3.007 Design Thinking and Innovation
Subject Chosen for 2D Integration:
10.017 Technological World

By F01 Group 4: CommuThinkers

Keith Law Ger Kang (1008268),
Kiran Ratheesh Thekkedath (1007819),
Loh Shao Cong (1007770),
Nicholas Peck Jun Le (1007771),
Richard Calvin Yong (1008018),
Neo Yew Young* (1004900) *(*DTP II only)*

PLANE X PAVILION

Our DTI Problem Statement:

Our project aims to **transform our site**, which is the plane spotting site at Changi Business Park, into an **interactive aviation-themed attraction** for both **visitors on the ground** and **plane passengers in the sky** through **architecture and an interactive message display**.

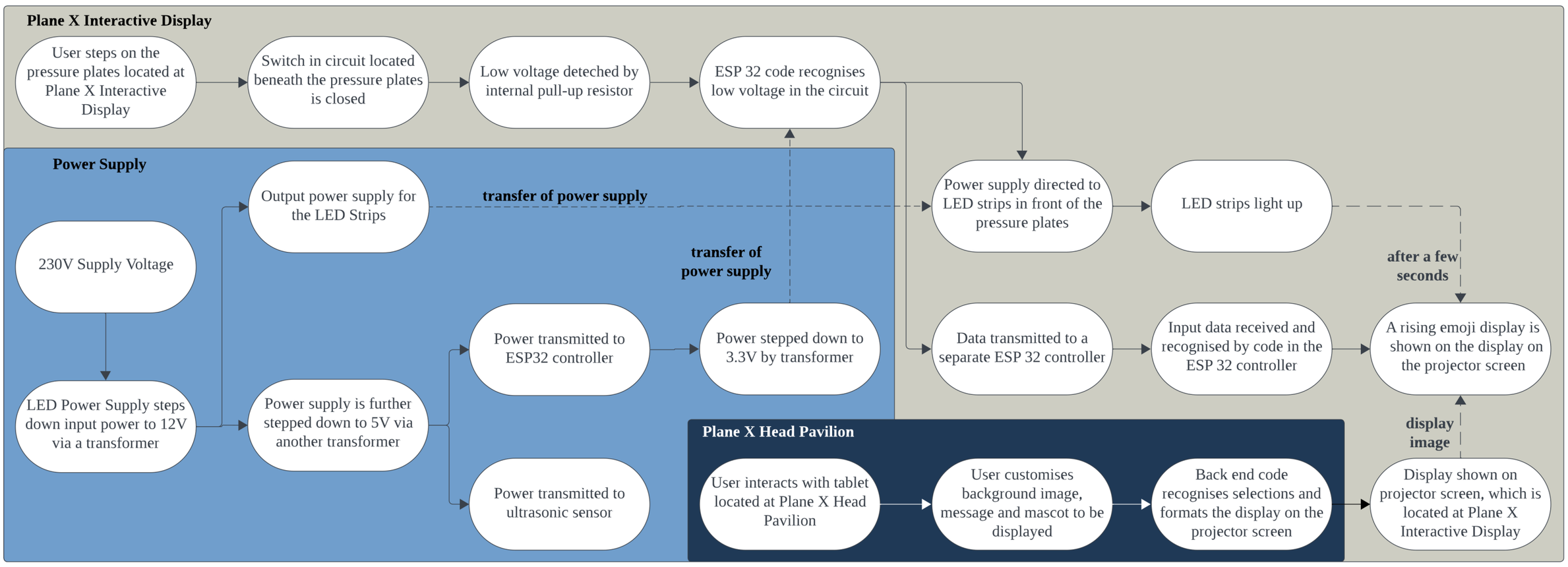
Our Design Ideas and Prototypes:

Our design idea, Plane X Pavilion consists of 4 key elements:
(1) Plane X Tail Pavilion, a tail shelter with an infinity mirror
(2) Plane X Wing Pavilion, a wing structure with a dome and rest areas
(3) Plane X Head Pavilion, an arch structure with terminals where visitors can customize their messages onto the interactive display
(4) Plane X Interactive Display, consisting of a projector screen, pressure plates for site visitors to interact on and LED light strips.

