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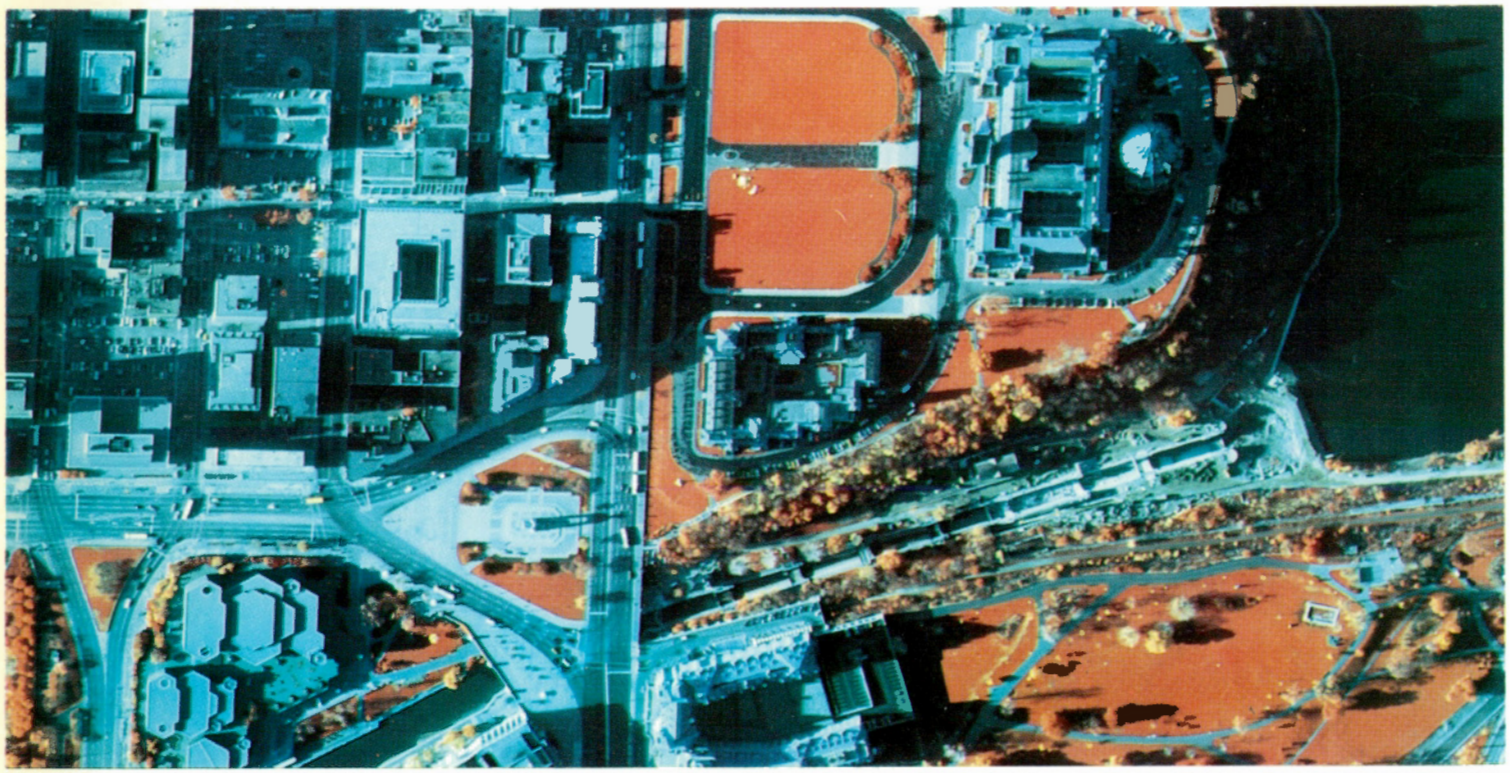

CANADA CENTRE for REMOTE SENSING AIRBORNE PROGRAM

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COVER – MEIS II image of Ottawa showing Parliament Hill (upper right).

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Introduction

In July 1969 the Canadian Department of Energy, Mines and Resources (EMR) established an Interdepartmental Committee on Resource Satellite and Remote Airborne Sensing, supported by a program planning office. In 1970, this office instituted an Airborne Remote Sensing Program. From modest beginnings, the Canada Centre for Remote Sensing (CCRS) began operations in 1972 with the mandate to carry out an integrated remote sensing program. The program comprised acquisition of remotely sensed data from airborne and satellite platforms, development of sensor systems and methodologies for treatment and interpretation of data, and development of new applications for remotely sensed data.

