Applied Photogrammetric Methods in Eastern Venezuela

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ABSTRACT: *This paper presents the aerial mapping methods, radial line control and sketchmaster compilation, used in preparing planimetric maps from existing photographs. It should be of special interest to organizations which have their operations over vast areas, where inexpensive topographic information for terrain studies, prior to undertaking a field project, is desired.*

UNTIL 1952 the oil fields in Eastern Venezuela were confined to a small area of short lines of supply and communication. With the recent discoveries of many new fields in outlying districts it was necessary to present some form of planimetric map to meet the increasing need for planning the engineering projects required for production in these vast new areas. Most of the fields were inaccessible because of bad terrain and/or lack of roads. The majority of the existing maps contained only the main rivers; these serve as concession boundaries, and routes of primary dry-season dirt roads. An inexpensive system had to be devised to meet the increasing demands for map information. Photogrammetry was then introduced into the engineering aspects of this Company.

For a number of years there have been available aerial photographs with scales of from 1:17,000 to 1:60,000 taken with cameras of different focal lengths, at various times during the past 18 years. The overlapping stereopairs and subsequent mosaics made from them have been used by field geologists, seismograph crews and for photo-geological interpretation.

During the past three years, valuable and time-saving information has been compiled from these pictures through photogrammetric means to prepare 1:20,000 maps for use in the following engineering projects:

1. *Exploratory work.* Establishing the theoretical ground location of a proposed "wildcat" well to its actual terrain relationship.
2. *Approach road to "Wildcat."* This is the most direct distance from the location of a drilling "rig" to the location to which it will be moved. A drilling "rig" is constructed in such a manner as to permit its "skidding" upright from one location to another. Almost all "rigs" are moved in this way. A route with a uniform change in elevation is desired for the move.
3. *Access Road to "Wildcat."* This may follow the same route of the approach or "skid" road; in most cases it will follow the ridge tops and simplest stream crossings to the well. It serves as communication for the working crews and as the supply route for materials to keep the "rig" drilling. Should the "wildcat" produce, it will serve as the main route to the new field. A road network branching from this main one to new surrounding drilling locations in the area is made. All of this is a production "build-up" starting with the producing "wildcat."
4. *Gas and water line routes* to service the drilling "rig" boilers. These are generally of a temporary nature and are laid on the most direct route.
5. *Production lines* from producing wells to gathering stations.
6. *Oil lateral and trunk lines* from gathering stations to tank farms. These are permanent lines usually located in accessible terrain for servicing in case of a line break.
7. *Routes of gas injection lines and high tension lines.*

8. *Sites for gathering stations, gas repressuring plants, camp sites and landing strips.*

Contact prints are the primary factors in the map construction. The radial-line method of photogrammetric control is used with a sketchmaster as the medium for compilation.

A job is done on an exploratory area or one in which the field is being developed. The compilation area is usually 70 to 100 square kilometers. Once an area is assigned, the photographs are laid out and the known control stereoscopically identified, pricked on the pictures, inked for future use, the coordinates marked on the back of the photos, and then listed on a job history sheet.

Established ground-control, based on a True North plane meter grid system, is used. Office compilation is a fixed hourly charge per square kilometer. Field surveying is a variable charge increasing per day of work. The costs of field surveys for these photogrammetric jobs are not justified in the application of the information plotted. Consequently it is financially practical to use only existing control for the work. This consists of identifiable:

1. *Locations of producing wells.*
2. *Installations* (i.e. corners of gathering stations, company road interesctions, camp fence corners, etc.).
3. *Large rivers surveyed* as far back as 1927 (i.e. prominent meanders and stream intersections).
4. *Established old trails* (camino reales).
5. *Stratigraphic test holes.*
6. *Intersections of seismograph trails* (picas).
7. *Fence corners of property lines.*

Where control is not available in the working area, the aerial triangulation has to be extended outside the field to adjoining identifiable points. This presents one of the major problems in preparing these maps, for at times it is necessary to use points ten kilometers distant from the immediate area being compiled.

Within recent months a new system for control has been initiated. Usually in an exploratory area a surveyor establishes the parcel corners of the Company's concession, using iron pipes, before locating the "wildcat" site within it. Prior to going to the field, a hasty sketch is prepared from the aerial photographs giving terrain detail and showing his approximate survey line. Prominent points near this line which are identifiable on the photos, and desired for control, are marked on this sketch for him to establish. In this manner, expense for the map control is a part but not a heavy charge to parcel survey and is incidental to the cost of producing the planimetric map.

When there is not enough time to prepare a hasty sketch, the surveyor establishes prominent features on his line or just off it. A full crew's day need not be wasted for a point or two when they can be located on a relative job. In both cases control in the immediate compilation area is established providing for a closer photogrammetric plot.

