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Geostationary meteorological satellite data collection systems

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ABSTRACT

There are three geostationary meteorological satellite data collection systems currently being operated: Geostationary Operational Environmental Satellite (GOES) by the USA; METEOSAT by the European Space Agency (ESA); and Geostationary Meteorological Satellite (GMS) by Japan. Regional or domestic reply frequencies are the same for the METEOSAT and GMS systems while those for the GOES system are different. All three systems have common international frequencies and data rates, i.e., 100 bits per second (bps).

Rules for using these data collection systems vary. Use of GOES is limited only by non-USA users being able to obtain a USA organization to sponsor their use. Use of METEOSAT is governed by costs per message which varies in amount depending upon whether or not the user is from a member-state of ESA. Use of GMS is governed to a large degree by the Japanese Postal, Telephone and Telegraph Rules.

The GOES ground system will be upgraded and expanded during the latter part of this decade to support more than 200 channels including some channels at higher data rates (300 and 1200 bps).

Future data collection systems will include the Geostationary Operational Meteorological Satellite (GOMS) operated by the USSR. GOMS will use the same frequency band as GOES and will operate at 100 bps.

GEOSTATIONARY METEOROLOGICAL SATELLITE DATA COLLECTION SYSTEMS

Currently there are three operational geostationary meteorological satellite data collection systems: Geostationary Operational Environmental Satellite (GOES) operated by the USA; METEOSAT operated by EUMETSAT and the European Space Agency (ESA); and the Geostationary Meteorological Satellite operated by Japan. All three systems use the same data rates, i.e., 100 bits per second (bps). Regional or domestic reply frequencies are the same for METEOSAT and GMS (402.1-402.4 Mhz) while those for GOES (401.7-402.0 Mhz) differ. However, common international frequencies (402.0-402.1 Mhz) are used by GMS, GOES, and METEOSAT (fig.1). By international agreement, frequencies used are limited to the collection of environmental data only.

These data collection systems use satellites, located in geostationary orbit over the equator (fig.2) at an altitude of 35000 km, to relay signals from in situ data collection platforms to properly equipped earth stations. METEOSAT uses a spacecraft at 0° longitude; GMS uses a spacecraft at 140° East longitude; and GOES uses two spacecraft, one located at 135° West longitude,

FREQUENCY ALLOCATIONS FOR DATA COLLECTION

		UPLINK REPLY FREQUENCIES (MHZ)	
SPACECRAFT	LOCATION	REGIONAL	INTERNATIONAL
METEOSAT	0°	402.1 - 402.4	402.0 - 402.1
GMS	140° EAST	402.1 - 402.4	402.0 - 402.1
GOES EAST	75° WEST	401.7 - 402.0	402.0 - 402.1
GOES WEST	135° WEST	401.7 - 402.0	402.0 - 402.1
GOMS	70° EAST	401.7 - 402.0	402.0 - 402.1

FIG.1 Common data collection uplink frequencies

the other at 75° West longitude. With these locations, virtually the entire globe, except for the polar regions and some Asian mid-latitude areas, is covered within the radio footprint of one of these spacecraft. Rules for using these data collection systems normally vary from one to another. However, international frequencies are common to all spacecraft and use is limited to platforms reporting from mobile vehicles such as ships, aircraft, balloons, etc.

The International Data Collection System (IDCS) Users Guide published by the Secretariat of the Coordination of Geostationary Meteorological Satellite (CGMS) organization contains detailed information pertaining to the IDCS. Use of GOES is limited only by non-USA users being able to obtain an authorized USA organization to sponsor its use. Until the upgrade of the GOES ground system later in this decade, there will be an additional limitation on the use of GOES by all large users. METEOSAT use is governed by costs per message which varies in amount depending upon whether or not the user is from a member-state of ESA. Use of the GMS is governed to a large degree by the Japanese Postal, Telephone and Telegraph rules.

In order to more thoroughly understand a Geostationary Meteorological Satellite Data Collection System, the GOES Data Collection System will be described in detail in the following paragraphs by MacCallum (1983).

The GOES DCS is a data relay network consisting of many individual data gathering platforms frequently referred to as data collection platforms (DCPs) which can transmit their data to one of the two satellites. Each spacecraft has a capacity of 233 channels at 1.5 khz separation of centre frequencies. This would theoretically allow more than 9000 DCPs to transmit via each spacecraft transponder in each one hour period. In reality, the total number of DCP transmissions per space craft is closer to 6000. There are up to 200 channels available in the domestic frequency band (401.7-402.0 Mhz). Channel spacing accommodates DCS message rates of 100 bps. Error rate probabilities of 10^{-5} or better can be expected.

