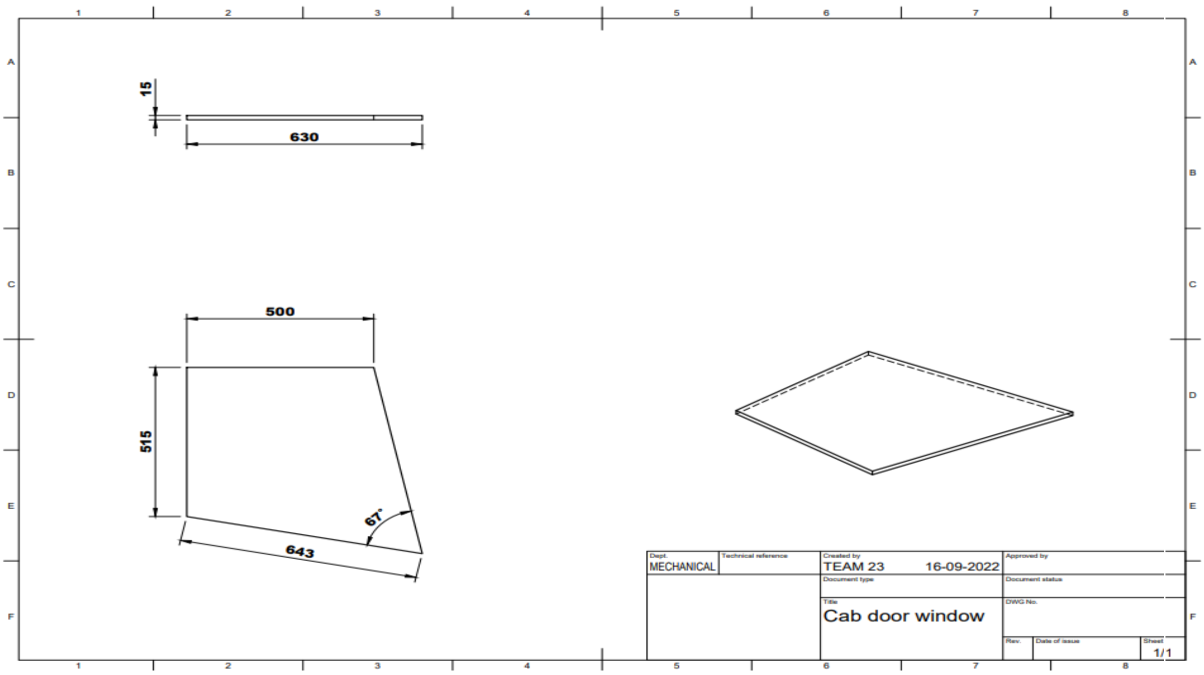

Figure: 9.7

2D drawing of the window glass of the cabin door.

