

Mobility redux: Post-World War II prosthetics and functional aids for veterans, 1945 to 2010

MARCHING ON THE U.S. CAPITOL: 1945

Protesting World War II (WWII) veterans marched on the U.S. Capitol in Washington, DC, in mid-1945 after the war ended, many defiantly holding their prosthetic legs and arms in the air and shaking them as if wielding clubs and intimidating their enemies—members of the U.S. Congress.

Their protests came from the Capitol's gallery, where the veterans gathered to voice their anger about their inferior artificial arms and legs, provided by the lowest-bidding contractor because of prevailing Government regulations. This was the way WWII veteran amputees shouted their message loud and clear: Congress, we have a big problem—one that affects our lives every day—substandard prostheses for us, returning veterans, as compared with higher-quality devices prescribed for civilian amputees.

This march of defiance and anger over how they were inadequately treated immediately drew the attention of journalists who reported the plight of the amputees in the Sunday newspapers and supplements. The headline stories around the nation informed Americans of the veterans' plight for the first time [1].

No Government agency or process was in place after WWII to fit and provide quality artificial limbs to wounded veterans. In the end, this new awareness by Congress and American taxpayers of veterans' real and urgent problems after returning from battle positively influenced the passage of important legislation for post-WWII veterans. On November 1, 1945, in response to both the angry amputee veterans and Congress, the Veterans Administration established the Prosthetic Appliance Service [2], which would evolve into the Veterans Administration's Prosthetics and Sensory Aids Service (PSAS) in 1948 [3].

FEBRUARY 1945 IN YALTA AND CHICAGO

Earlier, in February 1945, just days before Roosevelt, Churchill, and Stalin met at the Yalta Summit, an important meeting took place on the Chicago campus of Northwestern University. Among the attendees was U.S. Army Surgeon General Norman Kirk, an orthopedic surgeon.

As a result of this meeting, Dr. Kirk asked the National Academy of Sciences (NAS) to initiate and plan a research and development (R&D) program with the mandate to improve prostheses by applying technology from other specialized fields. This meeting was significant in the history of prosthetics because it marked the start of Federal funding for rehabilitation research. In addition, the Chicago meeting established the fields of science, medicine, and

engineering as integral specialty disciplines required to solve the complex problems of restoring mobility to veteran amputees. This point in history is when prosthetic fabrication, traditionally considered a craft, began its future trajectory into the scientific method.

The National Research Council (NRC), established in 1916 during World War I (WWI), is known as one of the four NASs. The NRC again convened after WWII in response to the large numbers of war-injured. The NRC then formed the Committee on Prosthetics R&D, which was organized to care for and treat the 27,000 U.S. soldiers who lost arms or legs during the battles of WWII.

During his WWI service, Dr. Kirk established clinical policies in response to the NRC initiative. The goal was to provide the best possible care to amputees. After WWI, Kirk also helped establish a network of amputee centers around the nation that provided the specialized care that veteran amputees needed. Then in the post-WWII years, he drew on this valuable experience for the unprecedented expansion of hospitals and other care centers.

“The U.S. Army built seven amputation centers under Kirk’s leadership, each with the capability to provide up-to-date surgical, medical, prosthetic, and rehabilitative care” [4].

GENERAL OMAR BRADLEY ESTABLISHES PROSTHETICS AND SENSORY AIDS SERVICE: 1948

Six months after the Yalta Summit, in August 1945, President Harry S. Truman appointed U.S. Army General Omar Bradley as Administrator of the Veterans Administration. General Bradley began to modernize and restructure the antiquated Veterans Administration system to meet the challenges brought forth from 12 million demobilized veterans post-WWII [5]—a historic record number of discharged veterans. Before the end of WWII, the Veterans Administration was responsible for approximately 5 million veterans. By 1946, almost 17 million were on its rolls [5].

Among the many changes General Bradley initiated during his 2 1/2 years as Administrator of the Veterans Administration was the development of the new service that would be responsible for the provision of prosthetics—the PSAS [5].

