EDC DOCUMENT #0043

UNITED STATES GEOLOGICAL SURVEY

EROS DATA CENTER

SIOUX FALLS, SOUTH DAKOTA, USA

AVAILABILITY OF COMMUNICATION LINKS FOR TRANSFER OF LANDSAT DATA

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September 28, 1979

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AVAILABILITY OF COMMUNICATION LINKS FOR TRANSFER OF LANDSAT DATA

1.0 SCOPE

This document outlines the availability of civil satellite and ground communication links existent within the international community and the USA which have direct applicability in the operational transfer of Landsat data between nations.

2.0 PURPOSE

The information presented in this document is meant to provide the Landsat station operator agencies and the user community with a ready reference as to the availability and types of communications circuits that could be used for Landsat data relay (transmission or reception).

3.0 INTRODUCTION

The Landsat series of remote sensing spacecraft are providing data to users both in the United States and many countries located in other parts of the globe. At the present time, Landsat data are received directly by several ground stations around the world with its distribution to the final users usually in the form of film or low density tape products via ground postal or commercial freight systems. With the advent of improved techniques for digitally processing Landsat data, increased bit rates and resolution provided by the new sensors, decentralized data bases, and the greatly expanded utilization of Landsat data in recent years, turnaround time for availability of data products is becoming a key issue. Clearly, some new, standardized, yet cost effective communications network should be considered for the expeditious transfer of Landsat data within and between all countries and their associated data processing and distribution facilities. This report addresses an existing operational Landsat data communications system in the U.S., the types of data which should be considered for interchange, the several link alternatives which are available, and some comments regarding the associated costs.

4.0 TECHNICAL DISCUSSION

4.1 General

The transfer of two types of Landsat data are considered: data base inventory data and/or the digital image data itself. Other considerations are the requirements for fully-processed data vs. partially-processed data, complete coverage vs. selected coverage, and satellite data communications vs. some hybrid with traditional ground distribution methods. The selection of the communication technique for the international transfer of Landsat-related data will depend primarily upon the countries involved, the extent of data utilization, and the required turn-around times. Since several different scenarios are possible, only generalized, relative costs and technical guidelines are possible. However, certain scenarios appear to be logical configurations and will be discussed in greater detail. In all discussions, photographic and CCT product generation and dissemination are assumed to be user oriented and independent of the initial data transfer scheme.

4.2 Internal U.S.A. Landsat Data Transfer

Internal to the U.S.A., NASA is presently using a Domestic Communications Satellite (DOMSAT) with a 20 Megabit (Mb) transponder channel to transmit Landsat 2 and 3 data received by Fairbanks, Alaska, and Goldstone, California, tracking stations to the GSFC preprocessing facility at Greenbelt, Maryland. In addition, NASA and the Department of Interior use the same DOMSAT to transmit preprocessed data from GSFC to the EROS Data Center (EDC) located in Sioux Falls, South Dakota, where the data receive final processing and the photographic and digital user products are generated. The present NASA and EDC links use the RCA SATCOM II geosynchronous satellite located 35,860 km (22,282 mi.) over the equator at 119°W longitude. The turnaround time from NASA station reception to fully processed data availability in the EDC archive is on the order of 10 days. The system is configured to transfer up to 200 MSS scenes and 160 RBV subscenes (plus IRIG time code) each day, a total of $2x10^{11}$ bits of Landsat data per day.

During the 1980's time frame, Landsat D data will be relayed via a tracking and data relay satellite (TDRS) to a ground station at White Sands, New Mexico. The data will be slowed down and retransmitted to GSFC via DOMSAT for preprocessing, thence to EDC for product generation. Direct S- and/or X-band transmission to non-U.S. Landsat receiving/data processing centers will also be available.

4.3 International Landsat Data Transfer

4.3.1 Data Types

4.3.1.1 Data Base Inventory Data

As more national agencies install and operate Landsat ground receiving stations, the geographic locations of Landsat data depositories become more decentralized and wide spread. One method of keeping agencies informed as to the specific coverage, type of sensor data obtained, and date of coverage would be to periodically transmit updated inventory data on Data Base Interchange Tapes (DBIT) to interested parties and, specifically, to EDC for entry into the master Landsat data base. If no more than the inventory data are communicated, EDC will refer all user inquiries/orders to the associated agency for product generation and dissemination. If a complete interchange of inventory data is performed between all international regional centers, the same cooperative referal procedure should be applied. In most cases, the DBIT could be recorded on a standard computer compatible tape and transferred on a weekly or biweekly schedule from the capture agency to the requesting agency(s). An internationally approved standard file format should be used for recording the DBIT, and the existing U.S.A. DBIT file format is recommended. See Appendix A for Landsat DBIT File Format Specifications.

4.3.1.2 Digital Image Data

The transfer and interchange between international agencies of the complete format image data from the various Landsat sensors can be considered for three separate issues:

- to provide constant, rapid turnaround in response to emergency situations in the agency's regional area
- to provide a means to augment an agency's archive when a Landsat receiving ground station is out of service or for redundancy purposes
- to provide for standing orders from national

processing centers within an agency's regional area

4.3.2 Data Transfer Links

4.3.2.1 Commercial Freight

Certainly, the most cost efficient method of inter-agency Landsat data transfer is via commercial ground, ship, and/or air freight services. As will be shown, the data transfer/turnaround time to average users are not significantly affected or degraded when the initial international data transfer is handled by such services, preferably air freight. The key to this, however, is the assurance that, as a minimum, procedures have been formally established for the regular interchange of data base inventory data between international agencies.

4.3.2.2 Terrestrial Data Links

Landsat data can be transferred between international agencies via high quality land lines and/or microwave relay ($\geq$ 9.6 KHz bandwidth). This mode of data communication is faster than commercial freight, but is very bandwidth and distance limited. For international agency use, terrestrial links should only be considered for the transfer of the DBIT data and user inquiry/order data. An intraregional microwave relay is usually used in conjunction with the interagency transfer of Landsat data via communications satellite when the Earth terminal is located away from the agency's processing facility. These techniques have been used very successfully by carriers in the U.S.A., the European Post and Telegraph (PTT) services, and by the European Space Agency (ESA) between the satellite receiving station in the Odenwald and the control center in Darmstadt (FRG). Error detection and correction (EDAC) schemes should be employed along with some form of block retransmission to ensure bit error rates (BER's) of less than $1x10^{-8}$.

4.3.2.3 Communications Satellite Data Links

Various global relay satellites are currently in service or planned for the 1980's. The technical possibility exists to transfer either or both types of Landsat data from/to the U.S.A. and any international agency using global relay satellite systems. This possibility is contingent upon the solution of several basic problems:

- ° Negotiation of international communication carrier agreements between the U.S.A. and other agencies.
- ° The acceptance of common formats, overhead, editing criteria, preprocessing schemes, error detection/correction coding, and bit error rates.
- ° The determination of an operational schedule for the relay of data that will optimize the use of

dead time, non-peak periods, and common equipments.

