Enclosure, Air Quality, Target and Image Processing and Sampling Tube Integration Test Report

Project: UAVPAYG19 **WP Name:** ED & AQS & TAIP & ST Testing **WP Number:** WP-ED-AQS-TAIP-ST-02	**Type of Test:** Unit Test	
Test Article:	**Part Number:** N/A	**Serial Number:** N/A
System Requirements: REQ-M-08 REQ-M-09 REQ-M-12	**Test Equipment:** See "equipment used" section of each test	
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Test Summary

This test report aims to confirm if the TAIP processed imagery can be displayed on the LCD screen. In addition to this the functionality of the sampling tube activation stage will be tested. This is to be activated only if the UAV is below 700 mm altitude of a desired aruco marker. As a fail safe the sampling tube must also be operational through the command line interface. Overall all of these requirements were met.

Revision Record

Document Issue/Revision Status	Description of Change	Date	Approved
1.0	Initial Issue	28/10/22	M.B

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Definitions

Acronym	Definition
WVI	Web Visualisation and Interfaces
TAIP	Target Analysis and Image Processing
ST	Sampling Tube
AQS	Air Quality Sensor
UAV	Unmanned Aerial Vehicle
QUT	Queensland University of Technology
API	Application Programming Interface
PC	Personal Computer
Wi-Fi	Wireless Fidelity
GPS	Global Positioning System
LAN	Local Area Network
GUI	Graphical User Interface

1 Introduction

The team members of Group 19 have been appointed to research, design, plan and implement an Advance Sensor Payload (ASP) for Unmanned Aerial Vehicle (UAV) target detection and air quality monitoring in GPS denied environments. The group has committed to the specified budget whilst implementing the project requirements stated by the client. The team has also committed to meeting the deadline date specified by the client with a full functioning ASP that has been tested to ensure the client requirements have been met. This test report covers the integration tests completed between the AQS, TAIP and ST subsystems.

1.1 Scope

The scope of the project is to research, plan, design, implement and test the ASP for UAV target detection in GPS denied environments. This document contains the objectives of the test, the equipment used, in depth descriptions of the tests, results, an analysis of these results and a conclusion with recommendations. The purpose of this test document see if the test satisfies the state System Requirements/HLO's in RD-1

1.2 Background

The Queensland University of Technology's Airborne System Lab (ASL) has commissioned the group UAVPAYG19 to design and develop a payload capable in detecting specific objects, recording air quality data to be displayed on a web interface and to pierce a ground sample. This payload is to be attached to a S500 UAV which will complete an automated flight path. The payload is mounted on the bottom of the UAV using a provided bracket. This payload must contain all components to complete its required tasks. These components are:

- Raspberry Pi 3b+
- Raspberry Pi Camera
- Pimoroni Enviro+ sensor
- DF15RSMG 360 Degree Motor

The payload is required to identify three targets, a valve (In open or closed position), a fire extinguisher and an ArUCO marker. The Pimoroni sensor is to be used to record air temperature, pressure humidity, light and potentially hazardous gas level data. This data along with a live feed of the Raspberry Pi Camera is to be visualized on a Web Interface. Lastly a soil sample must be obtained using a sampling mechanism.

2 Reference Documents

2.1 QUT avionics Documents

RD/1	UA–System Requirements	UAVPayloadTAQ System Requirements
RD/2	UA –Customer Needs	Advanced Sensor Payload for UAV Target Detection and Air Quality Monitoring in GPS Denied Environments
RD/20	UAVPAYG-19-ED-TR-01	Enclosure Test Report
RD/21	UAVPAYG-19-AQS-TR-01	Air Quality Sensor Test Report
RD/22	UAVPAYG-19-ST-TR-01	Sampling Tube Test Report

2.2 Non-QUT Documents

3 Test Objectives

One hardware test is being carried out with the ST Subsystem to ensure that it can operate in conjunction with the Enclosure and passing data through the AQS Subsystem's Enviro+. This test will confirm that the ST Subsystem is ready to be further integrated with the WVI Subsystem.

Table 1: Integration Subsystem Requirements

Requirement Code	**Description**
REQ-M-08	The payload shall include a sampling tube design to collect a simulated soil sample. The payload system must protrude or push into the simulated soil. A mark must be left on the simulated soil (10mm deep, 10mm diameter hole), to ensure the sampling tube has made contact with the soil.
REQ-M-09	The payload shall activate the sampling tube mechanism to collect a simulated soil sample only after the UAV has landed on a designated Aruco marker. Once the soil is sampled the sampling tube must retract to its original position.
REQ-M-12	The LCD screen should display live feed of target detection as well as temperature readings from the Pi and the Enviro sensor board

4 Testing

The hardware test being carried out is to ensure that the ST Subsystem can operate in conjunction with the AQS Enviro+ and with the Enclosure Subsystem design. With software tests to confirm that imagery data can be displayed on the Enviro+ LCD screen was well as confirming that ranging to an aruco marker can toggle a button on the WVI.

