ARLINGTON NATIONAL CEMETERY WALKING TOUR

MILITARY TECHNOLOGY

ENGAGE

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ARLINGTON NATIONAL CEMETERY WALKING TOUR

MILITARY TECHNOLOGY

Length: ~3 miles | **Starting Point: Section 5 (0.4 miles from Welcome Center)** | **Exertion Level: Moderate**

There are three types of stops on this walking tour:

HONOR stops mark the gravesites of specific individuals.

REMEMBER stops commemorate events, ideas or groups of people.

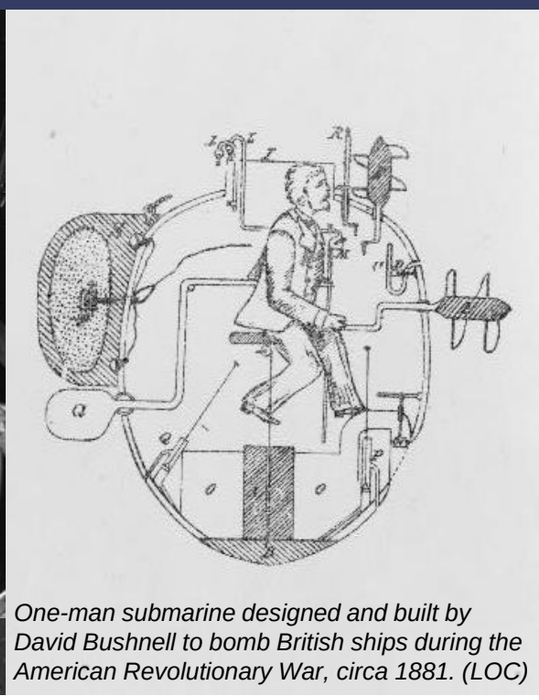
EXPLORE stops invite you to dive deeper into this history.

1	Hyman Rickover	*Section 5, Grave 7000-NH*	HONOR
2	George Westinghouse	*Section 2, Grave 3418*	HONOR
3	George Sternberg	*Section 2, Grave 994*	HONOR
4	Montgomery Meigs	*Section 1, Grave 1-EH*	HONOR
5	Challenger and Columbia Memorials	*Section 46*	REMEMBER
6	William Hammer	*Section 6 Grave 9644-NH*	HONOR
7	Grace Hopper	*Section 59, Grave 973*	HONOR, EXPLORE
8	Francis X. Kane	*Section 59, Grave 4724*	HONOR, EXPLORE
9	Ted Hall	*Section 57, Grave 392*	REMEMBER, EXPLORE
	Thomas Selfridge *(optional additional stop)*	*Section 3, Grave 2158*	HONOR

MILITARY TECHNOLOGY

Grace Hopper in a U.S. Navy computer room in 1978. (Lynn Gilbert)

Transit satellite, a precursor to GPS, before its 1960 launch. (DARPA)



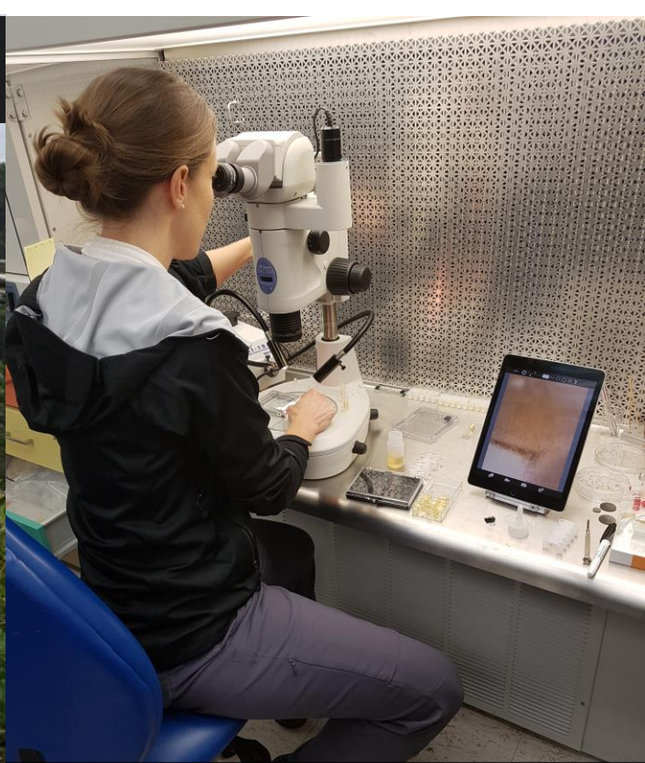
One-man submarine designed and built by David Bushnell to bomb British ships during the American Revolutionary War, circa 1881. (LOC)

Arlington National Cemetery is the final resting place for approximately 400,000 service members and their families. We remember and honor the individuals buried here for their service to the nation—whether on the battlefield or at a research center, in uniform or not. This walking tour honors those individuals buried at Arlington who dedicated their careers to technology and innovation. Some, like Hyman Rickover and Grace Hopper, did so while serving in the military. Others, like George Westinghouse and William Hammer, contributed to technological advancement outside of their military service.

Although this walking tour focuses on individuals, technological innovation depends on collaboration. Collaboration is found in many forms — between individuals across military, civilian and private organizations, and over time as scientists and engineers build on, maintain, and improve the work of their predecessors. While reading about the individuals on this tour, notice the connections. What existing technologies were they using and adapting? Who were they working with? What is the legacy of their work?

Today the U.S. military continues to innovate. The Army, Navy and Air Force Research Laboratories conduct their own research; the military also funds research projects at universities and with other government agencies and private companies across the nation. These projects currently include developing a miniature remotely accessible self-driving car robot, therapeutic drug research and models to track emerging world events. Scientists and engineers conduct research and technology development across a wide spectrum of scientific fields, including biomedicine, environmental science, space sciences, chemistry and nanotechnology.

Scientists install a radio-telemetry tower in Oahu, Hawaii to track fruit-eating birds. The collected data showed how non-native species disperse native, endangered plants, 2015. (U.S. Army Corps of Engineers/Carmen Daugherty)



U.S. Naval Research Laboratory geologist Kate Burgess examines a meteorite sample at NASA's Johnson Space Center. (U.S. Navy/Michelle Thompson)

VICE ADMIRAL HYMAN RICKOVER

HONOR

WALKING TOUR STOP 1

Section 5, Grave 7000-NH

Rickover inspecting the USS Nautilus, ca. 1954. (U.S. Navy)

BIRTH: January 27, 1900, Maków Mazowiecki, Poland

DEATH: July 8, 1986, Arlington, VA

EARLY & PERSONAL LIFE: Known as the "Father of the Nuclear Navy," Hyman George Rickover was born in 1900 to Abraham Rickover and Rachel Unger in Poland, then part of the Russian Empire. Facing anti-Semitism, Rickover's father immigrated to the United States the same year that his son was born, hoping to earn enough money to bring over the rest of the family. At age six, Rickover fled Poland with his mother and sister to escape the Russian pogroms against Jews during the Revolution of 1905. They joined his father in New York City before moving to Chicago.

To contribute to the family's income, Rickover worked as a Western Union delivery boy. Unable to afford a college education, he sought an appointment to the United States Naval Academy. He graduated from the Academy in 1922.

CAREER: Rickover served as an engineer and electrical officer aboard Navy ships. In 1927, he returned to school. He graduated with a master's degree in electrical engineering from Columbia University.

During World War II, Rickover was appointed head of the Electrical Section for the Navy's Bureau of Ships. Under his tenure, the department developed a casualty power system (which provided temporary power to vital electrical equipment in the case of a ship's power outage) an infrared signaling system and, in partnership with General Electric, magnetic minesweeping capability.

In 1946, Rickover was assigned to Oak Ridge, Tennessee to study atomic energy. Oak Ridge had been one of the sites of the Manhattan Project — the secret U.S. government project that developed the atomic bomb during World War II. In the postwar era, it continued as one of the nation's premier sites of nuclear research and development. At Oak Ridge, Rickover became convinced that nuclear-powered ships were the future of the Navy, and that the Navy should start with submarines. Nuclear power would allow submarines to stay submerged underwater for long periods, since the engine would no longer require air to operate. Submarines were also the most difficult vessels to make nuclear-powered, so Rickover believed that if the Navy succeeded with a submarine, it would be sure to succeed with all other ships.

Rickover did not initially receive support from the Navy for his proposal to develop nuclear-powered submarines, but his persistence eventually paid off. In 1949, he was named Director of the Nuclear Power Division in the Bureau of Ships. He was also appointed chief of the Naval Reactor Branch in the Atomic Energy Commission. In these roles, Rickover oversaw the development of the first nuclear-powered submarine, the USS Nautilus, and the first commercial nuclear power plant used for generating electricity, Shippingport Atomic Power Station in Pennsylvania.