- The acceptance of the capital receive/transmit station investments and high rental cost per month for the service.

Since the orbiting of the SCORE communications satellite by NASA in 1958, there have been over 200 satellites launched (or identified for near-future launch) which are primarily for communications applications. These satellites are owned by individual countries, international consortia, and by commercial organizations. The orbits range from low altitude to the 35,860 km (22,282 mi.) high geosynchronous orbits. The applications range from general purpose voice transmission to TV and wideband digital data transfer. The frequency ranges are typically 4/6 GHz (C-band) and 12/14 GHz (Ku-band) for the down-link/up-link, with increased use of 20/30 GHz (K-band) transponders planned. Data bandwidths up to 36 MHz are available now which will handle digital data rates up to 20 Mbps. This, therefore, would permit transmission of MSS at the 15.06 Mbps real-time rate. Higher bandwidths are expected in the near future. The SBS satellite, for example, will feature ten, 49 MHz transponders plus six switchable spares, each capable of up to 43 Mbps digital data rates. The near-future Advanced Westar/ TDRS satellite will have a 4-channel transponder that will provide extremely high data rate service (up to 1 Gbps total, or 250 Mbps per channel) at K-band. Digital data transmission raw bit error rates (BER) of $1x10^{-7}$ are typical, with $1x10^{-9}$ easily obtainable using low-overhead error detection and correction (EDAC). Table 4.1 is a listing of the primary geosynchronous communications satellites around the world listed in order of orbital positions for each country. The launch year, applications, and down-link/up-link transmission bands are also given.

The geosynchronous communications satellite offers greater advantages as follows:

- ° Of the 72 launched since 1963, there are 63 functional geosynchronous communications satellites presently in orbit with 85 more funded and planned for the early 1980's. Of these, 90 are specifically designated for domestic and international data communications.
- ° The satellite remains almost stationary relative to the Earth antennas, so the cost of computer-controlled tracking of the satellite is avoided. A fixed antenna is satisfactory (with provision for manual adjustments).
- ° There is no necessity to switch from one satellite to another except in cases of long distance, east-west multi-transfer of data.

TABLE 4.1

PRIMARY GEOSYNCHRONOUS COMMUNICATIONS SATELLITES

Nation and/or Organization	Satellite Designation	Launch Year	Type	Longitude	Down-Link/Up-Link Frequencies (GHz)
USA					
DCA	DSCS-III	U	M2	51.0°E	7, 20/8, 30
Comsat General	MARISAT I-3	76	M1	73.0°E	0.248-0.26, 1.5, 4/0.3-0.312, 1.6, 6
Hughes Comm.	LEASAT	82-83	M2	75.1°E	0.3, 7/0.3, 8
DCA	DSCS-II F8	77	M2	175.0°E	7/8
DCA	DSCS-II F10	78	M2	174.5°E	7/8
DCA	DSCS-III	U	M2	175.5°E	7, 20/8, 30
Comsat	MARISAT I-2	76	M1	176.5°E	0.248-0.26, 1.5, 4/0.3-0.312, 1.6, 6
Hughes Comm.	LEASAT	82-83	M2	177.0°E	0.3, 7/0.3, 8
Western Union	Advanced WESTAR/ TDRS-2	80	D/N	171.0°W	2.2, 13/2.0, 15
NASA	ATS-6	74	E	140.0°W	0.86, 1.55, 2, 2.6, 4/0.15, 1.6, 2.25, 6
DCA	DSCS-III	U	M2	139.0°W	7, 20/8, 30
RCA Amer.	SATCOM-1	75	D	135.8°W	4/6
RCA Amer.	SATCOM-3	79	D	132.0°W	4/6
DCA	DSCS-II F9	78	M2	130.0°W	7/8
Comsat General	COMSTAR-1	76	D	128.0°W	4/6
Western Union	WESTAR-2	74	D	123.5°W	4/6
Sat. Bus. Sys.	SBS-A	80	D	122.0°W	12/14
RCA Amer.	SATCOM-2	76	D	119.0°W	4/6
Sat. Bus. Sys.	SBS-B	80	D	106.0°W	12/14
DOD/MIT	LES-8	76	E	104.0°W	UHF, 7, 32/UHF, 8, 36
Western Union	Advanced WESTAR/ TDRS-3	81	D/N/S	101.0°W	2.2, 4, 12/2.0, 6, 14
Hughes Comm.	LEASAT	82-83	M2	100.8°W	0.3, 7/0.3, 8

TABLE 4.1 (cont'd)

Nation and/or Organization	Satellite Designation	Launch Year	Type	Longitude	Down-Link/Up-Link Frequencies (GHz)
USA (cont'd)					
USN	FLTSATCOM F1	78	M2	100.0°W	0.24-0.27, 7/0.29-0.32, 8
Western Union	WESTAR-1	74	D	99.0°W	4/6
Western Union	Advanced WESTAR/ TDRS-4	81	D/N	98.0°W	2.2, 4, 12, 13/2.0, 6, 14, 15
Comsat General	COMSTAR-2	76	D	95.0°W	4/6
Western Union	WESTAR-3	79	D	91.0°W	4/6
Comsat General	COMSTAR-3	78	D	89.7°W	4/6
RCA Amer.	SATCOM-4	81	D	83.0°W	4/6
DOD/MIT	LES-9	76	E	44.0°W	UHF, 7, 32/UHF, 8, 36
Western Union	Advanced WESTAR/ TDRS-1	80	D/N	41.0°W	2.2, 13/2.0, 15
USN	FLTSATCOM F2	79	M2	23.0°W	0.24-0.27, 7/0.29-0.32, 8
Hughes Comm.	LEASAT	82-83	M2	22.1°W	0.3, 7/0.3, 8
Comsat General	MARISAT I-1	76	M1	15.0°W	0.248-0.26, 1.5, 4/0.3-0.312, 1.6, 6
DCA	DSCS-II F7	77	M2	13.0°W	7/8
DCA	DSCS-III	U	M2	12.7°W	7, 20/8, 30
ANDEAN NATIONS	U	80's	R	68.0°W	4/6
ARAB LEAGUE	ARABSAT	83	R	19.0°E	2.5, 4/6
	ARABSAT	83	R	26.0°E	2.5, 4/6
AUSTRALIA	U	82	D	100.0°E	U
BRAZIL	SBTS	U	D	65.0°W	4/6
	SBTS	U	D	60.0°W	4/6
CANADA					
DOC	CTS-1	76	E	116.0°W	12/14
Telesat Canada	ANIK-C2	80	D	115.5°W	12/14
Telesat Canada	ANIK-A3	75	D	114.0°W	4/6
Telesat Canada	ANIK-D2	U	D	113.5°W	4/6
Telesat Canada	ANIK-C1	80	D	112.5°W	12/14

TABLE 4.1 (cont'd)