The origins of PSAS began on June 19, 1948, when Congress passed Public Law (PL) 792, which formally authorized a program of Veterans Administration research in prosthetics, orthotics, and sensory devices. Congresswoman Edith Nourse Rogers from Massachusetts introduced the law and became its primary advocate. PSAS was authorized a set budget of \$1 million a year, and the law mandated the Veterans Administration “to make available the results of such research so as to benefit all disabled people” [6].

This occasion was the first that an actual annual budget was set for prosthetic and sensory aids rehabilitation for WWII veterans. With this budget, the Veterans Administration funded both intramural and extramural R&D programs in the fields of prosthetics and functional aids, such as developing artificial legs and arms, hearing aids, and vision aids.

This substantial increase in research funding and the establishment of the R&D program during the postwar years resulted in more sophisticated and highly engineered prostheses that could be upgraded at any time during a veteran’s life. Moreover, the PSAS resulted in new research and a significantly improved system of transition of soldiers from Active Duty (with the loss-of-limb injury and initial treatment) to veteran status (with long-term rehabilitation, upgrade of prosthetic device, and specific advanced training for the amputee)—all to gain the most benefit and function from their body-prosthesis integration.

TRANSITION FROM ACTIVE MILITARY DUTY TO VETERANS ADMINISTRATION

Before the post-WWII years, the veteran’s transition from Active Duty military to active ranks of the Veterans Administration was often chaotic, with inconsistent and inequitable results. This chaos resulted because the process was not well designed, organized, managed, or executed. One Government regulation in particular that worked against war-

injured, rehabilitating veterans was the contractual procurement process that was designed to honor the lowest bids, thus setting up a conflict between cost and quality.

“A typical amputee received a temporary artificial limb when he left the service and was referred to VA [Veterans Administration] for a permanent limb. But when he went to VA, in many cases he got a ‘prescription’ for a prosthesis supplied through a contract with the lowest bidder” [3].

The system was not doing enough to provide quality devices to wounded veterans—that is why angry veteran amputees marched on the U.S. Capitol building in 1945 to vent their anger and let their voices be heard.

Even before PL 792 formally authorized the Veterans Administration’s R&D program, research was already under way. But starting in 1948, the all-important line item was added in the Veterans Administration budget to support it. Consequently, prosthetics research became a legal Veterans Administration entity 10 years before the medical research program was written into law in 1958.

From 1947 to mid-1970—when the Veterans Administration set up its own Rehabilitation R&D Merit Review Board—committees of the NRC of the NAS reviewed requests for support of rehabilitation research. Before the PSAS was established in mid-1948, the Committee on Artificial Limbs and the Committee on Sensory Devices established direct contracts on behalf of the Veterans Administration and the armed services. This contractual program continued until the R&D Merit Review Board was formed in the seventies.

“The Advisory Committee on Artificial Limbs was also formed in 1947, and multiple research facilities were organized through the Veterans Administration and the armed services. The program was funded by the Veterans Administration, Navy, Army, and Office of Scientific Research and Development. The responsibility of the Committee was to review potential research projects in the field of artificial limbs and advise the Veterans Administration when—in the Committee’s opinion—a device or technique had reached the point that it should be offered to amputee veterans” [7].

EVOLUTION OF ARTIFICIAL LIMBS SINCE WORLD WAR II

Prosthetics fabrication in the United States remained largely unchanged through WWII. During that war, an amputee typically received a temporary artificial limb when he or she left the service and was referred to the Veterans Administration for a permanent limb.

As previously mentioned, the Veterans Administration prescribed amputees a prosthesis that was supplied through a contractor who was the lowest bidder. After veterans marched on the Capitol in 1945, the Veterans Administration responded by centralizing its prosthetics operations and Congress gave Veterans Administration more flexibility in providing prosthetics.

