What Size is It?

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The evolution of photogrammetry[1] within CIA

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Man has been interested in the size of things since earliest time. The need for his knowing the size of objects has changed with the evolution of man himself. Primitive man, for instance, needed to know if a tree was tall enough, when felled, to use as a bridge across a stream. As time passed, he needed to know the height of an enemy fortress wall in order to build ladders long enough to scale the wall. Today, the intelligence analyst's need for measurements is of a drastically different nature. Even more significant is the high degree of precision now required.

The development of photogrammetry in this country began shortly after World War I. During the war, the Germans demonstrated the strategic importance of aerial photography. This was reiterated in November 1938 by General Oberst Baron Werner von Fritsch, chief of the German General Staff, who said, "The nation with the best photointerpretation will win the next war." Fortunately, the United States was well prepared to conduct aerial reconnaissance when World War II broke out. In the Pacific theater, 80 percent of all intelligence was obtained from aerial photographs. The history of aerial photography during World War II would require many volumes. Following the allied victory, however, little was accomplished in applying photography to peace time intelligence activities until the early 1950s when CIA activated a vigorous program to develop photography as a source of information.

To exploit intelligence information from photography, the Agency created the Photo Intelligence Division, Geographic Research Area/ORR in 1952. When something of interest is seen in a photograph, two questions are asked almost simultaneously: What is it? What size is it?

By mid-1955, a separate branch, composed of photogrammetrists,[2] was formed to answer the "size" question. In the branch's early days, relatively crude dimensions were produced using very simple equipment. The equipment available consisted of boxwood scales and tube magnifiers with etched reticles (Figure 1). Computations were performed by slide rule and, when luxury afforded it, a desk calculator. Measurements were usually confined to the length and width of buildings or the distance between objects.

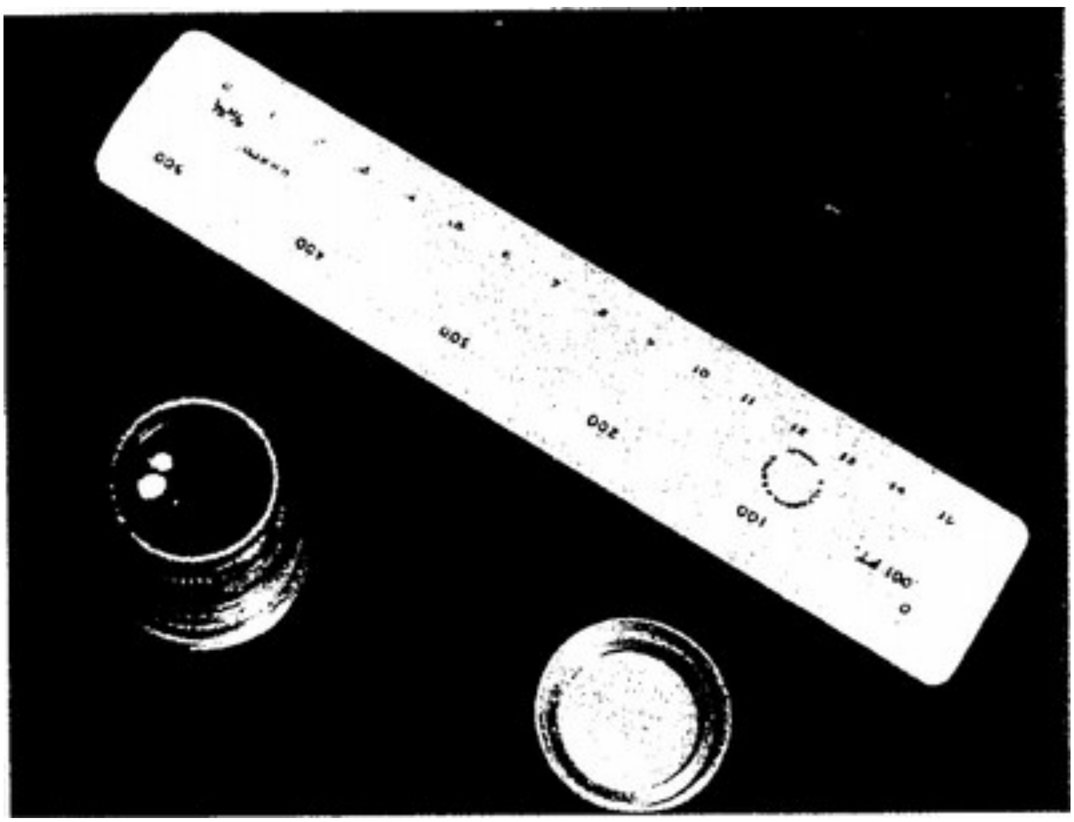

Figure 1. Scale and magnifier with measuring reticle.

