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Covered Narrow Track Tilting Three-Wheeler

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***Abstract*: Population explosion has created a void in the 2-wheeler market that requires a design overhaul. Lately, parking has become an emergency concern in cities like Bangalore. A technical way to resolve this is to dynamically resize the vehicles and improve parking prospects. In this study, the electric covered, narrow track tilting three-wheeler is redesigned to eliminate the issues faced by both two-wheelers and four-wheelers while fine-tuning and incorporating the best of both entities. Length of the proposed three-wheeler is lesser by 455 mm and 650 mm in width as compared to a typical micro car. Vehicle ingress and egress, wide door opening and ergonomics consideration of sitting, extended leg comfort, etc., have been taken into consideration. The redesigned three-wheeler is simple to manufacture, has fewer mechanisms and lack design complications. This narrow track design increases parking space and allows easy movement in narrow lanes.**

***Keywords*: Electric Vehicle, Narrow Track, Parking Efficiency, Tilting Three-Wheeler.**

1. Introduction

Transportation has been the lifeline of people since the dawn of time, and it had been fast evolving with technological advancements at the turn of the twenty-first century. Long ago, the electric vehicle revolution was attempted however; it failed owing to a lack of infrastructure and adequate resources. Current researches focus on automobile technology vis-a-vis global warming and government policies that have helped to drive electric car technology to the forefront. There are various types of automobiles on the road, in all shapes and sizes. However, due to production constraints, majority of them appear monotonous. Being the world's largest two-wheeler market [9].

India's two-wheeler market is swamped with various styles, sizes, and shapes. Increasing transportation demands are causing challenges in cities. These are mostly connected to individual automobile possession and historically developed motor transportation systems. Urbanization and population increase in many cities have exacerbated the situation. Hence, urban areas have issues such as air pollution, noise pollution, scarcity of land and structures that are inefficient. From societal advancements to travel behavior, along with vehicle selection, several societal transitions are being noticed. Carpooling is becoming more common in metropolises due to digitalization. A large spectrum of transportation options reflect the level of individualization that drive vehicle possession away from priority features, particularly among the youth. The more crucial factors encourage environmentally, morally, and economically sensible transportation. Possessing a personal vehicle remains a significant indicator of prestige in the community, as seen by the large percentage of car owners [1]. Substituting normative sized commuter vehicles with narrow electric vehicles might provide a more sustainable transportation strategy. Automobiles of car segment or light passenger vehicles are intended and manufactured for transportation of persons and include up to 8 seating including the seat of the driver. In contrast to small electric vehicles, typical size of passenger vehicles is normally classified as LMV and is called to as 'cars' hereafter. Small electric vehicles consume less resources and energy to manufacture and operate versus cars, and they occupy lesser area in both standing and moving traffic.

2. Observation and Methodology

A. Observation

As we all know, a square-shaped object can be placed in any direction and will not increase the space regardless of where it is placed. When it comes to rectangular objects, however, the manner we put them makes a big difference in terms of maximizing the available space and volume. This is especially true in the case of goods and materials packaging.

1) Requirement and Methodology

A rectangular parking space may improve personal transportation space wherein, the average number of passengers traveling per car is 1.5 [10].

Hence, a small two-seater vehicle is ideal for the urban transport.

2) Seating Arrangement in a Two-Seater Vehicle

- *Side by side*: Where in the passenger sits next to the driver in the same line similar to a car. The advantages being both the passenger and driver can see each other face. The disadvantage being the driver cannot see the extreme end of the passenger side and vice versa.
- *Tandem*: Here the arrangement resembles motorcycle seating where the passenger sits behind the driver. The advantage is here is that both the driver and the passenger have better view of the surrounding area. The disadvantage is that the persons cannot see face to face while talking.

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B. Methodology

To demonstrate the concept, an area 'A' with X-length and Y-breadth dimensions is taken and applied to an area 'B' which is 20 times larger to represent a parking lot or a theoretical space. Re-orienting the x and y axes of the object 'A' with a 90-degree twist and placing them in area 'B' to obtain a new viewpoint of that position is one way to demonstrate the difference. As shown in Figure 1, with a length of 12645.21 mm and a width of 4143.63 mm, the number of vehicles that can be maintained in the side-by-side arrangement is 16, compared to 22 in the tandem arrangement. The reason for this is that the isle in a side-by-side arrangement is wider, whereas the isle required in a tandem arrangement is narrower.

