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

Project: UAVPAYG19 **WP Name:** Final Testing **WP Number:** WP-TAIP-WVI-ST-AQS-ED-02	**Type of Test:** Unit Test	
Test Article:	**Part Number:** **N/A**	**Serial Number:** **N/A**
System Requirements: REQ-M-08 REQ-M-01	**Test Equipment:** See "equipment used" section of each test	
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Test Summary

The tests performed within this integration report is involved all subsystems of this project. This being ED, AQS, ST, TAIP and WVI. This was the final integration report to be completed before the acceptance test. There were one software test and 3 hardware tests and these tests involved the sampling tube activation and functionality and the total weight of the payload. All these tests resulted in a success

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Definitions

AQS	Air Quality Sensor
TAIP	Target Acquisition and Image Processing
ED	Enclosure Design
ST	Sampling Tube
WVI	Web Visualization and Interface
QUT	Queensland University of Technology
GPS	Global Positioning System
ASP	Advance Sensor Payload
UAV	Unmanned Aerial Vehicle

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 Integration test report covers the integration tests between the ED, AQS, TAIP, WVI 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
RD/23	UAVPAYG-19-TAIP-TR-01	Target Acquisition and Image Processing Test Report
RD/24	UAVPAYG-19-WVI-TR-02	Web Vision Interface Test Report
RD/25	UAVPAYG-19-AQS-TAIP-WVI-TR-01	Air Quality Sensor, Target Acquisition and Image Processing, Web Vision Interface Integration Report
RD/26	UAVPAYG-19-ED-AQS-TAIP-ST-TR-01	Enclosure, Air Quality Sensor, Target Acquisition and Image Processing, Sampling Tube Test Report

2.2 Non-QUT Documents

3 Test Objectives

The purpose of the tests within this report was to satisfy the requirements listed in Table 1. These tests aim to be able to complete a soil sample which mounted off or on the UAV and to ensure the entire payload weighed under the maximum 320g.

Table 1: Integration Subsystem Requirements

Requirement Code	Description
REQ-M-01	The UAVPayloadTAQ shall remain under the maximum weight of 320 g and comply with an IP41 rating. The air quality sensors must be exposed to the environment to allow for accurate reading.
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.

4 Testing

The two hardware tests being carried out is to ensure that the ST Subsystem can operate in conjunction with all the other integrated Subsystems. The first is to test if the ST Subsystem still meets the requirements that were confirmed in RD/26, while the second test confirms that the WVI Subsystem has been integrated correctly.

4.1 Software Test

The main software tests that were performed regarding the TAIP, WVI and ST subsystems were performed to test the sampling tubes activation and deployment with the deployment button dependent on the proximity to an ArUCO marker, which once pressed would begin to deploy the sampling tube.

4.1.1 Software Test 1: Web Interface Enabling sampling tube mechanism when within distance

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:

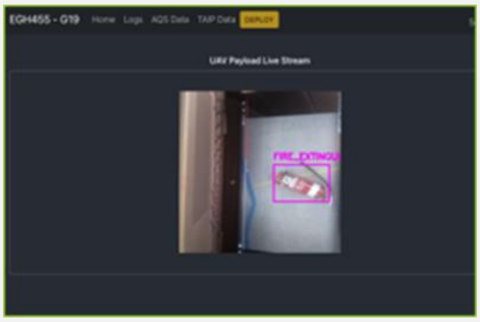
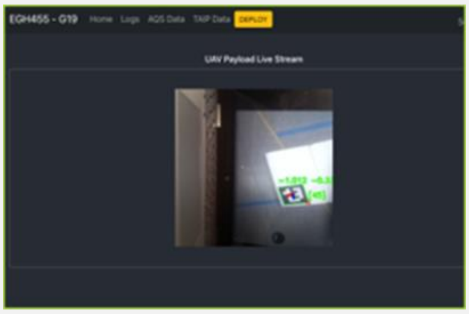
1. First the raspberry pi and webserver were set up, with the camera attached to the pi
2. Next the ground control station was set up
3. Then on the raspberry pi the main script was executed
4. Then the screen of the ground control station was recorded as the raspberry pi camera was moved around and 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 G19-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.

Outside 700mm of Aruco Marker with Id 45	**Within 700mm of Aruco Marker with Id 45**
	

4.2 Hardware Tests

The main hardware tests that were performed to test the sampling tubes activation and deployment with the deployment button dependent on the proximity to an ArUCO marker, which once pressed would begin to deploy the sampling tube. Additionally, the total weight of the System was measured.

