**California State University, Long Beach, Department of Electrical Engineering**

**EE 400D Verification Test Plan, Spring 2018**

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**Project:** Goliath

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## **Purpose**

The purpose of this document is to provide a comprehensive Verification Test Plan of the Spring 2018 Goliath, including the Project ConOps/Mission, Test Methodology, Verification Matrix, and Test Cases.

## **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. In a second event the robot must travel through a predetermined route in the maze while avoiding running into other robots

##

## **Testing Types and Methods**

This subsection contains the 4 types of Verification 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.

### **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.

### **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.

### **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.

### **Verification by Test**

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.).

**Verification Matrix**

This matrix provides complete traceability of every requirement. Specifically, every requirement is mapped to its description, success criteria, Verification testing designation and method, and Test Case(s) where the requirement will be tested.

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| --- | --- | --- | --- | --- |
| Requirement Number | Requirement Text | Success Criteria | Verification Method (Analysis, Demonstration, Inspection, Test?) | Test Case(s) |
| L1-1 | Goliah shall be completed by May 15, 2018. | Finished product is presented to the customer on the correct date. | Inspection | 2 |
| L1-2 | Goliah shall be less than $250. | The customer inspects cost report. | Inspection | 2 |
| L1-3 | Goliath shall be fabricated using in-house resources; including a laser cutter, 3D printer, pick-and-place, and IR oven. | Customer inspects that Goliah is 3D printed, and the pick-and-place and IR oven were used to make the PCB | Inspection | 2 |
| L1-4 | Fabricated parts must not exceed a maximum print time of 2 hours per part. The total print time of all parts cannot be more than 6 hours. The print material must be PLA plastic with the minimal amount of infill and supports. | Customer inspects print report from Maker Society | Inspection | 2 |
| L1-5 | Goliaths shall utilize a 3DoT version 6.43a board powered by a 3.7V RCR123A battery and defined in the Mission Constraints section. | Customer sees that 3DoT board is used to command Goliath | Inspection | 2 |
| L1-6 | Good construction techniques: Goliath will be designed in such a way that there are no dangling or exposed wires. Connectors and ribbon cables will be used between all electronic and electromechanical components. Jumper wires will not be used, gauge of wires should be consistent with current requirements for the device. | The Goliath looks pleasing to the customer | Inspection | 2 |
| L1-7 | Good construction techniques: all moving and rotating parts will use bushing or bearings, hinges will be interlocking and include a hidden latching mechanism. No gaps will be greater than 1 millimeter, direct access shall be provided to all external connectors (USB, switches). | The Goliath looks pleasing to the customer | Inspection | 2 |
| L1-8 | Goliath disassembly time shall be 10 minutes. In general, all 3Dot boards will be clear of electronics, motors will be disconnected, UV sensors, range finder, gyro, and I2C expander will be disconnected. | Engineers disassemble the Goliath in front of customer. | Demonstration | 4 |
| L1-9 | Reassembly time shall be 10 minutes. Goliath’s team will be allowed to use a system block diagram and/or cable tree as well as an assembly diagram/instruction as necessary. Goliath will be tested after reassembly to confirm its functionality. control panel, including battery level. | Engineers disassemble the Goliath in front of customer. | Demonstration | 4 |
| L1-10 | Goliath shall drive on Paper, Cloth, and Baltic Birch surfaces. | Goliath drives 20 cm forward, across paper and linoleum. | Test | 4 |
