

Failure Mode	Test Method	Expected Results	Error Message	Actual Results	Date	Testers	Signatures
Draping/Cleaning							
Water gets into motor controller enclosure and causes damage to controller	Pour water on all parts of robot to test seal	No water should get through seals	NA	No water penetrated seals	3/7/2013	Jonathan Kriss, Kevin Olds	
Inadequate draping/undraping procedure	Spray drape with paint before removal	No paint should get through drape.	NA	No paint penetrated drape	1/30/2013	Jonathan Kriss, Kevin Olds	
Drape tears	Attempt to tear drape during normal operations, adjust handles, scope, etc.	Drape should not tear during normal operation	NA	The drape did not tear under normal working conditions	1/30/2013	Jonathan Kriss, Kevin Olds	
Joint/Arm Mechanical Failure							
Passive arm joint clamp becomes loose	Loosen joint clamp	Friction Collar should stop motion.	NA	Friction Collars(Properly tightened) stop motion as expected	1/10/2013	Jonathan Kriss, Kevin Olds	
Friction collars not tightened correctly	Loosen collars	Loose joint will be clearly noticable while trying to make adjustments during setup.	NA	Joints are able to fall is joint is loosened. Add check in set up instructions to verify tight enough friction collars	1/10/2013	Jonathan Kriss, Kevin Olds	
Incorrect Attachment to bedrail	Loosen attachment to bedrail	Robot should be unstable but not fall	NA	Robot is slightly unstable but not in danger of falling in any way, as expected.	1/10/2013	Jonathan Kriss, Kevin Olds	
Object blocking arm or internal jam in arm	Block joint with immovable object, do not damage robot.	Galil current/torque limits stop robot.	Error! Motor Error Detected!	Galil error stops motion and turns off motors, as expected	1/10/2013	Jonathan Kriss, Kevin Olds	
Motor failure due to broken wire or short	Disconnect power from a motor during motion.	Robot will not move on that axis.	None	Motion Stops, no error, as expected	1/10/2013	Jonathan Kriss, Kevin Olds	
Mechanical break between the motor and joint	Loosen pot attachment during operation then command motion.	PC pot/encoder check will fail and stop motion. Estop activated.	System Error! Encoder Failure	Axis A: Encoder Failure Error, as expected. Axis B: Encoder Failure Error, as expected. Axis C: Encoder Failure Error, as expected.	1/10/2013	Jonathan Kriss, Kevin Olds	
Switch/Joystick Failure							
Broken wire, short causes robot to become electrified	Test that case is properly grounded(Using multimeter)	All metal parts of the case should be electrically grounded.	NA	Case is properly earth-grounded.	1/10/2013	Jonathan Kriss, Kevin Olds	
Limit switch mechanically fails during operation	Disconnect each limit switch in turn during operation	Software limits/physical limits stop motion. No apparent change in behavior	None	Software limits stop all axes, as expected.	1/10/2013	Jonathan Kriss, Kevin Olds	
Limit switch mechanically fails before operation begins	Remove each limit switch in turn before operation	Physical limits should stop robot during calibration. Galil Motion Error should stop calibration	Calibration Fail	Motor Error during calibration, as expected	1/22/2013	Jonathan Kriss, Kevin Olds	
Joystick mechanical failure: joystick cannot change switch settings	Remove switch assembly.	Robot should not respond to commands. Program should throw an error.	Joystick Error	Joystick Error, as expected.	1/10/2013	Jonathan Kriss, Kevin Olds	
Joystick double switch failure	Simulate single switch failure(short switch)	Robot should not respond to commands. Program should throw an error.	Joystick Error	Joystick Error, as expected.	1/10/2013	Jonathan Kriss, Kevin Olds	

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Potentiometer/Encoder Failure							
Pot has electrical or mechanical failure before operation begins	Disconnect wires from each pot in turn before operation	Calibration will fail or runtime checks will fail. Estop activated	Calibration Failed	Calibration Failed, as expected	1/22/2013	Jonathan Kriss, Kevin Olds	
Pot has electrical or mechanical failure during operation	Disconnect wires from each pot in turn during operation	Runtime checks will fail immediately. Estop activated	Encoder Error	Encoder Error, as expected	1/22/2013	Jonathan Kriss, Kevin Olds	
Encoder has electrical or mechanical failure before operation begins	Disconnect each encoder in turn before operation	Calibration will fail or runtime checks will fail. Estop activated	Calibration Failed OR Encoder Error	Calibration Failed, as expected	1/22/2013	Jonathan Kriss, Kevin Olds	
Encoder has electrical or mechanical failure during operation	Disconnect each encoder in turn during operation	Runtime checks will fail immediately. Estop activated	Encoder Error	Encoder Error, as expected	1/22/2013	Jonathan Kriss, Kevin Olds	
Both encoder and pot have electrical or mechanical failure	Disconnect several combination of pots/encoders(same, different axes) during and before operation	Calibration will fail or runtime checks will fail. Estop activated	Calibration Failed OR Encoder Error	Calibration Failed, as expected	1/22/2013	Jonathan Kriss, Kevin Olds	
Communication Failure							
Estop gets disconnected from PC	Unplug USB cord before/during run.	Before: Program should give error on startup. During: Program should stop. Power will be disconnected from motors.	System Error! Estop Connection Failed	Estop Connection Error, as expected	1/10/2013	Jonathan Kriss, Kevin Olds	
Ethernet failure: motor controller loses communication with PC	Disconnect ethernet cable during different operation states (Initialization, Calibration, Runtime)	Init: Should see error during startup. Calibration: Robot should complete last issued move command then stop. Runtime: Watchdog timer should stop robot from PC. Estop activated	Connection Error! Check Connections and Restart System	Robot stops and an error is thrown as expected	1/10/2013	Jonathan Kriss, Kevin Olds	
Galil Controller crashes or loses power	Turn off Galil during operation.	Watchdog timer should stop robot from PC. Estop activated	Connection Error! Check Connections and Restart System	Connection Error, Estop, as expected.	1/10/2013	Jonathan Kriss, Kevin Olds	
Computer crash due to power surge or other failure	Kill PC program process during different operation states.	Watchdog timer should stop robot from Galil.	NA	Galil enters Abort mode and stops all motion, as expected	1/10/2013	Jonathan Kriss, Kevin Olds	