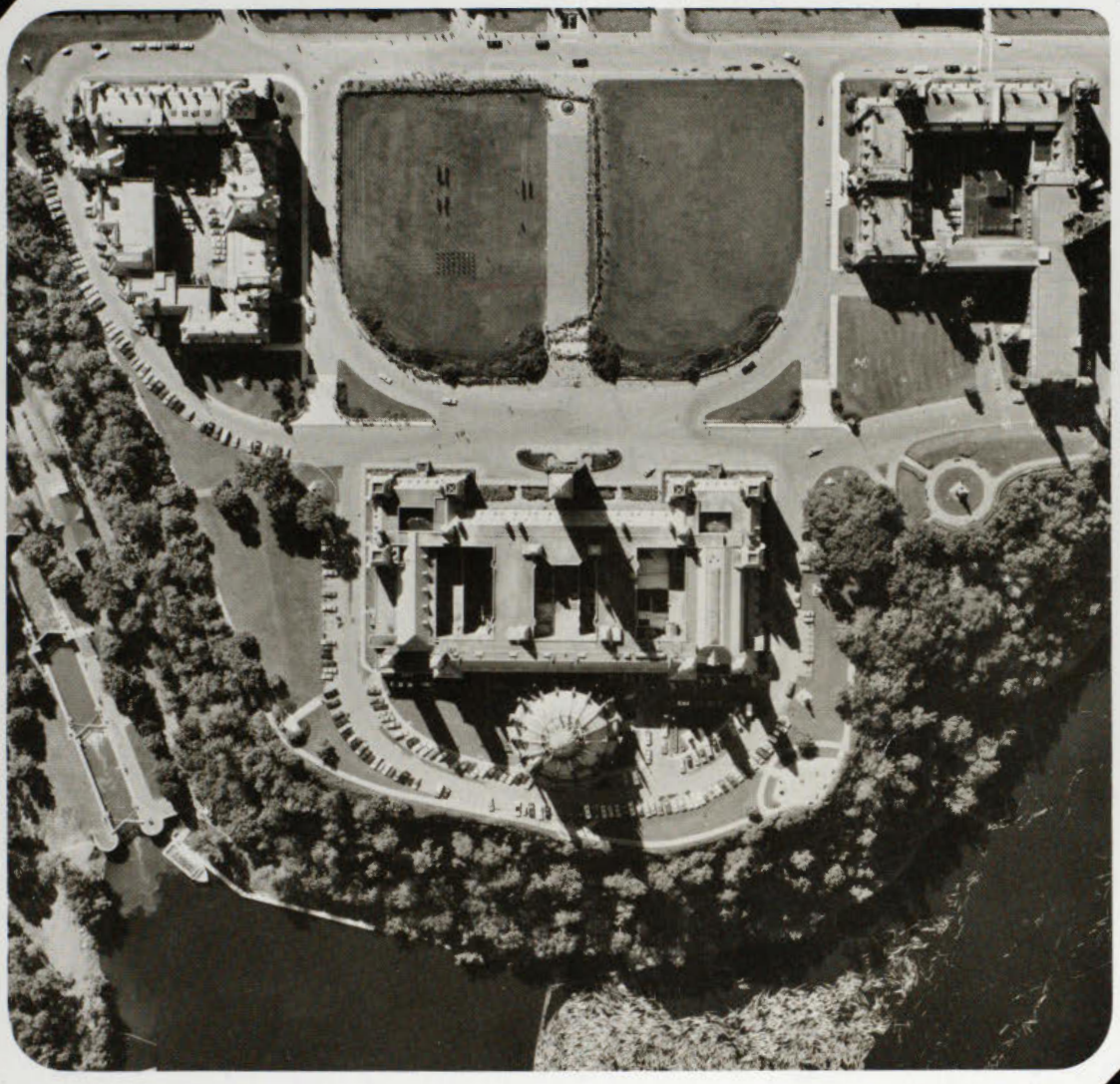
CANADA PHOTOGRAPHED FROM THE AIR



Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

Prepared for Surveys and Mapping Branch
by Information EMR

(aussi disponible en français)

