Factors to Consider when Selecting a Powered Elbow Prosthesis

• **Weight Lifting Ability** - the Boston Digital™ Arm is an extremely strong powered prosthesis. It delivers more than 10 ft-lbs of torque, more than three times that of its closest competitor. This results in a maximum lift for a typical prosthesis (with a forearm length of 14", elbow centerline to TD grasp point) of about 9 pounds. Since elbows are generally equipped with electric hands or grippers weighing as much as 1.2 pounds, the active lift is reduced to about 8 pounds.

• **Reverse Locking Clutch** - the Boston Arm has a reverse locking mechanism so that it can lift greater weight passively once the elbow's motor is locked. Depending on the socket and harnessing, it can lift 50 pounds passively. The Boston Arm's reverse locking clutch can be unlocked under load, enabling it to lower a heavy weight.

• **Speed** - the Boston Arm is fast, completing a full excursion in about one second. Its superior torque shows up in the measure of speed when a terminal device is added (1.2 pound Greifer). The elbow is essentially unaffected by this weight.

	no load	with 1.2 lb load
flexion (against gravity):	1.1 sec	1.2 sec
extension (with gravity):	1.0 sec	1.0 sec

• **Weight of the Elbow** - the Boston Arm assembly weighs about 2 lb 4 oz. It is compatible with the Centri UltraLite hand, SteeperLite hand, Steeper Powered Gripper, Otto Bock hand or Greifer. When prosthesis weight is an issue, the Boston Arm can use one of the light-weight hands listed above to accommodate the patients physical limitations. For example, a Boston Arm with a SteeperLite hand weighs just 2 lb 15 oz, approximately 4 oz lighter than competitor's systems.

• **Weight Distribution** - the Boston Arm has the heavier components mounted proximally in the forearm. The electronic circuits are located in the forearm and the battery is mounted near the elbow joint. The center of mass of the prosthesis is 3.5" from the rearmost point on the elbow.

• **Control Options** - the Boston Arm has many control options to suit the patient's unique needs based on anatomical, muscular and other physical or neurological constraints. The prosthesis can be controlled with myoelectrodes, Touch Pads (FSR - force sensitive resistors), switches or a servo transducer. This wide variety of choices allow the prosthetist to fit each patient with the optimal control strategy. The Boston Arm is a myoelectric system that can be configured to one of the following controls:

  • **Myoelectrodes** - the Boston Arm's electrode preamplifiers are significantly smaller than competitors, about half the size. Prosthetists want to create a socket that does not have unsightly bumps where the electrodes sit, so these electrodes are beneficial. The Boston Arm's electrodes measure; 1" long x 11/16" wide x 3/16" thick. Myoelectrodes provide proportional control of the prosthesis.

  • **Touch Pads**™ - the Boston Arm can be configured to use Touch Pads in lieu of myoelectrodes. These are wafer-thin disks that adhere to the inside of the socket or the frame where the amputee can conveniently press them. They are an excellent alternative to myoelectrodes for amputees who have weak muscle signals or a shoulder disarticulation. Touch Pads also provide proportional control of the prosthesis.

  • **Servo** - the Boston Arm can be configured to operate with a positional-servo transducer. This is a small cable-operated device that mounts to the harness. It provides both speed and position control of the prosthesis.

  • **Switches** - the Boston Arm can be configured to operate with switches. These are available in a wide variety of pull and push choices. Switches do not provide proportional control of the prosthesis.

  • **Multiple or Sequential** - the Boston Arm can be configured to allow multiple control of two or even three devices at the same time if the amputee has sufficient control sites. Other amputees may prefer sequential operation of their prosthesis, where Myoelectrodes or Touch Pads control several devices, one after the other.

• **Mode Selection** - the Boston Arm offers several function switching options for sequential operation of the elbow, TD and wrist (if used). Co-contraction of input signals (myoelectrodes or Touch Pads) is the most popular, but various switches (i.e. nudge, chin, harness, bump, etc.) can also be used to select mode.

• **Proportional TD Controller** - the Boston Arm has proportional control for the elbow and terminal device(s). The proportional controller allows the patient to regulate the speed of the device (elbow, wrist, hand) for better control.

