NOAA Technical Report ____

Geostationary
Operational Environmental
Satellite/Data Collection
System

Washington, D.C.
July 1979

Series

The and satellite research is for the establishment and operation

Publication as report and a and preclude later publication in an and. Technical Reports is a continua- respective number. former series, ESSA Technical Report national Satellite Center (NESC) Weather Bureau Meteorological facilities NSL Reports. Reports 1 publication NESC 56 of this ser- ies.

Reports in series are available from the National Technical Information Service (NTIS), U.S. Department Commerce, Sills Bldg., 5285 Port Royal Road, Springfield, Virginia 22151, in paper copy or mi- crofiche order by accession number, when given, in parentheses. Beginning with 6, printed copies reports, if available, can be ordered through the Superintendent of Documents, U.S. Gov- ernment Printing Office, Washington, DC 20402. Prices given in request from the Superintendent of Docu- ments request.

ESSA Technical Report

Temperature & Emission and Albedo Months Based on Measure- ments TIROS and TOS VII. J. S. Winston and T. Taylor, September 1967, 32 pp.

Objectives Using Digitized ATS-1 data. M. B. Whitney, April 1968, pp. (PB-178-18)

Some Synoptic-Scale Cloud Spirals. Edward W. Ferguson, Jr. and Harry E. Herman, plus appendices A and B. (PB-178-86)

Global Charts of Variances from ESSA ESSA 5 Digitized Pic- tures January W. Roy Taylor and Jay S. Winston, November 1968, 9 pp.

Carbon Dioxide and Water Vapor in the Atmosphere. William L. Smith, February 1969 pp. (PB-183-296)

Squares the potential height distribution from Satellite L. Smith February 1969, pp.

Some Developments Satellite-Viewed Cloud Jane June 1969 (PB-185-065)

Reflected Solar Radiation Data. L. F. May 1969, pp. (PB-185-111)

National Satellite Center Operations. Karl R. Anderson, Allen R. Shirk and L. Schneider, John L. Oliver, Arthur Schwalb, March 1970 (replaces and revision of NESC Supplement, October 1971, and Supplement 2, March 1973),

Satellite Multichannel Radiometers. Terrence H.

Satellite John A. Leese, 1971, pp. 1-2---4-4 plus references and appen- dices

Atmosphere. P. Krishna Rao,

Studies. L. M. Wallace,

NOAA Technical Report NESS 78

Geostationary Operational Environmental Satellite/Data Collection System

Office of System Engineering
Washington, D.C.
July 1979

Title: GEOSTATIONAR
DATA COLLECT

Author:
NOAA, Natio:

Report: Jul 79 (NO.

OUT

CONTENTS

CONTENTS (Con.)

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

ASCII	American Standard Code for Information Interchange
BER	Bit Error Rate
BPS, bps	Bits per second
CDA	Command and Data Acquisition
CPS	Characters per second
CRC	Cyclic Redundancy Check
dB	Decibels
dBm	Decibels referred to 1 milliwatt
DCPRS	Data Collection Platform Radio Set
DCS	Data Collection System
DDD	Direct Distance Dial
CDF	Central Distribution Facility
e.g.:	for example
EIRP	Effective Isotropic Radiated Power
E/N_o	Bit Energy to noise spectral power density ratio
GOES	Geostationary Operational Environmental Satellite
Hz	Hertz
IBM	International Business Machines Corporation
ID	Identification
LRC	Longitudinal Redundancy Check
LSB	Least Significant Bit
max	Maximum

GLOSSARY (Con.)

min	Minimum
MLS	Maximal Linear Sequence
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NESS	National Environmental Satellite Service
NOAA	National Oceanic and Atmospheric Administration
op. cit.	In the work cited
PSK	Phase shift keyed, -ing
P_{t1}	Probability that the transmission path loss will be less than the value used
RCP	Right-hand Circularly Polarized
S/C	Spacecraft
s	Seconds
SEM	Space Environment Monitoring
SFSS	Satellite Field Service Stations
SMS	Synchronous Meteorological Satellite
sync	Synchronization
UHF	Ultra High Frequency
UTC	Coordinated Universal Time
VISSR	Visible and Infrared Spin-Scan Radiometer
WEFAX	Weather Facsimile

GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE/ DATA COLLECTION SYSTEM

ABSTRACT. The Data Collection System portion of the NOAA Geostationary Operational Environmental Satellite program has the potential and capacity for many and varied uses. The purpose of this report is to describe to potential users the carrier system and its data processing capabilities. User qualifications and requirements for participation in the Data Collection System are also defined.

SECTION 1

INTRODUCTION

1.1 GOES System Description

1.1.1 What Is GOES?

The United States of America Geostationary Operational Environmental
Satellite (GOES) service is an integrated system of Earth and space
environmental sensors which provide nearly continuous observational
information to ground-based user stations. The service is operated
and controlled by the National Oceanic and Atmospheric Administration
(NOAA) of the U.S. Department of Commerce, and was developed at the
National Environmental Satellite Service (NESS) in conjunction with
the Synchronous Meteorological Satellite (SMS) program of the U.S.
National Aeronautics and Space Administration (NASA).

1.1.2 How Is the GOES System Implemented?

The GOES service currently operates two satellites located in Earth-
synchronous orbits approximately 35,500 kilometers above the Equator
at longitude 75°W and longitude 135°W. Both satellites are controlled
from the NOAA Command and Data Acquisition (CDA) Station at Wallops
Station, Virginia.

1.1.3 What Does GOES Do?

The GOES service performs five missions. Each of the missions
is carried out by a dedicated subsystem, as described below.

1.1.3.1 Visible and Infrared Spin-Scan Radiometer (VISSR)

Each satellite has a visible/infrared radiometer that provides nearly
continuous imaging of the viewed portion of the Earth's surface and
cloud cover. The visible images are produced during daytime, whereas
the infrared images provide day and night coverage.

1.1.3.2 Retransmission of VISSR and WEFAX Data

The CDA is uniquely equipped to receive the high-speed VISSR data from
the spacecraft. These data are reformatted at the CDA and retransmitted
through the spacecraft transponder to Satellite Field Service Stations
(SFSS) within view of the spacecraft. SFSS activities located in
San Francisco, California; Kansas City, Missouri; Suitland, Maryland;
Miami, Florida; and Honolulu, Hawaii; and Anchorage, Alaska, currently
receive and process the retransmitted VISSR data for distribution to
weather forecast stations throughout the United States.

In a similar fashion, Weather Facsimile (WEFAX) pictures are transmitted
through the spacecraft transponder to such users as ships at sea,
aircraft, and weather forecast stations located within view of the space-
craft.

1.1.3.3 Space Environment Monitoring (SEM)

SEM equipment onboard the spacecraft measures the energy and trajectory of incident particles. These data are transmitted to the Space Disturbance Forecast Center at Boulder, Colorado, for distribution and analysis.

1.1.3.4 Command and Telemetry

The "housekeeping" functions necessary to maintenance of correct attitude and position, and monitoring spacecraft status, etc., are provided by the Command and Telemetry subsystem under control of the CDA Station.

1.1.3.5 Data Collection

The Data Collection capability enables atmospheric and Earth-based sensors within view of the spacecraft to transmit synoptic or interrogated data to the CDA through the spacecraft transponder. These data are relayed to the Central Distribution Facility (CDF) at Suitland, Maryland, for dissemination to users.

1.1.4 Is There a Standby Satellite?

To serve as a backup in event of failure of either operational satellite there is a third geostationary satellite in orbit at longitude 105°W (located midway between the other two). The backup satellite can readily be moved to either the east or west satellite position should such a need arise.

1.1.5 Will Service Interruptions Occur?

There may be interruptions during the periods of solar eclipses. The GOES satellites undergo spring and autumn eclipses during a 46-day interval at the vernal and autumnal equinoxes. The eclipses vary from approximately 10 minutes at the beginning and end of eclipse periods to a maximum of approximately 72 minutes at the equinox. The eclipses begin 23 days prior to equinox and end 23 days after equinox; i.e., March 1 to April 15 and September 1 to October 15. The outages occur during local midnight for the satellites' mean meridian. There will also be shutdowns for periodic maintenance at the Wallops CDA station. These scheduled outages will be reduced in the future as redundancy is added to the Wallops Station facility.

1.2 Description of the Data Collection Subsystem

In consonance with the primary purpose of this brochure, the following paragraphs discuss in some detail those aspects of the Data Collection System that will be of particular interest to users.

1.2.1 How Can an Organization Become a GOES/DCS User?

An organization having a requirement for data collection, or which plans to collect data using the GOES DCS capability, must formally request permission to participate. Requests are processed by: National Oceanic and Atmospheric Administration, National Environmental Satellite Service, Washington, D.C. 20233.

The prospective user must describe the proposed use of the DCS for examination by the NESS DCS Review Committee, which recommends appropriate action to be taken by the Director of NESS on the request. A questionnaire (see Appendix A) is provided to facilitate presentation of information needed to properly consider the user's request.

Upon approval of the user's request for participation in the DCS, a Memorandum of Agreement will be prepared to detail the rights and responsibilities of both NESS and the participating user. This agreement is attached as Appendix B.

1.2.2 What Does It Cost?

Collection of data from user sensor platforms and processing the data for dissemination using the GOES DCS facilities is without charge to the user. The user will be responsible for his own costs of sensor platforms, such as procurement, maintenance, and installation, and such tests as are required to establish conformity to the DCS performance specifications. The user will also be responsible for the costs of communications lines, modem equipment, and data terminals necessary to the dissemination capability of the GOES/DCS. Unless an exception is justified, data collected for individual users will be made available by NESS to other users or interested parties upon request.

1.2.3 What Geographical Coverage Is Provided by the DCS?

The DCS was based on the practicality of an Earth-sited transmitter operating with a suitable antenna to provide an Effective Isotropic Radiated Power (EIRP) of 50 dBm (max.) at a minimum antenna elevation angle of less than 5°. The minimum antenna elevation angle defines the portions of the Earth's surface having geocentric angles up to approximately 77°, measured from the subsatellite point. Figure 1 described the geometry of the DCS. Figure 2 presents the actual Earth surface coverage for the DCS of both GOES satellites.

1.2.4 What Is the DCS Message Capacity?

Access to the spacecraft transponder is shared among all platform site transmitters within its field of view. (See Figure 2.) The DCS has the capacity for handling at least 10,000 transmissions (30-s average message duration) from platform sites via the spacecraft transponder in each 1-hour period. Frequency division multiple access with time-shared channel occupancy is the technique used to meet the data traffic requirements. 200 channels are available for domestic user assignment with an additional 33 channels provided for cooperative working with international users. The channel spacing accommodates the 100-bits-per-second DCS message data rates.

1.2.5 What Type of User Sensor Platform Can Be Used?

The simplest user platform configuration requires:

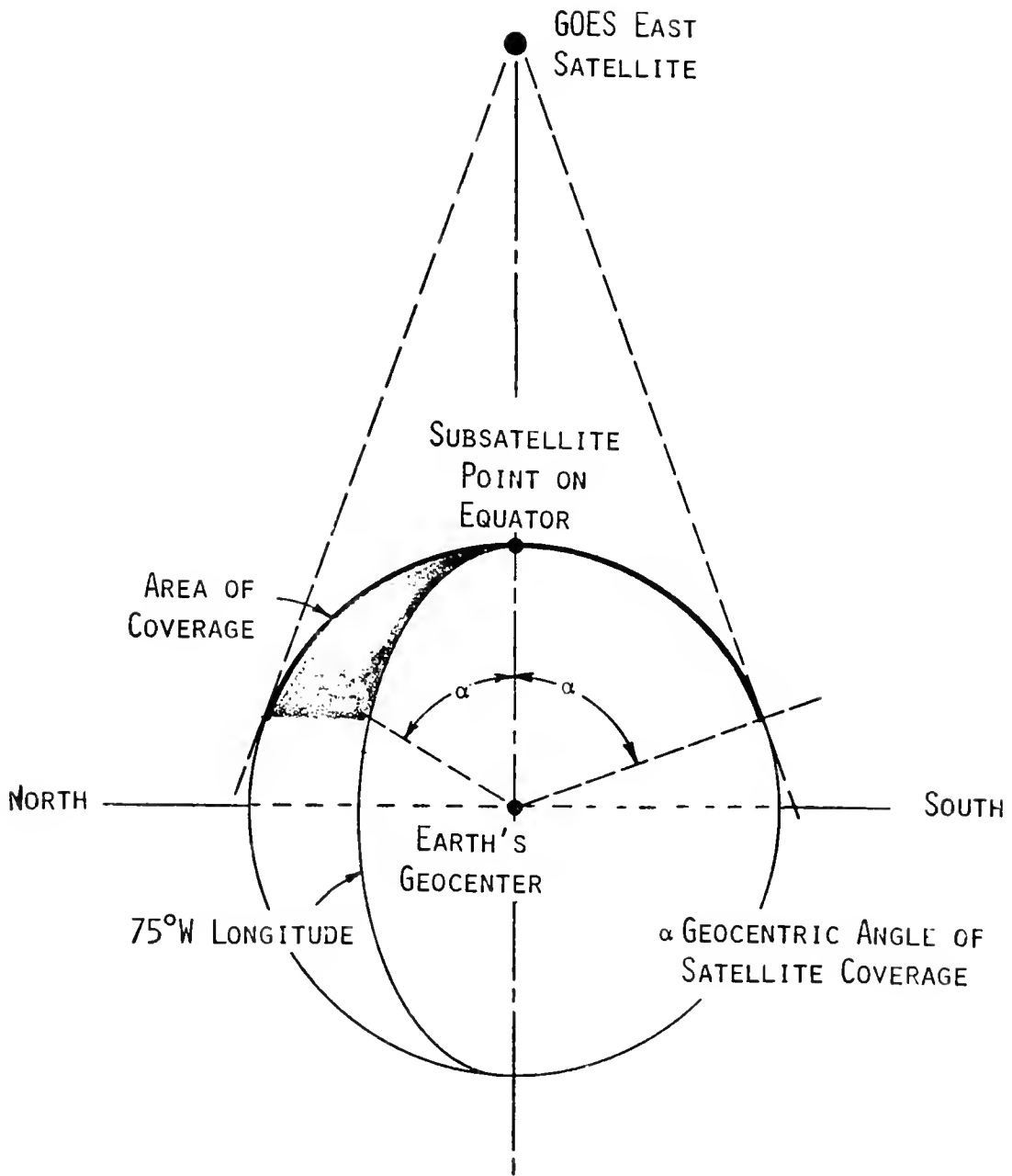(1) An UHF transmitter and antenna combination capable of producing +50 dBm EIRP.
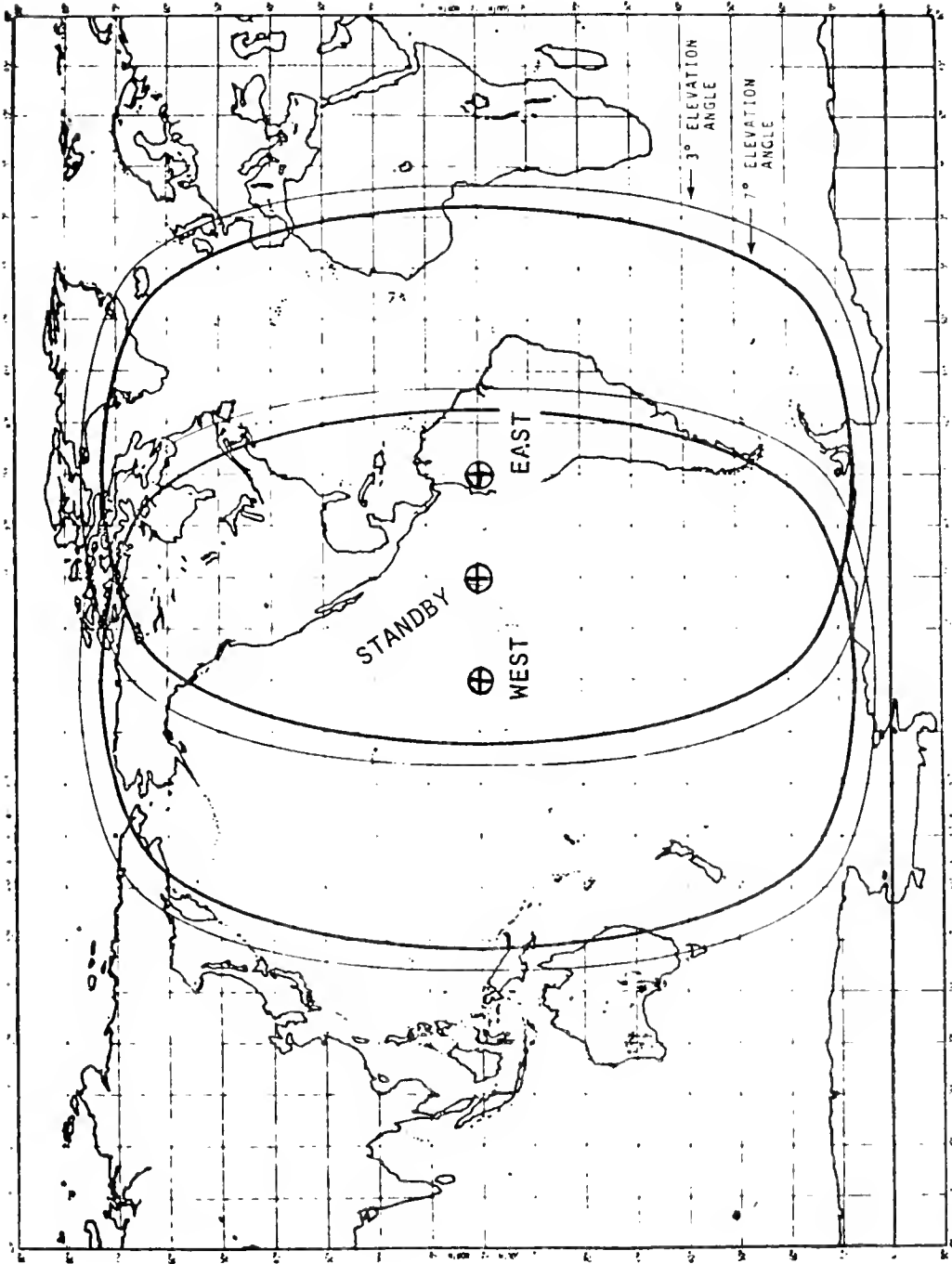
FIGURE 1

GEOMETRY OF THE DCS COVERAGE

FIGURE 2
SMS/GOES COVERAGE

(2) A sensor data interface to provide ASCII data coding and formatting.

(3) A timer, or sensor threshold logic, to initiate transmission on a regular timed basis, or on the detection of conditions exceeding predetermined levels.

The addition of an UHF receiver capable of receiving and decoding the command/interrogate signal provides the capability of remotely commanding sensor platform responses.

To qualify for participation in the GOES DCS, the data being collected must be observations and measurements of physical, chemical, or biological characteristics of the Earth or its surrounding space. A wide variety of sensor platforms can work with the Data Collection System, for example:

(1) fixed location sensors; temperature, wind, and rainfall gages on land and sea; river level and tide gages; seismic detectors; experimental environmental monitors.