LEGACY: Rickover was awarded two Congressional Gold Medals and the Presidential Medal of Freedom for his work in nuclear energy. President Jimmy Carter once said that Rickover "deplored nuclear powers' use for destruction and, as a pioneer, was responsible for its use for peaceful purposes… A superb engineer, his record for careful design, installation and operation of nuclear power plants in ships and on shore has set an example of safety which can never be surpassed."[1]

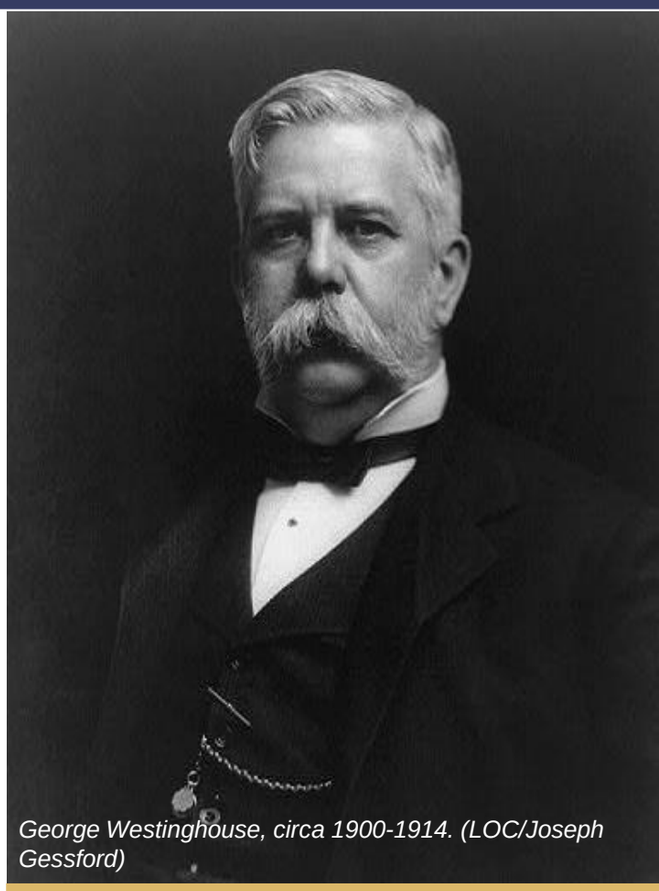
Secretary of the Navy Dan Kimball (right) and Capt. Rickover inspect a model of the USS Nautilus, 1952. (U.S. Navy)

TECHNOLOGY WALKING TOUR

From the Welcome Center, continue straight onto Roosevelt Dr. Turn right on Weeks Dr and then right on Sheridan. Rickover's grave is in the last row behind Weeks'.

GEORGE WESTINGHOUSE

WALKING TOUR STOP 2
Section 2, Grave 3418



George Westinghouse, circa 1900-1914. (LOC/Joseph Gessford)

BIRTH: October 6, 1846, Central Bridge, NY

DEATH: March 12, 1914, New York City, NY

EARLY & PERSONAL LIFE: George Westinghouse was the fifth of six children born to Emmeline and George Westinghouse Sr. His father owned a successful manufacturing business. It was there that Westinghouse developed an interest in machinery and engineering.

The American Civil War broke out when Westinghouse was fifteen years old, and he enlisted in the Army in 1863, shortly before his 17th birthday. After initially serving in the cavalry, in 1864, he obtained a commission in the Navy as a third engineer on the USS Muscoota. After the war, he returned to New York to attend Union College in Schenectady, New York. Westinghouse attended the school for three months but dropped out after obtaining his first patent in 1865: the rotary steam engine.

CAREER: Westinghouse next turned his attention to the railroad industry. He developed a series of innovative improvements to then-current railroad technology, and he began to travel the country selling his inventions. During his travels in 1866, Westinghouse witnessed a head-on collision between two freight trains. The accident inspired him to invent the air brake, which allowed locomotive engineers to control when a train stopped instead of having to coordinate with other brakemen. The air brake significantly advanced the development of the railroad industry by making it safer for engineers to maneuver trains and for people to ride them. Westinghouse's invention soon spread across the world.

Westinghouse was also interested in electricity, and in 1884 he formed the Westinghouse Electric Company. Around the same time, inventor Nikola Tesla began experimenting with alternating current (AC) electricity. At the time, direct current (DC) electricity was the standard since there was no reliable motor that could run alternating current. Tesla hypothesized that he could build a motor using rotating magnetic fields to power alternating currents, and he began experimenting.

TECHNOLOGY WALKING TOUR

Return to Sheridan Drive and turn right. At the plaza in front of the JFK Memorial, bear left onto Grant Dr. Turn right on McClellan Dr. Westinghouse's gravesite is just beyond the large "Hopkins" gravesite on your right.

Alternating current (AC) and direct current (DC) describe how energy flows. Direct currents move in a straight line in one direction. Alternating currents regularly switch directions and move in a wave-like pattern. AC is the standard type of electricity in the U.S. Power outlets use AC to bring electricity from power plants to your home. DC is used to power electronics. Batteries are the most common example of DC power.

Tesla's experiments led to the induction motor, which made AC electricity viable. Westinghouse saw the value in AC electricity and purchased the patents for Tesla's working system. He also invited Tesla to work at the Westinghouse Electric Company.

In the late 19th century, supporters of alternating current and direct current electricity battled for dominance. By supporting Tesla, Westinghouse threw himself into the middle of the fight. Westinghouse and alternating current emerged victorious by designing and providing the lighting system for the 1893 World's Fair in Chicago. The success of the fair convinced the Cataract Construction Company to hire Westinghouse Electric Company to build generators at Niagara Falls in 1893. Alternating current, and by extension the Westinghouse Electric Company, became the dominant force in American electricity.

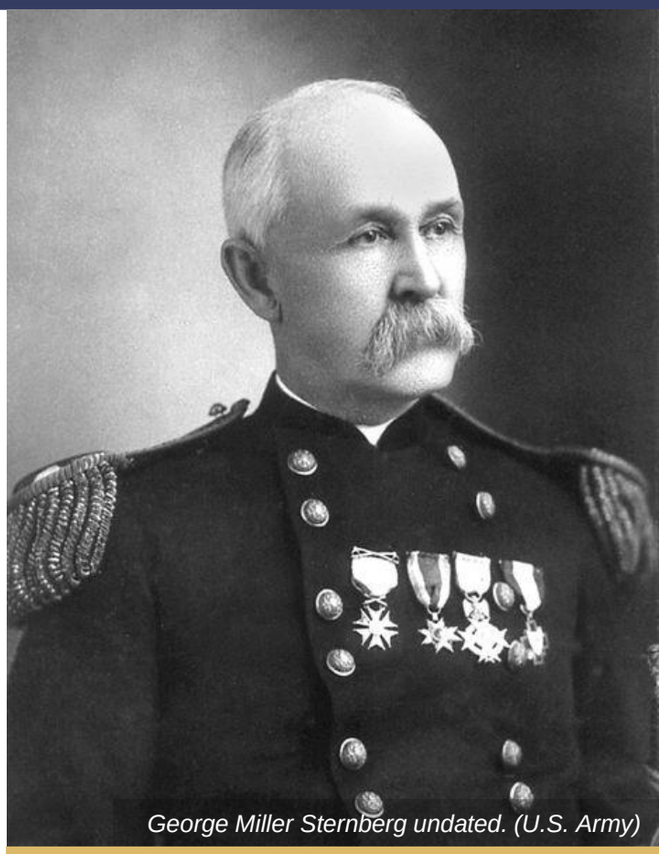
LEGACY: George Westinghouse was both an inventor and a businessman. His career resulted in 361 patents and the creation of over 60 successful companies. While some of Westinghouse's 361 patents were for his own inventions, Westinghouse purchased many patents from other inventors and his own employees. He was a firm believer in intellectual property and worked to obtain patents in ways that compensated the inventors. These actions attracted some of the brightest inventors and encouraged loyalty among his employees. When Westinghouse died, eight of his original employees served as pallbearers at his funeral at Arlington.

SURGEON GENERAL GEORGE MILLER STERNBERG

HONOR

WALKING TOUR STOP 1

Section 2, Grave 994



George Miller Sternberg undated. (U.S. Army)

BIRTH: June 8, 1838, Hartwick Seminary, NY

DEATH: November 3, 1915, Washington, D.C.

EARLY & PERSONAL LIFE: George M. Sternberg was one of the first bacteriologists in the United States. He dedicated his life to studying how diseases worked, specifically bacterial diseases like yellow fever and typhoid.

During the Civil War, disease killed more people than battlefield injuries. At the time, few understood how diseases worked. However, rising scientist George Sternberg was working to change that. Raised at Hartwick Seminary in New York, where his father was a faculty member, Sternberg earned his medical degree in 1860 from the College of Physicians and Surgeons in New York City. At the start of the Civil War (1861-1865), he enlisted in the Army as an Assistant Surgeon.

CAREER: Sternberg never expected to spend his career in the Army. However, after the Civil War ended, he remained in the Army, serving in conflicts with American Indians on the western frontier. During his service, he repeatedly encountered disease. A cholera outbreak killed his first wife, and he witnessed multiple yellow fever outbreaks, including one that almost killed him. These experiences sparked his interest in the origin of infectious diseases and the importance of sanitation.