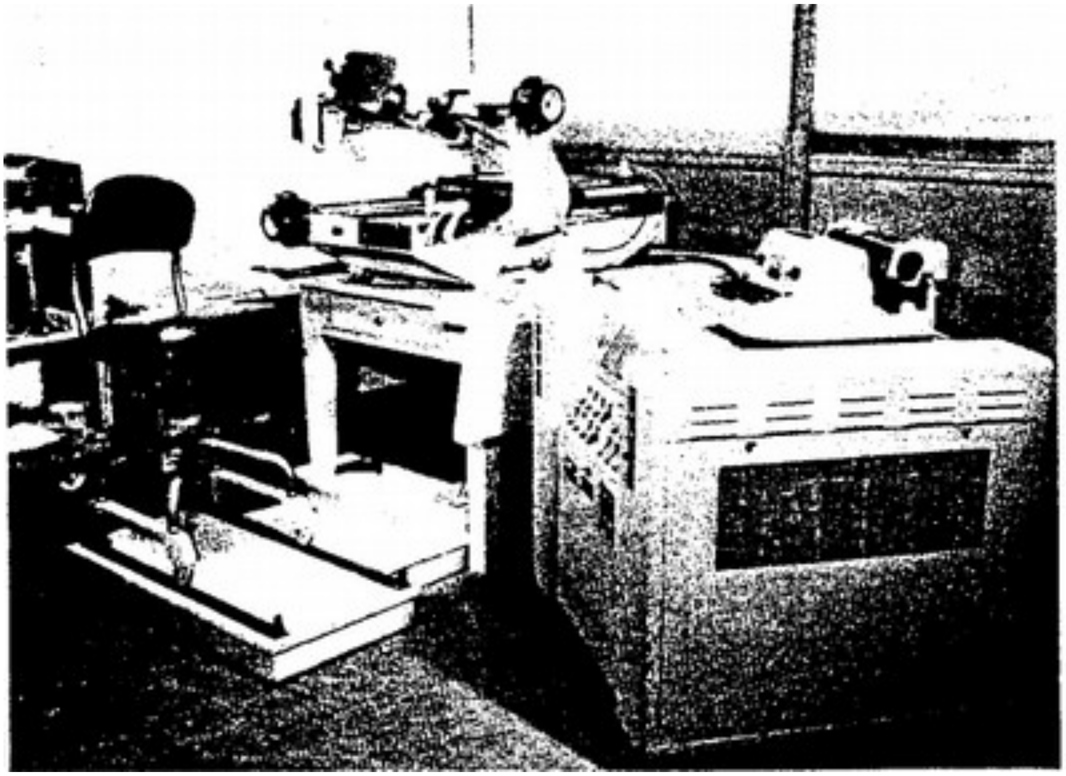

Figure 2. Mann Comparator Type 621.

Other intelligence organizations, such as the Air Force Foreign Technology Division (FTD) and the Navy Photographic Interpretation Center (PIC), had also established photogrammetric capabilities. FTD was concerned with determining the performance capability of Russian aircraft and the Navy with submarines and shipyards. They used time honored graphic methods in extracting dimensions from photographs. Such methods were laborious and posed many limitations. Benefiting from Air Force and Navy experience, CIA photogrammetrists soon realized these limitations. Consequently, they turned to analytical methods which were just then being explored and which offered much greater potential.

As the Photo Intelligence Division grew from a mere handful of people to more than 40 persons, it moved from "Q" Building to the Steuart Building in July 1956. Shortly thereafter, more precise measuring instruments, called comparators,[3] were acquired, such as a Mann 621[4] and a Nistri TA-3[5] (Figures 2 and 3). Comparator coordinate measurements were read from dials and hand recorded. Calculations were still performed by the use of desk calculators. In September 1957, a small digital computer was acquired to aid in handling the increasing volume of measurement requests and demands for more complex measurement computations made possible through analytical methods. This computer, an ALWAC

IIIE, was the first computer in the Agency (Figure 4). Simultaneously, encoders[6] were installed on the comparators and electronic auxiliary equipment was added to convert the encoder output into digitized form. These additions permitted image measurements to be automatically recorded on punched paper tape, which in turn could be read by a flexowriter for direct entry into the computer. Thus, the computer, combined with automated instrument readout, opened the door to faster computations on a volume basis. Measurement of dimensions other than length and width was now feasible.

