*Photo Interpretation: An Application to Radiation Studies of Survivors of the Hiroshima and Nagasaki Nuclear Explosions**†*

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ABSTRACT: *In a study of the effects of radiation dosage upon the survivors of Hiroshima and Nagasaki, it is necessary to establish the location and amount of shielding of each individual at the time of the blast. This is being done by means of large scale maps prepared from aerial photographs. In addition to standard map detail, interpretation of the photographs provides structure densities, height of buildings, building floor space measurements, slope of roof cover, and other information. This application of photographs is making possible important medical research in radiation effects.*

In einer Untersuchung, welche die Folgen der Austrahlungen an blossgestellte Ueberlebende in Hiroschima und Nagazaki festsetzt, ist es notwendig, die Lage und gesamte Protektion jedes Einzelnen waehrend der Zeit der Explosion festzustellen. Dieses wird ermoeglicht durch Landkarten in grossem Mass-Stabe, die von Luftbildern hergestellt werden. Im Zusatz zu normalen Verzeichnungen in Landkarten, Interpretation der Photographien ergibt Dichtheit der Strukturen, Hoehe der Gebaeude, Raumgroesse der Gebaeude, Abhang des Dachwerkes und andere Auskuenfte. Diese Anwendung der Photographien ermoeglicht wichtige medizinishe Nachforschungen im Studium von Austrahlungen und deren Folgen.

IN A study of radiation effects the areas most often eliciting questions are those dealing with critical dosages and effective shielding. Because the tolerance of man to radiation has been based almost entirely on data of radiation effects upon animals, as determined in laboratory experimentation, specific effects of radiation upon man are not too well established. The survivors of the Hiroshima and Nagasaki nuclear explosions are the only humans upon whom studies can be made concerning the effects of specific radiation dosages.

DOSAGES AND SHIELDING

The estimated lethal dosage is 350 roentgens. However, there is a wide range of individual sensitivities from 225 to 675 roentgens which will cause death. Even more important than individual sensitivities in a study of radiation effects are shielding and distance from the explosion.

Individuals nearest ground zero are subject to greatest radiation effects as well as to the greatest heat and blast effects. With increasing distance from ground zero *or with shielding*, the radiation dose is greatly decreased.

* Members of the Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., and members of the Photogrammetry Division of the Aeronautical Chart and Information Center, St. Louis, Mo. contributed through technical activities and project monitorship to the over-all success of the pilot study. Without their work there would have been no study and no report.

EDITORS NOTE: This paper is a part of the 1960 Commission VII, International Society for Photogrammetry program under Working Group No. 5 "Interpretation of Urban, Rural and Industrial Structures." For other Working Group reports and a foreword by Charles Coleman, President of Commission VII see Vol. XXV, (1), p. 116. For the report of Working Group No. 4—"Interpretation of Vegetation"—see Vol. XXIV, (4), p. 603.

TABLE 1

DOSAGE EFFECT

Total Dose in Roentgens	*Continuous Exposure for 24 Hours*	*Survivor After Effect*
0–75	0% Sick	None
100	2% Sick	None
200	50% Sick, nausea in 24 hrs.	None
300	100% Sick, nausea in 4 hrs. 24% Die, death in 2–4 weeks	Some
650	100% Sick, nausea at once 95% Die, death in one week	Some

Since almost all materials have some shielding effect, it becomes necessary to locate all objects, in their proper relationships, to each individual survivor—in order to calculate the actual radiation dose received by each survivor of the explosion. With accurate determination of individual survivor dosages, correlations can be made with medical data which had been collected by the Atomic Bomb Casualty Commission (ABCC). This agency had accumulated a large amount of medical data concerning individual survivors of the Hiroshima and Nagasaki explosions. These medical data combined with the new techniques of dosimetry developed by the Oak Ridge National Laboratory (ORNL) would make possible accurate dose evaluation for many of the survivors—*if the survivors could be accurately located with reference to the point of explosion so that shielding effects could be measured.*[1]

