



Bio-Robotics: The DEKA Luke Prosthetic Arm

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Agenda

- **About DEKA**
- **Prosthetic Arms**
- **Bio-robotics**
- **DARPA Revolutionizing Prosthetics Program**
- **The DEKA Luke Arm System**
 - Arm overview
 - Arm demo

About DEKA Research & Development Corp.

- Invention and systems engineering company founded and led by pioneering inventor Dean Kamen
- Located in the historic Manchester Millyard for over 30 years
- Birthplace of the Segway
- Successful track record for commercializing sophisticated medical devices including an FDA Class III stair-climbing wheelchair
- FDA-inspected and approved development processes and systems
- Medical device manufacturing facilities shipping a variety of patient-connected devices for Fortune 500 clients





Prosthetic Arms

- **An artificial device used to replace a missing or defective limb**
- **First prosthetic arms thought to be used 1,000 years ago**
- **Movable joints with control used in early 1800s**
- **US government agency for advancing protheses formed in 1945 after WW II**
- **Largely unchanged since then**
- **The standard of care today is a body-powered "hook"**



What is Bio-robotics?

- A sub-field of robotics in which robots emulate or simulate a living biological organism
- Most work is done in Research settings



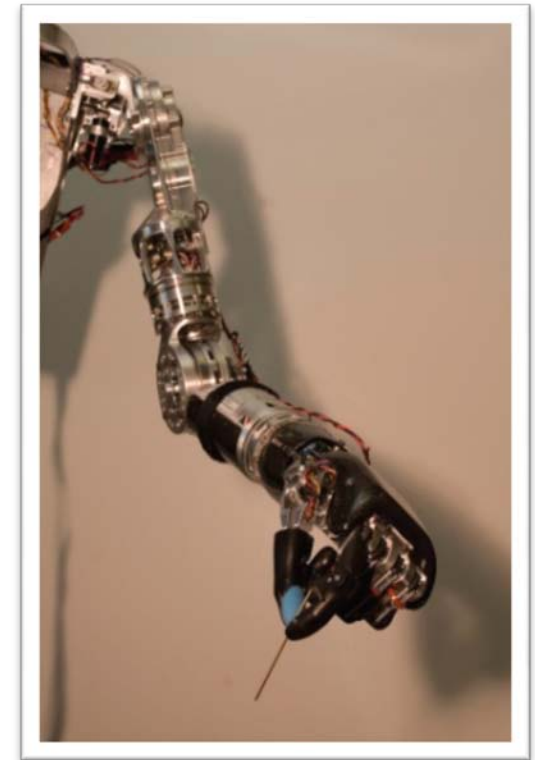
DARPA Revolutionizing Prosthetics Program

- **DARPA: Defense Advanced Research Projects Agency, an agency of the Department of Defense**
- **RP Program launched in 2006 to advance the state-of-the-art of upper limb prosthetic technology**
 - Far behind lower-limb prosthetics
- **Created to support US military wounded warriors**
- **The program includes:**
 - Research on brain control and other advanced control schemes for robotic assist devices
 - Development of advanced, modular prosthetic arms
 - Testing of the arms in a clinical setting

