IEEE PHILADELPHIA 1903 2003

IEEE in the Delaware Valley from 1903 to 2003

— Part 4 of 4 —

Electro-technology has played an important role in the development of the Delaware Valley, and the IEEE has been instrumental in bringing together the professionals who have made it all possible.

During this, the Centennial Year of the IEEE Philadelphia Section, we are endeavoring to highlight many of the projects, products, and services that have taken place here. This is the last of four issues of the Almanack that tells this story.

THE ALMANACK ISSUES INCLUDE:

1. Electric Power Industry.
2. Consumer, Commercial, and Industrial Products and Communications.
3. Computers and Instrumentation.
4. **Defense, Aerospace and Engineering Universities.**

A good case can be made that what was accomplished within the territory of the Philadelphia Section is the most innovative and far reaching of any of the IEEE USA Sections. Many of our members were employed by these institutions and played an important role in the development of this innovation. You can form you own assessment after reading this history.

This issue completes the Centennial record of Electrotechnology activities in the Delaware Valley. Many individuals contributed to this project and are listed on page 22. We are most grateful for their time and efforts.

In a project of this scope there are certainly some companies and activities that were not mentioned or information that could not be located. To this we hope you will be understanding and forgiving. I would like to acknowledge the section's Awards and Centennial committee (Merrill W. Buckley Jr., Donald Dunn, Thomas Fagan, Donald Schnorr, Dr. Victor Schutz, Dr. Marvin Rozansky), Kent Ringo, and Edwin Podell our late Almanack Editor for a job well done!

Defense and Aerospace

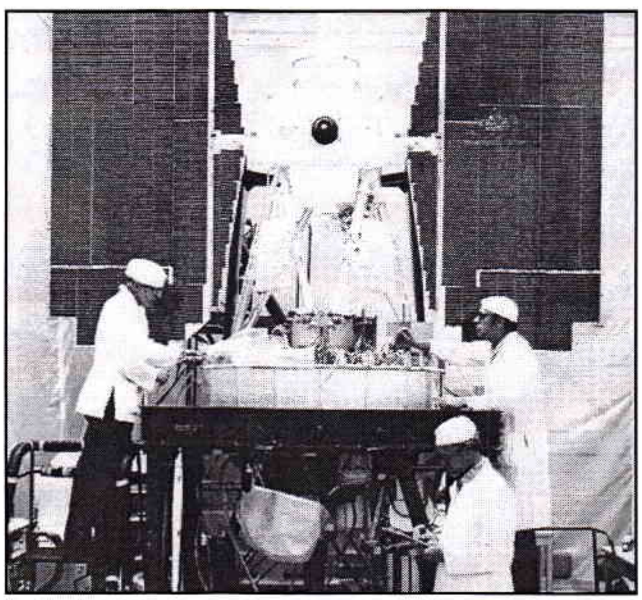
GENERAL ELECTRIC/ LOCKHEED MARTIN

Valley Forge – King of Prussia – Philadelphia

The year was 1960 when ground was broken for the complex of buildings that today is the headquarters of one of the nation's major aerospace companies, General Electric's Space Systems Division. Some of the most significant achievements in the space program have been developed, engineered, built and brought to fruition through the efforts of the men and women at the Valley Forge complex and its associated field operations.

The division received the National Space Club's Scoop Jackson Award for the most significant space achievements of 1960, the recovery of Discoverer XIII from orbit.

AEROSPACE — General Electric's close association with NASA's space exploration programs can be traced through the alphabet soup of NASA acronyms — OAO, BIOS, GEOS, GGTS, and more. In its work for NASA, earth atmosphere and resource monitoring have long been a specialty including the series of Nimbus weather satellites.



Nimbus Weather Satellite

The 70s saw the advent of the highly successful Landsat series of satellites. This development introduced a new, experimental tool for collecting data with remote sensing instruments on a space platform and has been a system for examining and managing the earth's resources. Today many nations worldwide receive

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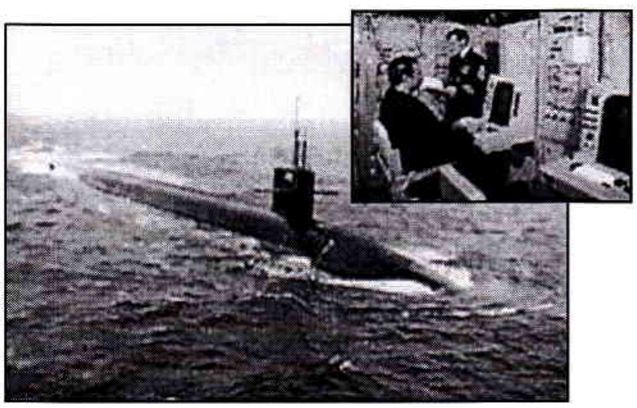
data directly from the satellite. Landsat images provide complete earth surface coverage and are recognized for their value in oil and mineral exploration, agriculture, land use planning, forestry, water management, map-making, and other endeavors.

GE has been involved in numerous successful manned spacecraft missions. During Apollo, GE was responsible for pre-launch checkout stations; launch-complex controls and checkout equipment; reliability assessment; and systems integration. It also handled the technical support of the static testing of the booster stage and engines for the Saturn rockets that carried the astronauts into space and to the moon. Today, Space Systems Division is similarly committed to the Space Shuttle program.

GE provided the deceleration module for the Galileo Probe. The module included entry thermal protection, parachute retardation, separation subsystems, lithium battery power supply, transit thermal control, and probe/orbiter adaptor.

GE was involved in a comprehensive NASA-directed research program to see how the chemistry of the upper atmosphere has been affected by the activities of mankind and if those activities are altering the protective shield of ozone.



1972 Trident IRR

DEFENSE — Supporting United States' efforts to maintain a deterrent defense structure, the division has over the years provided reentry systems for the Titan II and Minuteman II & III missiles. For the Army it has provided transportable DAS3 data automation systems for field combat service support and Combat Information use. GE also developed a maneuvering reentry system as an option for the Trident missile and the DSCS III — Defense Satellite Communications System capability. This system featured electronically steerable antennas on each spacecraft, achieving simultaneous connection of a wide range of users at different places. Four DSCS satellites in synchronous orbit provide global communications with long life and anti-jam capability. The first satellite launched in 1982. GE upgraded the DSCS III with solid-state amplifiers, EHF transmitters, and adaptive nulling processor capability. The Department of Defense's Worldwide Military Command and Control Systems, the U.S. Navy, the White House Communications Agency, NATO, and the United Kingdom use the system.

International Programs — GE designed and built for Japan the first communication satellite dedicated to TV direct broadcasting. Launched in 1978, it relayed two color TV channels throughout Japan. An improved version was launched in 1984.

Data Automation — GE developed the GES-CAN 2 high-speed search and retrieval system as a hardware solution to textual information search and retrieval applications. GESCAN is worked at the United States Government General Accounting Office.

RCA / GE / LOCKHEED MARTIN / L3

Camden NJ

RCA's heritage in communications systems dates back to 1919, the year the corporation was formed. Upon acquiring the Camden plant in 1929, RCA began manufacturing its own products and, with the formation of its first Government Department in 1931, began producing communications equipment for the Navy.

World War II caused RCA Camden to redirect its talents and efforts from commercial and consumer products to defense communications products. The division's technical advances in radio and television were applied to produce innovative yet practical tools to help the US and Allied forces win the War. The post-war era marked the beginning of the Space and Computer Age, and RCA Camden was at the forefront.