MILITARY MEDICINE
WALKING TOUR

Continue on McClellan Dr. Turn right onto Crook Walk and then cross Sheridan Dr. Continue straight then make a right at the garden. At the garden, continue about halfway down the path next to section 2. Sternberg's grave is in the first row.

While stationed in Walla Walla, Washington Territory, Sternberg began studying how sanitation impacted the spread of disease. In 1885, he published a paper on the importance of disinfectant. While researching smallpox, Sternberg invented a neutralization test that eventually helped eradicate yellow fever. During the 20th century, the test was used to detect new viruses and test the strength of vaccines.

In 1893, Sternberg was appointed Army Surgeon General, the highest position in the medical corps. Attempting to make scientific medical research a larger part of Army work, Sternberg established the Army Medical School in Washington, D.C. The school taught courses in preventative medicine and sanitation.

In April 1898, the United States declared war on Spain. The Spanish-American War was fought entirely in the tropical climates of Cuba and the Philippines, and disease proved to be the biggest killer. Sternberg suspected that this would be the case before the war began, and he published a guide for maintaining sanitation in Army camps. However, the guide was too little, too late — few officers were trained in sanitation practices, and most often, the recommendations were ignored. Within five months, the disease death rate for American service members was higher than it had been in the Civil War.

Sternberg then created a typhoid investigation board tasked with discovering the cause of the disease. He appointed Walter Reed (Section 3, Grave 1869), Edward O. Shakespeare and Victor C. Vaughan to the board. The board concluded that typhoid could be contagious and asymptomatic, which allowed the disease to "scatter." The board also reiterated the importance of sanitation, especially latrine sanitation.

Before retiring in 1902, Sternberg organized a yellow fever commission headed by Walter Reed. The commission traveled to Cuba, where it discovered that mosquitoes transmit yellow fever. This discovery eventually led to the elimination of yellow fever.

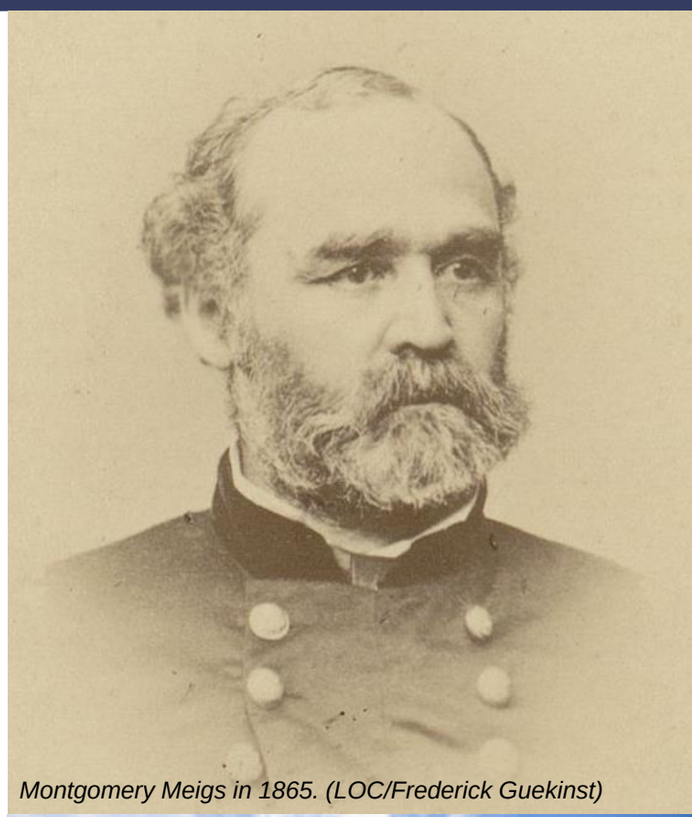
LEGACY: Sternberg's early research on sanitation, his efforts to ingrain medical research in Army medicine, and his work researching and fighting bacterial diseases changed the course of medicine. His work also established the basis for future medical advances like the yellow fever vaccine in 1937.

GENERAL MONTGOMERY MEIGS

HONOR

WALKING TOUR STOP 3

Section 1, Grave 1-EH



Montgomery Meigs in 1865. (LOC/Frederick Guekinst)

BIRTH: May 3, 1816, Augusta, GA

DEATH: January 2, 1892, Washington, D.C.

Montgomery C. Meigs, an engineer and career Army officer, directed the establishment of Arlington National Cemetery in 1864. As quartermaster general of the Army during the Civil War, Meigs oversaw Army logistics, including military burials. When the U.S. Army seized Robert E. Lee and Mary Custis Lee's former estate, Arlington House, in May 1864, Meigs designated part of the land as an Army cemetery. Meigs directed much of the early development of Arlington National Cemetery. His contributions to the cemetery include Tanner Amphitheater, the McClellan Gate and the Tomb of the Civil War Unknowns.

Prior to serving as quartermaster general, Meigs served in the Army Corps of Engineers. He supervised several important prewar projects in Washington, D.C. — including the Washington Aqueduct and the construction of the wings and dome of the U.S. Capitol.

CONTINUE TO NEXT PAGE

James R. Tanner Amphitheater, June 2019. (ANC/Elizabeth Fraser)

TECHNOLOGY WALKING TOUR

Continue on McClellan Dr. Turn right onto Crook Walk and then left onto Sheridan Drive. Follow Sheridan to Meigs Dr. About 100 yards down Meigs Dr, look for a white sarcophagus on your right, toward the middle of the section.

The Civil War Unknowns Monument in Section 26, June 2015. (ANC/Rachel Larue)

Meigs ordered the construction of McClellan Gate, the original entrance to the cemetery. You can spot Meigs' name on the gate's left column. Meigs was known for inscribing his name on projects that he worked on in order to ensure his role would not be forgotten. His name has also been found on the U.S. Capitol and Union Arch Bridge.

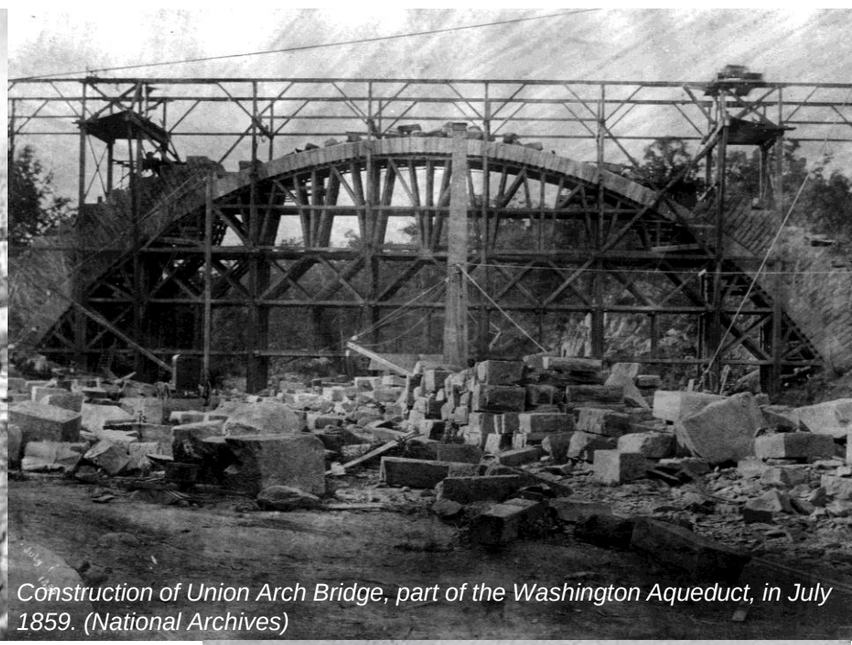
McClellan Gate between Sections 12 & 33, April 2018. (ANC/Elizabeth Fraser)

GENERAL MONTGOMERY MEIGS (cont.)

Washington Aqueduct

In the early 1850s, Washington D.C. needed a new, reliable water supply for its growing population. At the time, the city relied on a network of wells and springs to provide drinking water and fight fires. In December 1851, after a fire destroyed the Library of Congress and nearly destroyed the U.S. Capitol, Congress commissioned a new public water system. The Army Corps of Engineers assigned Meigs to survey the region and propose a new water source. Meigs proposed three options: Rock Creek, the Potomac River at Little Falls or the Potomac River at Great Falls. He recommended Great Falls – the most expensive and difficult option, but also the option that could best supply water for a rapidly growing city. In 1853, President Franklin Pierce approved the Great Falls plan and Secretary of War Jefferson Davis chose Meigs to construct the 12-mile aqueduct, which included six bridges and two reservoirs. Completed in 1863, the (modernized and expanded) Washington Aqueduct still supplies public water to the capital city and surrounding areas, including Arlington.