Nation and/or Organization	Satellite Designation	Launch Year	Type	Longitude	Down-Link/Up-Link Frequencies (GHz)
CANADA (cont'd)					
Telesat Canada	ANIK-B1	78	D	109.0°W	4, 12/6, 14
Telesat Canada	ANIK-A2	73	D	108.5°W	4/6
Telesat Canada	ANIK-A1	72	D	105.0°W	4/6
Telesat Canada	ANIK-D1	82	D	104.5°W	4/6
CBS	CBSS	U	T	92.0°W	12/14
CHINA	STW-2	79-80	E	70.0°E	4/6
	STW-1	79-80	E	125.0°E	4/6
COLUMBIA	SATCOL	U	D	73.0°W	4/6
EBU	EBS	83	T	7.5°E	11/14
ESA					
MESH	OTS	78	E	10.0°E	0.138, 11/0.149, 14
Eutelsat	ECS-1	81-82	R	10.5°E	11/14
Eutelsat	ECS-2	81-82	R	11.5°E	11/14
MESH	MARECS	80	M1	40.0°E	1.5, 4/1.6, 6
Eurosat	H-SAT	83	E	19.0°W	11/14
MESH	MARECS	81	M1	12.5°W	1.5, 4/1.6, 6
FRANCE	TELECOM I	83	R	9.5°W	4, 12/6, 14
	TELECOM I	83	R	7.0°W	4, 12/6, 14
FRANCE & GERMANY (FRG)	SYMPHONIE-II	75	E	49.0°E (11.5°W in '79)	4/6
	SYMPHONIE-I	74	E	12.0°W	4/6
GERMANY (FRG)	TVSAT-1	82	T	20.0°W	12/18
	TVSAT-2	84	T	19.5°W	12/18
	U	85	T	10.0°W	11/14
INDIA	INSAT-1	81	D	74.0°E	2.5-2.69, 4/6
ISRO	ARIANA	80	E	76.0°E	U

TABLE 4.1 (cont'd)

Nation and/or Organization	Satellite Designation	Launch Year	Type	Longitude	Down-Link/Up-Link Frequencies (GHz)
INDONESIA	PALAPA I-2	77	D	77.0°E	4/6
	PALAPA I-1	76	D	83.0°E	4/6
	PALAPA II	82	R/D	180.0°E	4/6
	PALAPA II	82	R/D	113.0°E	4/6
	PALAPA II	82	R/D	118.0°E	4/6
IRAN	ZOHREH-2	U	D	26.0°E	11, 12/14
	ZOHREH-1	U	D	34.0°E	11, 12/14
	ZOHREH-3	U	D	47.0°E	11, 12/14
INTELSAT	INTELSAT	U	I	56.5°E	4/6
	INTELSAT IV F5	72	I	57.0°E	4/6
	INTELSAT V MCS	81	I	59.9°E	1.5, 4, 11/1.6, 6, 14
	INTELSAT IVA F3	78	I	60.0°E	4/6
	INTELSAT IVA F6	78	I	62.9°E	4/6
	INTELSAT V MCS	81	I	63.0°E	1.5, 4, 11/1.6, 6, 14
	INTELSAT IV F8	74	I	173.9°E	4/6
	INTELSAT	U	I	174.0°E	4/6
	INTELSAT IV F4	72	I	178.9°E	4/6
	INTELSAT	U	I	179.0°E	4/6
	INTELSAT V	80-82	I	34.5°W	4, 11/6, 14
	INTELSAT IVA F4	77	I	34.4°W	4/6
	INTELSAT IVA F2	76	I	29.5°W	4/6
	INTELSAT V	80-82	I	29.4°W	4, 11/6, 14
	INTELSAT V	80-82	I	27.5°W	4, 11/6, 14
	INTELSAT IVA F1	75	I	24.5°W	4/6
	INTELSAT V MCS	82	I	24.4°W	1.5, 4, 11/1.6, 6, 14
	INTELSAT IV F3	71	I	21.8°W	4/6
	INTELSAT V	80-82	I	21.5°W	4, 11/6, 14
	INTELSAT V	80-82	I	18.5°W	4, 11/6, 14
	INTELSAT IV F1	75	I	18.4°W	4/6

TABLE 4.1 (cont'd)

Nation and/or Organization	Satellite Designation	Launch Year	Type	Longitude	Down-Link/Up-Link Frequencies (GHz)
INTELSAT (cont'd)	INTELSAT IV F2	71	I	6.0°W	4/6
	INTELSAT IV	U	I	4.0°W	4/6
	INTELSAT IV F7	73	I	1.1°W	4/6
	INTELSAT	U	I	1.0°W	4/6
ITALY					
CIR	SIRIO	77	E	15.2°W	11/17
JAPAN					
NASDA	BS	78	E	110.0°E	11/14
NTT	Domestic	U	D	128.0°E	4, 20/6, 30
NASDA	ETS-II (Kiku-2)	77	E	130.0°E	0.136, 1.7, 11.5, 34.5/0.148, 2.1
NASDA	ETS-3	81	E	132.0°E	U
NASDA	ETS-4	82	E	132.5°E	U
NASDA	CS (Sakura)	77	E	135.0°E	4, 20/6, 30
NASDA	ECS	79	E	145.0°E	4, 31.7/6, 34.8
NATO	NATO-III B	77	M2	140.0°W	2.3, 7/1.8, 8
	NATO-III C	78	M2/S	50.0°W	2.3, 7/1.8, 8
	NATO-III A	76	M2	16.5°W	2.3, 7/1.8, 8
	NATO-IV	U	M2/S	U	U
NORDIC NATIONS	NORDSAT	81	D	5.0°E	12/14
USSR	STATSIONAR-2A	77	I/R	35.0°E	4/6
	LOUTCH-P2	81	I	45.2°E	11/14
	STATSIONAR-9	80	I/R	45.4°E	4/6
	GALS-2	79	M2	45.6°E	7.25-7.75/7.9-8.4
	VOLNA-3	80	M3	45.8°E	0.240-0.328, 1.5/0.335-0.399, 1.6
	EKRAN-3	79	I	53.0°E	4/6
	LOUTCH-2	81	I	58.3°E	11/14
	VOLNA-4	80	M3	58.6°E	1.5/1.6
	STATSIONAR-1B	76	I/R	80.0°E	4/6

TABLE 4.1 (cont'd)