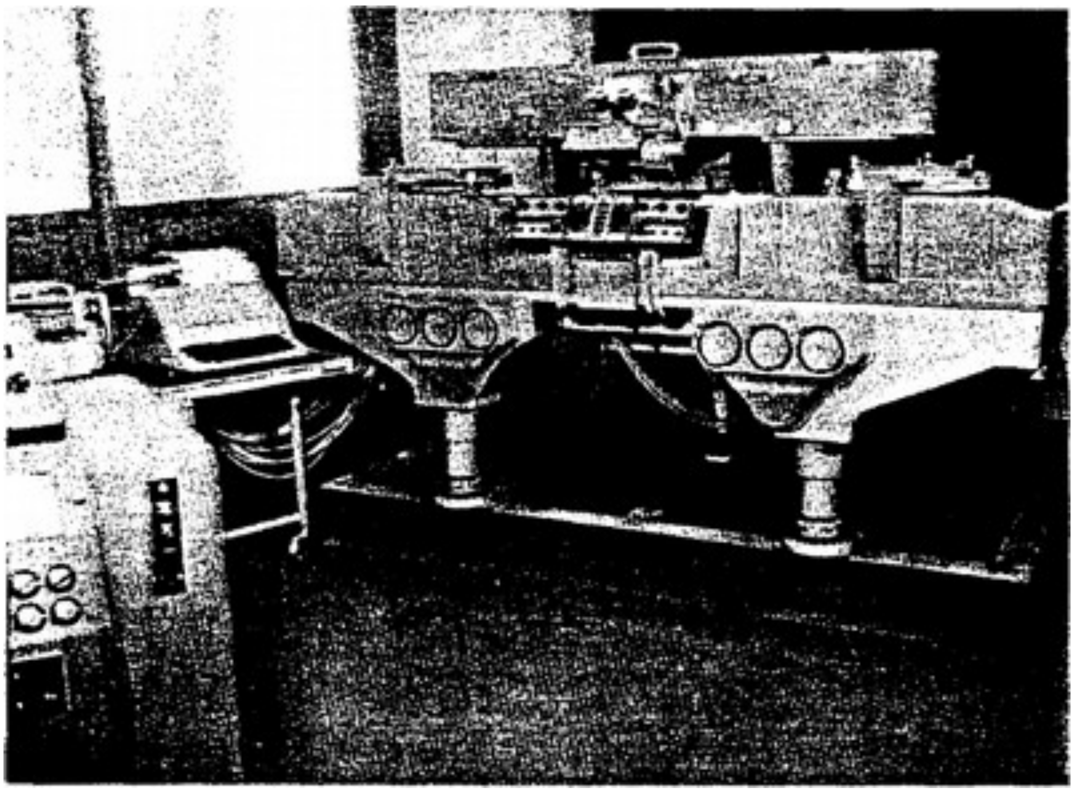

Figure 3. Nistri Stereocomparator TA-3.

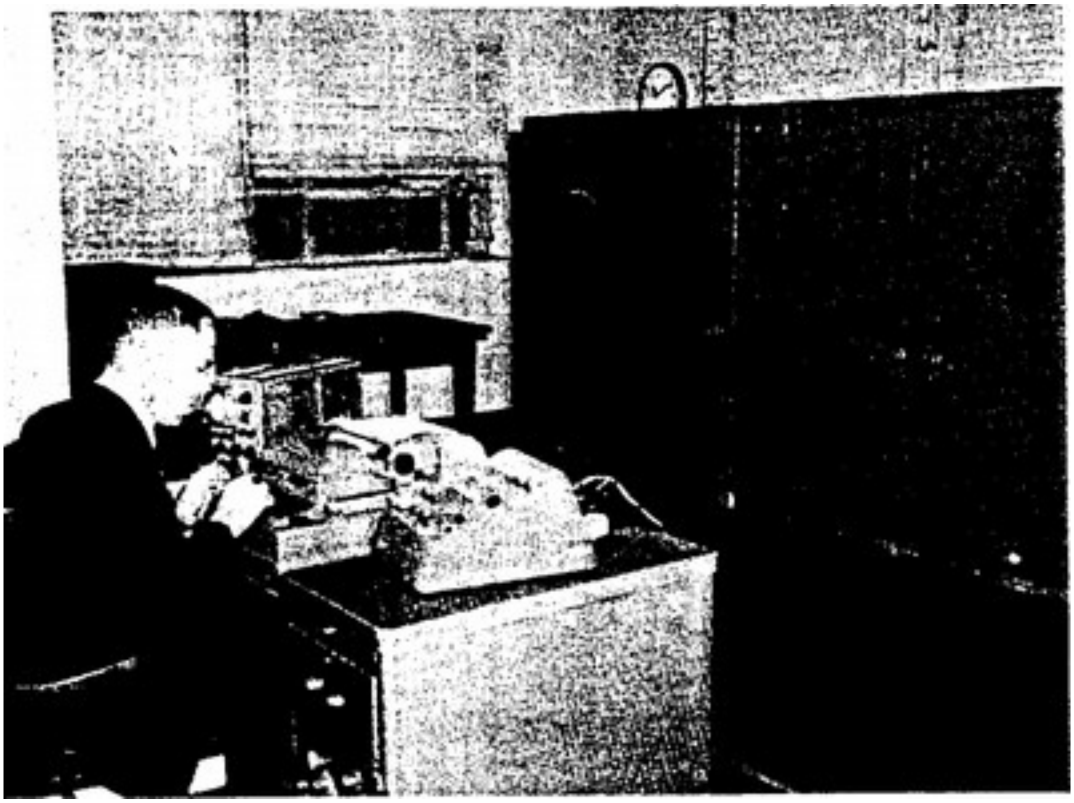

Figure 4. ALWAC III E Computer.

Many interesting and challenging measurement problems were tackled in the formative days which influenced the growth and pattern of mensuration capability development. These problems ranged from measurement of the diameter and depth of craters at Semipalatinsk in determining the magnitude of nuclear test blasts, to measurement of crates on ship decks in postulating the contents, to the geodetic location, orientation and measurement of the herringbone SAM sites ringing Moscow. Such measurements proved the value of dimensional information in analyzing the Sino-Soviet military posture and potential. The varied scope of requirements for measurements—distances, heights, areas, azimuths,—contour maps, profiles, and geodetic positionsstrengthened the decision to develop analytical methods and automated instruments.

When the National Photographic Interpretation Center was formally chartered on 18 January 1961, it included a division devoted exclusively to mensuration. The division was responsible for providing measurements and developing mensuration techniques and instruments. NPIC photogrammetrists recognized that the type of photo measurements required for intelligence purposes was unique and that precision measuring instruments had to be developed for this purpose. Until this time, off-the-shelf instruments were used. Many of these instruments were designed for the compiling of maps from photography and were not adequate for meeting intelligence requirements. NPIC, therefore, initiated an instrument development program. The significance of precise measurements was dramatically portrayed during the 1962 Cuban missile crisis when dimensions were crucial in analyzing the threat and influencing decisions.

