Famous Fort Monmouth and Team C4ISR Firsts

(Disclaimer: This is not a comprehensive list of Fort Monmouth and Team C4ISR firsts and patents. The contributions of many individuals with a close relationship to the Fort are listed even though they were not formally stationed at or assigned to an activity at Fort Monmouth at the time. Some of our key scientists and engineers have inventions and patents listed that were awarded after their separation or retirement. For clarification on any of these items, please contact the CECOM LCMC History Office)

1918	William R. Blair, commissioned in 1917, was issued Patent Number 1,275,372 for his "Wax Top for Sewing Machines." [1]
1918	Captain Edwin Armstrong, a Signal Corps Officer who would later work closely with the Fort, developed the super heterodyne in Paris. This device not only amplified weak radio signals but also enabled precise tuning. [2]
1918	Standardization and quality control of vacuum tubes for military radios resulted in a total standard for vacuum tube production for both military and civilian applications. This improvement significantly aided the infant commercial radio industry.[3]
1919	The success of courier pigeons in World War I led to the decision, after the Armistice, to perpetuate the service. To this end, Chief Signal Officer Squier established the Signal Corps Pigeon Breeding and Training Section. The officer in charge of the British pigeon service supplied 150 pairs of breeders; they arrived in Camp Vail, without loss, in October 1919. There they were kept, together with some of the retired "hero" pigeons of the World War, in one fixed and fourteen mobile lofts. [4]
1926	1926 saw the development of the SCR-136 and SCR-134 ground to ground and ground to air radios. These were the first extended range voice radios put into military production.[5]
1926	William R. Blair and William J. Smith were issued Patent Number 1,573,584 for their "Oil Well Pump."[6]
1928	The first radio-equipped weather balloon was launched in 1928. This was the first major development in the application of electronics to the study of weather, and of conditions in the upper atmosphere.[7]

1929	William R. Blair was issued Patent Number 1,753,399 for an “Ocean Going Water Craft” in 1929. [8]
1931	William R. Blair was issued Patent Number 1,815,286 for a “Sea Going Craft” in 1931.[9]
1932	William R. Blair and Louis Cohen were issued two patents, numbered 1,884,536 and 1,884,537, for “Radio Signaling” in 1932.[10]
1933	Four patents for frequency modulation were awarded to MAJ Edwin H. Armstrong in 1933. [11] Armstrong was a former Signal Corps Officer during WWI and worked closely with the Signal Corps labs on FM radio.
1933	In 1933, Dr. Harold Zahl filed for a patent for his “Altimeter for Aircraft.” [12]
1934	Dr. Zahl filed for a patent for “The Art of Locating by Heat Radiation” in 1934. [13]
1936	William R. Blair and Paul E. Watson were issued Patent Number 2,035,456 for the “Radio Frequency Choke Coil” in 1936. [14]
1936	In 1936, Patent Number 2,027,367 was awarded to William R. Blair for the “System of Determining Meteorological Conditions by Radio.” [15]
1937	William Blair was awarded Patent Number 2,075,797 for a “Gyroscopic Indicating and Control Device” in 1937.[16]
1937	The Fort Monmouth laboratories developed a “mystery ray” which was demonstrated in 1937. This was a prototype of the Radio Direction and Ranging (RADAR) sets SCR-268 and SCR-270, which would locate and

	track airplanes. [17]
1938	Aircraft Detection RADAR was developed at Fort Monmouth, the Evans Signal Laboratories, and at Fort Hancock at Sandy Hook in 1938, providing the first U.S. capability of aircraft detection and early warning. RADAR sets, such as the SCR-270, not only helped win World War II but provided a boost to the civilian aviation industry.[18]
1938	In 1938, Dr. Harold Zahl conceived and patented a pneumatic cell detector. This was a major component in the Army's first radar set, the SCR-268-T1. The SCR-268-T1 was successfully demonstrated in 1938. [19]
1939	In 1939, Dr. Zahl filed for a patent for the "System for Detecting Sources of Radiant Energy" with co-inventor M.J.E. Golay. [20]
c.1940	Development of the SCR-300 first portable, hand-held, FM "walkie-talkie," for use in the front lines occurred. This was the first major development in the miniaturization of radio equipment.[21]
1940	Post retirement, Blair was awarded Patent Number 2,196,187 for his "Directive Antenna Array."[22]
1940	Dr. Zahl invented the GA-4 Transmitter-Receiver Tube in 1940. This tube first made it possible for early radars to transmit and receive from the same antenna. [23]
1941	1941 saw the development of the SCR-510, the first FM backpack radio. This development was an early pioneer in frequency modulation circuits, providing front line troops with reliable, static-free communications.[24]
1941	The Zahl tube (VT-158) was introduced in 1941, making possible the use of a high 600-megacycle frequency. This allowed for small antennas. Dr. Harold Zahl had worked on this project for several years, reportedly blowing his own glass and shaping hundreds of tubes. [25]
1943	Multichannel FM Radio Relay AN/TRC-1, developed at the Signal Corps Laboratories, was first fielded in 1943.

1943	Dr. Zahl filed for a patent for “Spark Gap” with co-inventor J.E. Gorham in 1943.[26]
1943	Dr Zahl, along with co-inventors G.F. Rouse and J.E. Gorham, filed for two patents for “Electronic Tubes” in 1943. [27]
1945	COL William R. Blair finally applied for the radar patent entitled “Object Locating System” in 1945.[28]
1946	On 10 January 1946 Fort Monmouth took the first electronic step into space when the first radar signal was bounced off the moon using a modified SCR-271. It took the Diana radar 2-1/2 seconds to reach the moon and return. This proved the feasibility of extraterrestrial radio communications. [29]
1946	The Automatic Mortar Locating Radar was developed in 1946. The AN/MPQ-3 and the AN/MPQ-10 became standard equipment and both were used as major electronic weapons during the Korean War.[30]
1948	The first Weather Radar was developed at Fort Monmouth and observed a rainstorm that was at a distance of 185 miles. The radar was able to track the storm as it passed over the Fort.[31]
1948	Post retirement, Blair was issued Patent Number 2,451,317 for the “Microphone Adapted to be Actuated by a Bone Structure of a User.”[32]
1948	The first synthetically produced large quartz crystals were grown by researchers at Fort Monmouth. The crystals were able to be used in the manufacture of electronic components, and made the U.S. largely independent of foreign imports for this critical mineral.[33]
1949	A technique for assembling electronic parts on a printed circuit board, developed by Fort Monmouth engineers, pioneered the development and fabrication of miniature circuits for both military and civilian use.[34]

1949	On September 28, a record height of 140,000 feet was set by a high altitude balloon of the Signal Corps Engineering Laboratories at Fort Monmouth. [35]
1950s	In the 1950's, the Cirrus Project, Signal Corps Scientists (working with Dr. Langmuir of Syracuse University) developed the ability to manipulate weather by seeding clouds. Some reports indicate that the technology was used effectively for clearing away cloud cover in Vietnam.
1950-1953	A major success of this era was the introduction of Automatic Artillery and Mortar Locating Radars AN/TPQ-3 and AN/MPQ-10, both products of the labs at Fort Monmouth. Other developments of the period included a lightweight field television camera with a backpack transmitter; a pocket dosimeter for detecting radiation; an ultrasonic quartz saw; and super-small experimental field radios. [36]
1953	In 1953, Fort Monmouth scientists discovered transistor action in silicon and invented a floating zone refining process to produce inexpensive, chemically pure silicon crystals. By 1964, silicon was the Army's principal transistor material. [37]
1957	After much litigation, COL William Blair finally received his radar patent, U.S. Patent Number 2,803,819. He is remembered as the "father of American radar." [38]
1957	A method of measuring polar ice using radar was developed by the Fort Monmouth Laboratories. This technique significantly aided in the study of the polar regions.[39]
1958	1958 saw the development of solar cells for satellite power in space. The solar cells developed by Fort Monmouth scientists powered the Vanguard I satellite in space for more than five years.[40]
1958	The first communication satellite, Project SCORE, was developed in 1958. Launched on December 18, Project SCORE (Signal Communications via Orbiting Relay Experiment) broadcast President Eisenhower's Christmas greeting, proving that voice and code signals could be relayed over vast distances using satellite communication technology developed at Fort Monmouth.[41]

