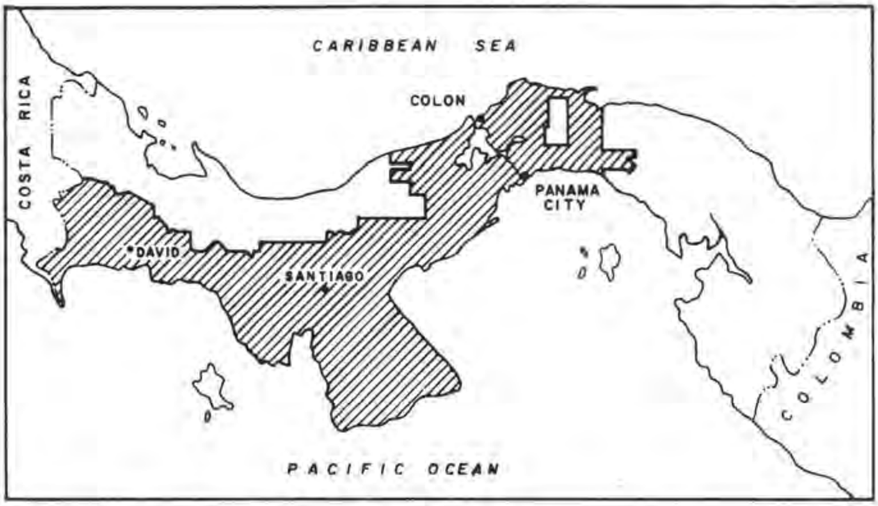

FIG. 1. The project area in Panama. The balance of the country is very sparsely populated.

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Resources and Cadastral Mapping of Panama

The purpose of the project was to provide the government with basic information to assist in planning and development.

INTRODUCTION

FROM 1964 TO 1969 CATAPAN, a joint venture of International Resources and Geotechnics, Inc., International Engineering Co., and J. L. Jacobs and Co., supervised a natural resources inventory and an agricultural land tenure and valuation of 14,000 square miles (Figure 1) for the Catastro Rural de Tierras y Aguas de Panamá. A major portion of the work was financed by US AID under the Alliance for Progress. The purpose of the project was to provide the government of Panama with basic information to assist with planning and development of the rural economy, implementation of agrarian reform, to record rural property ownership and establish an equitable value for the land.

Very briefly, here is how the project was done. A few months before the work started a thorough inventory of existing aerial photographs of the project area and an evaluation of the national photogrammetric capability were made. This determined what photography had yet to be flown as part of a continuing program, and how soon photogrammetric products could be delivered to the various work components of the project. Based on the availability of the photogrammetric products, a theoretical calender of events was drawn up, and the starting and finishing time of each component was determined by critical path analysis. Figure 2 shows how the components were highly dependent on these products, which were the basic tools of the work. A detailed work plan, outlining the sequence of activities for each component, was also made.

Production of mosaics, enlargements, and contact prints started along with the initiation of the work components at the outset of the program. The components performed photointerpretation of the geology, geomorphology, drainage, tectolinears, soils, ecology, non-metallic minerals, materials of construction, land use and land tenure, and made selective field checks on their results. Additional components worked on hydrometeorology, hydrogeology, geophysics, drilling, evaluation, and laboratory and field analysis, as well as consulted on title registration, legislation and electronic data processing. The project was basically oriented to tax improvement, therefore the natural resources were required to assist in establishing fair land values.

ABSTRACT: *A four-year program of resources mapping and a rural cadaster of the more populous part of the Republic of Panama was completed in 1969. Aerial photography was performed for most of the area under extremely limited weather conditions. Aerial photographs, mosaics and enlargements were the basic tools for the project, and the results of photo-interpretation and field work were compiled on over 5,000 maps. A system of providing land titles with property descriptions delineated on aerial photos was designed. The routine of the job was interrupted by a spectacular search and rescue mission when project officials were crash-landed in a remote area.*

Cartographic work for all of the components was finished by the mapping component which also supervised aerial photographic operations and procurement of photogrammetric products, and was the central agency for storage, reproduction and distribution of these materials. Figure 3 is a portion of the diagram that shows the flow of materials within the project.