Meigs standing next to Aqueduct equipment, August 18, 1859. (U.S. Corps of Engineers)

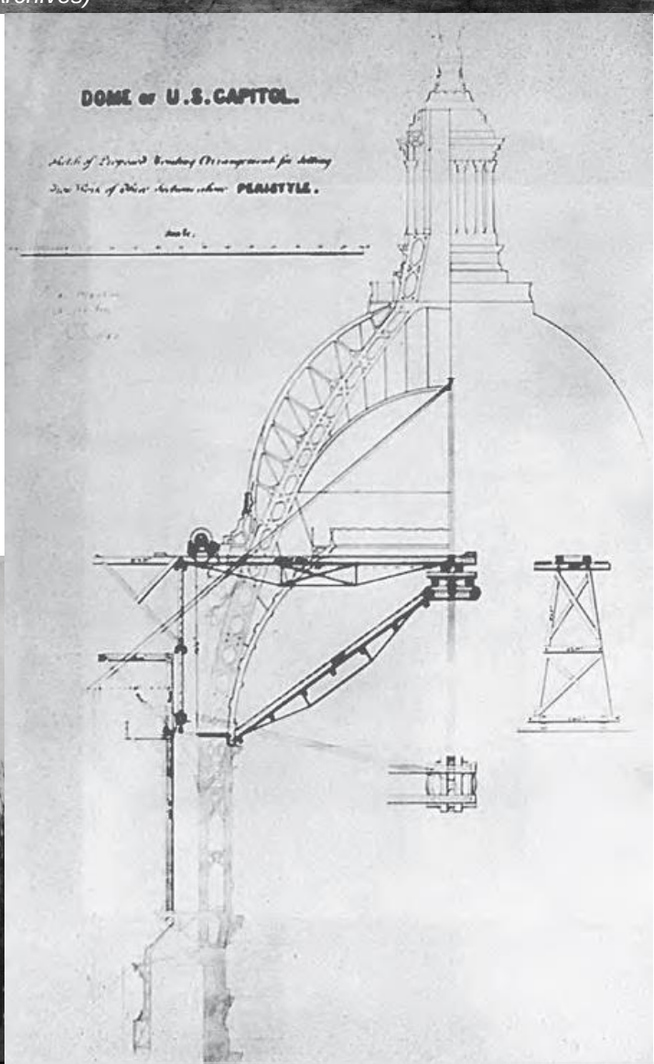


Construction of Union Arch Bridge, part of the Washington Aqueduct, in July 1859. (National Archives)

U.S. Capitol

In 1853, Meigs was charged with supervising the Capitol extension project — constructing the building's dome and its north and south wings. This involved figuring out how to lift over 8 million pounds of iron to build the dome. Meigs' solution was a feat of engineering. He designed a scaffold that rose from the center of the Capitol Rotunda, supported by a triangular base. The triangle base was necessary because a crypt lies below the Rotunda, creating a weak spot in the center of the floor. At the top of the scaffold, a steam-powered derrick lifted the iron into place. The U.S. Capitol, defined by its soaring dome, is a national icon that continues to inspire visitors.

Construction of the new Capitol dome in 1857. The steam-powered derrick is visible above the building. (Architect of the Capitol)



Sketch of Meigs's plan to raise the cast-iron pieces of the new dome, circa 1854. (LOC)

SPACE SHUTTLE CHALLENGER MEMORIAL

REMEMBER

WALKING TOUR STOP 4

Section 46, Grave 1129

Engineers prepare the Spartan-Halley spacecraft before loading it in the Challenger's payload bay. (NASA)

The communications satellite in the Challenger's payload bay. (NASA)

Challenger launch on January 28, 1986. (NASA)

On January 28, 1986, the space shuttle Challenger exploded just 73 seconds after takeoff, killing all seven crew members.

The Challenger launched from NASA's Kennedy Space Center in Florida at 11:38 a.m. It was the shuttle's 10th mission into space. The goal of the mission was to deploy a communications satellite and to deploy an astronomy spacecraft to study Halley's Comet. Most famously, the Challenger also carried the first teacher to go to space, Christa McAuliffe, who would teach science lessons from orbit.

On the morning of the launch, the shuttle's engineers expressed concerns about how unexpectedly cold weather might affect the integrity of the seals on the solid rocket boosters. Overnight, the temperature had dipped below freezing, and at the time of the launch it was 36 degrees Fahrenheit – 15 degrees colder than the next coldest launch temperature. After listening to the engineers' concerns, managers decided that the temperature was not enough of a reason to delay the launch, and they cleared Challenger for liftoff. This was a fatal mistake.

As the engineers predicted, the cold temperatures degraded the rubber seal on the right solid rocket booster, causing the shuttle's explosion. NASA made technical and operational changes in response to the accident. Scientists redesigned the solid rocket booster so the same malfunction would not happen again. NASA also increased its safety protocols and changed its organizational structure so that NASA management could better address safety concerns.

The space shuttle program ran from 1981 to 2011 and flew 135 missions. In addition to the Challenger disaster, the program suffered one other major accident. On February 1, 2003, the space shuttle Columbia was headed home after a 16-day scientific mission, its 28th venture into space. As Columbia re-entered Earth's atmosphere, it suddenly burst into flames, killing all seven crew members. Once again, NASA investigated the cause of the accident and made organizational and technical changes to try to prevent future accidents.

The first astronauts were all highly skilled test pilots with military experience. When NASA began selecting candidates for astronaut training in 1959, it asked the service branches to provide lists of personnel who met certain strict criteria; candidates had to be qualified jet pilots and graduates of test pilot school, with a minimum of 1,500 hours of flying time. During NASA's first two decades, those selected to become astronauts tended to be current or former military pilots. The military background of early astronauts explains why many of them are buried at Arlington National Cemetery. This also explains why there were no women astronauts until 1983, when Sally Ride became the first American woman in space.

As of 2021, 29 astronauts are buried at Arlington. Only some chose to include the designation of astronaut on their headstone. Learn more about the astronauts buried at ANC here.

TECHNOLOGY WALKING TOUR

Return to Meigs Dr and turn right on Wilson Dr. At the entrance to the USS Maine Memorial, turn right and then right again. The Challenger and Columbia Memorials are directly ahead.

Challenger crew members (L-R): McAullife, Jarvis, Resnik, Scobee, McNair, Smith and Onizuka. (NASA)

WILLIAM J. HAMMER

HONOR

WALKING TOUR STOP 5
Section 6, Grave 9644-NH

While working for Edison, Hammer also worked on his own inventions. He patented an improved can opener, a heavy-duty electrical switch, and a combination tool for wiring buildings. He also designed and built the first electric sign. The sign spelled "Edison" in electric lights.

Hammer sitting in his lab, ca. 1900. (NMAH)

BIRTH: February 26, 1858, Cressona, PA

DEATH: March 24, 1934, New York, NY

William Joseph Hammer, an electrical engineer and inventor, spent his life experimenting with and promoting new technologies.

CIVILIAN CAREER: In 1879, Thomas Edison hired 21-year-old Hammer as a laboratory assistant at his "Inventions Factory" laboratory at Menlo Park, New Jersey. In that role, he worked on experiments to develop new technologies, including the telephone, phonograph and electric railway. Most of Hammer's work, however, focused on the incandescent electric lamp — an early version of the lightbulb. Hammer was responsible for performing tests and keeping records on the lamp.

Edison soon promoted Hammer, and he began traveling the United States and Europe to popularize electric lighting. In 1881, he helped build the Holborn Viaduct Central Electric Light Station in London, the first power station to generate electricity for public use. He later became chief engineer of Edison's lighting companies in England and Germany, supervising the construction of Edison electric lighting plants across Europe. Hammer was also in charge of Edison's world's fair exhibitions across Europe, including world's fairs in London (1882), Berlin (1883) and Paris (1889). These exhibitions introduced millions of Americans and Europeans to electricity and other inventions.

Hammer stands in front of a Wright Military Flyer during the 1909 Army trials at Fort Myer, Virginia. The man behind Hammer is likely Wilbur Wright. (NASM)

TECHNOLOGY
WALKING TOUR

From Memorial Drive, turn right on Roosevelt Drive. At the parking lot, turn left into Section 6. Hammer's grave is about 12 rows back.

In 1890, Hammer left Edison to become a private electrical engineer and independent inventor. He worked with prominent inventors Marie and Pierre Curie on radium, advocating for its use to treat cancer and tumors. He also worked with the Wright brothers on aviation. An important supporter of early aviation efforts, Hammer was one of the first individuals in the United States to own an airplane.

MILITARY CAREER: During World War I, the U.S. Army drafted Hammer, at the age of 60, to lead the Inventions Section of the War Plans Division. New advances in military technology played a major role in the war. The machine gun and chemical warfare, zeppelins and airplanes, and submarines and torpedoes all changed and escalated the conditions of warfare on land, air and sea. Therefore, scientists, engineers and inventors became crucial to the war effort. Hammer evaluated and tested thousands of electrical and aeronautical war inventions sent to the Army's Inventions Section. He also delayed patents that could have aided the enemy and analyzed intercepted enemy documents for technical intelligence.