| L1-11 | Goliath shall detect non-navigable obstacles at a distance of no less than 10 cm and no more than 25 cm. Non-navigable obstacles are defined in S’18 General Requirement document, Section 1.3.3. | Goliath detects objects at a distance of 10cm and stops. | Test | 3 |
| L1-12 | Once detected, Goliath should stop and continue driving when the obstacle is removed. | Goliath continues to move forward after object is removed | Test | 3 |
| L1-13 | Goliath shall successfully make left, right, and U turns within 10 seconds. | Goliah makes left,right, and U turns while timed. | Test | 1 |
| L1-14 | If mission cannot be completed as defined in rules of the game, as a minimum functional requirement, Goliath shall walk the shortest path of the maze. | Goliath walks the shortest path of the maze | Test | 6 |
| L1-15 | Goliath shall stop 10 cm from any other robot or non-navigable obstacle to avoid collision from occurring. | Goliath detects objects at a distance of 10cm and stops. | Test | 3 |
| L1-16 | During teaching mode, ArxRobot app via mobile devices shall be used to teach Goliath to navigate the maze. | Goliath moves according to directional pad on Arxterra App | Demonstration | 1 |
| L1-17 | During teaching mode, Goliath shall record the user’s input. |  |  | 1 |
| L1-18 | During playback mode, Goliath shall be able to repeat the previous route defined by the user. The software algorithm is defined in 400D E&C lab sequence. | Goliath repeats previous route. | Demonstration | 1 |
| L1-19 | During playback mode, the ArxRobot shall transmit telemetry and battery level to the Arxterra control panel. | Customer is able to see telemetry and battery level on control panel | Inspection | 1 |
| L1-20 | The mission shall be completed when Goliath exits the maze and stops in playback mode. | Goliath stops after exiting maze | Demonstration | 6 |
| L1-21 | Goliath shall not detect robots in a parallel section of the maze. | Goliath doesn’t detect placed parallel objects | Test | 3 |
| L1-22 | The robot shall be a scale replica of a Goliath 302 Tank. The scale factor will be 1:11.5 with a mean square error (MSD) over all three axis (x, y, z) of no greater than 10%. | Engineers measure Goliath as customer inspects | Inspection | 2 |
| L1-23 | Goliath shall house a custom PCB | Custom PCB is visible and working as intended. | Inspection | 2 |
| L2-1 | The goliath shall be smaller than 5x4x3 inches. L1-22 | Engineer verifies measurements of Goliath |  | 5 |
| L2-2 | Goliath shall use IR range finder to detect objects. L1-11 | Engineer tests the range finder | Test | 3 |
| L2-3 | Main PCB shall have two UV sensors, 2IR LED’s, Gyro, and connectors to range finder. L1-23 | Customer verifies the components | Inspection | 2 |
| L2-4 | Arx-robot App will have different operating control modes and direction pad to control Goliath’s movement. L1-16 | Customer inspects different modes displayed on App | Inspection | 1 |
| L2-5 | Goliath shall have 10mm x 5mm cut out on back of chassis to provide access to charging and programming hookup. L1-8 | Customer sees cutout | Inspection | 2 |
| L2-6 | The Goliath will not have any electrical parts mounted outside. L1-7 | Customer inspects outside of Goliath | Inspection | 2 |
| L2-7 | The Goliath shall have a latched lid. Interlocking mechanism. L1-8 | Customer verifies the latch | Inspection | 2 |
| L2-8 | Goliath will have all-terrain tracks. L1-10 | Goliath drives over many surfaces | Test | 1 |
| L2-9 | The goliath shall have 2 gears for movement. L1-10 | Customer inspects number of gears | Inspection | 2 |
| L2-10 | The goliath shall have 2 motor(s), located in the back of the chassis. L1-10 | Customer inspects Goliath has two motors | Inspection | 2 |

## **Master Test Case List**

### **Test Cases**

### **TC-01: Goliath’s Movement**

Description: The Goliath will use MOVE commands uploaded to the 3DoT board in order to move forward.

Test Environment: Occurs inside, on a flat surface with 0% grade

### **TC-02: General Inspection**

Description: Customer inspects the Goliath.

Test Environment: Inside a classroom

### **TC-03: Goliath’s detection capability**

Description: Print 3D models in less than 6 hours, and no part takes longer than 2.