AERIAL PHOTOGRAPHY

Panama is an extremely difficult country to photograph.* It is situated just North of, and is strongly affected by, the Intertropical Convergence Zone, an equatorial low-pressure area of warm, unstable air fed by the trade winds of both hemispheres. This Zone annually shifts northward over Panama resulting with a wet and dry season, the latter commencing usually in December and lasting about four months.

The dry season is, of course, the best time for aerial photography; however, the daily weather pattern is a photographers nightmare. The nights are crystal clear, but in the morning, before the sun reaches the proper angle, the target areas are usually obliterated by clouds generated from local convection currents. These local currents also usually sweep the coastline clear up to a mile or two inland. The balance of the land, composed of low to medium mountainous terrain, demands a large amount of reconnaissance to take timely advantage of infrequent cloud-sweeping by high winds which, at altitude, makes it difficult to hold the flight line.

Aerial photographic work in Panama therefore requires a consideration of months, rather than weeks, of standby time to be successful. Over a period of four continuous years, using various aerial survey firms from the United States, only 83 percent of the intended area was photographed due to weather restrictions.

Added to the frustrations mentioned were some unanticipated technical, diplomatic and personnel problems. In one instance, negatives of over 300 square miles of hitherto

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* See Crandall, "Radar Mapping in Panama" in the July 1969 issue of this magazine.

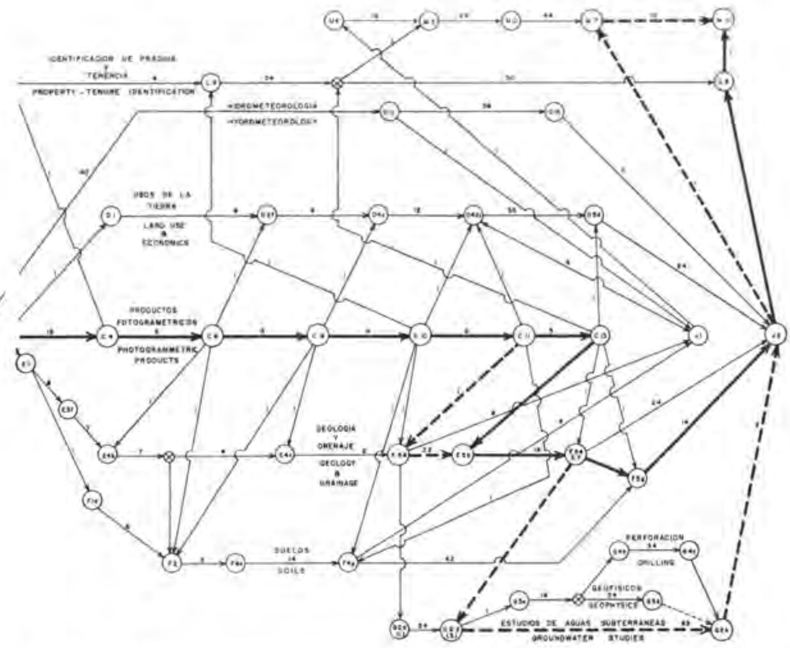

FIG. 2. The Critical Path Diagram. The dotted line was the intended path whereas the solid line was the actual result.

unphotographed terrain were lost due to malfunction of a brand-new but not debugged camera. Hundreds more square miles were lost when, in a locally set-up photolab, a whole roll of freshly processed film was wound up wet at quitting time to be dried the following morning (it dried up tightly during the night), and three rolls of negatives were all developed in the same solution (the second roll was weak, the third roll didn't make it). And a whole photographic season was lost while one contractor sat out a diplomatic break between Panama and the United States for the length of his contract.

