Quadcopter Docking On A Moving Platform

Test Plan

Team E – Dock-In-Piece

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Introduction

This document lays out the progress that team Dock-In-Piece expects to make over the course of the semester, the times at which key subsystem milestones are to be achieved, and how each capability will be tested and shown to function as designed.

Part one(Logistics) contains a list of test equipment and personnel, as well as locations in which testing will occur. These items will be common to two or more unit, subsystem, or full system tests.

Part two(Schedule) lays out the capability milestones, along with the requirements the capability satisfies. Unless otherwise indicated in another portion of this document, any subsystem or capability tested as a milestone may be considered complete and under a configuration freeze for the remainder of the development cycle.

Part three(Tests) describes each test called out in **part two** under the capability milestone support heading**.** Test descriptions are comprised of the objective (component or final test), what level of indenture (single capability, subsystem, full system), location, test apparatus specific to that single test (when applicable), how the test will be administered, and the metric used to measure a successful test.

Logistics

Most tests will contain a common set of test apparatus (personnel, equipment, and location). Please refer to table 1 for a full listing of common test apparatus and which tests will require the personnel, equipment, or location. Test apparatus will also often be configured in much the same way in each test they are involved with. The 'configuration' category refers to a common configuration, diagrammed in Appendix A.

Table 1 – Common Test Apparatus

Apparatus	Type	Test
Matrice 100 Quadcopter	Equipment	1, 2, 7, 12, 13 15, 17, 19, 18, 20, 21, 22, 23, 24, SVE
Wooden Launch Pad	Equipment	1, 2, 7, 12, 13 15, 17, 19, 18, 20, 21, 22, 23, 24, SVE
Blast Shield	Equipment	1, 2, 7, 12, 13 15, 17, 19, 18, 20, 21, 22, 23, 24, SVE
Monocular Camera	Equipment	10, 13, 16, 17, 19
Palantir Laptop	Equipment	6, 7, 8, 9, 10, 13, 14, 16, 18, 21, 22, 23, 24, SVE
Dock / Platform	Equipment	8, 9, 10, 11, 13, 14, 16, 17, 19, 18, 20, 21, 22, 23, 24, SVE
Nicadrone Electropermanent Magnet	Equipment	3, 11, 15, 20, 21, 23, 24, SVE
Aishanou	Personnel	2, 7, 16, 18
Roy	Personnel	1, 2, 9, 10, 14, 17, 18, 22
Paul	Personnel	3, 5, 11, 12, 15, 20
Keerthana	Personnel	4, 8, 10, 12, 13, 17, 19, 22
Rushat	Personnel	3, 9, 11, 14, 15, 16, 18, 19, 20, 22
NSH B-level Hall	Location	1, 2, 12
NSH MRSD Lab Third Room	Location	3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, SVE
NSH MRSD Lab Team E Bench	Location	4, 5, 6
Test Setup A1	Configuration	13, 17, 19, 20, 21, 23, 24, SVE
Test Setup A2	Configuration	8, 9, 10, 16, 18
Test Setup A3	Configuration	13, 17, 19, 20, 21, 22, 23, 24, SVE
Test Setup A4	Configuration	TBD

Schedule

We anticipate all major capabilities will be completed by the first of March, leaving over a month to integrate in preparation for SVE. Our three main project milestones before SVE will be the quadcopter docking on a stationary platform on the 20th of February, the Palantir communicating accurate prediction data to the quadcopter on the 29th of February, and docking on a moving platform on the 15th of March two of these fall within the same PR because of Spring Break. Please refer to table 2 for a full listing of our tests, milestones, and what capabilities they capture.

