Publicity photo of the author with Generals Grant and Lee used to advertise Dewberry's presentation on the role of surveyors and mappers during the U.S. Civil War—presented on 3/4/2011, the 150th anniversary of the inauguration of Abraham Lincoln as president

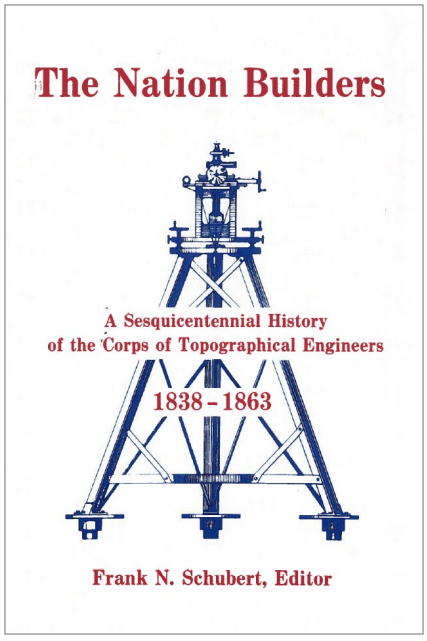
We're all Topographic Engineers, with a Proud History

If you google "What do engineers do?" you will learn that engineers apply the principles of science and mathematics to develop economical solutions to technical problems. Their work is the link between scientific discoveries and the commercial applications that meet societal and consumer needs.

Whether you realize it or not, most LiDAR specialists today are topographic engineers who apply their knowledge of LiDAR to map topographic surfaces and/or to use that information in thousands of ways for the betterment of society. Members of the geospatial profession follow in the footsteps of some very famous Americans, including presidents George Washington, Thomas Jefferson, and Abraham Lincoln—all of whom started their careers as land surveyors.

For my inaugural article, I thought it would be good to review the history of topographers (topogs) who preceded us, starting with the Corps of Discovery which formed the nucleus of the Lewis and Clark expedition (1804-1806) that was sent by President Jefferson on a dangerous scientific expedition to explore the Louisiana Purchase and hopefully also find a practical commercial (water) route to the Pacific.

BY DAVID F. MAUNE



U.S. Army Corps of Engineers book on the history of the U.S. Army Corps of Topographical Engineers

Captain Meriwether Lewis and Second Lieutenant William Clark determined the latitude and longitude of river junctions, waterfalls, mountain passes, native villages and other landmark features using tools of the day (octant, chronometer, sextant, artificial horizons, surveyor chains and compasses) and returned with maps that provided knowledge of the topography, flora and fauna along their routes to and from the Pacific Ocean.

The Corps of Discovery was followed in 1838 by the founding of the U.S. Army Corps of Topographical Engineers. These topogs surveyed the Mexican border, the Great Lakes, railroad routes to the West Coast and other nation building projects that today would be called Civil Works programs of the U.S. Army Corps of Engineers (USACE). The Corps of Topographical Engineers merged with the Corps of Engineers in 1863 during the midst of the U.S. Civil War and has remained as one Corps ever since. Prior to the Civil War, Captain George G. Meade, a topog, was mapping the U.S. Great Lakes; less than a decade later, he was Major General George G. Meade, the hero of the Battle of Gettysburg, after only a few weeks in command.

In 1988, on the sesquicentennial (150 year) anniversary of the founding of the U.S. Army Corps of Topographical Engineers, I was honored to lead a ceremony that celebrated major accomplishments during its 25 year history. At that time, I was the Commander and Director of the U.S. Army Engineer Topographic Laboratories (ETL), subsequently the U.S. Army Topographic Engineering Center (TEC), responsible for developing new topographic engineering technologies for DOD and technology transfer to the civilian world. USACE published "The Nation Builders," edited by Frank N. Schubert, which documented the Corps' significant accomplishments. I retired from Army active duty at the end of 1991 and joined Dewberry in 1992 as senior remote sensing project manager.