On 1 January 1963, NPIC moved into its present quarters in Building 213 in the Naval Weapons Plant. Several significant improvements in NPIC's mensuration capability occurred at this time. The small ALWAC IIIE computer was replaced with a UNIVAC 490 real-time computer (Figure 5): The speed and capacity of this computer were several magnitudes greater than those of the ALWAC IIIE. A specially designed instrument area with environmental control was built to house the increasing number of precision measuring instruments acquired through NPIC's R&D program. Cables were installed from the computer site to each of the instrument rooms so that eventually all instruments could be operated in a real-time mode, on line[7] with the computer.

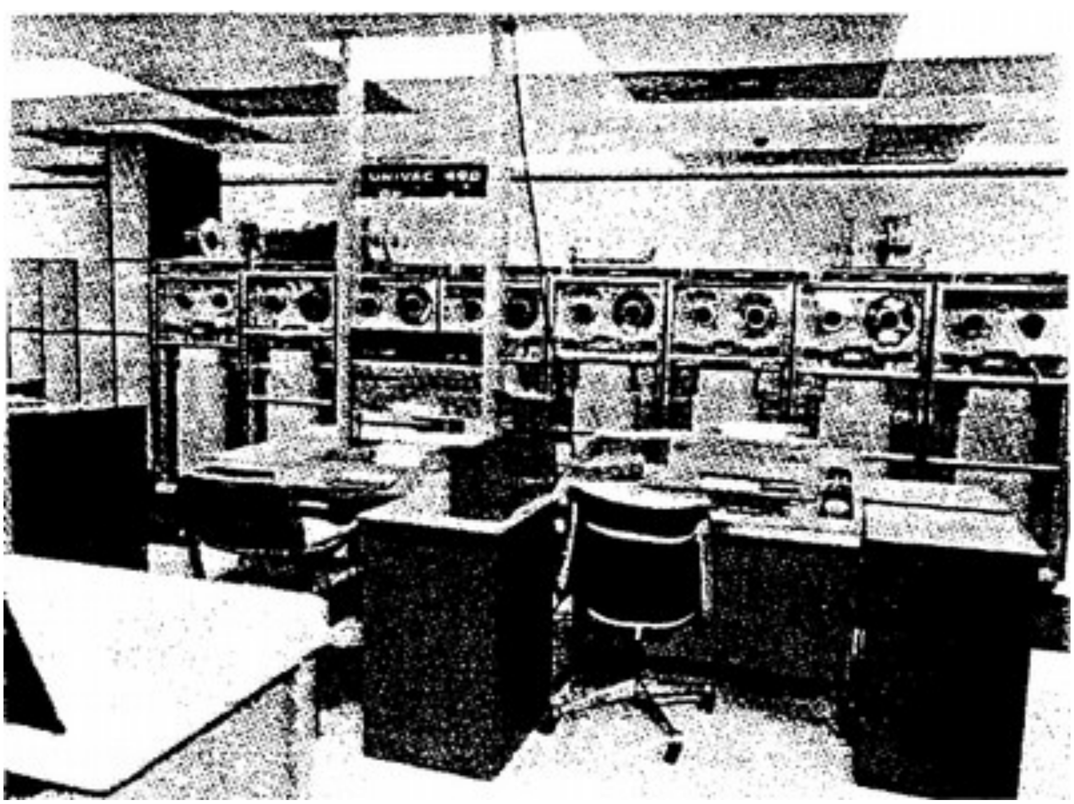

Figure 5. UNIVAC 490 real-time computer.

Recruiting qualified photogrammetrists has been a major problem in realizing the full potential of NPIC's ability to answer the question—what size is it? The number trained each year by the few American universities that offer instruction in photogrammetry is far below the needs of government and industry. To acquire the photogrammetrists it needed, NPIC has built up a small but competent cadre of specialists by hiring persons with a mathematics or engineering degree, or with equivalent scientific background, and training them in the fundamentals of photogrammetry. Its extensive training program includes contracts for college level courses taught at the Center and sponsorship of selected individuals for a year of graduate training. NPIC's unquestioned leadership in photogrammetric talent, mensuration instruments, techniques, and accuracy attests to its farsightedness and the photogrammetrists' dedication in constantly seeking improvement Occasionally, NPIC's measurements have differed significantly from those provided by other organizations. Consultations and exchanges of ideas to resolve these differences have benefited both NPIC and the other organizations. In most cases, NPIC has successfully substantiated its figures. Such conflicts have strengthened confidence in the dimensional data NPIC produces and further inspired progress in improving its mensuration techniques.

As the quality of photography improved—permitting interpretation of greater and greater detail—a parallel demand for measuring this detail occurred. NPIC's mensuration capability in both techniques and instrumentation (Figures 6 and 7) has kept pace with this demand for greater detail and accuracy. Today, most instruments are operated in a real-time mode. The UNIVAC 490 computer has been replaced by two UNIVAC 494 computers. (The computers serve other automated data processing needs besides mensuration computations.)

Additional stereo measuring instruments (Figure 8) are being acquired to supplement existing instruments (Figure 9) to meet expanding requirements for vertical as well as horizontal dimensions. The measurement of heights, areas, azimuths, geodetic positions, and slopes, as well as compilation of contour maps, is now commonplace along with determining length and width dimensions.

