Dawn of a New Era, 1940–1950

By Joseph F. Dracup

The most progressive and productive era in American geodesy began innocuously enough, continuing much as it had in the 1930s and earlier decades. Coast and Geodetic Survey (C&GS) triangulation and leveling parties roamed the land establishing geodetic control, while a small office force processed the data for publication. This is how it had been for more than 100 years. There was little indication of the vast changes to come in the next five decades.

Full Time Field Parties

Not surprisingly, field parties were to see the first of the changes. In the past, most personnel were hired for the length of the project and once the job was finished, they were paid off and advised where and when another project was to begin. Party members had to travel to the new location at their own expense. This practice changed in the 1930s and field parties became more permanent units, working the cooler climates in summer and the warmer regions in winter.

These arrangements made it possible for party members to bring their families with them, living in privately owned house trailers in a self-contained environment, usually in town parks, fairgrounds and the like. The all male tent encampments of the past, with their mess facilities, which contributed so much to the legends of field life, disappeared, except for some mountain work and Alaska assignments. Field parties operated in this fashion for about 30 years before economic and other conditions made it impractical to continue that way of life.

> **Geodetic History Summary**
>
> Last installment (November/December '96):
> - **Conclusion of the Age of Bowie**
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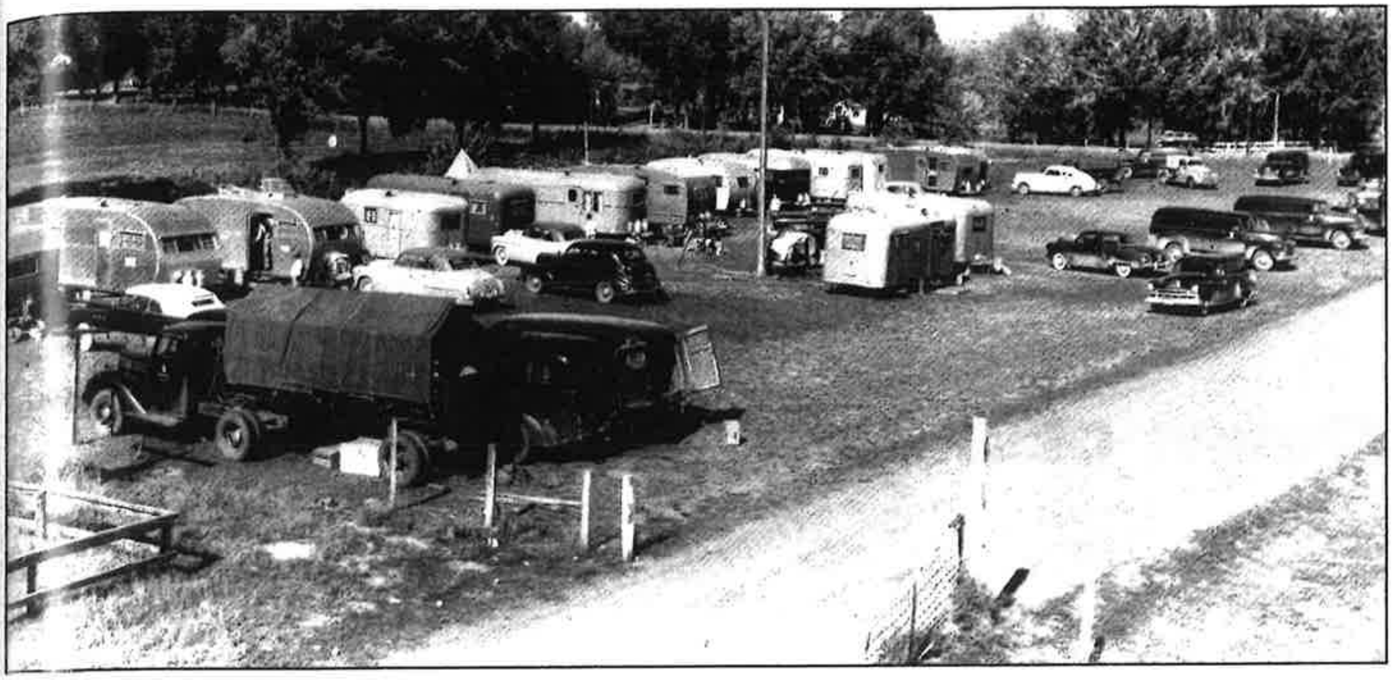
> Coming Up:
> - **Breaking with the Past: 1950-1970**
> - **The New Age of Geodesy Begins: 1970-1990.**