LEGACY: William J. Hammer helped pioneer modern electricity and aeronautics. He not only invented new technologies and improved existing technologies, but also promoted and increased public access to emerging technologies. Hammer's dedication to his craft and country affords him recognition as one of the United States' preeminent innovators in electrical engineering.

REAR ADMIRAL GRACE HOPPER

HONOR

WALKING TOUR STOP 7
Section 59, Grave 973

BIRTH: December 9, 1906, New York City, NY

DEATH: January 1, 1992, Arlington, VA

EARLY & PERSONAL LIFE: From an early age, Grace Hopper loved understanding how things worked. At age seven, she dismantled all the alarm clocks in her family's home in order to understand their mechanics. Hopper's curiosity only grew as she aged. Hopper originally wanted to be an engineer, but, at the time, only men were allowed to pursue engineering. Instead, she studied mathematics. She earned a bachelor's degree in mathematics at Vassar College and later a Ph.D. at Yale University in the same subject. Upon receiving her Ph.D., Hopper returned to Vassar to lead the mathematics department.

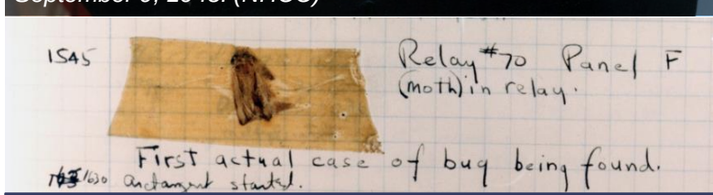
CAREER: At Vassar, Hopper implemented a series of curricular reforms to ensure that her students received an up-to-date education. She discarded old textbooks, mandated that mathematics students develop strong writing skills and integrated the latest developments in the field of physics into the curriculum.

After the U.S. entered World War II in December 1941, Hopper wanted to contribute to the war effort. However, the government prohibited scholars in certain crucial fields, including mathematics, from volunteering for the military. It took over a year for Hopper to convince Vassar College to grant her a leave of absence. In December 1943, she enlisted in the Navy Women's Reserve (WAVES).

In June 1944, after Hopper graduated at the top of her class at the Naval Reserve Midshipmen's School, the Navy sent her to Harvard University to work on the Automatic Sequence Controlled Calculator, also known as Mark I. She was the only woman in the lab. Mark I was the first operating machine that could execute long computations automatically. The Navy used data computed by Hopper and the rest of the team to develop modern technology for warfare. Some of the weapons systems that relied on Hopper's work included naval guns, acoustic and magnetic mines, self-propelled rockets and the atomic bomb.

Above: Commodore Grace Hopper, January 20, 1984. (NHHC)

Below: The first "computer bug" pasted in Hopper's notes on September 9, 1945. (NHCC)



On September 9, 1947, the Mark II glitched. Hopper traced the problem to a moth caught in a relay wire. She "debugged" the wire and taped the moth to her report with the caption, "First actual case of bug being found." The term "bug" already meant "problem" in other fields, but this was its first use in relation to a computer.

TECHNOLOGY WALKING TOUR

Continue down Eisenhower Dr. Hopper's grave is 12 rows back from Eisenhower, 25 headstones in from York Dr. Section 59 is an active burial site, so please be mindful of funeral services and family or friends who are grieving loved ones nearby.

Hopper wrote the first operations manual for the Mark I and assisted with the construction of the Mark II and Mark III computers for the Navy's use after the war. Her work underscored the importance of mathematics in warfare and provided the Navy with the tools needed to conduct modern, high-tech military operations.

Hopper retired from the Naval Reserve in 1966 but was called back to active duty seven months later to assist with data processing for the Vietnam War. While she was only supposed to serve for six months, she remained in the Navy for 19 years. During this part of her military career, Hopper standardized the Navy's computer languages, which allowed for more efficient data management systems. Hopper retired from the Navy with the rank of rear admiral in 1986. At 79 years old, she was the oldest serving officer in the Navy at that point. In 1987, she received the Defense Distinguished Service Medal — the highest award granted to service members who did not serve in combat roles — as well as the Legion of Merit and the Navy Meritorious Service Medal.

LEGACY: Grace Hopper recognized the importance of modernization in the field of mathematics. As warfare evolved, her pioneering work transformed the technology accessible to the Navy and ensured that officers had the information needed to succeed. As one of the few women in a male-dominated field, Hopper continues to inspire female students to pursue careers in the STEM field.

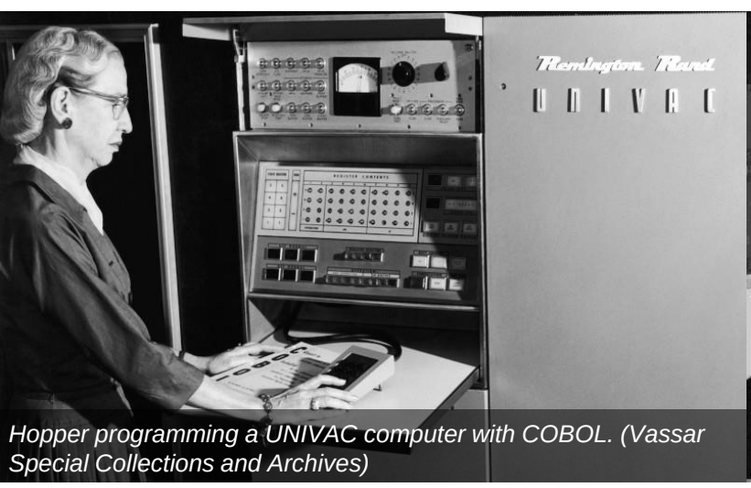
THE QUEEN OF CODING

EXPLORE

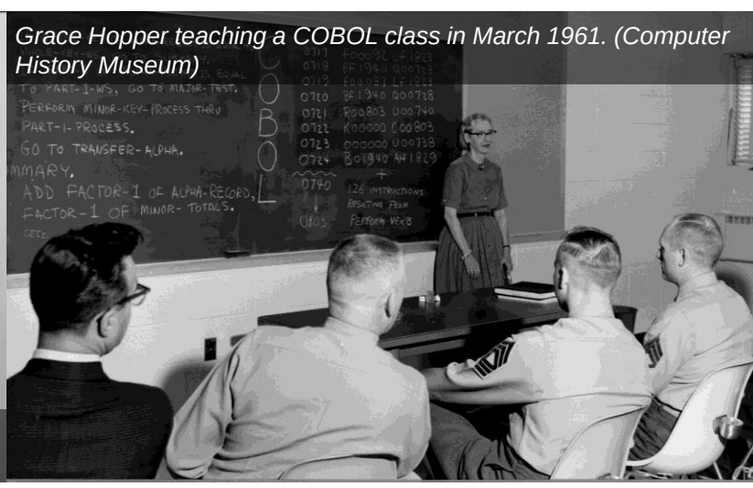
Every time you turn on your computer, you owe a debt to Grace Hopper. In 2016, President Barack Obama awarded Rear Admiral Grace Murray Hopper a posthumous Presidential Medal of Freedom. Speaking of her contributions to military-technological innovation and social change, President Obama remarked: "If Wright is flight, and Edison is light, then Hopper is code."[2]

With support from the U.S. Navy, Grace Hopper was among the world's first computer programmers — male or female. During World War II, Hopper wrote code and a 500-page operations manual for one of the first iterations of the computer, MARK I. The MARK I was a huge, noisy machine that filled up an entire lab. It was 8 feet tall, 50 feet long and contained over 750,000 parts! The Navy used the machine to make ballistics calculations during the war. Although Hopper's programming skills proved instrumental during World War II, she ultimately hoped "to make computers a part of ordinary life for ordinary people."[3] She envisioned that the computer would one day be small enough to fit on a desk, and available to people who were not professional computer scientists. She even believed that children would eventually use computers to do homework and learn in school.

After the war, Hopper worked towards making the computer more accessible for the public. In addition to building smaller scale computers, she advocated for designing user-friendly computer programming languages. She understood that technology did not matter if people did not use it. She wanted to design a program that anyone could use — not just mathematicians. Realizing that many people found mathematical symbols confusing, Hopper designed a program, or compiler, that used basic, English words for commands, instead of symbols. When proposing an English-based coding language, Hopper encountered resistance because "computers couldn't understand English." But Hopper knew that it did not matter what a programmer inputted into a computer; whether English words, Spanish words, or mathematical symbols, what mattered was telling the computer what those words or symbols meant. Hopper's FLOW-MATIC program was the first English-like computer programming language, and the predecessor to the COBOL (common business-oriented language) program, which is still used today. As a woman in a male-dominated field, Hopper combined her unique experience as a teacher with her knowledge of mathematics and coding to make technology accessible for a wider audience.