In addition to routine requests for the dimensions of objects, the photogrammetrist is frequently tasked to answer unusual questions. Such projects have included identifying an individual in a photograph by means of ear measurement; [8] determining the time of day a photograph was taken by measuring the azimuth of shadows; and proving a photo has been faked or doctored[9] by comparing the scale and relative position of various objects in it.[10] All cases of determining a doctored photograph are not as obvious as the one appearing in a recent issue of Life Magazine[11] (Figures 10 and 11). The SA-2 missile shown in Figure 12 is known to be 35.6 feet in length. However, in relation to the soldiers, the measured length of the missile as pictured is found to be much greater than 35.6 feet.

Some problems have taxed the ingenuity of the photogrammetrist, such as the request to determine the dimensions of a submarine photographed in the open sea (Figure 13). There appeared to be no means for determining the angle from which the photograph was taken or a scale to use. A solution was achieved by measuring the distortion of the seating ring for underwater rescue, which was known to be a circle, to obtain the angle and using the spacing of depth marks for a scale. From such challenging tasks, NPIC photogrammetrists have gained invaluable experience enabling them to answer almost any measurement request.

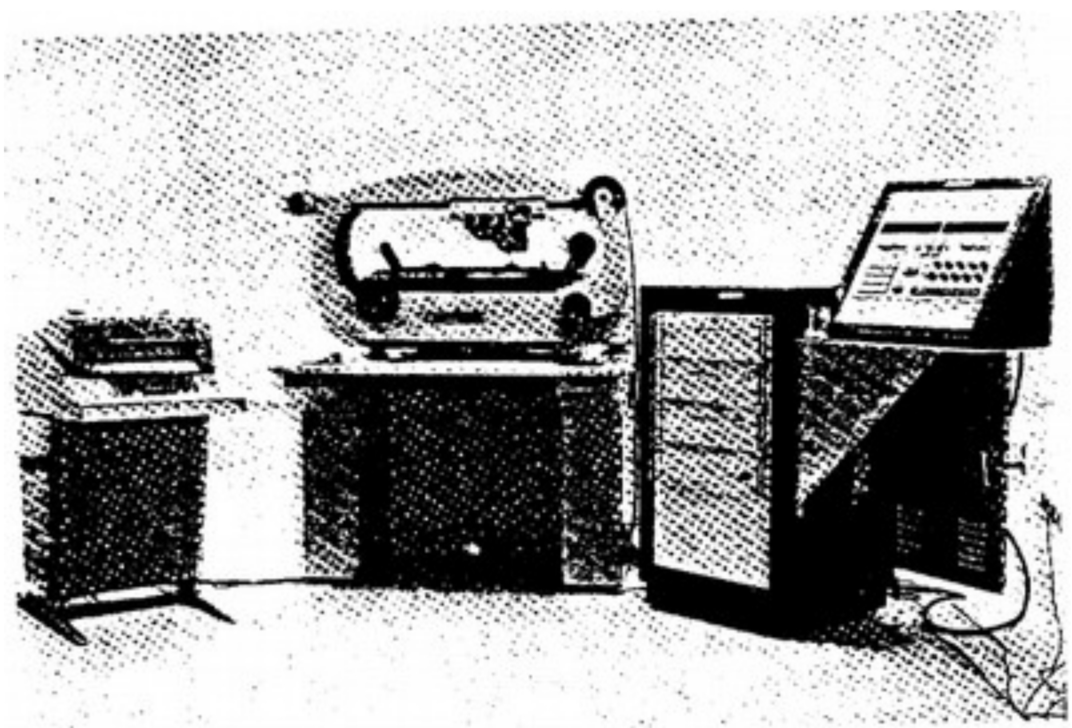

Figure 6. Mann Comparator Type 1210.

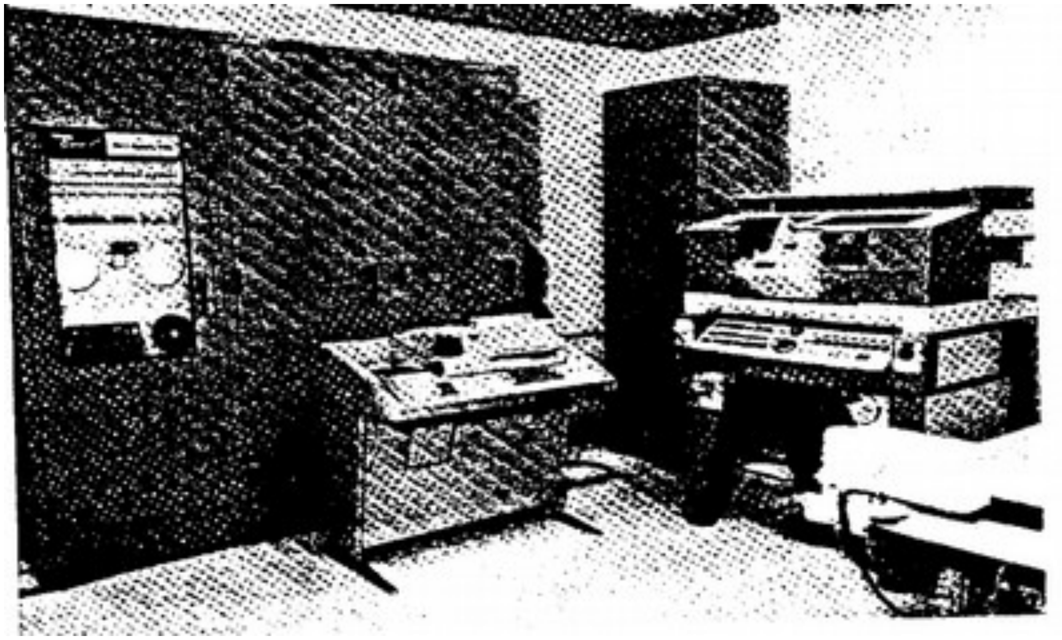

Figure 7. Nistri-Bendix AP/3 analytical stereoplotter (a special purpose instrument primarily used to compile contour maps and terrain profiles).