1959	The first Weather Satellite, the Vanguard II, was launched on 19 February 1959, equipped to map the earth's cloud patterns by a varying infrared scanning device. The electronics for the satellite were developed by Fort Monmouth.[42]
1959- 1960	Scientists at Fort Monmouth participated in Project WOSAC, the World Wide Synchronization of Atomic Clocks. The project, carried out with the aid of the U.S. Navy, U.S. Air Force, Harvard University, the British Post office, established a global standard for time measurement.[43]
1960	In 1960, the patent for "Piezoelectric Ceramic Resonators" was issued to Oskar Mattiat. [44]
1960	The first televised weather satellite, Tiros-1, was developed under the technical supervision of the Fort Monmouth Laboratories. Tiros-1 sent the first televised weather photographs of the earth's cloud cover and weather patterns to the giant 60-foot "Space Sentry" antenna at Fort Monmouth.[45]
1960	The first Large Scale Mobile Computer, the Mobile Digital Computer (or, MOBIDIC), was developed at Fort Monmouth. It was the first computer developed for use at the Field Army and theater levels. This van-mounted computer was the first experiment in automating combat support function in artillery, surveillance, logistics and battlefield administration.[46]
1960	The first High Capacity Communication Satellite, Courier, was developed and built under the supervision of the Fort Monmouth Laboratories. The Courier Satellite was an experimental communications satellite that proved high-volume communications, up to 100,000 words per minute, could be relayed through space.[47]
1961	In 1961, the patent for an "Antenna Release Mechanism" was issued to Richard A. Marsh. [48]
1961	Signal Corps scientists from the U.S. Army Signal Research and Development Laboratory at Fort Monmouth, in conjunction with New York University's College of Engineering, developed a method to measure rain. The device was designed to be placed outdoors where it would size and collect information on all the raindrops falling in a 1 ¼ inch square. Knowing the size and number of raindrops is critical to perfecting radar measurements of water particles in the atmosphere. [49]

1962	An experimental ten-pound radar unit, using the latest micro-miniaturization technology, was able to spot moving targets more than a mile away. This prototype model, developed at Fort Monmouth, was the first step in the production of light, hand-held tactical electronic equipment. It also was the prototype for the radar units used by all police departments across the United States.[50]
1963	Marilyn Levy was awarded a photography patent titled "Heat Eraseable photosensitive coating and process of using same." [51]
1963	The AN/VRC-12/PRC-25 radio family is first deployed to Military Assistance Groups in South Vietnam.
1964	The Morse Code Readout device, developed at Fort Monmouth, plugs into any Army radio and transforms the dots and dashes of Morse Code into letters formed by a light-emitting diode (LED). This device allows a soldier with no knowledge of Morse Code to be able to receive coded messages.[52]
1965	In 1965, Charles H. Gager and Abraham E. Ruvin were issued a patent for "Apparatus for Double Cancellation Utilizing One Delay Line in a Moving Target Indicating System." [53]
1965	Walter E. Comfort was issued a patent for the "Socket for Micromodules."[54]
1965	David G. Eyre and Moses B. Sharenow were issued a patent for "Balloon Launching Apparatus."[55]
1965	Edward C. Wallbrech, Donald F. Willmann, and William T. Wood were issued a patent for "Channel Selector and Indicator System."
1965	George M. Kirkpatrick and Lewis J. Neelands were issued a patent for the "Monopulse Radar System."[56]

1965	The ECOM Labs developed the PRR-9 helmet-mounted receiver and PRT-4 hand-held transmitter for squad-level use in Vietnam, exploiting technology to provide miniature, all solid-state radio designs with lower power consumption. Follow-on products included the AN/PRC-68 in the 1980s, the AN/PRC-126/127 in the 1990s, and civilian counterparts (e.g., hand-held police radios). This "individual soldier radio system" might be considered a precursor of today's "Soldier System." [57]
1965	Multi-channel laser relay: A single pencil-size laser beam was used to relay simultaneously between two points at Fort Monmouth, all seven of the television channels broadcast from New York's Empire State Building. The volume of information, believed to have been a record, further demonstrated the high capability of laser as a means of relieving over-crowded radio channels.[58]
1965	The Mighty Mite Oscillator was a solid-state radio signal generator whose essential material – a speck of gallium arsenide invisible to the unaided eye – performed in laboratory tests a bigger and better job than conventional counterparts, which used ten times the power. The device was about the size of a grain of rice with its packaging. It was viewed as a major breakthrough with promising applications to miniature radars, microwave radio relay systems, and other electronic equipment. [59]
1968	A passive night vision device, using image intensifier tubes, was developed at Fort Monmouth and deployed in Vietnam. The device, which intensifies existing light, does not generate a detectable beam as do the infrared devices.[60]
1971	Since 1971, when the system test bed first demonstrated the ability from an airborne platform to intercept signals, GUARDRAIL evolved through multiple product improvements to become "the most prolific intelligence system in the field." Its many "firsts" include the first tactical, airborne, remotely controlled COMINT system, the first multiple platform SIGINT system, and the first COMINT system that could be controlled through a satellite relay. [61]
1971	The Electronics Command fielded a small omnidirectional radio ground beacon, the AN/TRN-30, for Army aircraft. The beacon is for use at remote airstrips and landing facilities.[62]
1972	Working with doctors from Fort Monmouth's Patterson Army Hospital, ECOM scientists developed life-saving combination of a defibrillator and pacemaker that can be implanted in the human body. Not only does it regulate the heartbeat, as does a pacemaker, but it also detects the start of fibrillation -- wild and discordant tremors of the heart's muscle fibers -- and briefly stops the heart to allow normal beat to resume.[63]

1974	The AN/APR-39 Radar Warning System was an analog system that identified and provided directional information of radar threats, thereby permitting avoidance flying and increasing the probability of survival. About 5,000 had been employed as of 1990. There is currently an improved, programmable digital version aboard most Army aircraft. [64]
1975	Automatic Telephone Central Office: The solid state AN/TTC-38 is smaller and lighter than manual switch systems. It is faster and more easily maintained. It gives the user touch-dialing to anywhere in the worldwide military telephone system.[65]
1975	Frequency Hopping: ECOM initiated a technology-base R&D effort to develop techniques for frequency hopping in a pseudo random pattern over a large number of frequencies, as a way of defeating enemy attempts to jam tactical VHF radio. The Army's Single Channel Ground and Airborne Radio System (SINCGARS) employed this form of spread spectrum transmission, as did the many of the tactical radios developed by other nations.[66]
1975-1976	The AN/ALQ-144 is an-board infrared jammer to defeat on-coming anti-craft missiles. It has been employed effectively world-wide and serves as well for the protection of civilian VIP aircraft. [67]
1976	FIREFINDER artillery and mortar locating radar systems were fielded. Firefinder detects and locates enemy mortar and artillery weapon firing positions.[68]
1980	CORADCOM Center for Communication Systems electronic engineers Dr. Theodore J. Klein, Paul F. Sass, and George E. Krause were awarded U.S. Patent number 4,197,500 for their apparatus for automatically selecting the best telecommunications channel. The apparatus provided extremely reliable communications over difficult terrain under varying propagation conditions. [69]
1980	Fort Monmouth physical scientist William B. Glendinning was awarded U.S. Patent number 4,194,187 for an ultra-miniature analog to digital converter silicon integrated chip. This invention increased circuit density and provided improved communications, surveillance, and intelligence signal type processing equipment. [70]
1980	Dr. Charles M. DeSantis, a physicist with the ERADCOM/Electronics Technology and Devices Laboratory, and Dr. Felix Schwering, an electronics engineer in the CORADCOM Center for Communications Systems, were issued U.S. Patent number 4,185,289 for their spherical satellite antenna having uniform signal radiation and reception. The apparatus comprised a small, lightweight antenna providing improved communications for satellite vehicles as well as ground based units. [71]

