SCOPE: NASA is providing a robot shell to universities. The robot will be able to accept umbilical power and will have a software API so that the universities can develop their own software for the system. This hazard assessment assumes that there are no software-based hazard controls.

Some of the hazards identified in the reports below are considered controlled. Other hazards will be the responsibility of the university to control. In these cases, the information necessary to control the hazard will be provided by NASA. This analysis assumes that there will be no modifications to the system other than software.

No.	Hazard	Cause	Effect	RAC Before Controls	Controls	Verification	Disposition RAC After Controls
1	Mechanical Hazards	Sharp Edges Pinch Points Appendage Entrapment	Personal Injury		All pinch points have been identified to the user. Users are instructed to be cautions when working on the internal components of the Robot as there may be sharp edges, holes, pinch points, or burrs present. The users are instructed to keep appendages clear of the robot's joints while motor power is active. All fans are covered with screens. All motors are inside of the system housing.	Inspection User Manual	
2	Touch Temperature	Accessible components get hot	Personal Injury		The users are made aware of potential hot spots internal and external to the system..	Test/Analysis User Manual	
3	Fire	Improper Circuit Protection	Personal Injury Hardware Damage		All components and wires used in the system are correctly rated for their expected use.	Analysis User Manual	

No.	Hazard	Cause	Effect	RAC Before Controls	Controls	Verification	Disposition RAC After Controls
4	Electric Shock	Improper Mating/Demating of power cables Improper Grounding Exposed Conductive Surfaces	Personal Injury		All conductive surfaces accessible to the user have a low impedance path to ground. The positive terminal of the power supply is DC isolated from the chassis and the ground. The negative terminal of the power supply is DC isolated from the chassis and the ground. The power connector is keyed to prevent clocking when mating the connector. The power connector is designed such that the backshell makes contact with the mating connector's backshell before the pins make contact. If internal components are being accessed, it is recommended that the user remove power from the system prior to opening the system. If power needs to be applied for maintenance activities, users will avoid contact with conductive surfaces.	Grounding test User manual Isolation tests	
5	Electromagnetic Interference	Emitters	Hardware damage		Known emitters are identified.	User Manual	
6	Non-ionizing radiation	LASERs Infrared Emitters	Personal Injury		The MultiSense SL 3D Range Sensor uses a 905nm Class I LASER. Class I LASERs are safe under all conditions of nominal use.	MultiSense SL User Manual Camboard nano manufacturer information and analysis.	

No.	Hazard	Cause	Effect	RAC Before Controls	Controls	Verification	Disposition RAC After Controls
					The Camboard nano 3D Time of Flight (ToF) sensors use a peak wavelength of 850nm and a radiant intensity of 320 mW/sr. At this intensity, the sensor can be viewed safely for up to 200s at a range of 2in from the emitter. There is no need for the user to be that close to the sensor for that length of time. The wireless Emergency Stop button uses several radio frequencies. These are all below levels that would create a risk to the operator under normal conditions.	E-Stop Radio Frequency analysis	
7	Lift-related injury	Improper Lift	Personal Injury		Shipping container includes features to facilitate proper lifting (handles, etc.) NASA will provide a lift plan.	Inspection Lift Plan	

No.	Hazard	Cause	Effect	RAC Before Controls	Controls	Verification	Disposition RAC After Controls
8	Toxic Materials	Exposure to Capacitor Electrolyte Exposure to Battery Electrolyte	Personal Injury		Capacitors and batteries are used within their ratings and specifications	Analysis	
9	Falling Mass	Failure of Support Structure Robot Falls when Free-walking	Personal Injury Hardware Damage		If the robot is free-walking (unsupported by external structure), maintain an 8 foot radius keep out zone around the robot (8' assumes the robot height plus a factor of safety). If the robot is supported by external structure, the users will ensure that the structure and cabling/harnesses can support up to 500lbm (weight of the robot plus a factor of safety). Robot attachment points can support up to 500lbm.	User Manual User-provided structural assessment Analysis	

No.	Hazard	Cause	Effect	RAC Before Controls	Controls	Verification	Disposition RAC After Controls
10	Excessive Force	Software Failure Hardware Failure	Personal Injury Hardware Damage		NASA will quantify the velocity/momentum capabilities of the robot based on conservative assumptions. The users are informed of the robot's capabilities. The users may develop software to limit the capabilities of the robot so that it is safe to interact with while powered. Until such software is in place and verified, the users will maintain a 5 foot radius keep out zone while system motor power is active (5' assumes the length of a limb plus a factor of safety).	User Manual	