William Bowie: Eminent Scientist and First Chairman (1926–1940) of ASCE's Surveying and Mapping Division

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Introduction

The ASCE Surveying and Mapping Division is the forerunner of the Society's present Geomatics Division. It was founded in 1926 thanks to the vision and inspiration of Major William Bowie who served as Chairman from its creation until his death in 1940. This article emphasizes Bowie's pioneering work related to surveying engineering and mapping in a tribute to his multifaceted scientific career that has not yet been well investigated.

Few members of ASCE are aware that a prominent scientist of the caliber of Major William Bowie (May 6, 1872–August 28, 1940) was the initiator and first Chairman of ASCE's Surveying and Mapping Division. The name of the division was changed to Surveying Engineering Division in 1986 and to the current Geomatics Division in 1997. William Bowie (Fig. 1) is internationally recognized in geodesy (astronomic, geometric, and physical geodesy), geophysics (gravity surveys and their interpretation and isostatic compensation), and, last but not least, engineering. In reading any of the many biographical accounts devoted to Bowie, which are listed in Appendix I, one senses the passion for engineering, in general, and civil engineering, in particular, that was copiously running through Bowie's veins. This article mainly concentrates on his engineering activities and accomplishments, the least researched aspects of his prolific scientific life.

Major Bowie, as he preferred to be addressed, always downplayed the fact that he also attained the superior rank of Captain in the Commissioned Corps of the U.S. Coast and Geodetic Survey (USC&GS). Born at Grassland, a historic state near Annapolis Junction in Maryland, Bowie attended public schools before enrolling at the historic St. Johns College in Annapolis. He received a scholarship to study at Trinity College in Hartford, Connecticut, where he earned a Bachelor of Science degree in 1893. Apparently, because his personal goal was to become a civil engineer, he also studied at Lehigh University in Bethlehem, Pennsylvania, where in 1895, he received a Bachelor's degree in Civil Engineering (C.E.). Later in life, he was awarded several honorary degrees: Master of Arts and Doctor of Science from Trinity College in 1907 and 1919, respectively; Doctor of Science from Lehigh University in 1922 and George Washington University in 1937; and Doctor of Law from Edinburgh University, Scotland, in 1936. As solely anecdotal information, it should be mentioned that William Bowie descended, on his father's side, from ancestors that fought in the Revolutionary War. His father, grandfather, and great grandfather all served in the Maryland state legislature. Bulloch (1915) and Fleming (1949) provide a brief sketch of his lineage.

Early Engineering Activities

Being a civil engineer by training, Bowie was instinctively attracted to surveying and mapping, an interest that remained forever imprinted into all aspects of his vocational endeavors. The same year that he completed his degree in C.E., Bowie was hired as a junior officer in the field engineering force by the USC&GS. It was here that he spent practically the rest of his professional career, except for a brief detail with the U.S. Army during World War I. His expertise in civil engineering was immediately put to work by his superiors who assigned him to plan and observe diverse types of geodetic, topographic, and hydrographic surveys. Perhaps owing to this experience, throughout his life, Bowie proudly penned his occupation as a geodetic and hydrographic engineer. Due to his proven keen intellect and likeable character, he was soon placed in charge of survey crews observing strategic astronomic, baseline, and triangulation projects, a journey that took him to many states of the Union and the territories of Alaska, the Philippines, and Puerto Rico. He returned to the USC&GS Washington headquarters in 1909 when he was appointed inspector of geodetic work under John Fillmore Hayford, a renowned geodetic engineer who was then chief of the Computing Division and a prominent member of ASCE. Hayford would develop the Hayford ellipsoid in 1910, which, renamed the International Ellipsoid 1924, was adopted by the International Union of Geodesy and Geophysics for worldwide use. Bowie succeeded him in 1915 when Hayford accepted a position as Dean of the newly established College of Engineering at Northwestern University in Evanston, Illinois. Shortly after, Bowie's official title was changed to Chief, Division of Geodesy, a position that he held until his retirement in December 1936.

Bowie is largely credited with inducing both Canada and Mexico to adopt the 1901 U.S. Standard Datum (Bowie 1919, pp. 5–7). Once these two countries accepted this United States–conceived datum to reference their national geodetic networks, the datum was renamed the North American Datum (NAD), a remarkable international agreement that was publicly announced in 1913 (Bowie 1913). North America then became the only continent in the world with a single geodetic datum for its horizontal control surveys, charts, and maps.

In 1927, a continental least-squares adjustment of all first-order triangulation stations began at USC&GS headquarters. The adjustment employed a procedure originally conceived by Bowie in 1924, therefore called the *Bowie method*, and subsequently made practical by Oscar Adams (1930). This colossal adjustment, the first of its kind, was completed in 1933, giving birth to the North American Datum of 1927 (NAD 27), which was in use until 1986 when NAD 83 replaced it. It is no exaggeration to emphasize how important the NAD 27 has been to all types of engineering applications during a period of almost 60 years. Millions of engineering projects of all types were tied to this horizontal datum before the more accurate NAD 83 superseded it more than a half-century later (Bossler 1982; Schwarz 1989; Snay 2012).

From the beginning of his impressive scientific career, Bowie was active within professional engineering circles. In 1914, he was elected President of the Washington Society of Engineers (organized in 1905). In 1915, he was chosen vice-president of the

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Fig. 1. William Bowie, oil on canvas (50 × 41 cm), 1922; by John Wycliffe Lowes Forster (1850–1938) (National Geodetic Survey, NOAA, Historical Archive; photograph courtesy of Eric Duvall, NGS)

Washington Academy of Sciences representing the Washington Society of Engineers, one of the Academy's 14 affiliated societies, and in March 1917 he became a full member of ASCE. From 1915 to 1923, Bowie worked on several committees of the Section of Engineering for the American Association for the Advancement of Science (AAAS), where he was named a fellow in 1907. In 1927, he was elected a member of the National Academy of Sciences.