Test Environment: In room that has an accessible 3D printer

### **TC-04: Assembly and Disassembly**

Description: Assemble and disassemble the Goliath

Test Environment: Inside a classroom

### **TC-05: Predetermined Mode**

Description: Goliath traverses the maze without user input

Test Environment: Inside a classroom

**Test Procedures**

This section contains details of every Test Case utilized for verification of project requirements. Each Test Case subsection within this section will contain the following: Test Case number and name, detailed scenario description, Test Case Traceability Matrix, detailed success criteria, detailed Test Environment description, Test Assumptions/Preconditions, Detailed Test Procedure Steps, and a Pass/Fail Matrix of success criteria per Test Case.

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| --- |
| **TC-01 Goliath's movement** |
| 1.1 Detailed Description | This test case provides the steps needed to move the Goliath in the forward direction. These steps are similar across a multitude of requirements. The point of this test case is to prevent repetition of the basic steps needed for movement. This includes the uploading of the code to the 3DoT, connecting to the 3DoT via Bluetooth using the mobile app, and using the D-pad for choosing a direction to move. In addition, engineers also test turning capacity and path memorization of Goliath. |
|  |
| 1.2 Test Case Traceability and Pass/Fail Matrix |  |
| Requirement Number | Description | Success Criteria | V Method | Procedure Step Results | Pass/Fail |
| L1-10 | Goliath shall drive on Paper, Cloth, and Baltic Birch surfaces. | Goliath drives 20 cm forward, across paper and linoleum. | Test | 7,8,9,10,11,14,15 |  |
| L1-13 | Goliath shall successfully make left, right, and U turns within 10 seconds. | Goliah makes left,right, and U turns while timed. | Test | 9,10 |  |
| L1-16 | During teaching mode, ArxRobot app via mobile devices shall be used to teach Goliath to navigate the maze. | Goliath moves according to directional pad on Arxterra App | Demonstration | 7,8,9,10,11 |  |
| L1-17 | During teaching mode, Goliath shall record the user’s input. |  |  | 7,8,9,10,11 |  |
| L1-18 | During playback mode, Goliath shall be able to repeat the previous route defined by the user. The software algorithm is defined in 400D E&C lab sequence. | Goliath repeats previous route. | Demonstration | 14,15 |  |
| L1-19 | During playback mode, the ArxRobot shall transmit telemetry and battery level to the Arxterra control panel. | Customer is able to see telemetry and battery life level on control panel | Inspection | 14,15 |  |
| L2-4 | Arx-robot App will have different operating control modes and direction pad to control Goliath’s movement. L1-16 | Goliath reaches 61cm mark | Inspection | 14 |  |
| L2-8 | Goliath will have all-terrain tracks. L1-10 | Goliath drives over many surfaces | Test | 7,8,9,10,11,14,15 |  |
|  |
| 1.3 Detailed Success Criteria | For this test case to be successful, the Goliath must be able to continuously move forward for a distance of 20cm, then turn left, move 20Cm, then turn right, move 20cm. The timer will verify that the Goliath did indeed move forward and complete the distances. In addition, Goliath must be able to repeat the previous route that was recorded. |
|  |
| 1.4 Test Environment | The test environment requires the completed Goliath, a smartphone with the ArxRobot application installed, and the presence of the customer. Test should be conducted indoors on a flat surface. |
|  |
| 1.5 Assumptions and Preconditions | Goliath is fully assembled | A location indoors with a flat surface for testing. |  |  |  |
|  |
| 1.6 Procedure Steps | Description | Pass Criteria | Recorded Data | Requirements Tested | Test Method |
| 1 | Place Goliath on flat surface | Goliath is on flat surface |  |  | Demonstration |
| 2 | Place measuring tape North of Goliath and extend tape to 20cm. Place a second, 20cm piece of tape, West of the ending of the first tape. Place a third, 20cm piece of tape, North of the ending of the second tape. | Measuring tapes are placed |  |  | Demonstration |
|  |  |  |  |  |  |
| 3 | Upload Goliath’s main code to Pro-micro | Code is uploaded |  |  | Demonstration |
| 4 | Connect ArxRobot mobile app via bluetooth to the 3DoT | Bluetooth symbol on app turns blue |  | L1-16, L1-21 | Demonstration |
| 5 | In Remote Control Mode, use D-pad commands on ArxRobot mobile app | Custom command is on ArxRobot app |  | L1-16, L1-21 | Demonstration |
| 6 | Start stopwatch | Stopwatch starts counting |  |  | Demonstration |
| 7 | Press forward D-pad button on mobile app | Forward D-pad button is pressed |  | L1-10, L1-16, L1-17,L2-8,9 | Demonstration |
| 8 | Press left D-pad to turn Goliath 90 degrees. | Left D-Pad button is pressed |  | L1-10, L1-14, L1-16, L1-17,L2-8,9 | Demonstration |
| 9 | Press forward D-pad button on mobile app | Forward D-pad button is pressed |  | L1-10, L1-16, L1-17,L2-8,9 | Demonstration |
| 10 | Press right D-pad to turn Goliath 90 degrees. | Left D-Pad button is pressed |  | L1-10, L1-14, L1-16, L1-17,L2-8,9 | Demonstration |
| 11 | Press forward D-pad button on mobile app | Forward D-pad button is pressed |  | L1-10, L1-16, L1-17,L2-8,9 | Demonstration |
| 12 | Stop stopwatch once Goliath finished route | Goliath is finishes route |  |  | Demonstration |
| 13 | Stop Goliath’s movement and place it back at starting point | Goliath is placed at starting point |  |  | Demonstration |
| 14 | Enter playback mode on mobile app | Playback mode is selected |  | L1-10, L1-18, L1-19L2-4,9 | Demonstration |
| 15 | Press allow movement for Goliath to repeat previous route across the tape. | Goliath moves according to previous route |  | L1-10, L1-18, L1-19L2-9 | Demonstration |