(2) mobile sensors; balloon and aircraft-borne monitors; free-floating ocean environmental sensors; shipboard weather and oceanographic reporting stations.

Any platform that has been demonstrated to meet the DCS performance specifications (Appendix C) may be used. A current list of approved platforms may be obtained from NESS.

1.2.6 How Are Transmitter Frequency Assignments Obtained?

When an organization is accepted as a DCS user, the sensor platform transmitter channel frequency assignments are provided by NESS. The user, however, is responsible for obtaining authority from the appropriate national agencies to operate each platform transmitter at its deployed location.

1.2.7 How Do the Sensor Data Reach the User?

Transmission of data from the user sensor platform may be initiated in several ways. The platform site transmitter may be commanded to transmit the sensor data, using the interrogation capability of the DCS. The transmitter may be activated at regular time intervals under the control of an internal timer. Sensor threshold or abnormal conditions may be used to trigger transmission of emergency information or data requiring immediate attention (such as seismic activity). Generally, transmissions initiated by different means (interrogated, self-timed, or emergency) will not share occupancy of a common response channel.

Each sensor platform site transmitter is assigned at least one 31-bit address identifier. The address identifiers are part of the required format for transmission of sensor data, and are used by the data processing subsystem to route the data to the user. Once a message is received by the DCS, it is entered in the system events log and

stored in the appropriate user's area of the data output buffer to await dissemination. The preferred method of dissemination is in real time over a dedicated communication channel assigned to the user. Alternative arrangements, such as dissemination over dialup circuits, may also be used.

1.2.8 How Is the DCS Operation Controlled?

DCS operation is controlled by the Data Processing Subsystem computer which handles the routine functions of message scheduling, status reporting, data reception, buffering, and dissemination. Manual operator intervention is provided for startup procedures.

Control of the DCS is exercised by comparison of real-time system activity to the system schedule stored in the computer. Messages are periodically sent by the computer to the CDA subsystem which include platform address identifiers scheduled for activity, channel occupation, and time of report, and whether the reporting platform is self-timed or requires interrogation. The CDA equipment receives the platform sensor data transmitted through the satellite transponder, performs character error checks, and temporarily stores the data. The received messages are checked at the CDA for expected address identifiers and transmitted to the World Weather Building Central Distribution Facility (CDF), along with all pertinent error information. If a scheduled message was not received at the expected time, the CDF computer notifies the user. The occurrence of an unexpected (unscheduled) platform message is analyzed by the computer to determine whether it was due to an equipment malfunction, platform site transmitter test, or emergency condition, with appropriate action automatically being taken and abnormal status indication provided to the user.

Received sensor platform messages and abnormal response messages are formatted into bulletins in the CDF data buffer. Dissemination of these bulletins to users will be attempted in real time, as the data replies are received, over the dedicated circuit assigned to the user. Reformatting of platform response data is not performed; these data appear unmodified in the bulletins disseminated to the users. Users must consider the effect of their platform sensor data format on their data terminal, e.g.:

    (1) Requirements for carriage return, line feed, and
         characters needed for proper display.

    (2) Compatibility of the terminal character set with the
         transmitted characters.

    (3) Use of characters or character sequences for special
         purposes.

1.2.9   What Data Error Probability Can the DCS User Expect?

Under reasonable conditions, the user can expect to obtain a bit error probability of 10^{-5} or better, using data received at the CDA and provided to the user at the Central Distribution Facility (CDF) at Camp Springs, Maryland.

Various factors affect the data quality. Some of these are determined by the GOES system design, and some are related to instantaneous spacecraft usage and propagation conditions. Appendix D treats the considerations involved in reception at Earth terminals other than the CDA.

The spacecraft down-link power at S-band is shared between the CDF response and occasional TIROS-N data relay transmissions. As the number of DCP's increases, somewhat less power is available to each simultaneously active channel. Furthermore, simultaneous operation of the VISSR subsystem reduces the total power available to the DCP/ TIROS-N down-link transmission by 4 to 5 dB. Sufficient power margin is provided in the system design to accommodate full anticipated loading under the above worst-case power sharing conditions when utilizing the CDA or an equivalent performance ground terminal.

Other factors that can affect data quality[1] are the DCP's geographic location with respect to the spacecraft, as losses are slightly higher at the "Earth's edge"; multipath propagation, in which DCP signals reflected from the ground, ocean, etc., interfere with direct signals; and ionospheric scintillation, which may occasionally produce greater than normal path attenuation. Maintenance of the DCP, adjustment of the DCP antenna positioning, and provision of an unobstructed path to the GOES are essential to minimum-error performance.

1.2.10   Can a User Achieve Direct Data Readout From the GOES
         Satellite?

Any user, with discretion, may implement a data collection ground receiving terminal and thereby achieve direct readout of the S-band reply data from the GOES satellite. This secondary data collection terminal enables a user to be independent of the primary CDA data collection receive terminal. However, the user will be required to adhere to the channel assignments and schedules coordinated for the GOES system by NESS. The design constraints and characteristics required of such a secondary user-owned data collection terminal are presented in Appendix D.

_____

[1]   At the CDA, the present demodulators are sensitive to data patterns, and some characters of the ASCII set cause difficulty. This problem is being remedied.

Figure 3.—GOES Data Collection System.

SECTION 2

A CLOSER LOOK AT THE DCS

2.1 DCS General Operation

The GOES Data Collection System (DCS) is a communication system
designed to be used by many organizations having the need to relay
environmental data from remote sensors to the user's processing
center on a timely basis. The system is designed to accommodate
10,000 individual sensor platform transmissions per hour operating
in three possible modes:

   (1) Interrogated; the sensor platform transmits
        its data in response to an interrogation
        signal from the CDF.

   (2) Self timed; the sensor platform transmits its data
        at fixed (synoptic) intervals controlled by a timer
        located within the sensor platform.

   (3) Emergency; the sensor platform transmits its data
        after a predetermined sensor threshold (trigger)
        level has been exceeded.

Figure 3 presents a pictorial diagram of the Data Collection System
showing its major functional subsystems:

   (1) Deployed sensor platforms; discussed in Section 2.2.

   (2) East and West spacecraft; discussed in Section 2.3.

   (3) Command and Data Acquisition Station (CDA); discussed
        in Section 2.4.

   (4) CDF and user dissemination circuits; discussed in
        Section 2.5.

The radio frequency plan for the DCS is shown in Figure 3. The exact
frequency or frequency range is associated with each specific
function.

2.2 Sensor/Platform Interface

2.2.1 Sensor Data Format

The CDF computer is programed to make only those modifications to the
sensor data necessary to disseminate the data to the user. No
capability is provided for analysis or interpretation of sensor data
or for code conversion or error correction. Sensor data are expected
to be binary-coded ASCII characters (conforming to the 128-character
code set shown in Figure 4) transmitted serially (least-significant
bit first), with odd parity determining the eighth bit for each

$b_4 b_3 b_2 b_1$	$b_7 \rightarrow 0$ $b_6 \rightarrow 0$ $b_5 \rightarrow 0$	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0 0 0 0		NUL	DLE	SPACE	0	@	P	`	p
0 0 0 1		SOH	DC1	!	1	A	Q	a	q
0 0 1 0		STX	DC2	"	2	B	R	b	t
0 0 1 1		ETX	DC3	#	3	C	S	c	s
0 1 0 0		EOT	DC4	$	4	D	T	d	t
0 1 0 1		ENQ	NAK	%	5	E	U	e	u
0 1 1 0		ACK	SYN	&	6	F	V	f	v
0 1 1 1		BEL	ETB	'	7	G	W	g	w
1 0 0 0		BS	CAN	(	8	H	X	h	x
1 0 0 1		HT	EM	)	9	I	Y	i	y
1 0 1 0		LF	SUB	*	:	J	Z	j	z
1 0 1 1		VT	ESC	+	;	K	[	k	{
1 1 0 0		FF	FS	,	<	L	\	l		
1 1 0 1		CR	GS	-	=	M	]	m	}
1 1 1 0		SO	RS	.	>	N	^	n	~
1 1 1 1		SI	US	/	?	O	--	o	DEL

☐ PRINTABLE CHARACTER   ☐ AUXILIARY DEVICE CONTROL CHARACTER
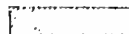
▨ PRINTER CONTROL CHARACTER   ▦ CODES GENERATED BY KEYBOARD BUT NO ACTION TAKEN

USASCII CONTROL CHARACTERS
(From USA Standards Institute Publication X3.4--1968)

ACK	acknowledge	ETX	end of text
BEL	bell	FF	form feed
BS	back space	FS	file separator
CAN	cancel	GS	group separator
CR	carriage return	HT	horizontal tabulation
DC1 = X-ON	device control 1	LF	line feed
DC2 = TAPE	device control 2	NAK	negative acknowledge
DC3 = X-OFF	device control 3	NUL	null
DC4 = TAPE	device control 4 (stop)	RS	record separator
*DEL = RUB OUT	delete	SI	shift in
DLE	data link escape	SO	shift out
EM	end of medium	SOH	start of heading
ENQ = WRU	enquiry	STX	start of text
I OT	end of transmission	SUB	substitute
ESC	escape	SYN	synchronous idle
ETB	end of transmission block	US	unit separator
		VT	vertical tabulation

* ot strictly a control character

Figure 4.--ASCII Character Assignments.

Bit # of Character: 8   7   6   5   4   3   2   1

  (see note)

Function:

```
Odd parity    Always "1"                        6 Bits of
                                                Binary data
```
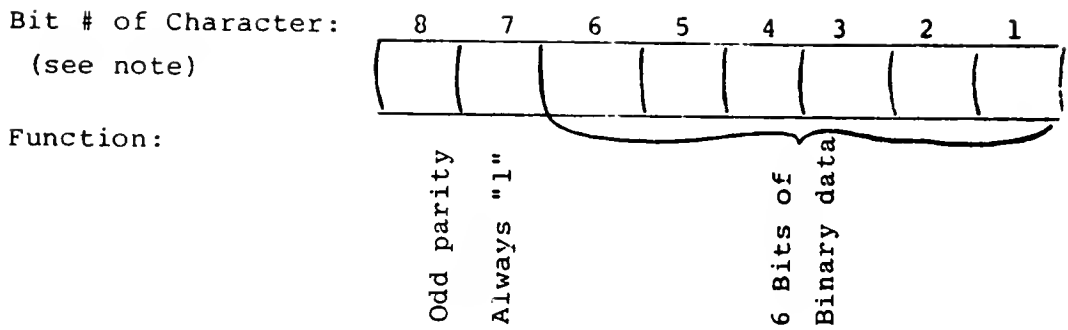
Figure 5.--Pseudo-ASCCII binary data format
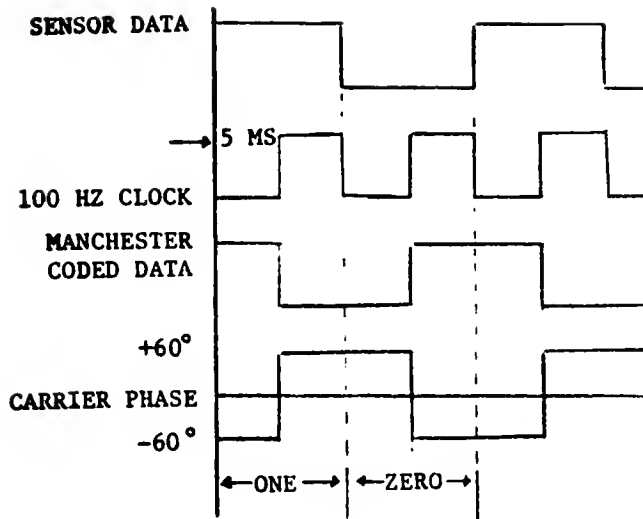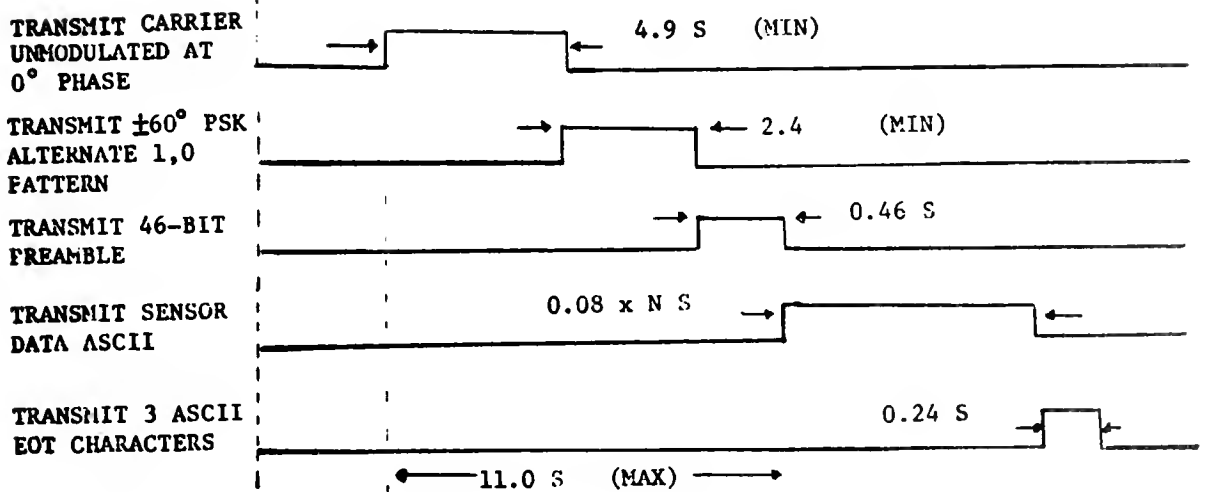
NOTE: Bit # is order of transmission -- #1 is first

Figure 6.--Modulation Definition.

NOTE: N = NUMBER OF 8-BIT ASCII CHARACTERS OF SENSOR DATA

Figure 7.--Platform Transmitter Response Timing.

character. If necessary binary data may be transmitted when formatted into pseudo-ASCII characters, as shown in Figure 5. These special requirements are needed to ensure that binary data are not mis-interpreted as control characters, affecting communications link operation.

The sensor data must not contain certain ASCII characters that have special control functions in the DCS dissemination system. These prohibited characters are: DLE,NAK, SYN, ETB, CAN, GS, RS, SOH, STX, ETX, ENQ, and ACK. EOT characters must appear only at the end of transmission and will be deleted from the data prior to dissemina-tion. Data characters containing parity errors will be replaced with NUL or $, depending on the specified dissemination link.

2.2.2 Sensor Platform Transmitter Response Format

The platform response format satisfies the CDA requirements for response signal acquisition, clock recovery, data bit synchroni-zation, message synchronism, and optimum response channel utilization. The data are Manchester encoded to provide a self-clocking signal which is used to modulate the transmitted carrier by phase shift keying (PSK). Figure 6 defines the coding and modulation characteristics of the platform transmitter response signal.

A platform response transmission (Figure 7) begins with unmodulated carrier (0° phase shift) for 5 seconds to allow the CDA data demodulator to acquire the signal and establish a phase reference. Next, the response signal is PSK'd with $2\frac{1}{2}$ seconds of alternate "one," "zero" data (Manchester coded) so the data demodulator may obtain the 100-Hz bit rate clock and data bit synchronization. Then the 46-bit preamble is sent, consisting of the 15-bit MLS message sync word (100010011010111) followed by the 31-bit sensor platform address identifier word with the most significant bit (MSB) of those sequences transmitted first. The sensor data in serial ASCII character (odd parity) format are sent immediately following the preamble with the least-significant bit of each character transmitted first. A postamble consisting of 3 8-bit EOT characters marks the end of the response message.

The CDF considers all the data in the platform response message framed by the preamble and postamble to be sensor data characters in ASCII. At the CDA, the received platform address identifier is compared with the expected address identifier obtained from the CDF computer, and the sensor data characters are tested for errors by examining received character parity. Detected error conditions will cause the appropriate error status to be transmitted along with the sensor data to the CDF computer. If no response is received at the CDA when one is expected, a "no message received" notice is sent to the CDF computer and on to the user.

2.2.3 Command/Interrogate Signal Format

The signal transmitted from the CDA to the deployed sensor platform field via the spacecraft transponder contains two information items:
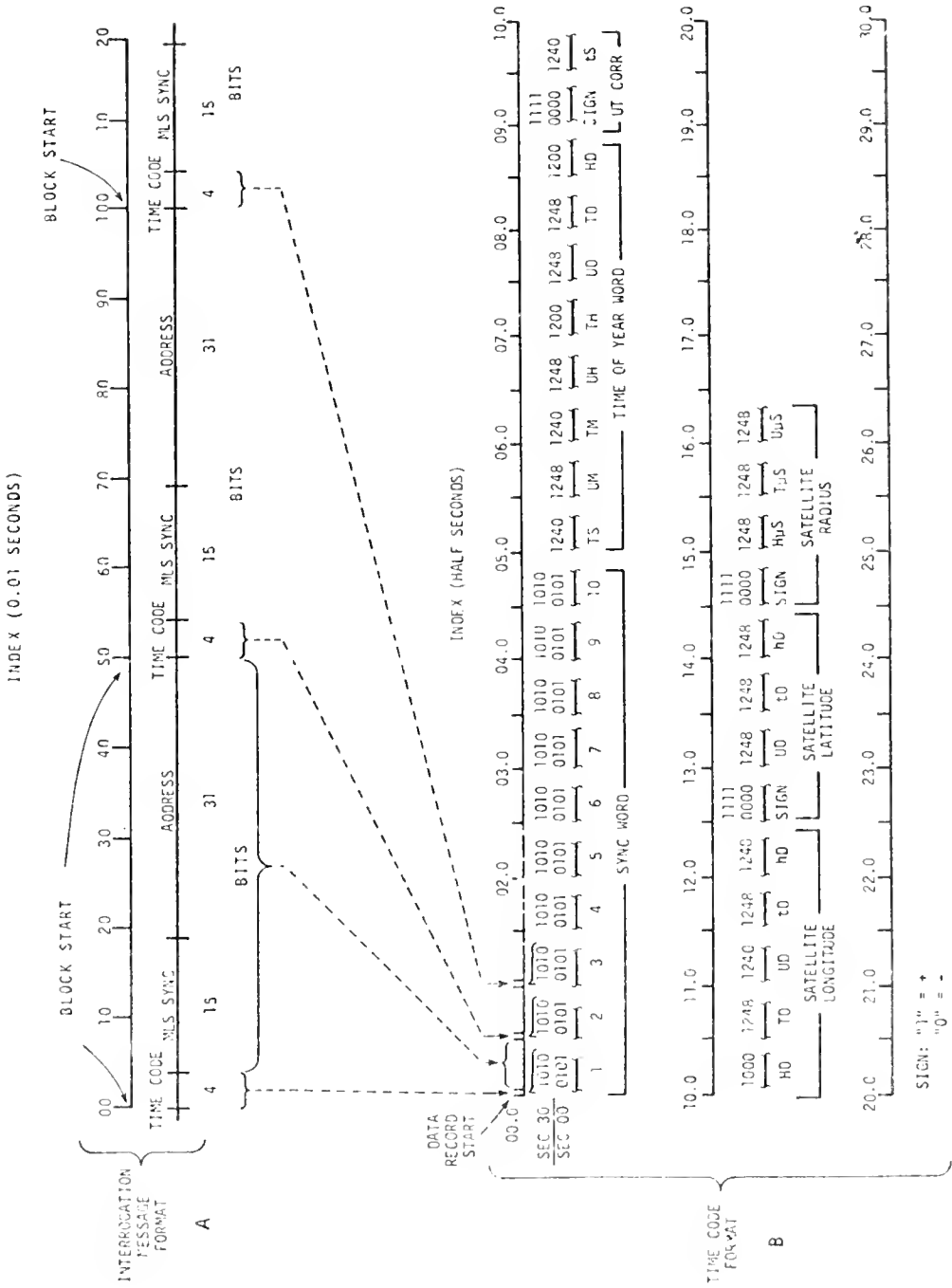
Figure 8.--Interrogation Message and Time Code Formats.