These data are relayed through the satellite either to a common Command and Data Acquisition (CDA) station at Wallops Station, Virginia, or to properly equipped ground direct readout stations at S-band (91694.5 Mhz). The uplink frequency from the DCP to the satellite is UHF. Data received at the CDA are demodulated, checked for parity errors and transmission quality,

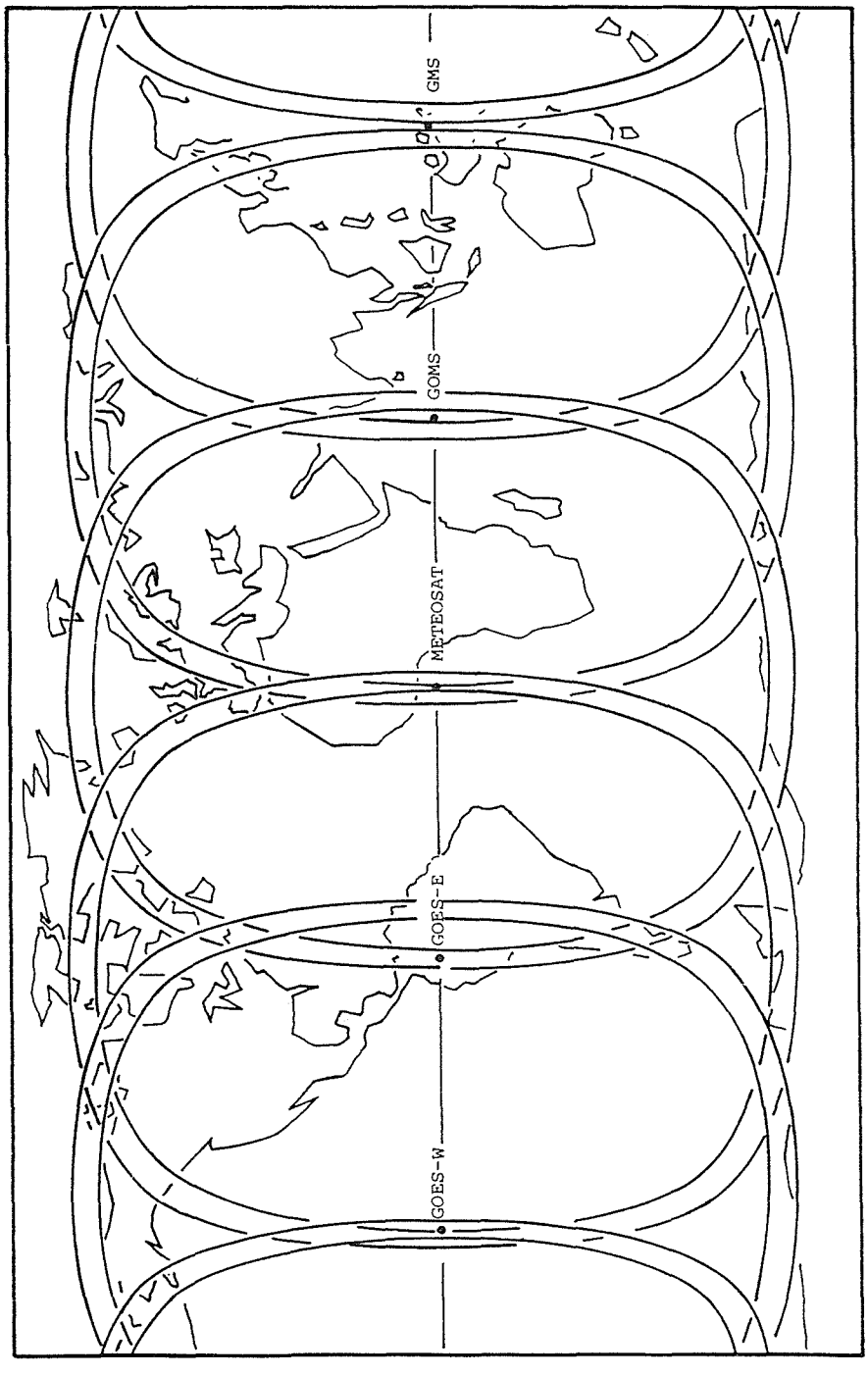

FIG.2 Geostationary meteorological satellite radio footprints
(Courtesy CGMS)