In 1918, the U.S. Army Chief of Engineers consulted with the USC&GS about the possibility of devising a grid system for military use that would be particularly applicable to coastal artillery defense maps. William Bowie proposed a scientific but conceptually simple solution that was finally adopted. The formulas involved were later developed by Oscar Adams who computed the required tables with the assistance of enlisted men from the 472nd Engineers who had been assigned to the office of the USC&GS. Perhaps due to the important service Mr. Bowie could provide to the Army in grid maps, he was detailed for a few months (August 1918–February 1919) during World War I to the Office of the Chief of Engineers, COE, U.S. Army, in Washington, DC, with the rank of major.

Major General William M. Black, Chief of Engineers, made the following formal request for Bowie's services in a letter addressed to the Secretary of Commerce:

> Mr. William Bowie, hydrographic and geodetic engineer of the United States Coast and Geodetic Survey has special qualifications which eminently fit him for duty in charge of the land defense map project under the Division of Fortifications and Mapping of the Office of the Chief of Engineers. If consistent with your policy, and provided his services can be spared, it is requested that Mr. Bowie be granted permission to accept a commission as major in the Engineer Reserve Corps.

The permission was granted, and Major Bowie was assigned to supervise surveying and mapping activities at strategic military camps where troops were trained to make sensitive defense charts along certain coastal areas of the United States. In addition to this work, he wrote detailed specifications for the special defense surveys and maps and also prepared the manuscript (except tables) for the USC&GS *Special Publication No. 59*, which describes the first grid system embraced by the U.S. Army for military maps (Bowie and Adams 1919). This publication was used as a textbook at West Point for many years until the U.S. Army adopted the Universal Transverse Mercator (UTM) projection in 1944.

Board of Surveys and Maps

On December 30, 1919, President Woodrow Wilson issued an executive order creating the Board of Surveys and Maps of the Federal Government. At the first meeting of the Board on January 16, 1920, William Bowie was elected vice-chairman. The Board was directed to make recommendations to several government departments and/or to the President himself for the purpose of coordinating government-related map making and surveying activities and to settle all questions at issue between executive departments relating to surveys and maps, in so far as their decisions did not conflict with existing law. All government map-making agencies represented at the Board (14 in all) became an advisory body compelled to furnish all available information called for by the Board (Bowie 1920; Anon. 1924). From this point on, Bowie started a campaign advocating for the production of accurate maps as a necessary measure to strengthen national defense and the thoughtful expansion of engineering infrastructures without neglecting the importance of conserving natural resources. Bowie was elected Chairman of the Board of Surveys and Maps of the Federal Government from 1922 to 1924. His engineering predisposition was such that he always lobbied for improving the engineering profession. Shortly after Bowie became Chairman of the Board, he wrote a letter to L. W. Wallace, executive secretary of the Federated American Engineering Societies that stated, in part

> [T]he board has more than justified its existence by helping the bureau of the government, carrying on surveying and mapping operations, coordinating the work of mapping and materially helping in carrying on the operations. The board has also made it possible for the engineers outside of the government to obtain surveying and mapping information more readily than was the case a few years ago.

From experience, Bowie was perfectly clear that lack of accurate geodetic control would undermine the effectiveness of maps. He envisioned the dawn of a higher surveying and mapping era that could benefit engineering on all fronts. In his own predictive words (Bowie 1930b)

> The time has come when the value of accurate surveying and mapping should be adequately recognized by the political subdivisions of this country and also by corporations. With the increased size and cost of engineering projects it is wasteful to skimp on the surveying part of the operations. The survey is as important as is the designing of the structure. In the old days when wooden bridges were the rule, it was an easy matter to fit the bridge trusses to the piers. Now with the steel trusses fabricated in the factory and sent to the field ready to be erected, an

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error of even a few inches in the location of the piers may mean an expensive operation in cutting or splicing the trusses. The use of a high grade surveying instrument and a high grade engineer on the surveying work can obviate any difficulty in making the parts of the bridge fit together.

Every biographer of Dr. Bowie, especially those who knew him personally, has emphasized his excellent qualities as an administrator and his innate persuasive abilities. One direct example will corroborate this generally accepted consensus. A brief note appeared in the March–April 1924 issue of the official journal of the Association of American Military Engineers, to which Bowie belonged, stating "*The Military Engineer* announces with much pride and pleasure its adoption as the official organ of the Board of Surveys and Maps of the Federal Government. In addition to its continued series of articles on maps and mapping, a special department will be included in each issue where the latest news on the subject will be found." A new section appeared in the same issue, accompanied by a fancy well-drawn heading and titled "Board of Survey and Maps" that would include among other items, recommendations of the Board, list of new publications, news notes, and reports of surveying and mapping work of the various member bureau and other agencies. Probably it is not coincidental that the Society of American Engineers was added in January 8, 1924, to the Advisory Council to the Board, a parallel advising body formed by nonfederal organizations (ASCE became one of the original members in July 1920). Bowie published his first article in *The Military Engineer* in March–April 1924, precisely in the same issue containing the inaugural section dedicated to the Board. Of the nine news items published in this section, four were related to activities at the USC&GS. Although it could be argued that all of these mentioned events are purely coincidental, it appears that Bowie's influence from his position as Chairman of the Board of Surveys and Maps and Chief of the Geodetic Division of USC&GS played a big part in convincing the editors of *The Military Engineer* to start publishing this new section of the journal. Conceivably, Bowie's intention was to publicize as much as possible the importance of geodetic engineering for mapping, supporting this new addition to the journal with an article of his own (Bowie 1924).