Test ID	Date	Major Capability	Test	Requirement
PR 7	29JAN	Preliminary Palantir Functionality – Fitting and Communication	Tests 1-7	
PR 8	10FEB	Quadcopter maintains hover point in XY Plane	Tests 8, 9, 12, 16, 17	F2.1, MP2.1
PR 9	24FEB	Quadcopter Docks on Stationary Platform	Tests 10, 11, 13, 14, 15, 20, 21	F1.2, F2.3, MP1.4, MP2.3
PR 10	16MAR	Quadcopter Docks on a Moving Platform	Tests 18, 19, 22, 23	F2.4
PR 11	30MAR	All dock motions produce correct outputs – Docks or refuses to dock	Test 24	F2
PR 12	11APR	Quadcopter lands within time limits and with 80% success rate	SVE rehearsal	MP2.3
SVE	20APR	All requirements met	SVE	ALL

Tests

Each milestone is supported by several unit tests which show limited functionality which combines into larger capabilities. Tests are numbered sequentially based on when they occur, and are also assigned a higher capability and subsystem. All tests will occur in one of three locations mentioned in the logistics section and will be tested by their lead developer; please see Table 1 for more information. Common equipment is also reserved for Table 1.

Test 1

Objective	Quadcopter moves from starting location to designated end location
Element / Higher Level Item	Quadcopter Stabilization
Specific Equipment	None
Procedure	From a stable hover point: send autonomous movement command to quadcopter
Verification Criteria	Quadcopter moves in direction specified by the program and lands on the expected landing point
Result	Success

Test 2

Objective	Quadcopter recognizes obstacles and takes appropriate action
Element / Higher Level Item	Quadcopter Stabilization
Specific Equipment	None
Procedure	From a stable hover point: send autonomous movement command to quadcopter, place obstacle near quadcopter, wait, remove obstacle
Verification Criteria	Quadcopter does not move while obstacle is present, then takes the actions specified in Test 1 when obstacle is removed.
Result	Success

Test 3

Objective	Nicadrone acceptance and verification
Element / Higher Level Item	Docking Apparatus
Specific Equipment	Scale, weights
Procedure	Place Nicadrone on weights ,activate Nicadrone, lift. Activate Nicadrone, place on weights, lift
Verification Criteria	Nicadrone able to lift 5kg of weight, scale reads 5kg at start of each test, and 0kg at end
Result	Part 1 success, part 2 required two Nicadrones
Further action	Modify docking procedure to activate Nicadrone

	when in contact or otherwise mitigate lack of Nicadrone force when Nicadrone is active prior to contact with docking face

Test 4

Objective	IR Sensor Acceptance Test
Element / Higher Level Item	Dock Motion
Specific Equipment	IR Sensor to be integrated with dock, paper
Procedure	Run program to visualize outputs, move paper to predetermined locations and check distances
Verification Criteria	IR Sensor outputs correct distance from paper
Result	IR Sensor output correct data

Test 5

Objective	Dock Motor Error Reduction
Element / Higher Level Item	Dock Motion
Specific Equipment	Laser Tachometer, Motor detached from Dock
Procedure	Run modified SVE dock motion code while monitoring the rpm of the motor with tachometer
Verification Criteria	Motor runs at equivalent of 0.3Hz if attached to dock with minimal error
Result	Motor ran equivalent with 10% error at highest rate
Further action	Further modification to dock motion code to optimize for speed

Test 6

Objective	Palantir fits a sinusoid to real TMS data
Element / Higher Level Item	Palantir / Docking Prediction
Specific Equipment	TMS data furnished by FMC Schilling
Procedure	Import TMS motion data, run function, view output
Verification Criteria	Palantir finds dominant frequencies and amplitudes
Result	Success

Test 7

Objective	Palantir communicates with quadcopter control system and sends accurate prediction
Element / Higher Level Item	Quadcopter Navigation / Palantir Docking Procedure
Specific Equipment	None
Procedure	Open connection from Palantir to Odroid Xu4 on Quadcopter, take example data for dock, have Palantir decide whether to dock and how, send data to quadcopter

Verification Criteria	Quadcopter acknowledges data sent, prediction correct in simulation
Result	Success