AERIAL PHOTOGRAPHY USED

Normally, health physicists concern themselves with such dosage and shielding problems. However, in the case of the Hiroshima and Nagasaki explosions, certain unique problems arose when attempts were made to measure the absorbed doses of fast neutron and gamma radiation. The density of structures in a Japanese urban agglomeration posed one difficulty in providing an accurate representation of the area of the bombing This had to be surmounted to allow correct measurements of the angular distribution of the radiation and measurement of shielding absorption.[2] At the same time, the representation of the bombed area had to provide adequate information to facilitate placement of each of the survivors in relationship to surrounding objects and structures. It was felt that large-scale maps of the region might offer a basic representation from which the necessary information could be analyzed. The information needed was as follows: structure densities, street patterns and measurements, height of buildings, contour representation, floor space measurements, slope of roof cover, and placement and heights of miscellaneous objects.[3]

However, with the total destruction that accompanied the nuclear explosion, all of the official Japanese maps of the cities, survey records, official city planning charts and diagrams, and street plans were destroyed. Lacking these kinds of records, the project directors (ORNL) attempted to reconstruct large-scale maps of the neighborhood areas where survivor clusters had occurred. These attempts included survivor interviews, survivor sketch maps of their city blocks, interviews with neighborhood committees, and field observations. None of these efforts produced sufficiently accurate and detailed information concerning placement of structures, material objects, and survivors; nor did they provide accurate dimensions and spatial relationships of known objects. In a final attempt to resolve their problem, members of the Health Physics Division of ORNL contacted the Human Resources Research Institute (HRRI), an inter-disciplinary government research agency. As a result of this inquiry the matter was brought to the attention of geographers assigned to the HRRI staff. This group considered aerial photographic interpretation to be the most feasible means of providing the needed maps. A study was initiated consisting of the following phases:

1. Determine the availability of adequate pre-strike and post-strike photographs.
2. Collect materials for horizontal and vertical information to control compilation.
3. Establish compilation procedures for

[1] G. S. Hurst *et al.*, *Rev. Sci. Instr.*, Vol. 27 (1956), pp. 153–156.

[2] For a complete treatment of the problem of angular distribution of radiation see: "Health Physics Division Annual Progress Report for Period Ending July 31, 1957," pp. 89–91; issued November 11, 1957 (ORNL 2384).

[3] There were many other considerations such as: burst height, location of ground zero, weather conditions, etc., which were necessary. However, most of these items were easily obtainable from records available to the project investigators. In addition, most of these items were not concerned with the large-scale map needs of those areas of survivor clusters scattered throughout the cities.

