A Survey and Research on The Existing Models of Electric Rickshaws in Dhaka And Their Possible Improvements

U. Dutta[1], K. Nahid[1], H. A. Naimul[1] and M. T. Aziz[2,*]

Abstract— The research paper explores potential e-rickshaw enhancements in Bangladesh, a rapidly growing market that offers employment and transportation. However, the industry faces challenges in stability and security, particularly in uneven terrains. Factors such as weight distribution, tire quality, suspension characteristics, brake performance, and road conditions can influence instability. To address these issues, improvements in vehicle design, maintenance procedures, and training protocols can be made. The center of gravity (CG), a key parameter affecting stability, can be improved by lowering it, instructing drivers in safe driving techniques, and implementing maintenance schedules. Implementing these improvements can enhance the efficiency, safety, and environmental sustainability of e-rickshaws, potentially increasing the dependability and sustainability of Bangladesh's transportation system.

Keywords— Center of Gravity, E-Rickshaw, Measurement, Stability, Safety, Solar Panel.

I. Introduction

E-Rickshaws have gained popularity in Asia due to their affordability and environmental benefits, making them a popular alternative to traditional gasoline-powered vehicles. In Bangladesh, the e-rickshaw sector has grown significantly, providing employment and income for millions of people daily. The high population density and insufficient public transportation infrastructure contribute to the growth of the industry. As of 2017, around 1.5 million e-rickshaws were operating in Bangladesh, providing work for over 4 million people. However, the sector faces challenges such as stability, safety, and maintenance. Stability is influenced by vehicle design, weight distribution, tire quality, suspension, and road conditions. Safety issues include careless driving, inadequate vehicle maintenance, and lack of safety equipment. Despite these challenges, the e-rickshaw sector in Bangladesh has the potential to continue its rapid expansion and development in the coming years.

Fig. 1: Traditional Rickshaw [29]

II. Background Studies

E-Rickshaws gained popularity in China in the early 2000s due to their affordability and environmental benefits. They spread to other Asian nations, including Bangladesh, where usage increased in the mid-2000s and by the 2010s, the sector became a significant source of employment and income [1].

E-rickshaws in Bangladesh come in various configurations, from simple and inexpensive to intricate and expensive. The CNG model is the primary inspiration, but these models are expensive and difficult to maintain. The PORAG-001 model, produced by Runner Automobiles Ltd. [2], is slightly better but has disadvantages. It has a heavy, lead-acid battery and a 1000-watt electric motor, leading to instability and increased weight. Maintenance is costly and not compatible with dual operating methods. Most available

Fig. 2: PORAG-001 model E-Rickshaw [2]

[1]U. Dutta, K. Nahid, and H. A. Naimul are students of the Department of Electrical and Electronic Engineering, Southeast University, Dhaka, Bangladesh.
[2]M. T. Aziz is working as an Assistant Professor at the Department of Electrical and Electronic Engineering, Southeast University, Dhaka, Bangladesh (e-mail: tarequeaziz@seu.edu.bd).

* M.T. Aziz is the corresponding author of this paper.

options are less expensive. On the other hand, the traditional modified model will provide some extra benefits such as [3].:

- Low upfront cost
- Easy to maintain
- Dual operation system

Note: The mechanical paddled rickshaw, an essential form of Bangladeshi transportation since around 1930, is essentially the traditional model we're working on [4].

III. Reasons and Effects of E-Rickshaw Ban:

On Dec 15, 2021, the High Court of Bangladesh again ruled banning battery-run three-wheelers, including e-rickshaws, from operating on highways in the country [5]. Chief Justice Hasan Foez Siddique decided in response to a written petition filed by a lawyer, who argued that the battery-run vehicles pose a significant risk to public safety due to their tendency to overturn and cause accidents [6] [7] [8]. In 2011, the Bangladesh High Court approved a ban on e-rickshaws. In the latter part of 2014, the High Court decided that all unlicensed battery-operated vehicles must be prohibited from operation.

The basic problems of rickshaws are as follows:

- **Brake Issue:** E-rickshaws with only front-wheel brakes face stability issues due to the lack of rear-wheel brakes, which can cause skidding and loss of control [8] [9].
- **High CG Point:** E-rickshaws with a high center of gravity (CG) can pose a significant risk to drivers, passengers, and road users. The battery and motor are typically mounted above the rear axle, raising the CG, making the vehicle unstable and potentially toppling. [10] [6] [7].
- **Uncomfortable Passenger Seat:** E-rickshaws often have uncomfortable passenger seats due to narrow or hard seats, inadequate cushioning, and rigid suspension systems [11] [9].
- **Uncomfortable Driver Seat:** E-rickshaws often lack ergonomic elements and uncomfortable driver seats due to rough, uneven roads. [12].
- **No Re-Useable Energy Source:** E-rickshaws use non-renewable energy sources like lead-acid batteries, which are inconvenient, expensive, and contribute to environmental pollution.
- **No Suspension System:** E-rickshaws often lack an adequate suspension system, causing discomfort and increased wear and tear on the vehicle [7] [13]. For low-cost E-rickshaws, more sophisticated suspension systems may be too expensive or complex [12] [14].

The Financial Express article discusses Bangladesh's proposed ban on battery-run vehicles, arguing that despite safety concerns, an outright ban may not be the best solution [15].

IV. Data Collection

Survey-1:

An inquiry was conducted to ascertain the primary challenges encountered by individuals while riding rickshaws. The obtained responses can be approximated as follows:

Table 1:Survey 1

Total number of people	No Suspension and Passenger Comfort	Seat height too high	Narrow Seat Space	Reckless driving/ poor driving skills	Poor Braking system/ Fear of Accident
50	40	20	35	8	30

Survey-2:

In this survey, we focused on collecting responses from drivers who have been operating electric rickshaws for at least a year. In addition to this, they have several issues with the current version of the E-Rickshaw.