Test 8

Objective	IR Sensor Reads Dock Motion Correctly
Element / Higher Level Item	Prediction
Specific Equipment	None
Procedure	Run dock, analyze sensor output
Verification Criteria	Sensor outputs same frequency and amplitude as input to dock
Result	Sensor outputs within 5% error

Test 9

Objective	Get Data on Palantir and Filter
Element / Higher Level Item	Prediction
Specific Equipment	None
Procedure	Run dock, get IR data to Palantir, pass through filter
Verification Criteria	High frequency content filtered, less noise on high frequency
Result	<1% Error on resulting waveform

Test 10

Objective	Detect minimum Z distance from Platform
Element / Higher Level Item	Quadcopter Stabilization
Specific Equipment	Fiducial
Procedure	Place fiducial under platform, run platform
Verification Criteria	Monocular camera outputs correct minimum distance between fiducial and dock
Result	Quadcopter hovered within 10cm of platform

Test 11

Objective	Locking mechanism on platform functional
Element / Higher Level Item	Docking
Specific Equipment	Weights
Procedure	Place Nicadrone on modified platform, attach 5kg weight to Nicadrone
Verification Criteria	New docking face remains attached to platform

Test 12

Objective	Increase quadcopter input resolution
Element / Higher Level Item	Stabilization
Specific Equipment	None
Procedure	Input smaller than 1m resolution, measure distance traveled

Verification Criteria	Quadcopter moves distance entered
Result	Quadcopter motion <1% error from input to output

Test 13

Objective	Maintain Z distance between stationary dock and quadcopter manually
Element / Higher Level Item	Stabilization
Specific Equipment	None
Procedure	Have quadcopter hover under dock at varying heights
Verification Criteria	Determine minimum stable distance
Result	Minimum stable Z distance is 10 cm

Test 14

Objective	Get Motion Function
Element / Higher Level Item	Prediction
Specific Equipment	None
Procedure	Run dock, get IR data to Palantir, run prediction function
Verification Criteria	Function output fits training data
Result	Output less than 5% error from training data

Test 15

Objective	Locking Mechanism Completed on Quadcopter
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	Manually dock quadcopter to stationary platform
Verification Criteria	Quadcopter remains on platform with no motive power

Test 16

Objective	Coordinate Transformation
Element / Higher Level Item	Stabilization
Specific Equipment	April Tag
Procedure	Place april tag under platform, run coordinate transform on camera outpt
Verification Criteria	CV Node outputs an error of 0 in X and Y
Result	Success
Result	Coordinates transform with <1% error

Test 17

Objective	Quadcopter Centers on Platform
Element / Higher Level Item	Stabilization
Specific Equipment	None
Procedure	Have quadcopter hover under dock, activate

	autonomous hover
Verification Criteria	Quadcopter moves to stable hover point TBD from stationary platform with less than 5cm difference between XY center of quadcopter and XY center of docking face
Result	Success

Test 18

Objective	Palantir Predicts Low Point of Dock
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	Run dock, transfer IR data to Palantir, run analysis, transfer analysis to quadcopter
Verification Criteria	Palantir predicts correct low point of dock and sends valid instructions to quadcopter based on the analysis

Test 19

Objective	Maintain Z distance between moving dock and quadcopter
Element / Higher Level Item	Stabilization
Specific Equipment	None
Procedure	Have quadcopter hover under dock, activate dock, activate autonomous hover
Verification Criteria	Quadcopter moves to stable hover point TBD from lowest point of platform

Test 20

Objective	Quadcopter Senses Dock Completion
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	Subtest 1: Depress limit switch Subtest 2: Manually dock quadcopter to stationary platform
Verification Criteria	Docking mechanism sends signal to Odroid that is has docked when limit switch is depressed and when quadcopter successfully docks

Test 21

Objective	Quadcopter Autonomously Docks to Stationary Platform
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	Have quadcopter hover under dock, activate autonomous docking
Verification Criteria	Quadcopter centers, finds lowest point, hovers there, waits for Palantir results, accepts Palatir

	results, takes action as guided by Palantir, docks with platform, deactivates propulsion, remains docked

