Ground Data Handling Centre of the Canada Centre for Remote Sensing, a branch of the Department of Energy, Mines and Resources.

But is this "photography" from space simply a continuation of more mundane aerial photography? The answer is an unqualified "no". Imagery from a satellite hurtling around the globe at more than 16,000 miles per hour with data retransmitted by radio back to earth prior to reproduction is much more precarious than photography from an aircraft cruising at a few hundred miles per hour with photographs subsequently delivered and processed in a darkroom. Moreover there are frequent cases where satellite photographs cannot be used without corrections being made — and if these corrections are neglected, ecologists and resource managers may be provided with misleading information with costly consequences.

Dr. Vladimir Kratky's objective was to give the Canadian user undistorted multispectral images of the whole mosaic of Canada. His unique contribution to Canada's ERTS program was to determine what factors were affecting the geometry of the photographs and film received from ERTS and then to provide methods for the computer processing of the rough satellite information in order to rectify the distortions and render the ERTS data more useful.

The principal sources of errors for both RBV and MSS images were analysed separately by Dr. Kratky. This analysis enabled him to draw up a model — an analytical description in the form of a set of equations — of how the image is distorted in two dimensions. Through a special computer program (involving the appropriate sets of equations taking into account these errors) which was prepared at the Canada Centre for Remote Sensing under his supervision, the source information from the ERTS-1 satellite can be corrected automatically for these distortions as the image is being generated.

The program is so designed that two passes of the source information through the computer are sufficient to give corrected images. On the first pass, the rough satellite information is reproduced in its rudimentary photographic form. Next, ground map information on the particular scene is fed into the computer together with calibration data. The computer then compares the uncorrected photograph with the analytical model and prints out a tape containing the information on all the corrections needed. On the second pass the major errors involved in satellite photography are rectified.

What are these errors? Dr. Kratky explains: "The RBV still photos from the satellite involve the frozen geometries of individual bundles of rays — this is the most common case which photogrammetrists deal with. Aside from errors inherent in the instrumentation itself — camera, transmitter to earth, receiving-station recorder and reproducer — an important error crops up in the scanning of the electron beam over the RBV faceplate where the image is formed. Note that the RBV shutter speed is so fast that no appreciable error is introduced because of the satellite's velocity. But the three RBV cameras are not exactly vertical and this introduces a projective distortion. A special stabilizing subsystem keeps this error low, below the level of the electronic distortion associated with the scanning electron beam.

"The multispectral scanner is much more difficult to deal with," Dr. Kratky says. "Here more serious errors arise because of the dynamics involved. The basic sensing part of the MSS system is in constant, complex motion as the satellite continues its orbiting. The MSS scans the cross-track or width of the strip whereas the satellite movement provides the long track or length. The geometry is not frozen as with the RBV's but varies with time.

"With the MSS cameras, then, in addition to basic insufficiencies in the extremely complex MSS instrumentation, appreciable distortion stems from the time the satellite needs to scan the earth's surface," Dr. Kratky says. "This distortion, the most serious for the MSS, shows up as a skewness due to the earth's rotation during the scan. In addition cartographic distortion occurs because the earth's curved surface is squashed on the film into two dimensions, whereas for standard mapping purposes the images need to be in the universally accepted Universe Transverse Mercator (UTM) system which involves cylindrical projections. There is also critical distortion due to inevitable changes in attitude (i.e. in the satellite's pitch, roll and yaw) made all the more complex by the dynamic process of scanning.

"Lastly, the photographic data is received and reconstituted into a picture by an electron beam image reproducer. Here again the picture undergoes distortion because of irregularities inherent in the use of electron beams for scanning, but this error is known from calibrations carried out prior to the experiment.

"Our main aim" says Dr. Kratky, "is to provide the user with multispectral images such that the real position of any point on the image can be determined within 250 yards on the terrain as determined in the UTM co-ordinate system. We are quite close to achieving this at the moment.

"ERTS-1 has opened up a new area for photogrammetry. For the first time we are dealing with dynamic geometries on a large scale — this means photogrammetry where the usually neglected time factor plays a key role. But although the field is new and there was little background material available, the solution developed here was essentially an extension of knowledge in analytical photogrammetry. And analytical photogrammetry was already a well-developed field at NRC."

Dr. L. W. Morley, Director of the Canada Centre for Remote Sensing, Department of Energy, Mines and Resources summed up Dr. Kratky's contribution to Canada's ERTS program in these words: "The design and implementation of the Canadian ERTS ground data handling system was a model of inter-departmental and industrial cooperation. Having the advantage of knowing the detailed design of the NASA system, Canadian scientists were able to make technical improvements and financial savings in their design. Dr. Murray Strome of the Canada Centre for Remote Sensing was responsible for the overall design of the Canadian system. Computing Devices of Canada Limited, an Ottawa electronics company, supplied a team of 30 scientists, engineers and technicians who provided the design of electronic circuitry and actually put the system together. Dr. R. E. Barrington of the Department of Communications was responsible for the redesign of the Prince Albert Satellite Station which receives the data from the satellite. The Space Engineering Division of the University of Saskatchewan, under contract to the Department of Communications, was responsible for the integration of the satellite receiving station which had to be made compatible with the Ground Data Handling System in Ottawa, Dr. Kratky's long experience and knowledge in the science of photogrammetry ensured that the final system was able to meet the rigid standards which photogrammetrists have for a long time applied to their science of map making." ☐ Earl Maser