The years from 1947 to 1948 were landmark for postwar prosthetics. With the new legislation in place, a mandated annual budget, and the start of the PSAS, other new technologies evolved more rapidly. An armada of developmental surges in several research areas and facilities—including materials sciences and, later, microprocessors—would create an entirely new generation of upper- and lower-limb prostheses.

The early R&D program was under the leadership of Paul B. Magnuson, Veterans Administration Chief Medical Director and architect of the Veterans Administration medical system after WWII (1948–1951) [8].

Eugene F. Murphy, PhD, joined the Veterans Administration prosthetics program as its Assistant Director for research in 1948—the same year the PSAS was established. Murphy was familiar with the earlier 1940s prosthetics studies of Paul Klopsteg at Northwestern University. Because of Northwestern’s proximity to Illinois Institute of Technology, Murphy was closely connected with Dr. Vern Inman’s landmark studies of human gait that began in 1945. (See 50-year time line chronology of prosthetics from 1945–2010 on pages x–xi and in the [Appendix](#), available online only.)

The Veterans Administration established 30 multidisciplinary amputee clinics across the country in 1949 and an educational program for the specialists

1940s



1945



1947



1948



1949

1950s



1952



1956

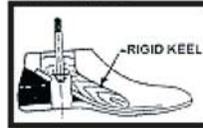


1956



1958

1960s



1960



1965



1968



1969

1970s



1970



1970s



1972



1974

1945: WWII ends in Europe; Germany surrenders in late April-early May.

1947: Hans Mauch and Ulrich Henschke design first hydraulic knee prototype in Ohio lab.

1948: Congress passes law to start VA's Prosthetics & Sensory Aids Service.

1949: VA builds 30 amputee clinics across United States.

1952: UCLA begins course for VA clinical teams in upper-limb prosthetics.

1956: VA Prosthetics Center, an R&D lab, opens in NYC.

1956: Prosthetics Research Lab opens at Northwestern University, Chicago, funded by VA.

1958: Congress passed law recognizing medical research as VA mission 10 years after prosthetics R&D law passed.

1960: SACH (Solid Ankle Cushion Heel) foot goes to market—improves component for lower-limb prostheses.

1965: Electric Elbow with flexion-extension motions (myoelectric prosthesis) is developed by VA & Northwestern PR lab.

1968: Closed-circuit TV reader for visually impaired. Thesis project by 2 MIT seniors. VA funds commercial tech transfer.

1969: Visotactor B reading machine for blind people is developed and tested by VA.

1970: VA R&D of "synergetic hook" prototypes, interchangeable with prosthetic hand. Amputee attaches hook to prosthesis.

1970s: CAD-CAM technologies is first adapted to prosthetics and socket design in 70s and 80s.

1972: Prototype upper-body prosthesis (with powered control of shoulder flexion, elbow, and hook) is tested by VA Prosthetics Center.

1974: "Talking Brooch": Portable communications device for people who could not talk but could input words on keyboard to be read.

1940s

1950s

1960s

1970s

1980s



1980s



1980s



1985



1987

1980s: Computer-Aided Robotic Arm/Worktable allows paralyzed patients to feed themselves. Chin controller works robotic arm or wheelchair.

1980s: Laser cane research helps blind Korean war vets. Laser canes emit 3 tones that match obstacles at head, waist, and curb levels.

1985: Hiking amputee rests on icy slope and inspects his Seattle Limb System (knee, leg, foot) developed by VA.

1987: RR&D funds advances in digital hearing aids in 80s. More than 300,000 vets with service-connected hearing loss; more with age-related impairment.

1990s



1990s



1991



1997



1998

1990s: Wheelchair racing is healthy sport for persons with paralysis, keeping them strong in body & spirit. Several *JRRD* articles cover racing techniques & wheelchair advances.

1991: Cleveland Functional Electrical Stimulation Center opens, with mission to regain function. Hand-grasp FES prosthesis implant with wireless on-wrist controller.