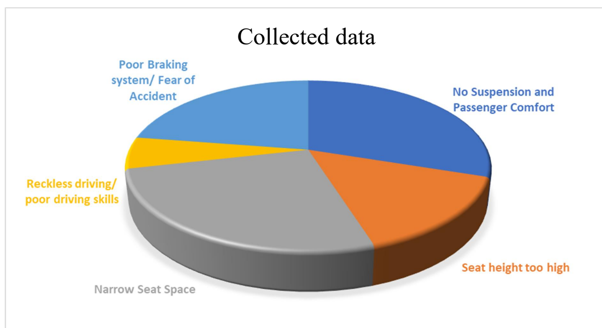


Fig. 3: Data Collection Chart

- Electric rickshaws' battery and DC motor weigh approximately 54 kilograms, making the vehicle very heavy.
- The configuration of the seats could be more conducive to a comfortable driving experience.
- When a motor is operating the rickshaw, they frequently experience discomfort when trying to keep their feet still because there is no suitable place for them to keep their feet.
- Most of them didn't feel comfortable using the braking system of the rickshaw either.

Measurements: The next thing we did was get some actual measurements of the E-Rickshaw model. However, it was challenging work because the values that are used for measurement are unique to each rickshaw. After that, we concluded that the best course of action would be to perform in-depth measurements on approximately ten E-rickshaws and then calculate the mean value of those measurements.

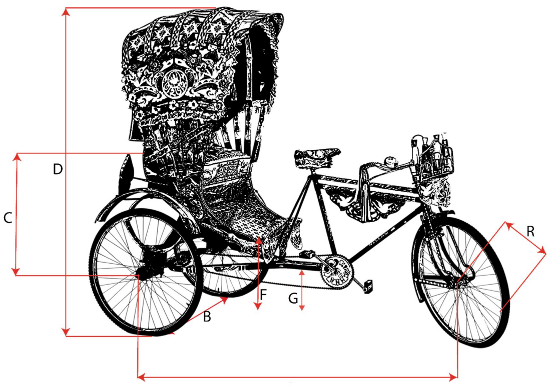


Fig. 4: Traditional Rickshaw Measurement

Table 2: Measurements

Measurement (inch)	***R***	***G***	***A***	***B***	***C***	***D***	***C_f***	***F***
1	14	15	71	38	21.5	70.5	23	20.4
2	14	13.5	69.8	38	22.6	71	25.4	19
3	13.9	14	70.5	38	22.5	71	26.8	19.8
4	14	14	71	37	22.5	68	24.2	21.7
5	14	14	71	38	22.1	70	27	22
6	13.7	13	72	38	21.9	71	27.8	20.5
7	13.9	14.5	70.5	38	21	72.8	25	21
8	14	15	71	37.5	22.5	70.6	24.8	22.8
9	14	13.8	69.4	38	22.7	69.4	26.5	19.9
10	14.1	13.8	70.9	38	22	70.9	27.6	20
11	14	14.5	70	37.9	21.7	68.5	26.2	21.5
Average	**13.96**	**14.1**	**70.65**	**37.85**	**22.09**	**70.34**	**25.85**	**20.78**

V. Instability Issues

Rollover Instability: Rollover instability in three-wheeled vehicles, such as e-rickshaws, is a significant concern due to their inherent instability. The elevated center of gravity (CG) and narrow track width increase the likelihood of rollover incidents.

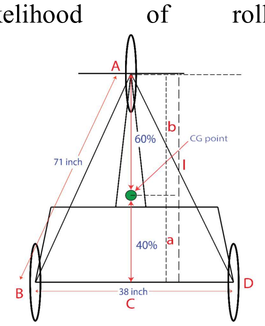


Fig. 5: CG point of old model:

Calculation of weight shifting during brake:
We know [16],

$$h_{cg} = R_f\left(\frac{a}{l}\right) + R_r\left(\frac{b}{l}\right) + \left(\frac{W_f l - W_a}{W \tan\theta}\right)$$

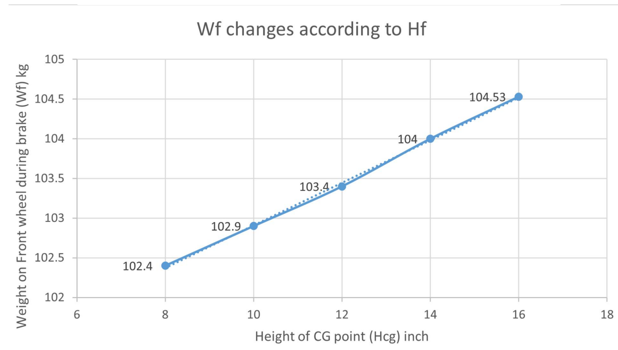
Here,
Height of CG, h_{cg} = 14 inch (In traditional model)
W_f = Shifted weight while brake
θ = created angle between rear wheel to ground while brake
Radius of Wheels (Front and Rear), R = 14 inch [$R = R_f = R_r$]
AB = 71 inch, BD = 38 inch
So, BC = 19 inch

Now, AC = $l = \sqrt{AB^2 - BC^2}$
$= \sqrt{(71)^2 - (19)^2}$
= 68.4 inch

Now,

$$W_f = \frac{\left[\left\{h_{cg} - R_f\left(\frac{a}{l}\right) - R_r\left(\frac{b}{l}\right)\right\} \times W\tan\theta\right] + W_a}{l}$$

Table 3: Wf Changes according to CG height



The graph illustrates a decrease in weight shifting when the Center of Gravity (CG) point height of E-Rickshaws is reduced. The height was reduced from 14 inches to 8 inches. Reducing the height to less than 8 inches may result in complications pertaining to speed bumps and uneven road surfaces.

The Lateral Instability: Lateral stability is a crucial aspect of vehicle design, ensuring a vehicle maintains balance while traveling along a curved path. Extending track width and lowering center of gravity can enhance stability [7] [17].