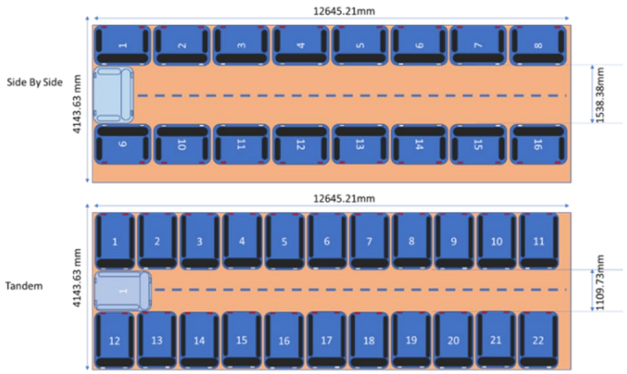

Fig. 1. Parking optimization in narrow vs wide vehicles

C. Proposed Idea

From the above facts, narrower vehicle is preferable to a shorter, wider one. However, under the current situation, removing all of the wide vehicles from the road and replacing them with narrow vehicles is impossible. A concept was created based on the above theory with the sole purpose of keeping the vehicle as narrow as possible. The vehicle design that best suited the situation was a narrow track tilting three-wheeler that is simple to manufacture, has few mechanisms, and is also new to India, making it a revolutionary design and a green field project. It is desirable to designate a parking area for narrow vehicles, where they can be parked similarly to motorbikes, optimizing the available space.

D. Narrow Track Vehicles

1) Introduction to Narrow Track Vehicles

Narrow vehicle is basically like a scooter with three wheels. Covered narrow vehicles have the potential to partially replace cars. This will significantly reduce traffic congestion and the need for parking. The narrow vehicle can give both the comfort of an upright standing car and the flexibility to maneuver like a motorcycle [2]. Being a smaller vehicle also helps reduce waste by consuming lesser material for construction, requiring lesser manpower, consuming lesser energy, and providing better logistics thereby, allowing shipment of a greater number of parts at once. Due to the slim frontal area, the narrow vehicles can slice through the air with more aerodynamic efficiency and increasing the distance travelled per charge of the vehicle. The advantage of a narrow track tilting vehicle is represented in Figure 2.

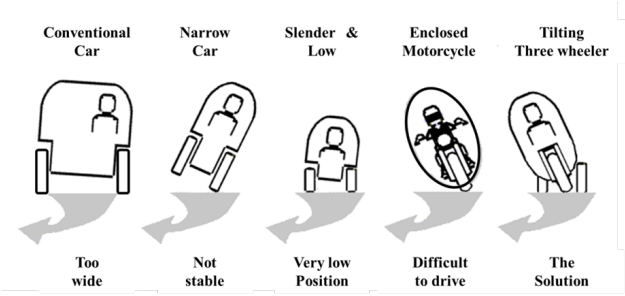

Fig. 2. Advantage of a narrow track tilting three-wheeler

Two types of narrow track three-wheelers are as below [3].

- *Tadpole version*: which has two wheels in front and a single wheel in the back; linkages are used to turn the front two wheels which are usually in parallelogram arrangement or which are connected to a steering wheel.
- *Delta version*: this has two wheels in back and a single wheel in the front which has a straight shaft with a shock absorber attached to the front wheels, similar to a motorcycle. This is with the exception of Carver being an electric vehicle with a steering mechanism and a linkage system is a narrow track three-wheeler.

E. Technical description

In order to keep costs down, the concept of delta is taken into consideration with a simple motorcycle version front suspension system. The delta variant has a differential in the back that transfers power to both rear wheels and aids in the smooth turning of the narrow track three-wheeler. A DC electric motor provides power to the rear wheels, which is controlled by a controller housed in the rear wheels' casing box. The vehicle's speed is controlled by an accelerator located on the handle bar and connected to the controller. The battery is connected to the motor, and the connection also passes through the controller, which provides more or less power, causing the motor to speed up or slow down.