The salient technical provisions of the contracts for aerial photography specified RC-8 or RMK 15/23 type, 6-inch focal-length cameras, negative scale of 1:16,000, solar angle of 30°, and standard parameters for crab, tilt and overlap, with the exception sidelap, which was a minimum 10 percent and average 20 percent. The item of sidelap was purposely stretched to minimize the number of flight lines.

The aerial photography for the project was started in 1962. The project commenced in late 1964. In 1965 the various components of the project were using the photographs rapidly and the pressure was on for more to complete the work on time. By 1966 the specifications had to be relaxed considerably to obtain at least partially usable results, as the photography had progressed from the more easily photographed terrain to the tougher, higher ground. The negative scale was changed from 1:16,000—originally intended to be used in conjunction with a 2 meter contour mapping program—to 1:20,000. Up to 10 percent cloud cover and a minimum of 52 percent forward overlap were accepted. Eventually, the sidelap and solar angle provisions were dropped entirely, and some successful photographs were taken just a few hours after sunrise.

From December 1964 to June 1966, 14 aircraft-months of standby was expended but not all of the time was lost. Various minor projects and twelve major cities situated on or near the coastline were photographed for the government when the project area was obscured.

PHOTOGRAMMETIC PRODUCTS

At the close of the project 185 controlled mosaics, over 4,400 enlargements, approximately 19,000 contact prints, and 1,310 autopositive map sheets had been made. The bulk of this work was done by a United States contractor, and he was given all of the materials recorded during the preproject inventory, such as topographic maps, control information, indexes and 50 rolls of aerial negatives.

Most of the negatives were at scale 1:

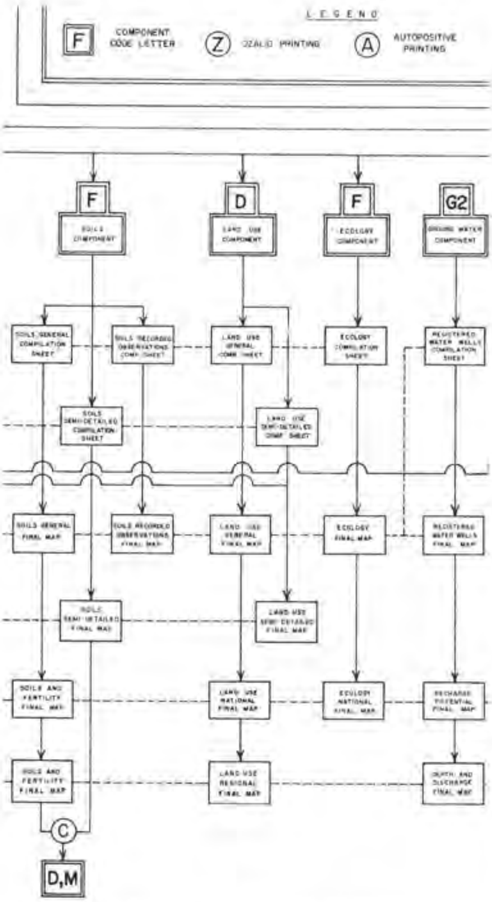

FIG. 3. A portion of the Diagram of Operations.

60,000 and were copies of coverage flown by the U. S. Government over a 10-year period. Although they had been considerably handled and contained occasional scratches, chemical stains, tears and loss of contact, the contractor did a marvelous job with the mosaics. They were constructed with rectified photographs at 1:40,000, copied and printed at scales 1:50,000 and 1:20,000 on cronaflex. In the areas where no topographic maps were available, slotted template methods were used, and the area was tied to photo-identified triangulation points. Joining of photographic detail was specified with no mismatch greater than 1/16 of an inch in relatively flat terrain with patching to maintain continuity of cultural features in the more rugged lands.

Enlargements printed on cronaflex were made of each alternate exposure of the 1:16,000 negatives. Rectification was considered for this work but the cost could not be justified in view of their intended use, which is explained below. Copies of the enlargements and mosaics, being readily available by diazo printing at minimum cost, proved to be very popular with many outside users.