In the first number of the Geodetic Letter published in 1934 by the Division of Geodesy, which Bowie supervised, there is a note titled "Information for the Editor" that said, "The Coast and Geodetic Survey is a contributor to the Board of Surveys and Maps of *The Military Engineer* issued every two months. The editor for the Bureau will appreciate receiving from time to time any items of interest which may be added to reading matter submitted by this Bureau. These may be sent to him at any time." It is perhaps not too adventurous to imagine that Bowie had a significant role in helping these initial editorial activities. His love and admiration for *The Military Engineer* as a reputable scientific journal never subsided. In 1938, he was named Executive Secretary of the Society of American Military Engineers and simultaneously Editor of *The Military Engineer*, an appointment that he enjoyed until his premature death. Prior to completion of Bowie's tenure as Chairman of the Board, the Advisory Council to the Board submitted a 3-year report to the President of the United States describing the Board's accomplishments during Bowie's term (Mathews 1924). Bowie continued to be associated with the Board of Surveys and Maps in other capacities until his death (e.g., member of the Executive Committee, 1920–1936; beginning in 1937 Bowie represented ASCE on the Advisory Council to the Board). The Board of Surveys and Maps was abolished by an executive order on May 25, 1942, and its functions were transferred to the Bureau of Budget, now the Office of Management and Budget (OMB). Thus, the OMB is the office directed to make recommendations to agencies and to the President regarding the coordination of all governmental map making and surveying (Folger 2011).

Engineering Ethos

Bowie's association with his alma matter, Lehigh University, a recognized civil engineering school, persisted throughout his adult life. He was a great sportsman, and during his junior and senior years, he participated in football and baseball at the varsity level. According to his son, the late Clagett Bowie, an aeronautical engineer, his father's batting average was well over 0.400, a circumstance that attracted some interest from major league scouts (Whitten 1992). His first scientific work was the thesis for his degree in civil engineering (Bowie 1895). William Bowie was a special lecturer at Lehigh on geodetic and surveying topics from 1922 to 1936. Lehigh was not the only university where he spent part of his vacation time teaching courses. He was in charge of the practical astronomy and geodetic training at Columbia University's summer camp from 1912 to 1917, and in 1927, he gave a well-received series of three lectures related to gravity applied to prospecting at the Geology Department of the Massachusetts Institute of Technology. There is no question that his ability as a fluent and direct speaker was a fundamental part of his successful scientific career and all national and international administrative positions that he occupied. Bowie was a popular speaker, and he volunteered to deliver many presentations at all types of scientific forums. To bring this point into perspective, it suffices to mention what *The Engineering Journal*, the official publication of the Engineering Institute of Canada, commented about a speech that Bowie delivered at its Ottawa Branch on January 3, 1923: "Dr. Bowie is an engineer of international reputation . . . [he] spoke in most happy vein. His speech was full of weighty facts given in a very simple and straight-forward manner, with no attempt at rhetoric. They were supported by such logical reasoning that they could not fail to carry conviction."

Every time that Major Bowie had an opportunity, he attended important Lehigh events or invited scholars from the university to give presentations in Washington, DC. For example, when Bowie was President of the Washington Society of Engineers in 1914, Dr. Henry Sturgis Drinker, President of Lehigh University, delivered a conference at the annual dinner of the Society on the topic "Public Service Movements in Our Universities and Colleges" in which he emphasized a measurable growth of the movement for conserving natural resources, a cause that Bowie also fervently advocated under the umbrella of accurate mapping. The Secretary of Commerce was another guest speaker at the banquet. In 1936, Bowie made a visit to Lehigh, which is often cited in the geophysical literature. Accompanied by Professor Richard Field of Princeton, he met a young Maurice Ewing (then 28 years old) to try to convince him to expand his pioneering gravimetric research to the continental shelf and the seafloor beyond. This investigation was of great interest to Bowie who, at the time, was looking for alternative evidence to support his theory of global isostasy. However, it was the Dutch scientist Felix Vening Meinesz, a great admirer of Bowie, who actually, with the help of Bowie's connections at the U.S. Naval Observatory, was able to employ submarines of the U.S. Navy to measure gravity at sea. Perhaps due to Bowie's involvement in these explorations, he was honored with the naming of two undersea features, *Bowie seamount*, a guyot west of British Columbia, Canada, and *Bowie canyon* located in the Bering Sea. A modern evaluation of Bowie's views about the theory of isostasy as it pertains to continental drift is included in Oreskes (1999).

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Major Bowie was officially appointed non-resident lecturer on Geodesy at Lehigh University, and annually visited the campus to deliver regularly scheduled 2-day lectures at the school's geology and civil engineering departments. These talks were followed by round table discussions with students. Dr. Bowie was greatly honored when Lehigh University invited him to represent the school at the bicentennial celebration of George Washington's birth, which was memorialized in the nation's capital at the auditorium of the Daughters of the American Revolution, Constitution Hall. He presided over a symposium on geophysics in March 1940 at his dearly beloved Lehigh University that sadly was going to be his last participation in a public event at his treasured Bethlehem institution.