Wobble Instability: Wobble mode, a driving condition where the vehicle's center of mass oscillates between two positions, can pose a safety threat to

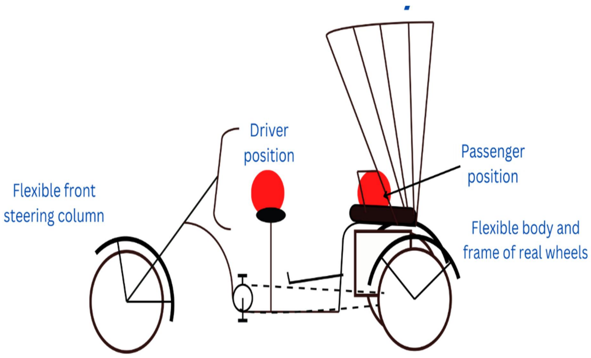
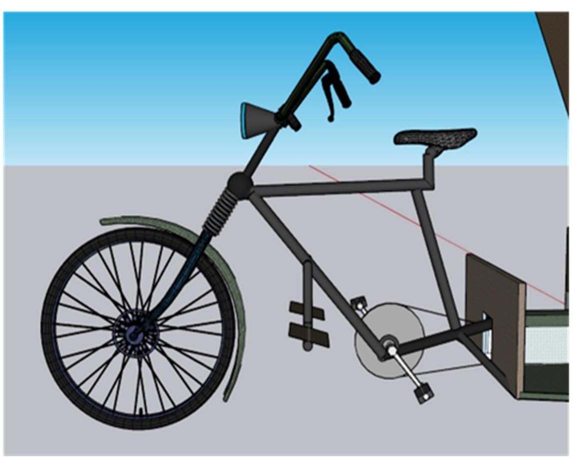


Fig. 6: Wobble Instability

drivers and passengers. Researchers from TVS Motor Company Ltd. and the Indian Institute of Science conducted a study using ADAMS-CAR to analyze the stability of a three-wheeled vehicle. The study found that stability depends on the wheelbase, and adjusting the steering wheel and passenger seat is crucial for maintaining stability [13].

VI. Physical Components Modification:

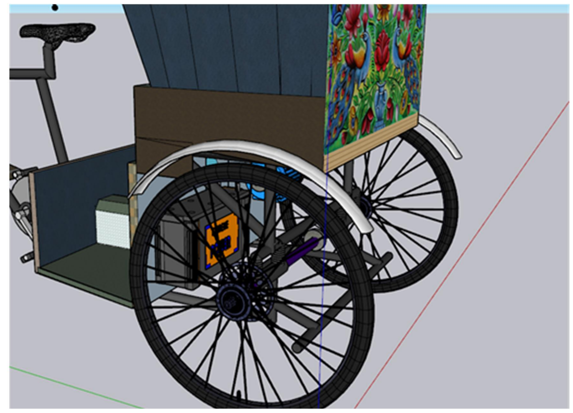
Front wheelbase: The rickshaw's wobble mode,



where the vehicle's center of mass oscillates between two positions, can be improved by adjusting the front wheel position. This can reduce rollover and wobble m

Fig. 7: Front Wheelbase

during b



steering mechanism closer to the driver and relocating the front wheel further [13].

Rear Wheelbase: Relocating rear wheels towards posterior region can enhance stability and passenger comfort, especially with suitable suspension system, resulting in an aesthetically pleasing configuration [13].

Suspension: E-Rickshaws require a well-functioning suspension system to enhance rider comfort and

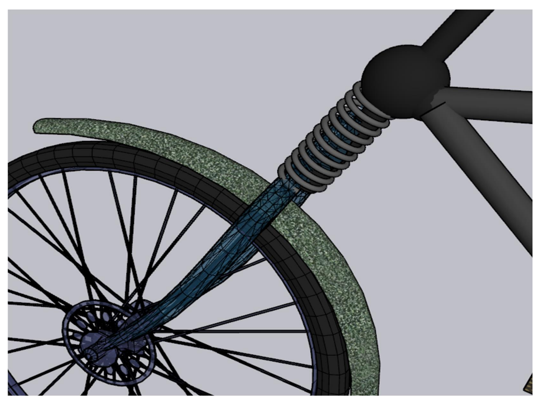


Fig. 9: Front Wheel Suspension

balance. A study by MIT students focuses on an enhanced suspension system for bicycle-powered rickshaws, using tire rubber as the spring component [18].

Rubber springs, known for their hysteresis and self-damping properties, offer a cost-effective and extended

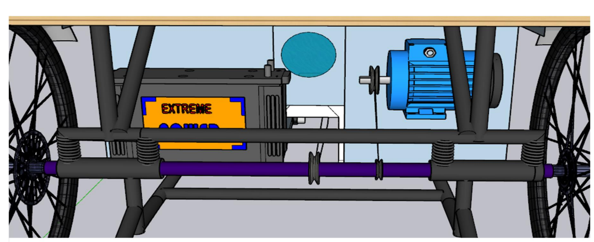


Fig. 10: Rear Wheel Suspension

lifespan compared to metal springs. The suspension operates within the 10-20 Hz frequency range, aligning with E-Rickshaws' primary operational frequency. The 3D Experience Platform from Dassault enables the application of digital multi-disciplinary technology in designing and constructing an electric rickshaw capable of transporting an 800-kilogram passenger load [18].

Driver Feet Rest: The E-rickshaw driver's footrest

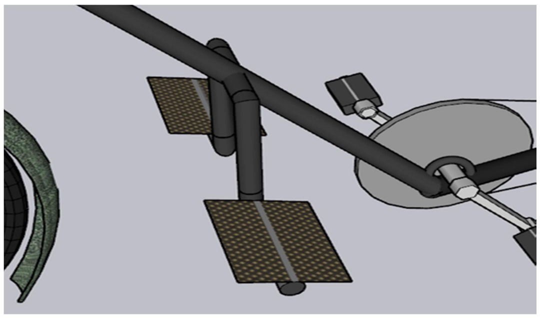


Fig. 11: Feet Rest

system features a foldable and adjustable footrest, providing a personalized and customizable experience. The foldable feature enhances mobility and access to the vehicle's controls, while the adjustable footrest height allows for easy adjustment to accommodate leg length [19].

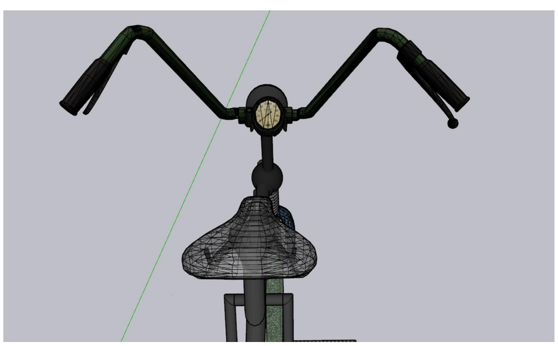


Fig. 12: Steering Handle

Modified Steering Handle: The steering handle in E-rickshaw ergonomics has been redesigned, incorporating Harley Davidson principles to improve driver comfort [20]. The handle's ergonomic design minimizes wrist movement and forceful gripping, promoting a more comfortable driving experience [21].