Nation and/or Organization	Satellite Designation	Launch Year	Type	Longitude	Down-Link/Up-Link Frequencies (GHz)
USSR (cont'd)	GALS-3	79	M2	85.2°E	7.25-7.75/7.9-8.4
	LOUTCH-P3	81	I	85.4°E	11/14
	STATSIONAR-3	79	I/R	85.6°E	4/6
	VOLNA-5	80	M3	85.8°E	0.240-0.328, 1.5/0.335-0.399, 1.6
	LOUTCH-3	81	I	90.0°E	11/14
	STATSIONAR-6	80	I/R	90.5°E	4/6
	STATSIONAR-1	75	D	98.5°E	4/6
	EKRAN-T	76	T	99.0°E	0.7/6.2
	EKRAN-2	77	D/R	99.5°E	4/6
	LOUTCH-4	81	I	139.5°E	11/14
	STATSIONAR-7	80	I/R	140.0°E	4/6
	VOLNA-6	80	M3	140.5°E	1.5/1.6
	GALS-4	79	M2	170.5°W	7/8
	LOUTCH-P4	81	I	170.0°W	11/14
	STATSIONAR-10	80	I/R	169.5°W	4/6
	VOLNA-7	80	M3	169.0°W	0.240-0.328, 1.5/0.335-0.399, 1.6
	GALS-1	79	M2	26.5°W	7.25-7.75/7.9-8.4
	LOUTCH-P1	81	I	26.0°W	11/14
	STATSIONAR-8	80	I/R	25.5°W	4/6
	VOLNA-1	80	M3	25.0°W	0.240-0.328, 1.5/0.335-0.399, 1.6
	LOUTCH-1	81	I	14.5°W	11/14
	VOLNA-2	80	M3	14.0°W	1.5/1.6
	STATSIONAR-4	79	I/R	13.5°W	4/6

SYMBOL LEGEND:

D = Domestic Communications
E = Experimental Satellite
I = International Communications
M1 = Maritime Communications
M2 = Military Communications
M3 = Mobile Communications
N = NASA Leased Service
R = Regional Communications
S = In-orbit Spare Satellite
T = Direct TV Broadcast
U = Undetermined

- There are no breaks in transmission since a geosynchronous satellite is permanently in view.
- Because of its distance, a geosynchronous satellite is in line-of-sight from 42.4% of the Earth's surface or 38% if angles of elevation below 5° are not used. A large number of Earth stations may, thus, intercommunicate.
- Only three properly positioned satellites are required to give global coverage with the exception of the polar regions.
- There is almost no Doppler frequency shift, whereas nongeosynchronous satellites experience Doppler frequency shifts when passing to and from Earth stations, with the shift being compounded and different, station-to-station, for noncircular orbiting satellites. Such shifts increase the complexity of the receivers, expecially when a number of Earth stations intercommunicate.

The disadvantages of geosynchronous satellites are:

- No Earth coverage is provided at latitudes greater than 81.25° north and south or greater than 77° north and south if angles of elevation below 5° are excluded. There is little other than polar ice at these excluded latitudes, however, providing minimum or no degradation at anticipated Landsat communication points.

° The transmission distances are long with the worst-case one-way distance between Earth station and satellite being 41,757 km (25,946 mi.). Thus, the received signal power is comparatively weak and the combined signal propagation delay is as much as 270 ms. The signal losses, however, are balanced by higher antenna and amplifier gains and the propagation delay causes degraded service only with voice and interactive data transmissions.

To lessen the complexity of international carrier negotiations and cross-agreements, the International Telecommunications Satellite Consortium (INTELSAT) network is recommended for any international, inter-agency transfer of Landsat data via satellite relay. INTELSAT is a long-established, efficiently operating consortium of over 100 countries, with reliable tele-communications services being provided via 25 existing or near-future satellites. As of 3/31/79, communica-tions were being provided through 240 antennas at 198 Earth stations in 104 countries. By the end of 1979, the number of INTELSAT Earth stations will have grown to 270, and the number of antennas will have increased to 330.

Table 4.1 includes the orbital positions and link frequencies of each INTELSAT satellite, and Table 4.2 lists the region, country, and name of each INTELSAT Earth station active as of 3/31/79.

TABLE 4.2

INTELSAT EARTH STATIONS

A. STANDARD "A" ANTENNAS

ATLANTIC OCEAN REGION

Algeria:	Lakhdaria 3
Angola:	Cacuaco
Argentina:	Balcarce 1 & 2
Barbados:	Barbados
Belgium:	Lessive 1
Bolivia:	Tiwanacu
Brazil:	Tangua 1 & 2
Cameroon:	Zamengoe 1
Canada:	Mill Village 1 & 2
Chile:	Longovilo 1 & 2
Colombia:	Choconta 1
Congo:	Mougouni
Dominican Republic:	Cambita
Ecuador:	Quito
Egypt:	Maadi
El Salvador:	Izalco
France:	Pleumeur-Bodou 1 & 2,
	Bercenay-en-Othe 1,
	Trou-Biran (French Guiana),
	Trois Ilets (Martinique)
Gabon:	N'Koltang
Germany:	Raisting 2 & 3
Greece:	Thermopylae 2
Haiti:	J-C Duvalier
Iran:	Asadabad 1
Iraq:	Dujail 2
Israel:	Emeq Ha'ela 1
Italy:	Fucino 1, Lario
Ivory Coast:	Abidjan 1
Jamaica:	Prospect Pen
Jordan:	Baga 1
Kuwait:	Umm Al-Asish 2
Mexico:	Tulancingo 1
Morocco:	Sehouls
Mozambique:	Boane
Netherlands:	Burum 1
Nicaragua:	Managua
Nigeria:	Lanlate 2
Panama:	Utibe
Paragua:	Aregua
Peru:	Lurin 1
Portugal:	Sintra,
	Ponta Delgada
Romania:	Cheia 1
Saudi Arabia:	Taif
Senegal:	Gandoul
South Africa:	Pretoria 1
Spain:	Buitrago 1 & 3,
	Aguimes
Sudan:	Umm Haraz
Sweden:	Tanum 1
Switzerland:	Leuk 1
Togo:	Cacavelli
Trinidad and Tobago:	Matura Point
United Arab Emirates:	Abu Dhabi
United Kingdom:	Goonhilly 1, 2, & 3
United States:	Andover 2 & 3,
	Etam 1 & 2
U.S.S.R.:	L'vov
Venezuela:	Camatagua 1

TABLE 4.2 (cont'd)

A. STANDARD "A" ANTENNAS (cont'd)

ATLANTIC OCEAN REGION (cont'd)

Yugoslavia:	Jugoslavija
Zaire:	N'sele

PACIFIC OCEAN REGION

Australia:	Carnarvon 2, Moree
Canada:	Lake Cowichan
China:	Peking 1, Shanghai, Taipei 1
Fiji:	Suva
France:	L'lle Nou (New Caledonia)
Hong Kong:	Hong Kong 1
Japan:	Ibaraki 3
Korea:	Kum San 1
New Zealand:	Warkworth
Philippines:	Pinugay 1
Singapore:	Sentosa 2
Thailand:	Si Racha 1
United States:	Brewster, Jamesburg, Paumalu 2 (Hawaii) Pulantat (Guam)

INDIAN OCEAN REGION

Algeria:	Lakhdaria 1
Australia:	Ceduna 1
Bahrain:	Ras Abu Jarjur
Bangladesh:	Betbunia
China:	Peking 2, Taipei 2
France:	Pleumeur-Bodou 4
Germany:	Raisting 1
Greece:	Thermopylae 1

INDIAN OCEAN REGION (cont'd)