Figure 8. High-precision stereocomparator developed under NPIC R&D program and currently being manufactured by Houston Fearless Corp. Calif.

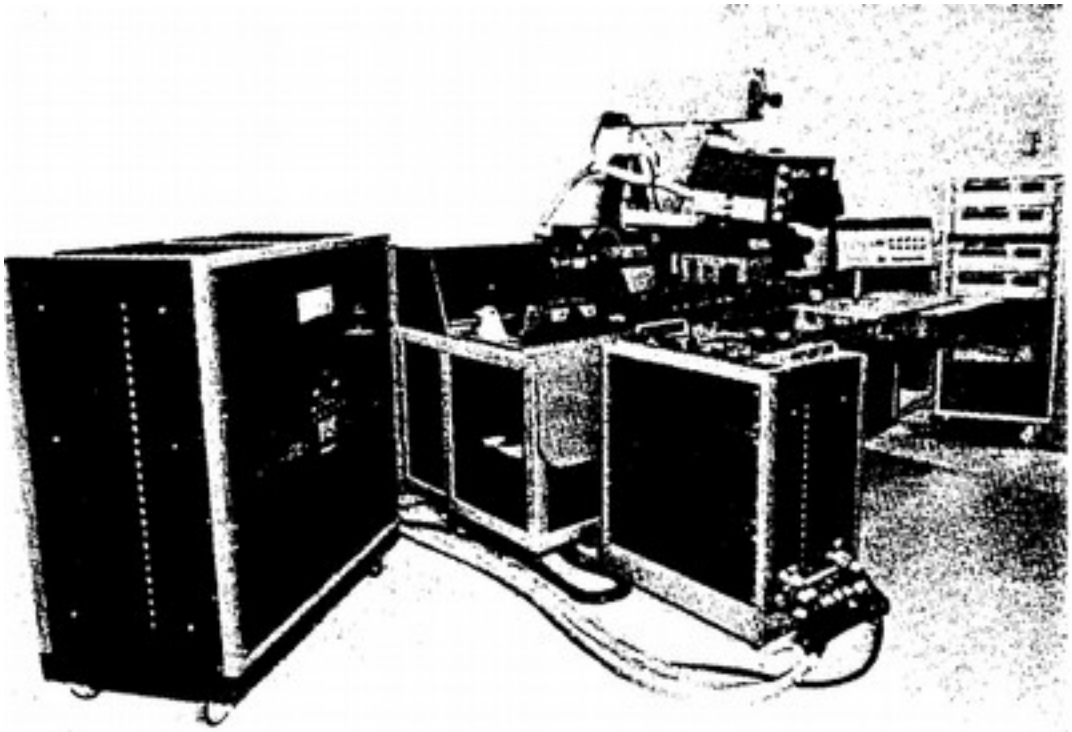

Figure 9. OPTOmechanisms stereoscopic point transfer device (a stereocomparator manufactured by OPTOmechanisms, INC., L.I., N.Y.).

Figure 10. Czech News Agency photo released in 1969.

Figure 11. 1970 release with Dubcek removed.