Fig. 7: Front Wheelbase

Braking: The addition of brakes on both front and rear wheels ensures a balanced and evenly distributed braking force, preventing skidding and loss of control. This comprehensive approach to braking accommodates various driving situations, promoting a safer and more confident driving experience for drivers and passengers.

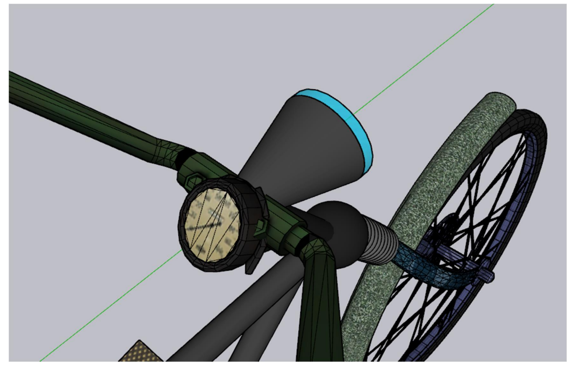


Fig. 14: Speedometer

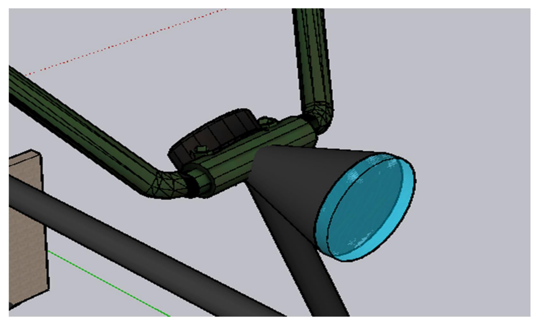


Fig. 15: Headlight

Speedometer: The instrumentation panel of the E-rickshaw features an analog speedometer, enhancing the driving experience by providing a visual representation of the vehicle's speed [22].

Headlight: A headlight enhances safety and visibility, allowing drivers to anticipate obstacles and dangers at greater distances.[23].

Lower CG Point: The safety of the E-rickshaw is significantly enhanced by incorporating a lower center of gravity (CG), which reduces the likelihood of tipping

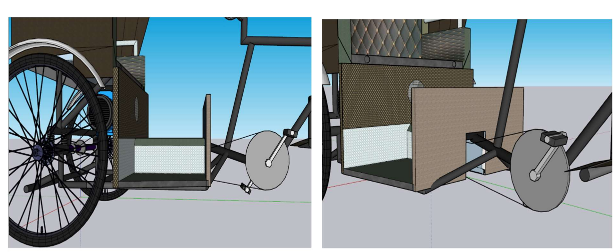


Fig. 16: Low CG point

or rollover incidents, thereby enhancing overall stability and maneuverability [24] [25].

here are some of the benefits of a lower center of gravity (CG):

- *Improved Stability*
- *Better Handling*
- *Reduced Rolling Resistance*
- *Increased Braking Stability*
- *Reduced Pitching*

Dual Driving Mode: The dual driving mode in E-rickshaw technology allows drivers to switch between two distinct modes of power, enhancing versatility and energy conservation.

- **Pedal Mode:**

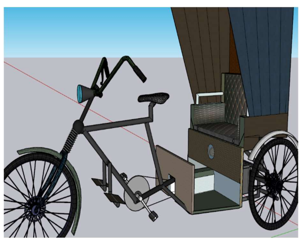


Fig. 17: Manual mode

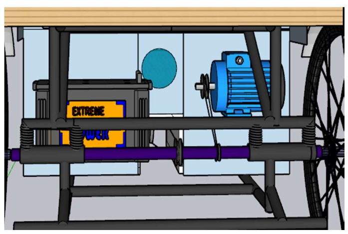


Fig. 18: Motor mode

- **Motor Mode:**

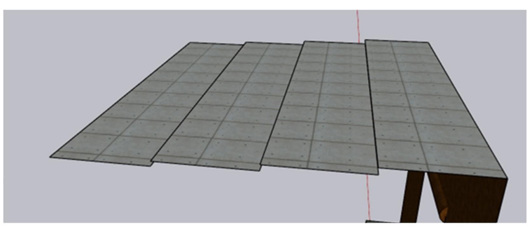


Fig. 19: Solar panel

Modified Hood for The Solar Foldable Panel: The Chinese hand fan system has been used to design a

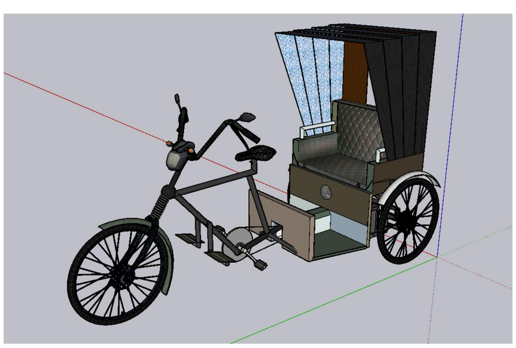


Fig. 20: Side View

folding mechanism for the E-rickshaw's hood, combining functionality with elegance. The hood can be unfolded and folded, providing ample coverage and protection for the solar panels.

The Complete Model of E-Rickshaw (In SketchUp)

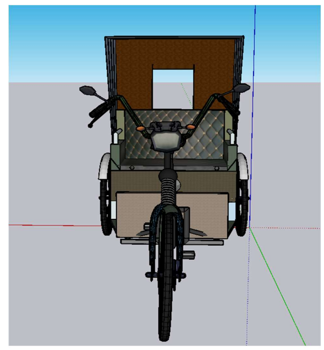


Fig. 21: Front view

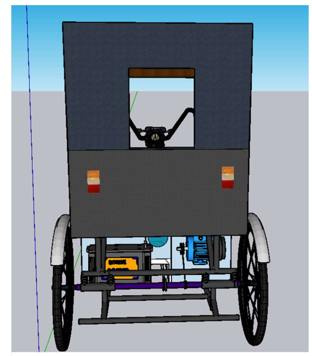


Fig. 22: Back View

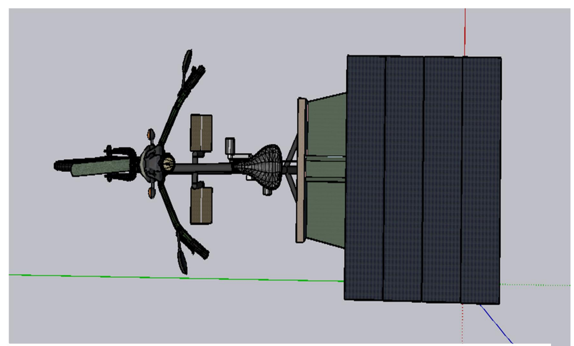


Fig. 23: Top View

VII. Software Used

A. *Sketchup:*

SketchUp, a cutting-edge 3D modeling software, was used to create an innovative E-Rickshaw model. The user-friendly interface and powerful tools allowed for an immersive design process, bridging the gap between imagination and reality [26].