(1)   Platform address identifier (or command word) which
           initiates the appropriate response activity from
           the platform to which it corresponds.

    (2)   Coded time data, updated at $\frac{1}{2}$-minute intervals,
           referred to an NBS source.

The CDA equipment which generates the Interrogate signal transmits
a different frequency for each spacecraft; a sensor platform receiver
must be equipped to receive the specific signal frequency trans-
mitted via the spacecraft serving its site.   Currently, both space-
craft transmit identical address identifiers.   The Interrogate signal
modulation characteristics are those shown previously in Figure 6.

The Interrogate message is formatted into blocks of 50 bits, as
follows:

    (1)   4 bits of time-code data.

    (2)   15-bit MLS for message sync; same as used
           in platform reply (paragraph 2.2.2).

    (3)   31-bit address identifier.

Message timing is derived from the CDA station atomic clocks which
are maintained by NBS to within a few microseconds of the master
NBS clock in Boulder, Colorado.   As an approximate accommodation of
the satellite transmission path time delay, the time signals as
provided to the CDA Interrogate signal generating equipment are
advanced 260,000 microseconds.   The leading edge of the first bit
of each message block coincides with the CDA station standard's
$\frac{1}{2}$-second mark.

A complete time-of-year data record is transmitted piecemeal in
the time code bits every 30 seconds, beginning on the minute-and
$\frac{1}{2}$-minute marks. Figure 8 shows the format of the Interrogate
message block and the time code record.

The serial bit transmission sequence is shown in real-time reading
from left to right.   In all message segments the LSB is sent first.

The format of the time-of-year data record is as follows:

(1)   Sync word, 40 bits in length, consisting of ten 4-bit
       time code characters which designate whether the trans-
       mission began on the minute-or $\frac{1}{2}$-minute mark.   (1010
       character for 1-minute records, 0101 for $\frac{1}{2}$-minute records;
       LSB sent first).

(2)   Time-of-year word as eight 4-bit time code characters with
       the hexadecimal value of each character representing a
       decimal digit of the sequence; seconds (tens); minutes (units),
       (tens); hours (units), (tens); days (units), (tens), (hundreds),
       of Coordinated Universal Time (UTC).

(3) Correction to universal time as 2 time code characters;
     sign of correction (1111 = +, 0000 = -), and tenths of
     seconds corrected.

(4) Satellite ephemeris in geocentric measure as thirteen 4-
     bit time code characters; longitude in degrees (hundreds),
     (tens), (units), (1/10's), (1/100's); latitude in degrees
     (sign), (units), (1/10's), (1/100's), orbital radius
     correction in microseconds (sign), (hundreds), (tens),
     (units).

NBS Technical Note 681, "A Satellite-Controlled Digital Clock,"
describes use of the time code data transmitted via the DCS
Interrogate signal to obtain continuously updated time-of-year
data at a sensor platform site to an accuracy of about 100 micro-
seconds with +20-microsecond precision.

2.2.4 Platform Radio Set Characteristics

A sensor platform does not need to be equipped to receive the
Command/Interrogate signal for operation in the DCS. The additional
flexibility provided by the Command/Interrogate capability may be
desirable, for example, when the data reporting schedule requires
modification or when the sensor activities must be directed
remotely.

The requirements for a sensor platform radio set are described in
NOAA/NESS Specification No. 200.004, "Data Collection Platform Radio
Set Specification." The design characteristics of platform radio
sets essential to operation in the DCS are presented in Appendix C,
"Platform Radio Set Certification Requirements."

2.2.5 Environmental Considerations

Efficient utilization of the DCS capability for timely data
collection from unattended sensor sites requires that platform radio
sets be able to operate within specifications for all environmental
conditions to which they are exposed. Environmentally induced
performance changes may result in loss of important data from the
affected sensor platform, as well as from other platforms which
experience interference produced by the malfunctioning equipment.

2.3 Spacecraft Function in the DCS

2.3.1 Communication Transponder

The spacecraft (GOES) operates as a cross-strapped transponder
within the DCS communications chain. Command/Interrogate signals
from the CDA station are received by the spacecraft at S-band, then
translated to UHF and retransmitted through an Earth-coverage antenna
to the field of deployed sensor platforms. Response signals from
the sensor platform sites are received by the spacecraft at UHF,
translated to S-band, and sent to the CDA Station. The spacecraft
transponder is fully redundant to guard against DCS outages, because
of premature equipment failure.

2.3.2 Conditions Affecting Access and Performance

Periodic preventive maintenance is scheduled for the DCS well
in advance, since no interrogated data collection can be
carried out during these periods.

Twice each year, the Earth's position will be such that the space-
craft orbit carries it through the Earth's shadow. Because the
spacecraft's prime power source is a solar array, safety considerations
may require the transponder to be operated in a low-power mode if
at all to conserve secondary power. This results in a satellite
transmitter power drop of from 1 to 3 dB.

DCP up-link response signals, occasional TIROS-N data relay signals,
and satellite receiver noise share the down-link power output of
the GOES. Increasing the number of active DCP channels thus decreases
the power per channel, and also simultaneously reduces the down-link
noise. Until the noise contributed by the CDA or other ground
terminal receiving system becomes the limiting factor, the net signal-
to-noise ratio is nearly independent of channel loading, and bit
error probabilities of less than 10^{-5} may be anticipated, as
described in paragraph 1.2.9 on page 8.

2.4 Command and Data Acquisition

2.4.1 Response Data and Command/Interrogate Signals

A UHF Pilot Response signal centered in the platform response
frequency band and derived from the CDA station frequency
standard is transmitted to the spacecraft transponder along with
replies from the deployed platforms. The corresponding signal
received at the CDA Station is recovered from the S-band receiver.
The recovered signal is applied to the response link receiver. The
recovered signal is applied to the response link Automatic Phase
Control and Multicoupler Chassis which compensates for spacecraft
oscillator variations, and divides the received CDA response signals
in order to drive the response channel data demodulators. Forty
data demodulators are presently implemented with the capacity to
expand at a future date.

Command/Interrogate data are applied to the Interrogate Channel Modulator which Manchester encodes the data and applies them to a Phase Shift Keying (PSK) modulator. The modulator output provides the input to the Interrogate Channel Frequency Control, which supplies the CDA S-band transmitter with the Interrogate Signal for transmission to the spacecraft transponder. The UHF Command/Interrogate signal is received at the CDA and applies to the Interrogate Channel Data Demodulator which produces an error signal for automatic frequency control and demodulates the Interrogate signal for bit error rate performance testing. (See Figure 3, page 19.)

2.4.2 Time Data and Command/Interrogate Signal Format

Details of the modulation and data contained within the Command/Interrogate signal are presented in paragraph 2.2.3. Since a Command/Interrogate signal is transmitted continuously, a dummy address is utilized in those periods when the CDF is not providing platform addresses for interrogation. In the absence of any address identifiers from the CDF for transmission to the sensor platform field, an idle pattern of 31 binary bits is used (0011010010000101110110001111). These bits are Manchester encoded and transmitted MSB first.

2.4.3 Response Data Demodulation and Transmission to CDF

After recovery of the response signals as described in paragraph 2.4.1, the response data are demodulated in the appropriate CDA Channel Data Demodulator and held in buffer storage until the entire response is received at the CDA. The response address identifier is compared at the CDA with the expected platform address, and the message characters are checked for parity errors. The platform sensor response and any applicable error conditions are then forwarded to the CDF for logging and dissemination, or for special attention based on error conditions.

Engineering tests of SMS-2 (op. cit.) showed that the average time delay of platform site interrogation (from transmission of address identifier to reception of response preamble) was 12.6 seconds.

2.5   Data Recovery-Central Distribution Facility (CDF)

2.5.1   Recovered Data Characteristics

Recovered data and other messages sent from the CDF to the users are in data record form, consisting of a heading and sensor platform data.   Each record represents one of the following:

    (1)   Platform sensor response.

    (2)   Abnormal platform response message.

    (3)   Operator message.

(An "abnormal platform response message" is a "canned" message from the DPS describing an unexpected event in a platform response, and is preceded by two carets (ΛΛ) for rapid identification.)

Each normal platform response data record contains:

    (1)   The platform sensor address identifier (in hexadecimal representation).

    (2)   A question mark (?) if the address had bit errors or a space if the address was received without error.

    (3)   The time platform data were received, as day-of-year (3 characters), hour (2 characters), minute (2 characters) and second (2 characters) of Coordinated Universal Time.

    (4)   Received data (as ASCII characters).

Characters received with parity errors will be replaced in the data with either a dollar sign ($) or NUL character, depending on the means of dissemination as explained in 2.5.3 below.   The EOT characters required to terminate the platform transmission are not included with data in the record. (For further details regarding this general subject, refer to the user interface manual listed in the references.)

2.5.2   Error Checks and Abnormal Responses

The CDF identifies as abnormal all responses with error conditions. All scheduled response messages will be routed to users even if the address is received in error.   (Only unscheduled unrecognizable messages will not be disseminated.)

The following error conditions are recognized in the CDF:

(1) A scheduled or interrogated message is not received when expected.

(2) A scheduled message is received slightly off schedule.

(3) An unscheduled response message is received (4)

(4) An interrogation was not performed as scheduled for some reason.

(5) A response message exceeded the expected channel occupancy time for the sensor platform.

(6) Data are received with parity errors. (For interrogated responses, the user may specify whether all responses are required, or only those without error. The maximum number of reinterrogations to recover bad data (up to 15) may also be specified.).

(7) Address identifiers received with 2 or fewer bit errors will be corrected within the data record by the CDF.

2.5.3 User Access to Recovered Data

2.5.3.1 User Dissemination Circuits

Three classes of communication circuits are utilized by the CDF for dissemination of sensor platform data. These classes differ mainly in the user terminal capabilities the CDF presumes to exist, and their respective information transfer rate. The three classes of circuits are:

(1) Full-time, dedicated.

(2) 1200 baud dial-up.

(3) 110 baud dial-up.

2.5.3.2 Dedicated Circuit

For the first class of circuit, the CDF uses synchronous data transmission at modulation rates (determined by the modem equipment) up to 9600 baud. The "handshaking" protocol between the CDF and user terminal follows the IBM Binary Synchronous Communication procedures ("General Information, Binary Synchronous Communications," IBM No. 6A2730042). Communication over the dedicated, full-time circuits of the CDF has the following characteristics:

Channel Type   : full duplex; half-duplex protocol

Modulation Rate: 0-9600 baud; 2400 baud nominal

Coding   : ASCII, odd parity, nontransparent

Error Control   : block transmission; alternating ack $\emptyset$, ack 1

Block Length   : 190 data characters maximum and 3 (or 4) framing characters

Block Check   : user option of Longitudinal

Character   : Redundancy Check (LRC) or Cyclic Redundancy Check (CRC-16)

Because the full-time circuits are permanent connections, the CDF knows which user is associated with each, and there is no need for identification procedures. If any platforms have emergency transmission capability, the CDF may identify such transmissions with a special header (optional) and data description in the disseminated data bulletin.[2] Operator intervention is not required for routine or emergency data dissemination over a full-time dedicated circuit.

The bulletin format used contains the following information sequence:

Function	Number of Characters
Control character (SOH); start of heading	1
3-digit message sequence number	3
Catalog number; identification of user	5
Control character (STX); start of text	1
6-digit data description; user constant	6
Space character	1
2-digits each; day of month, hour, minute of dissemination	6
DUP; Space, indicates possibly duplicate bulletin	4 (Optional)
End-of-line; carriage return, linefeed	2

Bulletin Preamble Transmitted Once

[2]Reference: User Interface Manual.

- 22 -

	Function	Number of Characters
	Control character (RS); record separator identifies start of platform replies	1
	Sensor platform address identifier	8
	? or space; shows whether address was correct or not	1
	Date-time of reception; # day of year, hour, minute, and second	9
	Platform data; without final EOT characters	-
	Control characters (RS); separates platform replies within bulletin	1

Repetitive Sequence brackets the six rows above.

Next reply follows, as above, from "Sensor Platform address identifier."

Bulletins are segmented into uniform length blocks for transmission. Bulletins are generally less than 10 full blocks; the only exception being when a report beginning in the ninth block spans one or more blocks. Each block is formatted as follows:

Control character; start of transmission block (SOH or STX)	1
Message characters	190
Control character; end of transmission block (ETB or ETX)	1
Block error control character; LRC (or CRC-16)	1 (or 2)

NOTES:

(1) Start of transmission block character is SOH for initial block, STX for subsequent blocks.

(2) End of transmission block character is ETB for initial blocks, ETX for final block.

(3) Final block may have 1 to 190 message characters

(4) Block error control character: if longitudinal redundancy check (LRC), it is composed to the MOD-2 sum of corresponding character bit positions of all characters following the start of transmission block character, except that its parity bit is odd parity; if cyclic redundancy check (CRC-16), it is the 16-bit remainder after division of the message characters (following the start of transmission block character) by the polynominal $x^{16} + x^{15} + x^2 + 1$.

2.5.3.3   1200 Baud DDD Circuit

The second class of circuit (1200 baud dialup) has the following characteristics:

Channel Type   :   DDD subscriber lines; half-duplex, AT&T
                      type 202C modem or equivalent

Modulation Rate: 1200 baud (120 characters/s)

Coding   :   asynchronous ASCII (10 bits) even parity

Error Control   :   block transmission: ACK/NAK

Block Length   :   320 (max) data characters, and 6 framing
                      characters with 6 device control characters

Block Check
Character   :   Longitudinal Redundancy Check (LRC)

NOTE: CDF assumes user terminal on 1200 baud circuits to have the characteristics of a Texas Instruments Model 742, with options:

(1)   "Auto-answer" line discipline.

(2)   "Answer-back memory" preprogramed with user ID.

(3)   Bell 202C data set compatible modem.

The TI Model 742 can transmit and receive at 120 characters per second (CPS), but its printer operates only up to 30 CPS.   The CDF uses control character sequences to remotely command the terminal recorder and printer.   Table 3 lists the possible commands.   The platform sensor data are disseminated at 120 characters per second rate with the terminal's printer OFF.   An end-of-line (carriage return, line feed) is inserted following every 80 data characters by the CDF.

TABLE 1

TI 742 COMMAND CHARACTERS

Command	Code
Record ON	*DC2
Playback OFF	*DC3
Printer ON	*DLE 9
Printer OFF	*DLE 0
Auto Device Control ON (ADC ON)	*DLE :
Auto Device Control OFF (ADC OFF)	*DLE ;

(*) Utilized by DPS/DCS.

The following procedures are employed for user-CDF communications over 1200 baud dialup circuits:

Procedures on 1200-bps Line

(1) Utilizing a Texas Instruments Model 742 (or equivalent) terminal, the user dials the telephone number for the 1200-bps line.

(2) The CDF answers the call, and when the answer tone sounds the user presses the DATA button or pushes down the exclusion key.

(3) The CDF waits 8 seconds from occurrence of the ring to permit the terminal to identify itself by auto-matically triggering its answer-back device. (If the terminal is equipped with an answer-back device, it must be programed to transmit either STX, user ID, ETX, LRC, or STX, user ID, "DIS," ETX, LRC. The correct LRC must be hand computed and preprogramed for for the answer-back, since normally it is not generated automatically in this situation.)

(4) If the CDF receives no identification within 8 seconds, it transmits the message:

<p align="center">DCS/CDF.   ENTER ID</p>

The user will sign on by responding with the framing character STX followed by the user ID (a maximum of six characters), and the framing character ETX. Optionally, he may enter STX, user ID, a comma, and one of the following: MSG, DIS, RLT. If DIS or RLT is specified the GMT (in the format DDDHHMMSS) may be included. All entries must be terminated by ETX and LRC.

(5) For either answerback or manual sign-on messages, CDF determines whether the ID is valid; and if only the ID was entered, determines whether any new message data have been acquired since the previous user inquiry (6).

(6) If the ID is invalid, the request is repeated up to five times, after which the CDF goes on-hook after sending the following message:

<p align="center">TOO MANY ERRORS</p>

(7) If the ID is correct, and if only the ID was entered, CDF informs the user of the number of messages received since the previous inquiry and the time of the last dissemination. The CDF then transmits:

<p align="center">ENTER MSG, DIS, RLT, OR STOP.</p>

(7a)   MSG Directive - the user may transmit a text message to the
        DCS operator (to be displayed on the console) by entering
        STX MSG ETX after the CDF informs him/her of the number of
        messages received since the previous inquiry (or by entering
        MSG following the user ID in the sign-on, separated by a
        comma).   The CDF responds with STX ENTER MESSAGE ETX, after
        which the user may enter the message.

(7b)   DIS Directive - the user may request transmission of the
        sensor platform data by entering STX DIS ETX after the CDF
        informs him/her of the number of messages received since the
        previous inquiry (or by entering DIS following the user ID
        in the sign-on, separated by a comma).

        Transmission of sensor platform data, if requested, begins
        with the oldest undisseminated message and continues to the
        newest message on the user's queue.

        Abnormal platform response messages are transmitted in lieu
        of data when appropriate, and are identified by two carets
        (ΛΛ) preceding the text of the message.

        Alternatively, the user may specify a new time (other than
        "time of last inquiry") from which dissemination of data
        in the queue may begin, by entering STX DIS DDDHHMMSS ETX in
        GMT (or UTC).

(7c)   RLT Directive - the user may request transmission of sensor
        platform data acquired after a specified time for information
        only, by entering STX RLT, DDDHHMMSS ETX after the CDF informs
        him/her of the number of messages received since the previous
        inquiry.   As in (7b) above, a new time interval may be
        specified to begin playback.   Data disseminated by this method
        are not recorded by the CDF.

(8)   Once transmission of the most recent sensor platform data (DIS
        only) has been completed, the CDF sends the following message:

                        NNN MESSAGES DISSEMINATED.

                        VERIFY: OK, NO, OR STOP.