Throughout the 1950s and 1960s, RCA Camden increased its tempo in defense research, development, and production, supporting U.S. Forces in both the Korean conflict and the Vietnam War. The Cold War posed new challenges to the U.S. Defense Industry. The greatest challenge was winning the race to put the first human on the Moon. RCA Camden was an important contributor.

In the 1970s RCA Camden's diversified technical base was instrumental to the division's survival during a major economic downturn in U.S. Defense Industry.

By the 1980s the site was solely dedicated to aerospace and defense products. In 1986, GE acquired RCA, starting a cycle of change that became common practice throughout the defense industry in the 1990s. GE Aerospace sold to Martin Marietta Corporation in 1993. Martin Marietta merged with Lockheed Corporation forming Lockheed Martin Corporation in 1995. The Camden Division

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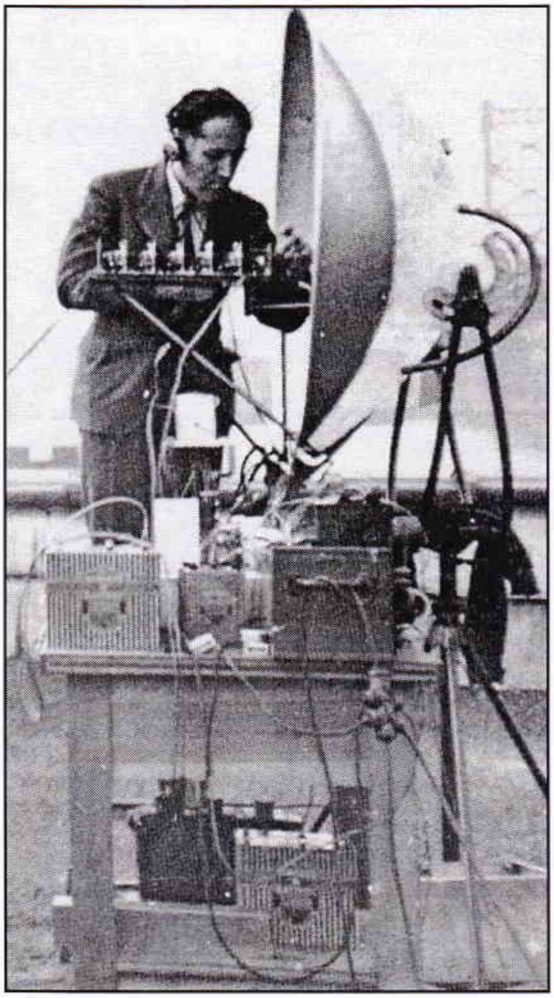
remained with Lockheed Martin until 1997, when nine communications products divisions of Lockheed Martin formed a new company, L-3 Communications Corporation.

Major Camden Defense And Space Projects

1917–1918 — The U.S. enters WW I, Camden operations curtail commercial production. The company converts its manufacturing to produce rifle fittings; detonator cases; shell assemblies and rifle stocks; and fabric-covered wooden wings for the Navy Flying Boat airplanes.

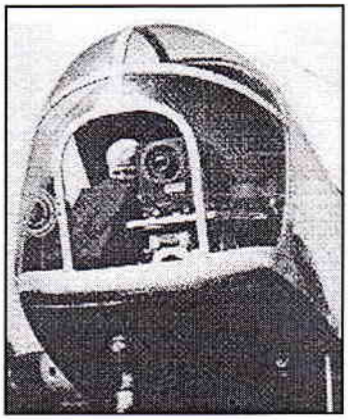
1937 — RCA Camden demonstrates a microwave scanning radar from the roof of a Camden Building that detects distance and location of ships passing in the nearby Delaware River. It is the first practical demonstration of a microwave scanning radar capable of identifying and locating moving ships.



The First Radar

1940 — First field tests conducted by Dr. Vladimir Zworykin on remotely controlled drones at Muroc Lake, CA. RCA produces miniaturized television cameras for the military. This leads to BLOCK/RING/MIMO programs and the first miniaturized airborne surveillance and TV guided missile systems for the U.S. in WW II.

1941–1945 — RCA produces massive quantities of miniaturized radio transceivers, employing radar principles and enclosed in a five-inch shell. The highly guarded project is known only as the *Madame X* program. It is the first *Variable-time* (VT), or proximity, fuse for bombs, and is successfully deployed by US Allied Forces to shoot down German V-1 bombs in Europe during WW II. Over 18,000 units per day are assembled. A total of 5.5 million units are produced by RCA during the War.



1941 TV Guided Missile System

1951 — RCA begins production of smaller, lightweight, backpack tactical radios. Known as *Walkie-Talkies*, these super-heterodyne radios are mass-produced for U.S. Forces fighting the Korean War.

1956 — A portable backpack TV camera system, built by RCA is unveiled by the U.S. Army Signal Corps for use by reconnaissance scouts to remotely transmit battlefield images to higher headquarters. It is the first man-portable TV surveillance system for the U.S. Army.

1956 Backpack TV

1961 — The first free flight of the Minuteman Intercontinental Ballistic Missile (ICBM) is successfully conducted at the U.S. Air Force Missile Test Center, Cape Canaveral, FL. RCA provides Command, Control & Communications (C3) systems for the program, and becomes a premier contractor with the U.S. Air Force and a major player in the U.S. Space Program.

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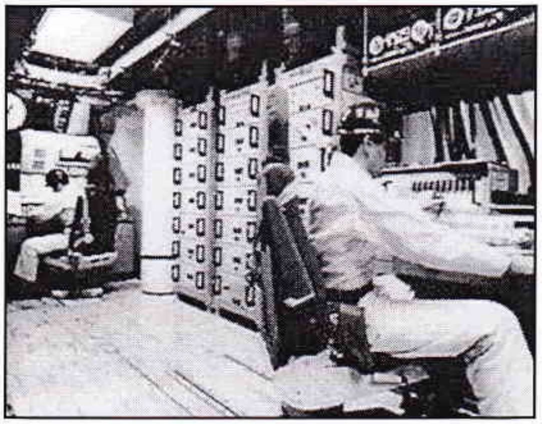


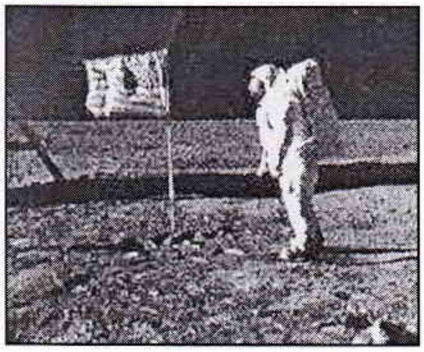
1961 ICBM

1963 — RCA produces a magnetic tape recorder, capable of storing telemetry data continuously for four hours and replaying the entire tape in 11 minutes, for NASA's Gemini manned space program (deployed on all 10 Gemini missions).

1965 — RCA begins production of military backpack radio, a fully transistorized, upgrade version introduced four years earlier. The PRC-77 becomes the communications workhorse for U.S. Ground Forces in Vietnam. It is the first all solid-state military backpack radio. 40,000 radios are produced throughout the 1960s.

1967 — RCA begins production of Ultra High Frequency (UHF) transceiver for the U.S. Navy aircraft, which along with the High Frequency (HF) model becomes one of the most successful products in the history of RCA Camden.

1969 — RCA as a major subcontractor to Grumman Corporation produces the VHF voice communications subsystem for the Command Module (CM), the Lunar Excursion Module (LEM), and the Extra Vehicular Communications System (EVCS) for NASA's Apollo manned space program. The EVCS is successfully deployed in Apollo 11 when, on July 20, 1969, the world hears astronaut Neil Armstrong say *"That's one small step for man — one giant leap for mankind"* as he becomes the first human to step on the moon. RCA Camden's equipment support all Apollo missions, from Apollo 7, 1968, to Apollo 17, 1972.