• **Batteries** - the Boston Arm is supplied with two 12 volt 1100 mAHr removable battery packs. One battery usually provides sufficient energy to power the prosthesis for an entire day. If the patient is an extremely heavy user, or if the prosthesis has several powered options (wrist rotator, electric hand/ gripper) and the battery does not have sufficient power to last all day, the user can top-off the battery while in the prosthesis using the fast charger provided. Alternatively, they may replace the battery. However, the 30% larger capacity battery means a significantly longer operating time for the user.

• **Battery Installation** - the Boston Arm's replaceable battery is inserted through an access cover on the top of the forearm. The Boston Arm's battery can be mounted remotely (when there is room above the elbow), but this rarely seems to be necessary in actual practice.

• **Battery Charging** - the Boston Arm has a built-in recharge connector that allows the patient to charge the battery in the prosthesis rather than removing it. The elbow is provided with a spare battery, but generally it is not necessary because of the on-board charging capability.

• **Chargers** - the Boston Arm comes with both a fast charger and a slow charger for the patient's convenience. The slow charger is a small, light-weight wall-mounted transformer that is convenient to use while traveling. The fast charger can recharge an elbow battery in about one hour and this can be done while the battery remains in the prosthesis.

• **Humeral Rotation Friction Adjustment** - the Boston Arm has patient-adjustable humeral friction that allows the patient to secure the elbow in any position or to rotate with controlled friction.

• **Elbow Disarticulation Patients** - the Boston Arm is available with a special elbow disarticulation coupling collar to minimize the length of the prosthesis and to keep the elbow hinge proximal. This collar allows the patient's residual limb to come to within 2.8 inches of the bottom of the flexed elbow, considerably shorter than competitive systems.

• **Forearms** - the Boston Arm is offered with custom forearms to match the anatomical dimensions of the patient and to accommodate various wrist and hand sizes. Forearms are available in four diameters and 11 standard colors to match the skin tone of the patient. The range of lengths of the elbow (from rearmost point of flexed elbow to wrist) is 8.5 to 14.5 inches and the maximum circumference is 9.5 inches.

• **Terminal Device Compatibility** - the Boston Arm can be used with many terminal devices: SteeperLite hands, Centri UltraLite hands, Otto Bock hands, Steeper Powered Grippers, Otto Bock Greifer and of course, body powered TDs if the patient prefers. The Boston Arm forearms can be ordered to mate with wrists from any of the major suppliers of friction wrists, quick disconnect wrists or even wrist rotators.

• **Free Swing** - the Boston Arm has a mechanical free-swing feature providing 45 degrees of free swing to facilitate a normal gait while walking. This feature uses no battery power!

• **Modular Construction** - the Boston Arm uses modular construction to facilitate assembly and servicing. Circuit boards are constructed with state-of-the-art Surface Mount Technology (SMT) for maximum reliability and durability. These are mounted on a back plane (mother board) and can be swapped-out rapidly for trouble-shooting and repairs.

• **Drive Train** - the Boston Arm uses modern direct drive gearing technology and a "wave generator" to achieve the necessary gear reduction resulting in superior torque and speed.

• **Noise Level** - the Boston Arm cannot be heard above the background noise level in most active environments (i.e. busy office or restaurant, mall, city street, industrial setting, etc.). Clothing over the prosthetic arm helps to reduce the noise emitted and generally, the noise level is lower for slower speeds and lighter loads. More power often results in greater noise, and the patient must consider this trade-off.

• **Cost** - prices vary considerably and it is difficult to make direct comparisons because of configuration differences, options, discounts, etc. However, generally a Boston Arm system is 15-20% less expensive than competitive electric arm prostheses.

• **Warranty** - Boston Arm's come with a two year limited warranty against defective materials or workmanship.

• **Reimbursement** - In January 1997, the Health Care Financing Administration (HCFA) revised their L-codes, making the Boston Digital Arm reimburseable under code **L7180**. Boston Arm systems that provide proportional control such as; myoelectrodes, Touch Pads, and Servo-control also qualify for L-code **L7274** - "Proportional Control". Boston Arm systems using switch control will now use code **L7180-52**. The "-52" modifier alerts the reimbursement agency that this is a less costly version of the Boston Arm system. Medicare reimbursement (2003 median) for L7180 is $28,924 and L7242 is $5,349.