B. *Adobe Illustrator:*

Adobe Illustrator is a vital tool for creating diagrams with precision and visual aids. It allows for the precise definition of forms, lines, and curves using mathematical vectors, ensuring the integrity of visually given information [27].

VIII. CG Point Shifting Calculation

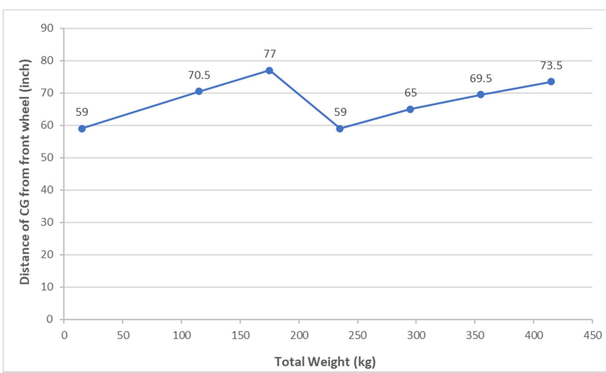
Width at CG (Center of Gravity) point,

$$d = d_r * W_r(\%)$$

d_r = Width at Rear Wheel
W_r = Total weight on rare axis in %

Table 4: Changes of CG point with weight added in a different point

Parameters	Weight (Kg)	Weight Distribution (Kg)		Total Weight on Rear axis in %	Weight Total (kg)	Width of CG Point (d)	Distance of CG from front axis
		Front	Rear				
Base	15	5	10	66%	15	29.7"	59"
Full Body	100	20	80	78%	115	35"	70.5"
Battery + Solar + Motor	60	0	60	85%	175	38.25"	77"
Driver	60	60	0	64%	235	28.8"	59"
1 Passenger	60	0	60	71%	295	32"	65"
2 Passenger	60	0	60	76%	355	34.2"	69.5"
3 Passenger	60	0	60	79.5%	415	35.8"	73.5"



In the illustration, it is evident that the position of the center of gravity (CG) undergoes changes in response to the distribution of weight applied to the E-Rickshaw. However, the observed change is not of considerable magnitude, and it is noteworthy that the center of gravity (Cg) consistently maintains a stable position, thereby contributing to the mitigation of "Rollover Instability." If the center of gravity point moves forward beyond a certain threshold, the likelihood of rollover incidents increases. However, our modified structure effectively mitigates this risk.

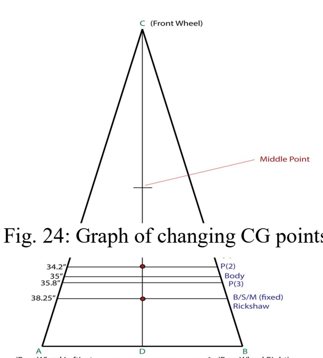


Fig. 24: Graph of changing CG points

IX. Solar Panel

The

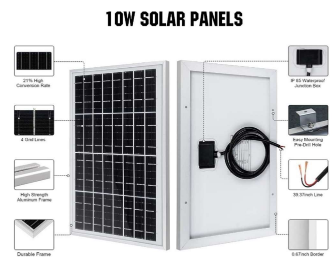


Fig. 26: Solar Panel

"WORTHY Solar Panel for Gate Opener, Chicken Coop, Off-Grid Applications" is a solar panel designed to provide a reliable and environmentally-friendly power supply for various applications [28], including E-rickshaws. Its compact dimensions (13.3 x 8.1 x 0.7 inches) and high efficiency solar cells make

Specifications:
Rated Power: 10W Solar Cell: Monocrystalline Maximum/Peak Voltage (Vmp): 18V Open Circuit Voltage (Voc): 22.41 V Short circuit current: 0.61A Maximum current: 0.56A Output Tolerance ±3% Temperature range: −40℃～ +85℃ Length of extension cable: 100cm（3.28ft）, 0.8mm²（18AWG） Size: 337*200*18mm (13.3x8.1x0.7 in); Weight: 0.76kg(1.67lbs)

Table 5: Technical Details of Solar Panel [28]

Panel Setup:

Fig. 27: Specifications of 10W MONO SOLAR PANEL [28]

Given that each "WORTHY Solar Panel for Gate Opener, Chicken Coop, Off-Grid Applications" produces the following specifications:

Voltage: 12V
Current: 1.5A

The voltage remains the same (12V) when twelve of these panels are connected in parallel, as it is unaffected by parallel connection. However, the output current and power will vary.

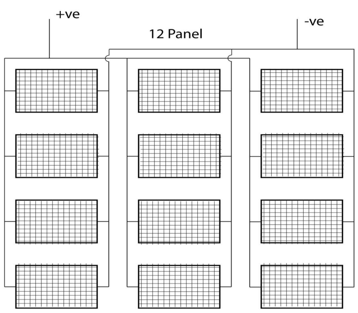
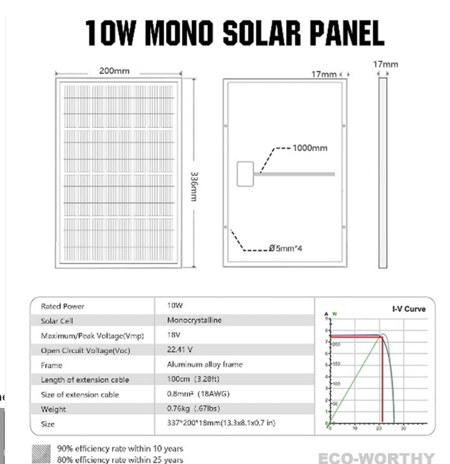


Fig. 28: Solar Panel Setup

Current Calculation:
For twelve panels in parallel:
Total Current = Current of One Panel × Number of Panels
Total Current = 1.5A × 12 = 18A
Power Calculation:
The power (in watts) can be calculated using the formula:
Power = Voltage × Current
For twelve panels in parallel:
Total Power = Voltage of One Panel × Total Current
Total Power = 12V × 18A = 216W

So, when twelve "WORTHY Solar Panels for Gate Opener, Chicken Coop, Off-Grid Applications" are connected in parallel, the combined output specifications are:
Voltage: 12V (unchanged)
Current: 18A
Power: 216W

.