Hopper programming a UNIVAC computer with COBOL. (Vassar Special Collections and Archives)



Grace Hopper teaching a COBOL class in March 1961. (Computer History Museum)

Nicknamed the "Queen of Coding," Grace Hopper continues to inspire generations of women to pursue careers in the military and in science, math and technology, generally. Numerous institutions and programs honor her legacy. Every year, the Anita Borg Institute and the Association of Computing Machinery host the Grace Hopper Celebration (GHC), a conference that provides a space for women in technology to share ideas, celebrate achievements and network with other women in the field. The Grace Hopper Program at Fullstack Academy in New York City is a software engineering bootcamp for female students. The program aims to empower women in technology by providing affordable education and mentorship. Although not directly connected to Grace Hopper, nonprofits such as Women Who Code, Girls Who Code and Women in STEM are working to close the gender gap in the technology field by building communities of women in the field and encouraging young girls to pursue careers in STEM.

REFLECTION QUESTIONS

- Hopper advocated for making technology accessible. Why do you think accessibility in technology is important? Can you think of a time when technology was inaccessible to you? Why was it inaccessible? What would have made it accessible?
- Hopper was one of the few women who successfully made a career in two male-dominated fields – the military and computer science. Why is it important to have diversity — gender, race, economic, etc. — in both STEM fields and the military?

COLONEL FRANCIS X. "DUKE" KANE

HONOR

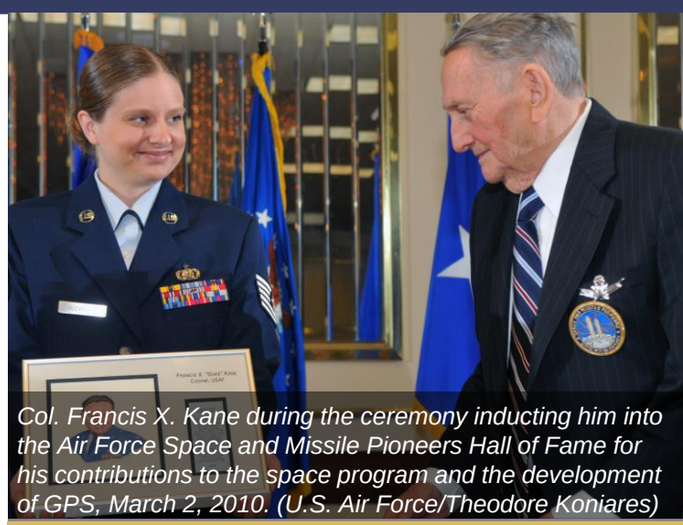
WALKING TOUR STOP 7

Section 59, Grave 4724

BIRTH: December 12, 1918, Philadelphia, PA

DEATH: July 18, 2013, San Antonio, TX

As an officer in the U.S. Air Force, Col. Kane aimed higher than the skies he often flew, dedicating his career to space technology. During the 1960s and 1970s, he helped plan and develop new space technologies. These included space-based missile warning and defense plans, space shuttles capable of re-entry and a navigation satellite system (621B), which became a basis for GPS (Global Positioning Satellite).



Col. Francis X. Kane during the ceremony inducting him into the Air Force Space and Missile Pioneers Hall of Fame for his contributions to the space program and the development of GPS, March 2, 2010. (U.S. Air Force/Theodore Koniares)

TECHNOLOGY WALKING TOUR

Kane's headstone is four rows back from Halsey Dr. and three plots in from York Dr. Section 59 is an active burial site. Please be mindful of funeral services and family or friends grieving loved ones nearby.

DEVELOPING GPS (GLOBAL POSITIONING SATELLITE)

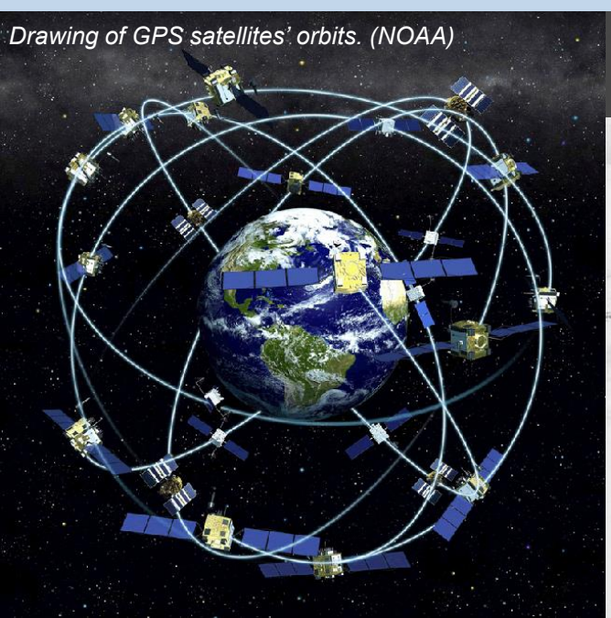
On October 4, 1957, the world watched as the Soviet Union successfully launched its Sputnik satellite into space, beginning the Cold War space race. While listening to Sputnik's radio transmissions, scientists at John Hopkins University's Applied Physics Laboratory (APL) realized they could trace the satellite's orbit by tracking its wave frequency in relation to a fixed point on Earth (known as the Doppler effect). They then started researching the opposite question: Could they pinpoint a location on Earth using the satellite's location?

This question particularly interested the Navy. At the time, the Navy was developing the submarine-launched Polaris missile. For the missile to hit its target, the Navy needed to know the location of the submarine at the time of launch. In 1958, the Navy sponsored APL to develop the Transit satellite navigation system for this purpose. The first prototype was launched in September 1959, but it failed to reach orbit. The second prototype successfully launched on April 13, 1960.

The Navy then turned its attention to a new satellite, called Timation, that transmitted an accurate time reference across the globe. By using two frequencies, it controlled for the time delay produced by radio signals. The first Timation satellite launched in 1967; the second launched two years later.

While the Navy was developing the Transit and Timation satellites, the Air Force began working on its own satellite project, known as 621B. Unlike former satellites, this system would be three dimensional (adding altitude to longitude and latitude). It also used a pseudorandom noise signal to prevent jamming.

In 1973, the Department of Defense launched Global Positioning Satellite (GPS)/NAVSTAR as a joint military service project. This project incorporated the best technologies from Transit, Timation and 621B into one system: GPS. First launched in 1978, GPS became fully operational in 1993. Since then, scientists have continued working to improve GPS technology for military and civilian use. Today, the United States Space Force operates GPS.



Drawing of GPS satellites' orbits. (NOAA)

Aerospace Corporation engineer Al Gallegly (left) and Grumman engineer M. Moore test a transmitter for Project 621B at White Sands Missile Range, New Mexico, 1972. (The Aerospace Corporation)

MAPPING ANC

EXPLORE

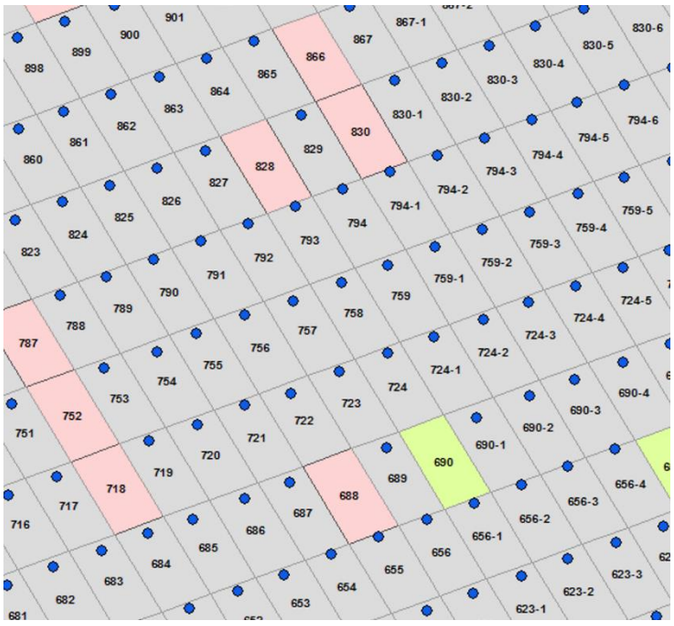
Today, Arlington National Cemetery uses GPS, GIS (Geographic Information System) and LiDAR (Light Detection and Ranging) to manage the cemetery's grounds. These technologies are crucial to the cemetery's mission to honor and remember the service and sacrifice of individuals buried here, and to enable visitors to explore the nation's history.

What is GIS?

GIS is a system that combines location data (GPS) with descriptive data. It can include aerial imagery, elevation data, the longitude and latitude of objects, and descriptive information about the objects represented, such as a name or date.

ANC uses GIS to keep track of all burial plots. Each burial plot is numbered, with information on who is interred in that plot (including their name, interment date, and the exact longitude and latitude of their headstone); plots that remain open are marked as such. Arlington conducts 140-160 funerals per week. Every week, ANC's GIS team updates the cemetery's GIS records with the new interment data, going into the cemetery to confirm the exact GPS location for every new headstone.

GIS is also the basis for the ANC Explorer app, Arlington's public, searchable tool for locating graves and points of interest in the cemetery.