1980	Dr. Robert J. Zeto and Sidney Marshall, both of the ETDL, were issued a patent for their improved method of fabricating integrated circuits. Their new method reduced integrated circuit processing temperatures by 200-400 degrees Celsius from those required in conventional procedures, thus improving device performance and reliability.[72]
1981	The first Tactical Fire Direction (TACFIRE) system was fielded. TACFIRE was a tactical ADP system that helped give the American soldier battlefield capabilities no other Army possessed. [73]
1982	CECOM fielded the first TTC-39 TRI-TAC switches. Tri-Services Tactical equipment was designed to accommodate the transition from the manual and analog systems currently being used to fully automated digital systems, and to provide message switching, circuit switching for voice communications, secure voice terminals, digital facsimile systems, and a user's digital voice terminal.[74]
1983	CECOM led a DOD initiative to define and implement a standard programming language for all mission-critical defense systems. The result, Ada, became a military standard (MIL-STD-1815a) in January 1983. Subsequently adopted as an international standard, Ada has been successfully employed in a wide variety of Army and DoD systems and has gained favor as well in the commercial sector. [75]
1983	CECOM awarded the first contract for production of Single Channel Ground and Airborne Radio Systems (SINCGARS) to replace radios of the VRC-12 family.[76]
1985	CECOM awarded Mobile Subscriber Equipment (MSE) contracts in a revolutionary $4.5 billion procurement. MSE supplanted TRI-TAC.
1986	The Center for Night Vision and Electro-Optics developed a technique using a coherent laser sensor to remotely detect the vibration of surface targets. Targets then could be identified on an aspect independent basis due to the unique features in their vibration spectra. A successful demonstration of real-time identification of helicopter targets, to ranges in excess of five kilometers, was conducted at the Center in April 1986. [77]
1988	Stanley Kronenberg of EW/RSTA was awarded Patent Number 4,721,857 for his “Sampling and Recording Dose Rate Meter.” The abstract for this invention reads as follows: “A wide range radiation dose rate meter for civil defense use, including an iger-Mueller tube used in a continuous counting mode and for measuring dose rates from the natural background to about 30. rads/hr., with an ion chamber arranged to measure higher dose rates up to 10,000 rads/hr. The instrument has a sample and record

	capability in which the selected radiation detector will have its output connected to a selected storage capacitor for a precise interval of time determined by a timing circuit and the storage capacitor will accumulate and hold a voltage proportional to the dose rate, which can be read by means of an electrometer at a later time. The instrument has a self contained hand cranked power supply and all components are selected for long shelf life."
1988	John Borowick, EW/RSTA, received Patent Number 4,746,926 for the "Phase Scan Antenna," which he co-invented with Richard A. Stern and Richard W. Babbitt. The abstract for this invention reads as follows: "A phase scan antenna suitable for millimeter wave radar applications is pided comprising a four-sided ferrite rod having a series of electromagnetic energy emitting slots along one side of the rod. The remaining three rod sides are enclosed by a metal, channel-shaped member which is spaced from the rod by a plastic, channel-shaped substrate member, so that energy emitted from the rod side which is opposite from the slotted rod side will be reflected to pass out the slotted rod side, to thereby enhance the antenna beam produced by the slotted rod side. A magnetic biasing coil having serially-interconnected coil portions is helically wound about the metal channel-shaped member with the coil portions disposed between the slots in the first rod side to cause scanning of the antenna beam. The ferrite rod may be end fed by either dielectric waveguide sections or hollow, metallic waveguide sections."[78]
1989	Development was initiated in September 1989 for eleven prototype Frequency Hopping Multiplexers (FHMUXs). Tactical vehicles with multiple antenna installations readily identified the vehicle as a Command, Control, and Communications (C3) platform and invited enemy fire. The FHMUX/ High Power Broadband Vehicular Whip Antenna (HPBVWA) would mask tactical C3 functions by reducing the vehicle's visual signature. The FHMUX would allow up to four SINCGARS and/or VRC-12 radios, in frequency hopping or fixed modes of operations, to use a single high power broadband vehicular whip antenna.[79]
1989	During fiscal year 1989, a serial line internet protocol (SLIP) interface was developed for the SINCGARS Packet Appliqué to allow attachment of personal computers and workstations without Ethernet capability to a SINCGARS Packet Network.[80]
1989	The CECOM Center for C3 Systems initiated the development of a fully digital radio, leveraged off DARPA's larger program for the Gallium Arsenide (Ga As) technology insertion. The first of this three phase program was to develop two digital brassboards exploring the application of GA As technology in handheld digital radios. Using the Ga As technology insertion, the goal of the program was to develop a multiband (HF, VHF, UHF) multimode (AM, FM, PM) programmable radio with built-in ECCM and COMSEC features.[81]

1989	The CECOM Center for Electronic Warfare/ Reconnaissance Surveillance and Target Acquisition (EW/RSTA) initiated the AN/PDR-77 program to design, test, and field a new alpha radiac to replace the existing fielded AN/PDR-56F and AN/PDR-60 with a modern device that was rugged yet sensitive enough for the augmented mission of the M8A1 Chemical Agent Alarm.[82]
1989	Dr. Stanley Kronenberg of EW/RSTA received Patent Number 4,859,853 for his "Solid Gamma Ray Dosimeter which measures radiation in terms of absorption in a material different from the detector material." The invention abstract reads as follows: "A solid state gamma ray dosimeter which measures radiation in terms of absorption in a material different from the detector material. A solid state detector, an amplifier, an analog-to-digital interface and a microprocessor are combined in circuit to correct for differences between absorption of radiation in detector material and absorption in other materials, especially tissue. A suitable cladding may surround the detector. A method of generating dose translation data for calibrating the microprocessor is also disclosed. The solid state detector is attached to a multichannel analyzer circuit and subject to known doses of various monochromatic gamma rays. Output pulses from the detector are amplified and introduced into the multichannel analyzer. The spectrum produced is used to determine an average channel number (or pulse height) for a given dose of monochromatic radiation. The given dose is in units specific to material different from the detector material. The partial dose represented by a single detector pulse at that energy is computed. Partial doses for other energies are likewise computed. Dose translation data associates a partial dose with a given detector pulse height. Dose translation data is set in the microprocessor of the dosimeter. Such dose translation data can be used to calculate total dose and dose rate in units peculiar to material other than detector material."[83]
1989	The Center for Night Vision and Electro-Optics created AUTOSPEC for use in developing and evaluating second generation image processing systems and the advanced Forward Looking Infrared Systems that employed them. AUTOSPEC represented the first phase in an aggressive effort to develop a digital electronic terrain board. It gave NVEO scientists and engineers the ability, for the first time, to analyze and evaluate both end to end and intermediate processing steps for any Aided Target Recognizer (ATR).[84]
1989	NVEO developed the Multi-Sensor Target Acquisition System (MTAS), a millimeter wave radio that would provide modern heavy forces with an independent, all weather sensor capability to augment infrared (IR) and visible sensor inputs. The radar afforded 360- degree independent search and acquisition of multiple ground and helicopter targets.[85]

1989	The NVEO Center developed a prototype Vehicle Infrared (IR) Beacon for use on Army vehicles during live fire training exercises. This safety device, quickly mounted on M1, M2, and M3 combat vehicles, could be seen at three kilometers and beyond through 360 degrees. It provided unambiguous identification during live fire exercises to prevent mistaken fire on friendly vehicles.[86]
1989	Tobyhanna Army Depot designed, fabricated, and deployed a new Defense Communications Satellite Subsystem (DCSS) operations van, the AN/MSC-74. This contained twenty-six baseband equipment racks and an operations console in a forty-foot trailer.[87]
1989	The CECOM Center for Electronic Warfare/Reconnaissance Surveillance and Target Acquisition (CEW/RSTA) developed a proof-of-principle model of the AN/PPN-20 Miniature Multiband Beacon (MMB) in an in-house program to demonstrate three new technologies (microstrip antenna, solid state transmitter, and digital signal processor) that would afford a two-thirds reduction in the size and weight of the fielded beacon, the AN/PPN-19. The proof-of-principle phase culminated on 24 October 1989 in a successful demonstration to representatives of TRADOC, the Special Operations Forces, the Test and Evaluation Command, and the Logistics Evaluation Agency. The experimental MMB system demonstrated beacon mode operation with simulated airborne radar, identity codes A through G, and side-lobe suppression. Intended for the use of Special Operations Forces, the MMB was capable of stand-alone and remote operation and could interface with a variety of airborne radar systems. It was to be used primarily as a point designator to permit accurate delivery of ordinance by tactical and strategic aircraft.[88]
1990	The Army completed the first Anti-Jam Control Modem (AJCM) modification of an AN/MSQ-114 GMF Satellite Control Terminal in FY 90 at Tobyhanna Army Depot. The modification permitted the planning, monitoring, and control of a spread spectrum AJCM tactical network.[89]
1991	The FY 91 achievements of the Center in antenna research included development of a synthesis procedure for a linear array of transversely fed, electro-magnetically coupled, printed dipoles; development of an accurate theory, substantiated by experiments, for microstrip discontinuity effects, including radiation and surface wave loss; confirmation of the accuracy and high numerical efficiency of diakoptic theory through application to canonical problems and comparison with the standard "method of moments" technique; assembly of a fully functional experimental model of a modulated scattering technique near-field antenna measurement system. The CECOM Center for C3 Systems also initiated an investigation on a new, unified theory of metal strip grating antennae.[90]