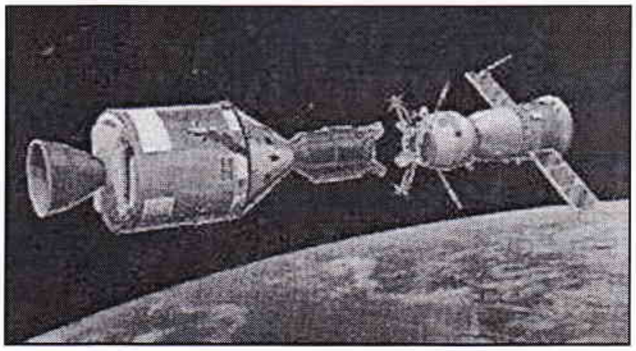


1969 Moon Mission

1973–1974 — RCA supplies the VHF ranging system, VHF telemetry transmitter, video tape recorders, and Airlock Module (ALM) data recorders for NASA's four-phase Skylab Program, the first US space station experiment. The video tape recorders are the world's first to be space qualified and proven.

1974 — RCA begins development of the STR-108 Standard Tape Recorder for NASA. Since 1978, the STR-108 has been deployed on 26 satellites. RCA Camden receives the NASA Group Achievement Award in 1989 for this unprecedented achievement. On December 8th, 1977, the STR-108 surpasses 4 million hours of failure-free performance in orbit.

1975 — RCA Camden supplies the VHF ranging system and video tape recorders used on the historic Apollo-Soyuz Test Project, the first international space station.



1975 Apollo-Soyuz

1978 — RCA is chosen by NASA to develop the Extra Vehicular Activity/Air Traffic Control (EVA/ATC) system. This is the first communications equipment for the US Space Shuttle program. The EVA/ATC has been deployed on all Space Shuttle missions to the present day.

1979 — RCA receives a US Navy contract to design, develop and produce the Integrated Voice Communications system (IVCS), the critical communications system for the new CG-47 *Ticonderoga* class AEGIS guided missile cruiser.

1982 — RCA receives sole-source, follow-on US Satellite Communications Agency (SATCOM) contract for the Full Scale Production Phase of the Tactical Satellite Communications Program.

1985 — RCA wins a National Security Agency contract to develop the Future Secure Voice System. This is the first desktop-style telephone designed to protect against electronic eavesdropping.

1986 (Corporate Change) — GE completes its purchase of RCA. RCA Aerospace & Defense is combined with GE Aerospace and renamed GE Aerospace Business Group.

1987 — GE-RCA receives subcontract from McDonnell Douglas Astronautics Company to develop the communi-

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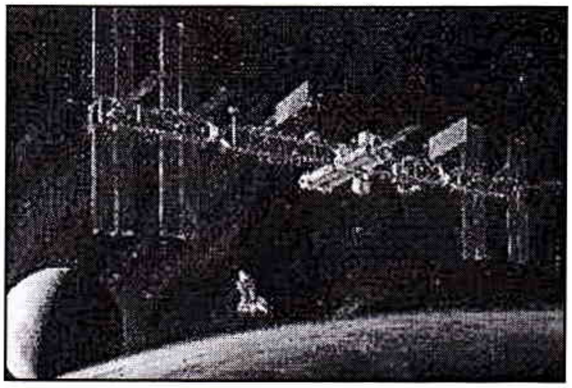
cations and tracking subsystem for NASA and the U.S. Space Station *Freedom* Program. The system is activated during a ten-day mission of the U.S. Space Shuttle *Endeavor*, launched on November 2000 to deliver and install a set of solar arrays on what has now become the International Space Station.



1987 Space Station

1993 (Corporate Change) — Martin Marietta Corporation completes its acquisition of GE Aerospace in April. GE Government Communications Systems Department Camden is renamed Martin Marietta Communications Systems.

1994 — Martin Marietta Camden fields the first Improved Remotely Monitored Battlefield Sensor System (REMBASS) a family of lighter-weight, miniaturized Unattended Ground Sensors for physical security applications, to the U.S. Army. The REMBASS program began in 1974 at RCA.

1995 (Corporate Change) — Lockheed Corporation and Martin Marietta Corporation merge on March 25th to form Lockheed Martin Corporation. The new Corporation becomes the nation's largest defense contractor. The Camden NJ division is renamed Lockheed Martin Communications Systems.

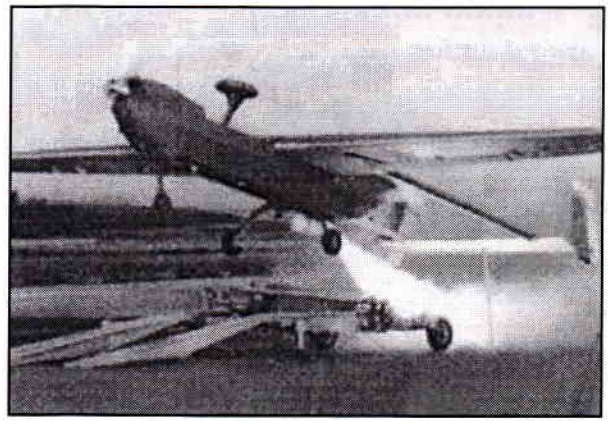
1995 — Lockheed Martin Camden wins a NSA contract to design and produce 300 units of Secure Telephone Equipment, the next generation of secure voice and data communications for the U.S. Government.

1996 — Lockheed Martin Camden wins a Navy contract to design, develop, and produce the Submarine Baseband Circuit Switch, the first product in the MARCOM family of integrated switching systems, as an upgrade to the radio room on the SSN-688 *Los Angeles* class attack submarines.

1998 (Corporate Change) — The new company of former Lockheed Martin and Loral communications businesses is officially registered as L-3 Communications Corporation.

1998 — L-3 Communications Systems-East, Camden introduces the Strategic/Tactical Airborne Recorder (S/TAR), an innovative suite of solid-state storage products for airborne platforms. The S/TAR represents L-3 CS-E's continuation of a 40-year heritage in high performance recording systems for space-borne and airborne applications.

2000 — L-3 Communications Systems-East, Camden successfully demonstrates the Prophet Risk Mitigation Payload (PRMR), an advance flown onboard a Hunter Unmanned Aerial Vehicle (UAV), for the US Army at Ft. Huachuca, AZ. This is the first successful demonstration of an advanced SIGINT payload on a small, tactical UAV.



2000 PRMP — Prophet Risk Mitigation Payload

RCA/GE/LOCKHEED MARTIN—MOORESTOWN

Radar Systems for National Defense

Through the World War II, RCA built shipboard, airborne and land-based radars in Camden, NJ. When peace came, the company formed a group of engineers assigned to continue radar development work. In 1946 the Navy awarded RCA a contract to conduct a study for the Bumblebee Guided Missile Program.

Year after year, the Navy added work to the Bumblebee contract. Army and Air force contracts for other radar developments were awarded and RCA's "know how" increased to the point in 1950 when it was able to compete successfully for production programs. It was time to move the radar business out of Camden and into an engineering/production plant of its own.