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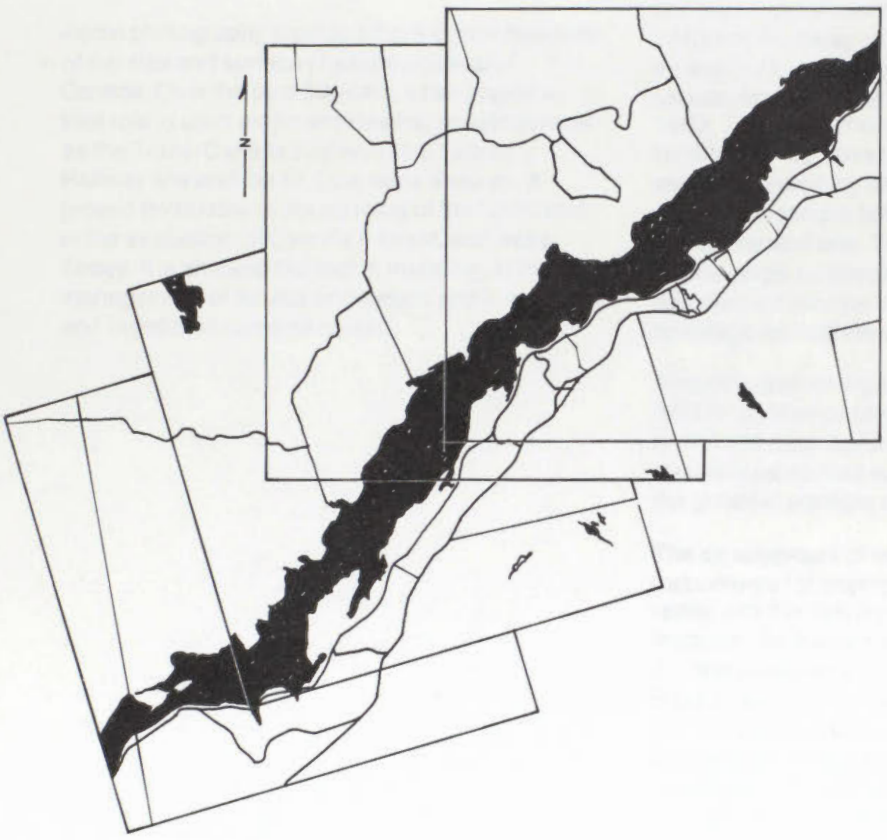

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History

Aerial photography records the ever changing face of Canada. It shows the surface features— the mountains, canyons, flatlands. Traces rivers from source to mouth. Reveals land resources— the lakes, forests and vegetation. Identifies population densities. And pinpoints environmental disruptions like the drifting oilslick, raging forest fire or rising flood.

Aerial photography provided the first true measure of the size and surface physical makeup of Canada. Over the past 50 years, it has played a vital role in such major engineering developments as the Trans-Canada Highway, the Labrador Railway line and the St. Lawrence Seaway. It proved invaluable in the opening of the North and in the evaluation of Canada's forest resources. Today, it is an essential tool in mapping, in the management of forests and waters and in pollution and vegetation damage control.

The first usable aerial photographs were taken from kites in France in 1839. It was discovered that not only was it possible to recognize and identify the photographic image, but reliable measurements for topographic mapping could be obtained from it. And thus the science of photogrammetry, the interpretation and measurement of photographs, began. From 1849 to 1900 through continued experiments with balloons and kite-balloons, the basic principles of photogrammetry as applied to mapping were developed by Aimé Laussedat, the father of photogrammetry. About 1900, Theodor Scheimpflug, an Austrian, extended the field coverage of the aerial camera from any one position by developing an eight-lens unit with seven oblique lenses grouped around a central vertical one. The eight exposures provided a wide-angle composite photograph that could be transformed into the equivalent of a single wide coverage vertical view.

A modification of this idea was still in use years later in airplane photography surveys when a tri-camera mount provided one vertical and two side oblique scenes at each photo station to give the greatest possible coverage.

The development of measuring and map-plotting instruments for photographs proceeded concurrently with the development of aerial photography methods. By the turn of the century, for example, the first stereoscopic instrument was invented. Based partly on the operation of the human eye, the stereoscope gives a three-dimensional effect to an image when two photographs with an overlapping field of view are simultaneously viewed through it. Many viewing and plotting devices in modern photogrammetry are stereoscopic.

With the development of modern aircraft and orbiting satellite platforms, aerial imagery has kept pace with technology, and has an ever growing role in studying our earth's surface. Modern methods of photo interpretation and utilization place aerial imagery in an important role in today's developing world.

Aerial Photography

Figure 1.
The Vickers Viking was among the first aircraft to be used for aerial photography in Canada. A crew poses on their craft, with a reconnaissance camera ready for shooting obliques.