Hong Kong:	Hong Kong 2
India:	Vikram, Ahmed
Indonesia:	Djatiluhur 1
Iran:	Asadabad 2
Iraq:	Dujail 1
Italy:	Fucino 2
Japan:	Yamaguchi 1
Kenya:	Longonot 1
Korea:	Kum San 2
Kuwait:	Umm Al-Aish 1
Lebanon:	Arbaniyeh 1
Madagascar:	Philibert Tsiranana
Malaysia:	Kuantan 1
Netherlands:	Burum 2
Nigeria:	Lanlate 1
Oman:	Al Hajar 1
Pakistan:	Deh Mandro
Philippines:	Pinugay 2
Qatar:	Doha
Saudi Arabia:	Riyadh 1
Singapore:	Sentosa 1
South Africa:	Pretoria 2
Spain:	Buitrago 2
Sri Lanka:	Padukka
Syria:	Sednaya
Thiland:	Si Racha 2
United Arab Emirates:	Dubai, Ras Al-Khaimah
United Kingdom:	Madley 1
Zambia:	Mwembeshi

TABLE 4.2 (cont'd)

B. STANDARD "B" ANTENNAS

ATLANTIC OCEAN REGION

Belize:	Belmopan
Bermuda:	Devonshire
Brazil:	Natal
Chad:	Goudji 1
Denmark:	Godthaab
Gambia:	Banjul
Guyana:	Georgetown
Libya:	Tripoli 1
Mali:	Sullymanbougou 1
Netherlands Antilles:	Vredenberg
Uganda:	Ombachi 1
Upper Volta:	Somgande

PACIFIC OCEAN REGION

France:	Papenoo (French Polynesia)
Nauru:	Nauru
Solomon Islands:	Honiara
Tonga:	Nuku'Alofa

INDIAN OCEAN REGION

Burma:	Rangoon
Malawi:	Kanjedza 1
Maldives:	Maldives
Mali:	Sullymanbougou 2
Mauritius:	Cassis
Niger:	Niamey
Seychelles:	Bon Espoir
Yemen:	Sanaa

C. NONSTANDARD ANTENNAS

ATLANTIC OCEAN REGION

Algeria:	Adrar, Bechar, Djanet, El-Golea, Ghardaia, In-Salah, Ain Amenas, Beni-Abbes, El Oued, Lakhdaria 2, Ouragia-Peggane, Tamanrasset, Timioun, Tindouf
Brazil:	Macapa, Manaus, Boa Vista, Porto Velho, Rio Branco, Tangua 3
Chile:	Punta Arenas
Colombia:	Choconta 2, San Andres
France:	Pleumeur-Bodou 5, St. Denis de la Reunion
Norway:	Eik, Ikofisk, Frigg, Isfjord
Oman:	Al Hajar 2, Buraimi, Salalah
Peru:	Iquitos, Lurin 2, Pucallpa, Tarapoto

TABLE 4.2 (cont'd)

C. NONSTANDARD ANTENNAS (cont'd)

ATLANTIC OCEAN REGION (cont'd)

Saudi Arabia:	Abha, Al-Baha, Hail, Jaizan, Jeddah 1 & 2, Medina, Nedjran, Riyadh 2 & 3, Sakakah, Tabuk, Two Mobiles
Sudan:	Dongola, Ed Damazin El Fasher, Juba, Kadugli, Khartoum, Nyala, Wau
Uganda:	Arua, Kampala
Zaire:	Kinshasa, Lubumbashi

INDIAN OCEAN REGION

Malaysia:	Kuantan 2, Kota Kinabalu
Nigeria:	Benin, Enugu, Ibadan, Jos, Kaduna, Lagos, Abeokuta, Akure, Bauchi, Calabar, Ilorin, Kano, Minna, Maiduguri, Makurdi, Owerri, Port Harcourt, Sokoto, Yola

To augment the long-range interagency Landsat data transfer, some type of short-range data link is required to and from the respective Earth terminals. With an investment already established in satellite communications, it is both logical and time effective to continue the relay of Landsat data using a domestic communications satellite (DOMSAT) link if the transfer distance exceeds 1600 km (1000 mi.). Several DOMSAT spacecraft exist around the world which, thus, provide the final key to a near-real time, optimal-turnaround, international interchange of Landsat data. Table 4-1 gives the names, countries, and orbital positions of the 57 primary domestic satellites (code symbol "D" and "R") which are either operational now or will be in the early '80's. Systems have been considered to be Regional (R) when they serve a geographical or linguistic grouping though different political entities may be involved. Domestic (D) systems are generally those with the same type of service grouping within, however, one political entity.

In many cases, communications satellite link(s) would decrease the data transfer time no more than 13% from the time of Landsat acquisition, assuming the associated inventory data had been previously transferred in a timely manner. In cases of national emergency or national disasters, however, the real- or near real-time transfer of Landsat data may be mandatory, though a case can be made for data transfer by chartered aircraft in such limited situations.

5.0 PROGRAMMATIC SCENARIOS AND COSTS

5.1 General Considerations

5.1.1 Data Types

5.1.1.1 Data Base Inventory Data

The capital investment for each agency to interchange Landsat inventory data would be relatively small. Also, the data turnaround time to the average user would not be significantly increased as long as the DBIT's and user inquiries/orders are transferred in a timely fashion. The frequency of DBIT transfers is a product of location, acquisition rate, resident processing capabilities, and user demand. The inventory data for one multispectral scanner (MSS) scene equals 1264 digital bits plus the equivalent of 6400 bits for interblock gap--a total of 7664 bits. One 732 m (2400 ft.) x 1.27 cm (0.50 in.) reel of computer compatible tape (CCT), therefore, can store Landsat inventory data for greater than 47,000 Landsat MSS scenes at 1600 characters per inch (cpi) in the DBIT format given in Appendix A. In most cases, the transfer of a single tape per month to EDC and other requesting agencies will be more than sufficient to ensure timely data-base updates and inquiry responses.

5.1.1.2 Digital Image Data

The capital investment and recurring costs to each agency for the transfer of the complete format Landsat image data are considerably greater and highly dependent on the required data quantities and quality, selected transmission media, extent of data processing, and the desired turnaround time. The resultant costs are greatly reduced by preediting for geographic area, time of year, and cloud cover. All systems should be configured to interface with the standard Landsat computer compatible tape (CCT) and/or high density tape (HDT) formats as delineated in the characteristics and interface control documents available upon request from EDC. The data content of a Landsat scene is given in Table 5.1 including that associated with the planned Landsat D thematic mapper (TM) sensor. Depending on the extent of processing, one MSS scene will be contained on one or two CCT's. Due to NASA data processing/tape generation procedures, only 42% of an HDT contains actual MSS image data. Thus, each 2815 m (9235 ft.) x 2.54 cm (1.00 in.) reel of high density tape (HDT) contains about 30 fully processed Landsat MSS scenes (33 partially processed scenes), plus interscene preamble/fill, parity, IRIG-A time code, inter-swath gaps, and leader/trailer. The raw

TABLE 5.1

LANDSAT SCENE DATA CONTENT

Sensor	Spacecraft	Processing	Bits per Scene
MSS*	1, 2, 3, D, D'	Raw	3.7×10^8
MSS*	1, 2, 3, D, D'	Partial (A)	2.4×10^8
MSS*	1, 2, 3, D, D'	Full (P)	3.0×10^8
TM	D, D'	Raw	2.2×10^9
TM	D, D'	Partial (A)	2.2×10^9
TM	D, D'	Full (P)	2.2×10^9

(* 4-band scenes)

cost of a blank CCT is about $20 each. The raw cost of a blank HDT is about $100 in the U.S.A. and Canada and $150 elsewhere per tape reel.