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| **TC-02 General Inspection** |
| 2.1. Detailed Description | This test case provides an inspection guide Goliath. The steps are similar across a multitude of requirements. The point of this test case is to fully inspect Goliath's physical body. This includes construction techniques and various subsystem requirements. |
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| 2.2 Test Case Traceability and Pass/Fail Matrix |  |
| Requirement Number | Description | Success Criteria | V Method | Procedure Step Results | Pass/Fail |
| L1-1 | Goliah shall be completed by May 15, 2018. | Finished product is presented to the customer on the correct date. | Inspection | 1 |  |
| L1-2 | Goliah shall be less than $250. | The customer inspects cost report. | Inspection | 2 |  |
| L1-3 | Goliath shall be fabricated using in-house resources; including a laser cutter, 3D printer, pick-and-place, and IR oven. | Customer inspects that Goliah is 3D printed, and the pick-and-place and IR oven were used to make the PCB | Inspection | 3 |  |
| L1-4 | Fabricated parts must not exceed a maximum print time of 2 hours per part. The total print time of all parts cannot be more than 6 hours. The print material must be PLA plastic with the minimal amount of infill and supports. | Customer inspects print report from Maker Society | Inspection | 4 |  |
| L1-5 | Goliaths shall utilize a 3DoT version 6.43a board powered by a 3.7V RCR123A battery and defined in the Mission Constraints section. | Customer sees that 3DoT board is used to command Goliath | Inspection | 5 |  |
| L1-6 | Good construction techniques: Goliath will be designed in such a way that there are no dangling or exposed wires. Connectors and ribbon cables will be used between all electronic and electromechanical components. Jumper wires will not be used, gauge of wires should be consistent with current requirements for the device. | The Goliath looks pleasing to the customer | Inspection | 6 |  |
| L1-7 | Good construction techniques: all moving and rotating parts will use bushing or bearings, hinges will be interlocking and include a hidden latching mechanism. No gaps will be greater than 1 millimeter, direct access shall be provided to all external connectors (USB, switches). | The Goliath looks pleasing to the customer | Inspection | 7 |  |
| L1-22 | The robot shall be a scale replica of a Goliath 302 Tank. The scale factor will be 1:11.5 with a mean square error (MSD) over all three axis (x, y, z) of no greater than 10%. | Engineers measure Goliath as customer inspects | Inspection | 8 |  |
| L1-23 | Goliath shall house a custom PCB and use control telemetry to navigate the maze. | Custom PCB is visible and working as intended. | Inspection | 9 |  |
| L2-1 | The goliath shall be smaller than 5x4x3 inches. L1-22 | Engineer verifies measurements of Goliath | Inspection | 10 |  |
| L2-3 | Main PCB shall have two UV sensors, 2IR LED’s, Gyro, and connectors to range finder. L1-23 | Customer verifies the components | Inspection | 11 |  |
| L2-5 | Goliath shall have 10mm x 5mm cut out on back of chassis to provide access to charging and programming hookup. L1-8 | Customer sees cutout | Inspection | 12 |  |
| L2-6 | The Goliath will not have any electrical parts mounted outside. L1-7 | Customer inspects outside of Goliath | Inspection | 13 |  |
| L2-7 | The Goliath shall have a latched lid. Interlocking mechanism. L1-8 | Customer verifies the latch | Inspection | 14 |  |
| L2-9 | The goliath shall have 2 gears for movement. L1-10 | Customer inspects number of gears | Inspection | 15 |  |
| L2-10 | The goliath shall have 2 motor(s), located in the back of the chassis. L1-10 | Customer inspects Goliath has two motors | Inspection | 16 |  |
|  |
| 2.3 Detailed Success Criteria | For this test case to be successful, the Goliath must be able to pass all inspection requirements, and the customer must be pleased with the product. |
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| 2.4 Test Environment | The test environment requires the completed Goliath and the presence of the customer. Test should be conducted indoors, preferably a classroom. |
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| 2.5 Assumptions and Preconditions | Goliath is fully assembled | A location indoors with a flat surface for testing. |  |  |  |
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| 2.6 Procedure Steps | Description | Pass Criteria | Recorded Data | Requirements Tested | Test Method |
| 1 | Customer confirms present date | Date is may 15,2018 |  | L1-1 | Inspection |
| 2 | Customer confirms cost to be less than $250 from looking at cost report. | Cost report for Goliath is less than $250 |  | L1-2 | Inspection |
| 3 | Customer inspects Goliath's chassis and PCB | Customer sees that the components used in house resources |  | L1-3 | Inspection |
| 4 | Customer confirms print time and material from Maker Society's report for Goliath's prototypes. | Print time for parts do not exceed 2 hours. Material for prototype is PLA plastic. |  | L1-4 | Inspection |
| 5 | Customer confirms that Goliath houses 3DoT version 6.43 board that uses RCA123 battery. | Goliath houses 3DoT board with RCA 123 battery. |  | L1-5 | Inspection |
| 6 | Customer checks Goliath's neatness | Goliath has no dangling wires, exposed wires, or jumper cables. Connectors and ribbon cables will be used between all electronics. |  | L1-6 | Inspection |
| 7 | Customer checks Goliath's neatness | All moving and rotating parts will use bushing or bearings, hinges will be interlocking and include a hidden latching mechanism. No gaps will be greater than 1 millimeter, direct access shall be provided to all external connectors (USB, switches). |  | L1-7 | Inspection |
| 8 | Customer inspects as engineer measures and calculate the size ratio of Goliath | Goliath has 1:11.5 scale ratio to the real Goliath Tank |  | L1-22 | Inspection |
| 9 | Customer checks if Goliath has custom PCB | Goliah houses custom PCB |  | L1-23 | Inspection |
| 10 | Customer inspects as engineer measures and calculate the size ratio of Goliath | Goliath is smaller than 5''Lx4''Wx3''H |  | L2-1 | Inspection |
| 11 | Customer examines the PCB for correct components | PCB shall have two UV sensors, 2IR LEDS, and Gyro |  | L2-3 | Inspection |
| 12 | Customer inspects accessible charging and programming port | Goliath has 10mm x 5mm cut out on back of the chassis |  | L2-5 | Inspection |
| 13 | Customer inspects Goliath for electrical parts mounted outside | Goliath has no electrical parts mounted outside |  | L2-6 | Inspection |
| 14 | Customer opens and closes Goliath's lid to check for interlocking latch. | Goliath has latching lid |  | L2-7 | Inspection |
| 15 | Customer counts numbers of gears on Goliath | Goliath has 2 gears |  | L2-9 | Inspection |
| 16 | Customer counts number of motors Goliath has. | Goliath has 2 motors |  | L2-10 | Inspection |