Development in Canada — Aerial photography caught on early and quickly in Canada mainly because of the pioneering efforts and foresight of Captain E. Deville, surveyor general of Dominion Lands in Canada, from 1885 until his death in 1924. Deville was a brilliant scientist, inventor and administrator. At the start of his career, for example, maps were plotted using photographs taken from mountain tops. By the 1920's regular air photography flights for mapping and forestry inventory had been established across the country, largely because of Deville's efforts and firm belief in the potential of this new surveying method.

It was Britain's donation of a few wartime flying boats and the formation of the Air Board of Canada in 1919 that got aerial photography off the mountain tops and into airplanes in Canada. The Air Board, responsible for the control of commercial and nonmilitary government flying, together with Deville's department, organized the first experimental survey over Ottawa in 1920. The results were sufficiently encouraging to establish aerial photography as a revolutionary topographical surveying method. Because of this development, Canada today has one of the most comprehensive storehouses of aerial photographs in the world, for the benefit of all users.

Over the years, aerial photography surveys were made on a regular basis for mapping, charting of the sea coasts, building of highways, town planning and any ground activity where a measure of size or change must be made.

Today, the provinces have their own annual aerial photography programs. Private forestry and mining firms also run surveys. However, the federal government commissions the most comprehensive air surveys. These complement provincial plans and fulfill a national interest.

An aerial photograph, in broad terms, is any photograph taken from the air. But, what makes one photograph differ from another of the same area? The answer is scale, overlap, type of film, verticality and season of photography.

Scale — Scale is the ratio of a distance measured on the photo to the corresponding distance on the ground. The greater the scale of the photo, the more detailed is the image. Scale is governed by the elevation above the ground at which the photo was taken and the focal length of the camera lens. There are two methods used to express scale. One is to indicate in inches, or fractions of an inch, on the photo, the number of miles represented on the ground. For example, a popular scale used in photography for provincial land inventory purposes is the four-inch scale, meaning that four inches on the photograph represent one mile on the ground. A scale can also be represented as the fraction of the proportion of photo distance to true distance. For example, a scale of 1:6,000 means that one inch on the photograph represents 6,000 inches on the ground. The scale of any aerial photograph can be calculated by comparing it with a topographic map of the same area as illustrated in Figures 4 and 5.

Exercise — Two points, as widely separated as possible, which can be identified on both the map and the photo, have been chosen so that you can calculate the photograph's scale (see circled road junctions on both map and air photo). To get the scale, first take the edge of a piece of paper and carefully mark off the distance between the two road junctions on the map. Measure the distance on the map scale; it will be found to be approximately 4,840 yards. Now measure the distance between the two road junctions on the air photo; it will be found to be about 4.81 inches. It is now apparent that on the aerial photograph 4.81 inches equal 4,840 yards, or 14,520 feet.