The engineering intuition of Major Bowie contributed, without a doubt, to the mechanization of geodesy by replacing, once and for all, the antiquated way that surveying crews and their heavy equipment were moved from one location to another. Traditionally, horse and mule drawn wagons were used for transporting survey crews and their equipment. In 1913, just 4 years after Bowie was named inspector of geodetic work, the first motor truck was put into operation by an astronomical field party (Dracup 1995). Once cars and tracks were introduced in the day-to-day geodetic work, the USC&GS significantly increased the number of triangulation points it observed per month. Furthermore, Bowie was influential in speedily adapting the portable, reusable, galvanized steel Bilby towers designed to observe between triangulation stations. This implementation drastically improved the availability of triangulation control points in flat wooded areas by elevating the observing instruments above the tree canopy, making the connection between network stations faster, more accurate, and cheaper than was possible with the previously used wooden towers (Ervin 1927; Bilby 1940). According to Bowie, as late as 1900 a triangulation party could establish no more than 15 stations in the course of a season's work. In 1932 a single field party could observe more than 100 geodetic points in the same amount of time (Slawter 1932). Bowie also concentrated on the steady improvement of all types of surveying instrumentation (Bowie 1929). There is no question that in today's digital revolution, Bowie would have embraced, without hesitation, all modern technologies, such as global positioning system (GPS) and terrestrial laser surveying. The record shows that his inquisitive scientific mind always demanded maximum accuracy in every enterprise (Bowie 1930a).

William Bowie, as previously mentioned, was extremely active among many engineering organizations. He was utterly convinced of the advantages of having accurate geodetic control to develop all mapping and engineering applications. Therefore, from his position as the Chief of the Geodetic Division he constantly tried to convey his ideas and educate the general public about the advantages of practicing geodetic-based mapping in engineering surveys. His first contribution about the topic in an engineering journal was published in 1912 in *Engineering News-Record*. He went on to publish more than 60 articles in engineering specialized journals. They were, in chronological order, *Engineering News-Record*; *The Military Engineer*; *Cornell Civil Engineer*; *Technical Engineering News*; *Proceedings of the American Society of Civil Engineers*; *Pacific Engineering*; *Bulletin of the Association of Engineers of Illinois*; *Civil Eng.*; *Bulletin of the Association of Field Engineers*; *Ingeniería*; *Connecticut Society of Civil Engineers*; *Bulletin of the Baltimore Engineering Club*; *Journal of the Association of Chinese American Engineers*; *California Highway and Public Works*; and *Engineering Bulletin*. He contributed a chapter titled "Geodetic Surveying" to the book *Vocational Guidance in Engineering Lines*, which was edited by the American Association of Engineers (Waddell et al. 1933). An exhaustive compilation of his publications appeared in Fleming (1949).

Dr. Bowie's concern for civil engineering as a profession became authenticated late in 1933 when, with a new generation of jobless fellow engineers and perhaps reliving his own personal experience, he was instrumental in hiring civil engineers onto the payroll of Civil Works Administration (CWA) local control projects under the general guidance of the USC&GS. This was a time of economic hardship, and the Great Depression was affecting all professions. In June 1935, 23 states were still conducting these surveys as relief measures, and approximately 2,900 people were employed to perform this task. Of this workforce, 2,000 were engineers or men who had some engineering education or college work. To paraphrase Bowie, "There is no job in the United States of which I know, where the percentage of engineers employed is larger" (Bowie 1935).

ASCE Surveying and Mapping Division

In 1922, ASCE authorized the formation of technical divisions within the Society. By 1926, there were eight such divisions. The Board of Directors, in January 18, 1926, approved a petition circulated by Bowie and signed by approximately 100 Society members requesting the formation of a Surveying and Mapping Division. A brief report of the activities of the Surveying and Mapping Division during the period 1926–1960 was written by Fennell (1961). To commemorate the 50th anniversary of the formation of the Division, a publication was edited by Wagner (1976) that contained various contributions describing the status of surveying and mapping at the time and their prospects for the future.

Probably nobody lobbied harder to reach the goal of creating ASCE's Ninth Division than Bowie himself. He was already fighting for more accurate mapping from the arena of the Board of Surveys and Maps, and with the support of the resolution signatories, he was deeply interested in this branch of civil engineering, welcoming the opportunity to develop this important area of expertise under the auspices of the Society. At a meeting convened in Philadelphia, Pennsylvania, in connection with the ASCE annual convention in October 1926, the Division was officially established by the Secretary of the Society who appointed a provisional executive committee that organized and elected a chairman and selected a secretary. The first official meeting of the Surveying and Mapping Division took place on January 20, 1927, starting at 2:10 p.m. in the Engineering Societies Building, New York, where the membership of the three initial committees (Control, Topographic, and Boundary) were announced, followed by several technical presentations.

Article I of the Constitution of the Surveying and Mapping Division specified, "The object of the Surveying and Mapping Division of the American Society of Civil Engineers is to develop and promote the science and art of surveying, mapping, and charting, and to increase the use of surveying data in engineering operations." Bowie's intentions were explicitly stated 3 years later:

> Members of the Society, recognizing the unsatisfactory condition of surveying and mapping in general through the country, created in 1926 the Division of Surveying and Mapping. The Division is making every practical effort to place surveying and mapping on a higher and better basis and to provide, wherever practicable, for co-ordination of effort by the private engineer and corporation. Much more must be accomplished along these lines, and it is hoped and expected that the Division of Surveying and Mapping will have a large part in accomplishing the desired results. (Bowie 1930b).

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Executive Committee

The first Excom of the Division was composed by Messrs. William Bowie, Chairman; Carey V. Hodgson, Secretary, Assistant Chief, Division of Geodesy, USC&GS; Claude H. Birdseye, Chief Topographic Engineer, USGS, Washington, DC; Clarence T. Johnston, F.ASCE, Professor, Department of Civil Engineering, University of Michigan, Ann Arbor, Michigan; Raymond Stanton Patton, Hydrographic Engineer, USC&GS; and Arthur L. Vedder, Deputy Superintendent of City Planning, Rochester, New York.