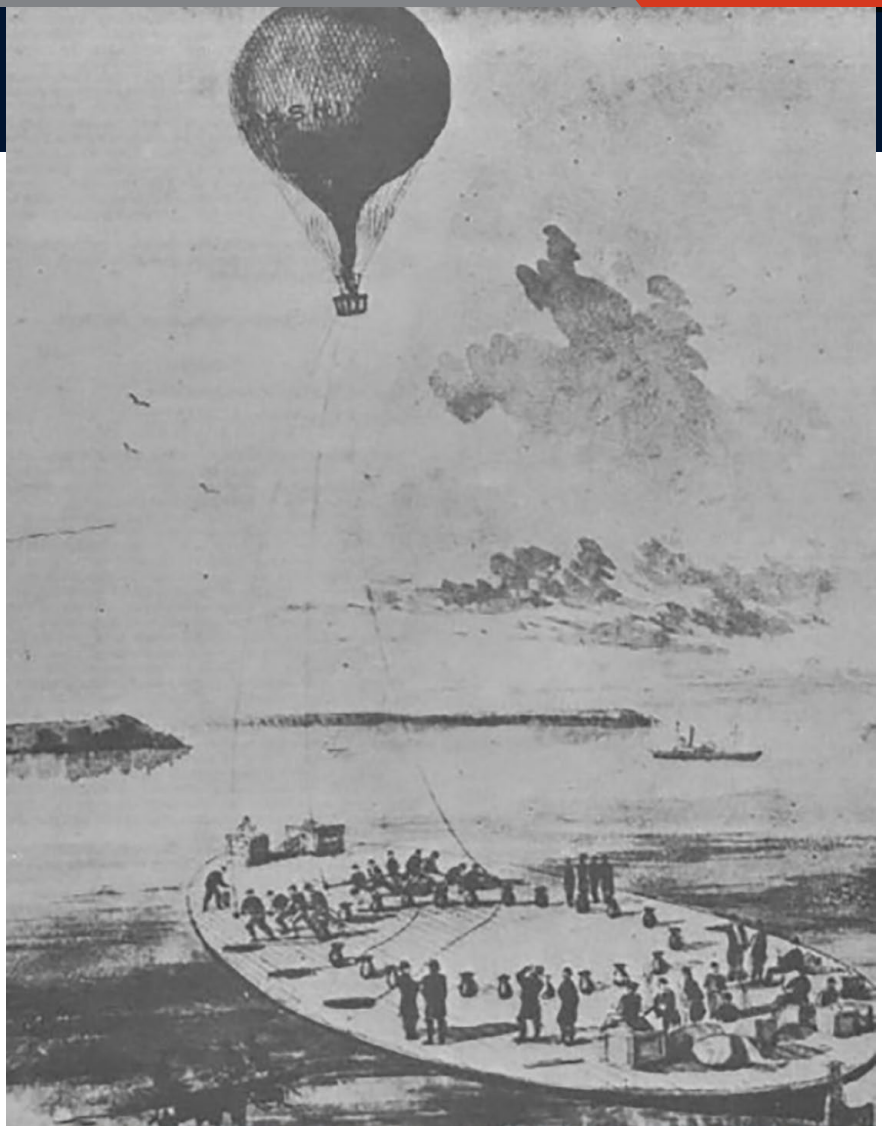
In 2011, to remember the beginnings of the U.S. Civil War, my boss (Sid Dewberry) asked me to don a Civil War uniform and give a presentation on the role of surveyors and mappers during the Civil War. Mr. Dewberry came from a Virginia family of rebels and I always considered myself a Yankee, so we agreed that the war was long over and all was forgiven. Mr. Dewberry rented a Union Army uniform for me, made the adjoining publicity photo, and we had a lot of fun. In preparing my presentation, I learned some interesting facts about topogs during the U.S. Civil War.

During its brief 25 year history, the U.S. Army Corps of Topographic Engineers arguably pioneered Army aviation and built America's first "aircraft carrier," long before we had airplanes; topogs developed "aerostat carriers." One such carrier was the George Washington Parke-Custis, a converted coal barge, outfitted to accommodate reconnaissance balloons and support equipment. The U.S. Army Corps of Topographic Engineers had a small Balloon Corps with seven aerostats (balloons) and hydrogen gas generators. Balloons and generators were transported to rivers with suitable coal barges converted to named aerostat carriers, with names like Intrepid, similar to the way we name ships today. These balloons were raised above several Civil War battlefields for reconnaissance and mapping purposes and to direct artillery fire. Lieutenant George A. Custer tried balloons for reconnaissance purposes, but fearing tumbling out he is quoted as saying: "I remained in the bottom of the basket with a firm hold on either side." He later learned that fighting in the Battle of Little Bighorn wasn't very safe either. Although innovative, the use of balloons did not prove to be an effective way to map battlefields because the balloons were too shaky, and their use was not widespread. Yet, after the war ended, a Confederate general said: "The Federals never appreciated the amount of roundabout marching the presence of observation balloons high above the field forced on the Confederates."