and relayed by landline to Camp Springs, Maryland, where these data are disseminated to the appropriate system user. There is no processing of data into engineering units accomplished at Camp Springs before these data are disseminated. NOTE: Other systems may process these data into engineering units. Potential users should contact the individual system manager to determine what data processing is available. Dissemination is in either real time, via dedicated circuits, or by direct dial-in on a user demand basis at low speed 300 and 1200 baud or at medium speed 2400 or 4800 baud (fig.3). Disc storage is somewhat limited and normally data storage cannot be guaranteed in excess of 24 hours.

There are three basic types of DCPs in the system. Each type uses binary coded ASCII or pseudo-ASCII characters. These DCPs are type certified by the National Oceanic and Atmospheric Administration (NOAA) prior to use in the GOES DCS. Each DCP has a unique 31-bit address which is transmitted with every message. The first type of DCP is the interrogate, which replies only when it is interrogated from the NOAA ground system via the satellite. There is an alarm reply channel for use after a certain pre-set sensor for use threshold is reached. Upon receipt of this address on the alarm channel, the DCS ground computer will schedule a special interrogation of this DCP within a few minutes and the DCP will transmit its special data via the normal reply channel. The second type is self-time and replies on its assigned time according to a pre-set internal clock. Self-timed DCPs normally are scheduled at either 3 or 4 hour intervals but, in some special cases, may report more frequently. The third type of DCP reports in a random manner in response to pre-set sensor thresholds. Random reporting DCPs repeat their message one or more times in a random manner to insure that at least one of these transmissions is received. Random reporting messages are brief (2-4 seconds including message protocol) when compared to interrogate or self-timed messages which may continue up to several minutes. Variations of the random reporting DCP may include both self-timed and random reporting capabilities as well as the ability to transmit on more than one channel depending on the nature of the message. NOTE: The GOES DCS is the only system which supports interrogated and random reporting platforms.

The current GOES DCS ground system has 72 active domestic channels and four international channels, with a total capacity of 80 channels. There are more than 7000 DCPs in the system with 4500-5000 active at any one time. The ground system has either complete redundancy of all components, or alternate routes for data flow to insure reliability of the system. In addition, a standby GOES, located at 107° West longitude, is available to assume data collection activities in the event of operational failure or during the two eclipse periods when spacecraft power limitations may preclude use of the satellite for data collection. To allow for efficient use of this space craft redundancy, all GOES DCS users have been urged to point their DCP antenna halfway between the location of the normal operational spacecraft and the standby spacecraft. In this manner, sudden changes in the active spacecraft used for DCS will not adversely affect the user's data collection activities.

Some special features of the current GOES DCS are:

(a) Time code. Coded time data, updated at 1/2 minute intervals by reference to a National Bureau of Standards source, are broadcast in the interrogate signal.

(b) Reinterrogation. Up to 15 reinterrogations are allowed.

(c) Remote commanding. Interrogated DCPs can alter their electrical or mechanical operating parameters in response to a message over the interrogate

