California State University, Long Beach, Department of Electrical Engineering

EE 400D Verification and Validation Test Plan, Fall 2018

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1 Introduction

This is the Goliath Fall 2018 Verification and Validation Test Plan

1.1 Purpose

The purpose of this document is to provide a comprehensive Verification and Validation (V&V) Test Plan of the Fall 2018 Goliath, including the Project ConOps/Mission, Test Methodology, Verification and Validation Matricies, and Test Cases.

1.2 Project ConOps/Mission

Create a toy robot capable of being manually "RC" driven through a 2D maze, and then be capable of repeating the route autonomously.

1.3 Document Overview

This document is organized as follows:

- Section 2 contains links to relevant and applicable project reference documents and presentations for this Test Plan.
- Section 3 contains a description of the Testing Methodology utilized in this Test Plan, including the Master Verification and Validation Matrix, a description of the 4 types of V&V testing performed, the Test Environment description, and a Master Test Case List of all (number #) Test Cases for this project.
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2 Applicable Documents

This section contains a table of all relevant and applicable project reference documents and presentations for the Goliath Fall 2018 Verification and Validation Test Plan.

Document Name	Document Description	Document Link
Final Blog Post	Final Blog Post contains a summary of all the work done Fall 2018 for Goliath	Final Blog Post
NASA Systems Engineering Handbook (2007)	Document containing Test Methodologies in Section 3	http://www.acq.osd.mil/se/docs/NASA-SP-2007-6105-Rev-1-Final-31Dec2007.pdf

3 Testing Methodology

This section contains the Master Verification and Validation Matrix, as well as detailed descriptions of the various Test Methods and Test Cases utilized in this Test Plan.

3.1 Master Verification and Validation (V&V) Matrix

This matrix provides complete traceability of every requirement. Specifically, every requirement is mapped to its description, success criteria, V&V testing designation and method, and Test Case(s) where the requirement will be tested. Note that some overlap between Test Cases' requirements V&V is okay.

Requirement Number	**Requirement Text**	**V&V Success Criteria**	**V&V Method** (Analysis, Demonstration , Inspection, Test?)	**Test Cases**	**Pass/Fail**
L1-1	Project shall be completed by Tuesday December 18th, 2018	Goliath meets L1 requirements	Demonstration	02 - update	
L1-2	Goliath shall be responsive to user input commands from and send data to the ArxRobot mobile App	Goliath is responsive to user input commands from and send data to the ArxRobot mobile App	Demonstration	01 , 04 - update	
L1-3	**Maintainability:** Disassemble and Reassemble the robot shall be less than 20 minutes (10 + 10 minutes).	Goliath is disassembled and reassembled within 20 minutes	Demonstration	02 - update	
L1-4	Autonomously traverse shortest path of maze	Robot Autonomously traverses shortest path.	Demonstration	10 - update	

L1-5	The Goliath shall traverse on cloth, paper and linoleum	Goliath moves across cloth, paper and linoleum at least 60cm	Test - source of 60 cm	10	
L1-6	**Manufactur-ability:** 3D printed robot shall be in compliance with the 3/3/3 rule.	Total print time is less than 9 hours, with no single print taking longer than 3 hours	Analysis and Demonstration	03 - update	
L1-8	The Goliath should use the 3DoT board	Goliath based on the 3DoT board	Inspection	08 - update	
L1-9	**Aesthetics:** Goliath shall be a scale model of Goliath 302 tank.	Goliath is a scale model of the real Goliath 302 tank.	Analysis	02	
L1-10	Responsive to user input commands and sends telemetry to Arxterra	Responds to user input commands and sends telemetry to Arxterra	Demonstration	04 - update	
L1-11	The total cost of the Goliath shall remain under $250	Customer reviews and approves cost report with receipts.	Demonstration	09 - update	

L1-12	The Goliath shall traverse a maze under remote control	Customer can control Goliath using the ArxRobot mobile app	Demonstration	04	
L1-13	The Goliath should remember the manual instructions given for navigating the maze.	Customer verifies Goliath successfully following pre-defined path.	Demonstration	01 , 04 - update	
L1-14	Access to USB Port without tools.	From operational state to charging indicator ON in less than 5 seconds.	Test	05 - update	
L1-15	The Goliath shall remain operating for at least 0.5 hours	Goliath operates for 0.5 hours	Test	06 - update	
L1-16	The Goliath shall be smaller by volume than previous version	Volume of 3D models of Goliath compared.	Analysis	02 - update	

