Evolution of the Utah Arm to Improve User Function
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An ambitious re-development of the Utah Arm was guided by direct clinical feedback, producing a list of features to improve the full-electric prostheses. The goals of the development focused on the following:

• Smoother transition from elbow motion to hand function, and vice versa, i.e., more effortless locking and unlocking by the wearer, with many more locking positions.
• Quieter operation of the elbow, both during the locking and unlocking operations (which can produce an audible “click” of the lock pin), and during the powered freeswing function, which produces audible motor and gear noise.
• More convenient connection of the prosthesis to the prosthetist’s or therapist’s computer for adjustment and training, which required a hard-wired connection of cables.
• Wider range of input devices, as well as TDs, to take advantage of all available input sensors and output devices.

Rather than “start over”, the technical capabilities and approach of the existing Utah Arm full-electric system were used as a starting point, giving more advantages than disadvantages. Development time is greatly shortened by taking the approach of modifying an existing component, without the risks of using unproven designs. It is important to realize as well – the product is intended for clinical, rather than laboratory use, so practicality is of a very high priority.

Design innovations were directed at improving ease and comfort for high-level prosthesis wearers and improving the ease of fitting. Improvements in the U3 ‘Plus’ system include:

• Dual Locking System – a continuous friction lock supplements the high-load lock pin. This innovation provides an infinite number of locking positions for the friction lock. Also, the first-stage friction lock can be more quickly engaged, since the lock pin (requiring motor activation time) only is used with the 2nd-stage of locking. The lock pin, used reliably with all previous versions of the Utah Arm, is activated in the dual-lock system only upon loading the forearm with over five pounds (2.2 kg.). Since the system retains the load-sensing system, the automatic lock required only a modification of the control system to implement the automatic locking. Early clinical use of the U3+ system shows that the 2nd stage lock is activated in ~10% of activities, since high-level prosthesis wearers seldom lift loads of this size.
Figure 1 – (left figure) The Dual-Locking system now allows continuous locking at infinite positions. Also, reactivating of flexion or extension is immediate after 1st stage friction locking, since the lock pin is not engaged. 2nd stage locking requires the lock pin, but is utilized only ~10% of tasks, according to wearers. Silent freeswing is now possible, with a new mechanism in the existing Link Arm. The mechanism will automatically disconnect the elbow drive at the fully-extended position of the elbow

• Silent Freeswing effectively lowers the perceived noise of the elbow operation, by incorporating an innovative automatic disconnect of the drive, saving battery power, and eliminating noise. The momentum of the elbow when it ‘bumps’ slightly at full extension (actually 15 degrees of flexion), disconnects the two-part Link Arm, so that freeswing without any power consumption, nor without sound, is now possible. The mechanism has been laboratory tested to several hundred thousand cycles without failure.

• Wireless Bluetooth Adjustment Communication – an inconvenience during adjustment and/or training during use of the prosthesis has been the hardwire connection of the Computer Interface Module, which limited the activities possible with the prosthesis during adjustment/training. Using the now ubiquitous Bluetooth communication, existing circuit board designs, and existing serial port communication systems can be utilized by connecting a simple “dongle” type transceiver to the prosthesis, and an existing Bluetooth/USB adapter to the computer. Modifications to software are the only other requirements. It is important to note that, the hardwired system, previously used, is still available as a backup whenever the Bluetooth system is unavailable.
Figure 2 – the Bluetooth adapter system easily converts the existing controller to wireless connection with the clinic’s computer, or laptop. A further advantage is that all previous microprocessor controllers made by Motion Control may be used with the Bluetooth system, without modification.

- Compatibility of Inputs and TDs – software innovations allow nearly all input sensors in the marketplace, and the full variety of TDs to be interchangeable with the new system.

Figure 3 – Compatibility with existing TDs, across the range currently available, is important in prosthetics. No single manufacturer, at present, offers all features available in all terminal devices.

- Modularity – the original design concept has been maintained, providing serviceability important with sophisticated systems.
Figure 4 – Modularity has always been a cornerstone of the Utah Arm system. New innovations have been developed without sacrificing this original concept, which allows easier service in the field, and practical interchangeability of components by prosthetists, and in the case of batteries, TDs, and a few other components, by the wearers themselves.