4.2.1 Hardware Test 1: Sampling tube leaving mark in Styrofoam (Not mounted)

The following test is to ensure that the ST Subsystem still operates when connect to the Raspberry Pi through the Enviro+ and into the enclosure. It will ensure that the sampling tube is able to meet REQ-M-08 by testing that it is capable of cutting into expanded polystyrene.

Equipment Used:

The equipment used in this test consists of the following:
- 3D Printed Sampling Tube Drive Shaft
- 3D Printed Sampling Tube Casing
- 3D Printed Sampling Tube Cutting Tool
- Raspberry Pi with Power Adapter
- 5V Regulator Adaptor Testing Unit
- Nylon motor output mount
- 1x provided motor output screw
- 4x provided M2 screws
- 4x M2 bolts & nuts
- DF15RSMG 360 Degree Motor
- Computer
- Wi-Fi Access Point
- Expanded Polystyrene piece
- Enviro+

Procedure:

1. Clean 3D printed pieces to remove any plastic build-up
2. Place and rotate the cutting tool into the end of the casing
3. Place and screw the nylon motor output mount onto the servo motor
4. Screw the drive shaft into the nylon motor output mount
5. Place the casing onto the drive shaft so that it fits within the casing, rotating the cutting tool as needed to align the hexagonal drive shaft
6. Using the M2 nuts & bolts, secure the sampling tube enclosure onto the servo motor
7. Connect power to Pi
8. Connect power to 5V Regulator Adaptor Testing Unit
9. Connect Servo Motor to 5V Regulator Adaptor Testing Unit
10. Connect 5V Regulator Adaptor Testing Unit to Enviro+ on pin #4
11. Ensure Enviro+ is connected to the Pi
12. Connect Pi and Computer to Wi-Fi
13. Connect Computer to the Raspberry Pi via SSH
14. Place and hold piece of expanded polystyrene 1-2mm away from the cutting tool and ensuring the motor is also secured in position
15. Run the test code to extend and retract the sampling tube, recording 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 1 – Code V2 used to conduct test.

Results and Evidence:

The final subsystem test for the ST subsystem has been deemed a success. The expanded polystyrene was successfully cut, with the cutting tool also retracting to its original position. A full video can be seen at https://youtu.be/DTUREn0UTus, with Figure 2 showing the width and Figure 3 showing the depth hole cut into the expanded polystyrene. The hole created meets the 10mm wide by 10mm deep hole requirement as the expanded polystyrene tends to grab as the balls can be up to 3mm wide, making the simulated soil not an ideal medium to test in.

Figure 2 – Width of cut hole.

Figure 3 – Depth of cut hole.

4.2.2 Hardware Test 2: Sampling tube leaving mark in Styrofoam (Mounted on drone)

The following test is to ensure that the ST Subsystem still operates when connect to the Raspberry Pi through the Enviro+ and into the enclosure after being initiated by the web-view interface. It will ensure that the sampling tube is able to meet REQ-M-08 by testing that it is capable of cutting into expanded polystyrene.

Equipment Used:

The equipment used in this test consists of the following:

- 3D Printed Sampling Tube Drive Shaft
- 3D Printed Sampling Tube Casing
- 3D Printed Sampling Tube Cutting Tool
- Raspberry Pi with Power Adapter
- 5V Regulator Adaptor Testing Unit
- Nylon motor output mount
- 1x provided motor output screw
- 4x provided M2 screws
- 4x M2 bolts & nuts
- DF15RSMG 360 Degree Motor
- Computer
- Wi-Fi Access Point
- Expanded Polystyrene piece
- Enviro+
- ED Subsystem
- WVI Subsystem
- TAIP Subsystem

Procedure:

1. Using the M2 nuts & bolts, secure the previously assembled sampling tube to the enclosure subsystem
2. Connect power to Pi
3. Connect power to 5V Regulator Adaptor Testing Unit
4. Connect Servo Motor to 5V Regulator Adaptor Testing Unit
5. Connect 5V Regulator Adaptor Testing Unit to Enviro+ on pin #4
6. Ensure Enviro+ is connected to the Pi
7. Connect Pi and Computer to Wi-Fi
8. Connect Computer to the Raspberry Pi via SSH
9. Place and hold piece of expanded polystyrene 1-2mm away from the cutting tool and ensuring the motor is also secured in position
10. Run the test code to extend and retract the sampling tube, recording any issues.