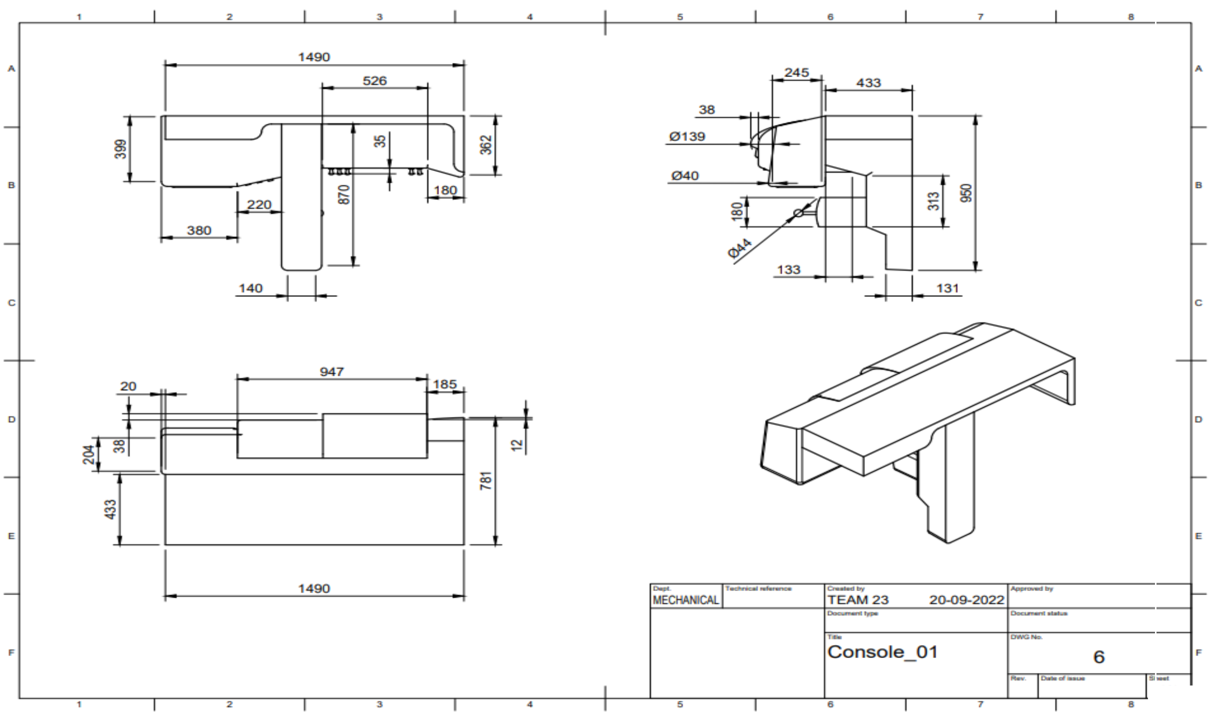

Figure: 9.8

2D drawing of the console of the cabin.