1991	John Mitchell of the Center for Signals Warfare (CSW) developed a prototype signal analysis tool for the use of CSW technicians and engineers in laboratory research projects. The system, known as the Fast Response Intelligence Analyst Resource (FRIAR), could provide a plug-in/plug-out signal identification capability for tactical intercept systems. It allowed signal analysts in Saudi Arabia to easily examine and identify unknown signals. John Mitchell was awarded the 1991 Milton A. Lipton Award. [91]
1991	Henry C. (Budd) Croley of the Center for Night Vision and Electro-Optics (CNVEO) Technical Operation Team invented a device known as the Budd Lite for the 24th Infantry Division. The Budd Lite consisted of two infrared light emitting diodes mounted in a rubber holder with circuitry to make them blink. When attached to a nine-volt battery, the lights, which were detectable only with night vision devices, would blink for hours. While Concurrent Engineering Directorate (CID) engineers belittled the device, troops on the ground found them to be indispensable for not only for their intended purpose of marking airfields, but also for marking vehicles, for unit identification, for light by which to read maps, and for marking lanes in fields.[92]
1991	Salvatore Romano and Martin Rosenzweig of C3 Systems designed and built a handheld, battery operated test set that allowed soldiers in the field to determine in under a minute if a cable was good or bad, and which of its twenty-six pairs were open or shorted. The innovative duo used parts from Radio Shack.[93]
1991	Matthew Zieniewicz and Sal Berone of C3 Systems designed a cable that permitted use of vehicle batteries to power GPS receivers.[94]
1992	CECOM initiated its first paperless procurement in 1992. It culminated in April 1992 in the release of solicitations on the Electronic Bulletin Board System (EBBS) for the engineering and manufacturing development of the Single Channel Anti-Jam Manpack Terminal (SCAMP) and the Secure Mobile Anti-Jam Reliable Tactical Terminal (SMART-T).[95]
1993	Long-term technical cooperation between the RDEC and McDonnell Douglas produced the Fiber Distributed Data Interface, an encryption-free secure fiber optic system. S&TCD demonstrated the system, which represented a first of its kind and a technological breakthrough, using a strategic deployment scenario and bulk encryption at a rate of one hundred megabytes a second. [96]

1993	In FY 93, the External Systems Team obtained a full materiel release for the AN/PRD-11 direction finder and coordinated the transfer of this non-developmental item from FORSCOM (Level I) management to the Level III care of the Materiel Management Directorate. The AN/PRD-11 was the first FORSCOM NDI system to achieve a full release and the first such system to transition to CECOM. [97]
1994	U.S. Patent 5,257,284, "Circuit for Accurately Measuring Phase Relationship of BPSK Signals," was awarded to William J. Scudera and Vasilios Alevizakos in FY 94. This provided an improved method of detecting low-level binary phase shift keying signals and for locating those signals by use of a dual-channel chirp-Z interferometer processor to measure the phase relationship of signals received at a plurality of antennae.[98]
1994	In January 1994, NVESD evaluated the first Laser Countermeasure System (LCMS) at the laser test range (Fort A. P. Hill). The evaluation measured the system's effectiveness against Direct View Optics in daylight and against various night vision devices at night. The system met operational requirements for nighttime use and exceeded those of daytime operations. Individual soldiers could use it to find and disrupt threat optical and electro-optical surveillance devices.[99] To improve the targeting accuracy of the LCMS, NVESD developed the High-Intensity Targeting System (HITS), a simple hand jitter and atmospheric turbulence compensation. The NVEO Project Manager tested the HITS successfully and incorporated it into the LCMS objective brassboard.
1994	To achieve high performance and reduce the failure rate of the Light Countermeasure System, NVESD developed the Lightweight Diode Pumped Laser Module, a fifteen-pound, battery powered laser with an output of 300 milli-joules at fifty hertz. This device, designed for operation at any temperature from thirty-two degrees below zero centigrade to forty degrees above, would deliver greater range from a smaller package.[100]
1994	To supply reduced-cost, impact-resistant modules for frequency diversity in lightweight electro-optic countermeasures systems, the RDEC developed a high frequency wavelength conversion module using solid-state dye laser materials. This technology had potential application as well in medicine and other commercial enterprises.[101]
1994	NVESD built the world's very first scanned electron beam x-ray source for use in the Photon Backscatter Imaging Mine Detector. The scanning rate of this device was approximately twice the rate of medical CT scanners.[102]

1994	The Visual Information Team achieved two Fort Monmouth "firsts" in FY 94. The first broadcast throughout the post of a simulcast of General Ross' farewell speech. The second relayed coverage of a live laboratory demonstration at Fort Belvoir through the Fort Monmouth Video Teleconferencing Center (VTC) and the local cable company (Command Channel 37) to the RDEC Conference Room in the Myer Center.[103]
1994	NVESD personnel designed, built, and integrated advanced electro-optic sensors -- a second generation Forward Looking Infrared Radar (FLIR), an eye-safe laser rangefinder, a high resolution daylight television camera, and a binocular television display -- into the M1 gunner's Primary Sight. NVESD demonstrated the system in a concept evaluation program for the Armor School at Fort Knox. In a Combat Systems Test Activity demonstration at Aberdeen Proving Grounds in late winter 1994, a group of distinguished tank gunners -- including the CECOM senior leadership (Guenther, Ferlise, Fiorilli, and Giordano) -- used the second-generation fire control system to find and "destroy" thirty of thirty stationary and moving targets. They reported that they were "very impressed" with the results of the quick-reaction in-house program that had produced the assemblage and with "the ability of the thermal system to recognize targets at long range, leading to precision shooting."[104] This first installation of a second generation FLIR capability provided the user an early prototype for operational evaluation.
1995	Patent Number 5,449,904 was awarded to Mary J. Miller, Gregory J. Salamo, William W. Clark, III, Gary L.Wood, Edward J. Sharp, and Brian D. Monson for the "Broadband Passive Optical Limiter Using a Photorefractive Crystal." The invention abstract reads as follows: "A passive broadband sensor protection and enhancement system and technique. Incident light is focused with a cylindrical lens on the optical axis into an intense light strip onto the input face of a photorefractive crystal on the optical axis. The crystal includes optional anti-reflection coatings proximate to the input and output face. A broadband high reflection coating is proximate to the input face for reflection of all radiation from approximately 0.68 out to at least 1.5 micrometers wavelength. Light exiting from the output face of the crystal results from a photorefractive process that includes a transmitted beam and beam fan. The beam fan is fanned out of the optical path in a direction determined by the c-axis, dominant electro-optic coefficient, and charge carriers participating in the photorefractive process. The transmitted beam contains only incoherent radiation as input to a sensitive detector resulting in broadband multiline protection from the visible spectrum for substantially all pulse widths and cw lasers, with enhanced time response and interaction length."

1995	Patent Number 5,408,359 for the **"**Visual Security Eyecup" was awarded to Donald A. Ferrett and Lewis E. Lough. The invention abstract reads as follows: "A self contained protective shutter assembly for an imager eyepiece including an eyecup, a powered shutter, switch, power supply, and interface coupling."
1995	Stuart B. Horn received Patent Number 5,385,010 for his "Cryogenic Cooler System." The invention abstract reads as follows: "A cryogenic cooler system which allows continuous and uninterrupted cooling within the system with minimized moving parts. A compressor assembly is included with more than one compressor so that at any one time, one of the compressors is active so as to provide a working gas pressure modulated by piston action. An expander assembly includes an expander associated with each compressor where working gas pressure expansion from the active compressor is expanded within. A conduit line couples each compressor to each expander for working gas connection between each compressor and respective expander. Heat pipe is coupled at one end to each expander for the transfer a coolant fluid to a cooling plate which includes a temperature sensor. Thermal switches within each of the heat pipes control coolant fluid flow to allow the activation of another heat pipe and associated compressor when failure of the currently operating compressor occurs."
1995	John E. Nettleton and Dallas N. Barr received Patent Number 5,434,612 for their **"**Duo-Frame Normalization Technique." The invention description reads as follows: "A duo-frame normalization technique and system for use in range gate image to determine a range coded image by use of two image frames. A transmitter emits a modulated energy pulse which is not gated when received by a single gated imaging camera to obtain an integrated first image frame and gated by the same camera when received as an integrated second image frame. The second integrated frame is divided by the first integrated frame to yield a range coded pixel intensity image. Three gated imagining cameras can also be used that share common imaging optics via filters and beam splitters so as to compensate for phenomenological issues that can vary the signals from one frame to another and lead to degraded range images."
1995	Patent number 5,420,414 for the "Night Vision Goggle Simulator and Method with Replaceable Fiber Optic Lens Assembly" was issued to Edwin W. Wentworth. The invention abstract reads as follows: "Night vision goggles that is internally modified such as to provide a reatic simulator without activation of any night vision enhancement and includes a depth perception loss. An assembly is positioned after the objective assembly on the same optical axis for the transfer of the focused incoming light, which light is also color filtered. A fiber optic rod achieves the transfer of the focused incoming light without any use of an image intensifier tube."