MPPT: The Maximum Power Point Tracker (MPPT) is a highly efficient direct current to DC converter that optimizes the power output of solar panels.

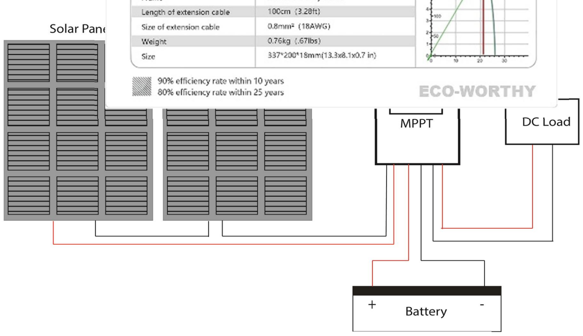


Fig. 29: MPPT Controller

Battery: A 48V total voltage is achieved by combining multiple 12V batteries in a series configuration.

Assume,
Each "WORTHY Solar Panel for Gate Opener, Chicken Coop, Off-Grid Applications" produces 12V and 1.5A.
The 12 panels are connected in parallel.

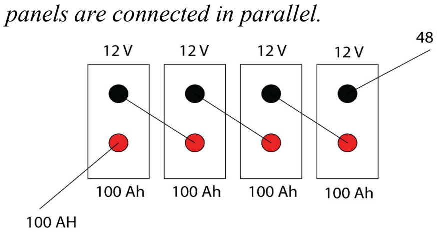


Fig. 30: Series Connected Battery

*The batteries are connected in series, resulting in a combined voltage of 48V (4 batteries * 12V each).*
Battery efficiency and charging losses should be considered in this simplified calculation.
Calculate the Power Output of One Solar Panel:
Power per Panel = Voltage × Current = 12V × 1.5A = 18W
Calculate the Total Power Output of Twelve Panels in Parallel:
Total Power Output = Power per Panel × Number of Panels = 18W × 12 = 216W
Calculate Daily Energy Production:
Daily Energy Output = Total Power Output × Sunlight Hours
Assuming an average of 5 hours of effective sunlight per day:
Daily Energy Output = 216W × 5 hours = 1080 Wh (watt-hours)
Calculate Energy Stored in Batteries:
Energy Stored in Batteries = Battery Voltage × Battery Capacity
Energy Stored in Batteries = 48V × 100Ah = 4800 Wh (watt-hours)
Calculate Charging Efficiency:
Charging Efficiency (%) = (Daily Energy Output / Energy Stored in Batteries) × 100
Charging Efficiency = (1080 Wh / 4800 Wh) × 100 ≈ 22.5%

Brushless DC Motor: The E-rickshaw design incorporates a high-performance Brushless DC motor, optimizing efficiency, power, and dependability. This

Fig. 31: Brushless DC Motor [29]

Table 7: Specifications of DC motor [29]

PM Brushless DC Geared Motor for ElectricTricycle	
Specification	
Drive Mode	Chain
Power	550W/700W/800W/1000W
Voltage	48V/60V
Rated Speed	600RPM
Chain Wheel	with 14teeth 420 chain wheel
Length of Motor	23.7cm/24cm/27cm
Mounting Size	5.5CM*7CM*13.2CM 5.5CM*9.5CM*13.2CM
Color	Black / Blue
Application	Electric boat, lift/elevator, equipment modification, electric tricycle/four-wheeler/quadricycle modification, etc.

motor operates within a 48-volt electrical system, achieving power outputs ranging from 550 to 1000 watts. [29]

Speed Control: 40 km/h is the maximum speed of an E-Rickshaw now.
40 km/h = 666.67 m/s
Here,

$$\frac{Rear\ Wheel\ Speed}{Motor\ Speed} = 0.7$$

$$Rear\ Wheel\ Speed \propto \frac{1}{Rear\ Wheel\ Gear\ Radius}$$

For 40 km/h or 666.7 m/s max speed, the rear wheel should rotate at 298.96 rpm. For this, the motor's full load speed must be 427.09 rpm.

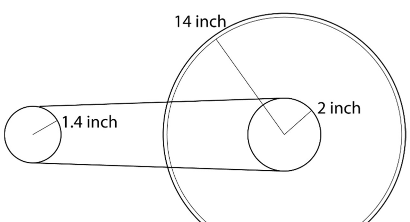


Fig. 32: Gear and Motor Radius

The new speed limit we set for E-rickshaw safety is 30 km/h or 500 m/s. So, the rear wheel should rotate at about 224.21 rpm, and the motor speed is 325 rpm. Now, we can achieve our desired speed via two ways.

1. Modifying the Gear radius.
2. Limiting the voltage of the motor.

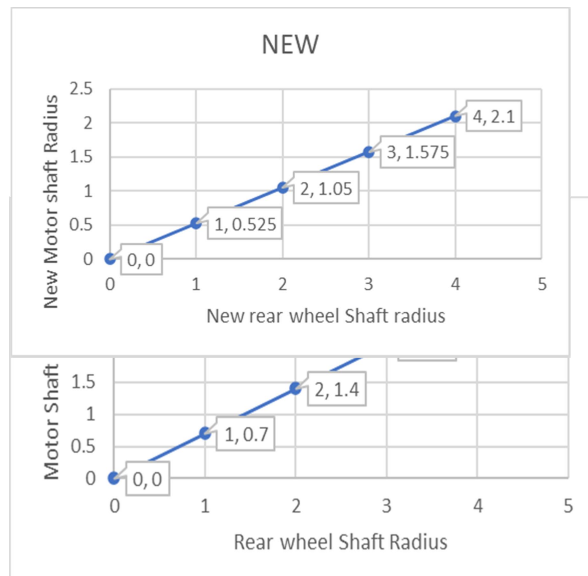
Modifying the gear radius: We can modify the radius of Motor Gear and Rear wheel Gear to limit the maximum speed at around 30 km/h. The graph below shows us the ratio of motor Gear radius and rear wheel Gear radius of the old model. In the old model the actual ratio is *(Rear Wheel Gear Radius, Motor Gear Radius) = (2", 1.4")*.

