Senior Design
ENG EC 463 / 464

# Memo: Customer Installation Report

To: Professor Pisano

From: Team 11

Team: Aerobatics Blackbox

Date: 5/4/2023

Subject: Customer Installation Report

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## 1.0 Installation

### *1.1 – Time and Members*

- Date: 5/3/2023
- Time: 5 PM
- Members: Max, Eli, (Qi & Yanbo went to 1st trial on May 1st)
- Client: Kenn Sebesta

### *1.2 – System Overview*

The system components, including the IMU 6050, C102-F9R-0 GPS, Arduino Due, and SD Card Reader, were securely placed in a box located at the upper left side of the cockpit. The See3CAM_24CUG - AR0234CS Full HD Color Global Shutter Camera was also part of the setup. An LED, encircled by blue tape, signals when the Arduino records data. The GPS antenna and dashcam were affixed to the upper diagonal bar across the cockpit using Velcro straps and pipe clamps to minimize movement during flight. Due to time constraints, a laptop was employed to read GPS data. A video of the setup is available at: https://youtu.be/uJsigei-6As.

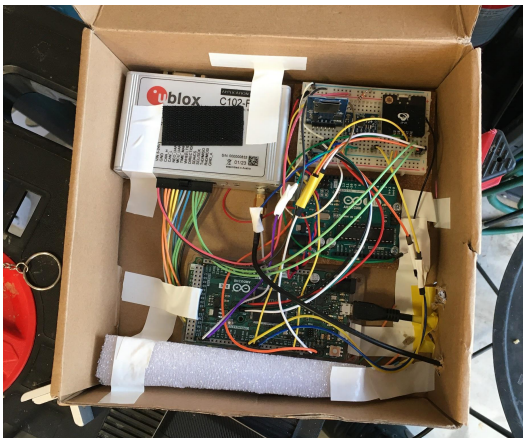

*Figure 1 - ((A) Box positioned in the cockpit, (B) Inside Box*

*Figure 2 - Devices on the upper bar: (middle-left) GPS antenna, (right) dashcam*

## 2.0 Testing

### *2.1 – Test Requirements and Outcomes*

| # | Requirement | Implementation | Status |
|---|---|---|---|
| 1 | Read & record meter values | 2 Convolutional Neural Networks | Partially Successful (more data & more fine-tuned parameters/architecture are needed) |
| 2 | Track Control Stick & Pedals | - - | Skipped for time |
| 3 | Record location (XYZ) data | GPS | Successful |
| 4 | Record acceleration | IMU: Accelerometer | Successful |
| 5 | Record orientation | IMU: Gyroscope | Successful |
| 6 | Run for multiple flights | Rechargeable Battery (USB) & Plane Power Rail | Successful |
| 7 | Visualize Data | Xplane | Partially Successful |

### *2.2 – Test Summary*

In the 2nd trial, the C102-F9R-0 GPS and IMU 6050 successfully gathered data during the last flight. The GPS was connected to a laptop and read data through the U-Center (U-Blox) application, while the IMU connected to the Arduino Due and stored data on an SD card. Ideally, both devices would record data on the SD card, but due to time constraints, separate devices were used.

The GPS data includes timestamps for each sample, while the IMU logs time every 5 seconds (since logging time extends sampling duration). The IMU data is recorded in standard units (m/s^2 & deg/sec), but the GPS data is in binary format, requiring conversion for Xplane use. However, U-Center allows exporting to KML files for Google Earth, enabling GPS data validation.

Regarding the CNN implementation, two pre-trained convolutional neural networks were employed to read and record meter values. However, due to the limited dataset, the results were not optimal, and further fine-tuning of the model's parameters and architecture is necessary. To supplement the real dataset, a Blender model was utilized to create an artificial dataset for training and validation purposes. This approach depends on the skillset of the team members and can be adjusted as needed.

On May 3rd (2nd trial), two flights were completed. During the first flight, the IMU experienced some errors, which were resolved before the 2nd flight. The See3CAM_24CUG - AR0234CS Full HD Color Global Shutter Camera operated during both flights but experienced intermittent outages, likely due to a weak connection to the airplane’s power rail.