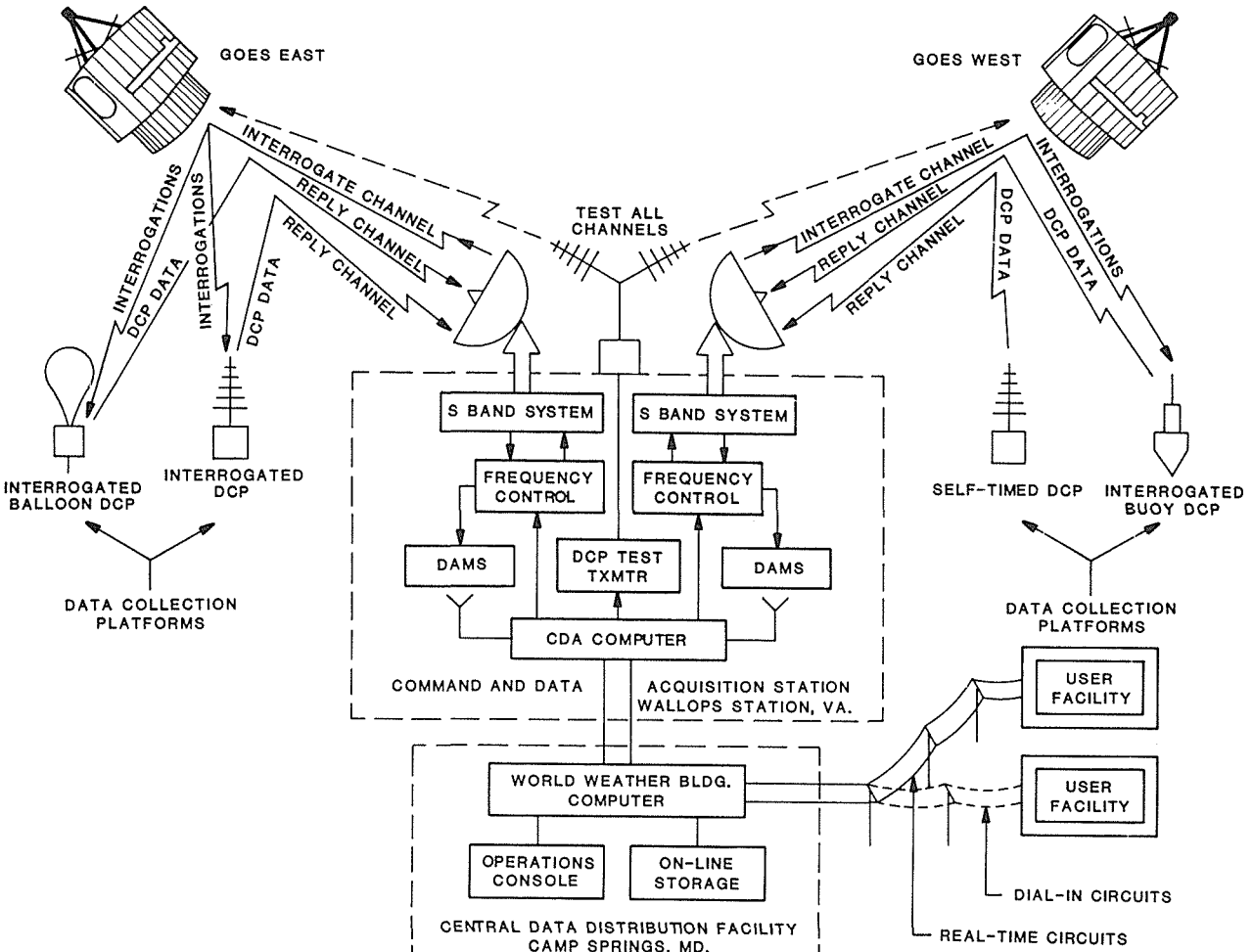

FIG.3 GOES DCS schematic
(NESDIS 2)

channel.

(d) Test mode/reply verify. A DCP in the test mode will have a reply verify transmitted upon receipt of each error free message.

(e) Emergency interrogate schedule. More frequent interrogations of DCP networks or segments of networks can be made by the DCS operator.

(f) Test transmissions. Transmissions from the test transmitter are used periodically to test each reply channel.

(g) Diagnostic messages. Each message is checked for errors and appropriate diagnostic information is appended to each message as necessary.

(h) Multiple user dissemination. Each DCP message will be sent to a primary user and up to three other users upon request.

(i) Remote access to the NOAA data base is possible in order to obtain specific information for each DCP.

(j) Appending diagnostic information from the Data Acquisition and Monitoring System (DAMS) to each message received by the NOAA ground system (fig.4).