1995	Robert C. Hoffman received Patent Number 5,409,548 for his **"**Ferroelectric Detector Array Utilizing Material and Fabrication Technique." The invention abstract reads as follows: "A ferroelectric material, its fabrication technique, and use as a detector aterial, in a ferroelectric detector array is disclosed. The material is an alloy of essential pure components of Pb.sub.2 (Fe, Nb)O.sub.2 and Pb.sub.2 (Fe, Ta)O.sub.2 each with respective Curie temperatures. An essentially linear relationship is made for mole fraction compositions versus Curie temperatures of each component in the alloy, between the pure mole fractions and respective Curie temperatures of the pure components. A Curie temperature for the composition of Pb.sub.2 (Fe, [Ta.sub.(1-x), Nb.sub.x])O.sub.6 is determined, where x is the mole fraction of Pb.sub.2 (Fe,Nb)O.sub.2 and 1-x is the mole fraction of Pb.sub.2 (Fe, Ta)O.sub.2, with x having a value greater than zero and less than one."
1995	A patent was issued for the "Delayed Laser Retroflector Pulse Technique System."
1995	Stuart B. Horn and Elizabeth H. Nelson were issued Patent Number 5,411,599 for their **"**Thermoelectric Device Utilizing Nanoporous Material." The invention abstract reads as follows: "A nanoporous semiconductor material and fabrication technique for use as thermoelectric elements. Starting precursors are mixed in solution so as to thoroughly dissolve in solution which is then reduced. A second phase may be added in solution to provide nanoinclusions which may be subsequently removed. A nanoporous semiconductor is formed whereby lattice thermal conductivity is greatly reduced, due to enhanced phonon scattering on the order of 10 W/cm.multidot..degree.K. The nanoporous semiconductor material may be used as the n- and p- legs in a Peltier couple utilized for a thermoelectric cooler, a cryogenic cooler, thermoelectric power generator, or a thermoelectric heat pump."
1995	A patent was issued for the "Cylindrical Lens and Filter to Protect Against Substantially all Pulse Widths and Continuous Wave Lasers."
1995	Jaime Sonstroem received Patent Number 5,448,842 for the **"**Enclosure Sign Device." The invention abstract reads as follows: "Enclosure sign device for unavoidable viewing of a sign before manipulation of an entryway opening device. An enclosure of an entryway opening device includes at least one side surface extending out at least as far as the entryway opening device, a back surface coupled to the side surface to accommodate the entryway opening device through the back surface, and a front surface releasably coupled to the side surface which can be releasably opened or closed over the entryway opening device. The enclosure is coupled to a surrounding surface of the entryway opening

	device and includes a display for releasably holding a sign attached to the outside surface of the front surface so that sign viewable when the front surface is closed. Access is obtained to an entryway opening device by releasably opening the latching so that there is unavoidable viewing of a sign before manipulation of the entryway opening device."
1995	James C. Sutton received Patent Number 5,447,091 for his "Dynamic Rotating Ballistic Shield." The invention abstract reads as follows: "A dynamic rotating ballistic shield for protecting an enclosed viewing dee. A rotating inner armor sleeve around the device includes a sleeve opening. When the sleeve aligned with a cap opening of an outer armor cap which concentrically surrounds the rotatable inner armor sleeve, a substantially unobstructed field-of-view for the objective window is obtained, with substantial ballistic shield protection."
1995	Lewis E. Lough and Donald A. Ferrett received Patent Number 5,440,134 for their **"**Infrared Borescope-Thermal." The invention abstract reads as follows: "A test target for thermal and similar rifle sights including a target, comating lens in a housing with a mandrel type boresighting attachment."[105]
1996	Dr. Vahakn Nalbandian from the CECOM RDEC Intelligence and Electronic Warfare Directorate submitted an invention disclosure to the CECOM Legal Office. The disclosure was entitled "Novel Impedance Matching of a Double Layer Microstrip Antenna by a Microstripline Feed." This research was financed by In-House Laboratory Independent Research.[106]
1996	Patent Number 5,561,541 for "Frustrated Total Internal Reflection Optical Power Limiter" was awarded to Ed Sharp, Gary Wood, Richard Schurtz, and Juergen Pohlmann. The invention abstract reads as follows: "In order to protect a delicate photodetector from high-intensity radiation, such as from a laser, a device for limiting optical power to the detector is interposed between the radiation and the detector. This device has an optical interface that totally reflects high-intensity radiation, but which freely transmits normal (low intensity) radiation to the detector. The interface is between two optical materials, one with a linear index of refraction with respect to radiation intensity, and the other with a non-linear index. At low intensity radiation levels, the two materials have the same indices of refraction, and such radiation is freely transmitted through the interface, but with high-intensity radiation, a mismatch of indices of refraction allows total reflection at the interface."
1996	The CECOM Logistics and Readiness Center wins the President's Quality Improvement Prototype award.

1997	Patent Number 5,563,409 for “Crosstalk Measurement System and Technique” was awarded to Khoa Dang, Chris Kauffman, and Zenon Derzko. The invention abstract reads as follows: “An automated test system and method for infrared focal plane detector array which utilize X-Y positioning of a focused laser spot scanning individual detector array elements Detector element outputs are processed for the entire focal plane array resulting in crosstalk measurement.”
1997	Patent Number 5,629,520 for “Laser Threat Status Detection” was awarded to Jay Sonstroem. The invention abstract reads as follows: “A system and technique to incorporate threat detectors within the FLIR's ical train and use the radiation reflected off of insertable protective filters, or a coated clear window, to determine if the threat is still present. If there has been some change in laser threat status then there is allowed the removal or insertion of the protective filter.”
1997	Patent Number 5,629,807 for “Helmet Mounted Image Intensifier” was awarded to John Hall. The invention abstract reads as follows: “A head-mounted vision enhancement system which provides crash survivability weight, and center of gravity superior to the currently fielded image intensifier goggle arrangements. This is accomplished by positioning the goggle objective lens assembly and intensifier tube closer in around the head and then using an eyepiece to bring the image back around into the eye. Hypersteropsis is thus avoided by folding the intensifier objective lenses from the center of the forehead.”
1997	Patent Number 5,638,162 for “Optical Signal Enhancement System” was awarded to John Nettleton, Dallas Barr, and Brian Redman. The invention abstract reads as follows: “An optical scheme and system involving a probe laser with simple analog pessing to detect an optical echo. This allows verification that a transmitter has hit a target receiver or will allow synchronized firing with another laser transmitter.”
1997	Patent Number 5,665,970 for “Directional Radiation Detector and Imager” was awarded to Stanley Kronenberg. The invention abstract reads as follows: “A radiation sensor and/or imager is formed by sandwiching two materials having different atomic numbers (Z) around a radiation detector, such as scintilator or Geiger-Mueller type radiation counters, or solid state radiation detectors, such as those made of silicon). In one embodiment of the present invention, a thin layer of lead (Pb) is placed on one side of a Geiger-Mueller radiation counter and a layer of Lucite.TM. is disposed on the opposite side. One example, of a preferred Geiger-Mueller counter which may be used in the present invention is a modified pancake Geiger-Mueller counter with thin ruby mica windows, approximately 2.8 mg/cm.sup.2 thick on both sides. By disposing a high Z material on one side of a radiation detector such as a Geiger-Mueller (GM) or a Scintillator Counter (SC) and a low Z material on an opposite side of either type of the counter, it is possible to detect the photo-Compton electrons emitted from the high or low Z material in the forward or backward directions and the attenuation of the emitted electrons by the