One CF-100 aircraft, owned by the Department of National Defence, with a limited sensor capability, was flown in 1970 in support of 12 projects. By 1975 two DC-3s, a Falcon-20 and a Convair-580 had replaced the CF-100. Innotech Aviation Limited was contracted to operate and maintain the aircraft. With the exception of one DC-3, now retired, the current fleet is unchanged. Descriptions and capabilities of the aircraft are outlined in a technical supplement.

The original complement of airborne sensors consisted of one super wide angle metric camera, four 70 mm cameras and an infrared linescanner. The inventory now includes:

- aerial cameras
- a multispectral scanner
- a pushbroom imager
- a bathymeter
- a terrain profiler
- microwave scatterometers
- a multispectral synthetic aperture radar system

Each of the current operational sensors is described in a technical supplement. These sensors are complemented on board the aircraft by inertial and very low frequency radio navigation systems, which allow precise determination of the geographical location of any feature in the remotely sensed data.

The Airborne Program

The Airborne Program provides a comprehensive and coordinated service which acquires airborne imagery. Resources of the Airborne Program are committed to supporting programs that develop new techniques and applications of remote sensing for federal and provincial governments, universities and industry. Equally important is the in-house development and flight testing of new sensors, development of new data-handling and interpretive methodologies, and introduction of new applications. Although the responsibility for the Airborne Program rests with the Data Acquisition Division (DAD), activities are divided functionally among the following groups.

- The **Airborne Operations Section*** coordinates airborne data-acquisition flights by receiving flight requests, resolving technical difficulties, preparing a résumé of the request for approval by the Airborne Project Review Team and instructing the contractor to perform flights on approved projects. The section provides quality control of data, indexes and annotates imagery, produces quick-look products from tape-recorded data, coordinates data processing and reproduction, and ensures timely delivery of data products to the user.
- The **Airborne Project Review Team**, consisting of one member from the Airborne Operations Section and one from the Applications Technology Division, reviews each external request for a data-acquisition flight and recommends acceptance or rejection by CCRS.
- The **Airborne Project Review Committee**, chaired by the Deputy Director General of CCRS, has members from each division of CCRS and includes the APRT. This committee sets criteria for airborne project acceptance, resolves conflicts and reviews operations of the Airborne Program. Any disagreement with a Review Team decision may be directed to the committee chairman.
- The **Sensor Section*** maintains, calibrates and modifies existing airborne sensors, develops and commissions new airborne sensors, and establishes procedures for operating these systems.
- The **Airborne Systems Section*** modifies and updates sensor interfaces to aircraft systems. The section also develops data-recording systems and aircraft track recovery software.
- The **Digital Methods Division** develops and operates processing equipment required to transcribe information on to computer-compatible tapes (CCTs), since data from many of the airborne sensors are recorded on high-density digital magnetic tape, which is not directly usable by investigators. The data are then analyzed on other facilities within the Centre or elsewhere. Synthetic aperture radar data are processed through to image form using either a specialized digital system or an optical processor.

*Part of the Data Acquisition Division

- The **Applications Technology Division** scientists work directly with user agencies to carry out multidisciplinary projects. The projects provide an opportunity for testing new remote sensing techniques and applications to resource management. Resource managers and environmental scientists can use the most up-to-date equipment at the Division's data analysis laboratories. Equipment consists of both conventional analogue photointerpretation equipment and complex computer-controlled systems for satellite and airborne data analysis. A Technology Enhancement Program helps provincial and territorial governments integrate remote sensing technologies developed by CCRS scientists into operational resource management procedures.
- The **RADARSAT Project Office** is an interdepartmental undertaking managed by EMR to design, construct and operate a remote sensing satellite system with a synthetic aperture radar (SAR) as its principal sensor. In collaboration with DAD, RADARSAT has developed a new C-band airborne SAR and a C-band scatterometer to collect data in support of the ultimate satellite sensors. RADARSAT also operates a small image analysis facility, particularly useful for analysis of SAR imagery.

CCRS hires a contractor to provide flight crews, maintenance personnel, sensor operators and technicians for all CCRS aircraft. The Airborne Operations Section directs all remote sensing flights.

All original photographic imagery obtained on remote sensing flights are reproduced, stored and retrieved by the **National Air Photo Library**, part of the Surveys and Mapping Branch of Energy, Mines and Resources Canada. The **National Air Photo Reproduction Centre** processes all original imagery and reproductions to user specifications. The film is stored in an archive vault within this facility.