L2-1	Mass of Goliath shall not exceed 350 grams	Goliath is under 350 grams	Test	02	
L2-2	Voltage drawn from the 3DOT should not exceed 3.6V	Goliath voltage is under 3.6V	Test	9	
L2-3	Goliath should withstand impact of wall and other robots	Customer sees Goliath operational after collisions	Demonstration	11	
L2-4	Total current drawn from the 3DOT should not exceed 650mAh	3DoT battery shows current limit is 650mAh	Inspection	07	
L2-5	The wires in Goliath shall be clean so no interference during disassembly	Customer sees Goliath has clean arrangement of wires inside	Inspection	12	
L2-6	The Goliath will be smaller than 4.71x 3.77 x 1.8 inches (Fall 2016 size)	Goliath is smaller than 4.71x 3.77 x 1.8 inches	Test	02	

3.2 Testing Types and Methods

This subsection contains the 4 types of Verification and Validation (V&V) testing, as derived from the NASA Systems Engineering Handbook referenced above in Section 2. Material is taken from Chapter 5 in the NASA Handbook, and replicated below.

Verification proves that a realized product for any system model within the system structure conforms to the build-to requirements (for software elements) or realize-to specifications and design descriptive documents (for hardware elements, manual procedures, or composite products of hardware, software, and manual procedures). In other words, Verification is requirements driven; verification shows proof of compliance with requirements; that the product can meet each "shall" statement as proven through performance of a test, analysis, inspection, or demonstration.

Validation is conducted under realistic conditions (or simulated conditions) on any end product for the purpose of determining the effectiveness and suitability of the product for use in mission operations by typical users; and the evaluation of the results of such tests. Testing is the detailed quantifying method of both verification and validation. However, testing is required to validate final end products to be produced and deployed. In other words, Validation is ConOps/Mission driven; validation shows that the product accomplishes the intended purpose in the intended environment; that product meets the expectations of the customer and other stakeholders as shown through performance of a test, analysis, inspection, or demonstration.

3.2.1 Verification by Analysis

The use of mathematical modeling and analytical techniques to predict the suitability of a design to stakeholder expectations based on calculated data or data derived from lower system structure end product verifications. Analysis is generally used when a prototype; engineering model; or fabricated, assembled, and integrated product is not available. Analysis includes the use of modeling and simulation as analytical tools. A model is a mathematical representation of reality. A simulation is the manipulation of a model.

3.2.2 Verification by Demonstration

Showing that the use of an end product achieves the individual specified requirement. It is generally a basic confirmation of performance capability, differentiated from testing by the lack of detailed data gathering. Demonstrations can involve the use of physical models or mockups; for example, a requirement that all controls shall be reachable by the pilot could be verified by having a pilot perform flight-related tasks in a cockpit mockup or simulator. A demonstration could also be the actual operation of the end product by highly qualified personnel, such as test pilots, who perform a one-time event that demonstrates a capability to operate at extreme limits of system performance, an operation not normally expected from a representative operational pilot.

3.2.3 Verification by Inspection

The visual examination of a realized end product. Inspection is generally used to verify physical design features or specific manufacturer identification. For example, if there is a requirement that the safety arming pin has a red flag with the words "Remove Before Flight" stenciled on the flag in black letters, a visual inspection of the arming pin flag can be used to determine if this requirement was met.

3.2.4 Verification by <u>Test</u>

The use of an end product to obtain detailed data needed to verify performance, or provide sufficient information to verify performance through further analysis. Testing can be conducted on final end products, breadboards, brass boards or prototypes. Testing produces data at discrete points for each specified requirement under controlled conditions and is the most resource-intensive verification/validation technique. As the saying goes, "Test as you fly, and fly as you test." (See Subsection 5.3.2.5.).

