

# Design and fabrication of Clone Segway personal transporter

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## ABSTRACT

The Clone Segway aims to create a low-cost but efficient device similar in function with its principal model but at a fraction of the cost by using simpler drive mechanisms, control equipment, and lesser aesthetics. This type of Segway is more economical and accessible to people in their day to day life.

**KEY WORDS:** Fabrication, Clone Segway, Personal Transporter, Mechatronics

## 1. INTRODUCTION

The transportation sector of today has always been an enigma for the various governments. The rise in the number of vehicles on the road as the years pass by continue to increase exponentially over passing time, which leads to more pollution as well as congestion on roads. Due to this naturally set off a chain reaction of events such as delay in the arrival of ambulances, more vehicular breakdowns, etc. to ease these type of congestions, a singular personal driver mobile platform or also known as the Segway was introduced. This is a two-wheeled, self-balancing, battery-powered electric vehicle invented by Dean Kamen. The advantages of the vehicle are that it produces zero emissions, zero turning radius and has a safe traveling speed.

**Literature Survey:** From the paper by Susan A. Shaheen and Rachel Finsen (Shaheen, 2003) sheds light on how efficient transit station access is often limited and a more comprehensive approach is needed that offers more connectivity, flexibility, and potentially increase transit ridership. The paper outlines a Segway pilot research project that explores safety and training issues and transit feeder service demand across various locations in the USA and aims at providing answers about consumer acceptance, safety, land use, market potential.

According to the Pilot Project for Evaluating Motorized Personal Transportation Devices: Segways and Electric Scooters by Pierre Lavallee, Centre for Electric Vehicle Experimentation in Quebec (Lavallee, 2014).

The transportation of goods and people is growing exponentially, and the adverse effects of mobility (dependence on fossil fuels, pollution in all its forms, greenhouse gasses, congestion, etc.) are all known and well documented and urgent measures for sustainable solutions. A wide range of users found it easy to use under normal situations and involving obstacles. Regarding stability, they were superior compared to bicycles or mopeds.

The report on Segways, Scooters and other Mobility Devices by Transport Cooperative Research Program (2011) states that "The use of non-traditional mobility aids is increasing, and there are confusion and lack of uniformity in how they are accommodated" is the main aspect which is highlighted. Segways have been included under EPAMD's (Electric Personal Assistive Mobility Device) and any person wishes to use an EPAMD have to apply and receive a free permit while carrying along with them, which were brought into effect as a Segway ran off the platform and onto the tracks in the BART (Bay Area Rapid Transit) system in the USA.

Segway Human Transporter (HT) quotes Potential Opportunities and Challenges for Transportation Systems by Rongfang (Rachel) Liu and Rohini Parthasarathy (2002) tries to explain what a Segway is, and how it functions, and how to implement into the transportation infrastructure. They also strive to point out potential opportunities of Segway HT in not only transportation but also can be supplemented by Segway HT.

The objective of this work is to produce a similar mobile platform at more budget level as well as make it into a more adaptive type of vehicle capable of adding or removing components

## 2. MATERIALS AND METHODS

**Design & Development of Segway:** The main concern would be the selection of materials, motors, and load bearing members for the proper functioning of the Segway. This mainly involves the selection of motor, selection of wheels and tires, selection of bearings, chains, and sprockets just to name a few

### Design Factors for the proposed Segway

Load Capacity : 80 Kgs.

Base Width : 17"

Base Length : 29"

Mast Length : 32"

Types of motion: Forward, Backward, Left, Right

Travel Speed : 5 Km/h

Power Supply : 12V, 7 Ah Pb-Acid Battery

### Materials Used For Each Part

Body of the Segway : Wood

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Mast : Metal piping  
 Angle brackets : Mild Steel  
 Wheels : Nylon

**Design of Parts****Selection of Driving Motor**

$$P = 2\pi NT/60000$$

Where,

P = Power of Motor (KW)

N = Speed (in rpm)