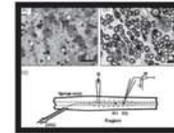
1997: C-Leg (Computer Leg) technology builds a prosthesis system that adapts to amputee's unique gait. Microprocessed hydraulics allows adaptation to all walking speeds in real time.

1998: AdVantage arm, an upper-limb prosthesis, is designed for veterans with short amputation levels. High elbow-flexion angle allows full range of motion, with mouth-grasping device.

2000s



2001



2002



2005-2010



2009-2010



2007

2001: Aerobic exercise program for manual wheelchair users improves upper-body endurance.

2002: Regeneration of damaged nerve tissue holds promise for persons with paralysis. Transplantation research with human neural precursor cells continues.

2007: i-LIMB Hand is first released in mid-2007. First prosthetic hand to move all fingers with 5 mini-motors.

2005-2010: BrainGate2 Neural Interface System decodes signals recorded directly from the brain to control external devices. Subjects during research have used BrainGate to control computer cursors and powered wheelchairs. Future research will determine if it can also control prosthetic limbs.

2009-2010: Generation II DEKA Arms. DEKA produces prototype Generation II arms. Frederick Downs, Jr., Director of PSAS, participated in a trial of the arm sponsored by DEKA.

1980s

1990s

2000s

who staffed them [7]. The Veterans Administration also began managing research contracts and established a testing and development laboratory in New York City in the 1950s—the Veterans Administration Prosthetics Center, which established standards and encouraged manufacturers to use new plastic laminates instead of wood.

The advances in limb design, fabrication, and fitting continued in the postwar decades. In the 1960s, Ernest Burgess, MD, chief of the clinic at the Seattle Veterans Administration Medical Center (MC), led a study on the practice of fitting prosthetic devices immediately after amputation, a technique eventually adopted nationwide. (Note that, in 1989, the Veterans Administration became a Cabinet-level agency, changing its name to the U.S. Department of Veterans Affairs [VA].) His team later developed the Seattle Foot (a prosthesis made of energy-absorbing, spring-like material) and went on to pioneer computer-aided design software to maximize prosthetic design and manufacturing efficiencies.

The clinic led by Burgess at the Seattle VAMC eventually became the Center of Excellence for Limb Loss Prevention and Prosthetic Engineering, with Director Bruce Sangeorzan, MD, and Associate Director Joseph Czerniecki, MD, heading up today's research effort. Center goals include actively seeking ways to preserve lower limbs and their functions, improve prosthetic design by comparing suspension systems, measure the effect of impact on absorbing prosthetic shanks in below-knee prostheses, and research the development of powered prostheses. While the VA focuses on veterans, it also emphasizes that the results would benefit all U.S. citizens with disabilities.

OVERVIEW OF PROSTHETICS AND SENSORY AIDS SERVICE

Today, one of the VA's major strategic goals is to restore the capabilities of disabled veterans to the greatest extent possible. The VA accomplishes this endeavor through several means. One example is the Office of R&D. It organizes, reviews, and funds all research efforts in its research centers across the

nation. Another is the VA's PSAS, which is the VA entity that procures and delivers the "durable goods required" and prescribes, fits, and trains veterans for their long-term use. The VA has an integrated delivery system designed to prescribe and procure prosthetic and sensory aids, devices, assistive aids, repairs, and services to disabled individuals to regain lost function from their medical conditions. The goal is "seamless service from prescription through procurement, delivery, training, replacement, and repair" [5].

According to VA's PSAS current Director, Frederick Downs, Jr, "The VHA [Veterans Health Administration] has an established record of providing prosthetics to more than a million disabled veterans every year, which it had been doing as part of its mission from the time of its establishment in 1948" [5].

Today, the mission of the PSAS has evolved far beyond its original purpose of fitting amputee veterans with custom-fabricated prostheses and orthotics for upper and lower limbs. In addition, the process of procurement and prescription has become more sophisticated over time.