	high Z material. Because the Geiger-Mueller or scintillation counter can detect single events, the directional radiation detector according to the present invention can detect radiation intensities down to background radiation levels, which is approximately 0.15 .mu.Gy h.sup.-1. Given the difference in the count rate (or intensity), the direction of the radiation source may be easily calculated by simply rotating the detector or by having two counters displaced in different angles (such as 180 degrees) so as to be able to take the difference of the number counts (or mirrors of the intensities)."[107]
1998	A patent disclosure was filed for an optical design for a true retinal writing display system. Estimates were that a thirty degree FOV device was well within reason with potential for even larger FOV.[108]
1999	The CECOM RDEC submitted a patent application for a "Double-Sided High-Technetium Superconducting Flux-Flow Transistor" (an In-House Laboratory Independent Research project in the Intelligence and Information Warfare Directorate) to the CECOM Legal Office. The transistor was an active device with gain that would find uses in ultra-sensitive Radio Frequency front ends, active filters, and Analog/Digital converters.[109]
1999	A CECOM RDEC Intelligence and Information Warfare Directorate scientist, Dr. Wei Su, was awarded two patents by the United States Patent Office. The first invention, "Methods and Computer Programs for Minimizing Logic Circuit Design Using Identity Cells," U.S. Patent Number: 5,974,242, created a logic gate array called "identity cell," and proved mathematical properties of using identity cells. This invention not only added a new element to the logic gate family, but also simplified the integrated circuit design process. The second invention, "Method and Apparatus to Process Drawing Images," U.S. Patent Number 5,946,415, presented an automated method for generating the computer-aided-design language called Very High-level Design Language (VHDL), based on scanned schematic images. This invention significantly reduced the design cycle and the cost of electronics systems.[110]
1999	CECOM and Tetra Tech Data Systems submitted a patent application for a patent co-invented by Ed Miles of Tetra Tech Data Systems and Neil Vallestero of the CECOM RDEC entitled, "Disclosure on Signal Generation by Filtering Optical Sidebands." The patent focused on single laser

	generation of high frequency millimeter wave without the use of high frequency component technology.[111]
2000	A patent entitled, "Signal Generation by Filtering Optical Sidebands," was filed (CECOM Docket #5446) by Neil Vallestero of the CECOM RDEC and Ed Miles/Jim Menders of Tetra Tech Data Systems. This innovative patent demonstrated a technique for generating millimeter waves as high as 120Ghz using a single laser and tunable fiber Bragg gratings.[112]
2001	CECOM used infrared cameras attached to PVC pipe to search through rubble at the World Trade Center. Twenty-four hours after the original improvised search cameras were deemed lacking, Fort Belvoir engineers delivered cameras capable of looking 360 degrees around. [113]
2001	CERDEC adapted the Laser Doppler Vibrometer (a technology being explored for landmine detection) to monitor shifts in structure at the World Trade Center. The PDV-100 was the first laser Doppler vibrometer with digital signal processing.[114]
2001	The phraselator debuted, a brick-sized one-way translation device designed for use by U.S. soldiers in countries where they do not know the language and do not have time to learn it. Each hand-held unit uses an SD card—the same one used by many digital cameras—that stores up to 30,000 common phrases useful for law enforcement, first aid, or war-fighting. To make the device work, a soldier simply says a phrase (such as "Stop at this checkpoint") into the device, and a few seconds later, the Phraselator repeats it in the chosen language—Urdu, Arabic, Pashto, and Korean are available, to name a few. This system was developed in conjunction with DARPA, and was critical because there were not enough trained linguists on the ground.[115]
2001	Patent Number 6,328,449 for the "Brewster - Angle Dispersion Filter" was awarded to Michael Hacskaylo of the Night Vision and Electronic Sensors Directorate on 11 November 2001. The patent abstract reads as follows: "A particular wavelength may be eliminated from the spectrum of a randomly polarized thermally radiative scene by a quarter-wave polarizer and a dielectric dispersive mirror angularly positioned at the Brewster angle for the particular wavelength. The scene radiation is linearly polarized in the plane of incidence of the mirror and the particular wavelength of the scene is transmitted. The other wavelengths of the scene whose indices of refraction are dispersive, i.e., different from the particular wavelength, are reflected and directed to a photodetector, some

	other radiative detecting device, or a human eye. The invention can thus provide protection from a laser or other high-power optical emitter when used as a counter-measure in a thermally radiative scene."
2001	Patent Number 6,318,271 for the "Fuse Igniter Adaptor Assembly" was awarded to Lawrence D. Clark of the Night Vision and Electronic Sensors Directorate on 20 November 2001. The invention abstract reads: "A fuse igniter adapter assembly that adapts various fuse cord sizes to a firing device for ignition by a primer. The assembly includes a hub subassembly, four retaining blades, a circular slide element, a circular cap element, a spring, and a snap ring."
2001	Patent Number 6,330,920 entitled "Mine Stripper" was awarded to Christopher Wanner of the Night Vision and Electronic Sensors Directorate on 18 December 2001. The invention abstract reads: "A mine stripper with numerous plow blades that rotate as they dig deeper to achieve an equilibrium depth of about nine inches and a basket that presses against the top of these blades to receive dislodged mines while sifting away attached soil."[116]
2002	The Agile Commander Advanced Technology Demonstration (ATD) was cited as one of AMC's Greatest Inventions of 2002. Known as "DaVinci," this system provides a framework to move the focus of digital planning away from the low-level details of movement routes to the higher-level concepts of plan, task, activity, and resource. The goal is to provide a planning and execution monitoring system in which the user can specify administrative and tactical tasks at a level of detail sufficient to enable the computer to "fill in the details." [117]
2002	Patent Number 6,335,526 for the "Infrared Sensor System Technique" was awarded to Stuart B. Horn of the Night Vision and Electronic Sensors Directorate on 1 January 2002. The invention abstract reads: "An infrared sensor system technique for fusing sensor outputs for display to a user, including sensor outputs from an internetted system."
2002	Patent Number 6,373,865 for the "Pseudo Monolithic Laser with an Intercavity Optical Parametric Oscillator" was awarded to John E. Nettleton, Bradley W. Schilling, and Dallas Barr of the Night Vision and Electronic Sensors Directorate on 16 April 2002. The invention abstract reads: "A subassembly for a high powered light pumped, Q-switched and linearly polarized laser with an optical parametric oscillator, the subassembly consisting of two or three rod shaped elements having precisely ground endfaces with selected coatings mounted on a special pallet that at least partially aligns the optical axes of the elements."

2002	John M. Hall of the Night Vision and Electronic Sensors Directorate was awarded Patent Number 6,411,435 for his "Monocular Viewer and Recorder" on 25 June 2002. The invention abstract reads: "A refocusing device for an optical image display consisting of back-to-back optical eyepieces and other optical elements that creates at least one additional displaced optical image and permits reverse viewing through optical imaging systems."
2002	Patent Number 6,341,551 for the "Landmine Hunter/Killer Technique" was awarded to William G. Comeyne of the Night Vision and Electronic Sensors Directorate on 29 January 2002. The invention abstract reads: "A technique for integrating detection and neutralization of land mines that can be used for both mine breaching and mine clearing. A land mine is sensed with multiple sensors to determine a mine signature with corresponding range and azimuth. Mine type and mine emplacement which correlates to the mine signature is determined, and a neutralizer type and configuration is determined which correlates to the mine type. A neutralizing magazine is selected for the neutralizer type and configuration. The selected neutralizer is configured, loaded, launched, and armed." [118]
2002	Dr. Wei Su of the U.S. Army Communications-Electronics Research, Development, and Engineering Center won a 2002 Thomas Alva Edison Patent Award for his invention titled "Phase and Magnitude Compensated Tuning for Suppression of Vibration Induced Phase Noise of Crystal Oscillator with Varying Vibration Frequencies."
2002	Peter Rathemacher and Marc Gietter, Power Sources Team along with Kenneth Brockel, Douglas Howe and Fenton Yip, CCS/Avionics Division were granted a Patent (#6,459,176) from the U.S. Patent Office for their submission of the survival Radio Battery Adapter. These battery adapters allow the survival radio user to substitute commercial consumer cells (CR123A photoflash battery) and power sources (solar panels) for previously military unique batteries.
2002	RDEC engineers designed a quartz crystal resonator that was capable of operation above 1 GHz, versus the current state-of-the-art of 200 MHz. This breakthrough was significant in that high (greater than 1 GHz) resonators would allow for ultra miniature C4I receivers.
2003	Patent Number 6,469,449 was issued to Louis Jarvis and Fee Leung for "Self Powered Cold Temperature Flat Panel Displays and Method of Making the Same." The invention abstract reads as follows: "A self-powered cold temperature capable flat panel display is provided to use a heat byproduct from a group of PEM fuel cells to warm the flat panel