T = Torque (Nm)

$$T = W \times R$$

**Where,**

W = Total load on wheels = Weight of the operator + weight of the mast + weight of the base + weight of the two motors + weight of the two batteries + weight of the electronics + weight of the wheels

$$= 55+3+22 = 80 \text{ Kgs.}$$

$$= 2\pi NT/60000$$

$$= 2\pi (2750) (0.003 \times 80 \times 9.81)/60000$$

$$P = 0.338 \text{ kW}$$

i.e. Power of a single motor = 0.338 kW

$$P = 338W$$

**Selection of Sprockets**

Diameter of the wheels = D= 200mm

Speed of Segway = S= 5 Km/h = 83m/min

Speed (in rpm) = N1 = S/D = 83/(0.2) = 133rpm

Rated speed of motor = N2 = 2550 rpm

$$i = N2/N1 = 2550/133 = 19:1$$

Sprocket on motor is 6mm diameter and has 13 teeth

$$Z2 = 13$$

$$1/D2 = Z1/Z2 = N2/N1 = i$$

$$1/Z2 = i$$

$$Z1 = 19 \times 13 = 247$$

$$D1 = 19 \times 6 = 114mm$$

**Length of Chain**

[Ref: Bhandari, V. B. (2010). *Design of machine elements, Ch. 14, Chain Drive; Section 14.7, Design of Chain Drive*. Tata McGraw-Hill Education. Chicago.]

$$L = 2 + ((+))/2 + ((D - d) 2)/4C$$

Where,

C = Centre distance between sprockets = 200mm

$$L = 2(200) + ((114 + 6))/2 + ((114 - 6)2)/4(200)$$

**Selection of Bearing:** A standard SKF 6205 DEEP GROOVE BALL BEARING, with static and dynamic load capacity of 6965N and 10690N respectively would be adequate with a shaft diameter of 25 mm

**Specification of the framework:** Simple Personal Transporter

Lift capacity - at least 100 kg's. Able to transport a person.

Small size - wheelbase able to fit through a standard doorframe

Wooden base: 29" x 17"

Mast: 32" tall, adequate for the grasp of an average adult.

Simplicity – a programmed gyro-accelerometer and hand controls mounted on the mast should act as controls

Electric propulsion – Electric motors powering each wheel by a Chain Drive Minimal cost.

The main drawbacks associated with a Segway limiting its use with the general public is the high cost. The clone Segway aims to create a low-cost but effective device similar in function with its primary model but at a fraction of the cost by using simpler drive mechanisms, control equipment, and lesser aesthetics

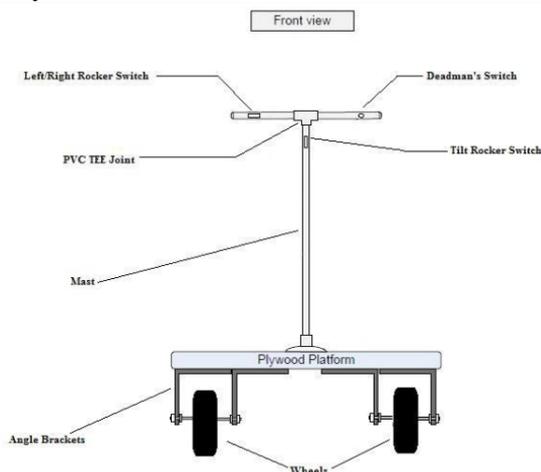
**Basic Outline of the Design:**

**The Base Frame and Wheel Assembly:** A wooden base which would be a mount for the wheels, motors, mast, power pack and act as a footing for the person to stand. The wheels will be preferably 200 X 50mm with nylon tires. The wheels are rated at 200 kg. Sprockets were attached to the chain which drives the motors; that takes the static load off the motor shafts.

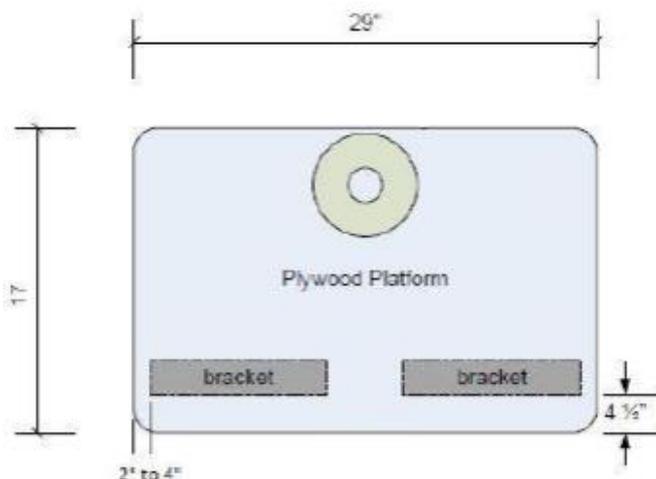
**The Mast with Hand Controls:** Mast made of PVC Piping fixed to the base frame and having a horizontal piping for the handle encasing the control switches. The masts would be approx. Be 31~32" tall, 1.25" circular PVC pipe. Right Hand will have the Dead Man's Switch to turn on the motors. The left hand will have a steering rocker switch for direction control. And a tilt rocker switch to adjust neutral balancing position.

