

## **Chapter 3: Methodology**

### **3.1 Problem Identification**

One of the difficulties on using the wind tunnel test is that the similarity of both the wind tunnel flow and the real world flow need to be achieved. Similarity can be found through assumptions and experiments, finding the relationships that can relate both the simulation and the real world. A number of testing has to be done to find the relationship between the two situations, plus some calculation for dimensional analysis.

The problem from the wind tunnel provided by the university is that it does not support the project fully. The wind tunnel is design to accommodate only one model at a time. This does not comply with the requirement of the project that need at least two models at one time. Modification to the original wind tunnel panel is not allowed by the lab technician, thus a new one has to be fabricated.

Another problem that rises is the fact that the size of the wind tunnel test section is quit small for a model to realy simulates the real situation. With the maximum speed of the wind to be  $60\text{ms}^{-1}$ , the size of the vehicle model has to be as large as possible to simulate the highest speed and at the same time does not block the air flow in the test section.

### **3.2 Fabrication and Setup**

The current WT04 wind tunnel needs to be modified so that it can fit in two or more models at a time. Modification will only focus on the test section. The steel cage of the section will not be tempered with; only the left and right wall of the test section will be modified. The right panel is made from perspex while the left panel is made from tempered glass. Both side can be detached and reattached. The plan is to replace both sides with perspex with holes on each opposite side to support the second model in the test section. More detail diagram is available in the appendix.

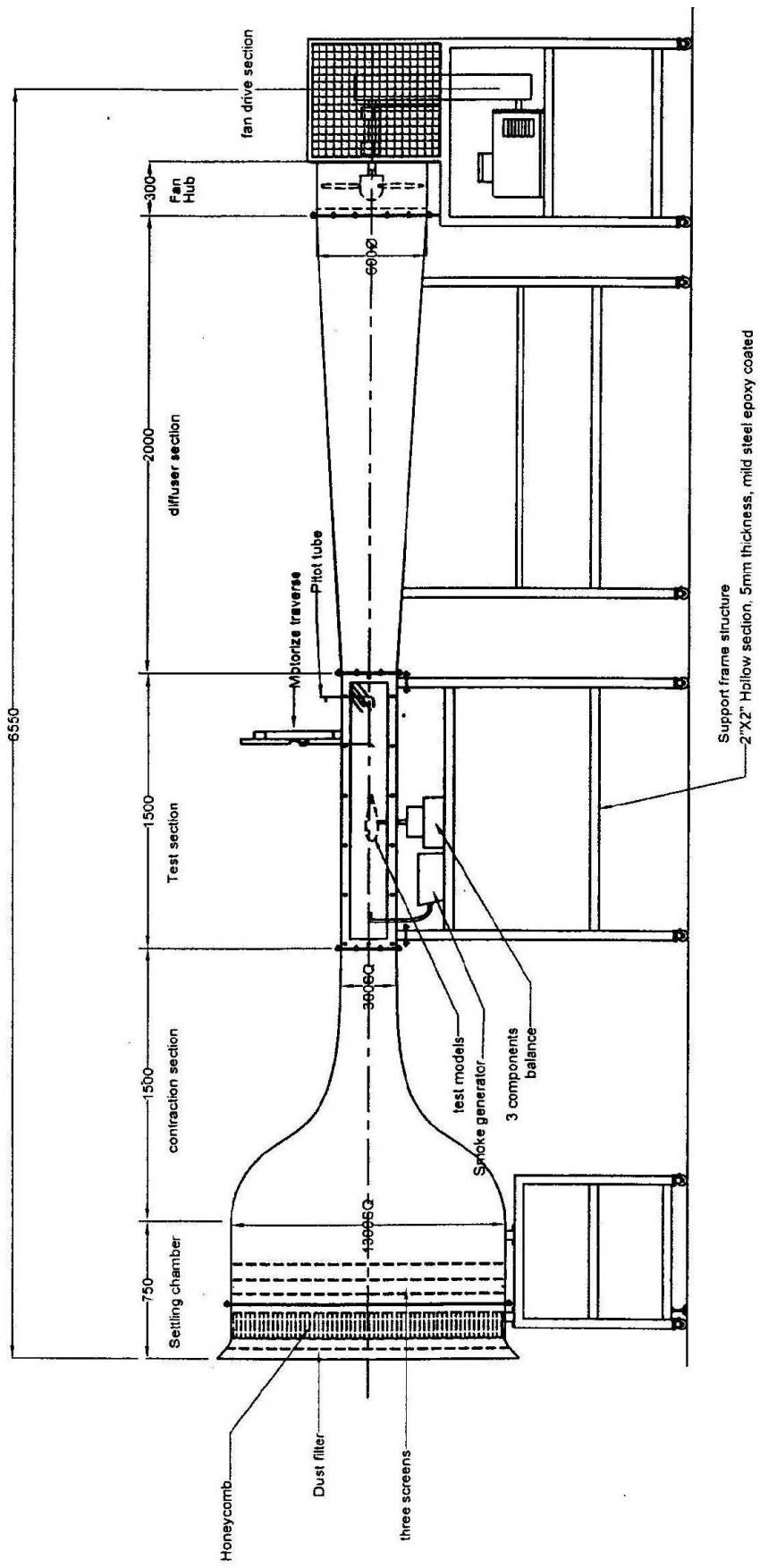
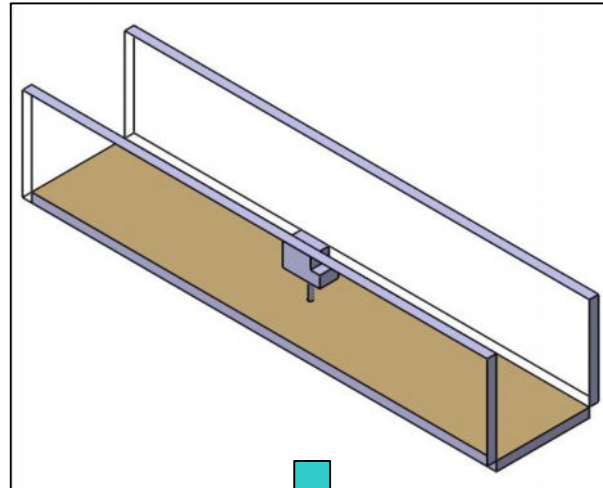
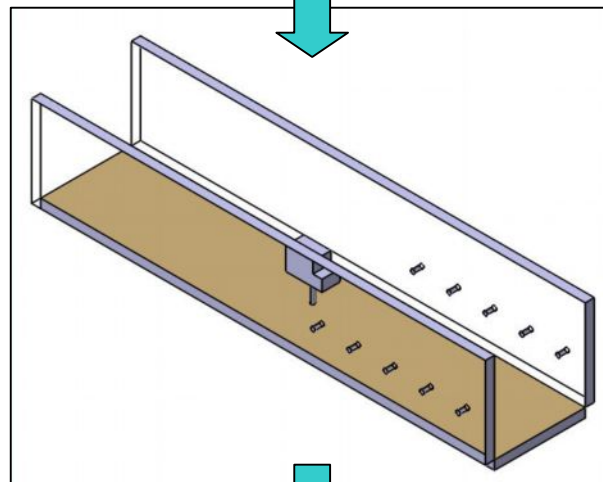