        If the user enters OK, after DIS (dissemination) the UTC of
        the last message disseminated will be inserted into the user
        Queue Table as the "last time of dissemination" (for use the
        next time he/she calls.)   The "number of messages" will be reset
        to zero, and the message pointers updated.   If the user enters
        NO, then the user Queue Table will not be updated.   After
        either OK or NO, the CDF solicits a new request with the
        following message:

                        ENTER MSG, RLT, DIS, OR STOP.

If at any time the user enters STOP, the CDF sends an EOT and goes on-hook. If the user hangs up without answering STOP, the CDF will assume that the <u>previously</u> <u>transmitted</u> <u>data</u> <u>were</u> <u>successfully</u> <u>disseminated</u>.

(9)   If the user disconnects the circuit prior to transmission of all the messages, then the <u>CDF</u> <u>considers</u> <u>that</u> <u>no</u> <u>messages</u> <u>have</u> <u>been</u> <u>disseminated</u>.

(10) Data transmitted on these circuits have all erroneous characters (containing parity errors) replaced with a dollar sign ($).

(11) If the CDF receives STX CAN ETX LRC from the terminal, signifying a playback error (cassette I/O error), it will send the following message to the user:

PLAYBACK ERROR.   TRY AGAIN.

The user will be able to reenter his request.

2.5.3.4   110-Baud DDD Circuit

The third class of circuit (110 baud dial-up) has the following characteristics:

Modem	:	AT&T Model 103A3
Channel Type	:	DDD subscriber lines; half-duplex
Modulation Rate:		110 baud (10 characters/s)
Coding	:	Asynchronous ASCII (11 bits) even parity
Error Control	:	None

The CDF assumes that the terminal on a 110-baud dialup line is similar to a Teletype Model ASR-33. User communications over these low-speed lines require the following procedures:

<u>Procedures on 110-baud Line</u>

(1)   Utilizing a terminal, the user dials the telephone number for the 110-baud line.

(2)   The CDF automatically answers, and transmits the message:

DCS.   ENTER ID

followed by the protocol character WRU (ENQ)

(3) The answer-back capability available on many terminals
     will respond to the WRU. At terminals not thus equipped,
     the operator will respond with the user ID (a maximum of
     six characters). Optionally, he/she may enter his/her user ID,
     a comma, and one of the following: MSG, DIS, RLT, or the
     time (in the form DDDHHMMSS of GMT).

(4) The CDF determines whether the ID is valid, and, if only
     the ID was entered, determines whether any new message
     data have been acquired since the previous user inquiry.

(5) If the ID is invalid, the request is repeated up to five
     times, after which the CDF goes on-hook after sending
     the following message:

                    TOO MANY ERRORS.

(6) If the ID is correct, and if only the ID was entered,
     CDF informs the user of the number of messages received
     since the previous inquiry and the time of the last
     dissemination. The CDF then transmits:

              ENTER MSG, DIS, RLT, OR STOP.

(6a) MSG Directive – the user may transmit a text message to
      the DCS operator (to be printed on the console) by
      entering MSG after the CDF informs him/her of the number of
      messages received since the previous inquiry (or by
      entering MSG with the ID entry, separated by a comma).
      The CDF responds with ENTER MESSAGE, after which the
      user may enter the message.

(6b) DIS Directive – the user may request transmission of the
      sensor platform data by entering DIS after the CDF
      informs him/her of the number of messages received since the
      previous inquiry (or by entering DIS after the ID entry,
      separated by a comma).

      Transmission of sensor platform data, if requested, begins
      with the oldest undisseminated message and continues to
      the newest message on the user's queue. Abnormal platform
      response messages are transmitted in lieu of data when
      appropriate, and are identified by two carets (ΛΛ)
      preceding the test of the message.

      Alternatively, the user may specify a new time (other
      than "time of last inquiry") from which dissemination
      of data in the queue may begin, by entering DDDHHMMSS
      (in GMT).

(6c) RLT Directive - the user may request transmission of
sensor platform data acquired after the connection is
made until the user hangs up, by entering RLT after
the CDF informs him of the number of messages received
since the previous inquiry (or by entering RLT after
the ID entry, separated by a comma). Optionally, RLT,
DDDHHMMSS may be specified to receive data disseminated
earlier. As in paragraph (7b), page 26, a new time interval
may be specified to begin playback. Data disseminated
by this method are not recorded by the CDF.

(7) Once transmission of the most recent sensor platform
data has been completed, (DIS only) then CDF sends the
following message:

NNN MESSAGES DISSEMINATED.

VERIFY: OK, NO, OR STOP.

If the user enters OK, the GMT of the last message
disseminated will be inserted into the user queue
table as the "last time of dissemination." The
"number of messages" will be reset to zero, and the
message pointers updated. If the user enters NO,
then the user queue table will not be updated.
After either OK or NO, the CDF solicits a new request
with the following message:

ENTER MSG, RLT, DIS, OR STOP.

If at any time the user enters STOP, the CDF dis-
connects. If the user hangs up without answering
STOP, the CDF will assume that the previously
transmitted data were not successfully disseminated.

(8) If the user disconnects the circuit at his/her end prior
to transmission of all his/her messages, then the CDF
considers that no message has been disseminated.

(9) Data transmitted on these circuits have all erroneous
characters (containing parity errors replaced with a
dollar sign ($).

REFERENCES

Cateora, J.V., Davis, D.D., and Hanson, D.W., 1976. A Satellite
    Controlled Digital Clock. NBS Technical Note 681, Time
    and Frequency Division, Institute for Basic Standards,
    National Bureau of Standards, U.S. Department of Commerce,
    Boulder, Colorado, 46 pp.

GOES Data Collection System, SMS2 Test Report, Test Report
    TER-383-002 for Office of System Engineering, NOAA/NESS,
    by Telcom, Inc., Vienna, Virginia, 24 pp.

McManamon, P., 1973. GOES Data Collection System Performance
    Estimates. Telecommunications Technical Memorandum OTM-
    73-125, Institute for Telecommunication Sciences, Office
    of Telecommunications, U.S. Department of Commerce, Boulder,
    Colorado, 66 pp.

User Interface Manual, NESS/NOAA/Department of Commerce, by GTE
    Information Systems, Systems Division, Silver Spring,
    Maryland, May 1978, 50 pp.

APPENDIX A

USERS REQUEST QUESTIONNAIRE

1. Describe fully your application
    Operational/Experimental
    If experimental, please complete the following:
        Name and address of the funding agency Administrator.
        Name and address of the party responsible for imple-
          menting your DCS program, i.e., the principal
          investigator.
        Give the starting and ending dates of the period during
          which you plan to collect data via satellite.
    Purpose of Data
    Data Perishability
    Final User of Data

2. Type of System
    Interrogated
    Self-time
    Hybrid

3. Number of Platforms
    Number of each Type
    Number of Platforms with Emergency Alarm Provision
    Time Scale for Deployment of each Type

4. Location of Platforms by Types
    State, ocean
    Nearest city if located in State
    Fixed station - Latitude/Longitude
    Mobile station operating area - Latitude/Longitude of
      Bounding Area

5. Data
    Format of Data
    Bits per Sensor Message

6. Reporting Times
    Interrogation Schedule
    Self-Timed Schedule

7. Data Delivery
    Data Form
      (Magnetic Tape, Paper Tape, Computer Printout, etc.)
    Address for Delivery
    How often required? (Delivery once per hour, per six hours,
      per day, etc.)

8. Explain why commercial services cannot meet your program needs.

9. Agency to install and maintain platform equipment.

APPENDIX B

MEMORANDUM OF AGREEMENT BETWEEN NOAA
AND THE USER

INTRODUCTION

The National Environmental Satellite Service (NESS), of the
National Oceanic and Atmospheric Administration (NOAA) hereinafter
referred to as the operator (of the Synchronous Meteorological
Satellite (SMS) and the Geostationary Operational Environmental
Satellite (GOES) and the Command and Data Acquisition (CDA)
(Station)) and the (user) (agency), hereinafter referred to as
the user (the provider of Data Collection Platforms and the
user of the data collected) agree on the "Joint Understanding"
below and agree to fulfill the undertakings specified.

I. Name of Program. The program to which this Memorandum applies
shall be known as the "National Environmental Satellite Service -
(user) GOES Data Collection System Program".

II. Joint Understanding.

    A. To qualify for collection by the GOES, the data from the
user's Data Collection Platforms must fall within the definition
of environmental data. Environmental data are defined as obser-
vations and measurements of physical, chemical, or biological pro-
perties of the oceans, rivers, lakes, solid Earth and atmosphere
(including space).

    B. Authority for the GOES to utilize the radio frequency
band 401.7 to 402.1 MHz as an uplink and the radio frequency band
468.750 to 468.950 MHz as a down link is contained in the Fre-
quency Assignment Subcommittee/Interdepartment Radio Advisory
Committee docket numbers 7422556 and 7422589, respectively.
Docket number 7422556 grants the operator the authority to make
frequency channels available to the user. However, it is understood
that the user must obtain authority from appropriate national
agencies to transmit on frequency channels, designated by the
operator, within the uplink band. The operator will also provide
address codes.

    C. The operator will not assign a channel to one user for
full time use; however, time periods within a channel will be
assigned and on a priority basis.

    D. The operator reserves the right to terminate or suspend
the user's participation in this program in the event of space-
craft or ground equipment limitations requiring curtailment or
elimination of services.

E.   Unless an exception is specified elsewhere in this memo-
randum, data collected for users shall be made available from
NESS to other interested parties as appropriate.

F.   Data Collection Platforms which the users plans to
implement as part of the GOES Data Collection System are subject
to certification by the operator before deployment.

G.   In consultation with the user, the operator will establish
the collection times and data lengths for the user's Data Collec-
tion Platforms and the schedules and methods for data dissemina-
tion.

H.   All transmissions from the Data Collection Platforms to
the GOES spacecraft will be coordinated with the operator prior
to such transmissions.

III.   Undertaking by the user.

The user shall:

A.   Provide the operator a list of the user's Data Collection
Platforms showing the type (self-timed, interrogate); where each
is to be located; and which platforms are equipped with emergency
alarm provisions.

B.   Provide the operator notification prior to Data Collec-
tion Platform relocation.

C.   Provide the operator with the data type and message load
planned for each Data Collection Platform.

D.   Provide the personnel, funds, and equipment necessary to
carry out the portion of the program at the Data Collection Plat-
form location.

E.   Operate and maintain the Data Collection platforms in
conformance with equipment performance standards as specified by
the operator in: National Environmental Satellite Service Speci-
fication for Data Collection Platform Radio Set (DCPRS).   Speci-
fication No. 200.004, January 27, 1975.

F.   Provide the personnel, funds and equipment necessary to
operate and maintain facilities for receipt of collected data.
These responsibilities include the cost of the communication
interface at the NESS facility and the means to forward the data
to the terminal point designated by the user.   The communication
interface is specified by the operator in: NESS GOES DCS User
Terminal Specifications, 1 January 1975.

G.   Provide periodic reports, upon request from the operator,
on the present application of the user's DCS data.

IV. Specific Undertakings on the Part of the operator.

The operator shall:

A. Provide and operate the GOES spacecraft and the NESS ground facilities for receiving data collected from the satellite.

B. Provide telemetry reduction sufficient to monitor the user's Data Collection Platforms for meeting system performance standards.

C. Notify the user by the most expeditious means available whenever NESS system monitoring indicates the user's Data Collection Platform is performing outside system specifications or is inoperative.

D. Assign priorities for participation in the GOES DCS, scheduling purposes, channel assignments and for special DCS data requests according to the following categories in order of priority:

1. Disaster Warning
2. Operational
3. Experimental

E. Notify the user of modifications to the established operational schedule for collecting data from the user's Data Collection Platforms. Notification will be prior to activation of such schedule changes unless the operator must enact schedule modifications to provide services for emergency warnings. Sudden adverse spacecraft conditions may also preclude the operator from providing the user notification prior to schedule changes. In any event, notification will be made as soon as possible.

This agreement shall enter into force and effect for one year after signature by both parties and if otherwise consistent with applicable authorization and apprpriation Acts of Congress, this agreement shall remain in force and effect unless and until terminated at the election of either the user or the operator provided notification of such termination is in writing and forwarded by one party to the other, no less than 90 days in advance of termination.

_____   _____

Director, NESS   Date   User   Date

APPENDIX C

DCPRS Certification Standards
(Interrogated & Self-Timed)

1. <u>RF Power Output</u>. The Effective Isotropic Radiated Power (EIRP) of a DCPRS and antenna shall not exceed 50dBm under any combination of service conditions.

2. <u>Frequency Characteristics</u>. DCPRS received radio frequency (RF) shall be 468.825 MHz[1]. The transmitter RF shall be in the 401.85 MHz to 402 MHz band. (See Table 1.)

3. <u>Stability</u>.

   A. <u>Temperature</u>. The transmitter carrier frequency shall change by less than 0.5 parts per million over the temperature range of -20°C to +50°C.

   B. <u>Long-Term</u>. The long-term stability (including temperature variations) shall be better than one part per million per year.

   C. <u>Short-Term</u>. The phase jitter on the transmit carrier shall be less than 3 degrees RMS.

4. <u>Electromagnetic Interference (EMI)</u>. All transmitter spurious emissions, when measured with modulation and with antenna and diplexer connected, shall be down from the unmodulated carrier level by 50dB.

5. <u>Transmission Format</u>. After a minimum of 4.9 seconds of unmodulated carrier, the carrier shall be modulated with the bit and message synchronization patterns which are at least 2.4 seconds of alternate 1, 0 data bits, and the 46-bit preamble consisting of the 15-bit MLS sync word followed by the 31-bit BCH command word. Transmission of the address shall be complete within 11 seconds after receipt of an interrogation. The binary data shall be Manchester-encoded 8-bit ASCII, odd parity and shall modulate the carrier in the following manner: a data "0" shall consist of +60° (+5°) carrier phase shift for 5 milliseconds followed by -60° ($\mp$5°) carrier phase shift for 5 milliseconds, and a data "1" shall consist of -60° (+5°) carrier phase shift for 5 milliseconds followed by +60° (+5°) carrier phase shift for 5 milliseconds. Data rate shall be 100 BPS $\pm$.1 BPS. (See Figure 1.)

6. <u>End of Transmission</u>. Immediately after sending the sensor data, the DCPRS shall transmit three 8-bit ASCII, odd parity, End of Transmission (EOT) characters contiguously with the ASCII sensor data characters (no break) and return to the standby condition.

---

[1]For the West Satellite. DCPRS assigned to the East Satellite will be required to receive on 468.8375 MHz.

7. Fail-Safe Design. The DCPRS shall incorporate a "fail-safe" design feature such that malfunctioning of the equipment shall in no way cause continuous transmission. Further, provision shall be made to retrigger the fail-safe via the interrogation link in 90-second intervals without interruption of data transmission by addressing the radio set.

8. Receive Signal. The DCPRS shall continuously receive and demodulate the standard GOES Data Collection System interrogation signal over an input signal level range of -100 dBm maximum to -130 dBm minimum centered at 468.825 MHz^2 and modulated $+60^O$PSK with 100-bit/second Manchester-coded data. The DCPRS shall be capable of simultaneous reception and transmission and meet all performance requirements of the DCPRS in this mode. The DCPRS shall be capable of auto-matically locking to the interrogation signal at an input signal level as low as -135 dBm (total signal power with the following data present: 15-bit Maximal Linear Sequence (MLS) sync word (100010011010111) followed by the 31-bit Bose-Chaudhuri-Hocquenqhem (BCH) command word (0011010010000101011101100011111)).

9. Acquisition Time. The receiver shall acquire lock on the interroga-tion signal in 2 minutes or less from standby condition, when the carrier is within _100 Hz of 468.825 MHz^1.

10. Spurious Emissions. Reradiated local oscillator and mixing frequency signals shall be less than 50 microvolts at the antenna or primary power in-out terminal.

11. Antenna Polarization. Polarization shall be right-hand circular, according to IEEE Standard 65.34.159.

12. Data Formatting Restrictions.

   The following ASCII control characters must not appear in the DCPRS message: DLE, NAK, SYN, ETB, CAN, GS, RS, SOll, STX, ETX, ENQ, and ACK. EOT characters may appear only at the end of transmission.

----

^{2}For the West satellite. DCPRS assigned to the East satellite will be required to receive on 468.8375 MHz.

TABLE 1

INTERROGATED DCPRS TRANSMIT FREQUENCIES

CHANNEL	FREQUENCY	CHANNEL	FREQUENCY
100	401.849569	150	401.924573
101	401.851069	151	401.926073
102	401.852569	152	401.927573
103	401.854069	153	401.929073
104	401.855569	154	401.930573
105	401.857069	155	401.932073
106	401.858569	156	401.933573
107	401.860070	157	401.935073
108	401.861570	158	401.936573
109	401.863070	159	401.938074
110	401.864570	160	401.939574
111	401.866070	161	401.941074
112	401.867570	162	401.942574
113	401.869070	163	401.944074
114	401.870570	164	401.945574
115	401.872070	165	401.947074
116	401.873570	166	401.948574
117	401.875070	167	401.950074
118	401.876570	168	401.951574
119	401.878070	169	401.953074
120	401.879571	170	401.954574
121	401.881071	171	401.956074
122	401.882571	172	401.957575
123	401.884071	173	401.959075
124	401.885571	174	401.960575
125	401.887071	175	401.962075
126	401.888571	176	401.963575
127	401.890071	177	401.965075
128	401.891571	178	401.966575
129	401.893071	179	401.968075
130	401.894571	180	401.969575
131	401.896071	181	401.971075
132	401.897571	182	401.972575
133	401.899072	183	401.974075
134	401.900572	184	401.975575
135	401.902072	185	401.977076
136	401.903572	186	401.978576
137	401.905072	187	401.980076
138	401.906572	188	401.981576
139	401.908072	189	401.983076
140	401.909572	190	401.984576
141	401.911072	191	401.986076
142	401.912572	192	401.987576
143	401.914072	193	401.989076
144	401.915572	194	401.990576
145	401.917072	195	401.992076
146	401.918573	196	401.993576
147	401.920073	197	401.995076
148	401.921573	198	401.996577
149	401.923073	199	401.998077

SELF-TIMED DCPRS DESIGN REQUIREMENTS

1. RF Power Output. The Effective Isotropic Radiated Power (EIRP) of a DCPRS and antenna shall not exceed 50 dBm under any combination of service conditions.

2. Frequency Characteristics. The DCPRS transmitted RF shall be in the 401.7-MHz to 401.85-MHz band. (See Table 1.)

3. Stability.

    A. Temperature. The transmitter carrier frequency shall change by less than 0.5 parts per million over the temperature range of -20°C to +50°C.

    B. Long-Term. The long-term stability (including temperature variations) shall be better than one part per million per year.

    C. Short-Term. The phase jitter on the transmit carrier shall be less than 3° RMS.

4. Electromagnetic Interference (EMI). All transmitter spurious emissions, when measured with modulation and with antenna and diplexer connected, shall be down from the unmodulated carrier level by 50 dB.