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| **TC-03 Goliath's Detection** |
| 3.1. Detailed Description | This test case provides the steps needed to check Goliath's detection capabilities. Various objects will be placed in front and to the side of Goliath as engineer controls it to move forward with the ArxRobot App. These steps are similar across a multitude of detection requirements. |
|  |
| 3.2 Test Case Traceability and Pass/Fail Matrix |  |
| Requirement Number | Description | Success Criteria | V Method | Procedure Step Results | Pass/Fail |
| L1-11 | Goliath shall detect non-navigable obstacles at a distance of no less than 10 cm and no more than 25 cm. Non-navigable obstacles are defined in S’18 General Requirement document, Section 1.3.3. | Goliath detects objects at a distance of 10cm and stops. | Test | 2,3 |  |
| L1-12 | Once detected, Goliath should stop and continue driving when the obstacle is removed. | Goliath continues to move forward after object is removed | Test | 2,3 |  |
| L1-15 | Goliath shall stop 10 cm from any other robot or non-navigable obstacle to avoid collision from occurring. | Goliath detects objects at a distance of 10cm and stops. | Test | 2,3 |  |
| L1-21 | Goliath shall not detect robots in a parallel section of the maze. | Goliath doesn’t detect placed parallel objects | Test | 4 |  |
| L2-2 | Goliath shall use IR range finder to detect objects. L1-11 | Engineer tests the range finder | Test | 2,3 |  |
|  |
| 3.3 Detailed Success Criteria | For this test case to be successful, the Goliath must be able to pass all detection requirements. |
|  |
| 3.4 Test Environment | The test environment requires the completed Goliath and the presence of the customer. Test should be conducted indoors, preferably a classroom. |
|  |
| 3.5 Assumptions and Preconditions | Goliath is fully assembled | A location indoors with a flat surface for testing. | Goliath's final code is uploaded | D-PAD on Arxterra app is working |  |
|  |
| 3.6 Procedure Steps | Description | Pass Criteria | Recorded Data | Requirements Tested | Test Method |
| 1 | Place detectable object 20 cm in front of S'18 Goliath. Place a section of the wall 20 cm in front of object. Place a second object 5 cm to the right of the first object, | Objects are placed |  |  | Demonstration |
| 2 | Put Goliath on "Avoidance mode" then press and hold forward on D-pad: Goliath moves forward and stops automatically when reaching 10 cm from the first object | Goliath stops successfully after detecting first object |  | L1-11, L1-12, L1-15L2-2 | Test |
| 3 | Remove first object, Goliath resumes moving forward automatically | Goliath moves forward successfully after object is removed. |  | L1-11, L1-12, L1-15L2-2 | Test |
| 4 | Goliath moves past second object without detecting it. | Goliath successfully moves past side object |  | L1-21 | Test |