1) Working concept

A tilting narrow track is a concept that allows the body to tilt around corners, allowing it to adjust to road turns and curves without rolling or losing its center of gravity. This is critical on a vehicle with a narrow track and a tall design, as opposed to the more common proportionate body styling of a wider body and shorter design. The body dimensions of a narrow tilting three-wheeler are similar to those of a motorcycle. As a result, a tall design will require a tilt to maintain stability while cornering and negotiating tight turns. The three-wheeled technology makes it convenient to incorporate stand-still technology allowing the rider to sit without having to balance with his/her foot as in scooter or motorcycle. Although self-balancing bike technology is not cheap or foolproof, this solution of self-balancing and tilt operation with the help of a tilt lock is simple to manufacture while retaining the necessary components. There are three types of tilt control methods: passive, free, and active. Passive tilt control is controlled directly or indirectly by user feedback or sensors that control the tilt mechanism. There are no sensors, actuators, or anything

in passive and free tilt control; it is basically like a motorcycle that tilts at its center of gravity or according to user input. The rider must control and adjust the tilt indirectly as the vehicle steers in the passive and free tilt. There are sensors and actuators in active tilt control that control the tilt angle in response to gyroscopic input to the sensors, vehicle speed, and other inputs to tilt the angle or keep the vehicle upright in very slow motion. The active tilt control can be applied in two ways: indirectly or directly. The rider of a passive and free tilting three-wheeler can apply a torque to steer directly, which in turn controls the tilt angle indirectly as seen in motorcycles and scooters. The tilt lock control is activated by a switch at the top of the handle bar, which keeps it upright when the vehicle is in slow motion or at a standstill. Some tilt mechanisms use active tilt technology, which continuously measures active tilt paths and steering angles and sends signals to the tilt mechanism to keep it in the correct tilt angle and position [4]-[6].

2) Ergonomics Consideration

The rider's position can be upright, which is an important consideration when choosing a tilting narrow track 3-wheeler because it helps the rider to sit ergonomically and comfortably rather than leaning forward as on bikes or motorcycles.

3. Objective

To design a narrow track three-wheeler considering

- Aesthetics
- Full covered body
- Safety
- User friendly design
- Ergonomics
- Good visibility
- Protection from dust and rain

4. Ideation

A. Trend study

Only one of the five trend boards is chosen as shown in Figure 3. This trend board is completely futuristic, giving the impression of speed and a cinematic feel, which is more akin to a future that will entice us to explore further. This is a very strong foundation for design inspiration as designers may wish to do future proofing to get a smarter, futuristic vehicle.

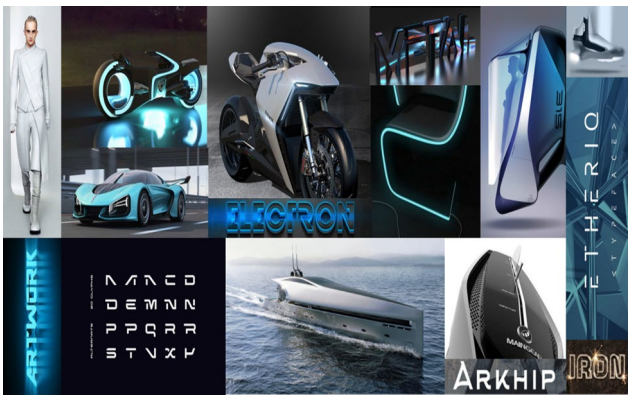

Fig. 3. Trend study board

B. Theme board

The Visual Theme Board has a tall and slim design. The images displayed show a variety of categories, ranging from origami concept to minimalist furniture, square building, printer, and coffee machine (Figure 4).

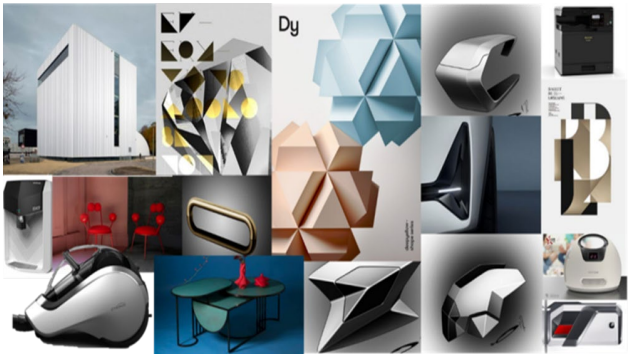

Fig. 4. Theme board

C. Mood board

The Visual Mood Board is inspired by existing product forms as well as one that conveyed futuristic, aggressive, overall simplicity, and minimalism vibes (Figure 5). To get the vibe of a tall and seamless design, the images displayed show a variety of categories, ranging from BMW concept to electric motorcycle. It also reflects ripples in water, flow from a tap, futuristic building, and waterfall. A mood board is intended to give an impression to function exactly as to what is intended to be done just by looking at it.