RCA purchased a 430-acre site in Moorestown and began construction in the spring of 1952. In December 1953, RCA dedicated the new facility in Moorestown, NJ. The original engineering staff developed radars and military fire control systems considered more accurate than any seen before. The first major radar to be developed

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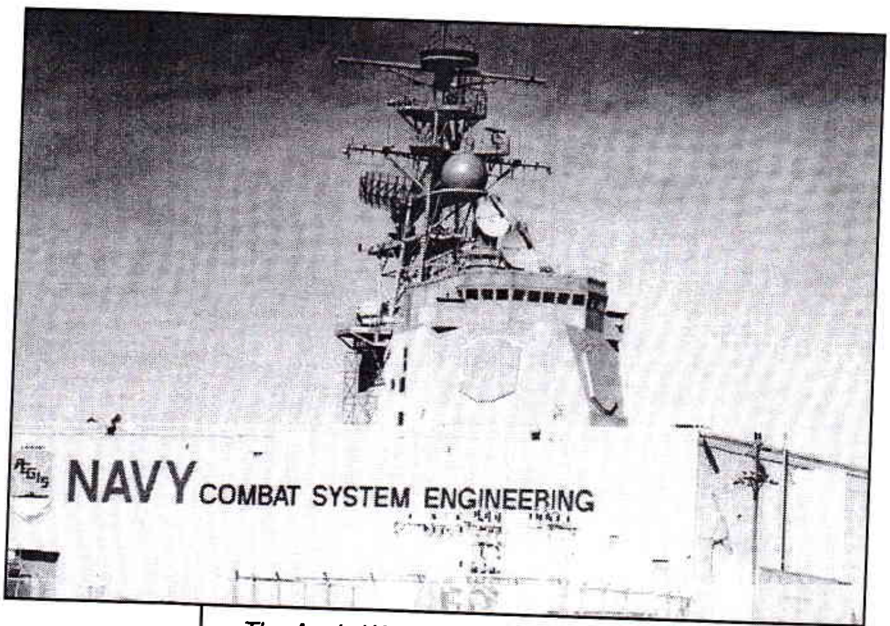
and produced in Moorestown was the AN/FPS-16 precision tracker, designed for the Navy and later put into service by the Army and Air Force. Between 1953 and 1957 MSR built 50 of these radars, many of which are still in service.

In the years that followed RCA won contracts for some of the nation's largest defense projects, including:

- **The Ballistic Missile Early Warning System** (BMEWS), one of the most advanced electronic detection systems of its time. The BMEWS radars in Alaska, Greenland and England provide a reliable warning system against missile attacks. BMEWS was one of the largest single electronic complexes ever assembled. It was the first time Moorestown was given complete system responsibility for a program, including concept design, production and test, site installation, integration and test, logistic support, and site maintenance and operation. Hundreds of subcontractors located in dozens of states supported the company in this huge effort.
- **TALOS Defense Unit** (TDU) program was established by the US Navy in 1954. Moorestown was selected to develop the TDU. Born out of the need to defend against Kamikaze-like aircraft attacks, this land-based, surface to air missile system was the first fully automated weapon system that could fire and control guided missiles. The first TDU was delivered to the Army in 1957 for testing at White Sands Missile Range in New Mexico. The Navy continued to rely on Talos for anti-air warfare until the Aegis Program was established. The Navy funded the Aegis study because Talos was designed for aircraft threats but not to counter the supersonic anti-ship missiles developed by the Soviet Union.
- **AEGIS** became the biggest project in Moorestown's history. Now in its seventh generation, the Aegis Weapon System is the Navy's most advanced, capable weapon system and is the backbone of the nation's sea based missile defense effort. Several International Navies have also chosen the Aegis Weapon System for their combat system requirements. Japan, and Spain have chosen Aegis and Australia, Chile, Germany, Canada, Italy, United Kingdom, United Arab Emirates, and Turkey have expressed interest in the technology.
- **The AN/FPQ-6** computerized radar and its transportable version, the AN/TPQ-18 descendants of the AN/FPS-16 are considered some of the most precise tracking radars in the world. These radars and other Moorestown systems tracked the Apollo orbital flights from ships and shore installations.



The Aegis Weapon System

- **Erectable antennas** used by lunar astronauts on the moon's surface to transmit signals back to earth. Similar antennas were carried on the Lunar Rover vehicles.
- **Communication antennas** built at Moorestown and used in NASA's Viking Lander spacecraft sent to Mars in 1976.
- **The Target Resolution and Discrimination** (TRADEX) radar installed on the Kwajalein atoll in the Pacific Ocean. It has an 84-foot antenna that can accurately track multiple targets.
- **The Downrange Anti-Missile Measurement Program** (DAMP). This shipboard system gathers data on missile performance during flight and reentry to aid in development of systems for defense against ballistic missiles.
- **Hand-held radars** designated AN/PPS-9 through -13, developed for the Army, Air Force and Marine Corps. These radars were designed for battlefield surveillance and identification of moving targets in all weather conditions.
- **The AN/MPS-36** integrated circuit radar, a mobile system designed for precise measurement of missiles and reentry vehicles. This system can track targets as far away as 32,000 nautical miles and measure range with an accuracy of one yard.
- **Digital Instrumentation Radars** (DIR), developed for the Air Force and later adapted for use by the Army and Navy. DIR's handle a variety of tracking jobs, from range safety to scoring and evaluation.
- **The Generic Phased Array Radar**, a project for the Army. This system simulated various classes of radars, enabling researchers to duplicate the signals of the latest equipment developed by potential adversary nations.

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AEL INDUSTRIES INC.

American Electronic Laboratories was founded in 1950 at 641 Arch Street in Philadelphia. The founders Leon Riebman, Conrad Fowler and Robert Goodman were members of the research staff of the Moore School. The company was operated under the name of AEL Industries until 1966. At that time it was acquired by Tracor Inc. and became a division of Marconi, and then British Aerospace (BAE Systems). It continues to operate today in its plant in Montgomeryville, PA.

1950–1953 Medical products formed the basis for the company's original business, however, the award of military contracts from the Signal Corps at Fort Monmouth during 1953 and 1954 provided the basis for the key technical developments that were to ignite AEL's entry into the Electronic Defense business. At its peak it employed over 1500 people. In 1967 AEL started a firm in Israel (ELISRA). ELISRA was sold to TADIRAN, a large Israeli firm during the 1990s. AEL's major products were related to countermeasures equipment and major systems covering the frequency range from HF to the millimeter bands including: antennas; microwave components; solid-state components etc.

1954–1980 The core technology, which formed the basis of AEL's entry into Electronic Defense systems, involved direct detection crystal video receiving systems. Developed on the basis of Lee Riebman's theory enhancing the sensitivity of the diode detector while proving that the famous Radiation Lab series (Valley and Wallman) was in basic error in specifying a maximum theoretical limit of detection for a diode. This stimulated new ideas and techniques for broadband components in the field of spiral antennas, wide dynamic range transistorized logarithmic video amplifiers, etc. These were all critical elements in creating new classes of intercept systems with improved performance and broad frequency coverage.

Over the years AEL became the acknowledged leader in advancing both the technology and utilization of crystal video receiver applications in a wider variety of systems in the field of broadband surveillance and detection. As a derivative of its work on the AN/TLR-8 surveillance system for the Army, AEL significantly improved the previous limitation on sensitivity for this class of receivers, which allowed for a much broader range of use and application with greater range of detection.

This technology then formed the basis for AEL's entry into the field of radar warning receivers. The advent of the Russian SAM systems created a worldwide market for this technology since every military aircraft had such an installation. It was the concept and need for broadband systems that then led AEL into the active countermeasures area, involving broadband distributed amplifier technology for jamming applications. AEL was awarded a contract for development of various frequency bands of the AN/ALQ-99 system for use on the EA-6B aircraft, which is still in current use today.