During the U.S. Civil War, most topogs performed reconnaissance

and made their map sketches while on horseback. Their toolkit included a small drawing board or pocket-size sketchbook; a soft lead pencil (tied by string to not be dropped while sketching on horseback); eraser, ruler, prismatic compass, and an aneroid barometer used to measure air pressure changes (1" mercury per 1,000' elevation). Distances were estimated by counting horse paces (stride varied by slope), counting turns of wagon wheels, or other innovations.

Civil War commanders did not require accurate maps in the conventional sense. They needed military intelligence and reconnaissance to help commanders visualize the battlefields and exploit the terrain quickly. They needed local knowledge of mountain passes and good maps of the best way to move an Army of over 100,000 men, 28,000 horses, 32,000 mules, 5,000 wagons, 800 ambulances and thousands of cannons across narrow, muddy roads and trails, fording rivers, cutting through forests and swamps, and finding food and water for men and animals en route. They knew that infantrymen could ford rivers ≤4' deep, cavalrymen could ford rivers ≤5' deep, but loaded wagons could only ford rivers ≤2.5' deep and emerge onto slopes ≤10°. But how do fording conditions change after 1,000 wagons have passed through? Unless a ford shallow enough for the rations and gunpowder to cross dry was found, the entire army was brought to a complete halt. In this way, the Confederate Army had the advantage because most of the battles were fought in Confederate territory where they knew the terrain better.



The George Washington Parke-Custis, an aerostat carrier operated by the Balloon Corps within the U.S. Army Corps of Topographical Engineers.

Although a self-taught amateur, Jed Hotchkiss was considered as the best of all topogs on either side during the U.S. Civil War. Although paid as an officer, he was a civilian who never succeeded in being commissioned as an officer, yet he was a key staff member for Confederate General Stonewall Jackson who was extremely secretive and never revealed plans until the last minute. Stonewall Jackson relied on Hotchkiss' reconnaissance and maps for bold offensive and defensive maneuvers, consistently using the topography to maximum advantage. General Jackson

US Army Corps of Engineers
Engineer Topographic Laboratories

Tech-Tran

Volume 16, Number 3 September 1991

USAETL receives 1991 Army Research and Development Organization of the Year award

The Honorable Stephen K. Conver, assistant secretary of the Army for research, development and acquisition, presents Col. David F. Maune, USAETL's commander and director, with the 1991 Army R&D Organization of the Year award. See story, page 2.

ALSO IN THIS ISSUE:

USAETL changes its name to TEC
Terrain Information Extraction System
Water Detection Response Team Activities

COL Maune accepting ETL's Army R&D Organization of the Year Award in 1991 for dozens of topographic engineering innovations by ETL scientists, engineers and contractors.

routinely told his Generals to wait, not issuing final orders until having first consulted with Hotchkiss and reviewing his maps to "see" the battlefield. After Jackson's death, Hotchkiss was a worthy topog also for several other Confederate generals.

In 1978, while serving in the Pentagon, I was able to rewrite Army doctrine for the use of U.S. Army topographic engineers, obtained Army approval to create Terrain Analysis Warrant Officers and 5-man terrain teams at division level, and documented the need for modern, digital mapping technologies to be used by these terrain teams.

Between 1988 and 1991, as Commander and Director of ETL and TEC, I was fortunate to manage the Army's development of many of those technologies, including technologies that we transferred to the civilian world. ETL had a lot of smart scientists and engineers who had previously developed automated image correlation and Terrain Contour Matching (TERCOM), both of which were used in the guidance systems for our first use of cruise missiles in 1991. TERCOM technology required the use of Digital Terrain Elevation Data (DTED) produced by what is now the National Geospatial-Intelligence Agency (NGA). The first cruise missiles compared DTED planned routes with actual terrain beneath the missiles to keep them on course. ETL won the Army's R&D Organization of the Year award in 1991 for 26 innovative topographic engineering technologies not previously used in combat. General Schwarzkopf listed those innovative technologies most vital to him for Operation Desert Storm, and ETL had helped to develop most of them. Before the ground war started in 1991, the commander of the 30th Engineer Battalion (Topographic) told me: "We know where their minefields and fire trenches are, and we know everything about the Iraqi Army except

> "General (Stonewall) Jackson routinely told his Generals to wait, not issuing final orders until having first consulted with Hotchkiss (his topog) and reviewing his maps to 'see' the battlefield."

for the names of the soldiers in their foxholes." This was largely the result of remote sensing technologies developed by topographic engineers.