4.1 Software Test

Two software tests were performed. Software test is to confirm if TAIP information is displayed to the LCD Screen. Software test two to test if the ArUCO marker was able to alert the web server that it was within the 700mm range. Before the sampling tube can be deployed.

4.1.1 Software Test 1: TAIP information is displayed live on the LCD screen

This test aimed to find if the target acquisition and image processing subsystem could display its data to the lcd screen.

Equipment used:

The equipment used in this test consists of the following:

- Raspberry Pi
- Camera
- LCD Screen
- Enviro+

Procedure:

1. First the raspberry pi was setup, with the LCD screen attached
2. Next the LCD testing script was navigated to and run on the pi
3. The LCD screen was then recorded while the camera was faced towards an image of an object on a laptop screen which the model needed to recognise

Results and Evidence:

The LCD screen could indeed show imagery data as it was being captured, with the test being of a fire extinguisher on the LCD screen which while being blue on the LCD could properly be picked up by the camera and displayed with included bounding box on the LCD screen.

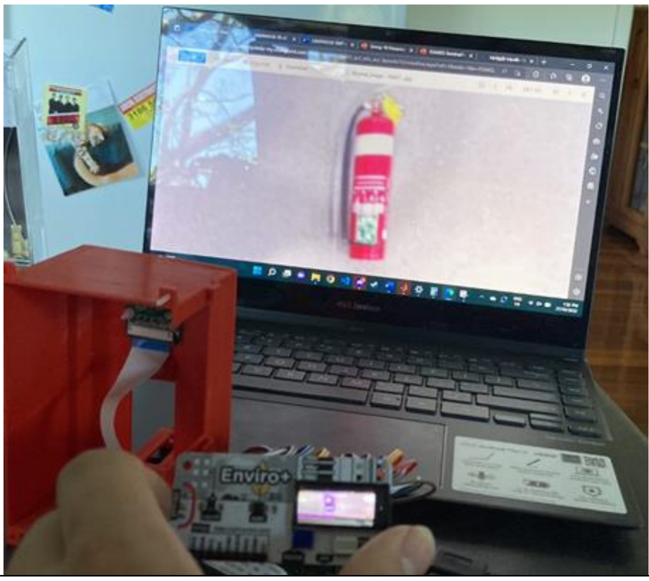
Enviro+ LCD Screen with Model running	Image of Test Setup
	

Figure 1 LCD screen test

Video Evidence of Validation Test: LCD Screen Image Detection on Enviro+

4.1.2 Software Test 2: Sampling tube Enabled within 700 mm of Target Aruco Marker

This test was performed to ensure that the web interface correctly enabled the sampling tube mechanism when distance to ArUCO marker with ID 45 was below 700mm, with the web interfaces button otherwise disabled to deploy the sampling tube.

Equipment used:
The equipment used in this test consists of the following:

- Raspberry Pi
- Camera
- Webserver
- Ground control station

Procedure:
Following is the procedure used to conduct the test:

1. First the raspberry pi and webserver were set up, with the camera attached to the pi
2. Next the ground control station was set up
3. Then on the raspberry pi the main script was executed
4. Then the screen of the ground control station was recorded as the raspberry pi camera was moved around and the camera was faced towards a ArUCO marker on a laptop screen playing a test video to check distance values as well as if the deploy button appeared when it was close enough to the marker.

Code:
The code that was used for this test was the main IntegrationV2.py code of the program.

Results and Evidence:
Running the test it was found that the deploy button did correctly become pressable when on the screen when the camera was close enough to the ArUCO marker, along with this is was able to be enabled and diabled by moving the Aruco Marker forwards and backwards from the camera. On button press this would then begin to extend the sampling tube. This is displayed in figure 2.