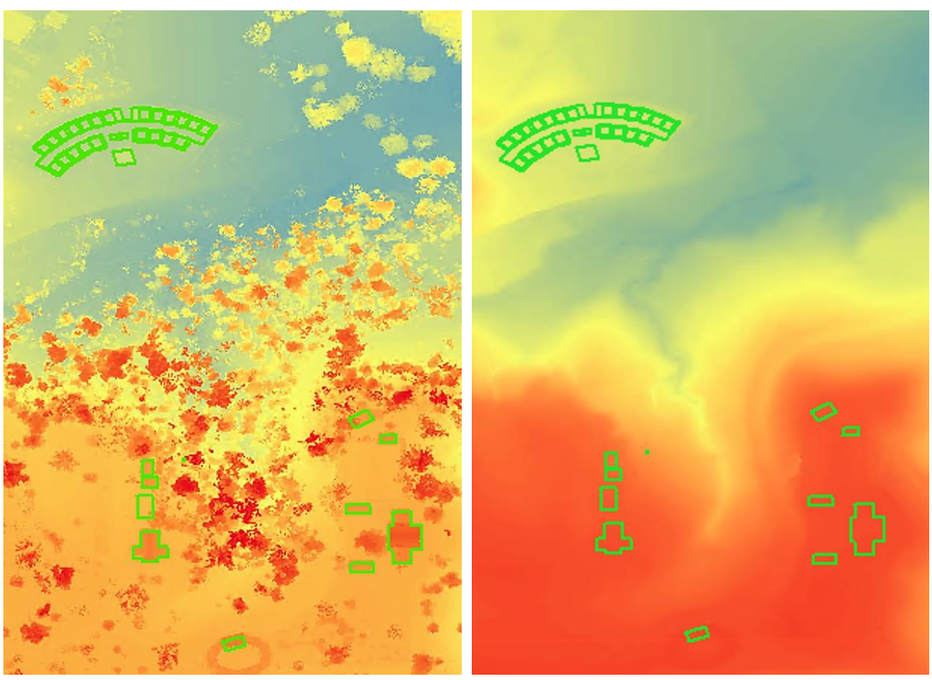


This is an example of the internal GIS map that Arlington uses to track burial plots. The green plots are open plots. Red plots are reserved. Gray plots are full. The blue dot indicates the headstone location. (ANC)

Use the ANC Explorer app to navigate to the final stop on the walking tour, Private Ted Hall. Notice what information about Hall is listed in his entry.

What is LiDAR?

LiDAR collects data using lasers – a form of light. Lasers can scan over an area and collect data points about how long it takes the laser light to hit an object and how the light reacts to that object. The time it takes for a laser to hit an object measures the height of that object. How the light reflects off the object tells you what the object is; for example, light responds to water differently than it responds to trees or concrete.



Since 2013, ANC has conducted LiDAR scans of the cemetery every few years. Some ways ANC uses these scans include:

- Planning pedestrian routes and disability accessible paths
- Identifying impervious surfaces for rainwater and stormwater management
- Identifying changes in tree canopy cover
- Creating mock-ups for proposed monuments and other building projects

LiDAR maps of the cemetery. The green outlines indicate buildings. The large building on the right is Arlington House. The cluster of buildings on the left are NPS administrative offices. The building at the top is the columbarium in Section 79. The map on the left shows tree cover — the red areas indicate trees. The map on the right shows ground elevation — red areas are higher ground; blue areas are lower ground. (Arlington National Cemetery)

PRIVATE TED HALL

REMEMBER

WALKING TOUR STOP 8
Section 57, Grave 391

BIRTH: October 28, 1917, Kansas City, MO

DEATH: December 7, 1941, Pearl Harbor, HI

TECHNOLOGY WALKING TOUR

Continue on York Dr. Turn left on Patton Dr. Hall's headstone is about halfway between Patton Drive's intersection with York and Marshall Drives, several rows into Section 57. Section 57 is an active burial site, so please be mindful of funeral services and family or friends who are grieving loved ones nearby.

In June 1941, two friends, Ted Hall and Don Lowery, enlisted in the Marine Corps. After completing boot camp, they were assigned to the battleship USS Oklahoma and stationed in Pearl Harbor, Hawaii. On the morning of December 7, 1941, Japanese planes torpedoed the Oklahoma as part of their surprise attack on Pearl Harbor. According to Lowery, who was able to escape the ship, Hall "went to breakfast that morning. I was told he was down there when one of the torpedoes hit and one of the gear lockers turned over on him. He was crushed."[4] The Oklahoma rolled over and sunk within 20 minutes of the first torpedo hit, taking with it more than 400 men.

Over the next few years, the Navy and the Army's American Graves Registration Service worked to recover and identify the remains of the Oklahoma crew. Their efforts were limited by the technology available at the time, however, and they were able to identify only 35 crew members. The rest of the recovered remains, including those of Ted Hall, were buried in group graves at the National Memorial Cemetery of the Pacific in Hawaii.

In 2015, armed with new DNA analysis technology, the Defense POW/MIA Accounting Agency (DPAA) and the Armed Forces Medical Examiner System (AFMES) launched an ambitious effort to exhume and identify the remains of the USS Oklahoma crew. They contacted family members of the crew to collect DNA samples they could match with the unidentified remains.

As of June 2021, DPAA has analyzed over 13,000 bones and identified 338 members of the USS Oklahoma crew. On January 16, 2019, DPAA and AFMES announced that they had used anthropological analysis (looking at bones for clues about height, age and other traits) and DNA analysis in order to positively identify the remains of Marine Corps Reserve Private Ted Hall. On October 18, 2019, nearly 78 years after his death, Hall was laid to rest at Arlington National Cemetery.

Above: Private Ted Hall, circa 1941. (DPAA)

Top right: USS Oklahoma under salvage at Pearl Harbor, March 1943. (National Archives)

Bottom right: John Hall (center) receives the U.S. flag during the service of his uncle, Pvt. Ted Hall, on October 18, 2019. (ANC/Elizabeth Fraser)

IDENTIFYING REMAINS

Dr. Gregory E. Berg weighs a portion of a test specimen in DPAA's isotope lab on March 9, 2020. (U.S. Air Force/James Thompson)

Anthropologists Audrey Schaefer (L) and Dr. Larkin Kennedy process remains from the USS Oklahoma, February 2019. (U.S. Air Force/Charles Haymond)

There are two types of DNA used for forensic testing and identification: nuclear DNA (nucDNA), which is found in the nucleus of the cell, and mitochondrial DNA (mtDNA), which is found in the mitochondria.

Nuclear DNA is made up of 23 pairs of chromosomes, with one chromosome from each pair inherited from the mother and one from the father. Pairs 1-22 are called autosomes, and the DNA within them is unique to each individual. Because DNA is passed along hereditarily, though, members of the same family will have a number of similarities in their genetic code. Autosomal DNA testing looks for patterns in specific locations of the genetic code to determine whether there are enough of those similarities to say the two samples are from related individuals.

The 23rd chromosome pair in nuclear DNA determines the sex of the individual — typically, XX for women and XY for men. Y-DNA passes from father to son nearly unchanged, so it can be used to identify whether two DNA samples come from individuals with a common male ancestor. Because women typically do not have a Y-chromosome, this kind of testing can only be used on men.

Mitochondrial DNA is passed from mother to child, and like Y-DNA, it does not change very much generation to generation. Mitochondrial DNA testing can be used to identify whether two DNA samples come from individuals with a common female ancestor.

When attempting to identify remains, the AFMES DNA Identification Laboratory usually by testing mitochondrial DNA. If they have the necessary samples, they may also conduct autosomal and Y-DNA testing to increase the likelihood of making a correct identification.

REFLECTION QUESTIONS

- Why do you think the military makes such an effort to identify the remains of fallen service members?
- There were multiple sets of brothers who were killed aboard the *USS Oklahoma*. How might this have complicated the use of DNA identification? What other methods could be used to identify them?

Defense POW/MIA Accounting Agency (DPAA)

DPAA's mission is to provide the fullest account of missing personnel to their families and the nation. The agency conducts historical and field research across the globe to identify missing service members from World War II through today.

Unlike the remains of the USS Oklahoma service members, not all unidentified remains are buried in group graves. Many are still missing abroad. To find these missing remains, the DPAA conducts archival research and interviews potential witnesses to determine sites to search for remains. Once a site is identified, recovery teams perform archeological excavation. Forensic testing is done on any recovered remains and artifacts.