$$\text{Therefore 1 inch} = \frac{14{,}520}{4.81}$$

$$= 3{,}010 \text{ feet}$$

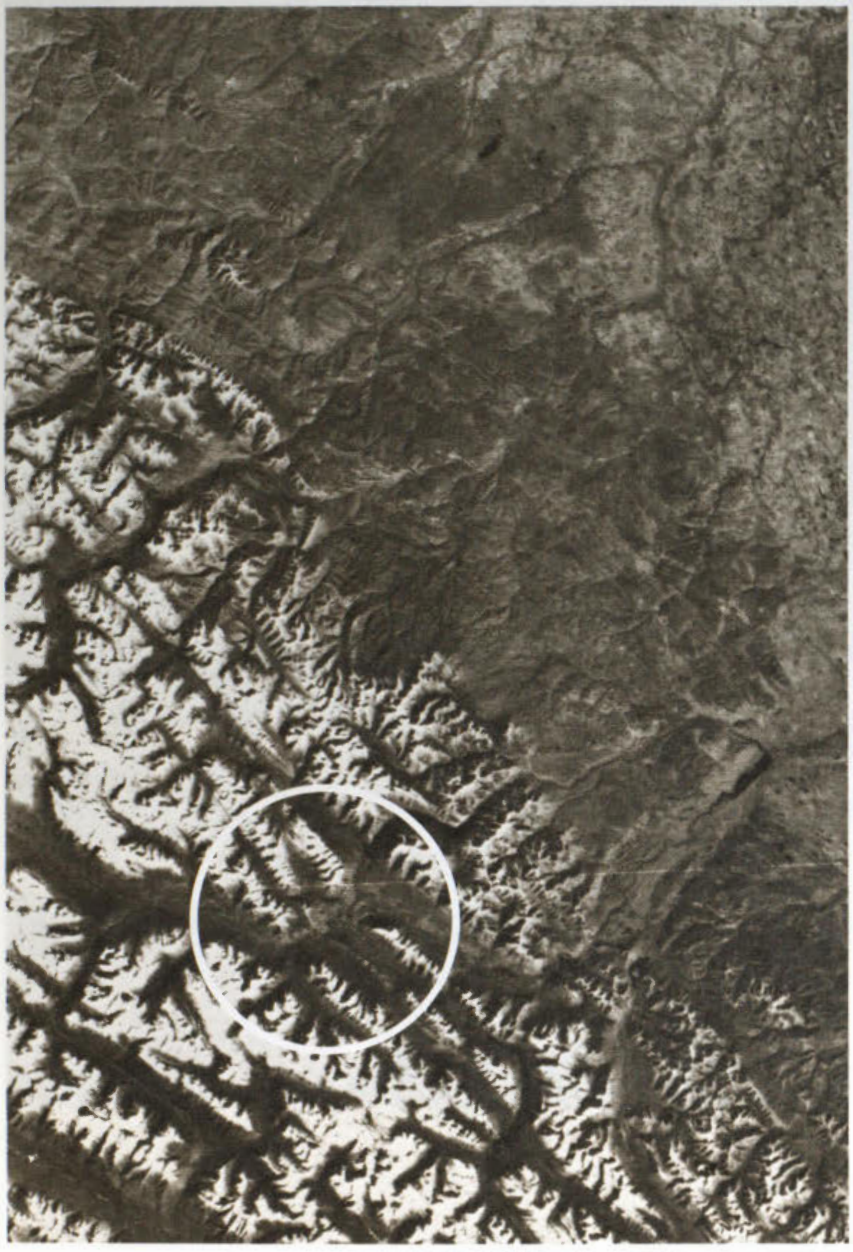
This can also be expressed as 1 inch = 36,120 inches, giving the approximate scale of 1:36,000.

Overlap — Overlap is the amount by which one photograph includes the area covered by another photograph. It is usually expressed as a percentage and plays an important role in photograph coordination because one point on the ground appears in at least two photographs giving them a common tie. The flight path generally is designed to provide about 60 per cent forward overlap between photographs. This allows stereoscopic viewing when the two overlapping photographs are placed in a stereoscope. In addition, from 20 to 40 per cent side overlap is allowed when complete coverage of an area is required. For mapping, inventory and vegetation studies, for example, the survey is flown in a series of to-and-from parallel strips with side overlaps between strips over the entire area. The resulting pattern is as if someone were cutting a lawn. For nonstereoscopic coverage, as in crop sampling or pollution detection, the photographer may make only 20 per cent forward overlap.

Film — Black-and-white, as well as color film, is used for mapping purposes. Normal color film, which registers colors as seen by the human eye, is often preferred for any application where identification of shapes must be made quickly and accurately. It helps to differentiate one type of tree from another in forest inventory, for example.