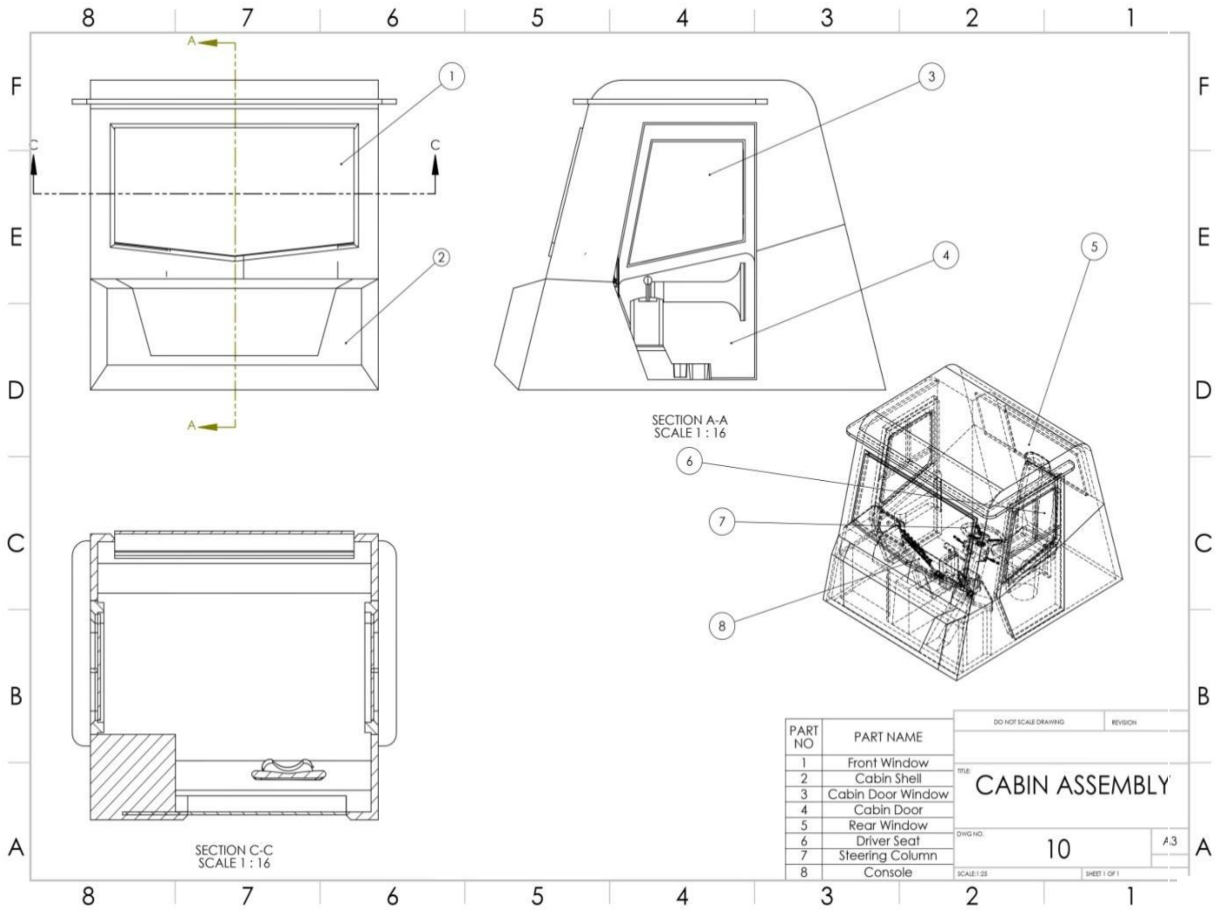

Figure: 9.9

2D drawing of the cabin assembly of the truck.

10. CAE ANALYSIS

10.1 Type of FEM Analysis and Justification

Air flow simulation was carried out on ANSYS to study the air flow pattern inside the cabin to determine the optimal location for placing the sensors to measure the pollutants and to get accurate results.

10.2 RESULTS

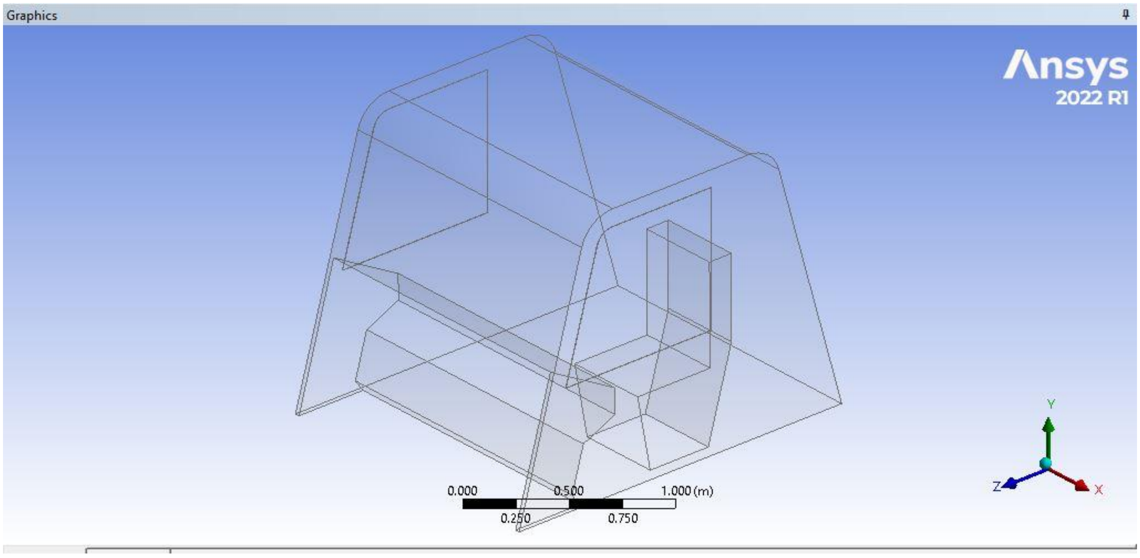

Figure: 10.1 Flow Domain of the truck's cabin.