First Computers Draw C&GS Interest

Work done at Iowa State University in Ames in the late 1930s and the University of Pennsylvania in the early 40s would affect nearly all people in the world in the ensuing decades. These events led to the construction of the first automatic electronic digital computer (EDC), the Atanasoff-Berry Computer (ABC) by John V. Atanasoff and Clifford Berry in 1942.

In 1946, J. Presper Eckert and John W. Mauchly, under U.S. Army sponsorship, developed the mammoth Electronic Numerical Integrator and Computer (ENIAC) at the University of Pennsylvania. From this and other pioneering efforts, John von Neumann developed the stored-program EDC in the 1950s, the forerunner of present day equipment. The C&GS, with an ever-increasing volume of computations, had a standing interest in anything that might ease the burden and the developments didn't go unnoticed. Accordingly, early in 1942, Lansing G. Simmons, chief of the Philadelphia Computing Office, made a visit to the University of Pennsylvania and found that the machine was still in a primitive stage and could not, for example, multiply positive and negative numbers and sum the results—an integral part of the adjustment process and geodetic computations in general. Nonetheless, while he and others in the Geodesy Division were convinced that such machines were the wave of the future, they recognized it would be a decade or more before the machines would become



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Survey party campsite: Triangulation field headquarters trailer camp in South Dakota, 1950.

available. In the interim period, high speed automatic computers were employed to ease the work load.

ADPs Used For Least-Squares Adjustment

In 1946, Charles A. Whitten made the first least-squares adjustment of triangulation using Bureau of the Census automatic, high-speed data processors. These International Business Machines (IBM) processors utilized punch cards in the calculations. The earlier computer developments had no direct bearing on this geodetic computation breakthroug. However, the fact that the technology was on the horizon was a contributing factor.

In 1948, the C&GS installed similar automatic computers (ADPs) and began the process of adapting them to geodetic computations. The ADPs were first employed to form and solve normal equations by the Doolittle method, up to and including the computation of the residuals stage. It wasn't that they could do the job faster, but more importantly, they could be run 24 hours a day, at a modest additional cost.

ADPs could solve about 15 equations in each 8 hour shift, and that was the solution rate most mathematicians (later changed to "geodesists"), in the Triangulation Branch, achieved in the same period. However, a few in the Branch developed superior speed and accuracy in operating rotary calculators. They used a feel and sound system, rarely, if ever, viewing the keyboard or dials before completing a series of multiplications. This small group averaged 20 or more equations solved per day.

The end was drawing near for mechanical calculators, although it would be 20 years or more before they were gone from most desks. More important to many involved in solving large sets of normal equations on such machines was the fact that the drudgery of that job would soon be just a memory.

World War II Intervenes

During World War II, regular geodetic activities were suspended for the most part and much of the effort was directed at carrying out needed surveys at defense facilities in the U.S. and Caribbean area. Field parties operated at reduced strength or were disbanded and the office staff also was reduced as members of both groups entered the military. The major field work accomplished in this period was measuring an arc of first-order triangulation from Skagway in southeast Alaska, over White Pass to Whitehorse in the Yukon Territory of Canada, then following the Alcan Highway road northwestward about 575 miles to Fairbanks.

Alaska Surveys Accelerated

At the end of the war, with the connection to the lower 48 triangulation observed, plans were made to complete the primary horizontal control in Alaska and to tie the several local astronomic datums to the North American datum of 1927 (NAD27). This was a wise decision, considering that the Cold War got colder and oil was found on the North Slope shortly thereafter.

