Product Name: Lamar System Name: Subsystem Name: Co nent		Development Team: Joel Gisbelong, Cole Pace, Kaitlyn Deets, Caleb Lamca, Colin Donnellan				Pages No. of FMEA Number Date			
Fa	Pote ntial	Potential Effect(s)	Severit y (S)	Potenti al	Occur rence	Curre nt	Detect ion	RPN	Reco mmen
Link 1	3d print ed link brea ks unde r stre s of the mido	The 3d printed material could crack and splinter pieces but these would be low velocity.	7	Failure in control of motor causin g it to spin past the rotatin n we	4	We will careful ly test both motors with an micro control ler with	5	140	Test differe nt materi als at differe nt torque speed s and find what
Link	Fract ure unde r	Loss of elbow support / robotic	7	Thin wall, large impact	4	Visual inspec tion to see	5	140	Thicke n wall and ey
Motor housing	Heat overl oad/ stall	Motor shutdow n, motor may heat up could cause burning around wi		Torqu e deman d too high, no proper coolin g		Test the limits of the motor and measu re the heat		112	Improv e ventilat ion, invest in an heat sink.
Motor	Cold windi ng dam age	Electrical short causing potential	9	Moistu re in motor, poor	2	Check insulati on in dated,	6	108	Add watery roof cover
Motor 2	Ther mal overl oad	Motor shutdow n, motor may heat up could cause burning around wi	7	Contin uous load, user learnin g heavily on	4	Test the limits of the motor and measu re the heat	4	112	Add torque limit and therma l cutoff. Improv e.
Wall bracket	Buck le or strap tear or dete chm ent	The robotic arm could drop and cause damage or injury to the	8	Fatigu e or overlo ad of belt or other mecha nical	3	We will visuall y inspec t the belt to make	5	120	To use an industr y standa rd belt, add secon dary
Wall	Belt slipp age durin g	Poor control, cause unexpect ed	5	Poor fabric friction belt	4	Includ ed adjust able	6	144	Additio nal tether added to
Hinge	Crac k or defor mati on arou	Arm position could shift to an	7	Screw s/bolts too lose or too	3	Ensur e the correc t	5	105	Invest in an reliabl e hinge or
Motor mount	Crac k or defor mati on arou	Motor misalign ment, large vibration s/screwho	7	Over tighten ing of screw s/bolts	5	Visual check to look for defor mation	4	140	Reprin t piece check ng print orienta
Motor mount	Bolts fled ener x incre ase	If the screw is too small for the hole the arm	7	Over tighten ing of screw s/bolts	5	Visual check to look for defor mation	4	140	Reprin t piece check ng print orienta
Motor mount	Crac k or defor mati on arou	Motor misalign ment, large vibration s/screwho	7	Over tighten ing of screw s/bolts	5	Visual check to look for defor mation	4	140	REprin t piece check ng print orienta
Arm connector	The thinn est piec e of the	Fastener cause motor misalign ment as well as	8	Over tighten ing of screw s/bolts	5	Inspec tion of solo part out of	4	160	Print part with onyx and carbo
Rear Motor	Defo rmati on of holes	Fastener s no longer fit part of the arm will	8	Over tighten ing of screw s/bolts	5	Inspec tion of solo part out of	4	160	Print part with onyx and carbo
Hinge base	Fract ure of steel part unde r wear	If the hinge base fractures then the hinge cam would detach causing the arm	8	Fractu re could occur due to fatigue over long period of	3	Inspec t steel part to check for any early signs of damag e or	3	72	Check arm once every year to check for any signs of
Hinge	Hing e pin loose ning	Loss of hinge function, arm	8	Fatigu e from repeat ed	3	Multipl e tests of bone	3	72	Perfor m fatigue testin
Elbow	Angl e misal ignm	Disconf ort/for user due to	2	Fasten ers loosen ing	3	Visual inspec tion of where	3	18	Test multipl e loads
Link arm	Link dete chm ent	Downwar d force causing sudden motion in	7	Fasten ers loosen ing caus	3	Visual inspec tion of where fasten	3	63	Disass emble arm except for the
Battery	Batte ry pack over heati ng/ short	An short or overheati ng could cause an combusti on causing	10	Physic al damag e to the battery or an interna	2	We will perfor m an curdin ully test to check	6	120	In case in fire retard ant materi al
Battery	Con nect or loose ned	System need could cause jerking/s poradic movemen t/ could	5	Vibrati on in battery , poor interna l wiring	4	Visual inspec tion and voltage monito r in	5	100	Use lockin g or threadi ng conne ctors to also
Wire	Insul ation dam age	Exposed short which could	9	Wiring may be cut or	3	Contin uity test, and	6	162	Use wire heavy duty
Elbow	Pad dete chm cave ing	Causes discomfo rt and abrasion	2	Adhesi ve failure due sweat and	4	Test differe nt glove and	6	48	Ensur e correc t glue for this
Thermostat	Crac k arou nd hing e mou	Hinge loses support and arm path becomes unstable. Could	7	Stress conce ntratio n aroun d mount	4	Visual inspec tion after repeat ed cycle	5	140	Add larger fillets/ washe rs, increa se
Thermistor	Wire ping or perm	Misalign ment between belt and arm	5	Heat from enviro nment/	5	Fit check after proton	5	125	Using an materi al which
Motor	Outp ut spike or	Unexpect ed arm movemе nt could	8	Softwa re bug, EMI	3	Bench test with travel	7	168	Add curren t limits, hard
FSR	Sens or drifts low and	Too much force may be applied	8	Sensо r aging, poor calibra	5	Multipl e calibra tion tests	6	240	Add calibra tion routine
Sensor	Fals e high readi ng	System may stop sensing	6	Electri cal noise, loose	5	Monito r live sensor values	5	150	Filter signal in softwa re
Wall bracket	strap loose ns or slips	loss of elbow alignmen t and	5	poor fit, low friction materi	6	fit test with repeati ed	5	150	Ensur e validity of
Harness	Disc onne ction from batt	Device can detach from user	7	Poor stitch ng quality	3	Pull test on strap assem bly	5	105	Produ ct has been well tested
Wall bracket	Belt rotat es arou nd	Arm geometr y shifts and sudden	6	Insuffi cient friction poor	6	Wear test while walkin g and	5	180	Add positin g/grip materi al and
Battery	Con nect or disc	Reduced power loss could	8	Poor retenti on, cable	5	Drop and tug test	4	160	Add lockin g conne
Battery	Cast ing crac ks and expo sure	Reduced protectio n for batteries and higher electrical flux cut	9	Impact from dropp ng, brittle printed housin	3	Drop test and visual inspec tion of housin g	2	54	Increa se wall thickn ess and add impact absorb

Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure
Link 1	3d printed link breaks under stress of the motor torque and the weight of the arm.	The 3d printed material could crack and splinter pieces but these would be low velocity. Arm could collapse therefore loss of support could injure clients arm.
Link 2	Fracture under impact	Loss of elbow support / robotitc arm/ ability.
Motor 1 (base)	Heat overload/ stall	Motor shutdown, motor may heat up could cause burning around 3d printed areas. Arm could freeze mid motion
Motor 2	Thermal overload	Motor shutdown, motor may heat up could cause burning around 3d printed areas. Arm could freeze mid motion
Waist belt	Buckle or strap tear or detachment	The robotic arm could drop and cause damage or injury to client
Hinge	Crack or deformation around bolt holes.	Arm position could shift to an painful position or the arm could collapse.
Motor mount 1 DET002	Crack or deformation around bolt holes.	Motor misalignment, large vibration screw/nut slipping out. Could cause the arm to fall and smash sudden movement may hurt client.
Battery pack	Battery pack overheating/ shorting	An short or overheating could cause an combustion causing an fire.

Wiring	Insulation damage	Electric short which could cause an stop or perhaps even fire.
Elbow cuff attachment SUB03-DET003	Pad detaches causing irritation to skin.	Causes discomfort and abrasion
Thermoform attachment	Crack around hinge mounting holes	Hinge loses support and arm path becomes unstable. could transfer sudden load to user arm.
Thermoform attachment	Warping or permanent deformation	Misalignment between belt and arm structure causing poor assistance and discomfort.
Motor controller	Output spike or software fault causes unintended motion	Unexpected arm movement could startle or injure user.
FSR sensor	Sensor drifts low and under-reads force	Too much force may be applied to arm before system reacts.
FSR sensor	False high reading due to noise	System may stop assisting or behave erratically.
elbow cuff strap	strap loosens or slips during use	loss of elbow alignment and reduced support.
Harness strap	Disconnection from belt	Device can detach from user torso and drop load suddenly.
Waist belt	Belt rotates around torso during use	Arm geometry shifts and assistance becomes inconsistent and potentially harmful
Battery connector	Connector disconnects during movement	Sudden power loss could drop the arm or reset controls.
Battery pack casing	Casing cracks and exposes batteries	Reduced protection for batteries and higher electrical/fire risk. If controller is damaged the entire arm could shut down.

Potential Causes and Mechanisms of Failure	RPN	Recommended Action
Failure in control of motor causing it to spin past the rotation we want. Wall thickness of printed geometry could be too thin.	140	Test different materials at different torque speeds and find what will not break. Also include FEA of material and geometry
Thin wall, large impact, poor printing material.	140	Thicken wall and try different materials.
Torque demand too high, no proper cooling method. Software malfunction	112	Improve ventilation, invest in an heat sink.
Continuous load, user leaning heavily on elbow cup.	112	Add torque limit and thermal cutoff. Improve ventilation.
Fatigue or overload of belt or other mechanical components	120	To use an industry standard belt, add secondary safety tether.
Screws/bolts too lose or too tight weak hinge condition. Undersized pin, poor alignment	105	Invest in an reliable hinge or prototype to find an better joint.
Over tightening of screws /bolts. Poor print orientation	140	Reprint piece checking print orientation using onyx with carbon infill.
Physical damage to the battery or an internal short.	120	In case in fire retardant material.

Wiring may be cut or twisted/broken by harsh edges or rapid movement.	162	Purchase heavy duty wires with extra insulation
Adhesive failure due sweat and shear forces	48	Ensure correct glue for this application is used
Stress concentration around mounting holes, repeated cyclic loading, holes printed/formed too close to edge.	140	Add larger fillets/washers, increase local thickness, and validate with repeated cycle tests.
Heat from environment/body and constant load causing plastic creep.	125	Using an material which will not be affected by low temp of body heat.
Software bug, EMI noise, or bad control signal.	168	Add current limits, hard stops, watchdog, and emergency stop.
Sensor aging, poor calibration, temperature effects.	240	Add calibration routine.
Electrical noise, loose wiring, sensor damage.	150	Filter signal in software and improve shielding/strain relief.
poor fit, low friction material, repeated motion.	150	Ensure validity of Velcro buy testing its grip multiple times.
Poor stitching quality, overload, wear from repeated donning.	105	Product has been well tested by an group member and likelihood of failure is very small
Insufficient friction, poor fit, asymmetric loading.	180	Add padding/grip material and improve belt adjustability.
Poor retention, cable tugging, vibration.	160	Use locking connectors and strain relief.
Impact from dropping, brittle printed housing, falling on an hard surface or squashing between an wall and the back of the belt	54	Increase wall thickness and add impact absorbing outer shell.