5.1.2 Data Transfer Links

5.1.2.1 Commercial Freight

The transfer by air freight of magnetic tapes containing Landsat inventory data or high-density digital image data between any two international agencies will average 3 days, portal-to-portal. The costs vary with nation and common carrier; however, the domestic and international air freight costs for one reel of CCT is about $25 and $75, respectively. The international shipment of a 2815 m (9235 ft.) x 2.54 cm (1.00 in.) reel of high density tape (HDT) would cost about $200 to $250 for one shipment of four HDT's.

5.1.2.2 Terrestrial Data Links

9.6 KHz band-line and microwave links are available around the world on a voice-dial up lease basis for the transfer of DBIT data. User inquiries and orders should be interchanged by commercial TWX/TELEX. The capital investment for each agency would be relatively small and it would call for the purchase of 1600 bpi magnetic tape units (MTU) and data modems to interface with the terrestrial circuits and/or satellite Earth terminal. The rental cost of the links could be shared, for example, by each agency being responsible for the cost of transmitting to or receiving from the International Gateway Terminal within the National borders. Both agencies would also share the cost of the transponder for the duration of the transmission period. The lease costs of a 9.6 KHz link would run from $4000 to $8000 per month depending on degree of dedication and required peak/off-peak service.

5.1.2.3 Communications Satellite Data Links

The interagency transfer of Landsat data by communications satellites is, by no means, inexpensive. This is particularly true with the transfer of already-processed Landsat digital image data due to the value-added nature, thus, higher cost of the data itself. Some agencies may already have Earth-station/DOMSAT/transponder investments and schedules for other data services; thus, the addition of Landsat data would present very little cost impact. The majority of agencies, however, would have to establish new agreements and facilities (and costs) to handle an international Landsat data interchange.

The combinations of data quantities, data rates, channel bandwidths, and transmission links are nearly infinite as are, therefore, the resultant costs. A few general guidelines can be stated, however.

When selecting the transponder BW and transmit times, one must consider the total amount of equivalent HDT data plus from 70% to 100% overhead (EDAC coding, support data, link test time, retransmission time, etc.) to maintain low BER's and accommodate peak traffic.

DOMSAT links for a typical daily quantity of Landsat-type data to one of the two U.S.A. INTELSAT gateway facilities would cost about $75,000 per year. If the regional center is greater than 1600 km (1000 mi.) from the receiving INTELSAT gateway facility, another DOMSAT link plus a receiving station is desirable, increasing the cost an additional $220,000 per year.

The connecting INTELSAT link is, by far, the most costly portion of the whole chain costing an estimated average of $2 million per year for the transmission of typical daily quantities of Landsat-type data per regional center. The recently increasing use of packet switching techniques would reduce both the DOMSAT and INTELSAT channel costs and should be investigated (outside this report) for the specific links which would be involved in each location.

The high INTELSAT system cost is due, primarily, to very large downlink charges made by INTELSAT signatories outside the U.S.A.. The possibility exists that, since the downlink charges are being made by one government department and paid (potentially) by another in the same using country, a special agreement could be established whereby the downlink charge is waived, with the only cost assessed against the Landsat data transfer process being the actual "out-of-pocket" expenses of the user country. This would reduce most downlink charges as much as 99%. For example, the downlink portion of the system would then be reduced in cost from some $25,000 per 64 Kbps channel per month to only $240 per channel per month (plus ground system costs).

5.2 Operational Configurations

5.2.1 Inventory Data Transfer

The international interchange of only the Landsat inventory data is a rather straight forward, easily implementable, cost effective, timely technique of maintaining a worldwide knowledge of Landsat data acquisitions, availability, and order sources. Typical costs would be approximately $10,000 a year per regional center for semi-monthly DBIT shipments to EDC and TWX/TELEX inquiry and order transfer. The annual costs would be less than $100,000 a year per regional center for a complete interchange of inventory amongst all 14 regional centers. See Table 5.2 for the quantities of data (scenes per day) anticipated for each regional center in the 1982-1987 Landsat D time frame.

5.2.2 Digital Image Data Transfer

A generalized plan of Landsat digital image data interchange to meet the requirements of each and every international agency and user is very difficult to develop. However, certain fairly specific programmatic scenarios appear to be logical configurations and can be delineated to provide complexity and cost comparisons. Five possible operational configuration scenarios are presented in this section with cost estimates for each of 14 regional centers. A number of programmatic assumptions are required and will be given in the next two paragraphs.

5.2.2.1 General Assumptions

For the operational configurations given in Section 5.2.2.4, the following general assumptions are made:

TABLE 5.2

DAILY DATA REQUIREMENTS SUMMARY

Regional Center	Average MSS/TM Scenes Per Day	Total Bits Recorded Per Day ($\times 10^{10}$)
Prince Albert, Canada	27	6.95
Shoe Cove, Canada	28	7.21
Cuiaba, Brazil	27	6.95
Santiago, Chile	27	6.95
Mar Chiquita, Argentina	27	6.95
Kiruna, Sweden	47	12.10
Fucino, Italy	34	8.76
Ouagadougou, Upper Volta	22	5.67
Kinshasa, Zaire	18	4.64
Tehran, Iran	35	9.01
Hyderabad, India	24	6.16
Peking, China	26	6.70
Tokyo, Japan	24	6.18
Alice Springs, Australia	29	7.47

- A mid-1982 start date (i.e., after Landsat D launch)
- The requirements will be for Landsat TM and 4-band MSS sensor data only
- Nighttime thermal data are not included
- U.S.A. archives all Landsat-acquired data at a central processing facility
- The pre- and post-transfer media will be 14- or 28-track HDT's
- Landsat spacecraft have the capability and will acquire all desired MSS and TM scenes and will include direct readout for non-U.S. stations
- The global user model is assumed to be represented by regional centers colocated at 14 existing or planned receiving sites
- The data requirement for each regional center is equal to the total number of MSS and TM scenes which are possible to be acquired by a Landsat spacecraft at greater than 5° elevation above the horizon, a circular zone of 4800 km (2873 mi.) centered at the regional station
- The total number of MSS and TM scenes available in each case will be factored by an average cloud cover figure for each region.