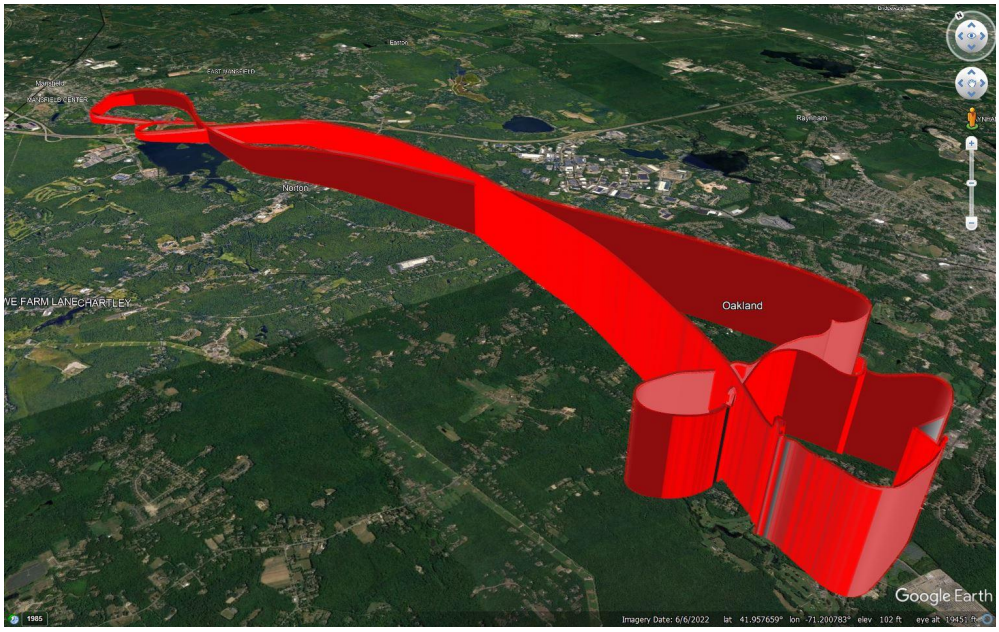


*Figure 3 - Flight #1 in Google Earth*


*Figure 4 - Screenshot from dashcam video during loop*

## 3.0 Assessment

### *3.1 – Future Recommendations*

After the 1st trial, the IMU 6050 successfully captured and stored data. However, GPS data was only recorded for the initial 10 seconds before disconnection. This issue may have been caused by unstable connections between the jumper wires and the breadboard. Additionally, the GPS sampling rate was set to once every 4 seconds, resulting in inconsistent data collection.

Before the 2nd trial, the issue was addressed. The IMU 6050 was configured to record independently of the C102-F9R-0 GPS at approximately 26Hz. The GPS sampling rate increased to 5Hz, but data storage on a laptop was still necessary. Although the binary format data worked well with Google Earth, it must be converted to appropriate engineering units to create an FDR file and open it in Xplane.

### *3.2 – Follow-up Plans*

Continuing from this year's progress, the next group should focus on improving dial detection and reading using machine learning. They can acquire more images from additional test flights and potentially gather a large group of volunteers to label the dataset using Matlab's Image Labeller or a similar program. The team could also consider developing their own network architecture rather than relying on transfer learning. Moreover, tracking the control stick should be incorporated into the project.

Blender may continue to be used for creating an artificial dataset, depending on the skillset of the team members. All processes, including dial detection and reading, converting IMU and GPS data to FDR files, and generating Xplane videos, should be streamlined and integrated into a single application. Additionally, it would be ideal for the IMU 6050, C102-F9R-0 GPS, and See3CAM_24CUG - AR0234CS Full HD Color Global Shutter Camera data to be sent to a single SD card, simplifying the process. Unlike the current group, the next team will have access to the equipment and code developed this year, providing a stronger foundation for further progress.