During Bowie's tenure as Chairman of the Surveying and Mapping Division, the following changes were made to the Executive Committee. In 1928, Gamble M. Bowers, Chief of the Bureau of Surveys at the Department of Public Works in Richmond, Virginia, replaced A. L. Vedder. In 1929, William N. Brown, Civil Engineer of W. N. Brown Inc. in Washington, DC, replaced G. M. Bowers. In 1930, Henry G. Avers of the Computing Division of USC&GS was elected Secretary, and George Leonard Hosmer, Professor in the civil engineering department at the Massachusetts Institute of Technology in Cambridge, Massachusetts, replaced R. S. Patton. In 1931, Robert Henry Randall, President and Chief Engineer of R. H. Randall & Co., Inc., in Toledo, Ohio, replaced C. T. Johnston. In 1932, George Frederick Syme, Senior Highway Engineer of the State Highway Commission of Raleigh, North Carolina, replaced C. H. Birdseye. In 1934, John Simpson Dodds, Professor in the civil engineering department at Iowa State College in Ames, Iowa, replaced G. F. Syme. In 1935, Charles Joseph Tilden, Professor of Engineering Mechanics at Yale University in New Haven, Connecticut, replaced G. L. Hosmer. In 1936, Richard King Hale, Associate Commissioner of the Department of Public Works in Boston, Massachusetts, replaced R. H. Randall. In 1937, Philip Kissam, Professor of Civil Engineering at Princeton University replaced J. S. Dodds. Finally, in 1940, Andrew Hall Holt, Professor in the civil engineering department at Iowa State University in Iowa City, Iowa, replaced C. J. Tilden.

Some of these original members of the Surveying Engineering Division emerged as future paladins of the surveying and mapping cause on their own rights. For example, Birdseye succeeded Bowie as Chairman of the Federal Board of Surveys and Maps, and in 1934, became the first president of the American Society of Photogrammetry; he will also be remembered for his epic survey down the Colorado River through the Grand Canyon. Rear Admiral Patton became Director of the USC&GS from 1929 to his death in 1937. Bob Randall was elected first president of the American Congress on Surveying and Mapping (ACSM) in 1941, and during 1955–1959, assumed the position of President of the Pan American Institute of History and Geography (PIHG). Johnston was a well-reputed professor who passionately defended, as Bowie did, the necessity of improving the surveying and mapping education for all civil engineers. Professor Hosmer wrote several popular treaties on geodesy and practical astronomy. Last, but not least, one of the books by Kissam, *Surveying for Civil Engineers*, continues to be used as a reference textbook at many U.S. universities. In 1946, he became Chair of the Division.

Because of the diversity of specialized scientific branches within the surveying and mapping field, an unavoidable situation that still persists today, the executive committee of the Division decided to form several working committees to gather recommendations for improving the techniques, prepare specifications, and write technical procedures. For historical interest, to know the evolution of the different committees at the dawn of the Surveying and Mapping Division, Appendix II lists all the committees instituted during Bowie's tenure.

During Bowie's chairmanship, the Surveying and Mapping Division actively participated in almost all annual and spring meetings of ASCE, where special sessions were scheduled and papers were presented, followed by discussions. At these assemblies, the participants in the different committees were elected. On several occasions, joint sessions with the City Planning Division were held.

Besides writing several committee reports that were published in the ASCE proceedings during the time that Bowie chaired the Division, the following *Manuals of Engineering Practice* related to the field of surveying engineering were published:

Technical Procedure for City Surveys, compiled by the Committee on City Surveys of the Surveying and Mapping Division, *ASCE Manuals of Engineering Practice No. 10*, includes illustrations, tables, and diagrams, 1934, 1950, 1953; revised 2nd ed. 1957; revised 3rd ed. 1963, 175 pp.

Definitions of Surveying Terms, prepared by the Committee on Definitions of Surveying Terms of the Surveying and Mapping Division, *ASCE Manuals of Engineering Practice No. 15*, 1938, 22 pp. This manual was reprinted, revised, and enlarged in 1954.

Horizontal Control Surveys to Supplement the Fundamental Net, prepared by the Committee on Control Surveys of the Surveying and Mapping Division, *ASCE Manuals of Engineering Practice No. 20*, 1940, includes illustrations, tables, and diagrams, x + 55 pp.

In addition to publishing the preceding manuals, the Surveying and Mapping Division cooperated with the writing of *Land Subdivision*, which was published by the Committee on Land Subdivision of the City Planning Division (*ASCE Manuals of Engineering Practice No. 16*, 1939, includes illustrations and diagrams, 75 pp.). The Executive Committee of the Surveying and Mapping Division also published a wide-ranging document summarizing the importance for the Federal Government to adopt a consolidated mapping plan:

Mapping for National Planning, sponsored by the Executive Committee of the Surveying and Mapping Division, ASCE, New York, 1935, 57 pp.

The Surveying and Mapping Division and the City Planning Division of ASCE on January 19, 1928, adopted a resolution endorsed by the Board of Directors of the Society that called for the completion of the triangulation and leveling systems in the United States that was signed by the Secretary of the Society and sent to the President of the United States. The resolution stated, among other things, that

> [I]n all major engineering operations, including city surveys and planning, highway development and extension, irrigation projects, hydroelectric developments, and improvement of rivers for navigation, a knowledge of elevations and geographic positions is essential to their efficient and economic operation.