For our new model the ratio (Rear Wheel Gear Radius/Motor Gear Radius) should be about 0.525.

Now, for limiting the speed to 30 km/h we can change the Motor Gear Radius to 1.05" and keep the Rear wheel

Gear unchanged which will be *(Rear Wheel Gear Radius, Motor Gear Radius) = (2", 1.05")* or we can change the Rear wheel Gear to 2.67" and keep the motor Gear radius unchanged *(Rear Wheel Gear Radius, Motor Gear Radius) = (2.67", 1.4")*. The below graph shows us the ratio for the new model.

Table 8: Comparison between New Rear Wheel Gear Radius and, Motor Gear Radius



Limiting the voltage of the motor: We can also set a limit to the input voltage of the Motor to control the maximum speed of the vehicle. The old input voltage of the motor was 48V. Now, new maximum input voltage will be,

$$New\ Voltage = \frac{New\ speed}{Old\ Speed} \times Old\ Voltage$$
$$= \frac{325}{427.09} \times 48$$
$$= 36.53 \sim 38\text{ V}$$

So, we need to step down the Motor voltage from 48 V to 38 V by using a buck converter.

X. Discussion and Conclusion

This study investigates how to improve e-rickshaws, which are essential urban transportation options in Bangladesh. It tackles a number of issues, including energy inefficiencies, braking, stability, and ergonomic constraints. The study suggests several innovative fixes, such as a lowered center of gravity, sophisticated braking systems, two driving modes, and hoods with integrated solar panels that fold up. By addressing the dangers of tipping and rollovers, these enhancements can enhance user experience, efficiency, and safety. Ergonomics, adaptive traits, and sustainable energy sources are also investigated in this research. The discoveries have the potential to completely transform urban transportation by bringing in more eco-friendly, safe, and effective options. The significance of innovation, sustainability, and the possibility of improving transportation systems for the betterment of society are all highlighted by this research.

XI. Limitations

The study aims to introduce novel improvements for E-rickshaws, but it has limitations that need further investigation and verification in real-world contexts. The methodology used for weight calculations may not fully capture the intricate weight distribution and dynamics of real-world E-rickshaws. The research's focus on specific models and components may limit its generalizability. The suggested improvements have not yet been subjected to thorough real-world experimentation and validation, and a comprehensive economic analysis is needed to evaluate their financial implications.

XII. Acknowledgement

The team members of this research would like to thank Dr Nahid A. Jahan for her valuable insights and helpful discussions during the designing part of the solar panel. Members would also like to express fervent gratitude to all faculty members and staff in the department of EEE at Southeast University for all the help and support throughout the process.

XIII. References

[1] "I. Online, “It’s cheaper: Dealers import rickshaw parts from China, assemble them here,” The Indian Express, Mar. 19, 2014. https://indianexpress.com/article/cities/delhi/its-cheaper-dealers-import-rickshaw-parts-from-china-assemble-them-here/".

[2] "“Auto Rickshaw - 1 pc.” https://ebangladesh.com/products/e551a000-edc9-11ec-afa3-291902bac0a0".

[3] B. N. E. o. Bangladesh, "Rickshaw Link: https://en.banglapedia.org/index.php/Rickshaw#:~:text=Dhaka%20got%20rickshaw%20from%20Calcutta,1938%20for%20their%20personal%20use.".

[4] [1]“Rickshaw - Banglapedia,” BANGLAPEDIA. https://en.banglapedia.org/index.php/Rickshaw (accessed Nov. 08, 2023)..

[5] bdnews24, "Bangladesh court bans battery-run three-wheelers from highways Link: https://bdnews24.com/bangladesh/bangladesh-court-bans-battery-run-three-wheelers-from-highways," 4 April 2022.

[6] "Huston, J., Graves, B., and Johnson, D., "Three Wheeled Vehicle Dynamics," SAE Technical Paper 820139, 1982".

[7] R. K. M. A. Saeedi, "Stability of Three-Wheeled Vehicles with and without Control System," International Journal of Automotive Engineering , 2013.

[8] D. Tribune, "Government to ban battery-run rickshaws, vans Home Minister Asaduzzaman Khan made the announcement on Sunday Lnik:https://www.dhakatribune.com/bangladesh/government-affairs/250146/government-to-ban-battery-run-rickshaws-vans".

[9] M. S. a. M. R. M.Iqbal Mahmud*, "Design of the Rickshaw to Improve Safety and Comfort of Passengers," *Journal of Engineering and Technology ,* vol. 6, no. 7, pp. 57-70, 2007.

[10] S. S. P. S. S. G. K. G. V. Shreyas M1, "Study on Effect of the Center of Gravity on Vehicular Acceleration," Mar-2018 .

[11] "Difference Between Drum Brake and Disc Brake [Notes & PDF] Link-https://themechanicalengineering.com/difference-between-drum-brake-and-disc-brake-with-pdf/".

[12] S. &. U. M. &. C. E. &. R. M. M. &. K. A. Khan, "The Million Improvised Electric Rickshaws in Bangladesh: Preliminary Survey and Analysis.," 2022.

[13] "Venkata Mangaraju Karanam, Ashitava Ghosal, [Studies on wobble mode stability of a three wheeled]," Research and Development, TVS Motor Company Ltd., Hosur, India, Mechanical Engineering, Indian Institute of Science, Bangalore, India., Delhi.

[14] M. Z. H. M. H. M. Z. R. K. M. A. H. Md Junaed Al Hossain, "Affordable Electric Three-Wheeler in Bangladesh: Prospects, Challenges, and Sustainable Solutions," mpdi, 22 December 2022.

[15] T. F. Express, "Rethinking ban on battery-run vehicles Link: https://thefinancialexpress.com.bd/views/opinions/rethinking-ban-on-battery-run-vehicles-1624640129".

[16] "C. A. Driver, "Explained: How To Measure a Vehicle's Center-of-Gravity Height," Car and Driver, Apr. 09, 2018. https://www.caranddriver.com/news/a18201745/explained-how-to-measure-center-of-gravity-height/".

