EXECUTIVE SUMMARY

The ModLock is a strong, easy to manufacture locking mechanism that can be used to quickly assemble and disassemble a modular robot. Modular robots are mechanisms built of modules that can be separated and recombined in a variety of configurations. The device is comprised of a plastic component and a stainless steel plate that lock together. The plastic piece has dowel pins pressed into it that slide into the steel plate's grooves, thus shifting four screws on the plastic piece into a locked position, hooking onto the metal plate. [1] Our sponsor uses the ModLock to construct various modular robots and now desires to build larger modules with higher load capacities and space for larger motors. Therefore, he has tasked us with redesigning the ModLock to be larger, stronger, and easier to use than the current model.

The most important user requirement of the new ModLock design is maintaining the functionality of the current ModLock while increasing the size and strength. The new ModLock must rigidly lock two modules together and be able to be unlocked when the modular robot is fully assembled. The current ModLock has the face dimensions of 60 mm x 60 mm and supports loads of 2 kN in tension and 15 Nm in torsion. The new ModLock must have a length and width of 100 mm and support four times the load (8 kN in tension and 60 Nm in torsion). We must design the new ModLock to maintain the low cost ($1-10 per ModLock), resistance to adverse environmental conditions, and ease of manufacturing. The new ModLock must also be quickly and easily assembled by the user (in less than 7 seconds). Our sponsor also desires that the new ModLock design have the ability to be scaled arbitrarily to connect modules of arbitrary sizes.

We have researched quick locking mechanisms and have generated many concepts for the new ModLock design. The final new ModLock design is similar to the original ModLock, but it utilizes translational rather than rotational motion to lock the connectors. The new design uses load-bearing screws fastened to metal thread inserts to secure the two connectors and support the tensile and rotational loads. The new design also has dowel pins in compliant levers to lock the connectors in place. The user inserts the screws on the plastic ModLock piece into the track on the metal plate and presses the compliant levers to allow movement. The user then slides the ModLock in one of four translational directions and the screws enter a locking groove. The connectors lock into place when the levers are released. The ModLock is released when the user presses the compliant levers and returns the ModLock to the unlocked position.

The new ModLock prototype meets nearly all our customer requirements. It can rigidly lock two robotic modules together and it allows the user to unlock any modules in a closed loop modular configuration. The design can be easily assembled because the linear engagement motion is intuitive. In addition, the new ModLock design costs $9.11 per ModLock, which fits into the low cost ($1-10) user requirements. The new ModLock maintains the ease of manufacturing of the original ModLock design because it utilizes similar components and a simpler manufacturing process. The female connector of the new design has a symmetric locking pattern for easier locking and the linear locking motion allows the design to be arbitrarily scaled. In addition, the new ModLock design holds the required torsion load of 60 Nm with no plastic deformation. The prototype also meets the quick assembly requirement with a user assembly time of less than 5.8 s.

The new ModLock can hold a tensile strength of 7.6 kN, which falls just short of the 8 kN tensile load goal. However, our sponsor indicated that this tensile strength of 7.6 kN is more than suitable for the project design. Our team has performed an FEA simulation to show that a thicker steel module should hold the 8 kN tensile load. However, the thicker steel would increase the ModLock price to $10.34, which is beyond the cost requirement. If our sponsor determines that the strength benefit outweighs the cost requirement, we recommend that our sponsor perform a physical tensile load test on the thicker steel to validate that it holds a tensile load of 8 kN.