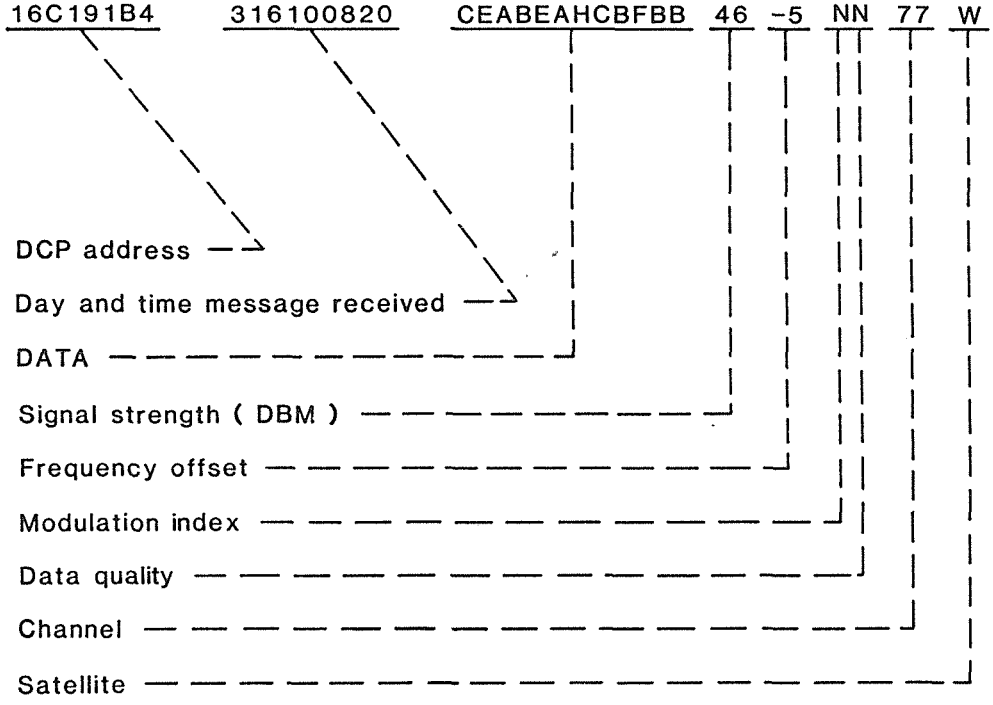

FIG.4 DAMS Message

The present user community consists of meteorological, hydrological, oceanographic, seismological, and environmental monitoring users. By far the largest number of DCPs (approximately 4500) is involved with hydrological measurements.

The GOES DCS ground system will be upgraded later in this decade. The ground data handling will be consolidated in one location at the Wallops CDA thereby eliminating the DCS data handling mission in Camp Springs, Maryland. Capacity of the ground system will be expanded from the present 80 channels to more than 200 and from 7000 active DCPs to approximately 100,000 DCPs. The new system will support data rates from 100 bps to 1200 bps and wideband random reporting channels allowing the reception of up to four different messages simultaneously (fig.5). Perhaps of more interest will be the additional data dissemination capability planned. While maintaining a dial-in longline capability for low volume users, large volume users will use a Domestic Communications Satellite (DOMSAT) associated with the NOAA-PORT system, or direct readout from the GOES spacecraft.