Applications for naval intercept systems also developed and AEL was awarded a contract for the AN/SLQ-21 countermeasures system. It was designed to automatically recognize enemy missile signals and energize high power jammers for the protection of naval vessels. Of particular interest was the development of an intercept system for the battleship New Jersey while it was being retrofitted for use in the Vietnam conflict. The rooms that house the equipment off the main mast are still visible on the New Jersey in Camden today.

Concurrent with this component, equipment and system business AEL expanded into other related military areas including opening various airport locations, such as Monmouth County airport. This facility outside of Fort Monmouth provided specialized services for high performance fixed wing and rotary wing aircraft, including electronic systems installation, airframe and ground vehicle modifications, electromagnetic testing, etc.

In addition to its R&D programs this period saw AEL expand its production capability to handle large scale production not only of its own products, but to compete successfully for contracts on other military systems. Principle among these programs was the AN/VPS-2 radar, which was produced and sold throughout the free world.

1980-Present — A key phrase in the company was "integrated diversification", which implied an expansion of products based in utilizing new technology in multiple areas. Typical of this approach was the entrance into cable television equipment manufacturing utilizing broadband distributed amplifier technology from military systems. This in turn led to an entrance into cable system ownership throughout the country under the corporate entity UltraCom. Eventually the financial and marketing aspect of the business resulted in the sale of the system portfolio and departure from the CATV business. This provided for focusing the R&D budget on the core business of electronic defense.

BOEING INTEGRATED DEFENSE SYSTEMS

Piasecki — Vertol — Boeing

The history of Boeing Co's large helicopter plant in Ridley Park, Delaware County began in Philadelphia over 60 years ago when Frank Piasecki and Harold Venzi, engineering students at the University of Pennsylvania, established the P-V Engineer-

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ing Forum in 1940 and began designing rotary winged aircraft. In 1943 after incorporating the company's first aircraft, the single-seat PV-2, with Piasecki at the controls, completed its first flight at their Roxborough plant. Progress continued as follows:

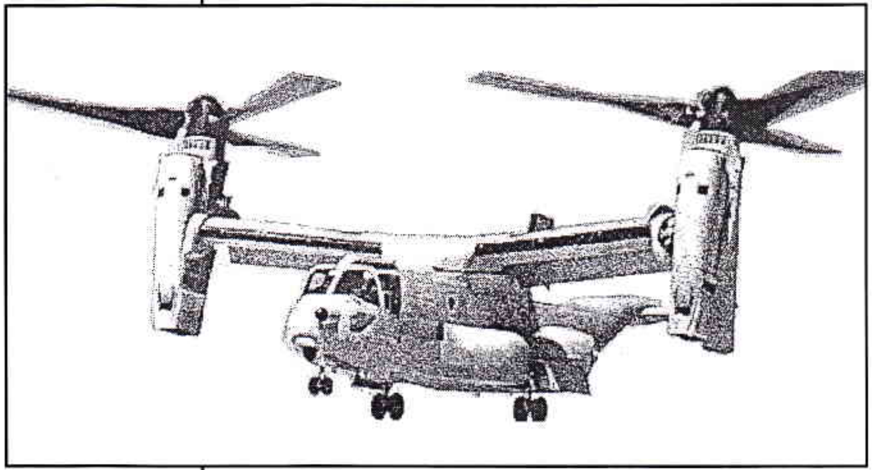
1940s — The Navy awarded a contract for development of a tandem rotor design. The result was a 10-place helicopter, the first large transport rotorcraft helicopter to feature counter-rotating tandem-rotor configuration, a design that improved aircraft balance and eliminated torque control problems. HRP helicopters demonstrated superior lift capability by lifting a one-ton jeep and later carrying 10 passengers, marking the start of modern helicopter transport. The Navy awarded another contract in 1946 to develop a utility rescue helicopter. The Army called on Piasecki for the design of a new long-range rescue rotorcraft. The company changed its name to Piasecki Helicopter Corporation in 1947 and opened a new manufacturing plant in Morton, PA.

1950s — During the Korean War, helicopter design, testing and production proceeded rapidly. The company was renamed Vertol Aircraft Corporation. Commercial production developed rapidly. In a busy 1958, a Vertol helicopter went into service with the New York Airline. At the same time the tilt-wing Vertol model, the world's first, successfully completed experimental test flights. The tandem-rotor transport helicopter, and a Chinook prototype were test flown, respectively. These proved to be two of the company's most successful designs.

1960s — The company was acquired by Boeing and renamed Boeing Vertol Division, closing down the Morton plant. During 1961 the Vertol helicopters began service with the Canadian and Swedish militaries and the Chinook completed its first flight. New York Airways began flight operations in 1962 and the U.S. Navy selected an assault transport helicopter and the Sea Knight was selected for the US Marine Corps. 1965 was the year when the armed/armored Chinook rolled off the assembly line just in time for the Vietnam War. At peak wartime production, Boeing engaged 14,000 people working three shifts to roll a Chinook and Sea Knight off the assembly line each day. The Chinook and Sea Knight perform with distinction at every subsequent US military engagement.

1970s — The first flight of Model 347, a modified Chinook developed for experimental test flight with tilting wing to improve maneuverability. Chinook International sales to Australia, Canada, Vietnam and Spain were completed. After Vietnam War Chinook production peaked, the company received its first contract for mass transit railcars from the Urban Mass Transportation Administration. In 1973 they began producing railcars for the Massachusetts Bay Transportation Authority, the San Francisco Municipal Railway Improvement Corporation and the Chicago Transit Authority. The company successfully tested a bearingless main rotor for helicopters and started construction of a new Flight Test Center in Wilmington, Delaware in 1978. British Airways placed the first order for a Boeing Model 234 Commercial Chinook.

1980s — Started with the first flight of the Boeing 234 Commercial Chinook. The U.S. Army awarded a developmental contract for the Advanced Digital Optical Control system (ADOCS). The Army also established the first production contract to modernize the Chinook fleet to the CH-47D configuration in 1981 and the company Training Center was opened. In 1983, the company announced a teaming agreement with Bell Helicopter Textron for JVX development and in 1985 a teaming agreement with Sikorsky Aircraft to develop a new light helicopter for the U.S. Army, the LHX. The Navy awarded the Bell Boeing partnership a full-scale development contract for the V-22 Osprey tilt rotor aircraft in 1986. The same year Boeing completed the first flight of the International Chinook. Japan began Chinook assembly and licensed production for its self-defense forces that year. CH-47Ds now operate in the United Kingdom, Spain, Greece, the Netherlands, Singapore, Japan, Australia and other Far Eastern nations. All together, about 20 nations operate Chinooks on six continents. The Boeing 360 tandem rotor helicopter, the world's largest all-composite aircraft to evaluate composite production techniques and integrated flight control system completed its first flight in 1987. During 1988 the first V-22 rolled out, flew in 1989, and accomplished its first full conversion from helicopter to airplane mode later that year. After several company-wide reorganizations and name changes, Boeing Vertol became Boeing Defense & Space Group, Helicopter Division.



V-22 Osprey Tilt Rotor Aircraft

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1990s — Began with modernization contracts for International Chinooks. In 1991 Bell Boeing received the 1990 Colliet Trophy, a leading aerospace award for developing the V-22 Osprey. In 1995 the Boeing Sikorsky RAH-66 Comanche and the first production-representative V-22 fuselage rolled off the Boeing assembly line in Philadelphia and was shipped to Bell where its wing assembly was installed. Also, the Bell Boeing V-22 Joint Venture Agreement was signed. 1996 welcomed the first flight of the RAH-66 Comanche and the Civil Tiltrotor Memorandum of Intent agreement. In December, Boeing and McDonnell Douglas announced a merger, bringing formerly competing manufacturing facilities in Philadelphia and Mesa together in a process that continued through the decade's end. In 1998 Boeing announced a reorganization designed to focus on its military rotorcraft products, which would phase out Commercial Airplane Group support programs. In 2000 there were more organization transitions designed to bring the Philadelphia and Mesa facilities into closer alignment. During 2001 V-22 tests and low-rate production were suspended following two fatal mishaps until 2003 when the program resumed successful flight tests following extensive reviews. In 2002 the Boeing Integrated Defense Systems Division was created. The Ridley Park plant's present employment is approximately 4500.