[17] "S. Gudmundsson, "LAT-DIR Stability and Control," Elsevier eBooks, Jan. 01, 2022. https://doi.org/10.1016/b978-0-12-818465-3.00025-2".

[18] "B. Hughey, "Beta-prototype of a rickshaw suspension system," 2011. http://hdl.handle.net/1721.1/68907".

[19] ""What is Dead Pedal and Why It is Necessary in Today's Cars | Tata AIG Blog." https://www.tataaig.com/knowledge-center/car-insurance/what-is-dead-pedal".

[20] ""Motorcycle Handlebars," Harley-Davidson. https://www.harley-davidson.com/us/en/shop/c/motorcycle-handlebars?format=json;i=1;locale=en_US;q1=parts;q2=motorcycle-handlebars;sp_cs=UTF-8;x1=primaryCategoryCode;x2=superCategoryCodes".

[21] "K. Howard, "Ergonomics & The Motorcycle Triangle (Of Pain)," TRO, Aug. 06, 2023. https://tro.bike/motorcycle-touring/triangle/#:~:text=According%20to%20the%20ergonomic%20experts,and%20monitors%20at%20eye%20level.".

[22] "A. Bhatt, "Insight – How Analog Speedometer Works," Engineers Garage, Jan. 22, 2022. https://www.engineersgarage.com/insight-how-analog-speedometer-works/#:~:text=The%20spiral%20groove%20passes%20through,generates%20a%20rotating%20magnetic%20field.".

[23] "J. Vrabel, O. Stopka, J. Palo, M. Stopkova, P. Droździel, and M. Michalsky, "Research Regarding Different Types of Headlights on Selected Passenger Vehicles when Using Sensor-Related Equipment," Sensors, vol. 23, no. 4, p. 1978, Feb. 2023, doi: 10.3390/s2".

[24] "V. Dzerkelis, Ž. Bazaras, and V. Lukoševičius, "INVESTIGATION OF THE INFLUENCE OF A-PILLAR ON PASSIVE SAFETY OF A VEHICLE IN CASE OF ROLLOVER," TRANSPORT, vol. 30, no. 2, pp. 194–201, May 2015, doi: 10.3846/16484142.2015.1045937.".

[25] "Shreyas M1, Shashank S P2, Sayan Surendran3, Gopal Krishna G V4., "Study on Effect of the Center of Gravity on Vehicular Acceleration," international Research Journal of Engineering and Technology (IRJET) , vol. 05, no. 03, Mar. 2018, [Online]. Available:".

[26] ""Sketch," Sketch. https://www.sketch.com/".

[27] ""Adobe Illustrator - Industry-leading vector graphics software." https://www.adobe.com/products/illustrator.html".

[28] Amazon, "ECO-WORTHY 12V Solar Panel 10W Solar Panel Battery Charger Portable for Vehicle Gate Opener Electrical Fence Chicken Coop Lawn Tractor Boat Link: https://www.amazon.com/WORTHY-Opener-Chicken-Off-Grid-Applications/dp/B00OZC3X1C?th=1.".

[29] ""[Hot Item] 550W~1000W 48V/60V BLDC MID Mounting DC Brushless Motor for Electric Tricycle," Made-in-China.com. https://lunyee.en.made-in-china.com/product/wdHGcgSbLupe/China-550W-1000W-48V-60V-BLDC-MID-Mounting-DC-Brushless-Motor-for-Electric-Tricycle.".

Uchchhas Dutta Swapno is a young and promising electrical and electronics engineer based in Bangladesh. He was born in Dhaka, Bangladesh in 2001. His passion for technology and problem-solving led him to pursue a degree in Electrical & Electronic Engineering from Southeast University in Bangladesh, where he developed a strong foundation in electronics, circuits, and computer systems.

Uchchhas's internship at Dhaka Electric Supply Company (DESCO) is an initial foray into the power and grid management sector. However, his interests extend beyond traditional electrical engineering, as evidenced by his fascination with physics and computer-based subjects.

Beyond his academic and professional pursuits, Uchchhas's interest in XDA, an online forum for Android developers, suggests a passion for technology and a desire to stay updated with the latest advancements. This involvement could indicate a personal interest in mobile technology or even potential freelance work in app development. He has also actively participated as Technical Secretary at Southeast University EEE Club.

Kamruzzaman Nahid graduated from Southeast University, where he pursued his passion for understanding the fundamental principles governing the physical world and exploring innovative solutions in electrical engineering.

Prior to his university studies, Nahid laid the foundation of his academic journey at Milestone College Uttara, where he honed his analytical and critical thinking skills. Throughout his academic career, Nahid has demonstrated a keen interest in research, delving deep into topics at the intersection of physics and electrical engineering. His research endeavors have focused on elucidating complex phenomena and developing practical applications in renewable energy, electromagnetism, and semiconductor physics. With a strong theoretical background complemented by hands-on laboratory experience, Nahid is committed to advancing scientific knowledge and contributing to technological advancements that address contemporary challenges.

Hasan Al Naimul is a graduate of Southeast University, where he obtained a Bachelor of Science degree in Electrical and Electronic Engineering (EEE). Hailing from Natore, Bangladesh, Hasan's academic journey has been shaped by his passion for physics and mathematics, which he has cultivated throughout his undergraduate studies.

With a keen interest in interdisciplinary research, Hasan's research interests span the fields of physics, mathematics, and electrical engineering. His fascination with the fundamental principles governing the universe drives his exploration of innovative solutions and theoretical frameworks within these domains.

Hasan's commitment to academic excellence and research innovation underscores his dedication to advancing knowledge and pushing the boundaries of scientific inquiry. As he embarks on his research journey, Hasan seeks to contribute to the intersection of physics, mathematics, and electrical engineering, leveraging his expertise to address complex challenges and drive technological innovation forward.

Dr Md Tareque Aziz got his PhD in experimental and theoretical Plasma Physics from University of Delaware, USA. After that he worked at IBM’s famous TJ Watson Center at New York, USA and after that he also did a Postdoc at Brookhaven National lab (BNL) at New York, USA. While at BNL, he was working at the Photon Science division of National Synchrotron Light Source II (NSLS II). He joined Southeast University in 2019 as an Assistant Professor. His research interest includes Turbulence, Strongly Correlated Systems, Application of ML in the realm of CFM.