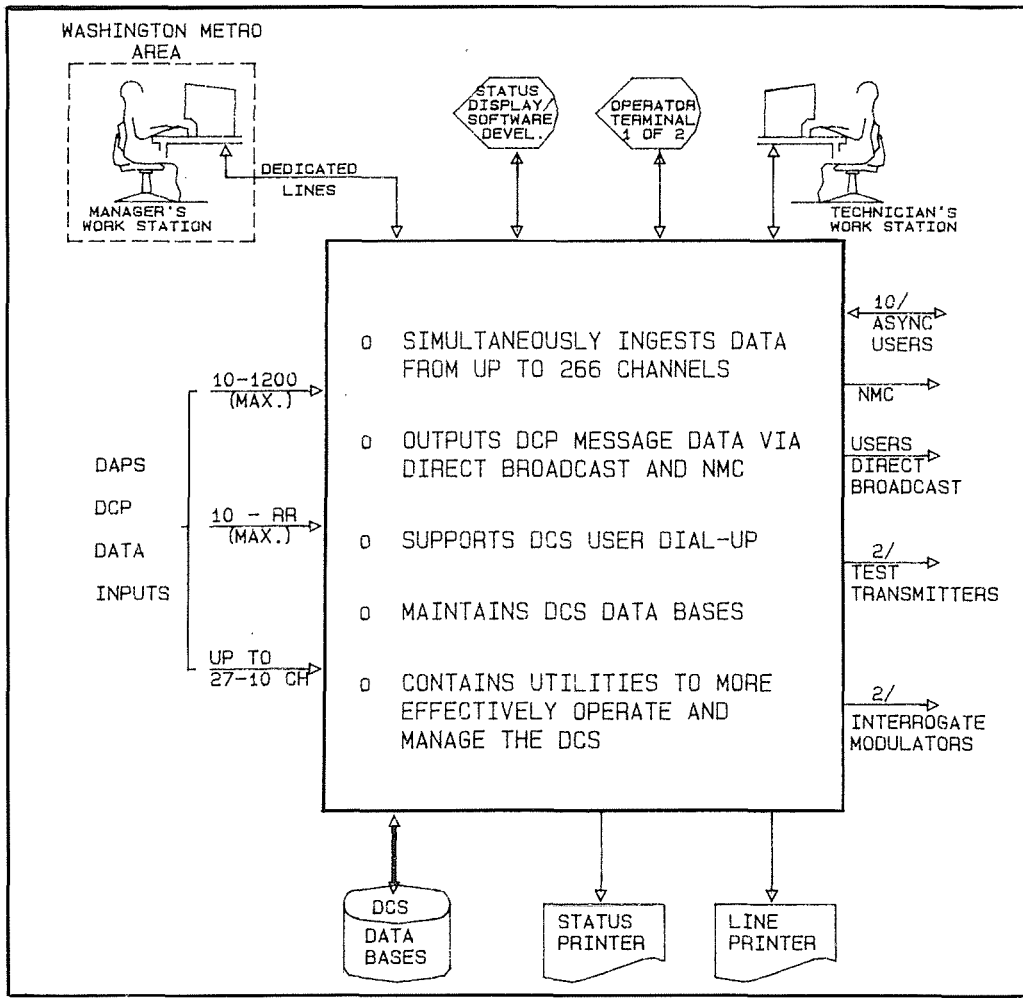

FIG.5 New GOES DCS ground system capabilities

DOMSAT (fig.6) will support up to 56K bps transmissions with a capability to retransmit a limited amount of data either by DOMSAT or asynchronous dial-in landlines. In order to accomplish the DOMSAT transmissions a DCS Read Out Terminal (DROT) will be developed in conjunction with the ground system upgrade. The DROT will be personal computer (PC) based and can be used as a front-end processor for larger computers or used independently. NOAA will fund the development of the DROT and provide users with the specifications for their own procurement of the equipment.

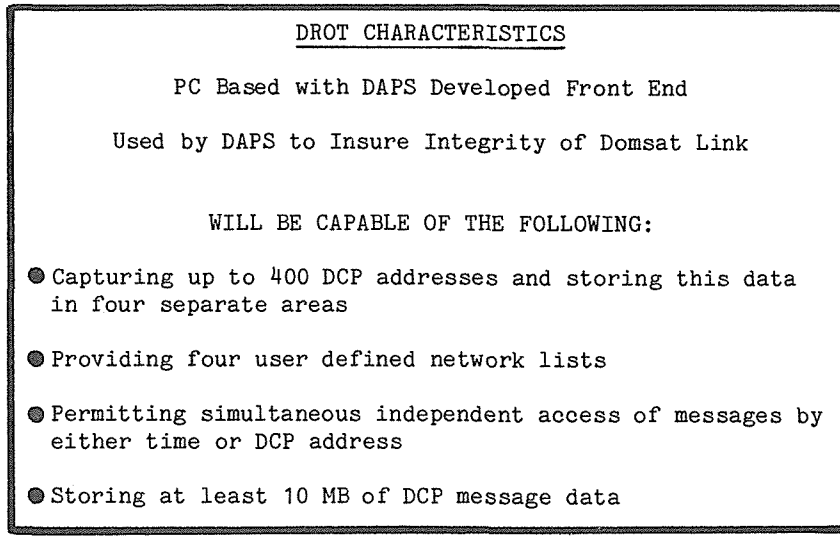

FIG.6 DROT characteristics

Future data collection systems for geostationary meteorological satellites will include the Geostationary Operational Meteorological Satellite (GOMS) operated by the USSR. GOMS will operate at 100 bps and include IDCS frequencies as well as domestic frequencies similar to GOES. With the addition of the GOMS system at 70° East longitude, the mid-latitude regions in the southern Indian Ocean and Soviet Asia will have complete coverage by a geostationary meteorological satellite data collection system.

In summary, current geostationary meteorological satellite data collection systems provide continuous coverage of the globe in the tropics and into the mid-latitudes, except in the southern Indian Ocean and Soviet Asia. With the addition of the GOMS system, coverage will be increased in these areas. Self-timed DCPs are supported by all of the current operational systems. In addition, the GOES DCS support both random reporting and interrogate DCPs. With the upgrade of the ground system, the GOES DCS will be able to support many more DCP networks for the benefit of interested western hemisphere users.

REFERENCES

International Data Collection System Users Guide, Issue 5, June 1986, p. 4.

MacCallum, D.H. and Nestlebush, M.J. (1983), NOAA Technical Memorandum NESDIS-2.