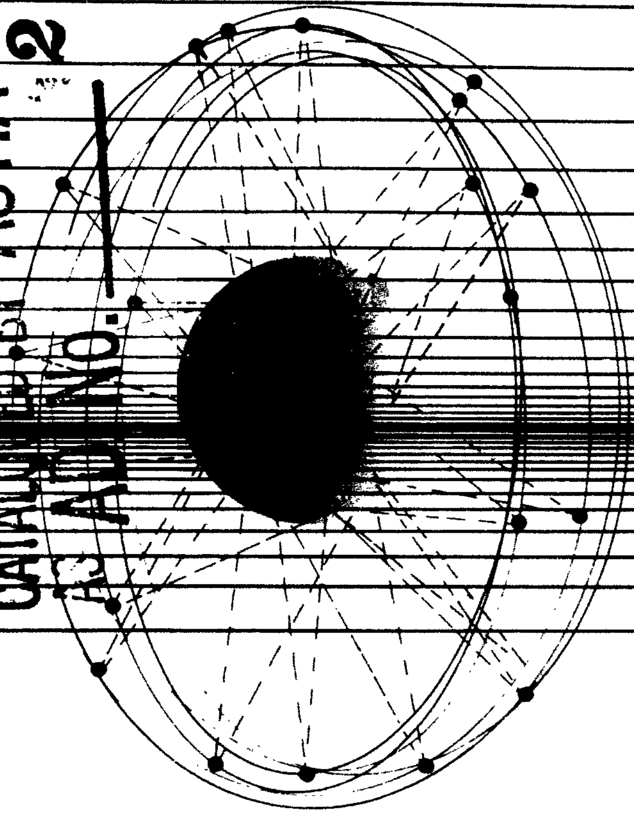
WDL-TR1931

REVISION I

28 FEBRUARY 1963

TECHNICAL OPERATING REPORT



MULTIPLE SATELLITE AUGMENTATION PROGRAM TRACKING STATION COMPUTER OPERATIONAL PROGRAMS (MILESTONES 2 AND 3)

PREPARED FOR:

AIR FORCE SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
INGLEWOOD, CALIFORNIA

AF04(695)-177

PHILCO
A SUBSIDIARY OF Ford Motor Company

WESTERN DEVELOPMENT LABORATORIES
PALO ALTO, CALIFORNIA

PHILCO CORPORATION — Western Development Laboratories

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Title	No. and Date
Multiple Satellite Augmentation Program Tracking Station Computer Operational Programs (Milestone 2 and 3)	WDL-TR1931, Revision 1 28 February 1963

PHILCO CORPORATION
Western Development Laboratories

R. W. Boyd

R. W. Boyd
Manager, Contracts Management

WDL-TR1931
Revision 1

TECHNICAL OPERATING REPORT

MULTIPLE SATELLITE AUGMENTATION PROGRAM
TRACKING STATION COMPUTER
OPERATIONAL PROGRAMS
(MILESTONES 2 AND 3)

Prepared by

PHILCO CORPORATION
Western Development Laboratories
Palo Alto, California

Letter Contract AF04(695)-177
AFSSD Exhibit 61-47

Prepared for

SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
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ABSTRACT

PHILCO WDL-TR1931, Revision 1 UNCLASSIFIED
MULTIPLE SATELLITE AUGMENTATION
PROGRAM TRACKING STATION COMPUTER
OPERATIONAL PROGRAMS (MILESTONES
2 AND 3) 44 pages
28 February 1963 Contract AF04(695)-177

This Technical Operating Report describes data processing subsystem operational computer programs to be used at remote tracking sites in support of satellite acquisition, tracking, commanding, telemetry, and station control operations as required.

FOREWORD

This Technical Operating Report on Definitive Contract AF04(695)-177 is submitted in accordance with Attachment 1 of Exhibit "A" to that Contract, and Paragraphs V-1 and V-2 of AFSSD Exhibit 61-47, "Computer Program Subsystem Development Milestones," dated 10 August 1961.