- MSS and TM data are kept separate and no tape will contain more than one-day's coverage
- Ephemeris and calibration data will be provided independent of image data
- Non-recurring cost elements include training and "turnkey" systems installed at existing regional center facilities based on "off the shelf" designs
- Annual system maintenance costs at 10% of installation costs (facility maintenance/utilities not included)
- Annual local labor costs at $40,000 per man-year (U.S.A./Canada) and $20,000 per man-year elsewhere
- Shipping and packing included in unit prices

5.2.2.2 Configuration-Dependent Assumptions

The following major assumptions apply only to the specific operational configuration scenarios (noted in parentheses) detailed in Section 5.2.2.4:

(1)

- Product prices are $1500 per TM or MSS HDT (with up to 10 TM or 30 MSS scenes per HDT) and include raw material and packing plus $200 to $450 air freight costs depending on daily quantity (ground transportation, taxes, duties, etc. at destination not included)
- Data shipped daily by air freight

(2)

- Includes data processing facility capital costs
- No costs included for data transmission from INTELSAT receiving station to the regional center
- White Sands tapes recycled after transmission to regional center (for a total of 10 times only per tape). INTELSAT received tapes are not recycled.

(3) and (4)

- Includes data processing facility capital costs
- 10% of data acquired is considered to be perishable and is transmitted via satellite
- No costs included for transmission from INTELSAT receiving station to the regional center
- All HDT's are shipped to the associated regional center following satellite transmission of perishable data
- INTELSAT received tapes are not recycled
- Destination ground transportation changes from major airport to regional center, also taxes, duties, etc. not included

(5)

- Includes data processing facility capital costs

- Includes $200,000 annual fee to U.S.A. for rights of access to the Landsat vehicles
- No costs included for data transmission between a remotely located tracking station and the regional data processing station

5.2.2.3 Daily Data Requirements

Based on the general data acquisition, requirement and availability assumptions itemized in Paragraph 5.2.2.1, the resultant average data quantities and total recorded bits per day were calculated for each regional center. See Table 5.2 for a worldwide summary of the daily data requirements. No corrections were made for any portion of the coverage zone which may be over open ocean.

5.2.2.4 Scenarios and Estimated Costs

The following five scenarios were selected for cost estimation:

(1) Each regional center purchases data in the form of fully processed (P) or partially processed (A) HDT's from a central processing facility in the USA, with delivery by air freight.

(2) Each regional center receives raw data directly from White Sands and performs the required digital processing to generate, as a minimum, partially processed (A) HDT's. All data are transmitted from White Sands via satellite

(DOMSAT, INTELSAT) relay links.

(3) Same as (2) except perishable data only are relayed via satellite links and the rest are delivered as HDT's via air freight.

(4) Same as (2) except all the raw data are delivered as HDT's via air freight (i.e., no satellite links).

(5) A Landsat direct readout terminal is established at each regional center, and raw data are recorded direct from the Landsat spacecraft. Each regional center performs the required digital processing to generate, as a minimum, partially processed (A) HDT's.

Table 5.3 is a "bottom-line" summary of the total 5-year program estimated costs for each of the regional centers, based on the programmatic assumptions given in Section 5.2.2.1 and 5.2.2.2. In each case, the estimated dollar figure is a composite of the one-time nonrecurring costs plus the annual recurring costs for a period of 5 years. It is reiterated that a significant reduction can be effected through downlink-charge negotiations in each member country as previously discussed in Section 5.1.2.3.

TABLE 5.3

5-YEAR ESTIMATED COST SUMMARY

($ Amounts in Millions)

Regional Center	Scenario				
	1	2	3	4	5
Prince Albert, Canada	11.00	26.44	20.68	22.15	29.47
Shoe Cove, Canada	11.00	27.52	21.72	23.05	30.68
Cuiaba, Brazil	11.41	37.58	29.50	26.80	35.73
Santiago, Chile	11.41	37.58	29.50	26.80	35.73
Mar Chiquita, Argentina	11.41	29.50	26.80	26.80	35.73
Kiruna, Sweden	19.98	31.26	27.25	27.25	36.28
Fucino, Italy	17.25	40.91	31.26	26.80	35.73
Ouagadougou, Upper Volta	11.41	24.02	16.87	14.35	23.28
Kinshasa, Zaire	8.67	21.22	15.97	13.85	23.00
Tehran, Iran	17.25	40.91	26.80	26.80	35.73
Hyderabad, India	11.41	36.27	25.80	14.35	23.28
Peking, China	11.41	36.95	32.41	26.80	35.73
Tokyo, Japan	11.41	24.22	19.77	14.35	23.28
Alice Springs, Australia	11.41	38.20	32.95	26.80	35.73

APPENDIX A

LANDSAT DATA BASE INTERCHANGE TAPES

FILE FORMAT SPECIFICATIONS

LANDSAT DATA BASE INTERCHANGE TAPES

FILE FORMAT SPECIFICATIONS

EROS DATA CENTER

COMPUTER SERVICES BRANCH

SIOUX FALLS, SOUTH DAKOTA

FEBRUARY 17, 1978

Revision A
November 1, 1978

LANDSAT DATA BASE INTERCHANGE TAPES

FILE FORMAT SPECIFICATION

DOCUMENT CONTROL PAGE

Revision	Date	Pages Affected	Remarks
Original Issue	January 16, 1978	--	--
Revision A	November 1, 1978	6	Scene ID changed to 13 bytes with station prefix.

Legend:

- * A single asterisk denotes a page which replaces an existing page.
- ** A double asterisk denotes a page which did not previously exist and is added to this document
- *** A triple asterisk denotes a page that is deleted from the document.

TABLE OF CONTENTS

FORWARD

This document defines data content and file structure for the Landsat Data Base Interchange Tapes. This tape format is proposed as a standard for data interchange between LGSOWG stations and the EROS Data Center (EDC) at Sioux Falls, South Dakota. These data may be entered into the data base at EDC, from which computer inquiries then provide imagery available at EDC as well as from participating countries worldwide.

Sections following suggest standard tape format, coding, and operational considerations to allow standard software at EDC to be used in processing tapes from all participating countries. EDC software is also capable of reading other tape formats and data coding where this proves easier for submitting stations.

1.0 PURPOSE

The purpose of this document is to suggest format, data content, and operating considerations in generation of Landsat Data Base Interchange Tapes.

2.0 RECORDING CONVENTION

The tape should be recorded on industry standard nine track, half-inch computer compatible tape in either 800 or 1600 BPI NRZI format. Physical tape characteristics are: (a) unlabeled, 800 or 1600 BPI, nine track, half-inch computer compatible tape; (b) ASCII character set; and (c) 156 byte record, 3120 byte block.

3.0 SCHEDULING

Schedules for EDC tape submission or generation should be established with the Chief, Computer Services Branch, EROS Data Center, TWX 910-668-0310. Tapes may be shipped as convenient; with suggested frequency no more than once per month.

4.0 EDC OPERATIONAL PROCEDURE

Data received at EDC are processed in two program steps (see figure 1). The first program reads the tape and checks for correctness by comparison to tables containing all valid coding for each particular data item. A printed inventory listing is produced containing all errors detected.