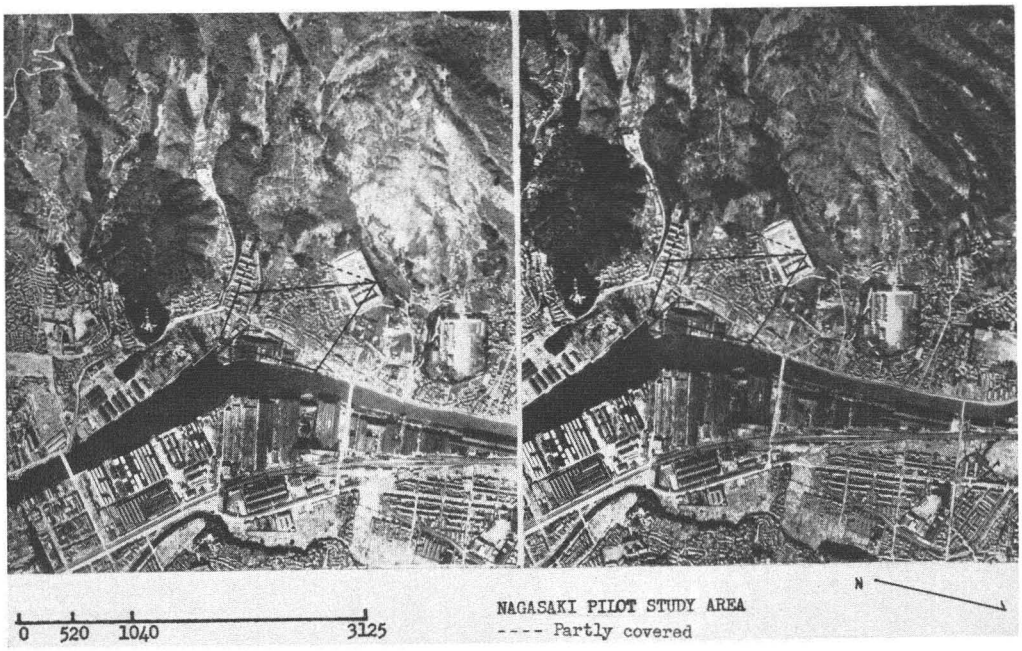

FIG. 1 Pre-strike photography used for culture compilation. USAF 2V 5M390 3PR F24 at 25,000′ (scale 1:12,500 before reduction).

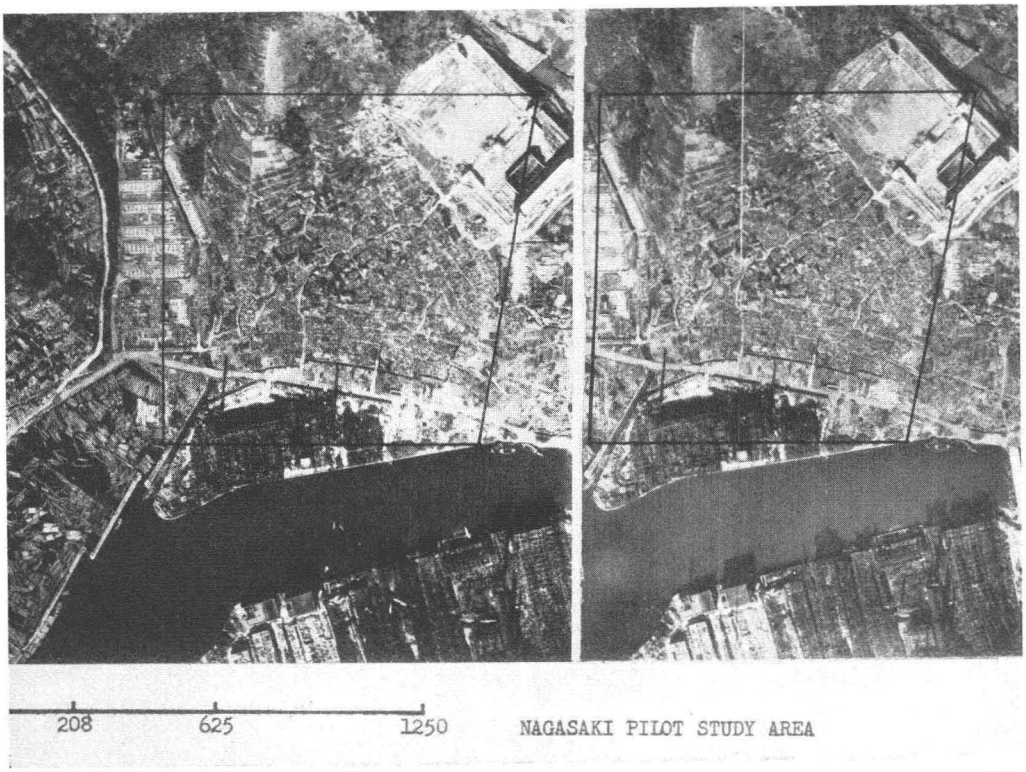

FIG. 2. Post-strike photography used for contour compilation. USAF 2V 3PR 5M421 F24 at 10,000′ (Scale 1:5,000 before reduction).

contour, planimetric, and cultural plates.

