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AN EXPERIMENTAL LANDSAT QUICK-LOOK SYSTEM FOR ALASKA

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I. ABSTRACT

The new Landsat Quicklook System for Alaska is described. This low-cost simple system allows generation of full-resolution image products from real-time data input in a timely fashion. Preliminary evaluations have shown that when the imagery data is available soon after reception, many beneficial applications are possible.

II. INTRODUCTION

Since 1972, Landsat Multispectral Scanner (MSS) data has been applied to surveys of natural resources and land use patterns as well as to ocean and sea-ice studies. Many of the applications involve episodic events such as navigation hazards, fires, floods and volcanic eruptions. For these applications, timely availability of the imagery is essential.

At the present time, United States users are experiencing large delays (two to six weeks) between data acquisition and delivery. For this reason, the Geophysical Institute of the University of Alaska, in cooperation with NASA and with funds from the Alaska Legislature, is developing a program to accelerate the delivery of high quality Landsat images of Alaska.

Over the past two years, a preliminary evaluation of the potential benefits of delivering Landsat MSS imagery to users in less than several weeks has been undertaken. With only a modest effort, many good applications of the data were discovered. Based on these encouraging results, a Quicklook Image Recording System (QLIRS) has been specified, designed and built. The new system (see Figure 1) when interfaced to NASA's existing Landsat ground station at Fairbanks, will generate 1:1,000,000 scale, full resolution black and white images as well as reduced resolution color images.

The system is intended as a limited volume production facility for users of Landsat MSS data in Alaska. The state-funded program, which will first serve the needs of all agencies of the state, is not intended to acquire all the data that is relayed by the Landsat spacecraft over Alaska, but primarily data from targets of known near real-time interest (i.e., it is not a general acquisition and archival facility).

This paper first discusses the potential benefits of near real-time Landsat images and then describes the Quicklook Image Recording System, its concept, components and operation.

III. POTENTIAL BENEFITS OF NEAR REAL-TIME LANDSAT IMAGES

As a special demonstration project, transmission of quicklook Landsat images on a dial-up telephone line from the Prince Albert (Saskatchewan, Canada) ground station was arranged. The Canadian images supported the evaluation of benefits that could be expected from a quicklook Landsat facility for Alaska. Many important applications were developed, and some of them have the potential for further development.

A. FOREST FIRES

An obvious application of real-time Landsat images is monitoring the extent and growth of forest fires. The synoptic and multispectral coverage obtainable from Landsat data is especially valuable in determining the details of fuel mixtures, terrain and water bodies in the vicinity of a wildfire. The ability of the reflective (non-thermal) infrared sensors to penetrate moderate amounts of haze and smoke can provide surveillance when visual perception is obscured for airborne observers. In 1979, some 60 Landsat quicklook images were acquired by facsimile to support fire suppression, and in one instance, located an undiscovered fire. These images were useful for containment efforts by state and federal agencies on four major fires which charred nearly a half-million acres.

B. BREAKUP OF YUKON RIVER

The annual spring breakup of Alaska's rivers is an important social and physical event with great significance to village life in rural areas. An annual concern is the hazard of water and ice overflowing river banks upstream from ice jams which can occur at bottlenecks in the river channels. Routine surveillance by Landsat can aid in monitoring ice and river conditions and, in some circumstances, also enhance forecasts of potential flooding. In 1981 quicklook coverage of a major ice jam on the Yukon provided vital information relating to potential flooding at Galena. Images were furnished to the River Forecast Center of the National Weather Service and to the local news media.

C. GEOPHYSICAL HAZARDS

For the majority of Alaska's hazardous events, real-time Landsat images can be of great value to agencies responsible for informing the public and for mitigating the impact of the events. For example Strandline and Beluga Lakes on the west shore of Cook Inlet constitute an outburst threat from the damming action of Triumvirate Glacier. During the summer of 1979, we noted on real-time Landsat surveillance that Beluga Lake was enlarging. By July 1, we inferred that Strandline Lake probably was in the process of draining. An outburst flood downstream at the mouth of Beluga River in fact did occur about July 10, and this event made the headlines of the next Sunday edition of the Anchorage Times. Fish camps and an oilfield dock and roads located in the floodplain of the Beluga River were damaged by the flood.