5. Transmission Format. After a minimum of 4.9 seconds of unmodulated carrier, the carrier shall be modulated with the bit and message synchronization patterns which are at least 2.4 seconds of alternate 1, 0 data bits, and the 46-bit preamble consisting of the 15-bit MLS sync word followed by the 31-bit BCH command word. Maximum duration of this preamble shall be 9.0 seconds. The binary data shall be Manchester-encoded 8-bit ASCII, odd parity, and shall modulate the carrier in the following manner: a data "0" shall consist of +60° (+5°) carrier phase shift for 5 milliseconds followed by -60° (+5°) carrier phase shift for 5 milliseconds, and a data "1" shall consist of -60° carrier phase shift for 5 milliseconds followed by +60° carrier phase shift for 5 milliseconds. Data rate shall be 100 BPS +0.1 BPS. (See Figure 1.)

6. End of Transmission. Immediately after sending the sensor data, the DCPRS shall transmit three 8-bit ASCII, odd parity, End of Transmission (EOT) characters contiguously with the ASCII sensor data characters (no break) and return to the standby condition.

7. Fail Safe Design. The DCPRS shall incorporate a "fail-safe" design feature such that malfunctioning of the equipment shall in no way cause continuous transmission.

8. Antenna Polarization. Polarization shall be right-hand circular, according to IEEE Standard 65.34.159.

9. Data Formatting Restrictions.

    The following ASCII control characters must not appear in the DCPRS message: DLE, NAK, SYN, ETB, CAN, GS, RS, SOH, STX, ETX, ENQ, and ACK. EOT characters may appear only at the end of transmission.

10. The DCPRS reporting time shall always be within 30 seconds of its assigned reporting time.

TABLE 1

SELF-TIMED DCPRS TRANSMIT FREQUENCIES

| Channel	Frequency	Channel	Frequency
1	401.700996	50	401.774450
2	401.702495	51	401.775949
3	401.703994	52	401.777449
4	401.705493	53	401.778948
5	401.706992	54	401.780447
6	401.708491	55	401.781946
7	401.709990	56	401.783445
8	401.711489	57	401.784944
9	401.712989	58	401.786443
10	401.714488	59	401.787942
11	401.715987	60	401.789441
12	401.717486	61	401.790940
13	401.718985	62	401.792439
14	401.720484	63	401.793938
15	401.721983	64	401.795437
16	401.723482	65	401.796936
17	401.724981	66	401.798435
18	401.726480	67	401.799935
19	401.727979	68	401.801434
20	401.729478	69	401.802933
21	401.730977	70	401.804432
22	401.732476	71	401.805931
23	401.733976	72	401.807430
24	401.735475	73	401.808929
25	401 736974	74	401.810428
26	401.738473	75	401.811927
27	401.739972	76	401.813426
28	401.741471	77	401.814925
29	401.742970	78	401.816424
30	401.744469	79	401.817923
31	401.745968	80	401.819422
32	401.747467	81	401.820922
33	401.748966	82	401.822421
34	401.750465	83	401.823920
35	401.751964	84	401.825419
36	401.753463	85	401.826918
37	401.754962	86	401.828417
38	401.756462	87	401.829916
39	401.757961	88	401.831415
40	401.759460	89	401.832914
41	401.760959	90	401.834413
42	401.7`2458	91	401.835912
43	401. .`957	92	401.837411
44	401..ö5456	93	401.838910
45	401.766955	94	401 840409
46	401.768454	95	401.841908
47	401.769953	96	401.843408
48	401.771452	97	401.844907
49	401.772951	98	401.846406
		99	401.847905

Figure 1.--Modulation Definition.

44
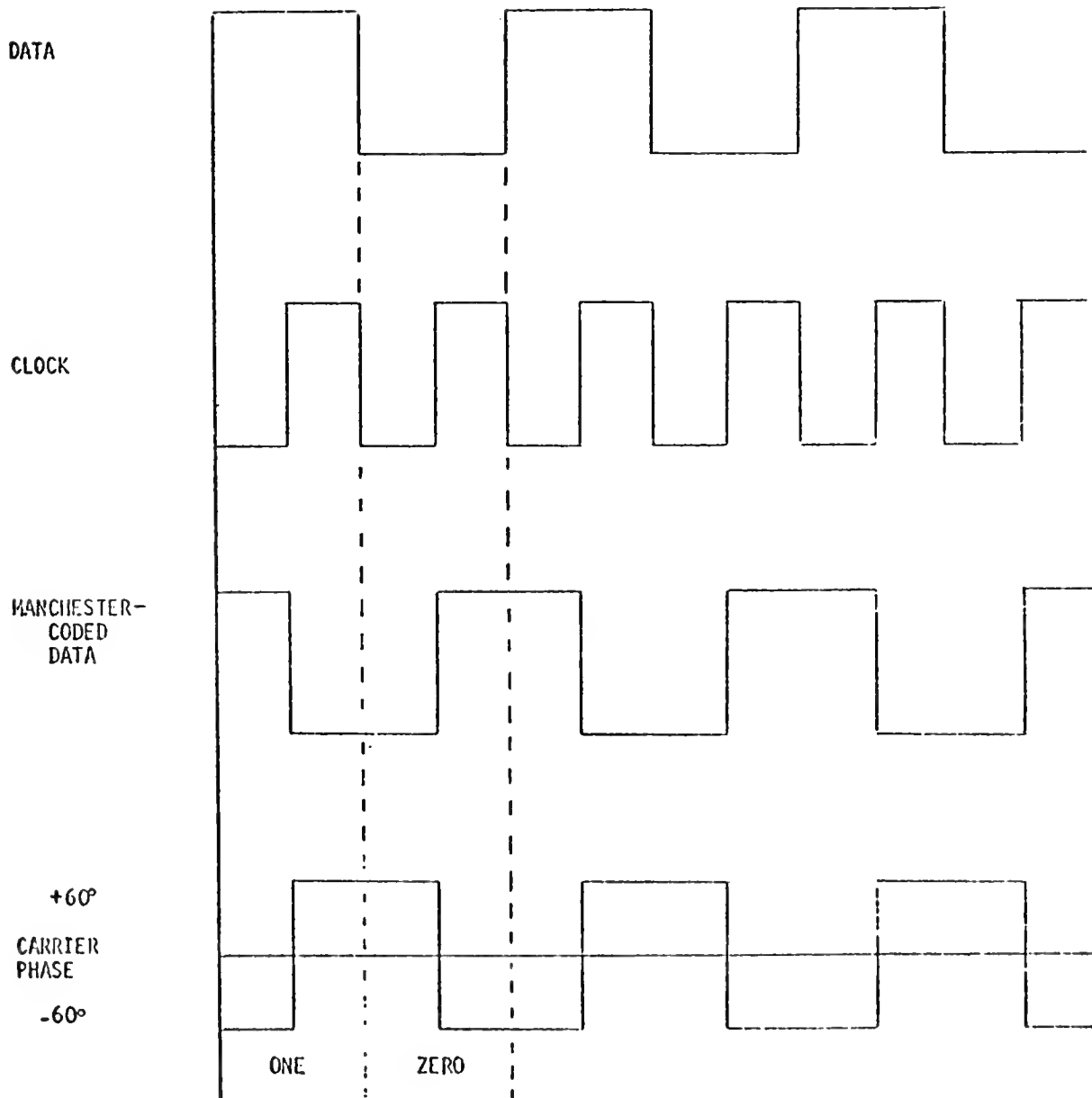
APPENDIX D

SOME CONSIDERATIONS IN THE DESIGN AND INSTALLATION
OF A RECEIVING SYSTEM TO RECEIVE DCS DATA DIRECTLY
FROM THE SMS/GOES FAMILY OF SATELLITES

December 1978

Prepared by:

JOHN J. NAGLE
Office of System Engineering
National Environmental Satellite Service
National Oceanic and Atmospheric Administration
Washington, D.C.   20233

CONTENTS

ABSTRACT. The equipment needed to establish a readout receiving station for the Data Collection System (DCS) is discussed in general terms. The parameters and characteristics of the DCS are described as they affect ground station equipment design.

I. INTRODUCTION

The SMS/GOES[1] family of meteorological satellites provides, along with other capabilities, a DCS to relay in situ environmental data obtained from a variety of sensors located in remote areas. Typical sensors measure hydrologic, oceanographic, meteorological, and other types of environmental parameters.

The National Environmental Satellite Service (NESS) provides ground facilities to receive the data transmitted to the satellite from the user's ground-based sensors and makes these available to users at the World Weather Building, Camp Springs, Maryland. DCS users must supply the ground communication link between their own facilities and Camp Springs.

Under some circumstances, users may wish to provide their own satellite ground receiving station facilities.

The equipment needed to receive DCS data directly from the satellite is both sophisticated and expensive; ordinarily this expense cannot be justified except where the communications links between the user and Camp Springs, Maryland, are long and expensive or where the time required to establish these links can compromise the usefulness of the data. Another consideration is that some emergency situations, e.g., floods, that the platforms are designed to monitor may destroy land line communication circuits from NESS to the user's processing facility. Further complicating the picture is the fact that a number of design tradeoffs are possible, so that there is no single optimum choice of equipment.

This report lists some of the parameters of the DCS system and describes the manner in which they affect the components of a satellite receiving system. It is assumed that the reader has a basic knowledge of physics and some experience with satellite receiving systems.

For the purpose of this discussion, the description of the DCS will will be divided into six parts. The first of these, Part II, is a brief description of a typical station for receiving satellite data. Part III discusses the signal level available on the Earth's

---

[1]SMS stands for Synchronous Meteorological Satellite; GOES stands for Geostationary Operational Environmental Satellite. The SMS satellites are prototypes for the GOES satellites.

surface. Although this quantity is beyond the control of the user,
if does determine the antenna and receiver noise temperature
requirements.

The remaining four items--antenna/receiver, demodulator/decoder,
frame synchronizer, and data processing equipment--are under the
user's direct control and are discussed in Parts IV, V, VI, and
VII, respectively. A breakdown of the necessary equipment is
shown in Figure 1.

II.   EQUIPMENT NEEDED FOR A TYPICAL DCS DIRECT READOUT STATION

The equipment that must be provided by the user in order to receive
DC replies directly is listed below:

ANTENNA

The antenna is usually paraboloidal and must be mounted on a
supporting structure or building; it should have an unobstructed
view of the satellite.

For normal operations, the ground station antenna is pointed
at a single satellite--GOES East or GOES West. As these satellites
are at fixed locations, the antenna can be adjusted to the proper
look angles and locked in position. However, the mounting structure
should be designed so that minor adjustments (say $\pm$ 10 degrees)
in both azimuth and elevation can be made conveniently to compensate
for installation inaccuracies. Because the inclination of the
satellite will be held to about $\pm$0.1 degree, it should not
ordinarily be necessary to reposition the antenna during normal
operations.

However, operation of the DCS may be changed from one satellite to
another during eclipse periods, so that direct-readout users must
reposition their antennas to another satellite to maintain continuity
of operations. While the satellite is in eclipse, operational
restraints are placed on the satellite, because of limited power
available. These eclipse periods occur for intervals up to 72
minutes a day each day for 6 weeks, twice a year.

If the antenna will be used with more than one satellite or family
of satellites, it is recommended that repositioning of the antenna
be done by remote control.

The S-band transmissions from the SMS/GOES satellites are linearly
polarized. If the full capability of the receiving antenna is
to be realized, the antenna must also be linearly polarized so that
it is parallel to the polarization of the received signal. Because
of different aspect angles to different satellites, the polariza-
tion of the signal cannot be predicted at the Earth's surface.
For this reason, the polarization of the antenna should be adjustable.
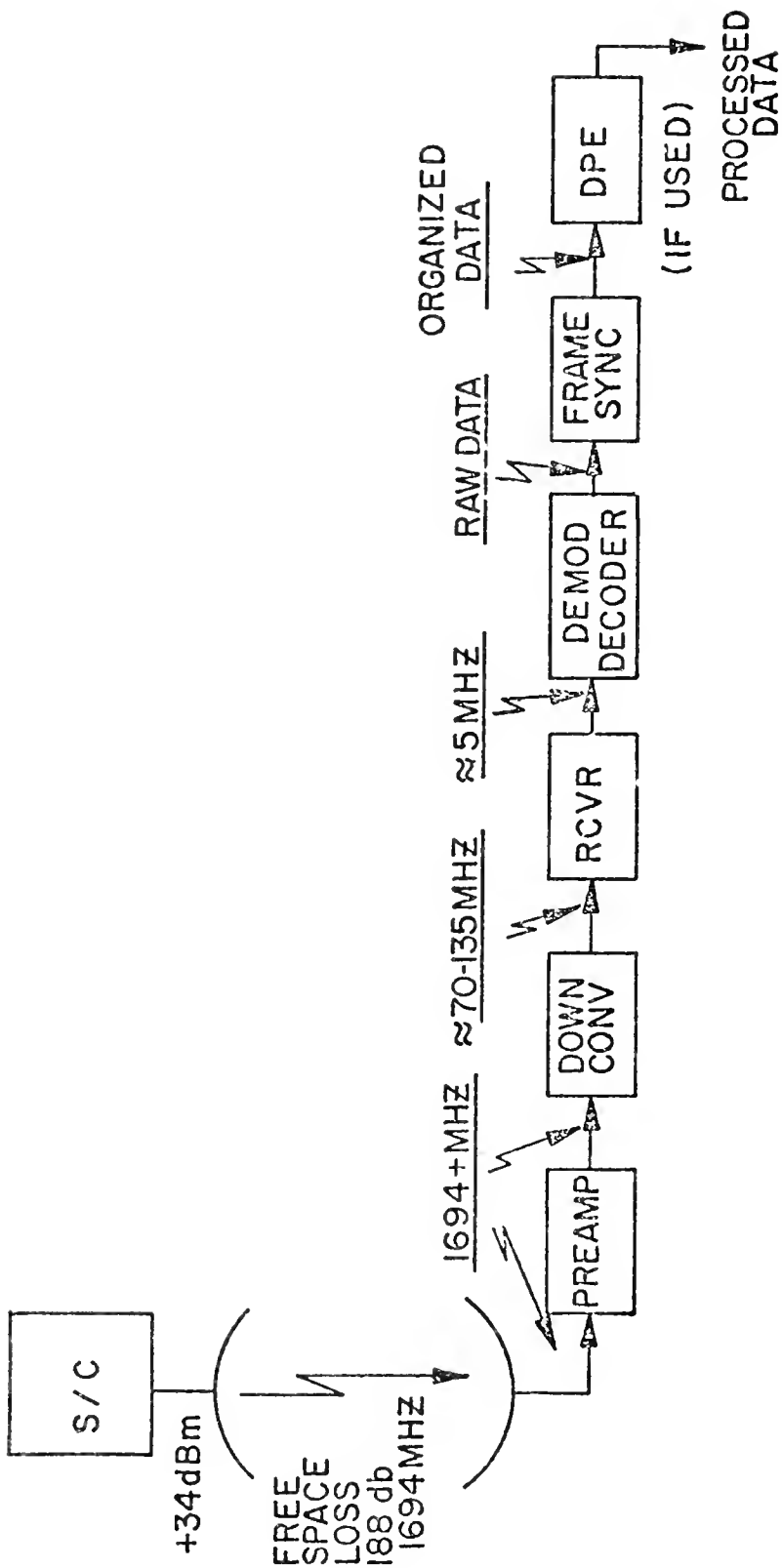Where the antenna will be used with only one satellite, the

FIGURE 1. COMPONENT PARTS OF A DCS
RECEIVING STATION.

49

polarization angle can be adjusted for maximum received signal and locked in that position. If the antenna will be used with more than one satellite, it will be convenient to make the polarization as well as the antenna position remotely controlled.

PREAMPLIFIER

Considerable thought should be given to the preamplifier as it will play an important role in determining the error rate of the system and the size of the antenna.

Many types of amplifiers are discussed in detail in the material that follows. For purposes of this discussion, the important parameter is noise temperature, with a low noise temperature being more desirable.

To maximize performance of the system, it is standard practice to mount the preamplifier on the antenna, making the connection between the preamplifier and antenna as short as possible. For a similar reason, the downconverter is usually located as close to the preamplifier as practical. Several manufacturers' supply a pre-amplifier and downconverter in one package for direct mounting at the antenna's terminals.

DOWNCONVERTER

The purpose of the downconverter is to translate the satellite signal from the vicinity of 1694.5 MHz down to a more convenient frequency. If the user is independently assembling a station using a surplus VHF WEFAX or APT receiver[2], the downconverter output frequency is usually in the vicinity of 137 MHz. Where the user is buying a complete package receiver, this frequency may be in the neighborhood of 70 MHz. Other conversion frequencies are also used.

RECEIVING SYSTEM

Although all the components discussed above can be considered part of the receiving system, the term "receiver" is generally reserved for that part of the receiving system that contains the power supplies and control circuits and provides most of the amplification. Special units may be acquired or available equipment adapted for this application.

In addition to the usual functions provided by the receiving system, it is desirable that the receiver lock onto and track a pilot carrier. This carrier is transmitted from the Wallops CDA station and is returned on a nominal frequency of 1694.450 MHz. The receiver should track the deviation from this pilot carrier frequency ($\pm$ 20 kHz) to compensate for drift in the satellite translation frequency and control internal receiver drift as well.

---

[2]/ Nagle, John J., "A Method of Converting the SMS/GOES WEFAX Frequency (1691 MHz) to the Existing APT/WEFAX Frequency (137 MHz)." Technical Memorandum NESS 54, NOAA/NESS Office of System Engineering, April, 1974.

The input to the receiver must be compatible with the output of the downconverter, and the receiver output must be compatible with the input requirements of the demodulator.

DEMODULATOR/DECODER

The output of the receiver is fed to a separate demodulator/decoder external to the receiver at a convenient intermediate frequency (IF). The demodulator portion converts this IF signal to a series of d.c. pulses. The decoder portion separates the clock and the data stream to recover the information.

If the user purchases a special receiver for DCS reception, the demodulator/decoder may be built into the receiver. In either case, the demodulator/decoder will recover the data from the phase shift signal. In principle, the output of the decoder should be the same as the sensor data input to the radio set transmitter at the remote platform.

FRAME SYNCHRONIZER

Following the decoder, a frame synchronizer must be provided to recognize the 15-bit Maximal Length Sequence (MLS) synchronizing data pattern and ensure that the data bits are outputted in the proper sequence.

DATA PROCESSING EQUIPMENT

Where a large amount of data is to be received, or where the data must be processed, automatic processing equipment is necessary. The design of this equipment depends on the requirements of the user and cannot be discussed in general.

III. DCS SIGNAL POWER

The energy available in the received signal plays an important role in determining the necessary quality and, hence, cost of the receiving system. Unfortunately, the received signal level can vary over a wide range; a 10dB variation may be typical (a numerical variation of 10). There are various causes for this variation, all of which are beyond the control of the user. The most probable cause is satellite loading; i.e., the number of other platforms transmitting at the same time.