4. Printing of stable base reproductions.

A thorough search of aerial photographs revealed pre-strike photos of overlapping stereo-pairs with contact scale of 1:12,500. These were used in making an inventory of cultural features. Post-strike photographs of overlapping stereo-pairs with contact scale of 1:5,000 were located and used in establishing contour data. Pre-strike photographs at a scale of 1:9,750 and post-strike photographs at a scale of 1:14,500 were located for planimetric compilations.

Photogrammetric Procedures[4]

The Japan City Plans Map of Nagasaki at a scale of 1:12,500, developed by Army Map Services, was used to control the compilations vertically and horizontally. Map detail points common to the photography were selected and used to establish the horizontal scale of the stereo model and the subsequent plot of detail. From the Army Map Service map, which had a 10 meter contour interval, vertical-control was extracted in the form of interpolated elevations derived from the contour values. These elevations and the Nagasaki harbor water level were plotted as vertical-control points on the base sheet.

The photographs used in determining contours are 9×8 format which were reduced 50 per cent and diapositive printed from the reduced prints. These stereo-pairs were erected in a Wild A-7 autograph, with 8″ focal-length settings, attaining a vertical-scale of 1:8,400 and a horizontal-scale of 1:5,600, the largest scale possible using this type of equipment. With this model-scale established, a compilation scale of 1:700 was established with a transmission ratio of 8:1 from machine to coordinatograph.

The harbor water level was indexed as 0′ elevation and the model leveled to contour elevations from the map source. A 10 foot contour interval was entered on the base sheet at 1:700 scale.

In compiling the planimetry, diapositives were printed from copy negatives at 100 per cent the size of the original prints. A stereo model was erected in the A-7 autograph with a model-scale of 1:5,600 horizontal and a vertical-scale of 1:28,000. An 8:1 transmission ratio was used to plot detail on the 1:700 scale base sheet. Cultural features, to be annotated on the base sheet, were obtained from photography on 9″×18″ format which was reduced 50 per cent and diapositives were obtained from the reduced prints. When introduced into the A-7 autograph with a focal-length of 6″, the largest horizontal scale possible, 1:9,600, and a vertical scale of 1:19,200 were obtained. Elevations and building heights could be read to ±4 feet. Because of this limitation and the difficulty of distinguishing ground features in congested building areas, the heights of those buildings most easily read were measured and the surrounding buildings compared to them. Building heights were indicated in stories to facilitate transfer and usage of nuclear explosion test data which had been gathered on Japanese-built homes at the Nevada Test Site.[5]

In the final stages of preparation of these maps, the contour plate and planimetry plate were engraved by negative preparation and stable based reproductions were made from the engraved plates. Cultural plates were engraved by negative preparation, and a printed overlay to the stable base reproductions was provided. The cultural features shown included location of garden walls, major vegetation clusters, roof lines, and pre-strike objects such as automobiles, railroad cars, ships, concrete buildings, tile roofs, plus miscellaneous objects of significance. Providing a cultural photo-image inventory is a difficult task, but it can be done rapidly and efficiently by aerial photographic interpretations.

Photo Interpretation

Representative examples of the application and utility of the techniques employed in this study are found in photo interpretation manuals.[6] The type of structure classification in this particular investigation was one in which the roof cover, construction materials, and building heights were highly significant. Outlines were prepared of the distinguishing features of each of these characteristics. These

[4] The procedures described were accomplished by the Photogrammetry Division of the Aeronautical Chart and Information Center (ACIC), St. Louis, Mo. All photography used was Multiple-Strip Vertical Reconnaissance.

[5] Under conditions of test procedures, a program is being carried on at the Tower Test Facilities of the ORNL to determine average values with standard deviations for shielding absorption rates of many aspects of Japanese homes: density of roof materials, thickness of roof materials, density of wall materials, thickness of wall materials, and absorption values for double shielding effects as a result of angular radiation. Almost all Japanese houses are standard in construction, thus prermitting generalizations of shielding values throughout the area under study.