D. NAVIGATION HAZARDS

Special hazards are posed to field parties deployed onto sea ice. Reconnaissance parties, seismic crews and exploration activities often work on the ice up to 100 miles or more from shore. Surveillance of ice conditions understandably is valuable in maintaining safety near the end of the ice season. Upon several occasions, satellite images have provided key information to support decisions to sustain and/or break camp and retreat toward shore.

E. AGRICULTURAL FORECASTS

As Alaska's agriculture develops into hundreds of thousands of acres of crops, there will be a need to maintain accurate acreage and crop-yield forecasts. Such forecasts, based upon the vagaries of weather, tillage and seeding activities, are made periodically throughout the growing season. The data which support forecasts of crop yields is of critical importance. When small acreages are involved, forecasts are customarily prepared from "windshield" surveys and interviews. Once Alaska's agri-business matures, Landsat, with its ability to survey vast areas instantaneously and record the variations in vigor and farming practices, should become an important part of crop forecasting--provided that the data can be made available repetitively and promptly with little delay. This could be possible only with products provided by a quicklook facility for Alaska.

IV. THE QUICKLOOK IMAGE RECORDING SYSTEM (QLIRS)

A. SYSTEM CONCEPT

Many of the present receiving and processing systems such as the U.S., Canadian and Australian ground stations, are intended for central government agencies which require high volume and high precision image production. The Quicklook Image Recording System is intended for relatively low budget groups which require data in a timely fashion. This inexpensive system generates partially corrected (radiometric and geometric), full resolution film or computer compatible tape (CCT) imagery (optional) under the supervision of one operator. The system is ideally suited for groups that have access to a receiving station and a computer on which imagery data can be further processed. In this case, the QLIRS system serves as an intermediate system to generate products (CCT) usable by the computer.

B. SYSTEM DESCRIPTION

The QLIRS (see Figure 2) is a microprocessor based system which accepts raw

MSS data at Real-Time (RT) rates and then reformats, corrects and outputs the full resolution data at a fraction of real-time (typically 1/4 RT). The data is radiometrically corrected for sensor striping, compensated for film gamma and contrast enhanced. Geometric corrections include line shifting to compensate for MSS sensor offsets and earth rotation. Capability for pixel and line replication allows the operator to select up to eight times enlargement. Images are produced with registration crosses, annotation and grey scale.

The system consists of seven major components (see Figure 3). The Landsat Image Formatter (LIF) performs most of the major functions, including operator interaction, image storage, image playback, image correction and image annotation. The LIF contains five microprocessors. One of these is the System Controller, which provides communication via the terminal with the operator, and issues appropriate commands to the various hardware units within the LIF. The other four identical microprocessors control the magnetic disk drives which provide for storage of Landsat scenes. Each of the four microprocessors controls two disks, each of which has a capacity of 66 megabytes, for a total storage of about 20 standard Landsat MSS scenes on 528 Mbytes of disk. The disks used are non-removable, "Winchester"-type. This technology provides relatively high speeds, low cost and excellent reliability, far in excess of current high-density tape recorders.

The LIF receives imagery data from the Landsat Format Synchronizer. This unit accepts the 15 Mbit/sec serial data stream, synchronizes to the video data and outputs the data in parallel form. The unit can also insert auxiliary data required if CCTs are to be produced.

The LIF also requires the spacecraft time which is decoded by the time code reader.

The corrected and annotated imagery data is output by the LIF to the Laser Film Recorder (FIRE 240) built by MDA. The FIRE is a monochrome, high-speed, high-resolution laser film recorder. It accepts digital input data and produces an image approximately 240 mm x 220 mm on roll film. The image produced is at a scale of 1:1,000,000 (without magnification) and the resolution is 4,096 pixels across-track by about 2,700 pixels along-track. The FIRE is capable of very high performance with a resolution of up to 16,384 pixels and speeds up to 36,000 lines per minute, or about 20 seconds per image.

Future expansion will allow for image data to be recorded on CCT.