Test 22

Objective	Palantir Sends Correct Docking Data for Moving Platform Dock
Element / Higher Level Item	Docking
Specific Equipment	TBD means of detecting precise location of platform
Procedure	Activate dock motion, have quadcopter hover far away from it, Palantir analyzes and sends instructions to quadcopter, quadcopter flies to point where dock would be if dock were above quadcopter
Verification Criteria	Quadcopter reaches Z coordinate of dock at the same velocity the dock is moving.

Test 23

Objective	Quadcopter Docks on a Moving Platform
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	Activate dock motion, have quadcopter hover underneath it, Palantir analyzes and sends instructions to quadcopter, quadcopter docks
Verification Criteria	Quadcopter centers, finds lowest point of platform, hovers there, waits for Palantir results, accepts Palatir results, takes action as guided by Palantir, docks with platform, deactivates propulsion, remains docked

Test 24

Objective	Quadcopter Docks on a Moving Platform and Rejects Bad Docking Conditions
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	Activate dock motion, Palantir analyzes and sends instructions to quadcopter Change dock motion between 0.15 and 0.3 Hz and between 10 and 20 mm amplitude.
Verification Criteria	Palantir identifies possible and impossible docking situations 80% of the time.

SVE

Objective	Quadcopter Docks on a Moving Platform within all

	required parameters
Element / Higher Level Item	Docking
Specific Equipment	None
Procedure	**Platform Subsystem Test/Check** **Action:** Turn on the power to platform **Action:** Enter frequency for platform motion on the Palantir within range of 0.15 to 0.3 Hz) **Result:** The frequency of platform motion changes to the input frequency **Result:** Motion is detected by sensors and graph is plotted on the Palantir showing that the motion is the desired frequency waveform (i.e. frequency detected is the frequency entered by the user), the lowest point is found by the Palantir **Persistence:** The platform and Palantir will remain active during testing of the quadcopter and overall system. Quadcopter Subsystem and Full System Test Procedure **Quadcopter Subsystem Test/Check** **Action**: Place the quadcopter on the ground within .25 m from the platform, start engines, begin autonomous hover **Result**: The quadcopter will hover a fixed distance below the lowest point platform (within 5 cm accuracy in X-Y plane) **Result**: The Palantir will give the quadcopter the time, velocity, and location it must reach to dock. At the appropriate time, the quadcopter will perform the maneuver required, engaging its Nicadrone docking magnet on successful completion **Metric**: The velocity of quadcopter with respect to the platform will be less than 50 cm/s when quadcopter is moving up towards the platform **Metric**: Quadcopter will remain securely attached to the dock with its propulsion turned off for at least 30 seconds. **Repetition**: Repeat above steps 5 times with different starting positions and different frequencies of platform, and 5 times with an impossible docking situation
Verification Criteria	**Actions**: Quadcopter centers, finds lowest point of platform, hovers there, waits for Palantir results, accepts Palatir results, takes action as guided by Palantir, docks with platform, deactivates propulsion, remains docked. **Metrics**

	Hover is within 50mm X,Y,and Z accuracy Possibility analysis 80% accuracy. Docking takes less than 10 minutes from identification that docking is possible. Dock success rate 60%