	display of a laptop computer. The self-powered cold temperature capable flat panel display system comprises a flat panel display, a PEM fuel cell assembly, a means for separating the display from the PEM fuel cell assembly and a hydrogen fuel source. A slot is located below the panel and the PEM fuel cell assembly is sufficiently thin to provide adequate space in the slot for the insertion of both the separation means and the PEM fuel cell assembly. Other embodiments include a cold temperature display system and an all-climate panel display and a method for warming a panel display." [119]
2003	Terrill Atwater and Arek Suszko filed a patent titled "Lithium, Manganese, Bismuth Mixed Metal Oxide for Rechargeable Electrochemical Systems." [120]
2003	Patent Number 6,464,742 was issued to Terrill Atwater and Fee Leung for the "Floating Air Breathing Power Source." The invention abstract reads as follows: "An air breathing power source is mounted in a water impervious housing with a hydrophobic membrane across an opening in its top surface. The housing is secured by flexible straps over a users shoulders so that it is normally carried across the users back, but floats up with the air breathing top surface above the water when the user enters water up to and above shoulder level." [121]
2003	Fee Leung was issued Patent Number 6,461,752 for his "Portable Electric Generator with Thermal Electric Co-Generator." The invention abstract reads as follows: "The invention is an electric generator comprising a portable electric generator and a thermal electric co-generator. The co-generator converts heat produced by the portable electric generator into electricity. In one embodiment of the present invention, the portable electric generator is a microturbine. In another embodiment, the portable electric generator is a fuel cell. In a further embodiment, the thermal electric generator comprises a hot thermocouple and a cold thermocouple."[122]
2003	Patent Number 6,551,748 for "Prevention of Polymerization in Li/Mn02 Organic Electrolyte Electrochemical Systems" was issued to Terrill Atwater, L. Branovich, and Anthony Pellegrino. The invention abstract reads: "This invention provides a number of phosphorous and arsenic reducing agents to eliminate gas formation and polymerization of Li/MnO.sub.2 and other lithium cells caused by the formation of dialcohol. The phosphorous reducing agents when added to the Li/MnO.sub.2 and other lithium battery electrolytes cause the phosphorous compound and alcohol to react and produce ether and orthophosphorous acid, which prevents gas formation and the polymerization of Li/MnO.sub.2 cells caused by the formation of dialcohol. The preferred reducing agent is phosphoric acid tri-ester. The arsenic reducing agents when added to the Li/MnO.sub.2 and other lithium battery electrolytes cause the arsenic compound and alcohol to

	react and produce ether and orthoarsenic acid, which also prevents gas formation and the polymerization of Li/MnO.sub.2 cells caused by the formation of dialcohol. Similar reactions and effects are also achieved with numerous other useful phosphorous and arsenic compounds that react with alcohol to produce ether and related acid compounds." [123]
2003	Patent No. 6,577,454, entitled "Folded Image Intensifier Objective Lens," was issued to John M. Hall of the Night Vision and Electronic Sensors Directorate. The invention abstract reads as follows: "An objective lens assembly for use in an image intensifier over the 0.6 to 0.9 micron spectral bandwidth resulting in a F# within a range of 1.0 to 1.5 and a field of view within the range of 35 to 45 degrees. The assembly includes an air-spaced doublet, a right angle fold prism for bending the optical axis 90 degrees to a reoriented optical axis, two lens subassemblies, and a field flattening lens."[124]
2003	A patent application was filed for a "De-Centered Field Lens with Tilted FPA" by the Night Vision and Electronic Sensors Directorate. [125]
2003	A patent application for "Range Accuracy Compensation Circuit for Single-Shot Laser Rangefinders" was filed by the Night Vision and Electronic Sensors Directorate. [126]
2003	An invention disclosure was received by the Night Vision and Electronic Sensors Directorate (NVESD) entitled "Dual Aperture Cold Shield." [127]
2003	The Army Power Division of the Command and Control Directorate (C2D) of the U.S. Army Communications-Electronics Command Research, Development, and Engineering Center (CERDEC) developed the BA-8180/U Zinc-Air Battery. The battery has up to 55-amp hours of capacity at 12 volts. One six pound BA-8180/U connected to a reusable interface adapter can replace up to five BA-5590s for extended missions. The BA-8180/U Zinc-Air Battery was cited as one of the top ten greatest U.S. Army inventions of 2003.
2003	The Portable Omni-Directional Well Camera System was developed by the U.S. Army Communications-Electronics Research, Development, and Engineering Center. It is a lightweight, waterproof, battery-powered camera system designed for safer, faster, and more efficient inspection of areas that are unfit or unsafe for human inspection. The system provides soldiers with a safe method for rapidly inspecting wells and other underground locations up to three hundred feet deep and at a radius of twenty feet. The system can look 360 degrees around. It operates by a BA 5590 battery for up to ten hours. [128] The Well Camera System was also cited as one of the top ten greatest U.S. Army inventions of 2003.

2004	Charlotte Lent, an industrial engineer at Tobyhanna Army Depot, was among those who earned second place in the National Institute of Packaging, Handling and Logistics Engineers (NIPHLE)-sponsored 2004 national packaging design contest. Lent designed, tested and guided the fabrication of the Frozen Specimen Shipping Unit (FSSU-24), which can be used with dry ice to transport any infectious matter in vials (such as blood specimens and tissue samples) and other non-infectious items.[129]
2004	Dr. Terrill Atwater of the Communications-Electronics Research Development and Engineering Center (CERDEC) collaborated with Dr. Alvin Salkind from Rutgers University to develop stable potassium lithium manganese oxide material to be used as a rechargeable lithium battery cathode.
June 2004	U.S. Patent #: 6,744,801. Title: "Monolithic solid state laser assembly and method of manufacture." Inventor(s): John E. Nettleton, Bradley W. Schilli and Dallas N. Barr. A one piece laser assembly including a rod of gain medium with one end-face bonded to a broad end-face on a stack of optical wafers that process light differently and mirrors plated on the remaining exposed end-faces of the rod and the stack of wafers.[130]
July 2004	U.S. Patent #: 6,760,134. Title: "Multicolor electronic holography and 3D image projection system." Inventor(s): Bradley W. Schilling and Ting-Chu Poon. A three dimensional true color holographic imaging system using thr primary color Fresnel-Zone-Pattern laser generators combined as a single beam that scans the target and the reflections of which are sensed simultaneously by a single electronic detector. The detector signals corresponding to each generator are then separated electronically and independently recorded.[131]
August 2004	U.S. Patent #: 6,774,366. Title: "Image integration and multiple laser source projection." Inventor(s): Melvin H. Friedman and John M. Hall. An apparat and method for enhancing an image relayed by a central beam of collimated light centered on the optical axis of a lens with an aperture area of A and focused on the focal plane of the lens. The apparatus having an aperture at least n times as big as A centered on the optical axis of the lens to admit a collimated relay beam including the central beam and a diverter means for separating the relay beam into n collimated facet beams equal to the central beam, but exclusive thereof, and redirecting them through the lens aperture produce n additional images on the same focal plane. The apparatus also including a processor with a separate opto-electronic device for each image

	that converts it between electronic and photonic states, the electronic image being stored in the processor.[132]
2004	The Army recognized the Lightweight Counter Mortar Radar (LCMR) as o of the top ten Army inventions of 2004. It provides 360 degrees of azimuth coverage and is used to detect, locate, and report hostile locations of enemy indirect firing systems.
1 March 2005	U.S. Patent No: 6,862,147 is titled "Decentered Field Lens With Tilted Foc Plane Array." It was invented by Jaime Sonstroem of CERDEC NVESD. T inventions is an Infra-red (IR) sensor device including an optical train, a foc plane array (FPA) for receiving incoming ray bundles that have passed through the optical train, and a decentered plano-convex field lens positione there between. The field lens is decentered in that it is positioned so that th optical axis intersects the field lens at an offset distance from the geometric center of the lens perimeter. When the field lens is positioned in this manne optical ray bundles that pass through the field lens establish a revised image plane. To compensate for the revised image plane, the FPA is tilted until th FPA is co-planar with the revised image plane. Any reflected optical ray bundles are refracted as they pass back through the field lens and are directe away from the pupil to prevent reflected optical ray bundles from entering t optical train and leaving the sensor as an IR retro-reflection during operatio of the device.[133]
7 June 2005	U.S. Patent No: 6,904,074 is titled "Diode-Pumped Micro Laser." It was invented by C. Ward Trussell, Jr. and Vernon King of CERDEC NVESD. This invention is a diode-pumped micro laser including a diode pump, a firs lens, a second lens and a laser glass. The diode pump generates an input pump beam. The first lens and second lens manipulate the pump beam by collimating the pump beam in focal planes that are perpendicular to each other. The laser glass receives the manipulated pump beam from the secon lens and converts the pump beam into a laser beam. The laser glass is furth doped with predetermined amounts by weight of Erbium and Ytterbium to ensure that an output laser beam with an eye safe wavelength is generated. The micro laser further includes a passive Q-switch made of a Cobalt-spine material, which receives the output laser beam and generates laser pulses using passive switching techniques, independent of any external temperatur control. This configuration allows the micro laser to function as a laser rangefinder over extended temperature ranges in a manner that is eye safe t the user.[134]
5 July 2005	U.S. Patent No: 6,914,928 is titled "Infrared Camera Deployed by Grenade Launcher." It was invented by C. Ward Trussell, Jr. A diode pumped solid state laser using a laser diode bar or a stack of bars with cylindrical lenses i used to end pump a rectangular cross section solid state laser slab. The combination of lenses and polished slab surfaces provides overlap of the