The resolution recommended to the President of the United States that the entire cost of the fundamental triangulation and leveling systems be considered as national projects to be paid entirely from the Treasury of the United States. This resolution was endorsed by unanimous vote by the Federal Board of Surveys and Maps. The President replied to the Secretary of the Society that the resolution would be given careful consideration in the preparation of the national budget. However, this comprehensive budgetary proposal never materialized, although the government continued to trickle money to different federal organizations to accomplish the basic surveying and mapping needs of the nation. In September

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1938, after assuming the presidency of the Society of Military Engineers and as directed by its Executive Committee, Major Bowie, still frustrated by the inactivity of the Federal Government to properly allocate funds to resolve the "urgent need for good topographic maps," wrote a letter to President Roosevelt complaining, among other things, that "much money is now being spent on mapping, but most of the maps made are for special purposes and they do not fit into a national plan." The reply of the President was swift and short, although not very encouraging: "I have asked the Acting Director of the Bureau of the Budget to give careful consideration to the estimates of appropriation for the fiscal year 1940 that have been presented to him by the various departments concerned..." (Anon. 1939). Unfortunately, Dr. Bowie's dream to create a plan to finish the mapping of the United States within a stated number of years and to have nearly the same amount of money allocated for each year never materialized.

Similarly, Bowie's struggle to promote surveying and mapping education in civil engineering departments resembles the current situation where this important scientific branch of engineering has been ostracized by some universities and relegated to its minimum existence. Just as in his time, a wave of new technologies has expanded the surveying and mapping horizon—GPS, terrestrial laser surveying, and digital photogrammetric cameras, etc.—has expanded the surveying and mapping horizon and the call for reconsidering the teaching of these important revolutionary measuring technologies by civil engineering departments is needed again.

In a 1930 paper published in the *Proceedings of the American Society of Civil Engineers*, William Bowie unreservedly commented

> There was a time, a few decades ago, when the subjects of surveying and mapping, which previously had been considered important ones in the curriculum of the civil engineering department of a technical school or university, were given scant consideration by the head of the department, for it was believed that these subjects were not really engineering in character. It was thought that almost anyone who had received a high-school education could attend to all the surveying and mapping needed to carry out an engineering project. These subjects were at a low ebb in most institutions of learning for some years. Fortunately for the engineers who are planning big operations and the corporations, individuals, or community furnishing the money to execute them, surveying and mapping have come back in almost full force to the curriculum of the civil engineering department, and even more exacting requirements may be expected of the students in those departments along the surveying and mapping line than have ever occurred in the past.
>
> Surveying and mapping have always been the means to an end. They are seldom better or worse than are needed for the projects of which they are made. Increased use of what may be called higher surveying may be expected in the years to come because of the great increase in the value of land and in the amounts of money that are involved in engineering projects. The Engineering Profession will be wise to anticipate in its surveying activities the needs of the construction engineer and owners of property. (Bowie 1930a).

Bowie was respected and well honored by all scientific establishments of his time. From his positions of authority, he always encouraged tolerance and national and international collaboration, appealing with a mix of geniality and efficient pragmatism, well animated by his entrepreneurial imagination. He died at Mt. Alto Hospital in Washington, DC, about 3 weeks after suffering a stroke. Major Bowie is buried in Arlington National Cemetery (section 8, site 5464) with his wife Elizabeth Wattles Bowie (see Fig. 2). The back of the tombstone simply reads "Bowie, US Coast and Geodetic Survey."

Epilogue

William Bowie was inspired by his firm belief that a strong educational background in surveying and mapping was essential to the development of civil engineers. As was shown, he was deeply involved in efforts to propagate among most engineering fields, but civil engineering in particular, the importance of accurate surveying and mapping. Along with his achievements in geophysics, his geodetic engineering accomplishments should be praised as another of his lasting legacies. His far-seeing initiatives on the significance of geodetic control for all kinds of engineering projects deserve enormous credit. By the accounts of his close friends and contemporaries, he was a humble man, a portrait of honesty, intellect, and determination, and an insatiable worker and innovator.

He was a true scientist and a perpetual seeker of truth. His diplomatic skills were bold enough to reach the pinnacle of national and international leadership. He used his extraordinary talents to maintain the required delicate scientific balance among two of the most important and innovative American scientific organizations of his time: the American Geophysical Union and ASCE.

The moment has come, following Bowie's experience, of focusing again on the revival of accurate and accountable surveying and mapping (today also termed geomatics) that Bowie envisioned more than 80 years ago. His prophetic preaching is taking, once more, a back seat in a critical juncture compounded by the recent accelerated trends in digital and methodological developments. This lack of up-to-date surveying engineering education undoubtedly will hamper the required geospatial skills of future civil engineers (Soler 2010). An immediate change of course is required in order to adapt the civil engineers of our time to the present deluge of high-tech surveying and mapping developments that are changing the way we practice civil engineering in all its branches: highway and bridge construction, building structural monitoring, dam deformation studies, machine control, etc. In essence, the need for the old personal cause tirelessly advanced by Major Bowie still continues unabated.