DEKA's role

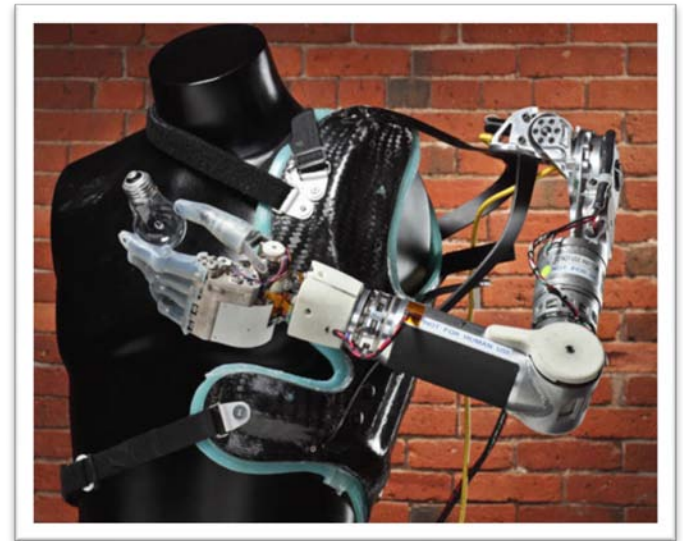
The DEKA Luke Prosthetic Arm – Gen 1

- **Project started at DEKA in 2006**
- **Design goals:**
 - Simultaneous control of multiple powered degrees of freedom
 - Advanced grasp control
 - Touch feedback
 - Strength, range of motion, and speed to perform Activities of Daily Living
 - Tolerance to outdoor environments
 - Advanced control schemes
- **Consulted with many industry experts such as prosthetists and research scientists**
- **Designed by a small team at DEKA comprised of mechanical, electrical, system, and software engineers**
- **World-class in-house machine shop including rapid prototyping capability**
- **First generation proof-of-concept functioning prototype produced in less than 1 year**



Luke Gen 2

- **Refinements made to the initial prototype**
- **Designed to be a clinical study platform**
- **Modular to support 3 different amputation levels**
- **Tested by many subjects during studies at DEKA and at VA Medical Centers**
- **Feedback from the studies was directly used to support the design of the production-intent model**