Several parties were in the field each working season and most of the work was done by 1956. Despite the hardships and danger, Alaska was considered a plum assignment—and the per diem was higher too. The versatility of Bilby towers and the ingenuity of the men who built them was demonstrated time and again in Alaska.

Assistance to National Topographic Mapping Program

The last of the great arcs had been observed in the early 1930s, from Providence, R.I. to Key West, Fla., following the Atlantic coast, a distance of about 1600 miles. With funding from civil works programs, the big push to complete the first-order network in that decade consisted mostly of arc surveys. However, late in the decade, the program to begin filling in the areas between the arcs was instituted. The program continued in the pre- and post-war years.

Much of the work was done in support of the nationwide topographic mapping program of the U.S. Geological Survey (USGS), involving control for a few quads here and a few quads there. This piecemeal approach was dictated by funding and other requirements. There was one exception, when the USGS reached an agreement with the Commonwealth of Kentucky to accelerate the program there. The triangulation was completed, but for two small areas, by about 1950.

Although the area work was classified as second-order (the then 1:10,000 standard), the observations were made to first-order specifications, with minor exceptions. New standards and specifications were drawn up in 1957, which took these exceptions into account, so that all area nets could be classified to the same order of accuracy.

Computing Offices and SPCS

Computing offices were set up in New York City and Philadelphia to aid in adjusting the numerous new surveys made in the 1930s. Among the assignments was the conversion of the published stations' latitudes and longitudes to plane coordinates on the recently created State Plane Coordinate System(SPCS). Early on, it was necessary to compute the required tables as well.

These field offices were sponsored by the C&GS and funded by various civil works agencies. The NY Computing Office was in existence between 1932 - 1964 and the Philadelphia Office from 1940 to 1943. Both offices were placed under the Civil Service system about 1942. Both contributed significantly to reducing the large backlog of work.

Calculating SPCs was a huge task, even after tables had been prepared. Originally both systems, Lambert and transverse Mercator, involved a combination of logarithms and natural functions and each computation was made in duplicate as a check. Tables for inverse computations were not available until the late 1940s. An addition check was made by computing selected grid distances between all points, converting these distances to geodetic values via scale factors, and comparing them with the published results.

Even at the beginning, Lambert plane coordinates could be computed using natural functions, provided a 10-bank calculator was available, and few were in the 1930s and early 1940s. In the late 1930s Lansing G. Simmons, then in charge of the Georgia Geodetic Survey, developed tables based on empirical formulas to compute transverse Mercator coordinates using natural functions. The computation time was cut in half.

Use of Logarithms Near End

Many geodetic computations were made using logarithms, including the preparation of side and length equations, and computation of triangle sides and geographic positions. The latter was a formidable chore, requiring 135 entries for longer lines. It was once estimated that the computation used up one mile of lead pencil. Others thought 0.5 mile was closer to the truth.

In 1941 Simmons, by then in charge of the Philadelphia Computing Office, conceived position computation formulas, based in theory on the transverse Mercator projection, which was amenable to natural functions. Tables covering only the conterminous states (latitudes 24°-50°) were prepared in feet, with the idea that some surveyors and engineers would use geographic coordinates. It didn't happen.

In 1944, tables were prepared in meters, extending from the equator to 75°. In conjunction with the conversion, natural function tables for sines and cosines, at 1" intervals, were computed in the same office. The resulting Special Publication (No 231) soon became a best-seller.