PHILADELPHIA NAVAL SHIPYARD

194 years from 1801 to 1995

For 194 years the Federal Government maintained a US Navy Shipyard in Philadelphia with the purpose of building, repairing, outfitting and storing Navy ships. 25 years after the Declaration of Independence, in 1801, Congress authorized the original Federal Street Navy Shipyard on a 10-acre site. During the Civil War, the site proved to be too cramped and 800 marsh acres, including the League Island, were obtained. Over the years many facilities including dry-docks, schools on damage control and ship operations, an ammunition depot, a systems engineering center, a propeller foundry, a testing center, facilities for docking inactive ships, a naval air station, etc. were added. The yard ultimately expanded to more than 1,400 acres, 1326 buildings and the Mustin Field Naval Air Station. Maximum employment was 47,000 during World War II.

The Navy base also became headquarters for the Fourth Naval District. During its 194 years the shipyard built over 200 ships and the air station assembled nearly 3500 airplanes from the 3 mast frigates built during the war of 1812 (USS Franklin 1st in 1815), to the famous WWII battleships USS New Jersey and USS Wisconsin — both 45,000 tons with 16" guns — and finally to the USS Blue Ridge in 1970, the Navy Shipyard built the best and finest. After 1970, the major effort of the shipyard was the Service Life Extension Program (SLEP) in which 146 vessels were modernized. Five aircraft carriers were in this effort to add at least 15 years to their service lives. The modernization of the USS John F. Kennedy marked the end of a Philadelphia industrial giant. On September 5, 1995, with the exception of three commands, the Navy base was closed. These commands are Naval Surface Warfare Center Ship System Engineering Station (NAVSSES), Naval Inactive Ship Storage and the Naval Foundry and Propeller Center.

NAVAL SURFACE WARFARE CENTER SHIP SYSTEM ENGINEERING STATION

Naval Surface Warfare Center Ship System Engineering Station (NAVSSES)/Carderrock Division of Naval Surface Warfare Center Situated within the old Philadelphia Navy base, NAVSSES includes the David Taylor model test Basin along with several other facilities to form the Carderock Division of the Naval Surface Warfare Center. It is responsible for propulsion, auxiliary, habitability and any other systems that make a ship operate and survive. NAVSSES employees number about 1600 including many engineers and specialists. Successful programs completed include:

- LHA mid-life upgrades,
- Submarine maintenance effectiveness reviews,
- Aegis program support,
- ISO 9001 certification
- Integrated condition assessment system delivery to the fleet,
- "Smart Ship" at sea testing

A major program is the Integrated Power Systems (IPS) study that promises to provide a revolutionary change in how US warships use power for propulsion, electric distribution and weapons needs. As a result, the 21st century Land Attack Destroyer (DD21) has been contracted for delivery by 2010. It will be the first US Navy Class of ships [DD(X)] to use the IPS for all ship power needs. Its use will eliminate the need for long drive shafts and reduction gears found in traditional naval ships, thus reducing cost, noise and maintenance demands. The Navy looks for benefits in 2 major areas, war fighting capability and quality of life with large amounts of space

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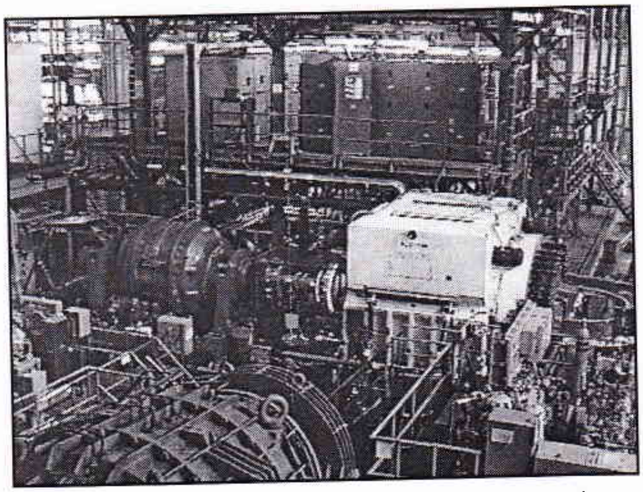

Test installation at the Naval Ship System Engineering Station (NAVSSES).

for crew habitability improvements. In addition, the DD(X) class ship will have a radical wave-piercing hull, stealth superstructure and two massive guns. The crew size will be substantially reduced.

Lockheed Martin continues to be a principal contributor to the development of the DD(X).

THE FRANKFORD ARSENAL

161 years of US Army Service

In May 1816, the Frankford Arsenal was founded as the 2nd of the "old line" arsenals. It was located 1/4 mile from the Delaware River, out of accurate canon range from warships on that river. When the Arsenal was retired in 1977, there were about 234 buildings within its 112 acres. In its beginning, the Arsenal was a principal depot for small arms and ammunition. Through the Mexican War (1846–48), the Civil War (1861–1865), Korean (1950–58) and Vietnam (1964–73), the technology and mission changed. After WWII, the Arsenal placed emphasis on engineering, testing and evaluation. There were 1200 engineers, scientists and technicians. As technology changed the Arsenal evolved into a principal research development and industrial engineering center.

The personnel complement of Frankford Arsenal at the height of World War II was 22,000 people. This dropped at the end of the war to approximately 7,000 and was further reduced in subsequent years. After 161 years of production and development, in 1977 the Arsenal was closed and its remaining functions moved to more remote locations. Over the years the Arsenal's involvement in electro technology was most pronounced before, during and following WWII. Optics technology and its use in fire control for anti aircraft, antitank and other purposes were extensive. The Arsenal could manufacture optical equipment without outside purchase while relying on industry for major production support. Its development engineering staff members accumulated "know-how" in the fields of servo-mechanism design and development from fractional to high horsepower levels; microwave circuitry for special and conventional needs, semiconductor application to high speed digital computers, analog computer and computer component design and development; digital computer logic applied to the solution of target acquisition and missile tracking problems; basic research, design and manufacture of precision optical equipment.

Vacuum tube (VT) Fuse activities, a Frankford Arsenal mission for many years, during and after WWII, were eventually transferred elsewhere. Experimental fuses, both electromechanically and electronic, for missiles, rockets, and artillery were developed, debugged, and readied for industrial mass production. Most spectacular of these was the VT proximity fuse, considered one of the more significant contributions to fire power of World War II. Since its founding, Frankford Arsenal had been a vital national resource.

NAVAL AIR DEVELOPMENT CENTER (NADC) 1944 TO 1996

Warminster Pennsylvania

NADC, had a 52 year history rich with advanced air research and development. It began in July 1944 at the Brewster aircraft factory in rural Bucks County, PA. The Brewster facility contained production shops and administration space with an adjacent airfield and hanger. Its original assigned task involved modification of new aircraft for combat use in the fleet. During 1947 the station was redesignated for centralized air research and development.

Neil Armstrong during astronaut training in Johnsville

Examples of systems developed in the post WWII to

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Avionics

early 60s were: in radar early warning and control systems and high range resolution systems, anti-submarine warfare systems including acoustic sensors for sono buoys and systems for automatic carrier landing.