During emergency situations many more platforms may be programed to respond in their emergency mode than would normally be transmitting. Unfortunately, this tends to lower signal levels at a time when the data are most needed.

The power radiated by the satellite in the DCS band under normal conditions is 2.5 watts. This power is known as the equivalent isotropic radiated power (EIRP). This 2.5 watts is available to be shared equally by all channels. Thus, if everything were ideal and

only one channel transmitting, the entire 2.5 watts would be available to this one channel. If two channels were transmitting simultaneously, the 2.5 watts would be shared equally between both channels. The power in each channel will be reduced by 3dB. (Note: A reduction of 3dB is equivalent to a numerical factor of one-half). Although there are 183 possible channels, statistically it is very highly unlikely that all 183 will ever be transmitting simultaneously. A more reasonable number of channels transmitting simultaneously might be 100, which will give a 20dB per channel reduction in signal level from 2.5 watts. (Note: A 20dB reduction corresponds to a numerical reduction of 100).

The situation is not ideal, however. The satellite uplink receiver puts out noise which is rebroadcast by the transmitter along with the desired signals. This rebroadcast noise requires transmitter energy that would otherwise be available for useful signals. The amount of energy converted into noise is equivalent to approximately 10 simultaneous signal channels. This amounts to a reduction of 10dB in the useful, available power when a small number of channels are active. (Note: A reduction of 10dB is equivalent to a numerical reduction of one-tenth). When a large number of channels are active, say 100 or more, this noise component tends to be suppressed. The available energy is then equally distributed among the active channels. The power reduction for 100 channels is only 20dB instead of 30dB. (Note: 20dB is equivalent to a numerical value of 100 while 30dB is equivalent to 1000). This is discussed in more detail in Appendix A.

From the above, it can be seen that available power per channel can vary from about 0.25 watts when only one channel is active to about 0.25 watts when 100 channels are transmitting simultaneously. This is a 10dB variation in the available received energy and can occur at random.

Another factor to be considered is that, beginning with the GOES-2 satellite, a low-power mode is used operationally. In this mode the total satellite transponder output power is 0.4 watts or a reduction of 8dB from the 2.5-watt level. (Note: 8dB is a numerical reduction by one-sixth). However, the DCS signal will actually be reduced by only about 2dB (40 percent); this is because VISSR and S-VISSR are not transmitted in the low-power mode so, except for telemetry which is small, the entire transponder power is then available to the DCS. It is expected that the low-power mode will be used during the predictable eclipse periods.

The free-space loss between isotropic antennas from synchronous altitude to the subsatellite point is 188dB; the free-space loss to Earth's edge is increased to 189.3dB. The satellite trans- mitting antenna gain is 2dB less at Earth's edge than at the sub- satellite point. In addition, the radiation pattern of the satellites favors the Northern Hemisphere, so that there is an additional loss of about 2dB at the Earth's edge in the Southern Hemisphere. The signal level that can be expected at Earth's edge in the Southern Hemisphere is, therefore, approximately

24dBm-(189.3 +2 +2) dB = -169.3dBm and about 2dB more in the Northern Hemisphere. (Note: In making signal level calculations it is convenient to express power levels in decibel form. Since a decibel represents a ratio of two power levels, it is necessary to specify a reference level when absolute power is specified in decibel form. By convention, one of two values is used as a reference. When a power level is specified in dBm, the reference is understood to be 1 milliwatt, 10^{-3} watts. When the power is expressed in dBw, the reference is understood to be 1 watt. Thus, +34dBm is a power level 34dB above 10^{-3} watts or 2.5 watts. Similarly, 4dBw is a power 4dB above 1 watt or 2.5 watts. A power level given in dBw may be converted to dBm, or vice versa, by adding or subtracting 30dB since the difference between 1 watt and 10^{-3} watts is 30dB).

The natural noise against which the signal energy must compete is composed of two components. The first is cosmic noise with an effective noise temperature of about 75 degrees Kelvin (^{O}K) for an elevation angle of 5 degrees or more. This noise will be nearly constant with increases occurring only when the antenna beam sweeps past radio stars or the Sun. The user has no control over this source of noise.

The second major source of noise is the receiver. The noise contribution of the receiver is measured by its noise temperature; another term often used is noise figure. As the noise temperature of a receiver is difficult to measure directly, it is standard practice to measure the receiver noise figure and convert this to noise temperature. The noise temperature and noise figure are related by equation (1).

$$\overline{NF} = 10 \; \log \left(\frac{Trec}{Tref} +1 \right) \qquad (1)$$

where

$\overline{NF}$ = receiver noise figure in dB

Trec = receiver noise temperature (degrees Kelvin)

Tref = reference temperature (degrees Kelvin see discussion below)

log = is the logarithm to the base 10

The reference temperature, Tref, is usually taken to be in the vicinity of ambient room temperature, approximately 293^OK. In the material that follows, a reference temperature of 289.855^OK will be used. The reason for this choice is that when 289.855 K^O is multiplied by Boltzmann's constant (1.38×10^{-23} joules per ^{O}K)

the product is a round number (4×10^{-21}) that is convenient to manipulate in both algebraic and logarithmic form $(10 \log 4 \times 10^{-21} = -204\text{dBw}$ per Hertz bandwidth$)$.

It is important to determine the reference temperature when comparing specifications from different manufacturers.

IV. ANTENNA/RECEIVER CONSIDERATIONS

The noise temperature of a receiver is largely determined by the input stage of the receiver. Typical noise figures and noise temperatures of various commonly used input amplifiers in the 1.7 GHz frequency range are given below:

	$\overline{\text{NF}}$ dB	Noise Temp. $^{\circ}$K	Approx. Cost
Typical bipolar transistor	4	438	$ 350.00
Premium grade bipolar transistor	3	289	$ 600.00
Gallium-Arsenide (GAS) FET	1.5	120	$ 1,500.00
Noncooled (ambient temp.) parametric amplifier	0.69	50	$ 25,000.00
Cryogenic parametric amplifier	0.29	20	$100,000.00

(Note: These numbers are approximate as they neglect the noise contribution of succeeding stages. This should be small if the gain of the input amplifier is large, say 10dB or more.

As an example, if a premium grade biopolar transistor amplifier with a noise temperature of 289°K is used, to which must be added the antenna noise temperature of 75°K, the result is a total system noise temperature of approximately 364°K. The noise power in a 1-Hz bandwidth is given by:

$$\text{Noise power} = 1.38 \times 10^{-23} \text{ (joules per } ^{\circ}\text{K) x}$$
$$365^{\circ}\text{K} = 5.02 \times 10^{-21} \text{ watts/Hz}$$

$$= -203\text{dBw/Hz}$$

$$= -173\text{dBm/Hz}$$

As the DCS information is 100 bits/s, the postdetection bandwidth must be 100 Hz. The noise power in a 100-Hz bandwidth will therefore be 100 times (or 20dB) greater than the noise power in a 1-Hz bandwidth. The total noise power at the receiver output will be -153dBm/100 Hz. This is the natural noise against which the signal must compete.

In addition to natural noise described above, there is a source of noise peculiar to the SMS/GOES family of satellites, called spin modulation or "spin mod."

The SMS/GOES satellites are spin stabilized, which means they must spin continuously to maintain correct attitude. The spin rate is nominally 100 revolutions per minute (rpm).

The antenna elements for the communications system are located around the periphery of the satellite. As the satellite spins, it is necessary to continuously switch the output of the transmitter to those elements that are facing the Earth. This is called an "electronically despun antenna."

As an antenna element on one side of the satellite is passing out of view of the Earth and is being switched off, an antenna element on the opposite side of the satellite is coming into the Earth's view and is being switched on. It can, therefore, be visualized that the electrical center of the antenna rotates around the satellite in a direction opposite to the rotation of the satellite. Therefore, the antenna pattern is always pointing toward the Earth.

The spin mod noise is peculiar to the electronically despun antennas that are used on the SMS-1 and 2, and GOES-1, 2, and 3 satellites. If the phase center of the antenna were located on the spin axis of the satellite, the problem would not exist. A more detailed descriptin of this source of noise is given in Appendix B.

At the time this report is being written, it is expected that the next generation of GOES satellites (GOES-D, E, and F) will use a mechanically despun antenna. With this type of antenna, the antenna mechanically spins in a direction opposite to the spin direction of the satellite, so that the antenna appears stationary with respect to the Earth. As there will be no switching of antenna elements, the phase center of the antenna will remain constant and there will be no spin mod. This will improve the operation of the system by reducing the noise against which the desired signal must compete. The spin-mod has been measured as 40° peak-to-peak for Earth stations located on the same longitude as the satellite and 70° peak-to-peak for Earth stations located on the horizon at the Equator.

Unfortunately, the desired signal information is also phase modulated on the carrier so that spin mod caused by the antenna switching appears as noise along with the desired information. This noise is in addition to the natural noise described previously.

It is therefore necessary to have a higher carrier-to-noise ratio (CNR) than would otherwise be required.

The CNR actually needed depends on the highest bit-error rate (BER) that is considered acceptable for the user. Considering

only natural noise (excluding spin modulation noise), the BER for
the DCS system is given by

$$BER = 1/2 \ e^{-0.794 \frac{C}{N}} \qquad (2)$$

where C/N is the CNR as a numeric (not in dB) and e = 2.71828.
This equation is derived from statistical communication theory.
Because of the spin modulation noise, the required CNR will be
somewhat higher than given by equation (2).

Direct measurements on GOES A, B, and C show that a CNR of 14dB
on the DCS over natural noise is necessary to give a BER of
1 in 10^{-5}. This CNR is greater than predicted by equation (2),
because it takes into account the spin modulation noise which
equation (2) does not consider. As mentioned earlier, it is
expected that the GOES-D, E, and F generation of satellites will
not have spin modulation noise. Lower CNR's, which are more in
agreement with equation (2), should be usable with these satellites.

The user should bear in mind that a CNR of 14dB is necessary for
a BER of 1 in 10^5. If the user requires more accurate data (higher
BER), then a higher CNR is necessary. This in turn will require
a larger and more expensive antenna and/or lower noise preamplifier.

Conversely, if a lower error rate is acceptable, a lower CNR is
permissible, resulting in a more economical receiving system.
Users should, therefore, carefully analyze their BER requirements
to ensure that they obtain adequate accuracy at the lowest cost.

As stated previously, the noise power at the receiver output will
be -153dBm/100Hz and that a CNR of 14dB is necessary for a BER of
1 in 10^5. Hence, a carrier level of -153dBm +14dB = -139dBm
is required. As a signal level of only -169.3dBm can be expected
the difference, -139dBm -(-169.3dBm) = 30.3dB, must be made up
by using an antenna with 30.3dB. This requires a paraboloidal
antenna with a diameter of 2.5 meters and assumes an aperture
efficiency of 55 percent, which is typical for antennas of this
type.

If the DCS system is heavily loaded (100 channels transmitting),
the received signal per channel will be 10dB lower and an antenna
diameter of 3.16 times 2.5 meters = 7.9 meters will be necessary.
(Note: The gain of a paraboloidal antenna is directly proportional
to its area. Therefore, the antenna gain is proportional to the
square of the diameter. Increasing the antenna diameter by
$\sqrt{10}$ = 3.16 will increase its area and hence its gain by a numerical
factor of 10. This is equivalent to a 10dB increase.)

If an uncooled parametric amplifier is used instead of a premium
grade transistor amplifier, the receiver and antenna noise
temperatures are now $50^{\circ}K$ $+75^{\circ}K$ respectively = $125^{\circ}K$. The noise
power in a 100-Hz bandwidth is now -157.6dBm instead of -153dBm.
This represents an improvement of 4.6dB and a reduction in antenna

size by the same amount (4.6dB and a reduction in antenna area by the same amount (4.6dB = a reduction of 1.7 in antenna diameter). Hence, for the single channel case, the required diameter becomes 2.5 meters/1.7 = 1.47 meters and for the 100-channel loading case, 4.6 meters.

These values can be used as points on two curves, one curve for a single channel loaded DCS, and the other for a fully loaded system. Points for the other types of preamplifiers can be plotted, and a smooth curve drawn between them.

Figure 2 shows a family of curves giving the required antenna diameter as a function of system noise temperature for various numbers of simultaneous active channels. In using these curves the following conditions should be noted.

1. The abscissa (noise temperature) is the overall receiving system noise temperature and is the sum of the preamplifier noise temperature and the 75^OK cosmic noise. The ordinate gives the required antenna gain.

2. A 3dB margin, as well as miscellaneous losses of 3dB, are included.

3. All calculations are based on the receiver being located at the subsatellite point.

For convenience, Tables 1 and 2 give the margin obtained with some typical preamplifiers and antenna sizes of 3 and 10 meters. A wide variation in the available margin is evident.

All users must bear in mind that the National Environmental Satellite Service (NESS) cannot guarantee that usage of the DCS will be limited to any maximum number of platforms, and therefore cannot guarantee a minimum signal level at the Earth's surface. Users must, therefore, carefully consider the consequences of lost or inaccurate data against the costs of building a better ground station.

V.   DEMODULATOR/DECODER

To recover the data, the output of the receiver must be demodulated and decoded. A separate demodulator/decoder should be used for each DCS channel in use, although a single antenna-receiver combination can be used to drive a number of them.

It is recommended that the demodulator/decoder be purchased from a manufacturer experienced with the GOES DCS. Four problem areas must be considered; these are:

1. The Spin/Phase Noise: As described earlier, the spacecraft rotation causes spin modulation which appears as noise at
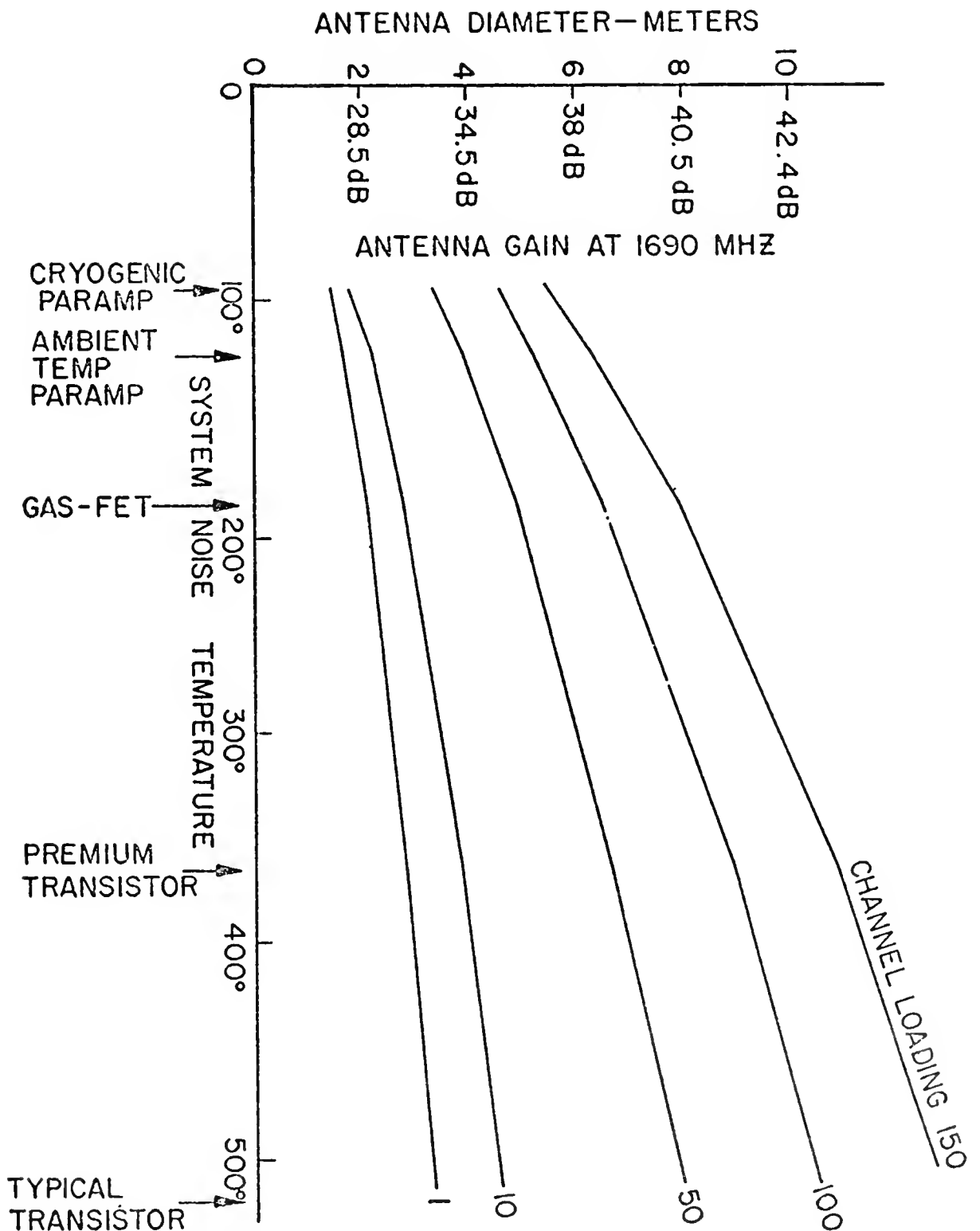
Figure 2.--Antenna diameter as a function of system noise temperature for various numbers of channels.

	Premium Grade Transistor Preamp $T_{rcvr}+T_{sky}=364^{\circ}K$ (=25.6dB-$^{\circ}K$)				Gallium-Arsenide FET* $T_{rcvr}+T_{sky}=195^{\circ}K$ (=22.9dB-$^{\circ}K$)			
Number of Simultaneous Active Channels	1	10	50	100	1	10	50	100
EIRP dBm	+34	+34	+34	+34	34	34	34	34
Share Loss + Noise Power dB	−10.4	−13	−17.8	−20.4	−10.4	−13	−17.8	−20.4
Free Space Loss dB	−188	−188	−188	−188	−188	−188	−188	−188
Receiver Antenna Gain dB (55%)	+32	+32	+32	+32	32	32	32	32
(Antenna Diameter-Meters)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Rx Input Power Level dBm	−132.4	−135	−139.8	−142.4	−132.4	−135	−139.8	−142.4
System Noise Temp. dB-$^{\circ}K$	.25.6	25.6	25.6	25.6	22.9	22.9	22.9	22.9
Boltzmans Constant (dBm/Hz − $^{\circ}K$)	−198.6	−198.6	−198.6	−198.6	−198.6	−198.6	−198.6	−198.6
Rx Input Noise N_O dBm/Hz	−173	−173	−173	−173	−175.8	−175.	−175.	−175.
Rx Input C/N_O dB/Hz	40.6	38.0	33.2	30.6	43.4	40.8	35.9	33.3
Required C/N_O (dB-Hz)	34	34	34	34	34	34	34	34
Miscellaneous Losses dB	3	3	3	3	3	3	3	3
Margin (dB)	3.6	1.0	−3.8	−6.4	6.4	3.8	−1.1	−3.7

* Field Effect Transistor.