The report was prepared by the Real-Time Programming Section of the Philco WDL Mathematical Analysis Department to fulfill the requirements of Paragraph 5.1 of Exhibit "A" to Contract AF04(695)-177, "Statement of Work, Computer Programming for Multi-Satellite Augmentation of SCF Remote Stations."

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SECTION 1
INTRODUCTION

1.1 GENERAL

This Milestone 2 and 3 report has been prepared as a design specification for selected modules of a computer program system for the Satellite Control Facility, Multiple Satellite Augmentation Program, Tracking Station Data Subsystem Operation Computer Programs.

These operational programs are general purpose, and include specific satellite functions as subroutines. The basic programs are a flexible as is possible within computer and affiliated equipment limitations.

These programs are being designed, documented, coded, debugged, validated and distributed to the Augmented Tracking Station Data Subsystems for operation of the CDC-160A Computers.

SECTION 2
DATA SUBSYSTEM FUNCTION

2.1 GENERAL

The data processing subsystem will be used operationally at the remote tracking sites to support the satellite acquisition, tracking, commanding, telemetry, and station control operations as required. It will be integrated with the timing subsystem, the inter- and intra-station communication subsystems, the precision Prelort tracking and command subsystem, the telemetry receiving subsystem, the command, control, and display subsystem, the precision Prelort tracking and command subsystem, and the checkout subsystem. These functions will be implemented at each site by two CDC-160A Data Processing Systems and associated interface equipment to perform the required functions.

2.1.1 <u>General Functions</u>

The following general functions are required of the data processing subsystem:

a. To accept predicted pointing data from STC, record, interpolate and furnish it to antennas under SOC or stored schedule data control.

b. To accept, record, edit, and transmit to STC antenna encoder and status data.

c. To accept, record, edit, smooth, compress, and format telemetry data for STC and printer.

d. To accept and record digital commands and control data from STC, transmit them under SOC or stored schedule control, and provide status to SOC, STC, and history tape.

e. To accept STC direction with respect to modification of command data or telemetry source or compression algorithms in real time.

f. To transmit text messages between tracking station and STC, equipment and duty cycles as permitted.

g. To provide a track data quality indicator at fade.

h. To accept STCW, for timing operational functions and time-tagging data for the history tapes.

i. To time-tag and record significant track, command, telemetry and status data on history tape.

j. To accept control data and provide status data to the SOC, and record selected data on the history tape.

2.2 ACQUISITION SUBPROGRAM

The acquisition subprogram shall accept the acquisition message transmitted by STA. A linear interpolation to one second will be developed for Δt up to 64 seconds between successive data points for each of azimuth, elevation, and range. During pass operation, the program will interpolate from 1 pps to 20 pps and supply this pointing data to the antenna systems in the pointing mode operation.

2.3 TRACKING SUBPROGRAM

The tracking subprogram shall read the azimuth, elevation, transverse, range or range rate, and control and status data through a digital data link from the antennas. These shall be sampled once every second and the selected information formatted for transmission to STA at a rate selected by STA.

2.4 COMMAND SUBPROGRAM

The command subprogram shall accept and provide command data to and from the station operation console (SOC), to and from STA, and shall provide digital command capability and ability to record selected events pertaining to analog and digital commanding.

This subprogram shall also provide the capability of printing out real-time command (upon receiving digital command control data from the (SOC) to the command logic equipment (CLE). Status information shall also be supplied to the SOC. Provision shall be made to accept command verification from the telemetry data processor or CLE and echo signals from the CLE.

2.5 TELEMETRY COMPRESSION SUBPROGRAMS

The telemetry subprogram shall provide the capability for processing telemetry data from the telemetry subsystem. It shall be capable of formatting and compression of the data from selected channels in real-time, sending selected outputs to the STA and locating command verification data. Compression modes will be provided as options in the computer program. The sources of telemetry, points, alogrithms and parameters shall be capable of modification by STA in real-time.