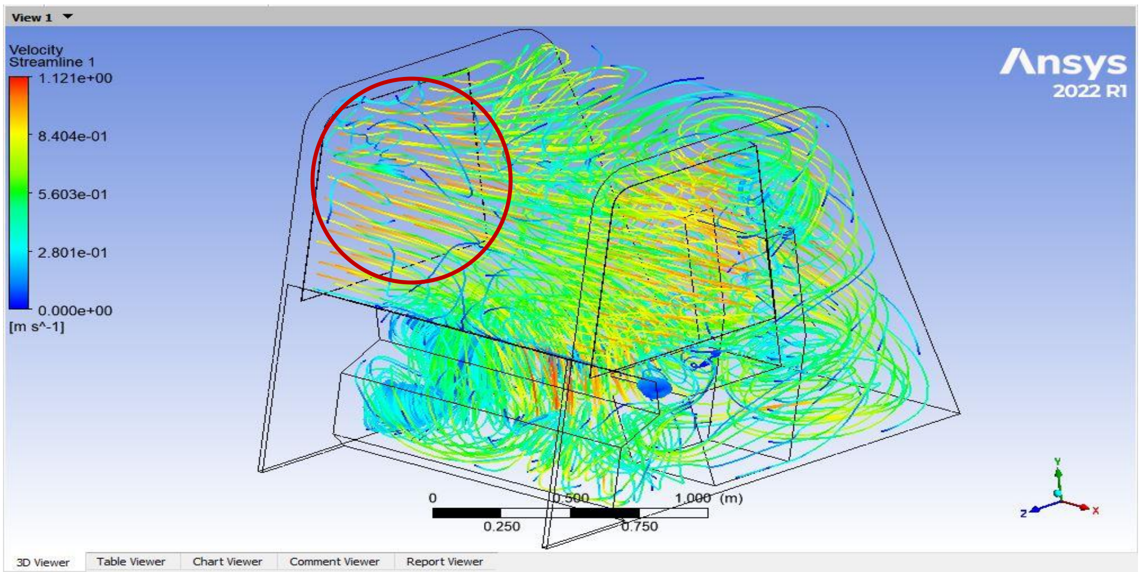

Figure: 10.2 Air intake through windows by adding streamline points.

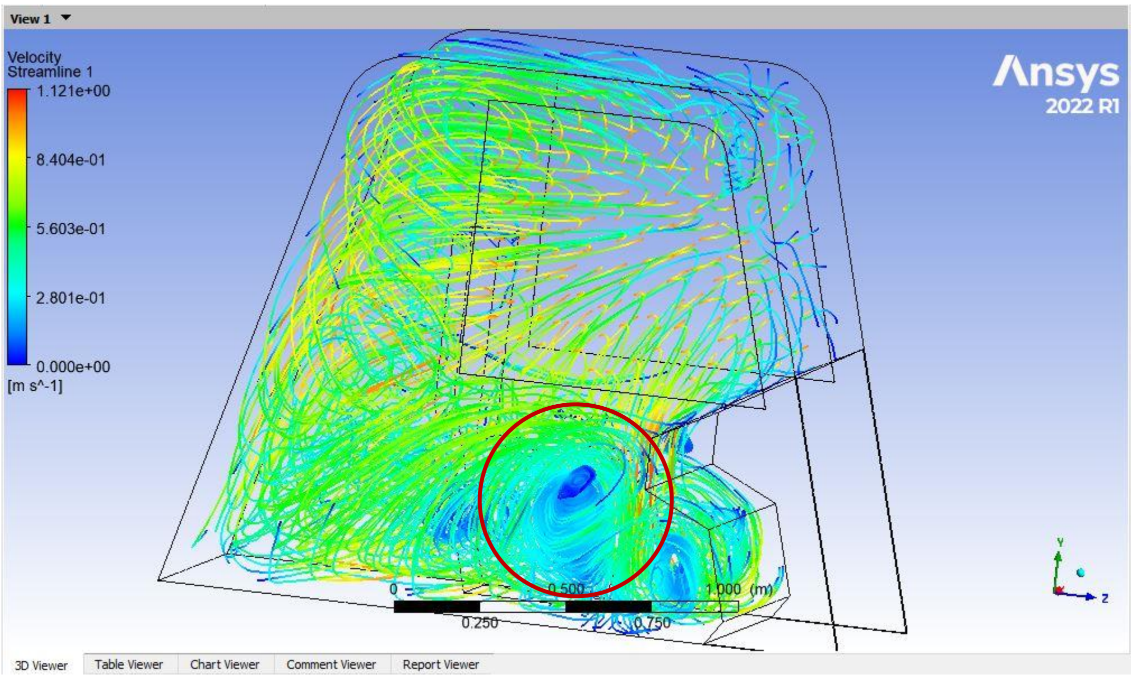

Figure: 10.3 in encircled area (blue region) velocity of air flow is 0.06 m/s.