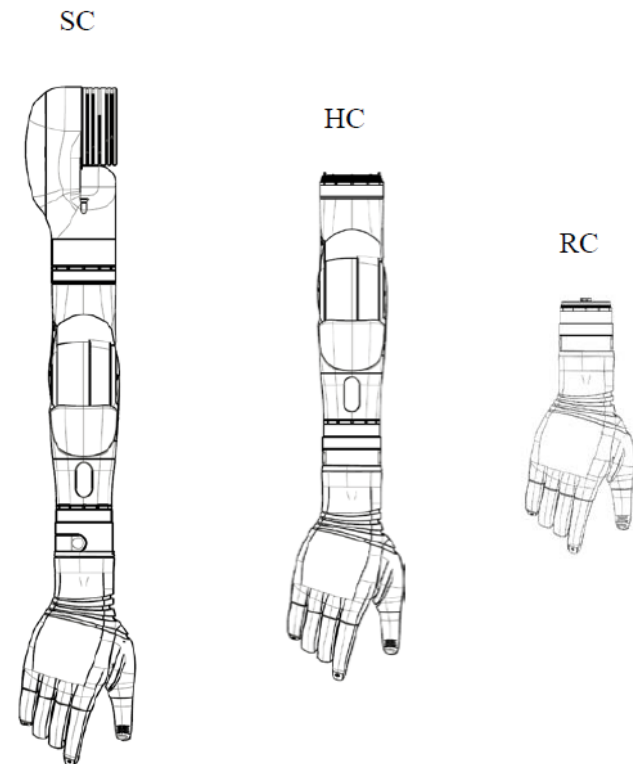
The DEKA Luke Gen 3 Arm System



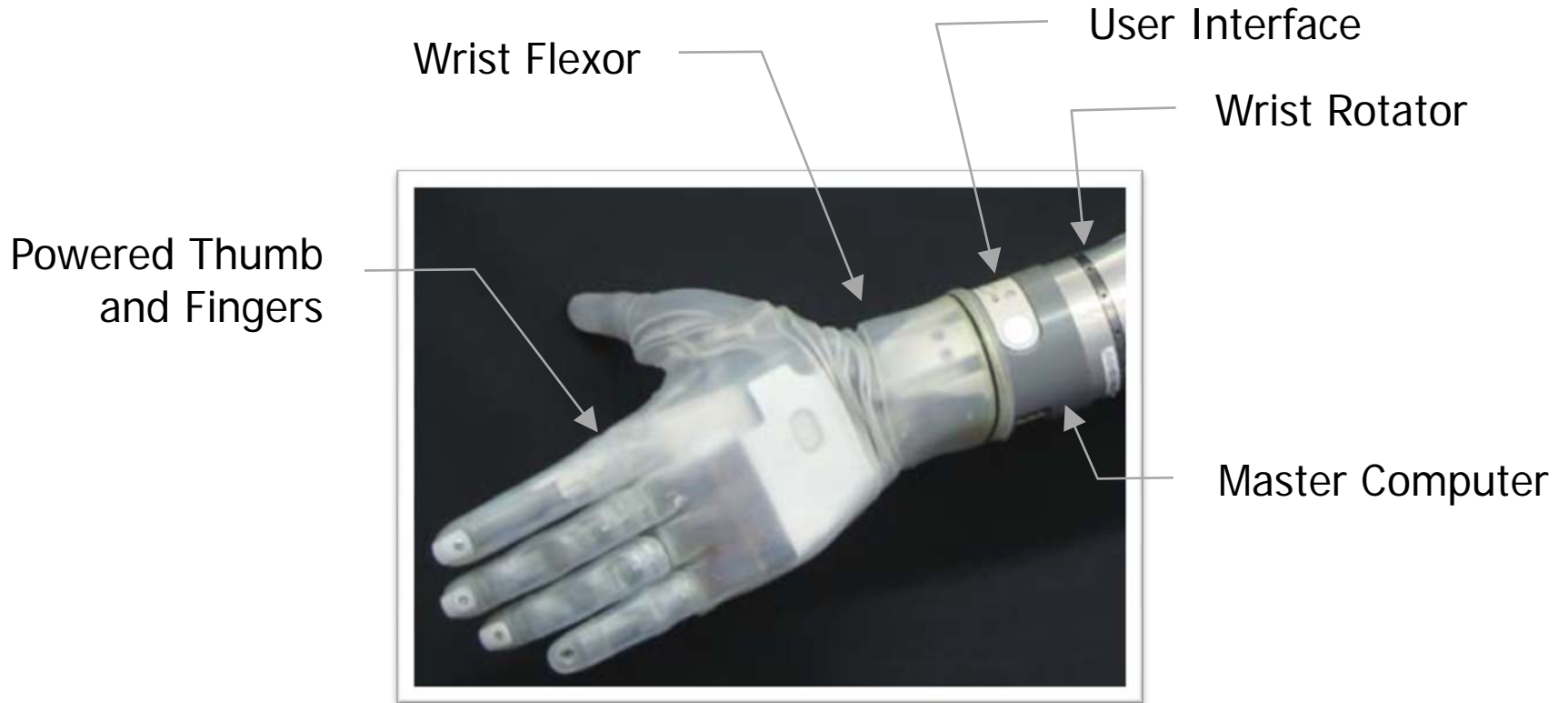
DEKA Integrated Solutions - Proprietary

Gen 3 Arm System Overview

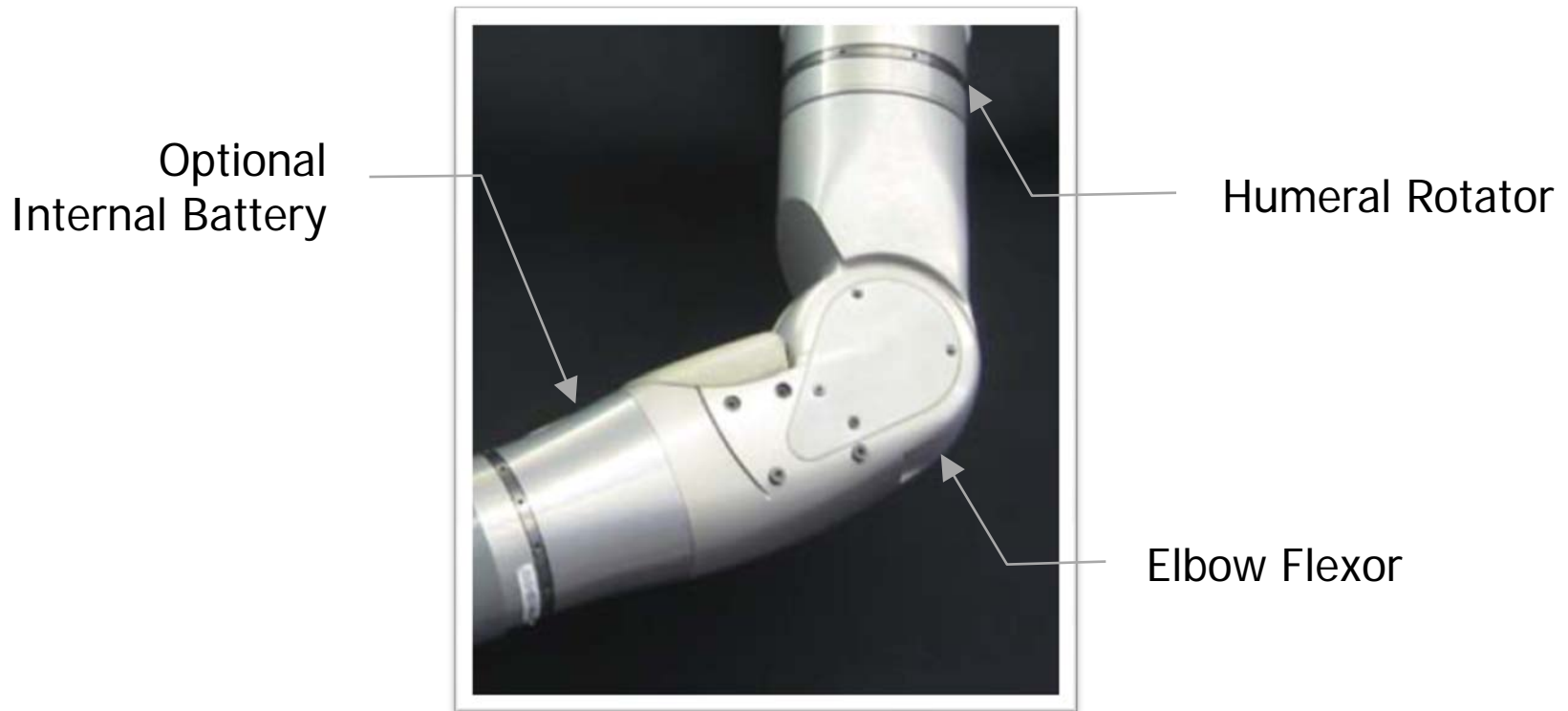
- **10 active degrees of freedom**
 - 5 brushless DC motors
 - 5 brushed DC motors
 - Absolute position feedback in all joints
- **6 pre-programmed hand grips**
- **Modular and available in 3 configurations for different amputation levels**
- **Configurable upper arm and lower arm lengths**
- **Rechargeable Li-Ion battery system**
 - Configurable battery system
 - Up to 2 batteries; 1 user-replaceable, 1 internal
- **Multiple user input devices available for control of the arm**



Hand and Wrist Module



Elbow Module



Shoulder Module

Tightly Integrated
Shoulder Flexor
and Abductor



User Input Devices

- **User input devices are either wired to an input module or connect wirelessly to the arm**
- **Industry-standard digital or analog input devices can be used such as:**
 - Surface Electromyography (EMG) sensors
 - Detect muscle contractions
 - Pull switches
 - Linear transducers
 - Bump switches
 - Force sensing resistors
- **DEKA-designed input devices:**
 - Pressure transducer with analog output
 - Inertial measurement unit (IMU)

Arm Demo





External References

- **Wikipedia, www.wikipedia.org**
- **University of California – Irvine, biorobotics.eng.uci.edu**
- **Carnegie Mellon University, www.biorobotics.org**
- **Boston Dynamics, www.bostondynamics.com**
- **DARPA, www.darpa.mil**