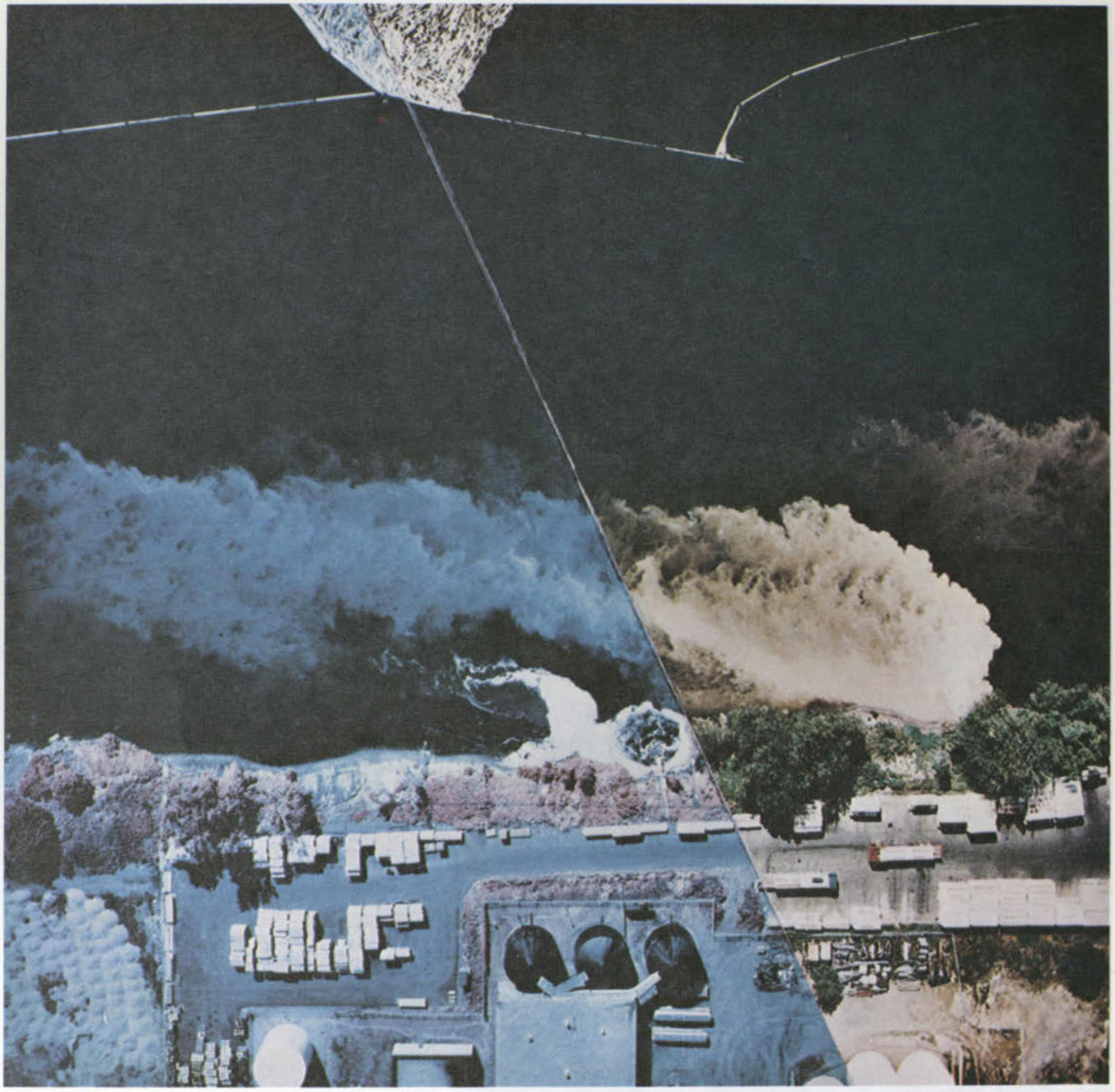
Figure 2.
Scale is an important feature to specify when ordering aerial photographs. It varies according to the height of the aircraft when the photograph was taken. Banff, Alta., is shown from a low-altitude flight of 12,000 feet, a high-altitude flight of 35,000 feet, and from the LANDSAT-1 satellite.

"False" color film, on the other hand, which is sensitive to near-infrared radiations, registers the chlorophyl content of healthy vegetation in reddish tones rather than in the actual green. It is used by experts to identify diseased or fume-damaged plants and trees. Black-and-white near-infrared film, too, produces a different image from conventional film and is specified by photograph identification of shapes through light haze or smog, for example.



Season of Photography — What is the best season for aerial photography? There probably is no best season because each season produces certain image effects impossible to duplicate at any other time of year. In winter, snow and ice increase the contrast between land types such as open plains and wooded hills but they obscure land detail and often make it difficult to distinguish between land and water. Spring is the best season for the study of the ground, or for the identification of trees, because details of branching, etc., can be more accurately observed. Most photographs filed in the National Air Photo Library are taken in the summer partly because of weather and partly because the appearance of coniferous vegetation remains constant during this season. Too, agricultural crops, fruits and flowers, for example, can be photographed best at their height of growth in the summer. For example, corn and potato fields can be confused when the corn is young, but when the corn is full grown, the difference is obvious. Fall, like spring, is a period of rapid change in the appearance of vegetation that often makes identification of tree types deceiving. But, as soon as the leaves have fallen, the obscuring effect of vegetation is again at a minimum and it becomes a good time to photograph topography and soil surface.

Verticality — Most of the photography on file at the National Air Photo Library is vertical photography, that is photography exposed with the axis of the camera pointing straight down. A limited number of scenic or oblique photographs are available. An oblique photograph has the axis of the camera pointed toward the horizon.



Canada Mosaic

Figure 3.
Normal and "false" color films record two versions of the same scene. To the right, normal color shows the scene as it appears to the human eye. To the left, false color records near-infrared radiations.

The Reproduction Centre (NAPL) has prepared a series of photomaps, using LANDSAT (satellite) imagery, which cover Canada south of 80 degrees latitude. Considering Canada's land mass of 3.85 million square miles, this is the largest undertaking of its kind in the world. Out of a total of 40,000 satellite images available, 1,004 were assembled in mosaic form.