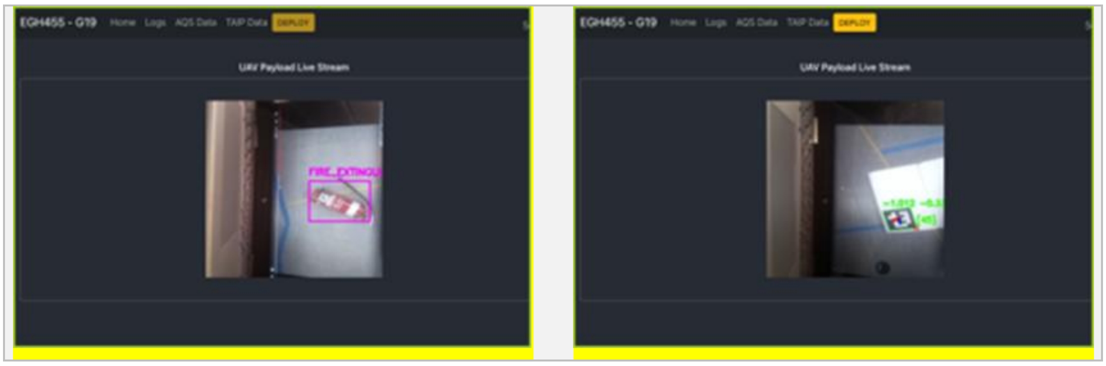


Figure 2 Deploy Button Web interface (Left: Out of range, Right: In range)

4.2 Hardware Tests

4.2.1 Hardware Test 1: Sampling tube operational from command line

The following hardware test will check the designed sampling tube's ability to extend and retract as per REQ-M-09 while connected through the Enclosure Subsystem. All parts of the sampling tube design will be assembled prior to this test and controlled by the Raspberry Pi.

Equipment Used:

The equipment used in this test consists of the following:

- Assembled Sampling Tube Subsystem
- Assembled Enclosure Subsystem
- 5V Regulator Adaptor Testing Unit
- 4x M2 bolts & nuts
- Computer
- Enviro+

Procedure:

1. Attach assembled ST Subsystem to the Enclosure Subsystem using the 4x nuts & bolts
2. Connect DF15RSMG 360 Degree Motor from ST Subsystem to the 5V Regulator Adapter
3. Connect 5V Regulator Adapter to GND and Pin #4 on the Enviro+
4. Connect Computer to the Raspberry Pi via SSH
5. Run test code with value larger than the nominal value, but within the range value to extend the cutting tool approximately 12mm. Record any issues.
6. Run test code with value smaller than the nominal value, but within the range value to retract the cutting tool approximately 12mm. Record any issues.

Code:

```
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
GPIO.setup(4, GPIO.OUT, initial=False)
p = GPIO.PWM(4,50)

# speed% = (<time_ns>-1.5)*100
# speed setting: <time_ns>/((1/50)*1000*1000)*100
# min value: 2 = Reverse/Up (max speed) -> 6.5
# max value: 12 = Forward/Down (max speed) -> 7.5
NOMINAL=7 # the 'zero' PWM %age
RANGE=5   # maximum variation above/below NOMINAL

p.start(7)

print("start")
#p.ChangeDutyCycle(5)
#time.sleep(5)
for x in range(18):
    p.ChangeDutyCycle(NOMINAL+5)
    time.sleep(1)
    p.ChangeDutyCycle(NOMINAL-1)
    time.sleep(0.25)
    p.ChangeDutyCycle(NOMINAL)
    time.sleep(0.25)

print("done")
p.ChangeDutyCycle(NOMINAL)
time.sleep(0.1)
GPIO.cleanup()
```

Figure 3 – Code used for command line activation.

Results and Evidence:

Via console, connected Pi within the enclosure was able to extend and retract the cutting tool approximately 12mm. The following two images were sourced from the two videos for the third test of this section containing the extension and retraction of the mechanism. Figure 4 shows it starting at 4.8mm, Figure 5 showing it extended at 6mm, and Figure 6 showing it finishing at 4.7mm.

Extending: https://youtu.be/xwcjZVV0yHs,
Retracting: https://youtu.be/AZXkdM1-_50.

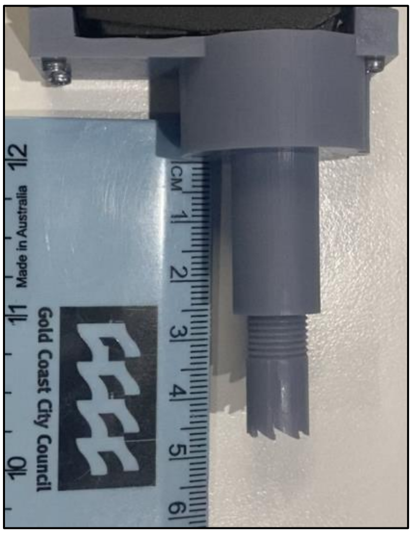


Figure 4 – ST Starting position.

Figure 5 – ST Extension.