The station subsequently grew to become one of the leading Naval Air research laboratories. It was home for one of the earliest and largest dynamic flight simulators, a human centrifuge. This was used extensively for astronaut training for the Mercury and Gemini space programs, for the high decelerations experienced during reentry. All 12 lunar astronauts trained at NADC, namely Neil Armstrong, Buzz Aldrin, Pete Conrad, Alan Bean, Alan Shepard, Edgar Mitchell, David Scott, James Irwin, John Young, Charles Duke, Eugene Cernan, and Jack Schmitt.

On October 31, 1996 the Warminster Naval Air Warfare Center was closed as part of the post Cold War shrinkage.

Some of NADC's most notable projects are:

Airborne Early Warning and Control Systems (AEW/C) — Based on the pioneering work of the MIT Radiation Labora-tory, NADC conceived, developed and demonstrated successive Airborne Early Warning and Control systems in the laboratory, in airborne prototype form, and provided technical assistance to the production contractors. Of special note was the development of the APS-20B search radar, the APS-45 height finding radar, and APA-56 radar indicator. These became the elements of the WV-2 Constellation (AEW/C) in the late forties and early fifties. The concept for digital surveillance and control system with automatic detection and height finding and intercept control via data link was developed by NADC and the bureau of Aeronautics and featured the General Electric Company developed APS-96 radar and a large rotating radome atop the aircraft.

Avionics — In the P-3A Avionics system, the crew was rapidly becoming overloaded and ineffective because of the overwhelming volume of information needed to perform anti-submarine Warfare (ASW) tactics. Early center research, development, and systems integration including extensive analytical studies and simulation identified areas of greatest potential pay-off in coping with this problem. Subsequently the Center provided major updates to the P3C avionics, mission software, and system test software in a systematic stepwise enhancement of the capabilities of the P-3C. The basic concept featured a central digital computer to integrate and provide tactical support.

High Range Resolution Radar — Basic investigations into high resolution radars for the purpose of detecting small targets (snorkels) in a sea clutter environment was initiated in 1959. This effort led to a preliminary design specification for the radar in 1966. This was followed by the development of AN/APS-116.

Igloo White — The Igloo White Program was assigned to NADC in 1965. The Igloo White System was composed of a sensor detection and encoding system plus an airborne and ground based processing/display system. NADC defined, developed, tested and prototyped the various elements. The Army, Navy, Marines and Air Force deployed this system in south East Asia.

Sonobuoys — Beginning in 1952, NADC conducted research and development in the use of acoustics for the detection, classification and localization of underwater vehicles. It provided leadership and expertise in the design and development of acoustic sensors for airborne ASW operations. The first significant airborne detection capability was the introduction of the Jezebel and Julie buoys in the late 1950s and the early 60s. Included with these was the airborne processors and other navigational aids and tactical displays.

Airborne Terminal — During the early 60s the Navy was in the process of developing an Automatic Carrier Landing System. This system accepts precision radar tracking data, converts and calculates ideal glide slope information and transmits the data to the aircraft for glide slope correction display and command data to the aircraft autopilot. Essential to the system was the requirement for a reliable airborne terminal of minimal size and weight. NADC proposed a program for in-house design development, fabrication and testing of micro-miniature airborne terminal equipment. Seven months after the date of assignment the breadboard version was flight-tested. This terminal provided the first scale use of digital microelectronic circuit technology for military aircraft avionic systems. More importantly the equipment fulfilled a Navy operational need.

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REGION ENGINEERING UNIVERSITIES

UNIVERSITY OF PENNSYLVANIA

Moore School

Biomedical engineering (bioengineering) originated in the USA, primarily due to activities of the IRE and AIEE (both now IEEE), forming the first professional group and organizing meetings of the field. The Moore school of Electrical Engineering at the University of Pennsylvania established one of the first laboratories in the late 1920's. Herman Schwan became head of this electromedical group in 1952. He secured significant funding for work of an electrophysiological orientation and on electromagnetic hazards and for construction of laboratories. In 1961 the electromedical division established the first doctoral program in the field and a graduate department group administering it. Other departments in the country were established by a significant number of students from the University of Pennsylvania program. In 1973 Schwan became founder head of a department which included an undergraduate program. Three present and former faculty members were elected members of the National Academy of Engineering. Today a large number of bioengineering departments exist. Their research includes almost all areas of engineering applied to medicine and biology, including electro-physiology and neurology, electromagnetic hazards, modern diagnostic and imaging technologies, tissue engineering and macromolecular chemistry. Several Nobel prizes were awarded for biomedical engineering contributions, highlighting the impact of the field on modern society.

Electrical and Systems Engineering (ESE) Department

The Electrical and Systems Engineering (ESE) Department of the University of Pennsylvania is a new academic subgroup within the University's School of Engineering and Applied Science (SEAS), created in 2002 from the merger of the formerly separate Electrical Engineering and Systems Engineering departments.

Electrical engineering traditionally has concentrated on the acquisition, processing, communication, storing and displaying of information. Systems engineering dealt with the function and use of information in complex systems, and concerned itself with information specification, processing and analysis, decision-making, and deployment. However, these disciplines are quickly converging.

The field of networking and telecommunications illustrates this new reality: it covers a wide spectrum of areas ranging from network processing, physical layers, communications, optimization, and statistical processes to control and management, network economics, and pricing, none of which can be straightforwardly classified as 'electrical' or 'system' issues. Hybrid systems, sensor and wireless networks are areas that have wide application to transportation systems, so-called "smart" buildings and highways, and environmental monitoring. These are examples where electrical and systems engineering are converging.

Electrical and Systems Engineering aims to balance strong core of key disciplines and a robust set of application areas emerging from these disciplines. The expectation is that most of the innovative and exciting research developments will occur at the intersection of traditional fields.

The Department's three main research areas are: Electrosciences (electromagnetics and photonics, sensors, MEMS, VLSI, and nanotechnology); Systems Science (signal processing, optimization, simulation, control and cybernetics, complex adaptive systems, stochastic processes, and decision sciences); and Network Systems and Telecommunications (networks, communications, logistics and manufacturing, transportation, and infrastructure engineering).

DREXEL UNIVERSITY

Drexel University was founded as Drexel Institute of Technology and dedicated on December 17, 1891. The institution started "instruction in electricity" in 1893, with strong emphasis on practical training. The first formal program was a two-year course taught by Professor of Applied Electricity Arthur J. Rowland, a graduate of Johns Hopkins University. In 1898 a formal three-year standard program at college level was introduced. Until 1918 all these programs and courses, including laboratories were created and administered by one person, Arthur J. Rowland.

The association of Drexel with the American Institute of Electrical Engineering (AIEE) started in 1915, when Rowland encouraged upper classmen to join the Institute. In 1921 Drexel established a student branch of AIEE. Today its student chapter of the IEEE is one of the largest and fastest growing in the Delaware Valley.

Drexel played an important role in accreditation of technical schools and was accredited by the Association of Colleges and Secondary Schools of the Middle States

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and Maryland in 1927. In 1925 the cooperative education program was extended to five years in the face of criticism that there was not enough time for academic training in the 4-year version.

In 1939 Drexel started a program of National Defense, and was one of the 12 Pennsylvania Institutes who participated in the Federal program of engineering defense training well until the late 1940s. Throughout the years the university has maintained a leading role in research and as recent as 2001 one of its own, Paul Baran, was granted the $200,000 Bower Award for Achievement and Science for his creation of the concept known as "packet switching" an idea that has made the Internet possible.