	pump light with the laser mode combined with sufficient length of material absorb the entire pump light to produce a compact, efficient laser source.[135]
2005	C-E LCMC rapidly develops and fields the Joint Network Node (JNN), a high bandwidth, integrated satellite and beyond line-of-sight communications network. The short cycle time from development of JNN to deployment of systems in Iraq was unprecedented.
2005	Team C4ISR provided valuable assistance in the Gulf Coast Region in support of Hurricane Katrina relief efforts. Satellite communications technologies and generators were sent to the region to aid rescue workers and government agencies.
2005	The Countermeasure Protection System is named one of the Top Ten Army inventions of 2005. Fielding Date: Eighteen Warlock-CMPS units were delivered to the Intelligence and Information Warfare Directorate for fielding to the Rapid Equipping Force in May 2005. Development of the Warlock-CMPS system directly led to the Warlock Increment 2 system commonly known as CREW-2. CREW-2 systems are currently under contract for production with a planned procurement of more units in 2006. The CMPS features advanced EW subsystems to counter the two predominant classes of radio-controlled Improvised Explosive Device threats critical to the Global War on Terror. An optimized architecture is used to provide a maximum protection radius while minimizing the overall system cost and prime power consumption requirements. The system design supports future enhancements with minimal hardware redesign.
2005	The Dual band Antenna is named one of the Top Ten Army inventions of 2005. Fielding Date: Approximately 8000 units were delivered by the end of 2005.T he antenna covers an unprecedented wideband frequency span from a single antenna structure. This is the first antenna that can be designated as the Army Common Antenna capable of performing multiple communications and electronic warfare functions critical in the Global War on Terror. The antenna provides an omni-directional pattern over the entire frequency band. The antenna has a two-port design to interface with multiple communications and electronic warfare systems. In addition to wideband coverage, the antenna was designed to radiate from the upper 18 inches of the radome. Such a design allows for maximum performance while reducing the degrading effects of vehicle obstruction.
2006	U.S. Patent No: 6,956,213. Issued: 10/18/2005. Title: Alternative pixel shapes for uncooled microbolometers. Inventor(s): A. Wayne Antesberger

2006	U.S. Patent No: 6,978,717. Issued: 12/27/2005. Title: Infrared camera deployed by grenade launcher. Inventor(s): Harry Hambric
2006	U.S. Patent No: 6,999,231. Issued: 02/14/2006. Title: Miniature high-resolution multi-spectral objective lens. Inventor(s): Kyle R. Bryant
2006	U.S. Patent No: 7,039,087. Issued: 05/02/2006. Title: End pumped slab laser cavity. Inventor(s): John Nettleton, Dallas Barr, Charlie Trussel
2006	U.S. Patent No: 7,042,646. Issued: 05/09/2006. Title: Infrared device havin an optical power limiter with improved optical gain Inventor(s): Thomas Colandene
2006	U.S. Patent No: 7,055,986. Issued: 06/06/2006 Title: Programmable LED spectral light source Inventor(s): Roy Littleton
2006	U.S. Patent No: 7,061,074. Issued: 06/13/2006 Title: Visible imaging device using Darlington Phototransistors. Inventor(s): Khoa Dang, Conrad Terrill
2006	U.S. Patent No: 7,068,699. Issued: 06/27/2006. Title: Multi-Function Combat Laser for the Dismounted Soldier. Inventor(s): John Nettleton, Dallas Barr, Johnathan Lei
2006	U.S. Patent No: 7,082,001. Issued: July 25, 2006. Title: Dual mode mirror imaging system Inventor(s): Jay Vizgaitis
2006	U.S. Patent No: 7,109,488. Issued: 09/19/2006. Title: Multi-color infrared imaging device. Inventor(s): A. Fenner Milton

2006	U.S. Patent No: 6,904,074. Issued: 7 June 2005. Title: Diode-Pumped Micro Laser. Inventor(s): C. Ward Trussell, Jr. and Vernon King
2006	U.S. Patent No: 6,914,928. Issued: 5 July 2005. Title: Infrared Camera Deployed by Grenade Launcher. Inventor(s): C. Ward Trussell, Jr.
2006	Title: Lithium, Manganese, Bismuth Mixed Metal Oxide for Rechargeable Electrochemical Systems Inventor(s): Terrill Atwater, Arek Suszko Patent No.: 7,026,068 Laboratory: CERDEC/C2D
2006	Title: Manganese, Bismuth Mixed Metal Oxide Cathode for Rechargeable Lithium Electrochemical Systems Inventor(s): Terrill Atwater, Alvin J. Salkind, Arek Suszko Patent No.: 7.011.908 Laboratory: CERDEC/C2D
2006	Title: Method for Making Lithium Rechargeable Batteries with Potassium Stablized Manganese Dioxide Inventor(s): Terrill Atwater, Alvin J. Salkind Patent No.: 6.982.048 Laboratory: CERDEC/C2D
2006	Title: Neutron Spectrometer with Aluminum Proton Absorber Inventor(s): Stanley Kronenberg, George J. Brucker Patent No.: 6,954,512 Laboratory: CERDEC/I2WD
2006	Title: Small Low Profile Antennas Using High Impedence Surfaces And High Permeability, High Permittivity Materials Inventor(s): Roland Cadotte, Jr., William D. Wilber Patent No.: 6,967,621 Laboratory: CERDEC/I2WD
2006	Title: Wideband Circularly Polarized Single Layer Compact Microstrip Antenna Inventor(s): Vahakn Nalbandian Patent No.: 7,006,043 Laboratory: CERDEC/I2WD

2006	Title: Passive Radio Frequency Power Spectrum Analyzer Inventor(s): Vahakn Nalbandian, Ernest Potenziani, II Patent No.: 7,061,220 Laboratory: CERDEC/I2WD
2006	Title: Piezoelectric Resonator with Reduced Deformation Sensitivity Inventor(s): John A. Kosinksi Patent No.: 7,067,964 Laboratory: CERDEC/I2WD
2006	Title: Ambient Air Alpha Particles Ionization Detector Inventor(s): Stanley Kronenberg, George J. Brucker Patent No.: 7,105,831 Laboratory: CERDEC/I2WD
2006	The Remote Urban Monitoring System is named one of the top ten Army inventions of 2006. RUMS hardware combines emerging technologies in Wireless Local Area Network technology, night-vision cameras and unattended ground sensors to eliminate false alarms. Tripped sensors transmit an alarm signal to the camera module and operator after video and audio from multiple camera modules confirm the unattended ground sensor's alarm signal.
2007	The Improvised Explosive Device (IED) Interrogation Arm was named one of the top ten Army inventions of 2007. The Interrogation Arm is totally controlled from inside mine-protected vehicles and provides standoff detection capability, detects metal, free-and pry-lifts objects, and carries out shallow digging. A camera allows the operator to view objects at the end of the arm. “The arm was created to help detect IEDs from greater standoff distances,” explained Team Leader Larry Jackson. When using the arm, the Soldier is at a distance of about 20-30 feet away. Interrogation of suspect threats using the arm provides an increased survival level for vehicle crews because of the increased distance between the Soldier and the threat.
Today	Team C4ISR continues to provide innovative and integrated C4ISR solutions to the Warfighter in support of the GWOT. Some of these technologies and capabilities include: counter remote controlled improvised explosive device systems to protect Soldiers from IEDs; radars to protect troops from mortar attacks; sensors to protect personnel and installations; night vision equipment; aircraft survivability equipment; situational awareness systems and high band width satellite communication systems.

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