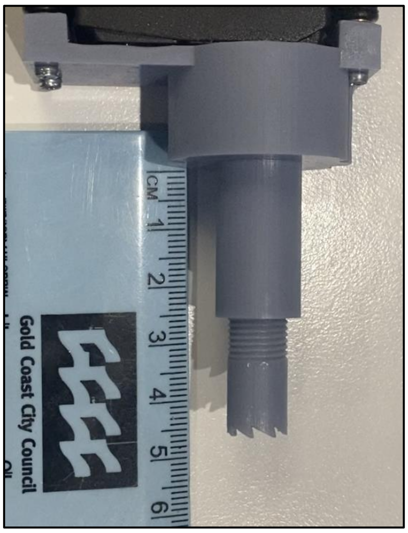
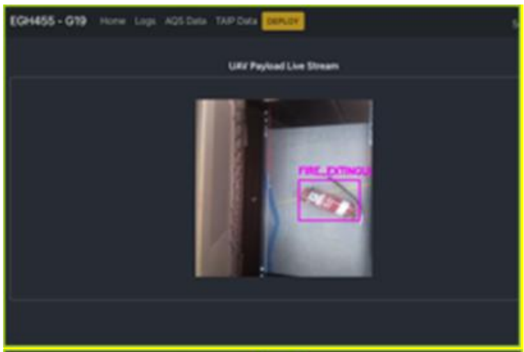
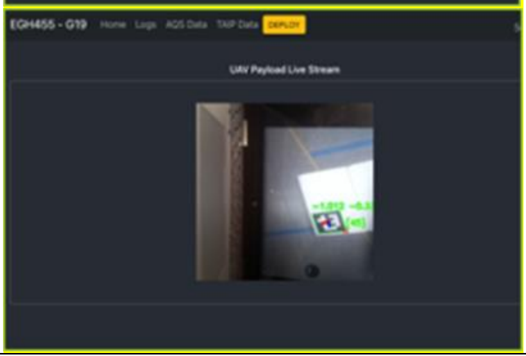
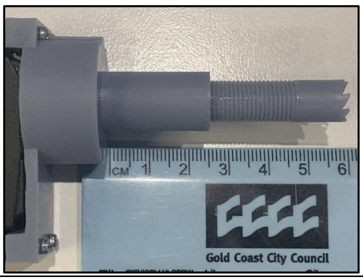


Figure 6 – ST Retraction.

5 Results

Table 2 shows the results of all the tests that were completed. All tests successfully completed.

Table 2: Results from tests

Test Title	Result	IMG	Requirement Met
Software test 1	Passed		REQ-M-12
Software test 2	Passed		REQ-M-08
Hardware test 1	Passed		REQ-M-09

6 Analysis

The analysis section will discuss if the aims of the test have been achieved and were there any issues involved with this.

6.1 Software Analysis

6.1.1 Software Test 1: TAIP information is displayed live on the LCD screen

The software analysis was a success as it was able to show that the LCD screen could show live data from the TAIP system. However, in testing the red and blue colour channels were flipped thus making the fire extinguisher show up as blue. With the floor having a red hue. This was not an issue for the detection model as this is only the display. This could be fixed programmatically, however, due to it not effecting any requirements this was left as a part of the system.

6.1.2 Software Test 2: Sampling tube Enabled within 700 mm of Target Aruco Marker

Software test 2 passed as well with the web page being able to detect the distance of the ArUCO marker, only displaying the deploy button when it was within range. Once pressed the sampling tube was successfully deployed. With this part of the integration working well without issue.

6.2 Hardware Analysis

6.2.1 Hardware Test 1: Sampling tube operational from command line

The hardware test was a success. Using WD-40 as identified in the individual testing and making a software alteration to relieve stress in the drive shaft. This allowed for a successful completion of the motor extending and retracting the cutting tool to the specified length of approximately 12mm.

7 Conclusions and Recommendations

This integration test report can conclude that all requirements that were aimed to be completed was done so all 100% successfully. The expectation for this was hardware test 1 were where the ST subsystem requires a manual activation of the sampling mechanism to activate. This is due to REQ-M-08 stating that the payload is to activate when the UAV lands. There are no further recommendations as the tests that was created that completed what they aimed to do.

Table 3: Requirements Met

Requirement Code	Description	Requirement Met
REQ-M-08	The payload shall include a sampling tube design to collect a simulated soil sample. The payload system must protrude or push into the simulated soil. A mark must be left on the simulated soil (10mm deep, 10mm diameter hole), to ensure the sampling tube has made contact with the soil.	**Met: -** Software test 2 and Hardware Test 1 meets this requirement
REQ-M-09	The payload shall activate the sampling tube mechanism to collect a simulated soil sample only after the UAV has landed on a designated Aruco marker. Once the soil is sampled the sampling tube must retract to its original position.	**Partially Met:** – Hardware test 1 meets this requirement but requires the WVI Subsystem to confirm the deployment once the Aruco marker has been identified.
REQ-M-12	The LCD screen should display live feed of target detection as well as temperature readings from the Pi and the Enviro sensor board.	**Met: -** Software test 1 meets this requirement