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| **TC-04 Assembly and Disassembly** |
| 4.1 Detailed Description | This test case provides the steps needed to check Goliath's detection capabilities. Various objects will be placed in front and to the side of Goliath as engineer controls it to move forward with the ArxRobot App. These steps are similar across a multitude of detection requirements. |
|  |
| 4.2 Test Case Traceability and Pass/Fail Matrix |  |
| Requirement Number | Description | Success Criteria | V Method | Procedure Step Results | Pass/Fail |
| L1-8 | Goliath disassembly time shall be 10 minutes. In general, all 3Dot boards will be clear of electronics, motors will be disconnected, UV sensors, range finder, gyro, and I2C expander will be disconnected. | Engineers disassemble the Goliath in front of customer. | Demonstration | 3 |  |
| L1-9 | Reassembly time shall be 10 minutes. Goliath’s team will be allowed to use a system block diagram and/or cable tree as well as an assembly diagram/instruction as necessary. Goliath will be tested after reassembly to confirm its functionality. control panel, including battery level. | Engineers disassemble the Goliath in front of customer. | Demonstration | 4 |  |
|  |
| 4.3 Detailed Success Criteria | For this test case to be successful, the Goliath must be able to pass all detection requirements. |  |  |  |  |
|  |
| 4.4 Test Environment | The test environment requires the completed Goliath and the presence of the customer. Test should be conducted indoors, preferably a classroom. |  |  |  |  |
|  |
| 4.5 Assumptions and Preconditions | Goliath is fully assembled | A location indoors with a flat surface for testing. |  |  |  |
|  |
| 4.6 Procedure Steps | Description | Pass Criteria | Recorded Data | Requirements Tested | Test Method |
| 1 | Put Goliath on clean, spacious surface. | Goliah placed on surface |  |  | Demonstration |
| 2 | Set timer for 20 minutes and press start | Timer starts counting down |  |  | Demonstration |
| 3 | Disassemble Goliath | Goliath is disassembled. (all 3Dot boards will be clear of electronics, motors will be disconnected, UV sensors, range finder, gyro, and I2C expander will be disconnected.) |  | L1-8 | Demonstration |
| 4 | Assemble Goliath (3D models, screws, wires, motors, 3DoT board, color sensors, LED array) | Goliath is assembled |  | L1-9 | Demonstration |
| 5 | Stop timer | Goliath is assembled before 20 minutes runs out |  |  | Demonstration |