Renaissance man is an overused cliché, but it is a perfect two-word synopsis of the personality and multidimensional aptitudes of William Bowie. He had the ability to share his knowledge of

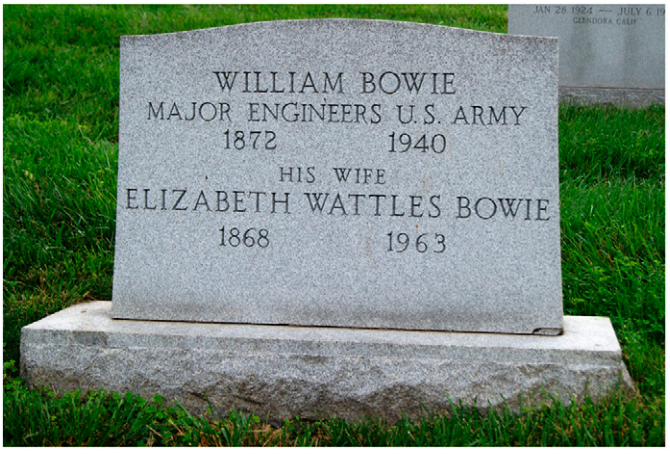

Fig. 2. Front of William Bowie's headstone at Arlington National Cemetery (photograph by Melissa Bohan, Arlington National Cemetery)

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science with audiences of all levels, forging tangible links amid a broad spectrum of scientific fields. This attitude of constantly nurturing all types of scientific interests earned him the genuine appreciation of his peers who rewarded his foresight by nominating him to responsible positions in a plethora of scientific societies and organizations, including that of President of the Washington Society of Engineers, 1914; First President of the American Geophysical Union, 1919–1922; he served a second term in 1929–1932, and is only person to hold this position twice; President of the International Geodetic Association, 1919–1933; Chairman of the Board of Surveys and Maps of the Federal Government, 1922–1924; President of the Philosophical Society of Washington, 1926; Chairman, since its foundation, of the Division of Surveying and Mapping of the American Society of Civil Engineers, 1926–1940; Honorary President of the Pan American Institute of Geography and History, 1929–1940; President of the Washington Academy of Sciences, 1930; President of the International Union of Geodesy and Geophysics, 1933–1936; President of the District of Columbia Chapter of the Society of Sigma Xi, 1935–1936; President of the Society of American Military Engineers, 1938; and Executive Secretary of the Society of American Military Engineers, 1939–1940. He was conferred as corresponding member of the Academy of Sciences of the Institute of France, the Academy of Sciences of Norway, the National Academy of History and Geography (Mexico), and the Russian Geographical Society.

His medals and awards include the Charles Lagrange Prix from the Académie Royale des Sciences des Lettres et des Beaux-Arts of Belgium in 1932; Elliott Cresson Medal by the Franklin Institute of Philadelphia in 1937; Officer in the Order of Orange-Nassau by the Queen of Netherlands in 1937; Cross of Grand Officer of the Order of St. Sava from Yugoslavia in 1939; and the first William Bowie Medal bestowed in his honor by the American Geophysical Union in 1939.

Bowie was a dominating scientific figure in a career distinguished for its focus on educating others on the advantages of accurate mapping for engineering activities. This profile of the engineering achievements of this charismatic and unpretentious man intends to recognize his accomplishments in this domain, which have been seldom investigated to date. This article is an attempt to remedy that void.

Quoting the words of Clarence T. Johnston, Fellow of ASCE, a close collaborator of Bowie who lived the same scientific engineering environment, and a member of the first Executive Committee of the Surveying and Mapping Division, is an appropriate conclusion. More than 80 years ago, supporting Bowie's perennial ideas, Professor Johnston wrote (1928)

> Many who are considered as engineers have so little training in surveying that they do not realize the necessity for accurate field work, even when the most critical data must be derived therefrom. Whether this condition results from a general attitude of engineers and possibly the public, or whether it is an outgrowth of the system of education, or a combination of influences, no one seems to know. Having carried the classification of surveys to a point where the work can rest for a time, the outline, as it stands, should furnish an impressive field of study for both the practicing engineer and educator.

Appendix I. William Bowie's Biographical Accounts

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Appendix II. Committees Formed by the Surveying and Mapping Division during Bowie's Tenure as Chairman

Committee on Control Surveys (Organized on January 20, 1927)

The purpose of this Committee was to act as an agency for answering, for the Society, questions on the subject of control surveys. The members of this original committee were C. V. Hodgson, Chairman; Urie Nelson Arthur, Chief Engineer, Department of City Planning, Pittsburgh, Pennsylvania; G. M. Bowers, Director of Public Works, Richmond, Virginia; Edward Morehouse Douglas, War Department, Washington, DC; G. L. Hosmer; Archie Burton Pierce, Professor of Civil Engineering, University of Michigan, Ann Arbor, Michigan; and R. H. Randall. At Hodgson's death in 1929, Clement Leinster Garner (Hydrographic Geod. Engineer, USC&GS) succeeded him as Chairman. William Bowie chaired this Committee from 1932 to 1935. In 1935, Kissam replaced Bowie. Reports were published in *Proceedings of the American Society of Civil Engineering* (papers and discussions), November 1928, p. 2491, and April 1929, p. 923.

Committee on Property Boundaries (Organized on January 20, 1927)

The purpose of this committee was to classify boundary surveys. Original members of this committee were Clarence T. Johnston, Chairman; George Marshall Ames, City Engineer, Grand Rapids, Michigan; George Harrison Fenkell, Superintendent and General Manager, Department of Water Supply, Detroit, Michigan; and Henry J. Sherman, Construction Engineer, New Jersey Board of Commerce and Navigation, Camden, New Jersey. In 1928, the name was changed to Committee on Property Boundary Surveys, and in 1930, it was shortened to Committee on Boundary Surveys. In 1938, Andrew Hail Holt, Professor of Civil Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts, became Chairman of the Committee. In 1939, this Committee was disbanded. Reports were published in *Proceedings of the American Society of Civil Engineering* (society affairs), March 1928, p. 2491, and April 1929, p. 923.