A multidisciplinary team (consisting of a physician, prosthetist, therapist, and prosthetic representative) at one of the many VA amputee clinics in the United States generates a prescription that is carefully formulated to the patient's individual needs. The team works up a detailed profile of the patient that includes vocation, recreational needs (such as swimming and skiing), general physical health, and home environment. Based on this information, the team designs prostheses using new and emerging technologies as they become available.

Today, the PSAS has 63 laboratories around the country responsible for fabricating, fitting, and repairing prosthetic limbs and braces as well as training the amputees in their efficient use. The laboratories employ 182 VA prosthetists and orthotists. The PSAS can also provide a patient any prosthetic or orthotic device through a commercial vendor if the examining physician deems it necessary. In 2004, approximately 176 veterans were fitted this way with the latest available computerized C-Legs (Otto Bock; Minneapolis, Minnesota) [9].

Frederick Downs, Jr, says that the average citizen does not really understand what VA's PSAS

does. “There is no equivalent to our service in any other health care system,” says Downs. “We are the VA’s pharmacy for durable medical goods and equipment” [10].

The VA provides items ranging from \$2 foam shoe inserts to stair-climbing \$30,000-plus iBOT (Independence Technology, Johnson & Johnson; New Brunswick, New Jersey) wheelchairs—all to help disabled veterans live independently. Home improvements and structural changes, as well as adaptive equipment for automobiles, are also provided to veterans with service-connected disabilities [8].

TYPES OF DURABLE MEDICAL GOODS AND EQUIPMENT PROVIDED BY PSAS

The artificial limbs and sensory aids that PSAS prescribes today represent only a small percentage of the durable medical goods dispersed to veterans. For example, in 2004, 631,000 veterans required eyeglasses, hearing aids, and other assorted sensory aids that cost the taxpayers about \$52 million. That compares with about 26,000 veterans who needed new artificial limbs or repairs and adjustments to older ones, costing about \$66 million [10]. The following is a substantial list of the types of prostheses, sensory aids, and other devices that PSAS provides veterans today:

- Artificial limbs.
 - Microprocessor knees, such as C-Leg, Rheo Knee (Otto Bock), Össur Power Knee (Reykjavik, Iceland).
 - Microprocessor ankles, such as Proprio Foot (Otto Bock).
 - Myoelectric and electric upper-limb components.
- Blind aids, such as talking watches/alarm clocks, magnifiers, closed-circuit television.
- Communication devices, such as global positioning systems, medical alert devices, environmental control units.
- Computers for the blind and/or disabled.
- Durable medical equipment.

- Home respiratory therapy, such as Home Oxygen, continuous positive airway pressure and bi-level positive airway pressure devices, nebulizers.
- Hospital beds.
- Items for daily living, such as blood pressure monitors, transcutaneous electrical neural stimulation units, reachers, long-handled sponges, canes, crutches, walkers.
- Orthotic devices, such as shoes, braces, inserts, compression stockings.
- Patient lifts, such as wheelchair seats.
- Recreational/rehabilitative equipment, such as swimming legs, hand cycles, archery arms, Braille dominoes.
- Surgical implants, such as pacemakers, implantable cardioverter defibrillators, orthopedic hips and knees, ocular lenses, cochlear implants.
- Wheelchairs, such as manual, powered, and iBOT wheelchairs and scooters.

FROM BASIC HOOK TO DEFENSE ADVANCED RESEARCH PROJECTS AGENCY REVOLUTION IN PROSTHETIC ARMS (2006–2010)

Frederick Downs, Jr, Director of VA’s PSAS for 30 years, lost his left arm in 1968 during combat in Vietnam, when he stepped on a land mine. Since then, Downs has been wearing the standard prosthetic arm.