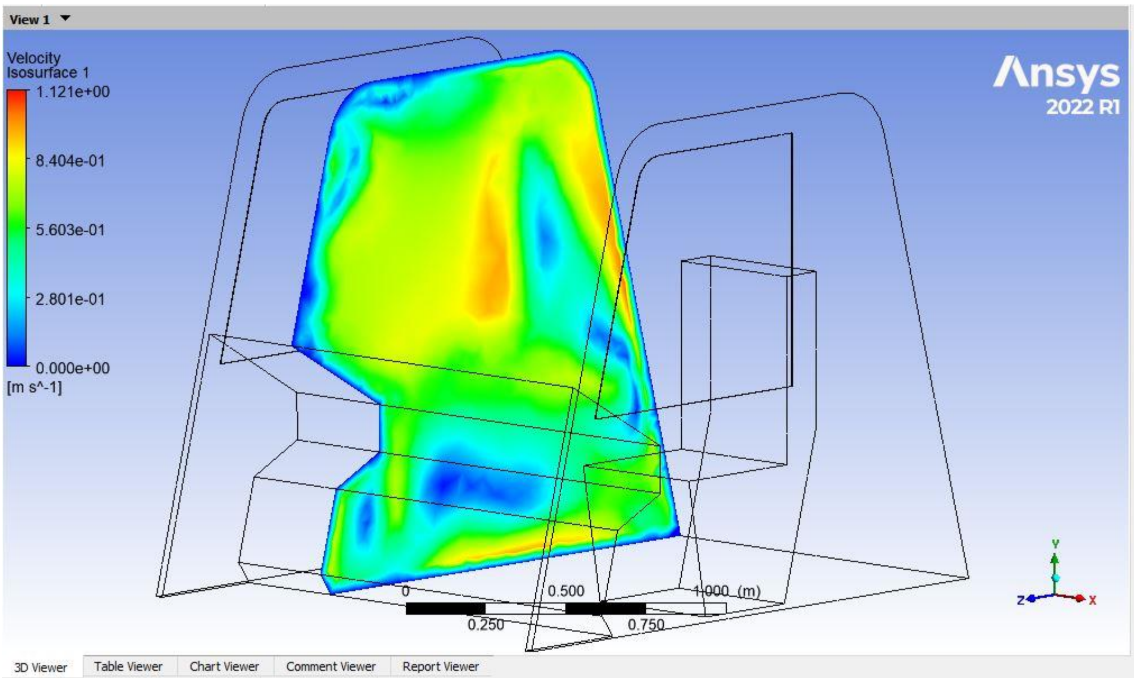

Figure: 10.4

Isosurface indicating the velocity of air flow at the distance of 0.4m from the window (air intake).

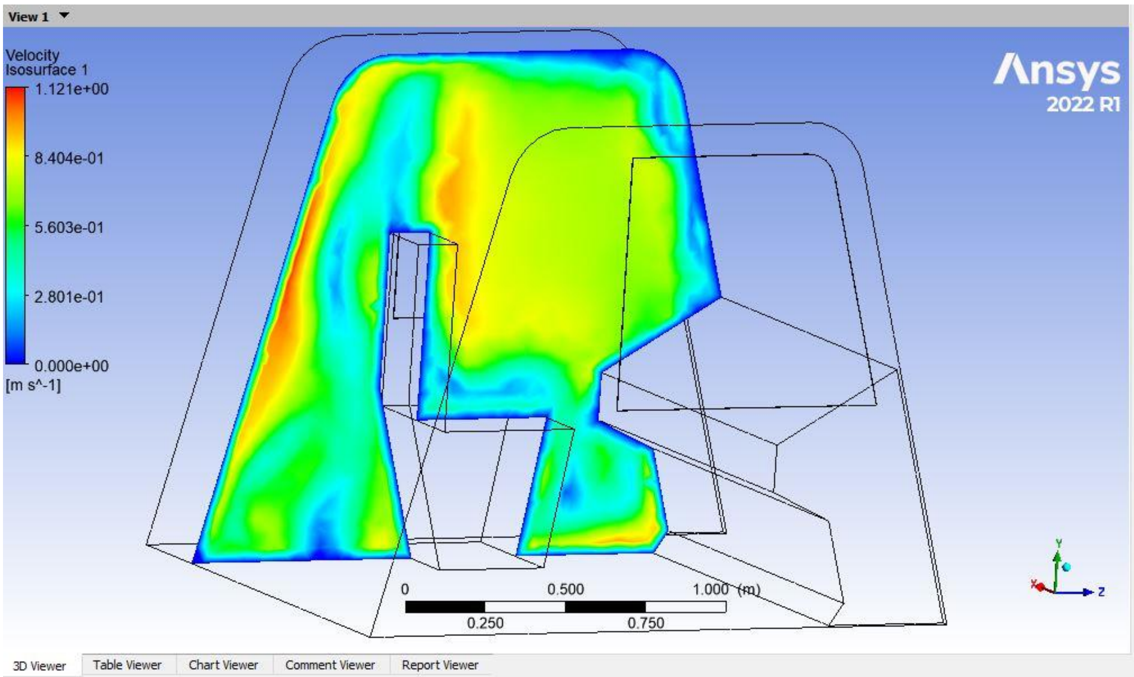

Figure: 10.5

Airflow velocity at the driver seating area is indicated by Isosurface.