It has been rather difficult to formulate criteria of the detail to be transferred from the photographs. The following has proven quite satisfactory and applicable to the petroleum-exploratory and production-projects carried on during these past three years:

CLASSIFICATION OF DELINEATED DETAIL

1. *Roads.* Primary roads and trails. These trails are later classified by the Chief Surveyor in the field as to their seasonal trafficability for heavy duty trucks. They are properly symbolized on the finished map.
2. *Streams.* Classified as perennial and deep incised "V" basin, or as intermittent with wash or approximately distinguishable in a flat "U" basin. There being only two seasons in Venezuela—the dry and rainy—it is necessary to classify streams for the different field crews taking their own routes cross-country.
3. *Buildings and Outhouses* (usually moriche and adobe huts).
4. *Fencelines.*
5. *Intermittent lakes.*
6. *Marshland* where it occurs and the flood plains of rivers.
7. "*Farallon.*" This is the outline of the edge of highly eroded land, varying from 10 to 100 meters in height, caused by the action of heavy rainwash. The terrain presents a hazard to transportation and communication.
8. *Outstanding hills* as shown by form lines.

All the above features are delineated directly on the photographs using colored ink for classification and identification.

With the delineation thus inked, the

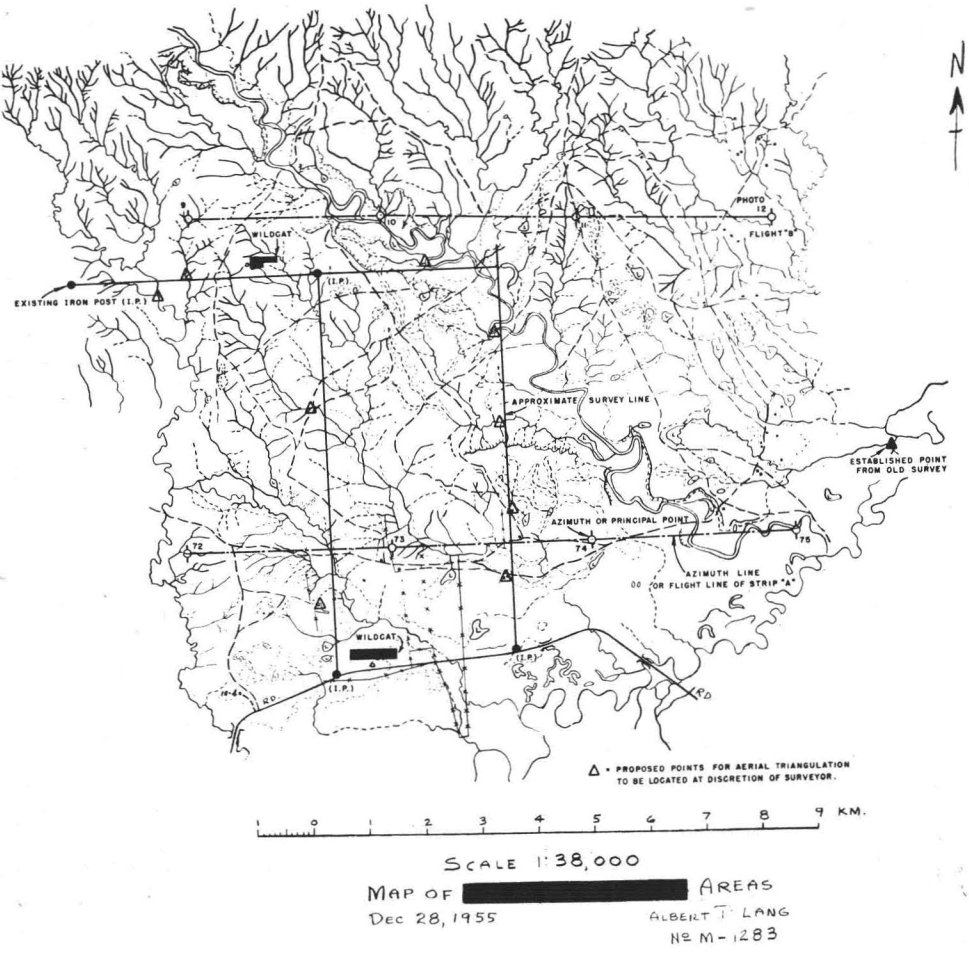

ILLUSTRATION ONE

azimuth and pass points pricked on the photos, the hasty sketch (refer to Illustration One) for the surveyors can be prepared. By orienting each succeeding photo on the flight azimuth line, the delineation is traced off with an over-all alignment forming the sketch. The scale being that of the photos. Fortunately there is enough known information in the surrounding area to approximate True North. The surveyor's proposed field lines can also be located. The desired photogrammetric ground control points are then marked on a print for his guidance.