Code:

```python
import RPi.GPIO as GPIO
import time


# 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
MODIFIER=3# the value to change by, must be smaller than RANGE
#TIME=5    # time in seconds to keep motor on
CYCLES=18 # number of cycles to perform

class servo:
    def __init__(self):
        self.p = None


    def start(self):
        GPIO.setmode(GPIO.BCM)
        GPIO.setup(4, GPIO.OUT, initial=False)
        self.p = GPIO.PWM(4,50)
        self.p.start(NOMINAL)

    # 0 = off, 1 = down, -1 = up
    def motor_change(self, mode):
        p = self.p
        if mode > 0:
            # Extend tube down
            #p.ChangeDutyCycle(NOMINAL+MODIFIER)
            #time.sleep(TIME)
            for x in range(CYCLES):
                p.ChangeDutyCycle(NOMINAL+5)
                time.sleep(1)
                p.ChangeDutyCycle(NOMINAL-1)
                time.sleep(0.25)
                p.ChangeDutyCycle(NOMINAL)
                time.sleep(0.25)
        elif mode < 0:
            # Bring tube up
            #p.ChangeDutyCycle(NOMINAL-MODIFIER)
            #time.sleep(TIME)
            for x in range(CYCLES):
                p.ChangeDutyCycle(NOMINAL-5)
                time.sleep(1)
                p.ChangeDutyCycle(NOMINAL+1)
                time.sleep(0.25)
                p.ChangeDutyCycle(NOMINAL)
                time.sleep(0.25)
        p.ChangeDutyCycle(NOMINAL)

    def cleanUp(self):
        GPIO.cleanup()
```

Figure 4 – Code used to operate sampling tube.

Results and Evidence:

The final functional integration test for the ST subsystem has been deemed a success. The expanded polystyrene was successfully cut, with the cutting tool also retracting to its original position. A full video can be seen at https://youtu.be/98DXXmkbLoI, with Figure 5 showing the sampling tube extended into the simulated soil, and Figure 6 showing it retracted.

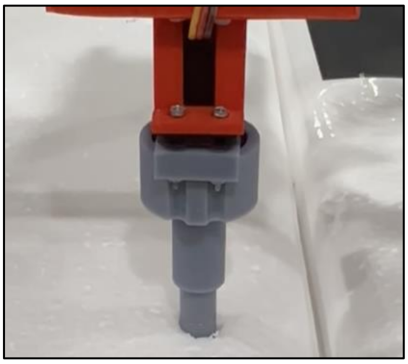


Figure 5 – ST Extended into simulated soil

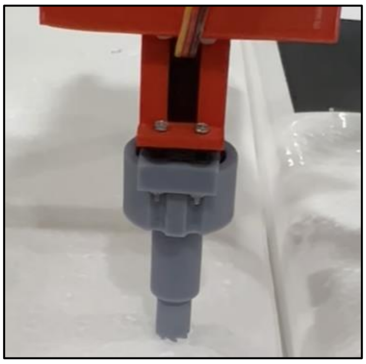


Figure 6 – ST Retracted from simulated soil.

4.2.3 Hardware Test 3: Weighting Payload

The purpose of this hardware test is to confirm that the payload weights under the maximum 320g. This is stated within the System Requirement document RD/2.

Equipment Used:

The equipment used in this test consists of the following:

- Raspberry Pi
- Enclosure
- Raspberry Pi Camera
- Enviro+
- Jumper leads
- Motor
- Motor leg mounts
- Sampling Tube components
- Nuts & Bolts
- Scale

Procedure:

1. Attach the Raspberry to the Enclosure plate using M3 bolts
2. Attach the Raspberry Pi camera to the Enclosure body using M2 bolts
3. Attach the motor leg mounts into the Enclosure body using M2 bolts
4. Attach the Sample tube components and motor into the motor leg mounts
5. Connect the wires from the Raspberry Pi to Enviro+
6. Slot the Enviro+ into the Enclosure
7. Attach the enclosure lid into the Enclosure with bolts
8. Turn on and tar the Scale
9. Place the payload on the scale and record the reading

Results and Evidence:

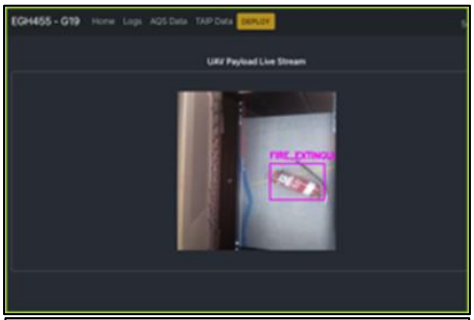
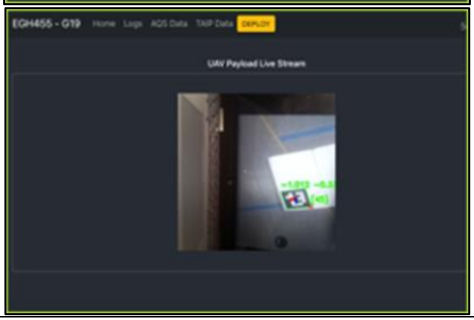
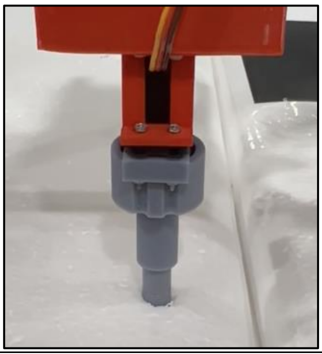
The result of this test was that the payload weighted a total of 240g which is 80g under the maximum limit of 320g. Therefore, this test resulted in success. Figure 7 displays the recorded weight.

Figure 7: Weight of entire Payload

5 Results

Error! Reference source not found. shows the results of all the tests that were completed. All tests s uccessfully completed.

Table 2: Results from tests

Test Title	Result	IMG	Requirement Met
Software Test 1	Success	 	REQ-M-08
Hardware Test 1	Success		REQ-M-08
Hardware Test 2	Success		REQ-M-08

Hardware Test 3	Success		REQ-M-01

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: Web Interface Enabling sampling tube mechanism when within distance

The Web Interface enabling sampling tube test showed that the ST subsystem deployment button on the Web Interface became available when the payload was within 700mm of Aruco Marker with Id 45. The test showed that the deployment system was disabled whilst outside the 700mm range of the Aruco marker. The test was successful, and no further changes were needed.

6.2 Hardware Analysis

6.2.1 Hardware Test 1: Sampling tube leaving mark in Styrofoam (Not mounted)

The unmounted cut test aimed to show that the designed sampling tube could cut into the simulated soil. Despite the testing conditions being suboptimal, it was able to cut through and take a sufficiently sized sample 11.5mm wide and 10.6mm deep. Although this sample is slightly oversized, the cause is due to expanded polystyrene being up to 3mm wide, so that cutting tool can take chunks out of the wall.

6.2.2 Hardware Test 2: Sampling tube leaving mark in Styrofoam (Mounted on drone)

The mounted cut test that was activated by WVI Subsystem after being detected within 700mm of the Aruco marker by the TAIP Subsystem. The material was successfully cut.

6.2.3 Hardware Test 3: Weighting Payload

This test was requirement so that the drone used can safety lift the payload. As stated in the Testing section of this report, the Payload with all its components weight a total of 240g. This is much under the maximum weight, there no further changes were required to be made.

7 Conclusions and Recommendations

REQ-M-08 and REQ-M-09 have been successfully tested and deemed fully operational within this integration test report. This is displayed in Table 3. As these tests had no issues when completing them there were no further recommendation required.

Table 3: Requirements Met

Requirement Code	**Description**	**Requirement Met**
REQ-M-01	The UAVPayloadTAQ shall remain under the maximum weight of 320 g and comply with an IP41 rating. The air quality sensors must be exposed to the environment to allow for accurate reading.	**Met: -** Hardware Test 3 confirms this requirement
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: -** Hardware test 1 & 2 were a combined test with the TAIP & WVI Subsystems to deploy the ST Subsystem when the UAV was within 700mm of the marker. The ST Subsystem was able to successfully make a 10mm wide by 10mm deep hole.
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.	**Met:** – Hardware test 1 & 2 were a combined test with the TAIP & WVI Subsystems to deploy the ST Subsystem when the UAV was within 700mm of the marker. The ST Subsystem could extend and retract to the original position.