MAPPING

The mapping component of the Catastro Rural de Tierras y Aguas de Panama produced 1,300 natural resources maps and over 4,000 property maps. The component also performed measurements for pay quantities for various contracts, produced many graphic items for project reports, specifications, flight line indexes, etc., and compiled various maps, charts, diagrams and photomosaics. Much of the latter was not anticipated in the original plan of work. For instance, the component produced a series of special maps and hundreds of copies therefrom, as a result of the Canal Zone Treaty Negotiations of 1967. Once it became known that the mapping component could produce rapid and precise cartographic work, it became most popular with other government agencies, and planned production schedules went right down the drain.

The component was supervised by a North American trained in photogrammetry and cartography. He established and managed the mapping program and its equipping and staffing. On the Panamanian side was one Chief Draftsman and an average of 22 draftsmen. A core of experienced draftsmen was recruited from various participating government agencies at the inception of the program and additional draftsmen were hired by means of a drafting test, designed to evaluate the experience, ability and understanding of cartographic principles of the applicant. This method kept the turnover of personnel to a minimum and they functioned very well as a unit. In some cases, draftsmen were assigned to an individual component to assist with preparation of map manuscripts, and as the work progressed they were gradually transferred to the mapping department to do the final drafting. This plan had obvious merit. A major portion of the draftsmen were also cross-trained to understand and draft as many as four different kinds of resources maps.

Almost all of the drafting room furniture—light tables, chairs, layout tables and flat files—was designed and fabricated locally, saving much time and money. Only three items of special equipment were purchased outside the country; an Ozalid machine, longitudinal paper cutter, and a Kail reflecting projector. A standard compliment of drafting tools was available locally and all of the drafting was done with Radidograph type pens and Leroy lettering guides. Drafting by scribe method was considered, but dropped because this process was unknown locally at the time and it was desirable to keep control of the operation under one roof rather than expand the supervision to include a photolab.

It is worth mentioning that the program did not suffer the inordinately long periods of waiting time for equipment or materials to arrive as has been experienced in other Latin countries. Panama is a crossroads for worldwide shipping and has an efficient Customs Department. However, an occasional impasse had to be resolved when a U. S. supplier would not ship until payment was made, and Panama would not pay until the shipment was received.

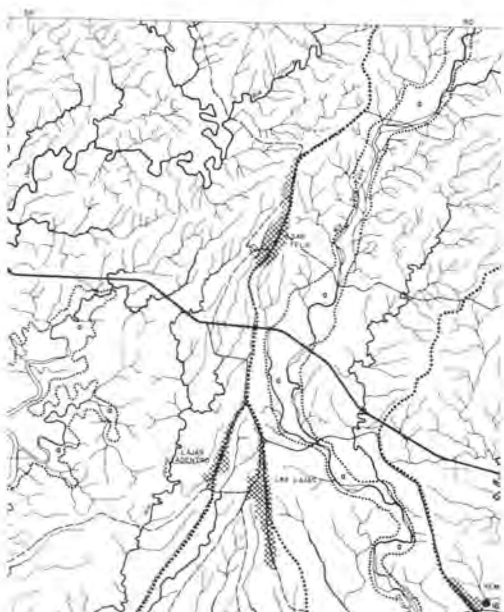

FIG. 4. A portion of the drainage map. The original scale was 1:50,000 and the legend was included on a separate sheet.