	Premium Grade Transistor Preamp. $T_{rcvr}+T_{sky}=364°K$ (=25.6dB-$°K$)				Gallium-Arsenide FET* Preamp. $T_{recr}+T_{sky}=195°K$ (=22.9dB-$°K$)			
Number of Simultaneous Active Channels	1	10	50	100	1	10	50	100
EIRP dBm	+34	+34	+34	+34	34	34	34	34
Share Loss + Noise Power dB	−10.4	−13	−17.8	−20.4	−10.4	−13	−17.8	−20.4
Free Space Loss dB	−188	−188	−188	−188	−188	−188	−188	−188
Receiver Antenna Gain db (55%)	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5
(Antenna Diameter-Meters)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
Rx Input Power Level dBm	−121.9	−124.5	−129.3	−131.9	−121.9	−124.5	−129.3	−132.0
System Noise Temp. dB-$°K$	25.6	25.6	25.6	25.6	22.9	22.9	22.9	22.9
Boltzmans Constant (dBm/Hz − $°K$)	−198.6	−198.6	−198.6	−198.6	−198.6	−198.6	−198.6	−198.6
Rx Input Noise N_O dBm/Hz	−173	−173	−173	−173	−175.7	−175.7	−175.7	−175.7
Rx Input $C/_{N_O}$ dB/Hz	51.1	48.5	43.7	41.1	53.8	51.2	46.4	43.7
Required $C/_{N_O}$	34	34	34	34	34	34	34	34
Miscellaneous Losses dB	3	3	3	3	3	3	3	3
Margin (dB)	14.1	11.5	6.7	4.1	16.8	14.2	9.8	6.7

Table 2.--Typical Gain Margins Using a 10-Meter Antenna

* Field Effect Transistor.

the demodulator output. Unfortunately, the switching rate
of the electronically despun satellite antenna is fairly
close to the data rate; therefore, the decoder must be able
to differentiate between valid data and spin noise.

2. Manchester Coding: The DCS uses Manchester coding to transmit
data through the system. This type of coding has the
advantage that the clock rate is imbedded in the data stream
and can be recovered from the data by the decoder. It is,
therefore, not necessary to transmit the clock information
separately or to impose extreme stability requirements on
the oscillator at the remote platform.

Manchester coding may be described in terms of digital logic
as the Exclusive OR function between the clock and data.
The Truth Table for the Exclusive OR function is given below:

TRUTH TABLE

EXCLUSIVE OR

	DATA	
CLOCK	0	1
0	0	1
1	1	0

As can be seen, the output is zero if the clock and data are both
one or zero, but is one if the clock and data are opposite. The
advantage of this may be seen in the timing diagram (Figure 3).
Regardless of the input data, the Manchester-encoded data will
change state once and only once during each input data bit. These
changes may be used to synchronize the decoder clock. In this
manner the remote platform clock information will be carried along
with the data.

3. Pattern Sensitivity: As stated above, the data collection
platforms use a Manchester Code to transmit data. The
decoder must be capable of extracting the clock rate from
the data in the presence of the spin noise described above.
Furthermore, it must be able to do this with any possible
data bit pattern. The GOES DCS has standardized on the use
of ASCII code with odd parity. The decoder, therefore, must
be able to accommodate data having as few as two "bit
transitions" per 8-bit character. Otherwise, loss of
synchronization will permit errors to be received until
the decoder resynchronizes. Unfortunately, consecutive
zeros can represent valid data from some types of platforms.
Some of the electronic techniques which can be used to
minimize the spin modulation noise complicate the clock
slip problem.

CLOCK
100 HZ

DATA   I   O   O   I   I   O
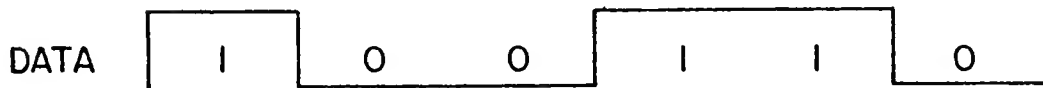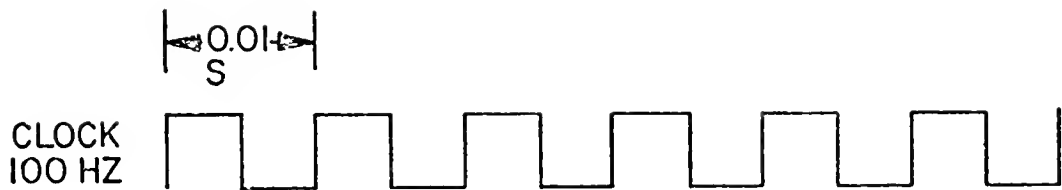
APPLY THE EXCLUSIVE OR TRUTH TABLE
AND OBTAIN

AS MANCHESTER−ENCODED
DATA

NOTICE THAT THE ENCODED DATA
CHANGES STATE ONCE DURING
EACH INPUT DATA BIT

FIGURE 3

4. Interface: In addition to the above, the demodulator/decoder
    must properly interface with the receiver which immediately
    precedes it and with the frame synchronizer equipment which
    it feeds.

VI. FRAME SYNCHRONIZER

After the signal has been decoded and the 100-Hz clock in the decoder
"locked up" by the 2.5-second alternating 1-0 pattern, the decoder
is ready to present data to the outside world. The next segment of
the reply format is a 15-bit Maximal Length Sequence (MLS) pattern.
The 15-bit MLS is recognized by a device called a "frame synchronizer"
which must wait for decoder lock before looking for the 15-bit MLS.
At the conclusion of the MLS, the frame synchronizer must be ready
to present the received data in 8-bit segments to the data processing
equipment.

VII. DATA PROCESSING EQUIPMENT

It is not possible to recommend a specific system for processing the
received data, as this depends on the requirements of the user and on
how the remote sensor outputs its data to the radio set. The cost
of data processing system can be minimized by considering the
processing, if any, that is done at the platform and user's data
processing equipment. Obviously, the form of the data provided by
the sensor and the computing system must be designed together if a
cost effective system is to be developed. These depend on the
user's specific requirements and can only be defined by the user.
Generally, the data processing equipment must, as a minimum,
include the following:

   A.   A proper interface to the frame synchronizer.
   B.   Interpretation of the 31-bit DCP address.
   C.   Parity error checking.
   D.   Storage of the data.
   E.   A means of retrieving the data from storage.

VIII. OBTAINING A DIRECT READOUT RECEIVING STATION

The above material has briefly described system parameters; readers
should bear in mind that NOAA/NESS cannot provide designs for
particular users. Anyone considering establishing his own direct
readout facility should contact vendors experienced in this area.

IX. COSTS

The following are rough estimates on costs of the various components:

1. Antenna and Feed (Excluding Mounting Structure)

Diameter (meters)	Cost (U.S. dollars)
1.2 (= 4 feet)	500
1.8 (= 6 feet)	800
2.4 (= 8 feet)	1,200
3.0 (= 10 feet)	1,750
3.6 (= 12 feet)	3,600
4.6 (= 15 feet)	8,950
9.1 (= 30 feet)	25,000

2. Preamplifier

Typical bipolar transistor:	350
Premium grade bipolar transistor:	600
Gallium-arsenide FET:	1,500
Ambient temperature parametric amplifier:	25,000
Cryogenic parametric amplifier:	100,000

3. Receiver   3,000

4. Demodulator: (Includes channel filter)   4,000

5. Data processing equipment: (Depends on application)

Note: This report describes the equipment and operation requirements for the GOES/DCS in a general way.

Additional information about the DCS system and its use can be obtained by writing to:

> David S. Johnson, Director (S)
> National Environmental Satellite Service
> FOB #4, Room 2069
> Washington, D.C. 20233

Readers should bear in mind that the U.S. Government cannot comment on the relative merits of a particular design of a particular vendor.

APPENDIX A

PER-CHANNEL SIGNAL ENERGY AS A FUNCTION OF THE NUMBER OF
ACTIVE CHANNELS

The Equivalent Isotropic Radiated Power (EIRP) on a per-channel
basis is given by

$$\text{EIRP}/_{\text{Channel}} = \frac{W}{X + N} \text{ watts (in watts per channel)} \quad (1)$$

where   W   = the total EIRP available over the
400-kHz DCS channel in watts (not
in dBm). This is normally 2.5 watts,

     X   = the number of equal power users
transmitting simultaneously. The non-
equal power users case will be discussed
later, and

     N   = the noise-to-signal ratio at the input to
the spacecraft receiver.

This ratio must be converted into a numerical form and not expressed
in dB. The noise power is calculated over the entire 400-kHz DCS
bandwidth and not over just the 100-Hz DCS data bandwidth. Typical
numbers are: noise power over a 400-kHz bandwidth at the input to
the spacecraft receiver = -117dBm and the signal energy from a
fixed platform is approximately -127dBm. Hence, the noise-to-
signal ratio is nominally 10dB which also happens to be a numerical
ratio of 10.

The EIRP as given by equation (1) will be given in watts which must
be converted into an equivalent dBm number for most link
calculations.

Applying the above to equation (1) gives, for typical cases,

$$\text{EIRP} = \frac{2.5}{X+10} \text{ watts/channel.} \quad (2)$$

As can be seen from equation (2), when the number of channels
transmitting simultaneously is small, say less than about five,
the EIRP per channel is approximately constant at about 0.2 watts
(= 23dBm) per channel. When the number of channels transmitting
simultaneously is large, greater than say about 20, the EIRP will
decrease linearly in watts as the number of channels transmitting
increases.

Equations (1) and (2) assume that all platforms are received at
the same level by the spacecraft. Where the signal levels of the
platforms as received at the spacecraft are not the same, as may
be the case when fixed and buoy platforms are received
simultaneously, the equation is slightly different. In this
case equation (1) becomes

$$\text{EIRP}/_{\text{Channel}} = \frac{W \text{ watts}}{\sum\limits_{a} (X_a + N_a)} \quad \text{(watts per channel)} \quad (3)$$

where
W = EIRP in watts, as before

X_a = number of channels received
simultaneously at a given level,
and

N_a = noise-to-signal ratio (expressed
as numeric) of those channels.

The summation is taken over all the different power levels and their
respective noise-to-signal levels.

Equation (2) or (3) can also be used when the satellite is trans-
mitting in low-power mode., as it will be during eclipse periods
beginning with GOES-2 satellite. In this case, the numerator is
0.4 watts (+26dBm) instead of 2.5 watts.

APPENDIX B

CALCULATION OF THE PHASE MODULATION INTRODUCED BY THE SWITCHED ARRAY ANTENNA *

The UHF antenna used for SMS is switched array. As the satellite spins, the transmitter and receiver are disconnected from one set of antenna elements and connected to another set (one element for transmit and one for receive). Since the radiating elements are in separate locations about the satellite periphery, the propagation path length from antenna to Earth terminal suddenly changes when the elements are switched. This effect causes a jump in RF carrier phase.

Also, because the phase center of the UHF satellite antenna is located off the axis of spin rotation, the propagation path length to the Earth terminal varies as the satellite rotates. This path variation introduces a phase (frequency) modulation on the transmitted and received carriers which may degrade link performance.

Figure B-1, shows the basic geometry, and Figure B-2 shows the phase shift as a function of time. The step in phase occurs when a new antenna is switched. The fundamental frequency of this phase modulation is eight times the spin rate (13.3Hz at 100 rpm). The worst case occurs on the DCP interrogation and reporting links with the DCP on Earth edge at the equator (in the plane of spin motion).

From Figure B-1,

$$\Delta L = R - R \cos (\theta - \alpha)$$
$$= R (1 - \cos (\theta - \alpha))$$
$$= 2R \sin^2 \frac{\theta - d}{2}$$

where R is the antenna radius, α is the angle from the vertical to the Earth terminal (in the equatorial plane); and θ is the position of the UHF antenna element relative to the vertical.

Also,

$$\Delta \phi = \frac{\Delta L}{\lambda} (360^\circ),$$

---

*Obtained from the Ford Aerospace and Communications Corp.

for

$$\alpha = -9.2^O \text{ (Earth edge + 0.5}^O \text{ tolerance)},$$
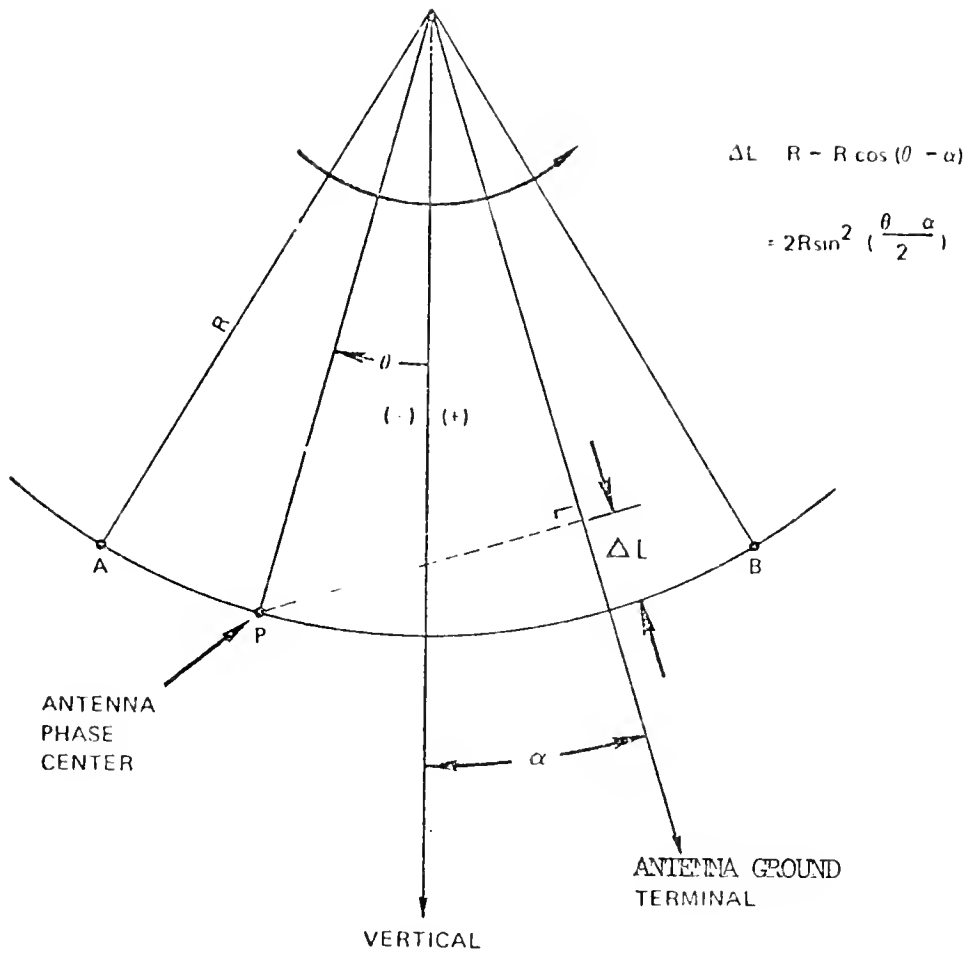
$$\theta = 22.5^O, \text{ and}$$

$$R = 26 \text{ in.}$$

Then,

$$\beta = \theta - \alpha = 31.7^O$$

and the phase shift is 47.7^O at 401.9MHz and 55.6^O at 468.8MHz.

A new element is switched in at this point, changing θ to -22.5^O and β to -13.3^O. The phase shift jumps to 8.6^O at 401.9MHz and 10.0^O at 468.8MHz. The step change in phase due to switching is 39.1^O at 401.9MHz and 45.6^O at 468.8MHz. This phase step occurs once every 75 μs for a spin rate of 100 rpm. Figure B-3 shows how the peak phase and phase jump varies with α.

$$\Delta L \quad R - R\cos(\theta - \alpha)$$

$$= 2R\sin^2\left(\frac{\theta \quad \alpha}{2}\right)$$

θ

$(-)$ $(+)$

ΔL

A

B

P

ANTENNA
PHASE
CENTER

α

ANTENNA GROUND
TERMINAL

VERTICAL

WHEN ANTENNA PHASE
CENTER ROTATES TO
B, THE ARRAY IS SWITCHED
AND THE PHASE CENTER
JUMPS TO A. THIS CAUSES
A JUMP IN PHASE OF THE
RF CARRIER.

