P09029 Your Project Name

Test Plans & Test Results

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General Notes to Teams:

P09029 Your Project Name
Test Plans & Test Results

1. MSD I: WKS 8-10 PRELIMINARY TEST PLAN

1.1. Introduction; Overview; Summary; Purpose; History

1.1.1. The long-term goal of this project is to design a robotic arm with full-range of motion capability. Prior phases of the project focused on finger motions. This iteration will focus on wrist, forearm and elbow motion. A software package will be developed that will include a controls system that can output to a 3D computer model for simulation as well as a physical prototype. The primary focus of this project is to create this computer simulation of joints used in making air muscle based robotic arms that can interface with the controls system and predict the forces. To ensure the accuracy of this simulation, joints will be made and compared to the computer model..

1.2. Project Description; Sub-Systems/ Critical Components Being Tested

1.2.1. Prototype joints.

1.2.2. Computer simulation of joints.

1.2.3. Controls system.

1.3. Approval; Guide, Sponsor

Approved by:
Team Members – Casey Dill.
Guide – Professor Lamkin-Kennard
Sponsor – Professor Lamkin-Kennard

1.4. Test Strategy

1.4.1. Product Specifications, Block Diagram, and Pass/ Fail Criteria

Specification (description)	Unit of Measure	Marginal Value	Ideal Value
Simulation			
Computer model needs to be able to predict collisions	Boolean		TRUE
Computer model needs to be able to predict the forces acting on the arm components	Boolean		TRUE
Computer model needs to prove the design feasibility	Boolean		TRUE
General			
Designs are open and adaptable to future projects	Boolean		TRUE
Prototype			
Arm is capable of incorporating the hand	Boolean		TRUE
Wrist has same number of degrees of freedom as the human hand	degrees of freedom		2
Forearm has same number of degrees of freedom as the human hand degrees of freedom	degrees of freedom		1
Elbow has same number of degrees of freedom as the human hand	degrees of freedom		1
Provides enough power to be able to maneuver previous hand	lbf	(arm's own weight)	(weight of arm and hand)
Hand length, wrist to fingertips	Inches	5-15	7
Bicep length	Inches	10-15	12
Forearm length	Inches	9-17	12
Test Stand			
Large enough to contain arm motion	Inches	24	36
Withstand catastrophic air muscle failure (safety glasses standard: 1/4" steel ball shot at su	ft/sec	150	250
Movement			
Wrist Sagittal Flexion replicates human motion (Wrist Down)	Degrees	60	80
Position Tolerance for Both the SolidWorks Model and the Prototype	Degrees	±8	±1
Wrist Sagittal Extension replicates human motion (Wrist Up)	Degrees	55	70
Position Tolerance for Both the SolidWorks Model and the Prototype	Degrees	±7	±1
Wrist Radial Deviation replicates human motion (Wrist Left)	Degrees	12	20
Position Tolerance for Both the SolidWorks Model and the Prototype	Degrees	±2	±1
Wrist Ulnar Deviation replicates human motion (Wrist Right)	Degrees	20	30
Position Tolerance for Both the SolidWorks Model and the Prototype	Degrees	±2	±1
Forearm Pronation (thumb in) resembles human motion (Rotate CCW)	Degrees	60	80
Position Tolerance for Both the SolidWorks Model and the Prototype	Degrees	±8	±1
Forearm Supination (thumb out) resembles human motion (Rotate CW)	Degrees	60	80
Position Tolerance for Both the SolidWorks Model and the Prototype	Degrees	±8	±1
Elbow Flexion resembles human motion (Elbow)	Degrees	130	150
Wrist Movement speed (median)	Degrees/Second	60	180
Forearm Movement speed (median)	Degrees/Second	90	210
Elbow Movement speed (median)	Degrees/Second	180	215
Controls			
Control system able to control both SolidWorks and Prototype	Boolean		TRUE
Control system able to take feedback from both SolidWorks and Prototype	Boolean		TRUE
Control system operates fast enough to control prototype (USB, Relay, DAQ, and Calculatio	milliseconds	100-500	<100