Fig. 5. Mood board

D. Reference Board

Fig. 6. Reference as carver electric three-wheeler

To come up with newer and more aesthetically pleasing concepts, a Reference Board with products on the market is created, as shown in Figure 6.

E. Concept Generation

The requirements serve as the foundation for the entire design process, as also the basis for the ideation process. Initially, the sketches were done by hand to get a good idea of what would look good by experimenting with different forms and concepts. Existing products, nature, the golden ratio, geometric forms, and simple lines and shapes served as inspiration. In the eight concepts shortlisted (Figure 7), one is chosen to be revised to get the final form of the product.

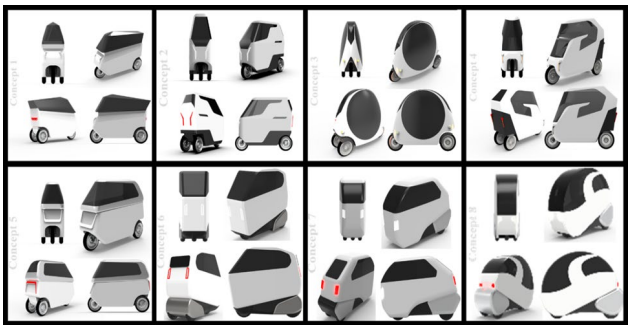

Fig. 7. Initial concepts

Pugh's Matrix is used to select concept no. 3, which is then redesigned for improved aesthetics and functionality. The concept no. 3 is chosen because of its simple design, which stood out during comparison.

The fourth concept from Figure 6 is chosen, and minor changes to the lighting are made to make it more realistic and additional details are added. All of this is done in Fusion 360, which allows for quick concept generation. The final concepts are shown in Figure 8.

Fig. 8. Final concepts

F. Concept Detailing

1) Dimensions

The dimensions of the vehicle are shown in Figure 9. The length of the vehicle is 1945mm, the height is 1530mm, width of the vehicle is 725mm, wheelbase of the vehicle is 1495mm and track width is 450mm.

2) Modelling Process

Autodesk Alias is used to create the final model (Figure 10) which is then tested under various diagnostic shaders for continuity and flow.

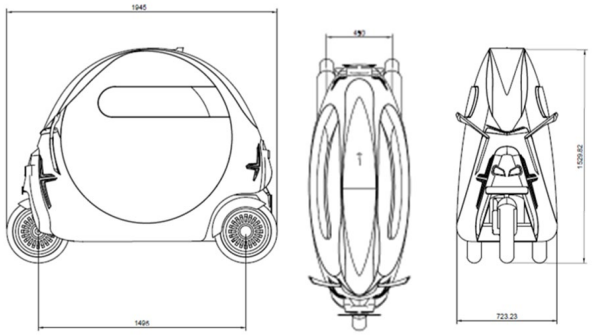

Fig. 9. Dimensions of the vehicle

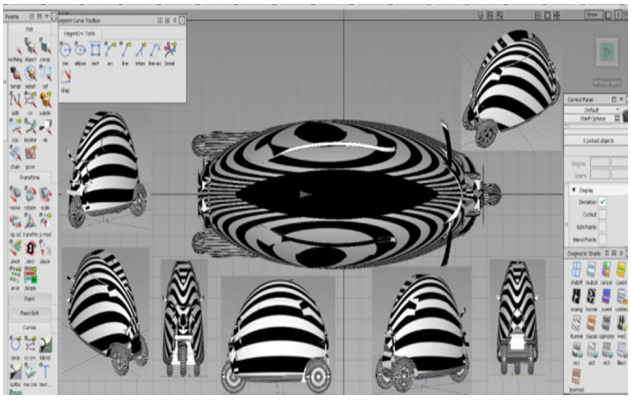

Fig. 10. Zebra diagnostics shader

3) Components

The primary goal of concept detailing in the virtual modeling process refers to deliberate designing of aesthetic, construction, ergonomic as well as manufacturing, structural, and surface detailing. Here to this concept, the aesthetic and ergonomics detailing is given top priority (Figures 11 and 12).