How to request airborne data

To use the Airborne Program's services, the client contacts the Airborne Operations Section to outline the overall requirements and check the availability of aircraft and sensors at the desired time. First-time users will be referred to appropriate groups within the Airborne Program for assistance in experiment design, data reduction methodology and interpretive techniques. A technical supplement explains the formal request procedure for an airborne remote sensing flight. The Airborne Project Review Team considers the request and accepts it in one of four categories described below. Subject to weather and aircraft schedule, every attempt is made to collect data under the client's specified conditions.

When the aircraft returns to its Ottawa base, quick-look imagery is produced so that data quality may be assessed and the user can select those regions which will be transcribed to computer-compatible tapes (CCTs) for further analysis. At the same time any aerial photographic imagery is processed. Quick-look imagery, processed photography and CCTs are the standard products of the Airborne Program. For analysis, interpretation and display of these data, the client is directed to facilities provided by other programs within the Centre. In addition, many agencies and institutions, as well as private industry, are now able to handle airborne data effectively and may provide special services not available through CCRS.

Airborne project categories

Airborne projects are accepted in four categories depending mainly on the method of cost recovery.

- **Internal CCRS Projects** are research and development projects originating within CCRS.
- **External Projects** which the Airborne Project Review Team deems to be research may be flown under a scheme which assists development of new applications of airborne remote sensing by reducing the user's total cost. The Principal Investigator is charged a fixed rate for each line-kilometre flown with sensors operating, plus costs of data processing and consumables. There is no charge for transit to and from the project area. External Airborne Projects are accepted under the following criteria:

- *The project must be experimental or research oriented, and the airborne data must make a potentially significant contribution to the science of remote sensing or its applications.*

- *The requestor must provide the Airborne Operations Section with background information and an assessment of the project's expected benefits. Such a benefit could be that the interpretive methodology being developed, with the help of the airborne data set, will result in significantly lower overall costs in a resource monitoring application. Hence there might be a strong probability that the new technique would become part of an accepted operational procedure and provide a commercially viable product.*
- *The project must be beyond the capabilities of Canadian industry. Normally this will exclude projects that use a photographic camera, infrared linescanner or X-band side-looking radar as the primary sensor.*
- *The requestor must be capable of using and analyzing the data and must agree to report the experimental results to CCRS.*
- **Lease Projects** are generally large operations for which the Canadian remote sensing industry does not yet have aircraft or sensors. CCRS has entered into a "dry leasing" agreement (aircraft and sensors only) with an aircraft operations contractor who in turn can "wet lease" (complete with crew, fuel and supplies) the aircraft to Canadian companies involved in aerial survey or remote sensing. Any company that does not normally provide a remote sensing service, and wishes to use the latter leasing facility, is recommended to work in conjunction with a Canadian remote sensing company. Hourly rates, set by the aircraft operations contractor, are approved by CCRS. CCRS does not normally supply flight maps or consumables, or process any flight data from lease projects. Arrangements for those services and any inquiries regarding scheduling, flight data, and invoicing must be directed to the contractor.
- **Cooperative Projects** are carried out by CCRS and other Government of Canada departments. Costs, recovered through interdepartmental transfers of funds, are based on a fixed rate for each aircraft hour flown (including transit) plus the cost of processing and consumables. Other costs such as crew travel expenses are recovered the same way.