He has a unique perspective and compares the first arm with a state-of-the-art prosthetic arm, developed by the DEKA Integrated Solutions Corporation as part of the Defense Advanced Research Projects Agency’s (DARPA’s) Revolutionizing Prosthetics Program. Since 2006, DARPA has provided over \$130 million to two performers, DEKA and Johns Hopkins University Applied Physics Laboratory (APL), to leverage technology advances and create advanced upper-limb systems to address all aspects of user needs from socket fit to hand function. While APL is focusing on a system that affords near-natural control of the limb by decoding brain signals from implanted arrays, DEKA was tasked to create a limb system that could be controlled without further

surgery, a “strap-and-go” system, as described by COL Geoffrey Ling, MD, PhD, DARPA program manager.

In October 2008, DARPA entered into a Memorandum of Agreement with the VA to gain clinical insights into the functionality of the Generation II DEKA Arm—insights DARPA would then have DEKA include in a Generation III Arm aiming toward commercial production in 2011. The 3-year VA Optimization Study complemented DEKA-run home trials (see **Figure**). Fred Downs participated in a 2-week DEKA take-home study as a private citizen in July 2009.

“My 1968 arm is a basic hook. And I can rotate the hook like this and lock it,” Downs told a television reporter from CBS in April 2009.

“In those days, they didn’t have a lot of sophistication about it. They fit you and say, ‘This is your arm, this is your leg.’ And it was the best technology in those days and you just had to make yourself learn how to use it and I did” [11].

Downs also told the CBS reporter that he was very skeptical at first about what the DEKA Arm could do: “Because I’ve seen lots of inventions come along in my years of being in charge of prosthetics, and some great stuff, but in the long run, it doesn’t really work because your body only has so much tolerance for gadgetry” [11]. However, that was the late 1960s—more than 20 years since WWII ended.

October 2008: Defense Advanced Research Projects Agency (DARPA) and VA sign Memorandum of Agreement. DARPA will fund DEKA to produce prototype arms. VA will fund researchers in VA to conduct clinical testing of the arms.

April 2009: First subject of research is studied at Manhattan VA Hospital, New York, New York.

2009–2010: Additional VA study sites are added at the Tampa VA, Tampa, Florida; Long Beach VA, Long Beach, California; and the Center for the Intrepid at Brooke Army Medical Center, San Antonio, Texas.

October 2010: Data collection for VA Optimization Study concludes. In all, 26 subjects were studied, 13 veterans, 5 Active Duty, and 8 nonveterans.

Figure.
Chronology of Department of Veterans Affairs (VA) Optimization Study.

During the late 2000s, Fred Downs has experienced the enhanced function of the state-of-the-art prosthetic arm and hand system—the Generation II DEKA Arm—which has gone where no other prosthetic limb has gone before and has been appropriately nicknamed “Luke” after Luke Skywalker, the fictional character of the original Star Wars film trilogy.

One of DEKA II’s advanced and unique functions over earlier upper-limb prostheses is that an above-elbow amputee can now lift an object overhead for the first time. The arm is an example of DARPA’s revolutionary highly technical approach, and the VA collaboration provides insight into the utility of the breakthrough.

When Fred Downs began testing the DEKA Arm at the corporate facility in New Hampshire in the summer of 2008, he was “brought to tears” when the prosthetic arm allowed him to smoothly bring a water bottle to his mouth and drink. This task would have been impossible with his “basic hook” arm of 1968.

“The feeling is hard to describe,” Downs said. “For the first time in 40 years, my left hand did this. I almost choke up saying it now. It was just . . . it was such an amazing feeling. I was 23 years old the last time I did that,” Downs said. “It felt so good to move my arm again—to do things with it. Not as fast, but it worked” [11].

The CBS journalist asked, “You just said ‘move my arm . . . again.’ Did it feel like your arm, all of the sudden?”

“It did. It did. It felt like my arm. It was me,” Downs said [11].

Since early 2009, the Generation II DEKA Arm has undergone additional engineering, resulting in a lighter prosthesis (weighs about the same as a human arm), improved electrical and internal connections, and an increased resistance to moisture. The engineering team also redesigned DEKA’s active socket design, making it more comfortable for amputees as well as improving the arm’s articulation.