Appendix A – Common Test Configuration Diagrams

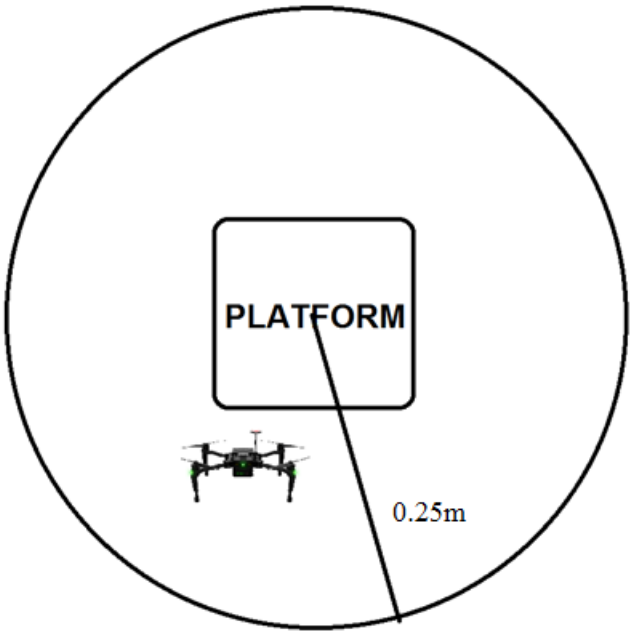

Fig A1 – Quadcopter and Platform Relative Locations

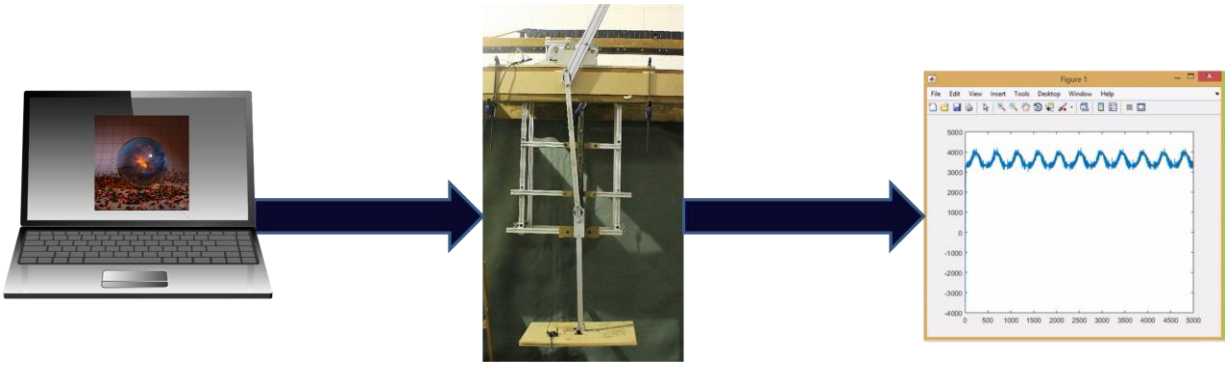

Fig A2 – Palantir Monitoring of Dock

QUADCOPTER :