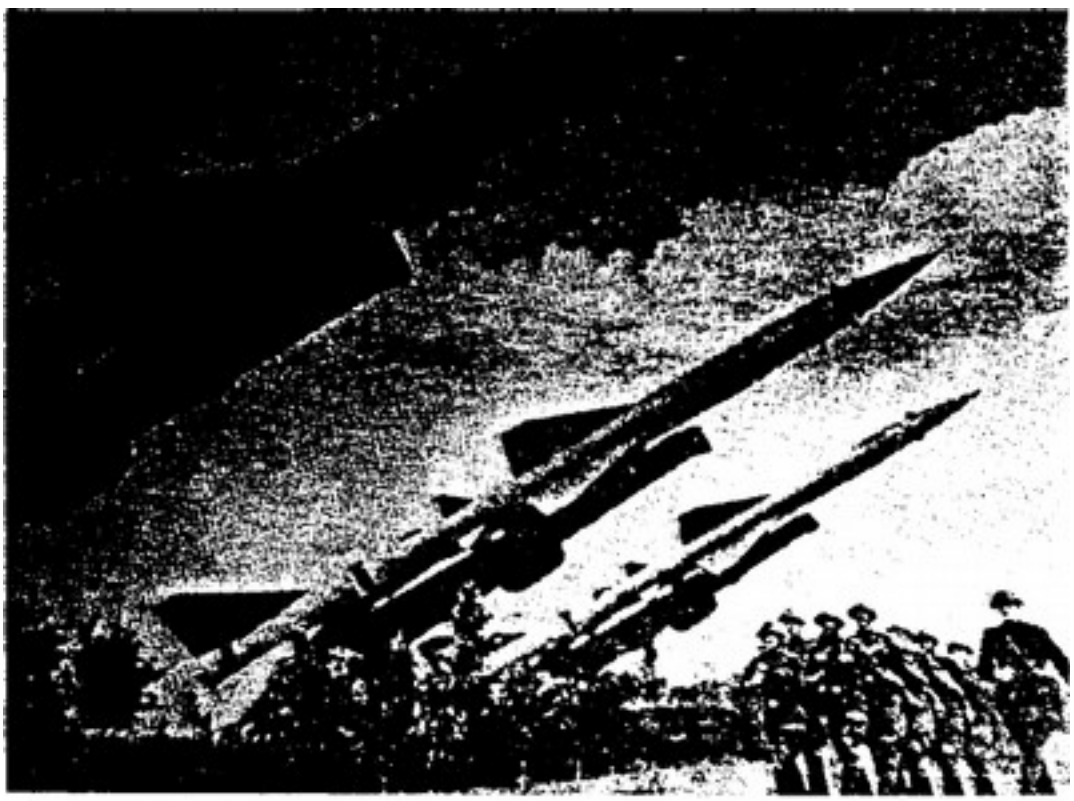

Figure 12. SA-2 missiles.

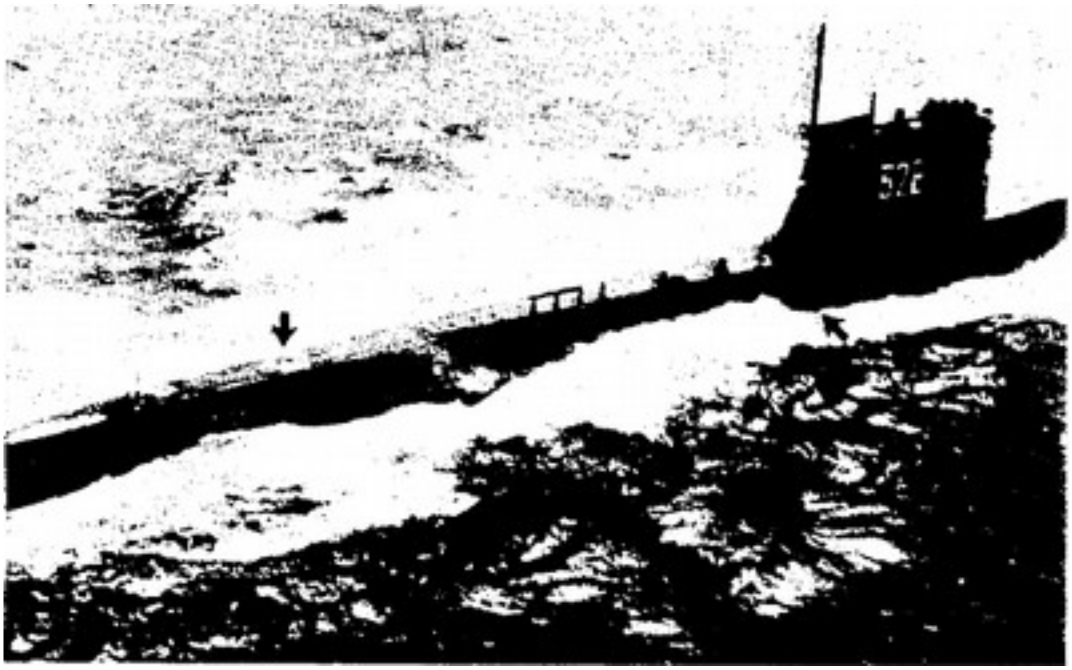

Figure 13. Soviet F Class submarine.

For several years, considerable effort has been devoted to improving the means for exploiting terrestrial[12] photography, such as obtained by attachés and tourists. Outstanding success has been achieved in this area of photogrammetric analysis. One noteworthy example is the technique for determining the three-dimensional shape of an object from a series of photographs taken at different angles and including pre-established measurements in the background. In a test of NPIC's ability in this field, a guideline missile photographed in the November 1967 Moscow parade was measured. The dimensions NPIC obtained were later compared with steel tape measurements of a captured missile. NPIC's measurement of the length of the 35-foot missile was in error by only 0.3 feet.

In his job of providing measurements, the photogrammetrist sometimes finds himself engaged in photointerpretation. In measuring a Guideline Mod 4 surface-to-air missile, a photogrammetrist discovered that dimensions of two of the four sustainer wings were different (Figure 14). This discovery indicated a radical departure from standard design for the USSR or the U.S. Photographic interpretation had not uncovered this fact; only when measurements were made was it revealed. Previous measurements of a Guideline Mod I SAM (Figure IS) were checked to determine if a mistake had been made or whether the fins of the Mod 1 were indeed identical. The fins were found to be identical as originally measured. When the asymmetric finding on the Mod 4 was presented for aerodynamic study, it was determined that the USSR had made a breakthrough, for greater stability was attainable with this design.

Today, CIA relies heavily upon photography as a source of intelligence information. NPIC is well equipped to measure what is photographed, and it is continually striving to improve the degree of accuracy attainable. To obtain precise dimensions, reliable camera and parameter data[13] are as necessary as a "good looking" photograph. The problems involved in precision measurement to micrometers,[14] from present-day imagery can be envisioned when one realizes that a human hair is 15 to 20 micrometers in diameter. Knowledge gained in studying these problems is being applied to instrument design, revised mensuration techniques, and new concepts in the continual evolution and expansion of NPIC's capability to answer the perennial question—what size is it? Lord Kelvin, the renowned British scientist, said, "When you can measure what you are speaking about and express it in numbers, you know something about it."