Committee on Topographic and Hydrographic Surveys (Organized on January 20, 1927)

The purpose of this committee was to prepare a manual on topographic surveys, maps, and specifications, which will assist the engineer making surveys for topographic maps, aid the map user in the selection of needed maps, and assist colleges in arranging courses in topographic engineering. The committee was formed by W. N. Brown, Chairman; James Kip Finch, Professor of Civil Engineering, Columbia University, New York, and Resident Director, Summer School of Surveying; G. P. Hevenor; Gerard H. Matthes, Chief Engineer, Mississippi River Commission; and Lieutenant Thomas P. Pendleton, Leading Photogrammetrist, USGS, Chattanooga, Tennessee. In 1930, William M. Beaman (Topographic Engineer, USGS) became Chairman of the Committee. In 1931, John George Staack (Chief Topographic Engineer, USGS, Washington, DC) replaced him. In 1935, the name was changed to Committee on Topographic Surveys, and P. Kissam became Chairman. P. H. Underwood replaced him in the position 1 year later. A report was published in *Proceedings of the American Society of Civil Engineering* (papers and discussions), April 1929, p. 1911.

Committee on Location and Construction Surveys (Organized on January 19, 1928)

The purpose of this committee was to accurately relate control points and leveling to construction projects. It was constituted by W. C. Taylor, Chairman, and Professor of Civil Engineering, Union College, Schenectady, New York; C. A. Garfield; Robert Hoppen, Jr., M.ASCE; Dwight B. La Du, New York State Engineer and Surveyor, Albany, New York; and John Hays Myers, New York City. This committee was disbanded in 1932.

Special Committee on City Surveys (Formed on January 19, 1928)

The purpose of this committee was to make available to the engineering profession and to officials of city governments, methods of technical procedure and of personnel organization for the conduct of surveys of metropolitan areas, and to keep this information up to date. Such surveys include precise triangulation, traverse and levels, topographic mapping, underground structures, property, buildings, and map reproduction, as applied to metropolitan conditions. This committee consisted of R. H. Randall, Chairman; U. N. Arthur; G. M. Bowers; and Robert Harris Simpson, Chief Engineer, Division of Engineering and Construction, Department of Public Service, Columbus, Ohio. In 1931, the name was changed to Committee on City Surveys.

Without any question, every engineer mentioned previously should be considered, one way or the other, founder of the present Geomatics Division. They were the first to altruistically contribute their time and effort to the initial success of the Division. During the years that Bowie was at the helm of the Division, and urged by the constant advancements in the surveying and mapping profession, several other committees were established. The names of these committees, their objectives, and their elected Chairs are mentioned subsequently in chronological order.

Special Committee on Third- and Fourth-Order Triangulation and Traverse (Organized in 1929)

The purpose of this committee was to give specifications for each grade of work and to give directions for doing the field work and making tests of accuracy in the field and office. Clifton O'Neal Carey served as Chairman and was also a Professor of Civil Engineering at the University of Michigan, Ann Arbor, Michigan.

Special Committee on Levels (Organized in 1930)

The purpose of this committee was to study the general subject of leveling and to prepare a manual covering the methods, instruments, and the form of computation to be used on the various classes into which leveling is divided. H. G. Avers served as Chairman.

Special Committee on Definition of Surveying Terms (Organized in 1930)

The purpose of this committee was to define surveying terms, both old and new, with a clarity and comprehensiveness that will convey only the one correct meaning to all minds familiar with the science and art of surveying. G. L. Hosmer served as Chairman. In 1931, the name was changed to Committee on Definition of Surveying Terms. In 1936, Charles Blaney Breed (Professor of Civil Engineering,

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Massachusetts Institute of Technology, Cambridge, Massachusetts) was elected Chairman.

Committee on Aerial Surveying and Mapping (Organized in 1931)

The purpose of this committee was to inform the engineering profession and the educational institutions of the possibilities of the application of aerial photography to mapping and to stimulate research in this field. Samuel Davis Sarason was its Chairman and was also Professor of Civil Engineering at Syracuse University in New York. In 1939, Howard Oakley Sharp (Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, New York) was elected Chairman.

Committee on Highway and Bridge Surveys (Organized in 1932)

The purpose of this committee was to prepare reports dealing with preliminary location and construction surveys from which to compile a manual for highway and bridge surveys. The manual will cover the field methods, form of notes, instruments, and crew organization based upon the accepted practice of the various local, state, and national agencies making such surveys. G. F. Syme was elected its first Chairman. In 1934, J. S. Dodds was elected Chairman; he was succeeded in 1937 by Morris Goodking (Bridge Engineer, New Jersey State Highways Department, Trenton, New Jersey). In 1940, J. C. Carpenter (Senior Highway Engineer, U.S. Bureau of Public Roads, Fort Worth, Texas) was elected Chairman.

Committee on Map Information Offices (Organized in 1936)

The purpose of this committee was to encourage the establishment of map information offices in several states in cooperation with all organizations mapping the state or any subdivision thereof and to encourage the adoption, establishment, and use of plane coordinate systems for mapping purposes. Samuel Sidney Steinberg served as its Chairman and was the Dean of the College of Engineering at the University of Maryland, College Park, Maryland.

Committee on Surveying and Mapping Courses in Educational Institutions (Organized in 1936)

The purpose of this committee was to promote the recognition of the importance of surveying and mapping to an engineering education by means of articles in leading engineering magazines and through correspondence with engineering colleges. William Bowie served as Chairman. This committee was discontinued after the death of Dr. Bowie.

Special Committee on Land Surveys and Titles (Organized in 1937)

The purpose of this committee was to study and recommend proper legislation for perfection of land titles. Philip Kissam served as Chairman. This committee, in conjunction with the Real Property Division of the American Bar Association, published two reports in the *Proceedings of the American Society of Civil Engineering*, November 1938, p. 1879, and June 1941, p. 1065.

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