The Moving Window Display Processor accepts high-resolution imagery from the LIF or from the Landsat Format Synchronizer and produces an output video signal. The video signal is used to drive the black and white monitor or the Matrix color camera. When the Moving Window Display Processor is driven by the format synchronizer, the black and white monitor provides an instantaneous view of the scene being acquired. The image displayed is of one spectral band, user-selectable, and can show the average of all six sensors in that band, or one sensor in full resolution along-track. Alternatively, when the processor is driven by the LIF, the black and white monitor can be used to display in reduced resolution the image being sent to the FIRE film recorder or to the Matrix color camera when it is used to generate a color image.

The whole system can be tested with the MSS Test Generator. This unit simulates the data from the Landsat Multispectral Scanner, providing a serial bitstream suitable as input to the Landsat Format Synchronizer. A variety of test patterns may be generated, including vertical and horizontal bars of width from one pixel to 128 pixels, stepped greyscales and crosshatch. The clock rate is variable from 100 bits/second to greater than real-time rate.

C. SYSTEM OPERATION

The system operation is illustrated in Figure 4. Prior to a satellite pass of interest, an orbit prediction program is run on an external computer. This program will give, for each selected scene, the time at which the satellite will begin transmission of that scene. This information, plus annotation information, is then entered by the operator into the LIF. The LIF then monitors the time from the Time Code Reader, and waits for the start time of the first scene to be acquired. The Moving Window Display Processor is selected, by its front panel switches, to display the Landsat data directly from the Landsat Format Synchronizer.

When the LIF finds a time code match, it begins recording of that scene. The 6-bit data from the Landsat Format Synchronizer is stripped of sync codes and band eight (far infrared) data, and packed into 8-bit bytes. The first swath of data is directed to the microprocessor associated with disk pair #1. While that swath is being written to the disk, a process which takes about 200 milliseconds, the second swath is directed to the second microprocessor, and so on with the third and fourth swaths. By the time the fifth swath arrives, the first microprocessor and disk pair are ready, and the entire process repeats in this cyclic fashion. During this time, the imagery is also displayed on the black and white monitor in order to allow the operator to verify that the system is working correctly, to estimate the cloud cover and the exact geometric location of the frame being stored. Once the entire scene has been recorded, the LIF reverts back to watching for the time code to match the start time of the next required scene. The entire disk space may be filled in this manner, or certain scenes may be retained from previous passes.

After the satellite is out of range, or when no more scenes are required, playback of the images and product generation can be started. During playback, the data is cyclically read from the disks and unpacked back to 6-bit words. The data is demultiplexed, corrected, annotated and sent to the output device. This process takes about three minutes for a full scene, or less for a magnified portion of the scene. The film is then automatically advanced on the FIRE (a process which takes one second) or a filter selected on the Matrix film recorder and the shutter operated. The next scene may then be imaged in a similar manner.

Magnification can be used to emphasize the detail of part of a scene to enhance surveillance of episodic events. When the FIRE film recorder is selected as the output device, this magnification is achieved without any of the distortion normally associated with an optical system.

As the output products are generated and disk space is freed, new images from a successive pass can be acquired.

V. CONCLUSIONS

This paper has summarized the results of a study of the potential benefits of utilizing Landsat images soon after acquisition and has described a Quicklook Image Recording System that can be used to obtain the Landsat data. The system is soon to be installed in Fairbanks Alaska and is expected to deliver full-resolution imagery by December, 1981.

Although the Alaskan configuration initially will not have provision for CCT generation, the system is easily upgradable to produce CCTs. The CCTs could be produced in standard format for further processing in an image analysis system as would be required for crop forecasts. Another future alternative is the transmission of data to a facsimile recorder in a remote location.

The present system serves users that require data in a timely fashion, without requiring the large budget of central government organizations. In the future, as disk technology progresses rapidly to high capacity optical disks, the scope of applications of this type of QLIRS system will grow.