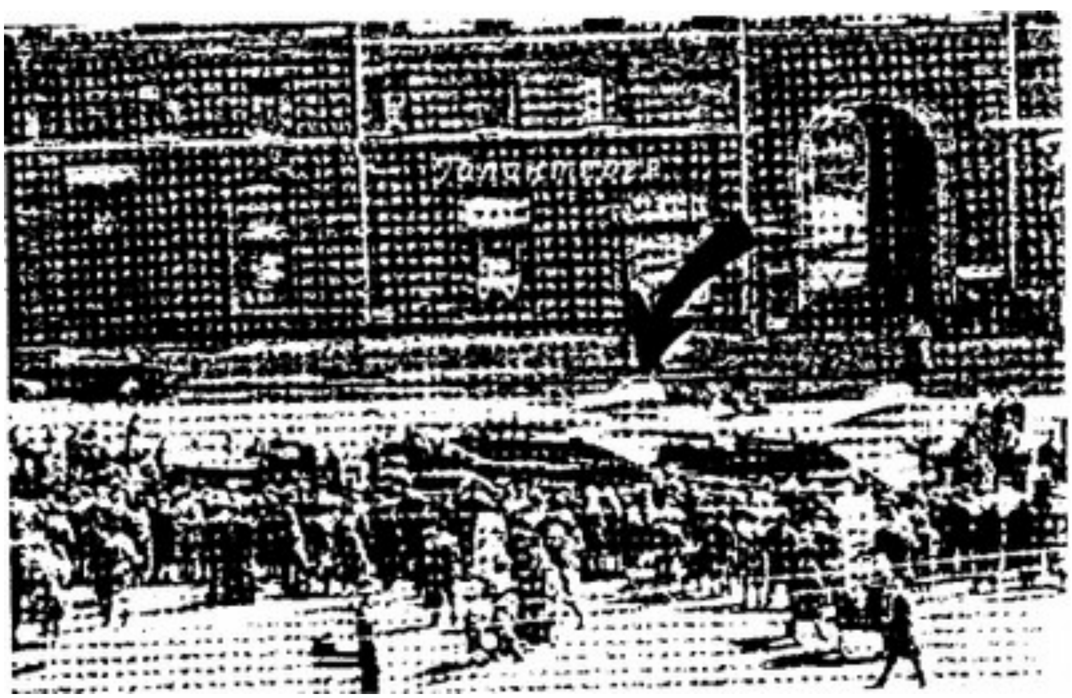

Figure 14. Guideline MOD 4 surface-to-air missile.

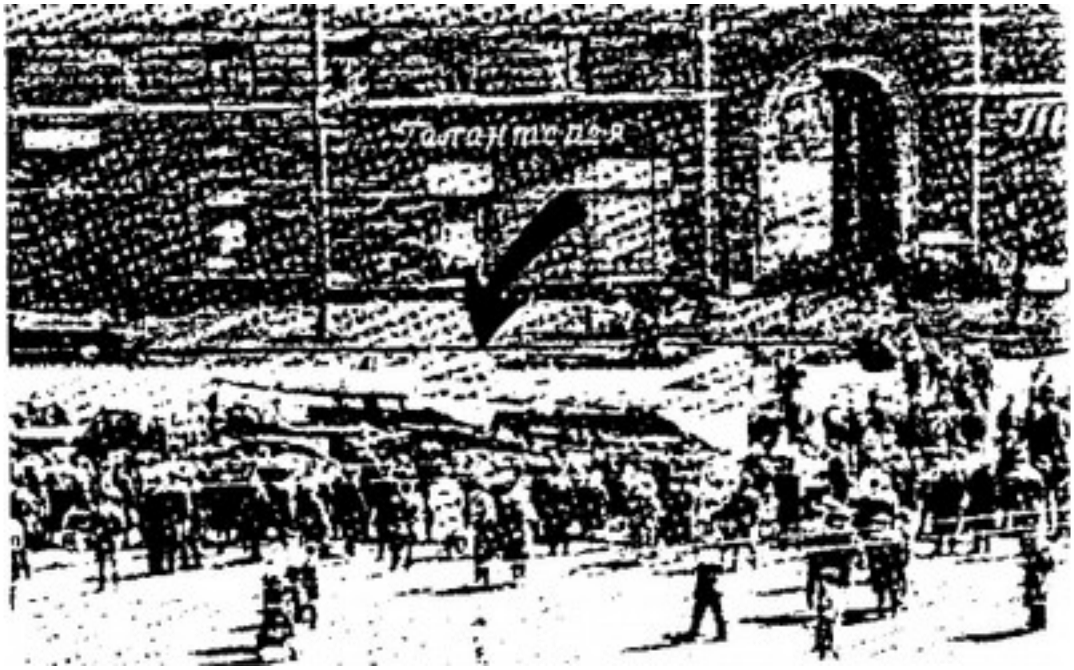

Figure 15. Guideline MOD 1 surface-to-air missile.

BIBLIOGRAPHY

1 Photogrammetry—The art, science, and technology of obtaining reliable measurements by means of photography.

2 Specialists with a strong mathematical background and trained in photogrammetry.

3 A comparator is a precision instrument that measures X and Y coordinates of a photographic image. A monocomparator measures from only one frame of photography. A stereocomparator permits the viewing of two overlapping frames of photography, thereby seeing the object in three dimensions, and measuring the X and Y coordinates of both frames, usually permitting a more accurate solution.

4 A particular model of a monocomparator manufactured by the David W. Mann Co., Mass.

5 A stereocomparator manufactured by OMI-NISTRI, an Italian firm.

6 A device that senses the amount of movement of the comparator