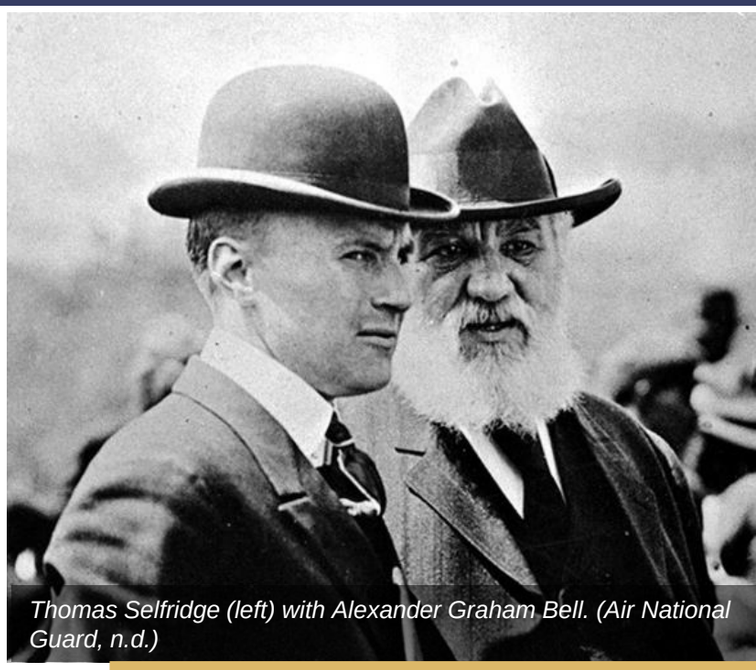
DPAA investigator Howard Mariteragi examines possible material evidence from an excavation in the Kom Tum Province in Vietnam, March 8, 2020. (U.S. Navy/Claire Farin)

LT. THOMAS ETHOLEN SELFRIDGE

HONOR

WALKING TOUR STOP 11

Section 3, Grave 2158



Thomas Selfridge (left) with Alexander Graham Bell. (Air National Guard, n.d.)

BIRTH: February 8, 1882, San Francisco, California

DEATH: September 17, 1908, Fort Myer, Virginia

EARLY & PERSONAL LIFE: A pioneer in Army aviation, Thomas Selfridge graduated from the U.S. Military Academy at West Point in 1903—the same year that Wilbur and Orville Wright accomplished their first flights in Kitty Hawk, North Carolina.

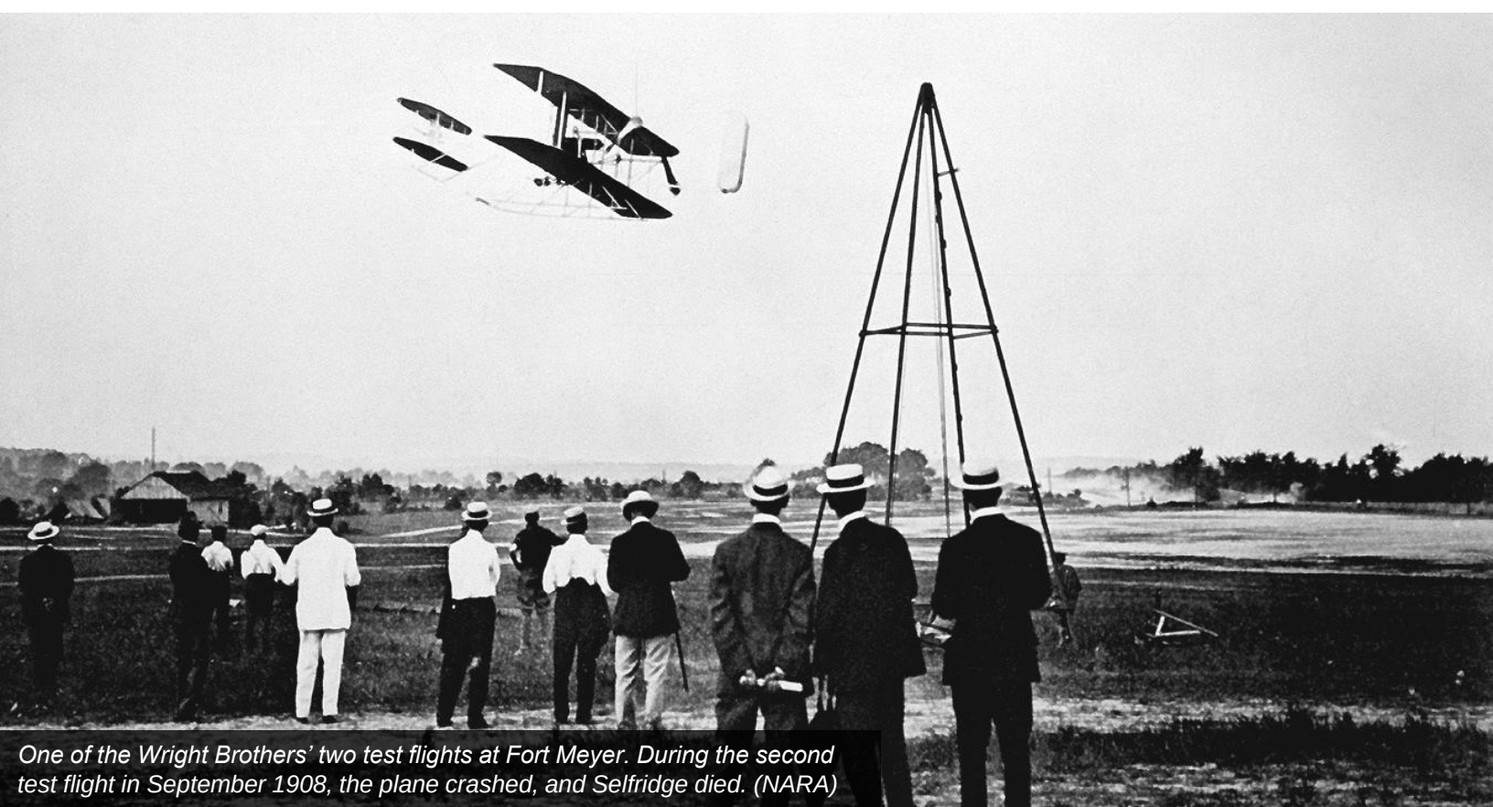
CAREER: Following his graduation, Selfridge was commissioned into the Artillery Corps, where he became interested in flight. After reading about Dr. Alexander Graham Bell's experiments with kites, Selfridge contacted him asking to observe one of his experiments. In the summer of 1907, Selfridge was reassigned to Baddeck, Nova Scotia, where Bell lived. He was appointed secretary of the newly formed Canadian-American Aerial Experiment Association (AEA). In 1908, Selfridge designed the AEA's first airplane, the Red Wing. Later that year, Selfridge became the first U.S. military officer to pilot an aircraft, the AEA's "White Wing." He flew about 93 yards, at a height of ten feet.

TECHNOLOGY
WALKING TOUR

From Porter Dr., turn onto Grant Dr. At the intersection of Grant and Pershing, turn right into Section 3 and walk up the hill. The obelisk marking Selfridge's gravesite is six rows in from McKinley Dr.

In August 1908, Selfridge was reassigned to the Aeronautical Division of the U.S. Signal Corps at Fort Myer, Virginia. There, he was a test pilot of the U.S. Army's recently acquired dirigible airship. He was then assigned to conduct trials for the Wright brothers' Model A Military Flyer. Orville Wright had already successfully piloted the aircraft, but needed to prove that it could carry two people at 40 miles per hour. On September 17, 1908, with a crowd watching, Wright and Selfridge took off. With Wright piloting and Selfridge riding alongside him, the plane circled Fort Myer. On the fourth circuit, the plane's propeller broke, causing it to nose-dive to the ground and crash. Onlookers pulled the two men from the wreckage. Wright recovered, but Selfridge never regained consciousness. He was the first recorded person to die in an airplane crash.

LEGACY: Selfridge was a pioneer in aeronautics. He advanced aircraft technology as a member of the AEA and fearlessly tested early aircraft for the U.S. Army.



One of the Wright Brothers' two test flights at Fort Meyer. During the second test flight in September 1908, the plane crashed, and Selfridge died. (NARA)

SOCIAL MEDIA CONNECTIONS

We love hearing about your visit! Share your pictures, questions and favorite parts of the tour on Facebook, Twitter and Instagram. Tag Arlington National Cemetery using @ArlingtonNatl and hashtags #ANCEducation and #ANCMilTech.

#1 THE IMPACT OF TECHNOLOGY

This walking tour includes many different types of technology. Share which stop inspired you the most, or which you think had the greatest impact on your understanding of the world today.

#2 MONTOMERY MEIGS

Check out the photos and sketches of General Montgomery Meigs' many contributions to the development of Washington, DC. Have you visited any of Meigs' projects outside of the cemetery? Share which project, either at the Cemetery or outside of it, is your favorite.

#3 PROBLEM SOLVERS

Technological advancement is about problem solving. George Westinghouse invented a better braking system for trains after witnessing a collision between two freight trains and Surgeon General George Miller Sternberg pioneered research on sanitation after witnessing repeated outbreaks of disease among soldiers. What problem would you like to solve using technology? Share the problem and how you would technology to solve it.

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2. Sharon Anderson, "Rear Adm. Grace Hopper Continues to Inspire Innovation," *CHIPS*, January-March 2017, https://www.doncio.navy.mil/chips/ArticleDetails.aspx?id=8789.
3. Kathleen Broome Williams, "'Amazing Grace' Hopper: The Woman Who Brought the Navy into the Digital Age," *Sea History* 168 (Autumn 2019): 26.
4. Jean Haley, "Japanese Bombs Exploded Lazy Pearl Harbor Sunday," *The Kansas City Times*, December 7, 1973, 34.

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