VI. REFERENCES

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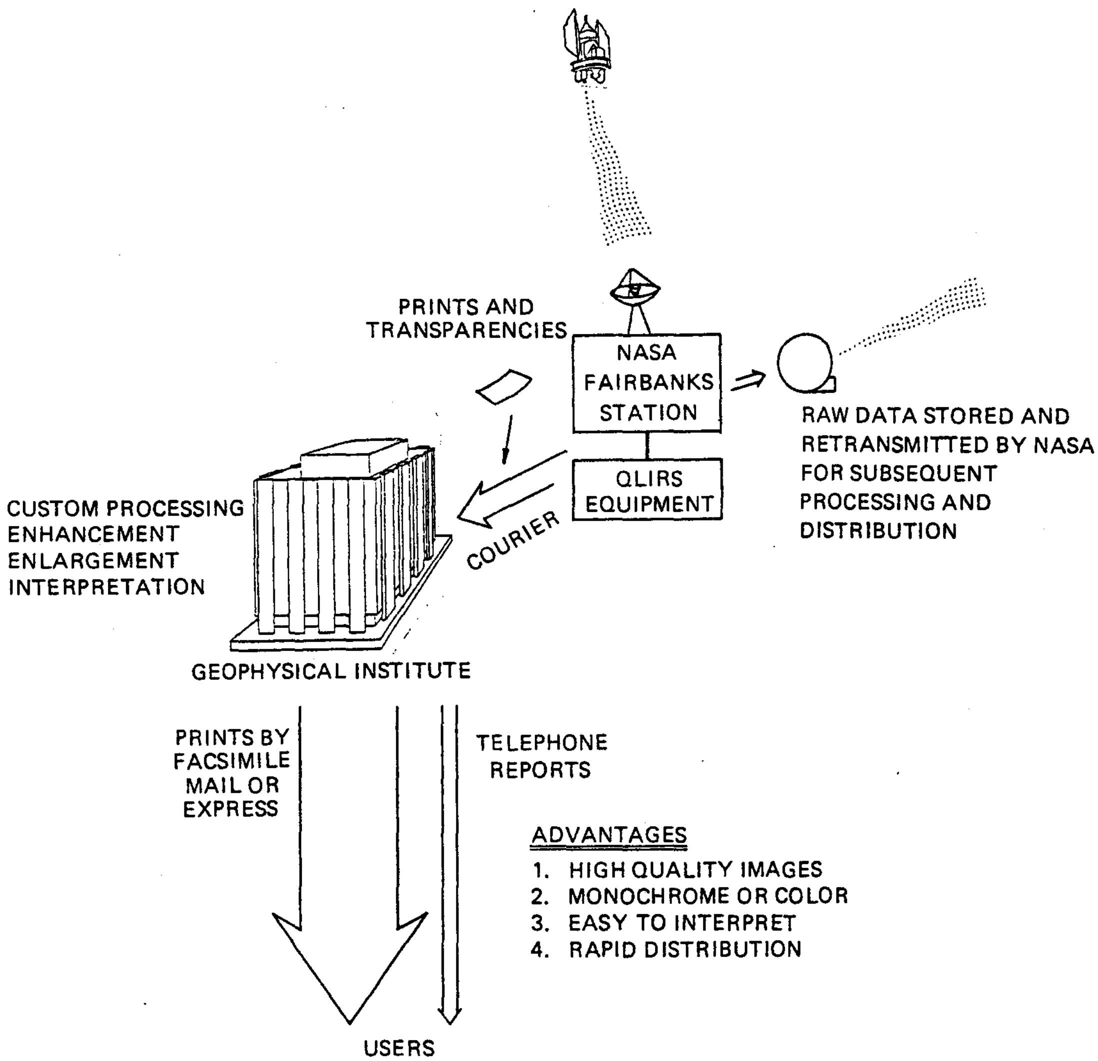

FIGURE 1. ALASKAN LANDSAT QUICK-LOOK IMAGE RECORDING SYSTEM (QLIRS)