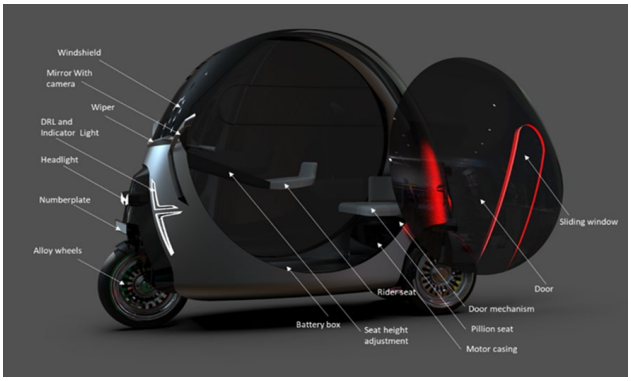

Fig. 11. Components from front side view

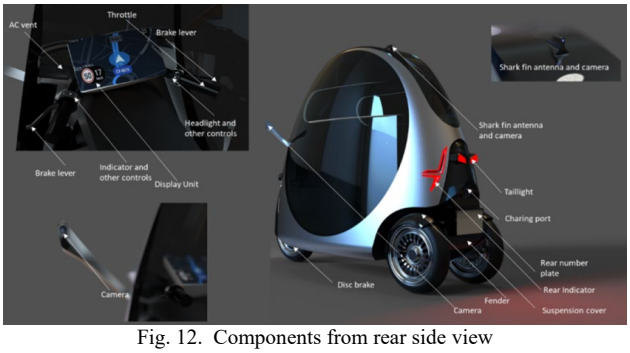

Fig. 12. Components from rear side view

4) Ergonomic Consideration

The ergonomics of the seating and extended leg comfort space are taken in to consideration and optimized for overall comfort. The vehicle ingress and egress have also been taken care of and a wider door has been provided for easy movement of passengers and luggage.

G. Concept Rendering

The concept rendering is done to stimulate how it may look in the real-world scenario and how it can be used. The nomenclature of colors of the Triton are based on planetary inspiration, where the blue is called as Neptune blue, the silver as Mercury silver, red as Mars red, and copper as in Venus Copper (Figure 13).

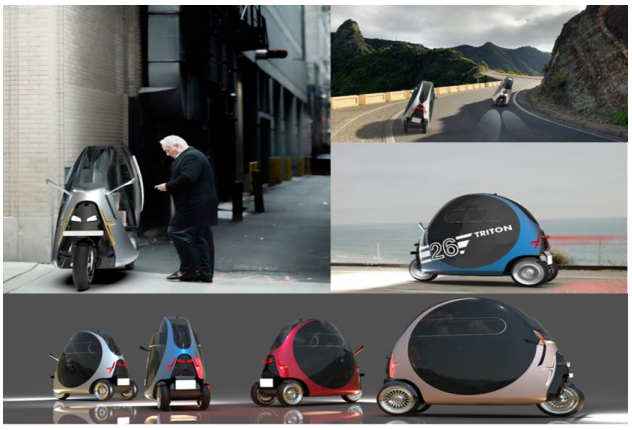

Fig. 13. Colors of the triton and rendered images

H. Color, Material and Finish

The whole vehicle material and finish is carefully selected keeping in mind the need of the user and the way it should be perceived.

1) Interiors

1. Colors
   - Trims-Metal Grey
   - Seats-White, Camel Brown, Black
   - Seat height adjustment-Metallic Black
   - Brake Lever-Metallic Black
   - Handle Bar- Metallic Black
   - Display Panel Sides- Metal Grey
   - Display Panel Front- Metallic Black
   - Rubber Mat -Black
   - Floor- Aluminum Paint
   - Motor Cover-Metallic Black
2. Materials
   - Trims, Instrument Cluster, Motor Cover-Plastic
   - Seat-Artificial Leather
   - Handle bar- Mild steel
   - Brake Lever-Aluminum Alloy
   - Interior Floor-Rubber Mat Over Aluminum base
   - Seat Height Adjustment Body-Plastic
3. Trim and Finishes
   - Plastic-Matt finish
   - Artificial Leather-Leather Finish
   - Metal -Glossy

2) Exteriors

1. Colors
   - Body-Sliver, Cherry Red, Deep Blue, Champagne
   - Glass-Tinted Grey
   - Number Plate- Metallic Black and White Board
   - Indicators- Translucent Smoky Grey
   - Wheels-Chrome Polished
2. Materials
   - Body-ABS
   - Front and rear glass-Tempered glass
   - Side Glass-Acrylic glass
   - Mirrors-ABS
   - Indicator and Lights- Acrylic
   - Wheels-Alloy
   - Fenders-ABS
   - Chassis-Mild steel
   - Shock Absorber-Black
   - Brake Caliper-Red
3. Trims and Finishes
   - Body-Glossy
   - Glass-Glossy
   - Indicators-Matt
   - Taillight and Headlights- Clear Transparent