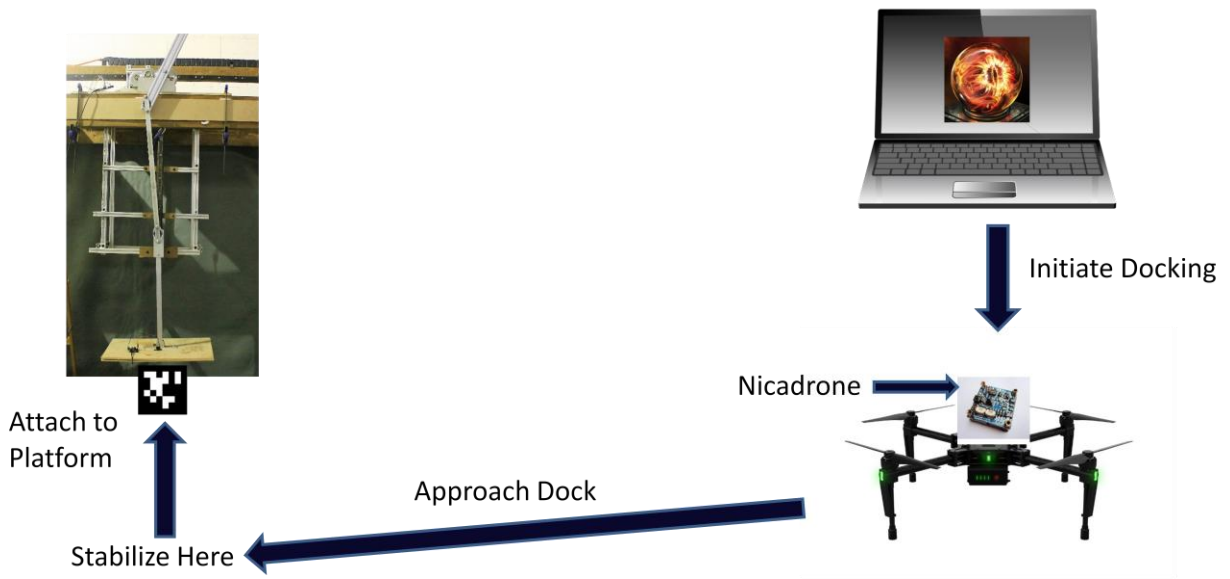

Fig A3 – Docking Test Configuration

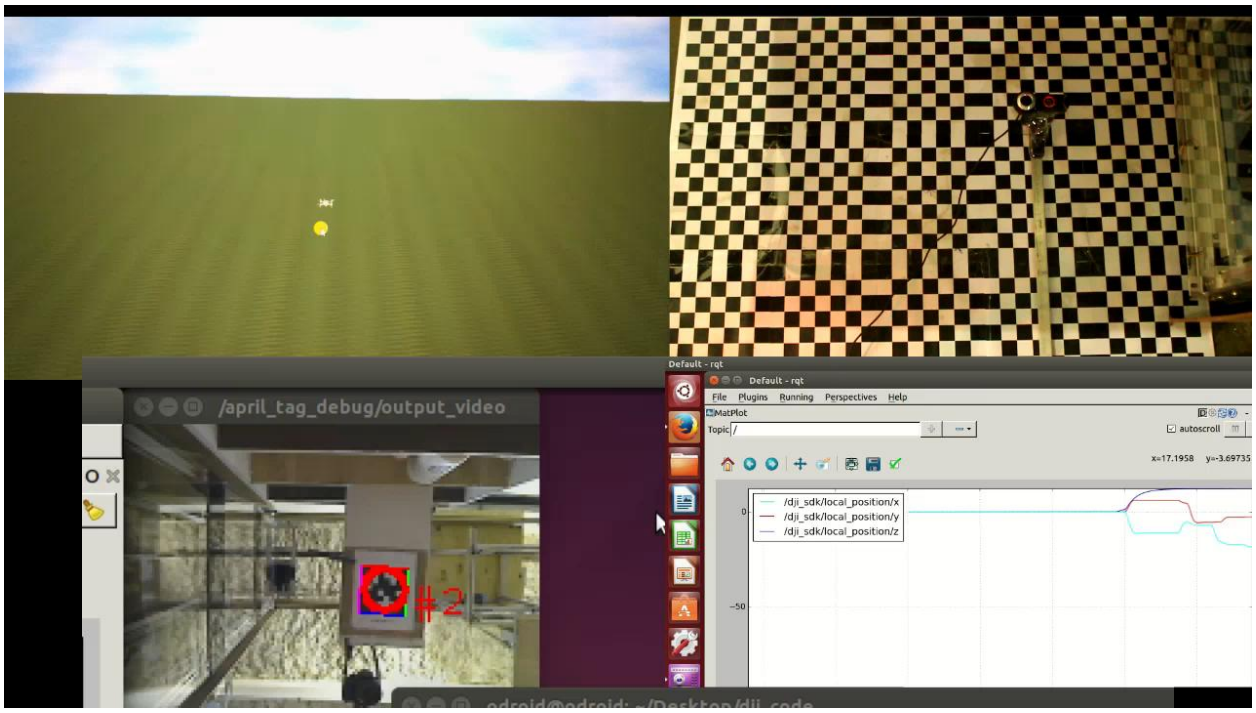

Fig A4 – CV Unit Test Configuration