In the second step, those image records not rejected are applied to the imagery data base, called the "Main Image File."

LANDSAT DATA ENTRY

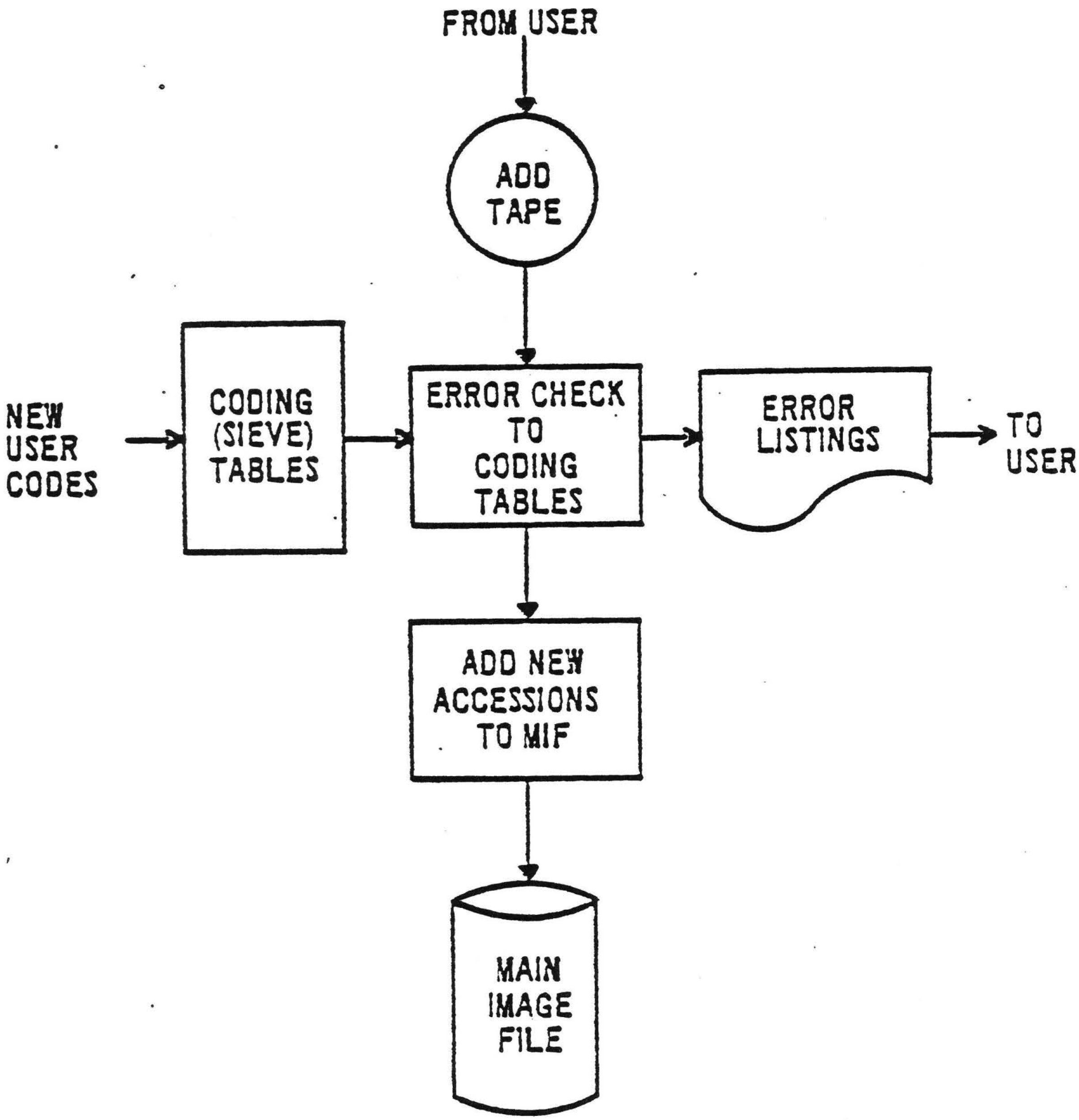

FIGURE 1

The listing indicates actions taken on all input tape records; whether deleted, added, replaced, or rejected due to error.

5.0 TAPE SPECIFICATIONS

5.1 General

Section 5.2 details tape record data structure, content, variable name, and data item description information.

Data items shown are those required to be provided. All other data items required by the computer inquiry programs are generated by the EDC load programs.

Generation of corner point latitude/longitude coordinates is optional but preferred. If left blank, approximated corner points (based on nominal scene size and spacecraft positional parameters) will be generated by the EDC input programs for use in the inquiry programs.

An "action code" field is provided which allows update capabilities as follows:

- Addition of new records or replacement of previously loaded records.
- Deletion of previously loaded records.

The scene identifier is used as the record key. This eleven-digit key may be any alpha-numeric combination of characters but should be the scene number to be used in ordering from the respective Landsat station. Duplicate scene identifiers cannot be allowed by the EDC software. (Duplicates resulting from different Landsat station users are provided for by affixing unique prefix characters.)

Optional flags are included which may be used to indicate archive formats available from the submitting site. These include:

- High density tape
- Computer compatible tape
- Film
- Color composites

These flags indicate general availability only, with no provision as to level of processing performed, image size, detailed formats, etc.

5.2 Data Specifications

The table on the following pages shows the data specifications. All fields should be character or character numeric in format. All fields are required except those indicated OPTIONAL. Any unused field should be blank. Numeric fields should be right justified and zero padded.

DATA SPECIFICATIONS

Element Name	Size (Bytes)	Description
PHOTOID	13	A unique identifier assigned by the foreign station for each Landsat scene. Two prefix (leftmost) bytes indicate station: 81, 82, 83 = USA(85,86 > 1000 days) 8B = Brazil 8C = Canada
WRSPATH WRSROW	3 3	The WRS path and row of this scene, numeric and right justified.
STATUS	1	Indicates new or edited disposition of this record. "1" means delete from data base; "0" means add new or replace an existing scene.
CLOUDCOVER	1	Number indicating cloud cover of the entire scene in tens of percent. Quarter scene averages may be used where necessary.
DATETAKEN	6	Scene acquisition date. Format is YYMMDD; where YY = year, MM = month (00-12), DD = day of the month (00-31).
SATELLITE	1	Landsat satellite number (1, 2, 3, etc.)
RECTECH	2	Number indicating sensor which acquired this scene: 36 = RBV (subscenes - Landsat 3) 37 = RBV (3-band sensor - Landsats 1, 2) 38 = MSS (descending - daytime) 39 = MSS (ascending - nighttime)
SUBSCENE	1	For RBV subscene sensor, indicates subscene (A, B, C, or D).
IMAGEQUALITY(5)	1	Image quality per band. Use first position for subscenes. Valid entries: 0 = 9 M = Missing
MICROFRAME	10	(Optional) Unique identifier for accession aid reference.