11. BILL OF MATERIALS

Table No: 11.1

Sl.no	Part Name	Quantity	Price(Rs)
1.	Arduino Uno R3	1	849
2.	Gas Sensor(MQ135)	1	270
3.	LCD 16x2	1	274
4.	Potentiometer	1	116
5.	Inductor	1	284
6.	Capacitor	1	178
7.	LED-Aqua	1	80
		Total	2051

12. ELECTRONIC CIRCUIT AND SENSOR DETAILS

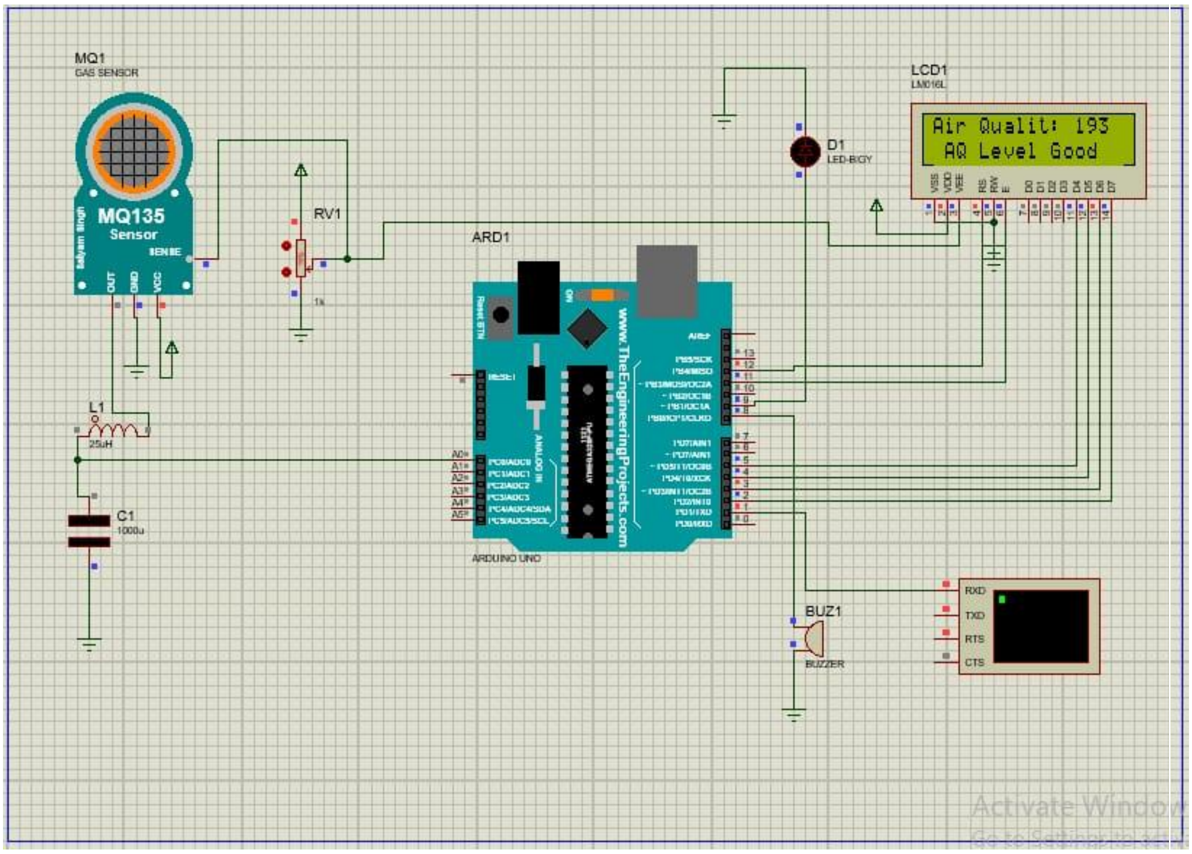

Figure: 12.1

The electronics circuit module for air monitoring is prepared in the Proteas software.