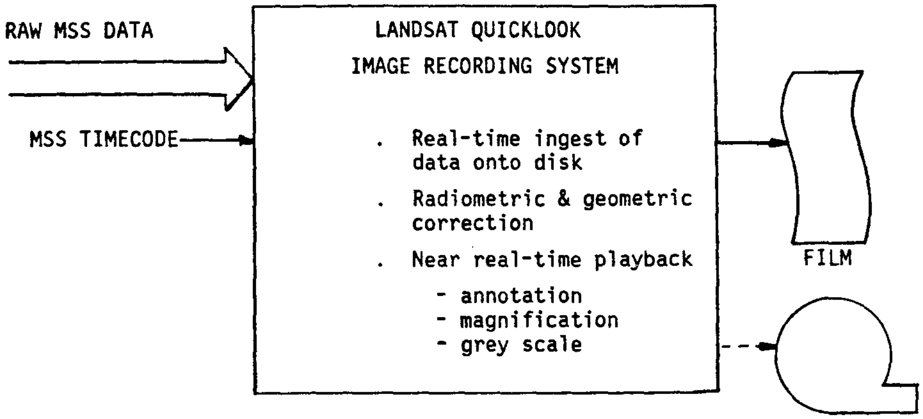

FIGURE 2. The QLIRS system accepts MSS data at the real-time rate and then reformats, corrects and outputs the full-resolution data at less than real-time rate.

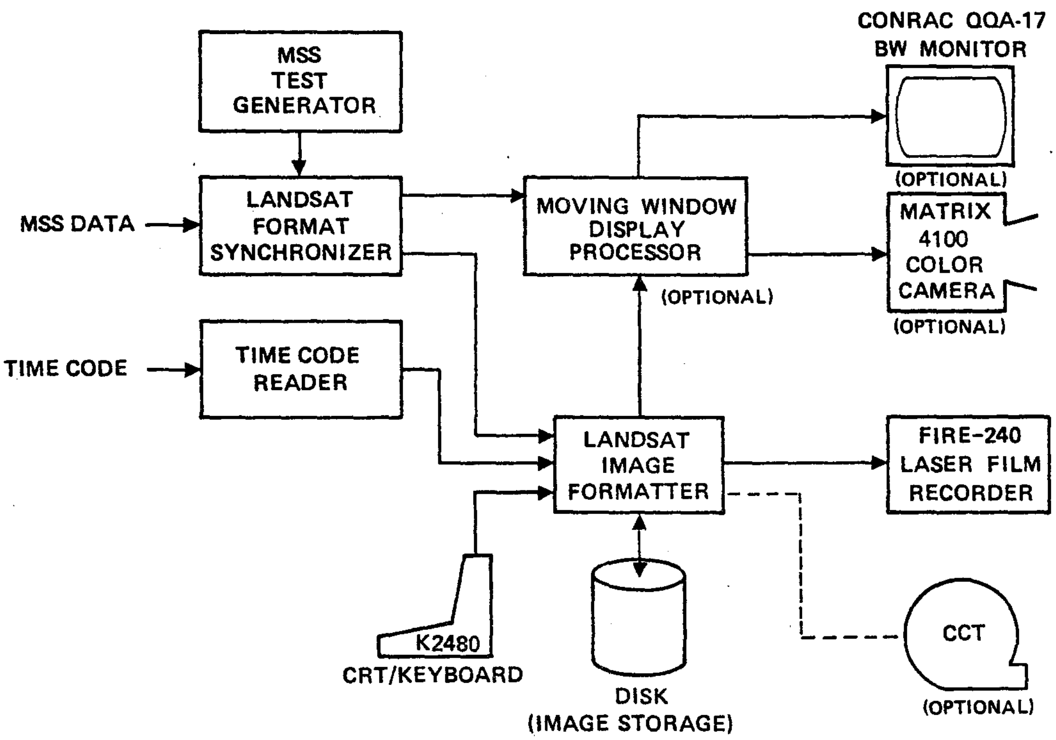

FIGURE 3. ALASKAN LANDSAT QUICKLOOK SYSTEM BLOCK DIAGRAM

(Dashed lines indicate future expansion.)