5. Prototyping

A. 3D Printing Process

The 3D printing process is shown in Figure 14. All of the designs are created in Alias and then reproduced in Fusion 360, where thickness is added and converted to .stl files, which were then sent for 3D printing. The 3D printing is done to get a symmetrical shaped detailing and finish. The 3D print is done in two methods: FDM-fused deposition modeling PLA and then SLA stereo lithography method for the minute parts like mirrors and indicator lights.

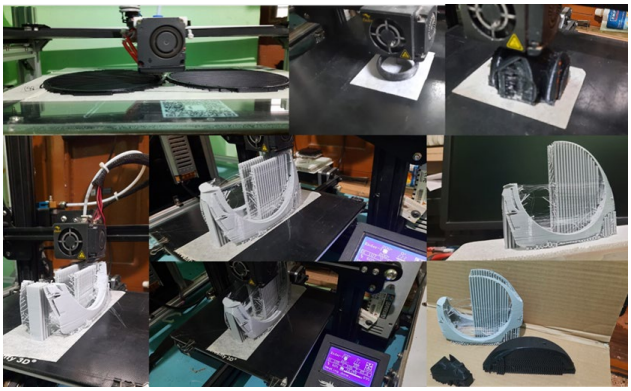

Fig. 14. 3D printing process

B. Painting Process

The painting process is shown in Figure 15. The holes and dents are first filled with filler, allowed to dry and sanded/filed

to achieve the smooth and seamless finish. After sanding, the filler is applied again until no visible marks or dents remain. The parts are again sanded to remove any uneven surfaces or dents that had occurred during the 3D printing support. This is followed by applying nitrocellulose putty and later with paint primer. The process is completed by applying the paint of desired colors and a clear coat lacquer is applied.

Fig. 15. Painting process

C. *Finishing Process*

The final results are seen once the final finished scaled prototype is ready after assembly operations. The finishing touches include detailing of lights and mirrors and all minute parts (Figure 16). The dimensions of the proposed tilting 3-wheeler is 1945 mm in length and 750 mm in width. The typical dimension of a micro car is ~2400 mm in length and ~1400 mm in width. The comparison of the existing micro car and the proposed tilting 3-wheeler car is shown in Figure 17.

Fig. 16. Finished prototype

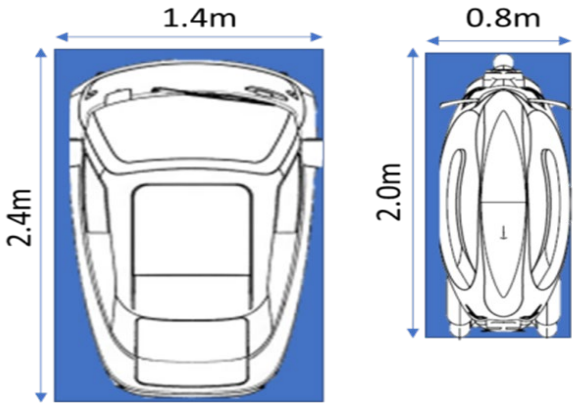

Fig. 17. Comparison of size and dimensions

6. Conclusion

The conceptual design of the narrow track three-wheeler offers promising potential to eliminate the existing shortcomings of personal transport in populated areas facing serious dearth of space. To materialize the concept in real-time scenario, we carried out a ground-check exercise and compared the parking space and dimensions of the existing two-seater micro car with that of the proposed model tilting car. The model car has an edge over the existing car in its customized smart design of re-arranged seating arrangement, narrow and tall tilting design structure and lesser aerodynamic losses. This is opposed to the larger standing area required by the existing micro car which is generally due to the side-by-side seating design requiring larger aisle thereby, severely limiting the parking space besides having more aerodynamic losses. These narrow vehicles are especially useful when houses are connected by multiple lanes that are too narrow for cars to pass through. When the vehicle is small enough to fit in the parking spot, the ability to park in a scooter parking lot is an additional advantage. Another advantage of the model car is that it can ply on the bike lanes without having to pay tax at toll gates.

Conclusion

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