12.1 COMPONENTS

1. Arduino Uno R3
2. Gas Sensor(MQ135)
3. LCD 16x2
4. Potentiometer
5. Inductor
6. Capacitor
7. LED-Aqua

12.2 SENSOR (MQ135) DETAILS

The MQ-135 Gas Sensor can identify dangerous gases and smoke, including ammonia (NH_3), sulphur (S), benzene (C_6H_6), and CO_2. This sensor, like the others in the MQ series of gas sensors, has a pin for both digital and analogue output. The digital pin turns high when the amount of these gases in the air exceeds a predetermined threshold. The on-board potentiometer can be used to adjust this threshold value. An analogue voltage that is produced by the analogue output pin can be used to approximately determine the concentration of various gases in the atmosphere. The MQ135 air quality sensor module requires about 150mA and runs at 5V.[9]

12.3 TECHNICAL SPECIFICATIONS OF MQ135 GAS SENSOR [10]

Table No: 12.1

Operating Voltage:	2.5V to 5.0V
Power consumption:	150mA
Detect/Measure:	NH3, Nox, CO2, Alcohol, Benzene, Smoke
Typical operating Voltage: 5V	5V
Digital Output: 0V to 5V (TTL Logic)	5V Vcc
Analog Output: 0-5V	5V Vcc

13. CONCLUSIONS and FUTURE SCOPE

13.1 CONCLUSIONS

Until now, it has proven difficult to guarantee sufficient air quality inside the cabins of trucks used in mines. In order to detect the contaminants present inside the cabin of trucks operating in mining areas, an effort has been undertaken to develop an air monitoring system. The fleet management team and the driver can both receive alerts from the suggested device concerning the cabin's air condition.

In order to analyse the air flow pattern inside the cabin and choose the best place for the sensors to monitor the pollutants, an air flow simulation was performed using the ANSYS software. According to the simulated air flow in the truck cabin, the air velocity inside the cabin rises to 1 m/s as the inlet velocity does. This displays the areas (blue region) where the air is moving at a velocity of around 0.06 m/s and the sensor can measure the pollutants accurately. Finally, it was agreed to install the sensor at some height and stay away from places where external sources could significantly affect the air quality. Since the sensor's response time is 1 sec, we decided to position the device where air flow velocity is almost at 0 or in a state of near stagnation.

13.2 FUTURE SCOPE

In the future, we can link our air monitoring gadget with air purification systems so that the system automatically cleanses the air whenever the air quality within the cabin deteriorates. With the help of an IoT strategy, real-time data that is fetched for this device can be updated. In the near future, drivers' health metrics like heart rate and blood pressure can also be measured by merging relevant technologies with our gadget, allowing for more effective monitoring of their health status.

14. REFERANCES

[1][2] Mine Safety and Health Administration (MSHA.com).

[3] Bin Xu, Xiaokai Chen, Jianyin Xiong, "Air Quality inside Motor Vehicles' Cabins: A Review", Indoor and Built Environment, 2016.

[4] Ramik Rawal, Department of computer science Engineering, Vellore Institute of Technology, "Air Quality Monitoring System", IJCSE, 2019.

[5] Andrzej Szczurek, Monika Maciejewsk, Marcin Przybyła, Wacław Szetelnicki," Improving Air Quality for Operators of Mobile Machines in Underground Mines", atmosphere, 2020.

[6] Ganesh, Anantha Kumar, Alagesan, Dinesh, Karthik, "Design and Simulation of Truck Cabin Cooling System by Vapour Absorption Refrigeration System using Engine exhaust", IJERT, 2017.

[7] A. B. Cecala, J. A. Organiscak, J. A. Zimmer, M. S. Hillis, D. Moredock," maximizing air quality inside enclosed cabs with unidirectional filtration and pressurization system", CDC, 2009.

[8] Rasmus Parsmo, Sarka Langer, Hakan Sahlberg, Sara Jutterström, Anne-Marie Rydström , Maria Bernander, Aleksandra Sebastian, Andreas Andersson , Olof Willstrand ," Improving cabin air quality in road vehicles", IVL, 2019.

[9][10] QUARTZ COMPONENTS (quartzcomponents.com).