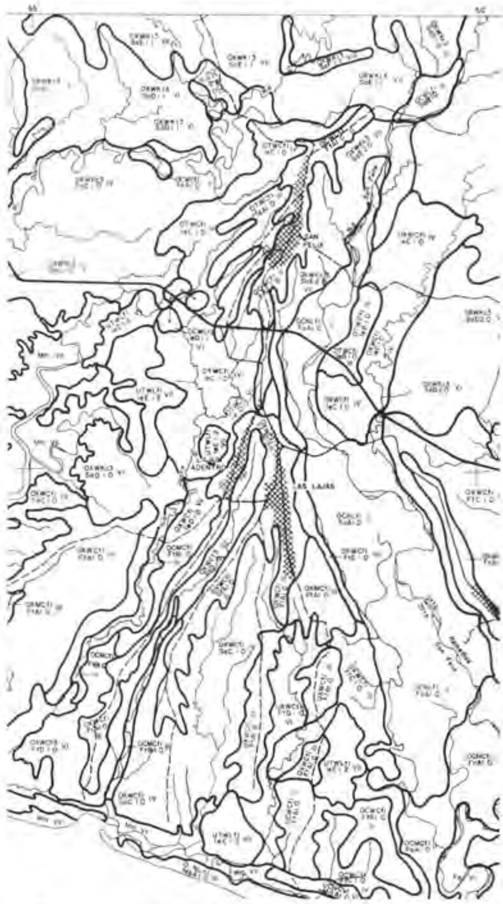

FIG. 5. A portion of the soils map. The original scale was 1:50,000 and the legend was included on a separate sheet.

For the natural resources mapping, a master planimetric map was drawn on cronaflex as an overlay to each mosaic, showing the major cultural, natural and political features in conformance with existing topographic, geographic and other special type maps. The mosaics were fifth-generation prints, and the existing maps were heavily referred to for tertiary drainage, trails and bridges. The alignment of some major roads, built after the photographs were taken, had to be researched and plotted. A number-letter index for maps and mosaics was established for the entire country but sheet names already in use were retained wherever possible. The density of planimetric information was kept light and uniform throughout because it served as the reference base for delineation of resources information, some of which was rather complex. Figures 4 and 5 are examples of resources maps.

While the planimetric base was in progress the personnel of the individual resources components; geology, soils, etc., were performing photo-interpretation and field checks and preparing their manuscript maps. The resources information was compiled with colored pencil on Ozalid copies of the mosaics. When completed they were turned over to the mapping department for final drafting. Some of the base mapping had to be revised to fit the resources information. For example, just as the planimetric mapping work was nearing completion it was found that a major portion of the villages had to be changed in shape, or eliminated, to conform with the classifications established by the Land Use Component.

Up to seven autopositive copies, with the emulsion side reversed, were printed from the master planimetric map. Final drafting was done only on the autopositive copies and the master sheet was filed away to be used in the event that additional sheets were needed; and they were, on occassion. In one instance, heavy rain during the night leaked through the roof and seeped into the files, literally welding several cronaflex sheets together as it dried

The resources maps were designed for production on cronaflex so that they could be overlayed on each other, or on the original mosaic, on a light table and examined in detail for planning, engineering or socio-economic studies. It was imperative that the information be legible and uniform throughout the project. Each component supervisor was consulted to determine what he wanted shown on his type of map, and how it was to be presented. Each supervisor naturally had his own ideas but after some arbitration and a few trial sheets, procedures were ironed out to everyone's satisfaction.

It was the nature of job that the map legend was constantly being revised to fit the results of the investigations, therefore the legends were among the last items drafted. It was impractical to design a standard size map sheet that could accommodate a legend of unknown size sometime in the future (for example, drainage resulted with 6 symbols, soils had 65 in 10 parts), so a separate legend sheet containing all symbols for all types of resources maps was made. This was a good idea in that it automatically acquainted the user with all the other types of information available to him.

The property maps (Figure 6) were compiled at scale of 1:10,000 as a graphic diagram of land tenure, and also showed selected planimetric features. They were drawn on high-quality tracing paper rather than cronaflex because of the large volume of work. At the outset of the program, a master format, large enough to accommodate the area of a 1:10,000 enlargement made from a 1:16,000 photograph and containing all the marginal information common to each sheet, was designed and offset printed locally on pre-cut reams of tracing paper.