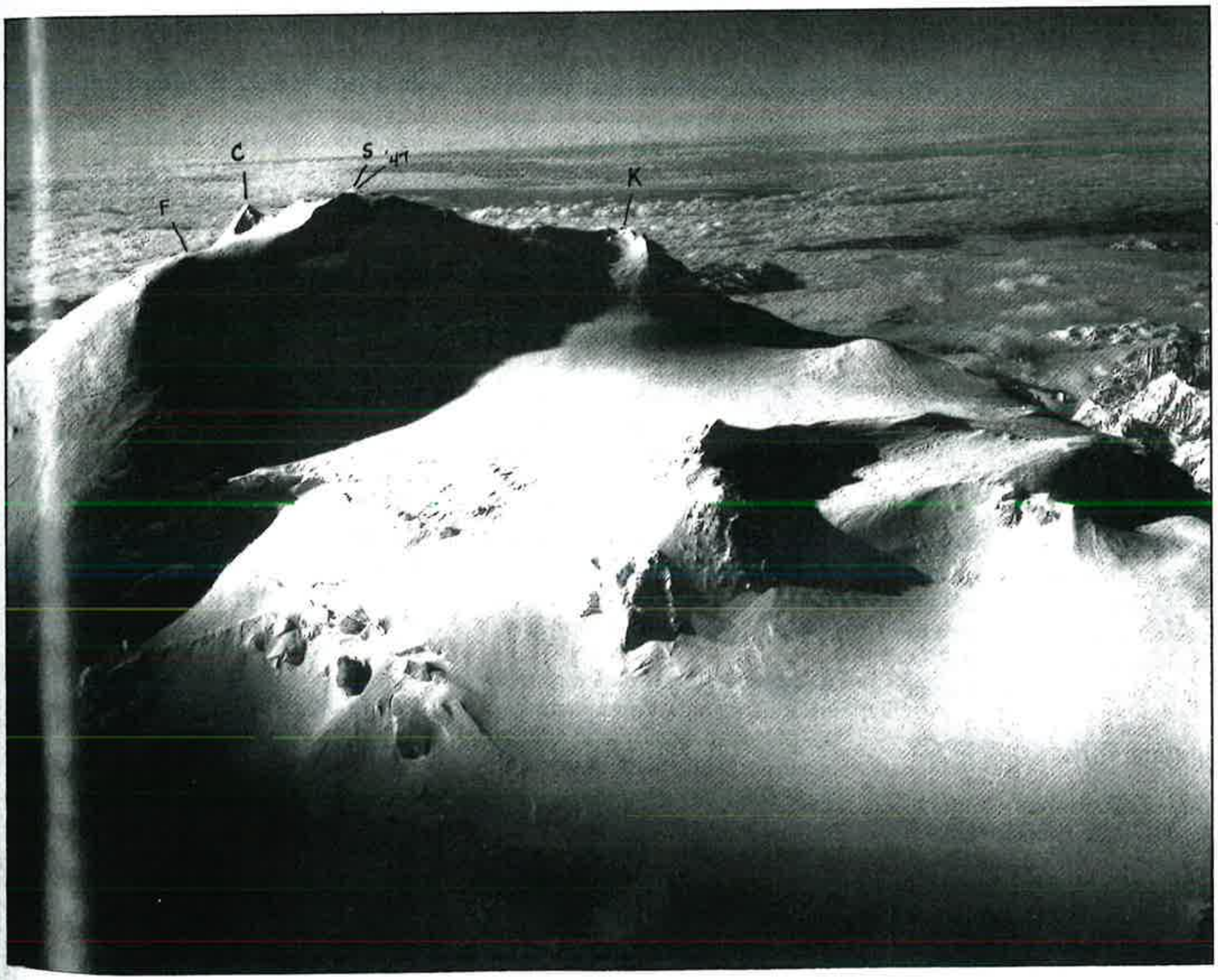
UTM Grid Developed

The Universal Transverse Mercator (UTM) grid, a worldwide plane coordinate system, was developed in the 1940s by the U.S. Army Corps of Engineers, following the recommendations of Oscar S. Adams of the C&GS Geodesy Division. The grid consists of bands, 6° of longitude wide, and a maximum scale reduction of 1:2,500.

Original tables (for the Clarke spheroid of 1866) were computed during the early 1940s by a civil works project in New York City, sponsored by the U.S. Lake Survey (USLS) . The USLS unit evolved into the Geodetic Division of the Army Map Service (AMS) about 1943. Later, tables were computed for other ellipsoids then in use. Floyd W. Hough, David Mills, Homer Fuller and Frank L. Culley were directly associated with the grid's development.