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| **TC-05 Predetermined Mode** |
| 5.1 Detailed Description | This test case provides the steps for the customer to use the Goliath to traverse the maze without user input. The point of this test case is to make sure the Goliath can complete the maze autonomously. |
|  |
| 5.2 Test Case Traceability and Pass/Fail Matrix |  |
| Requirement Number | Description | Success Criteria | V Method | Procedure Step Results | Pass/Fail |
| L1-14 | If mission cannot be completed as defined in rules of the game, as a minimum functional requirement, Goliath shall walk the shortest path of the maze. | Goliath walks the shortest path of the maze | Demonstration | 2 |  |
| L1-20 | The mission shall be completed when Goliath exits the maze and stops in playback mode. | Goliath stops after exiting maze | Demonstration | 2 |  |
|  |
| 5.3 Detailed Success Criteria | For this test case to be successful, the Goliath complete the maze in predetermined mode |  |  |  |  |
|  |
| 5.4 Test Environment | The test environment requires the completed Goliath and the presence of the customer. Test should be conducted indoors, preferably a classroom. |  |  |  |  |
|  |
| 5.5 Assumptions and Preconditions | Goliath is fully assembled | A location indoors with a flat surface for testing. | Hedge Maze |  |  |
|  |
| 5.6 Procedure Steps | Description | Pass Criteria | Recorded Data | Requirements Tested | Test Method |
| 1 | Place Goliath at start of maze | Goliath is placed |  |  | Demonstration |
| 2 | Select predetermined mode on Arxrobot App and allow Goliath to traverse maze | Goliath completes maze autonomously |  | L1-14,L1-23 | Demonstration |