VILLANOVA UNIVERSITY

The Augustinian Order of Priests and Brothers founded Villanova University in 1842. It resides on the Main Line 12 miles outside of Philadelphia. Its 6,300 full time undergraduate students are from 50 countries and all 50 states. Its selection as #1 in the US News' Best University Masters category for the North Region in 2003 and 12 other years demonstrate Villanova's quality.

During 1905, the College of Engineering's history began when Villanova's school of Technology initiated instruction with 12 students enrolled. Engineering was Villanova's 2nd degree granting program and it was the 4th Catholic engineering program in the U.S. after Catholic University (1896), Manhattan College (1896) and Notre Dame (1897). In the years following the Second World War, the College expanded its degree offerings to the master level, establishing graduate programs in each of its four engineering departments. A fifth undergraduate degree program in Computer Engineering was added in 1993. Beginning in 2003, the College of Engineering initiated a new interdisciplinary graduate program leading to a Doctorate of Engineering degree.

The Electrical and Computer Engineering Department has a tradition of offering innovative and up-to-date curricula and employs 19-full time faculty who are very actively involved with industrial and government sponsored research projects.

TEMPLE UNIVERSITY

Electrical Engineering at Temple University was established and accredited by ABET in the mid 1980's when the Electrical Engineering Department was chaired by Victor K. Schutz. Masters and PhD programs soon followed. Bachelor programs in Electrical Engineering Technology were in place in the early 1970's and phased out in 2003. The founding Dean, John L. Rumph, established the college of Engineering Technology in 1969. The college went through different name changes, reflecting the expansion of the academic programs, including the College of Engineering, Technology and Architecture to the present College of Engineering. It is one of 15 colleges and schools at Temple University.

ROWAN UNIVERSITY

The electrical engineering club at Rowan University was started in the winter of 1996. It grew in size over the next two years, and in the fall of 1998 became an official IEEE Student Branch. The student branch currently has over 50% of the electrical engineering students at Rowan as members, and this number is growing fast.

The College of Engineering graduated its first class in May 2000. One of the newest Colleges of Engineering in the U.S., this program was made possible by a transformational legacy from Henry and Betty Rowan, a $100 million pledge in 1992.

All of the programs including the electrical and computer engineering are ABET accredited.

SWARTHMORE UNIVERSITY

Swarthmore approach to engineering differs from that of other schools. Students are not required to commit to an engineering discipline before arrival and don't decide on their major until spring of their sophomore year. Engineering builds upon prerequisite courses of basic Math and Science. The educational process allows room for plenty of non-Engineering courses in the social sciences, humanities, and elsewhere (e.g., study abroad). Swarthmore College is a liberal arts college, and all our students, including the engineering majors, get a liberal arts education.

This approach results in degree students with a Bachelor of Science in Engineering, not one in ME, or EE, or CivE, or CompE, etc. Instead of trying to produce finished engineers the Swarthmore program produces students who are excellent candidates for graduate programs, or enlightened companies, to mold into specialists. As a result over 80% of the school's graduates go to graduate

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school eventually. This opens up a whole new set of career opportunities (both inside and outside of engineering) that require creativity and intellectual agility throughout your whole life.

Swarthmore has many international students and students of virtually every background and ethnicity, and our engineering program reflects that diversity. It is extremely important to have many cultural differences among engineers, so that the solutions they produce are culturally appropriate for the end users. This is especially important in a global economy.

WIDENER UNIVERSITY

Widener University Department of Electrical Engineering is dedicated toward developing, through knowledge and experience, the ability of students to be immediately and continually productive in their professional endeavors. To accomplish this the curriculum focuses in establishing graduates with strong foundation in the basic sciences, engineering science and mathematics to enable them to identify and solve engineering problems. Emphasis for electrical engineering students is on design experience that is integrated across the undergraduate curriculum, which serves to underscore the relationships between theory and practice.

Also as important is to provide students with the basic skills to communicate effectively and to develop the ability to function as members of multi-disciplinary teams. This requires a broad-based education to understand the context in which engineering is practiced, develop a better sense of ethical and societal issues, which impact engineering, and appreciate the global nature of the engineering profession.

ACKNOWLEDGEMENTS

IEEE PHILADELPHIA SECTION

The 2003 Centennial Committee — Acknowledgment

The Delaware Valley has a rich history of electrical electronic and computer innovation, projects, services and products. The centennial committee was formed to record at least some of these accomplishments for our 100 year anniversary. The committee members were:

- Mr. Merrill Buckley Jr. (Chair) — RCA/GE (Retired), Past IEEE President
- Mr. Donald C. Dunn — PECO (Retired), Past Section Chair
- Mr. Thomas L. Fagan — Gestalt, LLC, Past Section Chair
- Dr. Victor Schutz — Temple University, Past Section Chair
- Mr. Donald Schnorr — RCA/GE (Retired)

The following are principal contributors to the committee's efforts:

1. March Issue — Electric Power Industry (& Rail)

- Mr. Robert Cortiaus — Westinghouse (Retired)
- Mr. William Clune — PECO (Retired)
- Mr. Raymond Dotter — PJM
- Mr. Donald C. Dunn — PECO (Retired)
- Mr. Stanley Heyer — PECO
- Mr. William Kirn — PECO
- Mr. Peter Kudless — PSEGCO (Retired)
- Mr. Thomas Tonden — Stone and Webster

2. June Issue — Consumer, Commercial & Industrial Products and Communications

- Mr. Frederick Barnum — L3 communications
- Mr. Emidio Cimini — Megger

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- Mr. Thomas Martin — Threshold Technology
- Ms. May Ling — L3 Communications
- Mr. Ed Podell — RCA (Retired)
- Mr. C.W. Hargens — Franklin Institute (Retired)
- Dr. Victor Schutz — Temple University

3. September Issue — Computer and Instrumentation

- Mr. Paul Alfieri — Motorola
- Mr. Fred Barnum — L3 Communications
- Mr. Samuel Chappel — CSC
- Mr. Tom Fagan — Gestalt, LLC
- Mr. Guenter Finke — Magnetic Metals
- Mr. Griff Francis — Moore Products
- Mr. James Senior — Unisys
- Dr. Victor Schutz — Temple University
- Mr. Mark Soffa — K&S Industries

4. November / December Issue — Defense, Aerospace and Engineering Colleges

- Mr. Fred Barnum — L3 Communications*
- Dr. Onaral Banu — Drexel University
- Dr. Bruce Eisenstein — Drexel University
- Mr. E. Alan Karpowitz — NAVSSES
- Mr. Ray Markowitz — AEL Industries (Retired)
- Mr. John McCormack — Boeing
- Dr. S.S. Rao — Villanova University
- Ms. Betty Rucker — NAVSSES
- Dr. Victor Schutz — Temple University
- Ms. Melinda Wismer — Lockheed Martin, M&Ds Valley Forge
- Mr. Thomas Woods — Philadelphia Naval Shipyard (Retired)
- Chief Warrant Officer Angelo Zuino — U.S. Navy
- Courtesy of Lockheed Martin, Moorestown — Communications Department.

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- Mr. Ed Podell who edited the first three issues of this effort.
- Mr. Tasos Malapetsas for editing the fourth issue.
- Mr. Tom Fagan and L3 Communications for hosting the many committee meetings in Camden.

Valuable References:

- *First 100 years of IEEE (1985) in Delaware Valley* — Mr. John Bry, Editor
- *Historical publications from RCA, GE, L3, UPENN, Bell Telephone and K&S Industries.*
- *His Master's Voice in America (2003)* — Frederick O. Barnum III.

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- *1987 Space Station,* Page 13
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- *The Aegis Weapon System,* Page 14
- *V-22 Osprey Tilt Rotor Aircraft,* Page 16
- *Armstrong at Johnsville,* Page 18
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