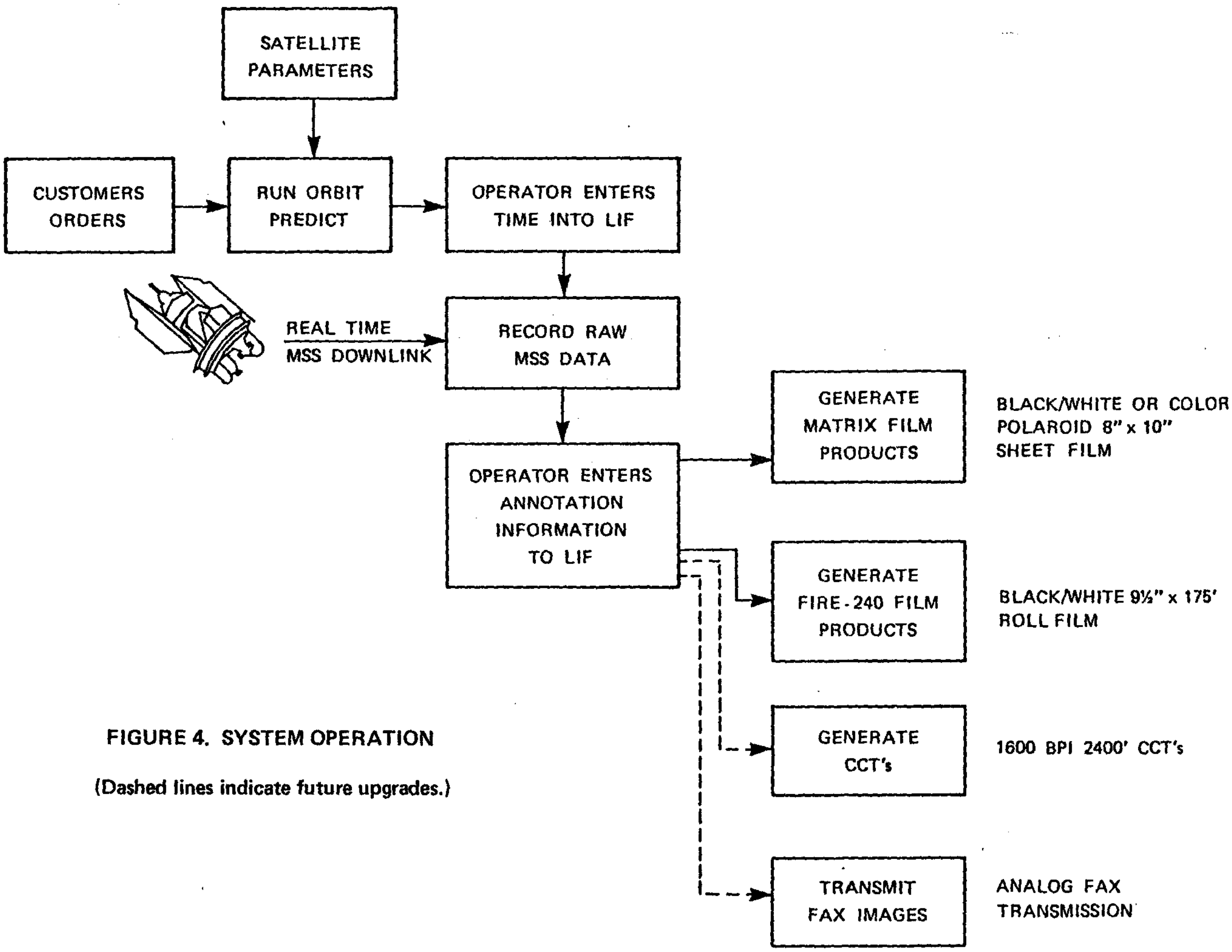

FIGURE 4. SYSTEM OPERATION

(Dashed lines indicate future upgrades.)

AUTHOR BIOGRAPHIC DATA

John M. Miller is Senior Applications Engineer, Northern Remote Sensing Laboratory, Geophysical Institute, University of Alaska. He received a B.S. in electrical engineering, 1960, and M.S. in engineering management, 1968, both from the University of Alaska. His interests have included development of HF radar for ionospheric research, satellite tracking and data acquisition, and development of operational applications for remotely sensed data. He is a member of Tau Beta Pi and the recipient of the NASA Exceptional Scientific Achievement Medal, 1974.

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