3.2.5 Validation by <u>Analysis</u>

The use of mathematical modeling and analytical techniques to predict the suitability of a design to stakeholder expectations based on calculated data or data derived from lower system structure end product validations. It is generally used when a prototype; engineering model; or fabricated, assembled, and integrated product is not available. Analysis includes the use of both modeling and simulation.

3.2.6 Validation by <u>Demonstration</u>

The use of a realized end product to show that a set of stakeholder expectations can be achieved. It is generally used for a basic confirmation of performance capability and is differentiated from testing by the lack of detailed data gathering. Validation is done under realistic conditions for any end product within the system structure for the purpose of determining the effectiveness and suitability of the product for use in NASA missions or mission support by typical users and evaluating the results of such tests.

3.2.7 Validation by <u>Inspection</u>

The visual examination of a realized end product. It is generally used to validate physical design features or specific manufacturer identification.

3.2.8 Validation by <u>Test</u>

The use of a realized end product to obtain detailed data to validate performance or to provide sufficient information to validate performance through further analysis. Testing is the detailed quantifying method of both verification and validation but it is required in order to validate final end products to be produced and deployed.

3.3 Master Test Case List

A **<u>Test Case</u>** can be described as *a scenario containing a sequence of detailed test steps, in order to perform verification/validation testing on multiple requirements that are similar in nature.*

For example, if a group has multiple requirements regarding starting up their robot project, they can group all these requirements to be verified/validated in a single test case. Similarly, if a group has multiple requirements that can be verified/validated via inspection, they can group all of them together in a single test case.

The purpose of this subsection is to provide a High-Level overview of all Test Cases utilized in this Test Plan. Each item in this subsection will contain the following: Test Case Number and Name, High Level Scenario Description, and Test Environment Description.

3.3.1 TC-01: Goliath move forward

Description: The Goliath will use commands from the ARXTERRA App. uploaded to the 3DoT board in order to move forward.
Test Environment: Occurs inside, on a flat surface with 0% grade

3.3.2 TC-02: Assembly and Disassembly

Description: Assemble and disassemble the Goliath within a specified amount of time. The Goliath must be within a certain range of mass as well as a scale model of the original Goliath 302 tank. The Goliath will be ready by Wednesday December 18th, 2018.
Test Environment: Inside a classroom

3.3.3 TC-03: 3D printing

Description: Print 3D models in less than 8 hours, and no part takes longer than 2.
Test Environment: In room that has an accessible 3D printer

3.3.4 TC-04: Arxterra Control Application

Description: Control the newly designed and assembled Goliath using the Arxterra App.
Test Environment: Inside a classroom

3.3.5 TC-05: Charging Goliath

Description: Testing the ease of access of the charging port.
Test Environment: Inside a classroom

3.3.6 TC-06: Battery Life

Description: Running the Goliath motors continuously for 0.5 hour.
Test Environment: Inside a classroom

3.3.7 TC-07: Measuring Goliath Voltage and Current

Description: Measuring the voltage of the sensor header and finding the current rating.
Test Environment: Inside a classroom

3.3.8 TC-08: Using the 3DoT board

Description: Goliath will use the 3DoT board.
Test Environment: Inside a classroom

3.3.9 TC-09: Final Cost

Description: Final cost should be under specified budget.
Test Environment: Inside a classroom

3.3.10 TC-10: Traversing maze

Description: Goliath will complete maze with predetermined path using user input. The Goliath will traverse the maze utilizing a playback mode.
Test Environment: Inside a classroom

3.3.11 TC-11: Goliath withstands hit with wall and other robots

Description: Goliath should be able to take a hit and still operate.
Test Environment: Inside a classroom

3.3.12 TC-12: Wires clean inside Goliath

Description: There should be no messy wiring.
Test Environment: Inside a classroom

4 Appendices

This section will contain any addition documentation needed to verify/validate requirements. For example, if a project has a cost constraint requirement, include the cost breakdown spreadsheet below as a subsection and reference the appendix subsection in the related Test Step in the Test Procedure. If another group needs to verify something by hand via calculation, include the calculations as a subsection below and reference the appendix subsection in the related Test Step in the Test Procedure.

4.1 Final Goliath Code

Link to final code will go here

4.2 Final Budget

Link to final Budget will go here