Cost recovery

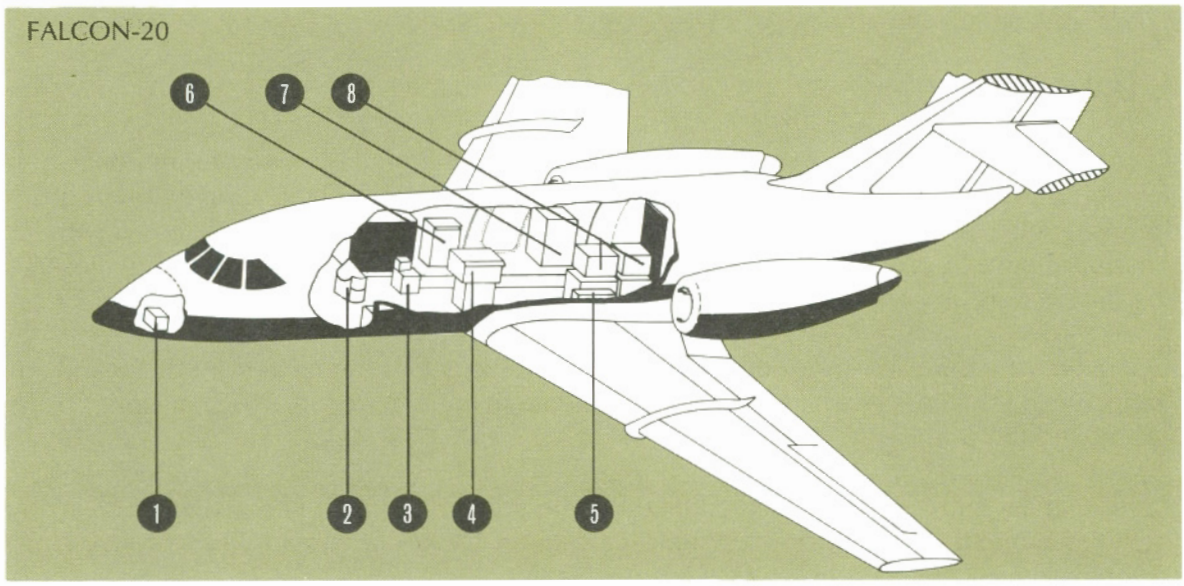
Costs for services provided have always been held to a minimum in order to introduce remote sensing techniques to the Canadian scientific community. Beginning in 1973, a line-kilometre charge has been applied in the External Project category. In keeping with Treasury Board directives, the charge has been increased gradually to reflect more closely the data acquisition costs.

Operation of the aircraft for Cooperative and Lease Projects is not funded by CCRS and so all incremental costs associated with the additional flying required in these categories are charged to the user.

Consumables, processing and reproduction of the final imagery are charged at CCRS cost in both the External and Cooperative Project categories. Details of current cost and invoicing procedures are contained in a technical supplement.