Billie Jane Randolph, PhD, PT, is VA’s deputy chief consultant for prosthetics and sensory aids. “It’s important, as a therapist, to have several different options available to our upper-extremity amputees,”

she says. “With the current technology, we cannot have an above-elbow amputee lift an object overhead and this prosthesis will allow that” [12].

VA’s prosthetic trials for the Generation II DEKA Arm are headed by Linda Resnik, PhD, PT, OCS, who teaches at Brown University and works at the VAMC, Providence, Rhode Island. The “optimization trials” began in April 2009.

Subjects participating in the trials are required to perform a list of tasks while researchers observe and collect data. Subjects also provide narrative comments and feedback regarding the ease or difficulty in operating their prosthesis. Resnik considers this subjective feedback the most important aspect of these advanced trials [13]. While DEKA sponsors its own take-home trial, the VA Optimization Study does not allow subjects of the research to leave the VAMC wearing the prosthetic arm.

“You’re sure I can’t take this arm with me?” Downs joked, after testing the DEKA Arm. “I’m ready for this arm” [11].

In July 2009, Downs again visited the DEKA Integrated Solutions Corporation in Manchester, New Hampshire, to be fitted with the prosthesis as part of DEKA’s take-home trial. Downs remarked how incredible it was for him to pick up his BlackBerry and be able to hold it while typing on it.

Billie Jane Randolph, VA’s deputy chief consultant for PSAS, speaks of the therapist’s perspective: “As therapists, we say that when someone loses a lower extremity, they lose their mobility. When they lose their upper extremity, they lose their independence,” she said. “The goal is to restore their patients’ function as much as possible and to help them regain as much independence in their lives as they can” [12].

THE ONGOING BATTLE FOR RESTORED FUNCTION

For more than a half century of developmental time since the WWII ended, a revolution in microprocessors and materials has taken prosthetic arms and legs to new heights of performance and patient satisfaction. The prototype of the DEKA Arm contained 3 processors, 25 circuit boards, and 10 motors. How-

ever, all the advanced technology would count for naught unless the veteran patients were willing to accept it.

Early testing and rigorous subject feedback clearly showed that DEKA II’s first active socket design was not what patients wanted or needed. The socket is where the body meets the artificial limb and they interact—the crucial point of wear, tear, and comfort. The evolution of this essential point of contact between the residual limb and the artificial device is a key measure for the developmental progress in prosthetics since WWII.

“Almost every socket design and component can trace its foundation to VA research,” writes Robert Gailey, PhD, PT, a physical therapist and researcher at the Miami VAMC [14]. Gailey has been developing new workshops that focus on evidence-based prosthetics to find the best ways to identify the functional deficits of amputees. These data are used in developing advanced training for amputees as well as for the prosthetists and physical therapists who fit the amputee. At the same time, the evidence-based data are sent to the engineering teams who are developing and improving prototype prostheses for amputees, including the Generation II DEKA Arm in 2010. The ultimate goal is to engineer prostheses that act and feel like natural limbs—and various engineering disciplines have progressed significantly toward this end some 6 decades after WWII ended.

Sixty-five years after WWII veterans marched on the U.S. Capitol to protest their inferior prosthetics produced by the lowest bidder, the Department of Defense and the VA partnership with the DEKA Integrated Solutions Corporation demonstrates that a combined, coordinated, and sustained effort will produce outcomes far exceeding efforts that are more modest by small businesses without the advantage of multisource funding.

Crucial in designing and developing new prostheses and functional aids are sophisticated data collection and in-depth feedback from veteran amputees on how to improve prototypes such as Generation II DEKA prosthetic arm, giving their personal insights on what they want from new designs. What they all want is their artificial arm or leg to “feel” like a real

human arm or leg. The DEKA prosthetic arm did that for PSAS Director Frederick Downs, Jr, in 2009, 40 years after he lost his arm in battle. And in the summer of 2010, the PSAS celebrated its 62nd birthday.

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Robert O. Williams designed the 50-year time line chronology of prosthetics on pages x–xi.

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