[6] Photographic Interpretation Handbook, Department of Defense, July 1953. Also "Urban Area Analysis," USAF, July 1946, Reprint 91-012286.

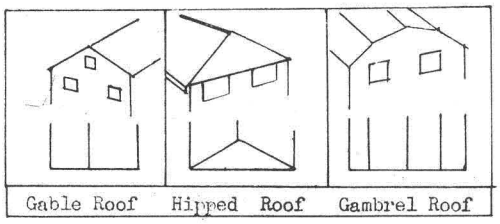

FIG. 3. Sample of individual photo-image key detail provided for interpretation inventory.

outlines, called "photo-image keys" were compared with known and well established urban identification-keys. Sample of the details of individual photo-image keys are given in Figure 3. In the preparation of photo-key guides, illustrations of specific characteristics were provided, along with narrative or description. Similar keys, or keys for other specific criteria could be developed. The determination as to the type of organization

FIG. 4. Survivor-Cluster area map of Nagasaki, Japan.

and presentation to be used in keying the desired objects or conditions was dependent upon (1) the number of objects, conditions, or classes for recognition, and (2) the variety and variability within each object, condition, or class. See Figure 3.

1. Roof characteristics
   a. Gable roof
   b. Hipped roof
   c. Gambrel roof
2. Construction materials
   a. Length, width, height, area, and space
   b. Spacing and arrangement
   c. Type of truss arrangements
      (1) rigid and hinged arch
      (2) crescent arch
      (3) curved trusses
3. Structure heights and densities
   a. Shadow-length, shape, and type of landscape
   b. Window rows
      (1) number and series
      (2) form and shape
   c. Relationship to surrounding and known heights
      (1) water level
      (2) outstanding buildings with known stories

In some cases essay-type photo interpretations keys were used. In others, the conditions dictated use of dichotomous-type keys or integrated-selective keys.[7] The cultural compilation, normally one of the most difficult phases of any photo interpretation study, was, for this project, greatly assisted by the homogeneity of Japanese residential structures.[8] The use of standard panel sizes for home construction materially affected the time factor in determining structure sizes, heights, shapes, and measurements of roof and floor dimensions. In addition, the widespread usage of tile roofs made the classification of roof construction an easy task.

The completed maps are currently being field-tested by ABCC in Japan. Should the tests prove wholly successful, the groundwork will be laid immediately for important medical research. While it is very possible that some other means might have eventually provided the necessary information by which the programmed medical research efforts at Hiroshima and Nagasaki could be completed, it appears certain that the use of photo interpretation greatly accelerated these efforts.

[7] Almost all types of photo keys were used prior to completion of the project. Both selective and elimination classes of keys were utilized throughout the photo collection phase. For a more thorough treatment of each particular classification of keys, see: Photo Interpretation Handbook, Department of Defense, July 1953 (AF M 200–50), pp. 102–103.

[8] The problems encountered in residential structure classification in the United States are described in: "Verification of Aerial Photographic Analysis of Urban Residential Structures: A Study of Rochester, N. Y.," Captain Robert B. Monier, USAF, ASTIA Document No. AD 152 113, AFPTRC Development Report, USAF, January 1958.

BOOK REVIEW

Basic Metrical Photogrammetry, by Duane Lyon, 1959, 475 pages, $4.00.

The author has prepared a college-type book dealing with fundamental principals of photogrammetry. The diagrams and explanations are very clear. The text is typewritten, but the reproduction of text, illustrations, and plates is very good.

The chapter on photogrammetric instruments is especially complete, covering instruments of U. S. and foreign manufacture. A considerable amount of information is included in this book for a very low price. It should become very popular with beginning students of photogrammetry and those who wish to review basic information.

The author anticipates the publication of another volume on applied metrical photogrammetry to supplement the basic volume. The new work will include the mechanical and mathematical methods of spacial control extension.

C. E. Cook, *Chairman*,
Publications Committee