**Power Pack with Electronics:** Two 12V 7AH lead acid batteries.

**Electronics:** Dual 12A Motor Driver, Gyro Accelerometer Board (MPU 6050 GY 521), Microcontroller board (Arduino UNO R3) The base model of the Clone Segway is shown below in figure 1 & 2 (Front and Top view of Segway)



**Figure.1. Front View of the Clone Segway**



**Figure.2. Top View of the Clone Segway**

**Fabrication of Segway:** The fabrication of such machinery is a comprehensive task and requires a lot of human effort and man hours. Each of the parts viz. the main frame, the wheel assembly and control assembly, and the gyro/accelerometer setup and other accessories were fabricated separately.

**Steps Involved In Fabrication Process:** Initially, the Wood Riding Platform was made, and then the sprockets were mounted on the wheels as shown in Fig.3. Once the sprockets were mounted, the wheels were mounted on the angle brackets as shown in Fig.4



**Figure.3. Sprocket mounted onto the wheel**



**Figure.4. Wheel setup mounted onto Angle Bracket**

Now fix the wheel setup and the motors onto the wooden base frame with the appropriate chain length as shown in Fig.5. Then the PVC pipes were cut to the required length for the handle bar, and the switches are inserted into it. Mount the batteries onto the wooden base frame as shown in Fig. 6

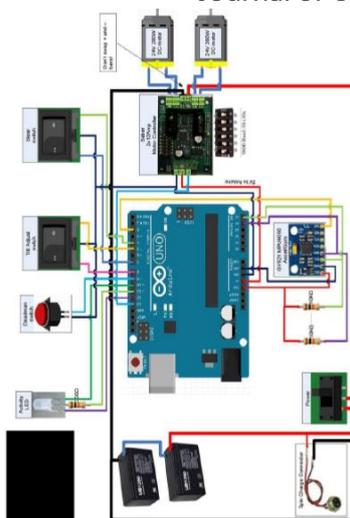


**Figure.5. Wheel and motor setup on the Base Frame**



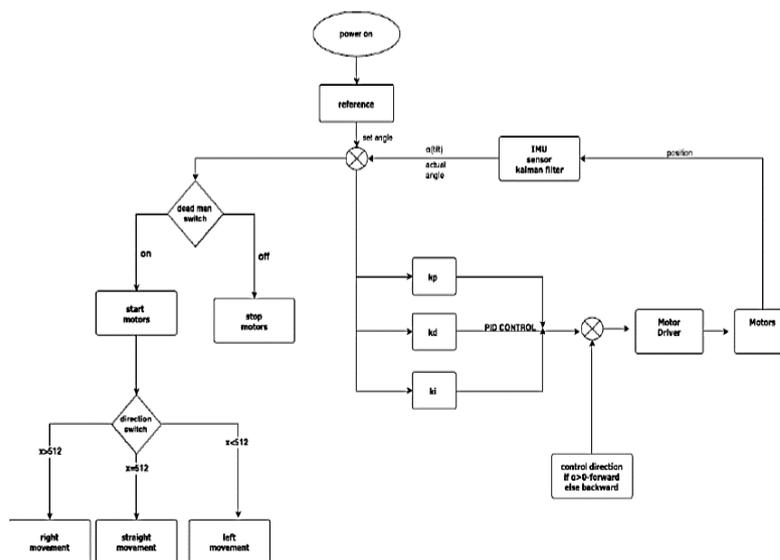
**Figure.6. Battery Mounted on the base with zipping ties**

Now wire all the electronic components as shown in Fig. 7.



**Figure.7. Circuit Diagram for the Electronics**

The Clone Segway Flowchart is shown in Fig 8. It describes the stage by stage progress of the Segway



**Figure.8. Flowchart of Arduino Coding**

The final fabricated and assembled model is shown in figure 9.



**Figure.9. Fabricated Model**

### 3. RESULTS

The fabricated Segway was tested on flat platform and it was running smoothly. The load bearing capacity was limited to 80Kg. Thus with the use of Arduino UNO R3 controller all the motions of the Segway was stable.

### 4. CONCLUSION

Fabricated a Clone Segway of a prototype which clearly demonstrates the advantages of this design for application as a safe and green personal transport. This design has been thoroughly tested, and all aspects have been taken into consideration. The proposed design may be used for fabrication of a full-scale personal transporter for personal use and is sure to cost much less compared to the original Segway, which costs a fortune in comparison.

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