Property-line information was investigated in the field and delivered to the draftsmen delineated with colored pencil on Ozalid copies of the 1:10,000 enlargements. These were placed under the prepared tracing paper and copied with pen and ink. Properties were then numbered and their areas calculated by planimeter. Edge-match between map sheets was sometimes a problem. Because only alternate exposures were used (in some cases of fracto-cumulous cloud cover, each exposure of a flight line was printed), repeated requests received were to *do something* about the *distortion* in the overlapping edges of the photographs where, in the mountains, relief displacement caused malformation of property shapes. After much conversation, in which the differences between displacement

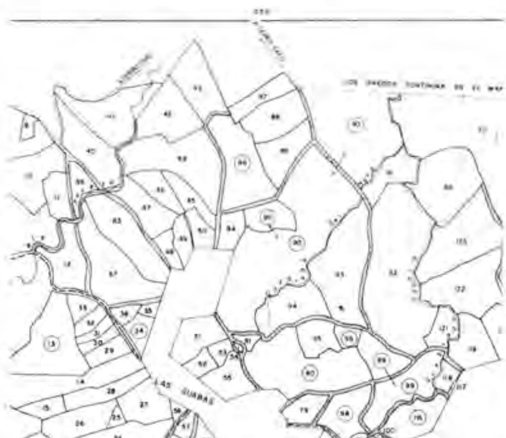

FIG. 6. A portion of a property map whose original scale was 1:10,000.

and distortion were explained, requests for rectification become fashionable and some exposures were rectified to prove that it really did not help much.

As mentioned, the purpose of the property mapping was to augment a program of tax reform and to record and evaluate all rural properties larger than approximatly one hectare. At least 80 percent of the properties mapped had never been surveyed and consequently had no title, which is a predicament for a tax collector. Recommendations on the use of the aerial photographs for provisional titling of landowners were submitted to Panama. In 1968 enabling legislation was passed by the National Assembly to this effect and it is expected that soon a legal form of conditional title showing the property line, approximate area, and adjacent properties drawn on a section of an aerial photograph will be issued to landowners as a temporary legal description.

Down in Darien

Once established, the project progressed in a reasonably routine manner with the exception of one extraordinary event.

In September, 1966, four North Americans and two Panamanians, all key personnel of the project, chartered a local Twin Beech to reconnoiter the Darien region of Panama for possible inclusion in the natural resources work. This is the famed *Darien Gap*—the last link of the still incomplete Interamerican Highway, and an area composed of rugged jungle-covered terrain, some impenetrable swamps, and practically uninhabited. One engine caught fire while over the remotest part of this region and in attempting to reach home base the aircraft was forced to crash land. Repeated radio calls (the airplane's radio had quit) and a check of emergency landing fields did not turn up the overdue aircraft. No flight plan had been filed, but soon word came from a mission school that they had spotted an airplane trailing smoke, and they gave its approximate heading. Local pilots began flying fruitless search missions.

Fig. 7. Portion of a vertical photograph of the Darien crash site during rescue. The aircraft's wings were broken off and the glide path through the foliage is discernible (USAF photo).

The next day, the U. S. Air Force from the Canal Zone joined in the search. On the third day it was decided to have the Air Force obtain low-level aerial photography beneath the clouds along three possible routes the aircraft might have taken from where it was seen by the mission school. Hundreds of aerial photographs were scanned for signs of wreckage or broken trees with no success. The prospects of finding the plane or its occupants grew very dim. No downed aircraft had ever been found by organized search in this region. Occasionally, prospectors, hunters or indians in this region stumble across the remains of crashed airplanes years after the search was given up.

On the fourth day a local pilot caught a lucky glimpse of the airplane in a mangrove swamp about 30 miles from home. The Air Force dispatched rescue helicopters (Figure 7) with paramedics to recover all of the passengers, injured but alive. The pilot, after making a brilliant landing, had succumbed to his injuries.

Thereafter, the rest of the CATAPAN group was less vocal about their own particular hazards—snakes in the country and traffic in the city.