Area of Focus:

Upon closer inspection and analysis of our prototypes, we decided to focus on the functionality of **Plane X Interactive Display**. Given the hardware and software systems involved and the inter-dependence of these systems, this would be a good aspect of the project for the analysis of the technical areas.

Functional Block Diagram:



How the Components Work and Physics Concepts:

Component 1: Power supply sources that use step-down transformers to step down power input

A step-down transformer operates based on electromagnetic induction. It consists of two coils: the primary winding and the secondary winding. This component is seen in the power supply block and is used to manage the excess voltage sent to the ultrasonic sensor and ESP32 controller.

When the primary winding experiences an alternating current, it generates a fluctuating magnetic field in the iron core. This magnetic field induces a voltage in the secondary winding, but at a lower voltage level than the primary winding. This follows Faraday's Law, which states that the magnitude of voltage is directly proportional to the rate of change of magnetic flux.

Component 2: ESP32 microcontrollers that make use of electromagnetic waves to transmit data

The ESP32 Microcontrollers is run by a series of code inputs. The output of these code inputs would vary on the written code. These may include transmitting the data to another ESP32 controller via electromagnetic waves. This is seen in the display creation when the microcontroller sends the data received from the input panel to the display screen.

When the ESP32 controllers transmit and receive data, they make use of Wi-Fi and Bluetooth networks, that operate using radio waves. These waves are a form of electromagnetic radiation. The ESP32's radio module generates and receives these waves.

Experimental Area of Focus:

An important aspect that affects the functionality of our project is the intensity of light, as this directly impacts the user experience when a site visitor interacts with the pressure plates at Plane X Interactive Display. The LED strips located at the Display are programmed in a manner where the light would 'travel' to the projector screen. In this process, the LED lights emitted would form a 'tail' where the LED light would fade away over time. The length of this 'tail' would alter the light intensity values. The time taken for the light to travel from the pressure plate to the projector screen is fixed at 1 second, and we have gathered data from the LED strip in our functional prototype that contains 10 LED units.

Experimental Data:

Formula for light intensity at a certain distance away from light source:

$$Light\ Intensity\ \alpha \frac{1}{4\pi r^2}$$

where:
r: Distance from LED Strip

Length of 'tail' formed by LED Light Strip	I/lux	
	Measured at r = 5cm	Calculated when r = 25cm
2	360	72
3	480	96
4	600	120
5	720	144
6	840	168

Experiment Results:

Based on the experimental results obtained, the length of 'tail' formed by the LED Light Strip has a direct relationship withe light intensity observed by the site visitor. However, taking into account other metrics such as the optimal amount of light intensity required for the site, we opted to program the LED light strips such that the length of tail would be 4 LEDs.

As we would only require sufficient brightness for site visitors to get around, we aimed for a light intensity of about 100 lux*, which led us to the final decision on the length of the 'tail'

*https://www.thegreenage.co.uk/lux-much-light-need/

Prototype Evaluation:

Limitations:

Due to the scale of the functional prototype, the interaction with the prototype is not representative of its intended functionality when Plane X Interactive Display is to scale. This might translate to a different point of view of the visitor who is standing on the pressure plate in reality compared to the demonstration of pressing the 'pressure plate' by hand.

Also, since the larger setup will require multiple ESP32 modules communicating wirelessly, coupled with its low operating voltage of 3.3V which makes it suspectable to receiving more noise, its functionality might be affected in ways that we cannot verify until we obtain the larger prototype.

Improvements:

One way we can try to ensure the proper scaling of the installations is to measure the optimum angle range between the observer and the light setup and design measures to account for a similar visual presentation when scaled up. An example would be the length of and spacing between each life-sized LED strip.

Another improvement we can make would be to measure the signal strength between our ESP32 modules to check their range and work within its range and rate of decay