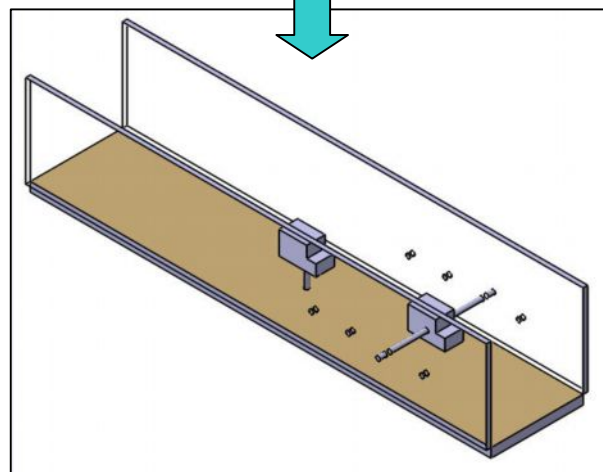
Figure 4: UTP WT04 Subsonic wind tunnel



a) Original setup of the wind tunnel.



b) Side replaced with drilled perspex.



c) The modified setup with model number two in front of the measured model.

Figure 5(a), (b) and (c): The setup for the testing is as follows. Both side of the wind test section is replaced with perspex with holes drilled to the side. A model will be supported using the hole and a rectangular bar, positioned in front of the measured model.