The mosaic images were chosen on the basis of snow, ice and cloud-free conditions, except in the case of the Arctic Islands where imagery for the months of July and August was selected. This selection did not provide complete arctic coverage and for some areas it was necessary to use imagery showing frozen lakes or some snow coverage.

The country was divided into 12 segments conforming with major geographic or political boundaries, and mosaics were produced at a scale of 1:2.5 million. Also available is 1:2.5 million Manitoba sheet prepared from winter imagery, a 1:1 million sheet of both Newfoundland and the Maritimes from summer coverage, a 1:10 million print of the entire nation, a 1:5 million print of the entire nation, and a series of 1:1 million N.T.S. primary quadrangles. The primary quadrangles are available as continuous tone prints with borders defined by the N.T.S. grid and containing an overlay of map information to provide certain name, evaluation and geographic detail.

The mosaics have an accuracy relative to the 1:1,000,000 aeronautical chart base of approximately 1 to 1.5 kilometres. They are an excellent educational medium, as a base for exploration or planning, or for display or presentation purposes.

Which is better — a map or an aerial photograph?

If the aerial photograph is so useful and so detailed, why bother with the line map? To answer this question, compare the type and amount of information given on the aerial photograph in Figure 5 and the map in Figure 4. Look at the southwest part of the map first. This is heavily wooded country, with occasional swamps among the trees. If you were a prospector moving through the area, the only definite landmarks you could find on the map would be the streams. Most of the time you would not be able to determine your exact position from the map information alone.

Now look at the aerial photograph. You will note that the photographic detail discloses a wealth of information, and, with practice, a person could move through this country and know his position exactly by locating the clumps of trees, little clearings and patches in the bush that can be seen on the photo. Prospectors, foresters, and others working in wooded areas have long preferred the aerial photograph to the line map.

However, continuing to look at the aerial photograph, see if you can locate: four gravel pits, a mine, a golf course, a post office, and a cemetery. All of these are easily found on the map because they have been located and symbolized by the topographer. Moreover, although the aerial photograph may give a vague idea of the hilliness of the terrain, the actual positions and heights of the hills are shown only by the contour lines on the map. The actual height above sea level of any point on the map can be closely estimated by noting the contour numbers and calculating between them.

10 Also look at the east edge of the map, and note the power line indicated by the dashed line and the black dots between every fourth dash. On the photograph the position of this line can be seen because hydroelectric engineers have cut a swath through the bush. This "cut-line" is evident in the photograph but it takes the map to tell why it is there.

Now look on the map at the west bank of the large river running through this area. The map shows the Canadian Pacific Railway line running very close to the bank. The position of this railway line can be seen in the photograph, but it might be confused with a road. Actually, experienced aerial photograph interpreters can generally tell the difference between a road and a railroad because the latter has gentler curves and easier grades. However, no interpreter could tell whether this was a CN or CP line.

Look now at the left edge of the map. A grey band indicates the existence of a township boundary. Is this boundary evident on the ground? A very faint line on the photograph shows that a line has been cut along the survey line marking the township boundary. Also note how thin this cut line is compared to the one previously noted under the hydro wires.

From this exercise, you can see that both maps and air photos have their own usefulness, and the information in one augments and complements that in the other.