FALCON-20

CONVAIR-580

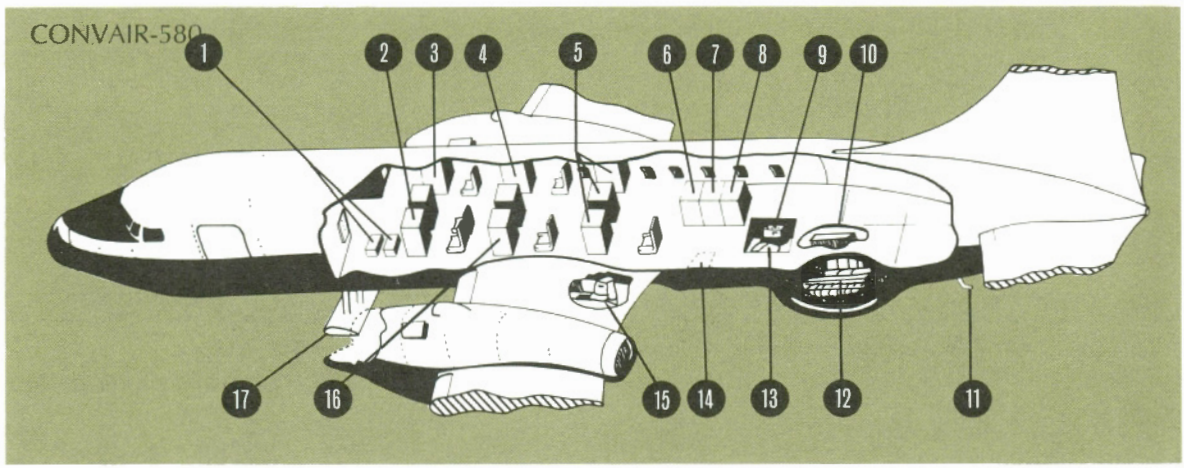


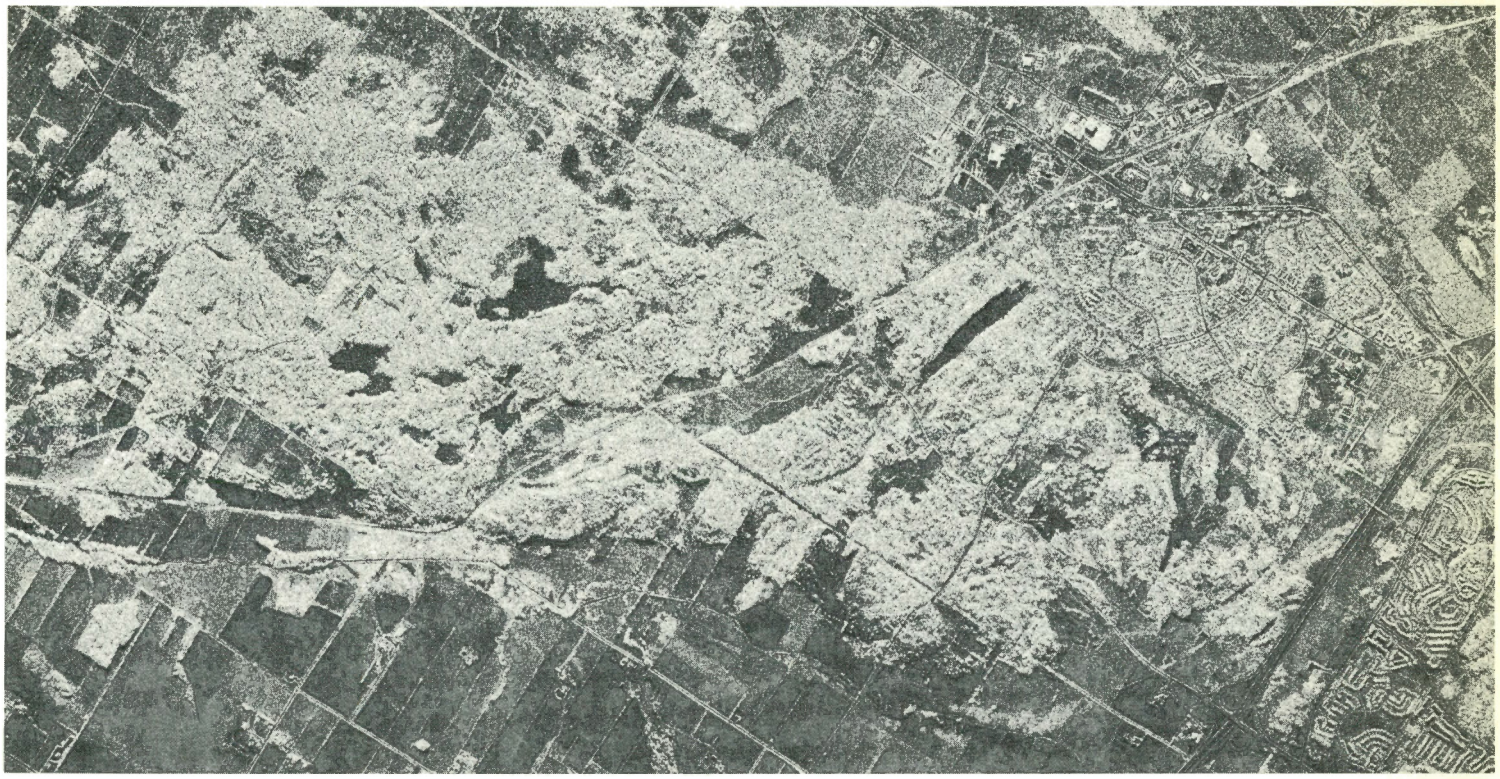
Cutaway view of the Falcon-20 aircraft showing systems used in a typical visible/infrared remote sensing project. The pushbroom imager (MEIS) or the multispectral scanner (MSS) is the principal sensor on all projects flown with this aircraft.

1. Multispectral Scanner (MSS-Daedalus 1260)
2. Metric Camera (RC-10)
3. Pushbroom Visible Imager (MEIS II)
4. Mission Manager's Console (camera controls and navigation data logger)
5. Inertial Navigation System
6. MEIS Console and Real-time Display for MSS and MEIS
7. MSS Console
8. High-Density Digital Tape Recorder
9. Navigation Data Logger Tape Recorder

Cutaway view of CV-580 showing location of sensor systems used during typical microwave remote sensing projects. The synthetic aperture radar (SAR) is the principal sensor on most projects flown in this aircraft.

1. High-Density Digital Tape Recorders for SAR and Scatterometer Data
2. C- and Ku-band Scatterometers
3. Navigation Rack
4. SAR Real-Time Processor
5. SAR Electronics
6. SAR X-band Transmitter
7. SAR X-band and C-band Receiver
8. SAR C-band Transmitter
9. Microwave Radiometer
10. Inertial Navigation Unit
11. Global Navigation System Antenna
12. SAR Antennas
13. Metric Camera (RC-10)
14. Ku-band Scatterometer Antenna
15. Downward-looking Low Light Level Television Camera
16. Navigation Data Logger (MAID)
17. C-band Scatterometer Antenna





C-band synthetic aperture radar image of Kanata, Ontario showing urban, agricultural and forested land.

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