Figure B1.-- Geometry of Propagation Path Length to ground
Variation Resulting from Satellite Spin Motion

71

FREQUENCY: 468.8 MHz
              (401.9 MHz)

EARTH TERMINAL LOCATED ON EQUATOR
AT EARTH EDGE (α = 9.1°)

ANTENNA RADIUS: 26 INCHES

(ΔL = 0)

55.6°
(47.7°)
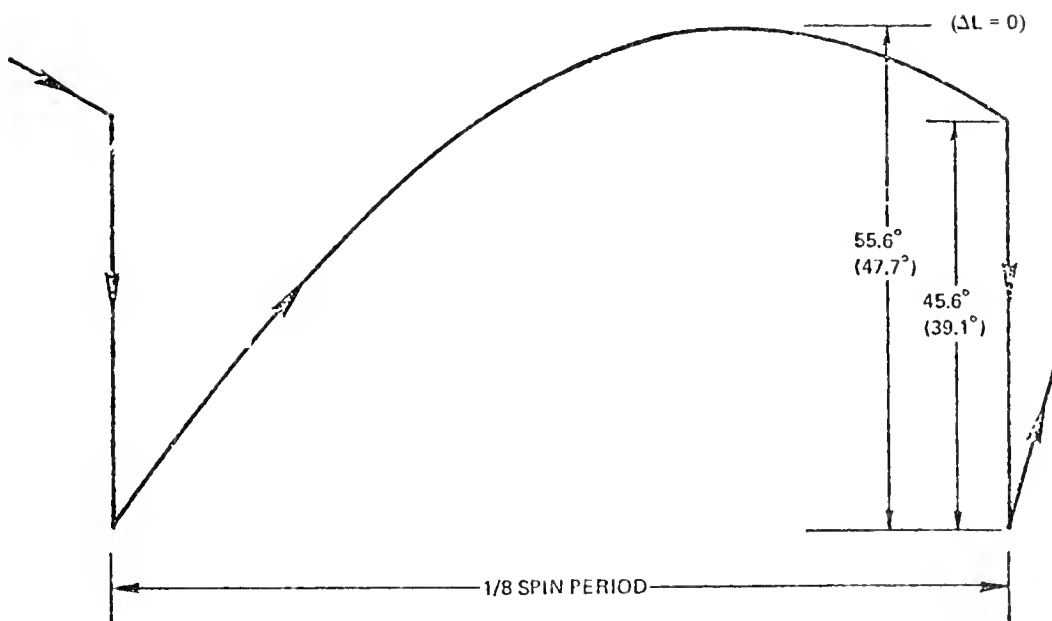
45.6°
(39.1°)

1/8 SPIN PERIOD

Figure B2.--Phase Shift Introduced by Satellite Spin Motion
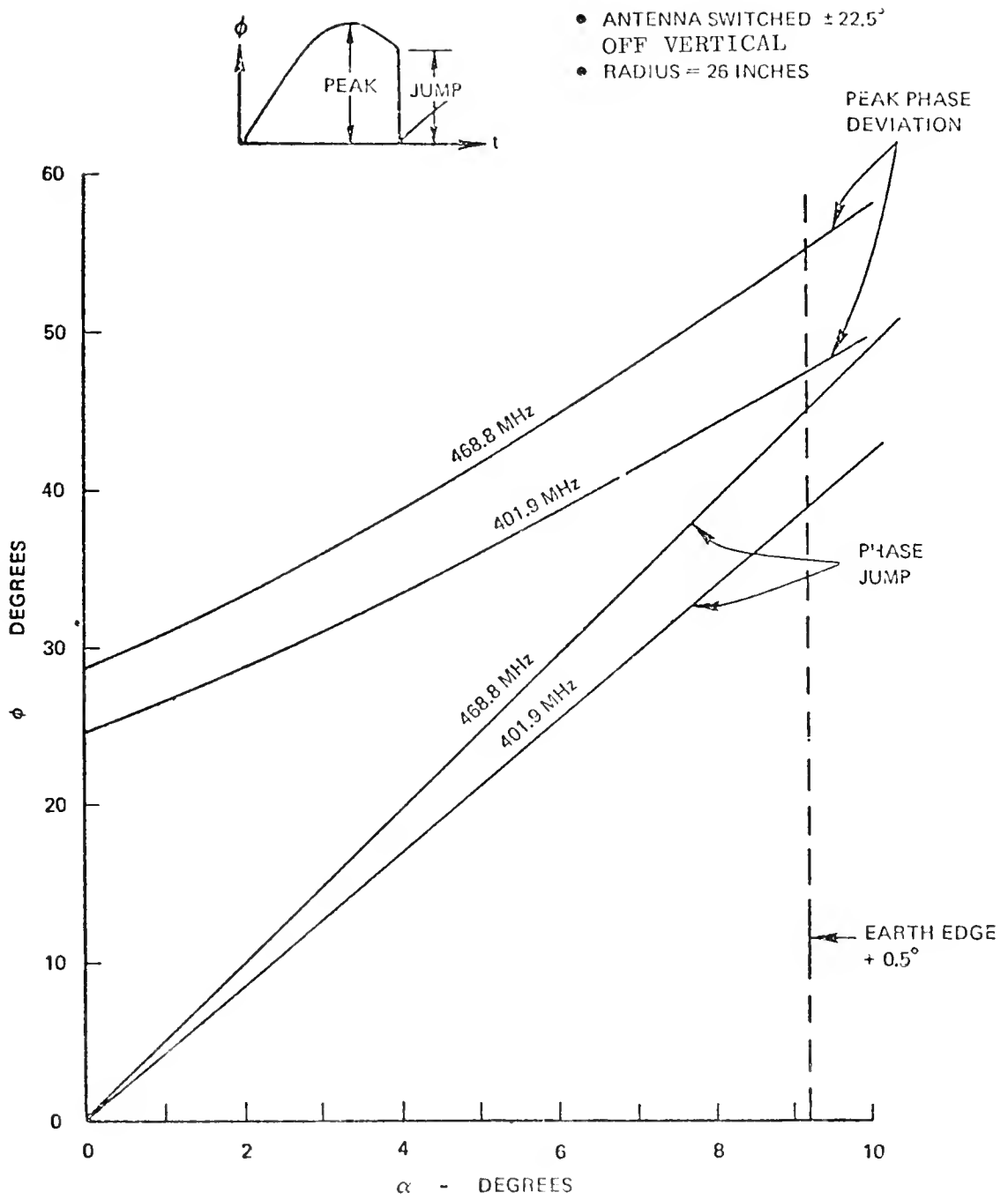and Element Switching in UHF Antenna.

72

Figure B3.--Phase Modulation Caused by UHF Satellite
Antenna Due to Spin Motion.

APPENDIX E

Certification Specifications for
International DCPRS

1. <u>RF Power Output</u>

   The Effective Isotropic Radiated Power (EIRP) of a DCPRS
   and antenna shall not exceed 52 dBm under any combination
   of service conditions.

2. <u>Frequency Characteristics</u>

   The DCPRS transmitted RF shall be in the 402.002577-MHz to
   402.098582-MHz band. (See Table 1.)

3. <u>Stability</u>

   A. <u>Temperature and Long Term</u>

       The transmitted carrier frequency stability shall be
       better than 1.5 parts per million against temperature
       variations and aging altogether. This specification
       applies typically over the temperature range of -20^OC
       to $+50^O$C and over 1 year, unless specified differently
       by the DCP operator.

   B. <u>Short Term</u>

       The phase jitter on the transmit carrier shall be less
       than 3° RMS when measured through a phase lock loop
       two-sided noise bandwidth (2BL) of 20 Hz and within
       ± 2 KHz. (See Fig. 1.)

4. <u>Electromagnetic Interference</u>

   Any transmitter spurious emissions, when measured with
   modulation and with antenna and diplexer connected, shall be
   down from the unmodulated carrier level by 60 dB, (referred
   to a measurement bandwidth of 500 Hz). International ship-
   board EMI specification should also be included.

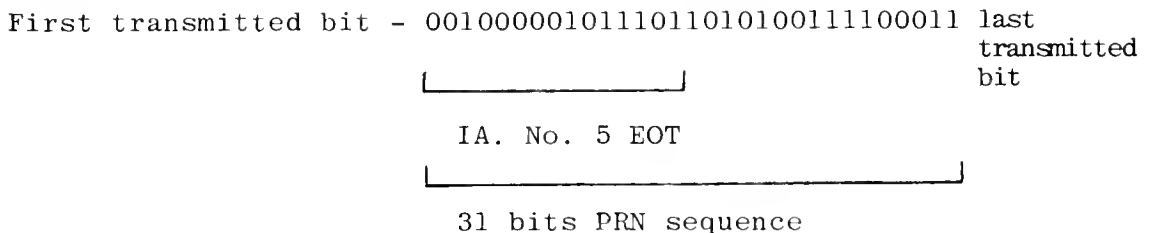5. <u>Transmit Data</u>

   After 5 seconds of unmodulated carrier, the carrier shall be
   modulated with the bit and message synchronization data
   patterns which are 2.5 seconds of alternate 1,0 data bits, and
   the 46-bit preamble consisting of the 15-bit MLS synch word
   (100010011010111) followed by the 31-bit BCH address word
   (different for each platform), and a message proper consisting
   of 8-bit data words. The binary data shall be Manchester
   encoded and shall modulate the carrier in the following manner:

   A data "0" shall consist of $+60^O$ carrier phase shift for 5
   milliseconds followed by -60° carrier phase shift for 5
   milliseconds, and a data "1" shall consist of -60° carrier
   phase shift for 5 milliseconds followed by $+60^O$ carrier
   phase shift for 5 milliseconds. (See Fig. 2.) The phase of
   the 5 seconds unmodulated carrier shall correspond to the
   phase of the modulated carrier.

6. End of Transmission

   Immediately after sending the sensor data, the DCPRS shall
   transmit 31-bit End-of-Transmission (EOT) code (bit pattern
   0010000010111010100111100011) continuously with the sensor
   data (no break) and return to the standby mode.

   The first 8 bits of the 31-bit EOT shall be the International
   Alphabet No. 5, 8 bits EOT (ODD parity Po):

   First transmitted bit - 0010000010111011010100111100011 last
                                                               transmitted
                           └─────────────┘   bit

                           IA. No. 5 EOT

                   └──────────────────────────────────┘

                           31 bits PRN sequence

7. Fail-Safe Design

   The DCPRS shall incorporate a fail-safe design feature such
   that malfunctioning of the equipment shall in no way cause
   discontinuous transmission. Furthermore, provision shall be made
   to automatically terminate the transmission at a time not to
   exceed the platform's allocated transmission plus 30 seconds.

8. Antenna Polarization

   Polarization shall be right-hand circular according to CCIR
   Report No. 321 (XIIIth Plenary Assembly, 1974 - Vol. XII).

9. Timing Accuracy

   The timer that determines the DCPRS reporting time shall be
   of sufficient accuracy to ensure that the DCPRS reporting
   time is maintained to within 30 seconds of its assigned
   reporting time. The timer shall provide for a reporting
   interval of 1 to 12 hours in 1-hour steps. Furthermore,
   the timer shall be capable of being set in steps of 60 seconds.

10. Clock Output

    The DCPRS shall provide a 100 Hz clock frequency. This frequency
    shall be used to clock in the reply data. The 100-Hz clock
    frequency shall have a long-term temperature stability
    better than 50 parts per million.

11. Data Input

    The DCPRS shall accept, from an interface unit with environmental
    sensors or manual data input device, a serial bit flow NRZ-L,
    100 bits/s coded in International Alphabet No. 5. (See Fig. 3.)

12. Start Signal

    The DCPRS shall provide a start signal at the required time of
    transmission. This start signal generated from the timer will
    initiate the read-out of data from the interface unit.

TABLE 1

FREQUENCY ALLOCATION FOR INTERNATIONAL
DCP RESPONSE CHANNEL

No. of Channel	Frequency MHz	Remarks
1	402.002577	
2	402.005577	
3	402.008577	
4	402.011577	
5	402.014577	
6	402.017578	
7	402.020578	
8	402.023578	
9	402.026578	
10	402.029578	
11	402.032578	
12	402.035579	
13	402.038579	
14	402.041579	
15	402.044579	
16	402.047579	
17	402.050579	
18	402.053579	
19	402.056580	
20	402.059580	
21	402.062580	
22	402.065580	
23	402.068580	
24	402.071580	
25	402.074581	
26	402.077581	
27	402.080581	
28	402.083581	

No. of Channel	Frequency MHz	Remarks
29	402.086581	
30	402.089581	
31	402.092581	
32	402.095582	
33	402.098582	

DATA

CLOCK

MANCHESTER-
CODED
DATA

+60°

CARRIER
PHASE

-60°

ONE   ZERO

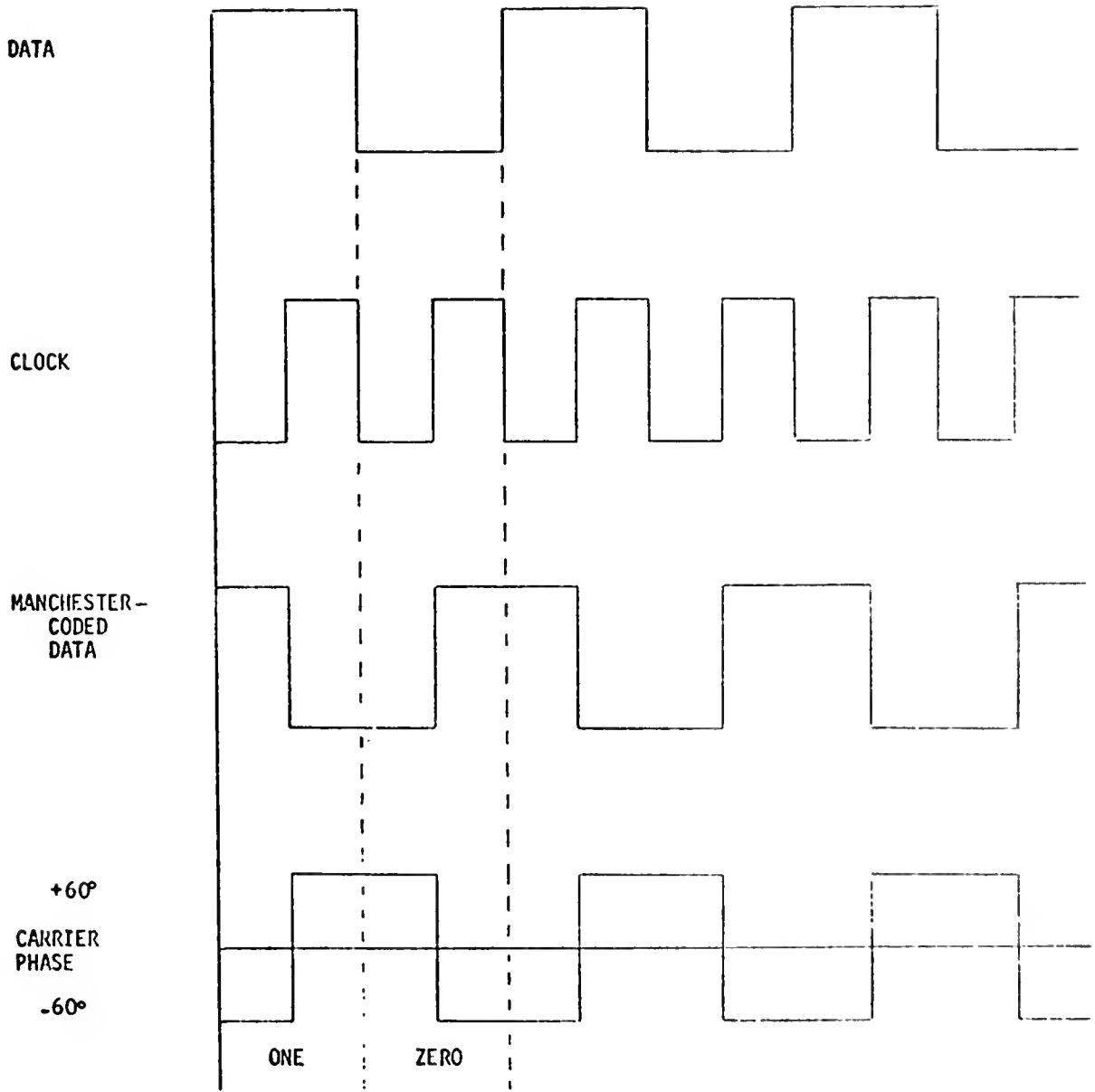Figure 1.--Modulation Definition.

80

NOAA Technical Reports

NESS 55 The Use of Satellite-Observed Cloud Patterns in Northern Hemisphere 5-mb Numerical Analysis. Roland E. Nagle and Christopher M. Hayden, April 1971, 25 pp. plus appendixes A, B, and C. (COM-73-50262)

NESS 57 Table of Scattering Function of Infrared Radiation for Water Clouds. Giichi Yamamoto, Masayuki Tanaka, and Shoji Asano, April 1971, 8 pp. plus tables. (COM-71-50312)

NESS 58 The Airborne ITPR Brassboard Experiment. W. L. Smith, D. T. Hilleary, E. C. Baldwin, W. Jacob, H. Jacobowitz, G. Nelson, S. Soules, and D. Q. Wark, March 1972, 74 pp. (COM-72-10557)

NESS 59 Temperature Sounding From Satellites. S. Fritz, D. Q. Wark, H. E. Fleming, W. L. Smith, H. Jacobowitz, D. T. Hilleary, and J. C. Alishouse, July 1972, 49 pp. (COM-72-50963)

NESS 60 Satellite Measurements of Aerosol Backscattered Radiation From the Nimbus F Earth Radiation Budget Experiment. H. Jacobowitz, W. L. Smith, and A. J. Drummond, August 1972, 9 pp. (COM-72-51031)

NESS 61 The Measurement of Atmospheric Transmittance From Sun and Sky With an Infrared Vertical Sounder. W. L. Smith and H. B. Howell, September 1972, 14 pp. (COM-73-50157)

NESS 62 Proposed Calibration Target for the Visible Channel of a Satellite Radiometer. K. L. Coulson and H. Jacobowitz, October 1972, 27 pp. (COM-73-10143)

NESS 63 Verification of Operational SIRS B Temperature Retrievals. Harold J. Brodrick and Christopher M. Hayden, December 1972, 26 pp. (COM-73-50258)

NESS 64 Radiometric Techniques for Observing the Atmosphere From Aircraft. William L. Smith and Warren J. Jacob, January 1973, 12 pp. (COM-73-50376)

NESS 65 Satellite Infrared Soundings From NOAA Spacecraft. L. M. McMillin, D. Q. Wark, J.M. Siomkajlo, P. G. Abel, A. Werbowetzki, L. A. Lauritson, J. A. Pritchard, D. S. Crosby, H. M. Woolf, R. C. Luebbe, M. P. Weinreb, H. E. Fleming, F. E. Bittner, and C. M. Hayden, September 1973, 112 pp. (COM-73-50936/6AS)

NESS 66 Effects of Aerosols on the Determination of the Temperature of the Earth's Surface From Radiance Measurements at 11.2 m. H. Jacobowitz and K. L. Coulson, September 1973, 18 pp. (COM-74-50013)

NESS 67 Vertical Resolution of Temperature Profiles for High Resolution Infrared Radiation Sounder (HIRS). Y. M. Chen, H. M. Woolf, and W. L. Smith, January 1974, 14 pp. (COM-74-50230)

NESS 68 Dependence of Antenna Temperature on the Polarization of Emitted Radiation for a Scanning Microwave Radiometer. Norman C. Grody, January 1974, 11 pp. (COM-74-50391/AS)

NESS 69 An Evaluation of May 1971 Satellite-Derived Sea Surface Temperatures for the Southern Hemisphere. P. Krishna Rao, April 1974, 13 pp. (COM-74-50643/AS)

NESS 70 Compatibility of Low-Cloud Vectors and Rawins for Synoptic Scale Analysis. L. F. Hubert and L. F. Whitney, Jr., October 1974, 26 pp. (COM-75-50065/AS)

NESS 71 An Intercomparison of Meteorological Parameters Derived From Radiosonde and Satellite Vertical Temperature Cross Sections. W. L. Smith and H. M. Woolf, November 1974, 13 pp. (COM-75-10432)

NESS 72 An Intercomparison of Radiosonde and Satellite-Derived Cross Sections During the AMTEX. W. C. Shen, W. L. Smith, and H. M. Woolf, February 1975, 18 pp. (COM-75-10439)

NESS 73 Evaluation of a Balanced 300-mb Height Analysis as a Reference Level for Satellite-Derived soundings. Albert Thomasell, Jr., December 1975, 25 pp. (PB-253-058)

NESS 74 On the Estimation of Areal Windspeed Distribution in Tropical Cyclones With the Use of Satellite Data. Andrew Timchalk, March 1976, 41 pp. (PB-261-971)

NESS 75 Guide for Designing RF Ground Receiving Stations for TIROS-N. John R. Schneider, December 1976, 126 pp. (PB-262-931)

NESS 76 Determination of the Earth-Atmosphere Radiation Budget from NOAA Satellite Data. Arnold Gruber, November 1977, 31 pp. (PB-275-)

NESS 77 Wind Analysis by Conditional Relaxation. Albert Thomasell, Jr., January 1979

... men of
million ... ... impact
... ... Earth,
... ...

... technical informa-
...

PREPRINTS ... ... TIONS — Re-
research ... ...ions, etc.
... ...ing precedition and
CONTRACT ... ... remain ...aining pa-
prepared ... ...tion serials; and
sponsor... ... ...

ATLAS ... ... The ... ...ar quality with
in the form... ... ...pments, or data
chemical ... ...
mesphere. ... ... — Reports of
mals, ones, ...ch or technol-
... like.