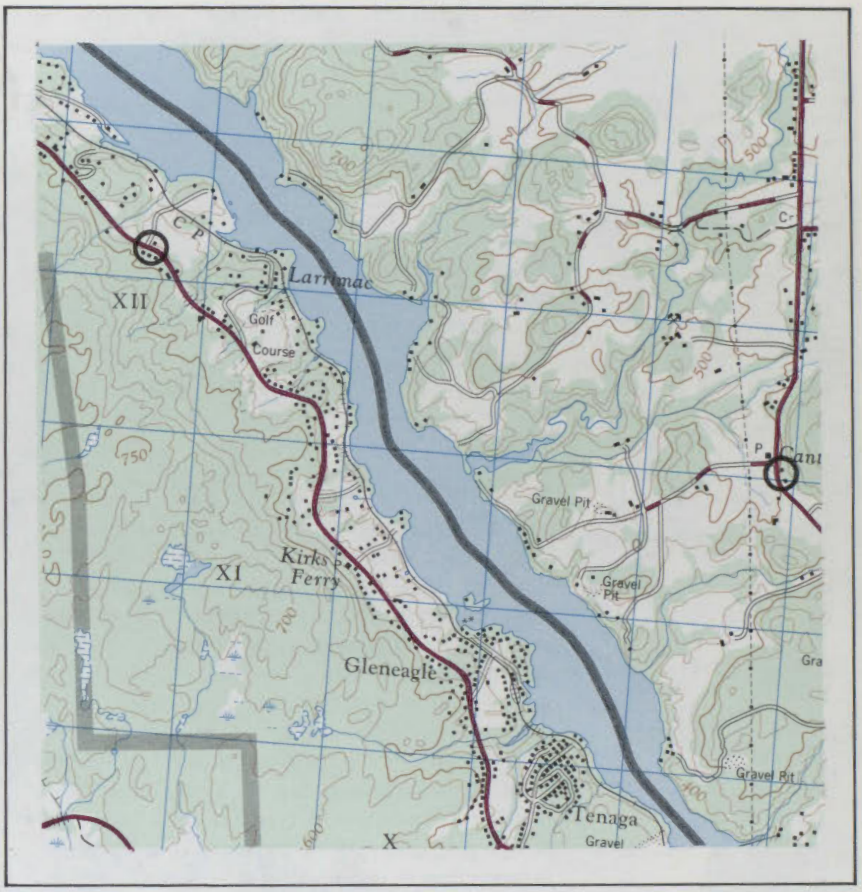


Figure 4.
Part of the Wakefield, Quebec, Sheet, Scale 1:50,000, made from the air photo in Figure 5.

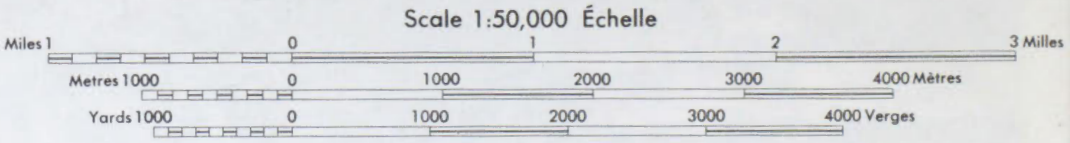


Figure 5.
Air photo taken 18 May, 1964 at a height of 18,000 ft., scale 1:36,000.

Interdepartmental Committee on Air Surveys, the National Air Photo Library and the Reproduction Centre (NAPL)

In 1925 the Interdepartmental Committee on Air Surveys and the National Air Photo Library were established to take charge of all nonmilitary, federal, air-photo activities. Originally part of the Department of the Interior, they are now key sections in the Department of Energy, Mines and Resources. And if today Canada has the competence to participate actively in the most advanced air-survey programs, it is largely because of the consistent effort made by the Interdepartmental Committee on Air Surveys and the National Air Photo Library to keep Canada in step with the latest happenings in this field.

Interdepartmental Committee on Air Surveys — This committee coordinates all federal air photography and works together with the provinces to align federal and provincial programs. It prevents duplication, if necessary establishes priorities and, in general, ensures that maximum benefit is derived from each flight. It also encourages and funds research and development in air photography and associated activities. Until 1956 many photographic surveys were flown by the Royal Canadian Air Force. Since then, however, all aerial photographs used in mapping are contracted to commercial survey firms. The committee puts each project out for tender, sets the specifications and inspects the results before payment. For mapping, for research and for environmental control, the federal government initiates the bulk of aerial photography in Canada; the Interdepartmental Committee on Air Surveys supervises and determines the contractor who will do the photography and the specifications he will follow.

National Air Photo Library — The National Air Photo Library is unique and fascinating. It functions as an archive, a record centre and an order office. Here, over four million aerial photographs of Canada, taken over the last half century, are indexed and stored. Each photo is cross-referenced to an index map or flight report that indicates the exact flight path and flight altitude; identifies film type, film number, photo centres, and specifies date, time of exposure, camera and weather conditions for that particular run.

In order to provide the users of aerial imagery with up to date information of the latest photography available, the National Air Photo Library has published a series of General Coverage System catalogues containing basic information on the photo coverage available from NAPL. One catalogue has been prepared for each of the provinces or territories, as well as a catalogue listing the Airborne Remote Sensing imagery for all of Canada. Each catalogue provides a graphic display of all of the aerial photo coverages exposed since 1966, and includes selected photography exposed prior to 1966, which is required to complete the single photo coverage of Canada. The catalogues are updated annually.

To compliment the coverage catalogue system, the library has also microfilmed a complete aerial coverage of Canada. The index maps showing the relative ground positions of these photographs have been placed on color microfiche. Interested users may buy these cassettes of microfilm or the microfiche cards for their own use, or they may view the cards or order the prints they want, at the National Air Photo Library. Soon, various reference centres will be established across Canada as an extension of the service.