After the 100-hour war, a U.S. Army Armored Division Commander, upon returning to the U.S. from Iraq, praised the contributions of Mr. Popp, his Terrain Analysis Warrant Officer, stating that he relied heavily on the advice of Mr. Popp on how to use the terrain to maximum advantage and see the battlefield. Doesn't this sound similar to General Stonewall Jackson and his relationship with Jed Hotchkiss? Terrain intelligence is a force multiplier that wins wars and reduces casualties. Today this is called GEOINT.

> "We know where their minefields and fire trenches are, and we know everything about the Iraqi Army except for the names of the soldiers in their foxholes."

During my 30-year military career as a Topographic Engineer officer in the U.S. Army Corps of Engineers, I utilized analog photogrammetric instruments (Multiplex and optical-mechanical stereo plotters), analytical plotters, and softcopy photogrammetry. In fact, while I served as Commander and Director, ETL developed the Terrain Information Extraction System (TIES) that included the first film scanner (subsequently sold by Intergraph as the PhotoScan-1) and the first digital stereo photogrammetric workstation (subsequently sold by BAE Systems as SocetSet and widely used today for digital photogrammetry and lidargrammetry). These two systems pioneered our transition from analytical photogrammetry to digital (softcopy) photogrammetry. Move forward 20 more years, and I am now absolutely thrilled that today's LiDAR is able to map the topography in dense forests that we've never been able to do with photogrammetry or radar, and I'm excited about the new LiDAR technologies that we'll discuss in future columns as these technologies mature.

In my future articles for LIDAR Magazine, I plan to review the evolving use of LiDAR by various federal agencies, states and counties since the late 1990s when I first became actively involved with LiDAR. I'll also focus on the 3D Elevation Program (3DEP) that resulted from the National Enhanced Elevation Assessment (NEEA) report that I authored in 2012. Once the 3rd edition of *Digital Elevation Model Technologies and Applications: The DEM Users Manual* is published by ASPRS, hopefully next year, I'll then feature manual highlights of broad interest to the LiDAR community. In the meantime, I welcome your recommendations.

Dr. David Maune is an Associate Vice President at Dewberry Consultants LLC where he is an elevation specialist and manages LiDAR, IFSAR and photogrammetric projects for USGS, NOAA, FEMA, USACE, and other federal, state and county governments. He specializes in independent QA/QC of LiDAR data produced by others. He is a retired Army Colonel, last serving as Commander and Director of the U.S. Army Topographic Engineering Center (TEC), now the Army Geospatial Center (AGC). In 1998, he authored NOAA's National Height Modernization Study on how to modernize the National Height System in the U.S. based on Continuously Operating Reference Stations (CORS) and differential GPS. Between 1998 and 2010, he authored all major FEMA guidelines for LiDAR. In 2004, he authored the Guidelines for Digital Elevation Data published by the National Digital Elevation Program (NDEP). In 2001 and 2007, he was the editor and principal author of the 1st and 2nd editions of Digital Elevation Model Technologies and Applications: The DEM Users Manual, published by ASPRS, with the 3rd edition planned for 2017. In 2012, he authored the National Enhanced Elevation Assessment (NEEA) report that provided the blueprint for today's 3D Elevation Program (3DEP). In 2014, he co-authored the ASPRS Positional Accuracy Standards for Digital Geospatial Data. In 2015, he was the editor and principal author of USACE EM 1110-1-1000, Photogrammetric and LiDAR Mapping. Dr. Maune earned his PhD in Geodesy and Photogrammetry from The Ohio State University in 1973. He is currently managing Dewberry's IFSAR mapping for all of Alaska, to include the 2015 GPS survey of the elevation of Denali (formerly Mt. McKinley) that established a new elevation for the top of the snow.