World War II Technology Advances Surveying

Technology developed during World War II began almost immediately to find a place in surveying. Shoran, a special type of radar, was used to control hydrographic surveys in 1945. In 1946 Carl I. Aslakson (C&GS) examined its possible use in locating islands, atolls and the like, that were beyond visual means to geodetic accuracy. In 1951 the method was employed,



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In the 1940s, surveyors trekked to many mountain peaks. Top left: Triangulation station on the Canada-Alaska line, 1943. Top right: at the peak of Mount McKinley, surveyed by the C&GS from 1945-51. Above: aerial view of Mount McKinley. Mark "S" in the top right photo is visible near the peak shown in the lower photo.

with the longer range C&GS-developed Electronic Position Indicator (EPI), to position four islands off Alaska in the Bering Sea.

In the early 1950s, the U.S. Air Force measured a Shoran trilateration net between Florida and Puerto Rico, continuing on to Trinidad and South America. A similar net connecting North America and Europe via Greenland, Iceland, Scotland and Norway was observed between 1953 to 1956 by the same organization.

In 1948 a novel survey procedure, flare triangulation, was used to connect the Florida mainland with the Bahamas. Flare triangulation involves simultaneous observations from at least three ground stations, on each land form, to a flare dropped at a prescribed location by a high flying aircraft. It was first used in 1945 to connect the triangulation of Denmark and Norway across the 90-mile span of the Skagerrak. While the experiment was viewed as a success, there were too many problems, including the need for near perfect weather conditions, for the method to be generally accepted.

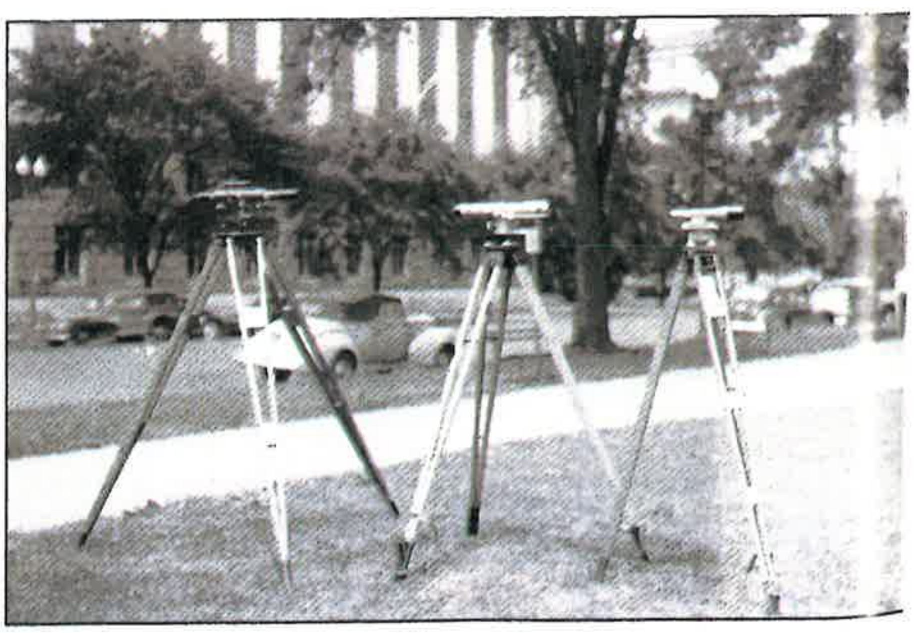
Birth of EDMI

In the late 1940s, Erik Bergstrand in Sweden successfully employed light to measure distances. This event was to have the same dramatic impact on geodetic surveying as did Jesse Ramsden's direction theodolite, reading to 1 second, in 1787. This instrument, named the Geodimeter, would reduce the time required to measure base lines from weeks to hours, without any reduction in the accuracy of the line. Furthermore, it permitted the measurement of regular length triangulation lines, doing away with the costly and less accurate expansion nets.

A very eventful decade thus ended, holding great promises for the future.

Next: Breaking with the Past, 1950-1970.

Measuring Horizontal Angles, Savin Hill, Mass., 1949.



Fisher, Zeiss, and Hildebrand levels on display in Washington, D.C., June 1945.