Each cassette may contain several rolls of photography with up to 2,400 images; the microfiche cards display up to eight index maps. The microfilm-microfiche system allows users and agencies to have as complete a reference system as they may require, without using the volume of space normally associated with an archive reference system. This new system allows a user to maintain aerial imagery of all of Canada, or of a particular geographic location.

Reproduction Centre (NAPL) — The Reproduction Centre, one of the most modern photographic laboratories in the world, produces all the imagery ordered by the National Air Photo Library in response to customer requests. The key to the Reproduction Centre's usefulness and flexibility lies in its ability to supply images of any type and of any location in Canada. The more than four million original film images stored in its environment controlled vault have been collected over the past fifty years to meet the requirements of the national aerial survey program, the airborne remote sensing program, and the LANDSAT (Earth Resources Technology Satellite) program. The Centre's role in

Figure 6.
Users of aerial photography can study microfilm, showing a complete aerial coverage of Canada, and microfiche index cards through viewers like these at the National Air Photo Library. Such systems provide a reference system without the space requirement of an archive reference system. They also facilitate the ordering of aerial photographs.

How to order an aerial photograph

these programs is at the end of the data acquisition process and involves producing a hard copy image which can then be used for specific purposes.

Present day airborne and satellite imagery is in use by practically all scientific disciplines as an economical data source for investigations, engineering projects, resource development and inventory programs, pollution and water studies, and a multitude of other non-mapping purposes.

To satisfy the requirements of new applications for specialized products, the Reproduction Centre has performed extensive experimental work and has introduced the use of a variety of new sensitized materials and processing procedures to the Canadian aerial survey and remote sensing community. In meeting these requirements, and those of the general public and private industry, the Centre operates a wide range of sophisticated printing equipment and employs the latest processing techniques to produce more than a million black and white and color photographic reproductions each year.

The library handles all inquiries for information on federal aerial photography and processes all requests for federal aerial photographs, microfilm cassettes and microfiche cards. The library and the reference centres are open to the public. Here one can view the photographic image of 50 years of Canada past and Canada present, side by side.

Full information on photographic coverage, prices and photographic products may be obtained from the library or the reference centres. Prints and enlargements, photo mosaics, microfilm cassettes, microfiche cards and copies of index maps on file at the National Air Photo Library can also be ordered at a nominal charge from these locations.

If you simply want to order *prints of aerial photography* from the library, the procedure is as follows:

1. Mark the area of interest on a suitably scaled topographical map obtainable from the Canada Map Office, 615 Booth Street, Ottawa, Ontario K1A 0E9.
2. Make a notation on the map to indicate what specific feature, lake, landmark, house or area should be visible in the photo. The more precise the information, the better the chance of getting the right photographs. Because much of Canada has been photographed more than once, you should also state that you would like the latest photograph, or the photograph with the largest scale, if you are not concerned with recent changes in the topography.
3. Write your name, company (if applicable), address, telephone or telex number together with the following photographic details:
   a. Is the coverage required stereoscopic or nonstereoscopic? If nonstereoscopic, only every other photograph along a line where 60 per cent forward overlap has been used needs to be purchased.
   b. The purpose for which the photograph is required. Perhaps you have not made the best choice as to color, scale, etc., relative to what is available, for your needs.

Figure 7.
Eastern Canada from a mosaic of photographs taken from the satellite LANDSAT-1. The circle almost in the centre is formed by lakes filling a crater called the 'Manicouagan Impact Structure', which was caused when an asteroid collided with the earth 210 million years ago.

Reference Centres

c. Should the print be:
- full negative (9 in. × 9 in.) or enlargement (excellent results are obtainable for up to 5 times contact size).
- black and white or normal color (if available); false color (if available).
- preferred scale (if choice available) or latest coverage on file:
  large scale (more detail)
  small scale (greater area)

d. Send map together with pertinent details to:

National Air Photo Library
615 Booth Street
Ottawa, Ontario K1A 0E9
Telex: 053-4328
Telephone: 613/995-4560
613/995-4552

The map will be returned when the required photography has been selected. The photographs will be forwarded as soon as processing permits.

If you would like any portion of an aerial photograph *enlarged,* mark it on the photograph and send it to the library. The portion must fall within a square between 2 in. to 8 in. in size with the sides of the square parallel to the sides of the picture.

Various catalogues and publications that illustrate the use of aerial photography are also available through the National Air Photo Library and will be forwarded on demand.

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Att: Map and Air Photo Sales Office
Telephone: (604) 387-3174

Maritime Resource Management Service,
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