1.4.2. Functions (hardware) and Features (software, customer needs)

Test Number	Trace	Test Name	Description	Reason
TN01	ES01	Collision Detection	The simulation needs to be able to predict collisions between moving parts.	Predicting collsions in the model will predict collsions for the prototype.
TN02	ES02	Force Prediction	The forces predicted by the simultion need to be similar to those found by the prototype.	Predicting the forces using the simulation will help future teams understand the forces they need to drive future systems.
TN03	ES03	Feasablity	The simulation needs to accuratle predict the motions of the prototypes.	Finding feasability issues before prototypign starts will save time and money for future teams.
TN04	ES04	Compatiability	The documentation needs to be such that future teams can read and understand and use the computer simulation.	
TN05	ES06, ES07, ES08	Degrees of Freedom	The design of the arm needs to have 4 degrees of freedom simlar to a human arm.	
TN06	ES09	Lifiting Stength	The arms (all joints) need to be able to support their own weight and that of attatched parts.	
TN07	ES10	Hand Length	The hand needs to be human-scale (5-15 inches).	Keeping the scale to human size is convenient for learning and understand the forces at work.
TN08	ES11	Bicep Length	The bicep needs to be human-scale (10-15 inches).	
TN09	ES12	Forearm Length	The forearm needs to be human-scale (9-17 inches).	
TN10	ES13	Test Stand Size	The moving parts all need to fit in an enclosure.	
TN11	ES14	Test Stand Safety	The test stand needs to withstand impacts without failing.	
TN12	ES15	Wrist Down	Wrist Sagittal Flexion replicates human motion (Wrist Down)	
TN13	ES17	Wrist Up	Wrist Sagittal Extension replicates human motion (Wrist Up)	
TN14	ES19	Wrist left	Wrist Radial Deviation replicates human motion (Wrist Left)	
TN15	ES21	Wrist Right	Wrist Ulnar Deviation replicates human motion (Wrist Right)	
TN16	ES23	Rotate CCW	Forearm Pronation (thumb in) resembles human motion (Rotate CCW)	
TN17	ES25	Rotate CW	Forearm Supination (thumb out) resembles human motion (Rotate CW)	
TN18	ES27	Elbow Flex	Elbow Flexion resembles human motion (Elbow)	
TN19	ES28	Wrist Speed	Wrist Movement speed (median)	Finding the right speeds are needed to find the forces needed.
TN20	ES29	Forearm Speed	Forearm Movement speed (median)	

TN21	ES30	Elbow Speed	Elbow Movement speed (median)
TN22	ES16	Wrist Up Tolerance	Wrist Up Position Tolerance for Both the SolidWorks Model and the Prototype
TN23	ES18	Wrist Down Tolerance	Wrist Down Position Tolerance for Both the SolidWorks Model and the Prototype
TN24	ES20	Wrist Left Tolerance	Wrist Left Position Tolerance for Both the SolidWorks Model and the Prototype
TN25	ES22	Wrist Right Tolerance	Wrist RightPosition Tolerance for Both the SolidWorks Model and the Prototype
TN26	ES24	CW Tolerance	CW Position Tolerance for Both the SolidWorks Model and the Prototype
TN27	ES26	CCW Tolerance	CCW Position Tolerance for Both the SolidWorks Model and the Prototype
TN28	ES31	Controls System Comands	The controls systems need to be able to output to botht the computer simulation and the physical prototypes.
TN29	ES32	Feedback Comunication	The controls system needs to take in input from both the computer model and the physical prototypes.

1.4.1. Test Equipment available

1.4.1.1. Test air muscles

1.4.1.2. Computers to run simulations

1.4.1.3. Force gauges

1.4.1.4. Stop watch

1.4.2. Test Equipment needed but not available

1.4.3. Phases of Testing

Note to Teams: Your testing needs may be a sequential. As an example, early testing in Senior Design I may be very informal for the purpose of evaluating the concept feasibility for the chosen technology. That is, component and/ or subsystem testing aids in gaining confidence in the chosen technology prior to full commitment. More advanced testing becomes more formal requiring good documentation. Define this plan within the team and then share with your Guide for potential feedback.

Note: The following is from Dr. Reddy's lecture notes.

1.4.3.1. Component/ Device (wks 2-12)

1.4.3.2. Relays

1.4.3.3. Air muscles

1.4.3.4. Potentiometers

1.4.3.5. Controls communication with the relays

1.4.3.6. Controls communication with SolidWorks

1.4.3.7. Subsystem (wks 6-13)

1.4.3.7.1. Elbow

1.4.3.7.2. Wrist

1.4.3.7.3. Forearm

1.4.3.7.4. SolidWorks Model

1.4.3.8. Integration (wks 11-15)

1.4.3.8.1. Commands sent to and received by Solidworks

1.4.3.8.2. Feedback sent from Solidworks, received by LabView

1.4.3.8.3. Commands sent to and received by relay bored

1.4.3.8.4. Feedback sent from potentiometers and received by LabView

1.4.3.8.5. Joints can support each other's weight

1.4.3.9. Reliability (wks 15-20)

1.4.3.9.1. Air muscle have already been tested for stress, just not at lengths needed for arm control.

1.4.3.10. Customer Acceptance (wks 20-21)