For various reasons the working scale of the planimetric maps has to be 1:20,000. In some areas 1:20,000, 7″ by 9″ photographs are available. Unfortunately the only coverage in the new exploratory areas consists of 1:30,000 and 1:36,000 prints. The majority of the photogrammetric work during these past three years involved the use of these photos.

The first sketchmaster that was used had a maximum enlarging ratio of 1:1.14. In using the 1:36,000 scale photos the aerial triangulation was done to 1:33,333. Compiled map manuscripts were photographically enlarged to 1:20,000 and the finished maps traced from the negatives. This method using photo reproduction work was expensive, so a new system of exploitation of detail was necessary. A sketchmaster with an enlarging ratio of 1:2.8 was bought.

After the radial templets have been constructed, using metal radial arms, an assembly is made to a scale of 1:30,000 for both the 1:36,000 and 1:30,000 photographs on a plane-meter grid. The established azimuth and pass points are scaled and their coordinates tabulated.

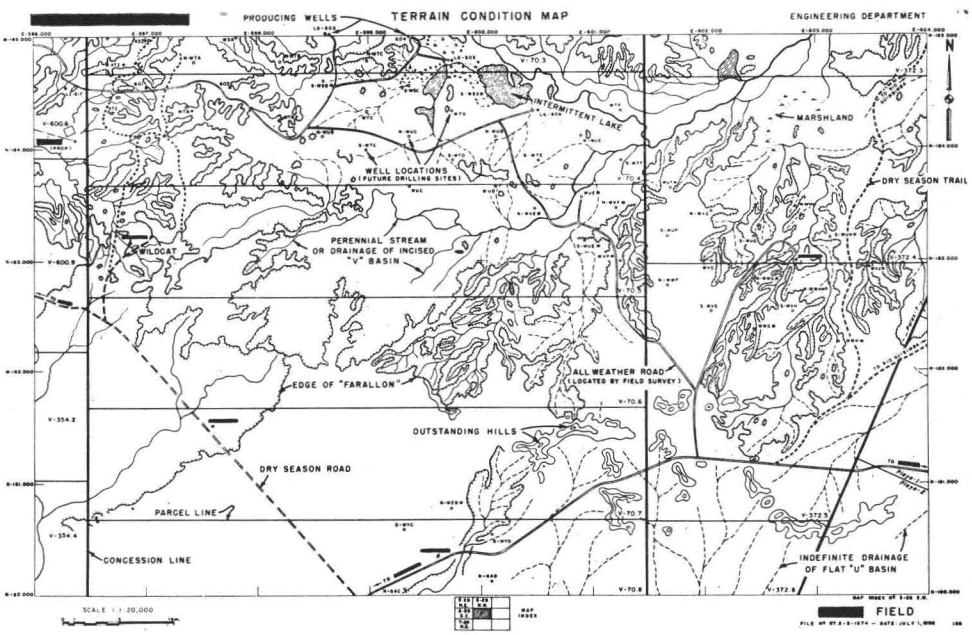

ILLUSTRATION TWO

All points are replotted on white heavy weight drawing paper to a scale of 1 :20,000. The 1:2.8 ratio sktechmaster does not permit orienting all the points on the photographs to the plot. At a 1:1.8 enlargement factor the eye-piece only covers a section of the print. It is necessary to orient the photograph by quarters. Compiled features are inked in color code on the compilation manuscript. All concession, parcel and latest-established well-locations, roads, pipelines and pertinent information are plotted. Since the aerial photograph is usually ten years old or more, there are plenty of additional features not on the pictures to be added to the photogrammetric compilation.

A standardized 1:20,000, five by eight kilometer (11 by 17 inches) sheet of matte film positive is used as a base for tracing the map designated for inside the specified quadrangle. The sheet (refer to Illustration Two) is part of an indexed 1:20,000 map series printed by multilith process to form a booklet called "Terrain Conditions of Active Fields." This booklet is revised quarterly using new ground-surveyed information and adding newly compiled sheets. The film originals are also used for reproducing individual ozalid prints. The information that these maps contain are further utilized in preparing and revising 1:50,000 road maps.

The following has been used for this type of mapping: Two strong table lamps, a kit of metal radial-arm triangulators, a pocket stereoscope, a sketchmaster having an enlarging ratio of 1:2.8 (to permit dealing with the various photo coverage available), accessibility to a photo lab, and the necessary drafting equipment. There is no need for a large staff. One Cartographer experienced in photogrammetry, who can plot from ground survey notes, can compute, knows photo reproduction, and who can draft-finish maps, are all that is necessary.

To date the combined total compiled area represents 3,200 square kilometers. Costly reflying of aerial coverage and subsequent precision compilation have been inadvisable because the area is partially developed, and it is financially impractical for the scope of oil operations.

The system is the outgrowth of an improvisation occasioned by the necessity for information and is based upon using what is available at minimum costs. There is much to be desired in the accuracy of this type of photomapping, but the results are sufficiently close for the requirements of the local oil industry.