Because of the limitation on the size of the model as a result of a small test section, the windtunnel test will only be done in using two vehicles model in a **tailing position** (one model in the front and another model in the back). The other setups like the side-by-side position, or opposite direction position will be excluded from the project.

### 3.3 Documentation

For the fabrication of the wind tunnel panels, both sides have been detached and the detail dimensions of the panels are taken. Refer to the appendix from Figure 28-35 for the detail design of the wall panel. The new panels have to have the exact size and dimensions as the original panel. This is because the gap for the test section panel between the contraction section and the diffuser section is exactly fit to the panels. Plus, the wind tunnel does not have any symmetric property either left and right, or the front and the back. The placement of the bolts at the wind tunnel metal frame is somewhat random, as long as it holds the wall panels in place.

The wind tunnel test results are provided by the three way balance of the wind tunnel. It is displayed on the attached computer system, using software called GraphWorX32 by ICONICS. The readings given are for freestream velocity of the wind, drag force, lift force, velocity pressure and the fan speed.

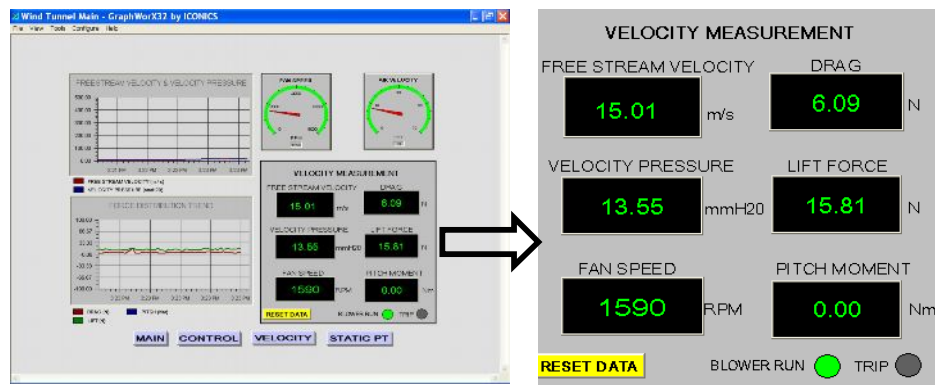


Figure 6: The result screen of the wind tunnel computer.

### 3.4 Testing

Several testing has been done using the wind tunnel equipments. This is rather important to get use to the setup and operation of the windtunnel. The first experiment is a test run using an available 1:40 scaled vintage truck model. The result is the drag and lift of the acting on the model. By plotting the drag and lift force against the wind velocity, a proportional relationship is observed. The result is in chapter 4.



Figure 7: A 1:40 Vintage truck model.

The next test is on an available 1:40 scaled sports car model. The relationship between the drag and lift force with the wind velocity is again observed. The next step is to calculate the Reynolds number, and then plotting it versus the drag. This step is to find the relationship of the flow that would be similar to the real situation. Further discussions are in chapter 4.



Figure 8: A 1:40 sports car model.

### 3.5 Size of the models

It is very important to determine the size of the model before completing the new wind tunnel walls. To determine the appropriate size, some calculations of dimensional analysis are used.

$$\text{Re}_{\text{prototype}} = \text{Re}_{\text{model}}$$
$$\left[ \frac{\rho V A_f}{\mu} \right]_{\text{prototype}} = \left[ \frac{\rho V A_f}{\mu} \right]_{\text{model}}$$

Where

- $\rho$  = density of air
- $V$  = freestream velocity of the air
- $A_f$  = frontal area of the prototype/model
- $C_D$  = drag coefficient
- $C_L$  = Lift Coefficient
- $F_D$  = drag force
- $F_L$  = lift force

For the test, the flowing fluid will be air. The density of the air remains constant as the temperature of the air is assumed to be constant. Therefore,  $\rho$  and  $\mu$  of both side are cancel out, thus the equation become

$$(V A_f)_{\text{prototype}} = (V A_f)_{\text{model}}$$

From here, by using a spreadsheet, and by manipulating the velocity and scale of the model in the wind tunnel, the velocity in the real situation can be calculated; keeping in mind:

- The maximum wind velocity is 60m/s. for safety reasons, the run will be limited to 50m/s
- The size of the wind tunnel's test section is 30x30cm frontal area. Therefore, the size of the wind tunnel must be as large as possible (to achieve higher velocity in real situation) and not blocking the flow field in the wind tunnel.