2.6 RECORDING SUBPROGRAMS

The history subprograms shall provide the capability to record and playback of the following information:

a. A chronological record of all command actions, analog or digital, including initiations, transmission, echo and check data, and vehicle reactions

b. Tracking data

c. Raw telemetry

d. Other data as dictated by operation requirements such as timing and SOC actions.

2.7 SYSTEM TIME

System time will be accepted from the ground timing equipment and used in timing or time tagging acquisition messages, command messages, telemetry data, and timing displays.

SECTION 3
DATA SUBSYSTEM EQUIPMENT AND CONFIGURATION

3.1 DATA SUBSYSTEM EQUIPMENT PERFORMANCE

3.1.1 CDC 160A Computer and 169 Auxiliary Memory

The CDC 160A is a parallel single-address computer whose operation is controlled by an internally stored program located in sequential addresses. The basic memory cycle-time of the 160A is 6.4 microseconds. The 160A computer and 169 auxiliary memory will, in this case, have a combined capacity of 16,384 12-bit words of high-speed core storage. Input/output operations can be carried on any one of three I/O channels, 2 buffered and one normal. Once initiated, information can be transferred to or from the computer on the normal channel; no other operation can occur until the I/O transfer has been completed. Thus, in general, time-consuming data transfers can be advantageously handled on the buffered channel. The 160A has four interrupt lines. The interrupt is a signal which notifies the computer program that a certain interval or external condition has arisen (e.g., the presence of external data). It is assumed that the console interrupt will be modified to be an external interrupt (line 10).

3.1.2 166-2-B Printer

The CDC 166-2-B Printer is a 188-line-per-minute buffered printer with 120 character positions per line. It can be connected to and controlled from the CDC 160A on-line. That is, data can be processed and formatted in the computer and then output to the 166 for printing. The 166 can also be used in an off-line tape mode.

3.1.3 161-Typewriter

The CDC 161-typewriter is a Soroban-modified IBM electric typewriter. For input, it can convert a keyboard operation into a two-octal-digit code, and, conversely, for output, it can convert a two-octal-digit code into a type function. It has a maximum speed of 10 characters per second and can be controlled from the 160A computer.

3.1.4 163 Magnetic Tape Unit

The CDC 163 magnetic tape unit is a high-speed input/output device consisting of control logic and several magnetic tape handlers. It has a maximum transfer rate of 15,000 12-bit words per second; tape data format can be either binary or BCD.

3.1.5 Philco Input/Output Buffer (IOB)

The IOB privodes for computer programmable input and output of digital data in real-time to and from a CDC 160A computer. The computer program sets the rate of input/output for each datum and selects the input/output device and function at the correct time by the use of function select codes. Computer interrupts are used to trigger input/output functions of the computer program.

The IOB will transfer (output) data from the computer to the following equipment under computer control:

a. Station Operator Console

b. Acquisition Servos for Slave Data Buss

c. Command Logic Equipment

d. Check-out Subsystem

It will transfer (input) data to the computer from the following equipment under computer control:

a. Selected Antenna Position Encoders (Via Computer Digital Terminals 1 and 2)

b. System and Vehicle Time Code Word and Offset

c. Station Operator Console

d. Command Logic Equipment

e. Checkout Subsystem

The IOB will interrupt the computer for: (1) the CLE, (2) 20 pps and (3) the CDT. The CLE has a single -purpose interrupt (line 10) because of the requirement for rapid-response by the computer program. the 20 pps and also Computer Communications Computer (CCC) interrupt functions, on line 40, are distinguished by subsequent status word which the interrupt routine requests of the IOB and CCC; these are not as urgent functions as the CLE. The CDT interrupts on line 30.

3.1.6 Telemetry Data Processor (TDP)

The TDP will be the interface between the telemetry subsystems and the 160A computer and will accept telemetry data from the GP-I(a), GP-I(b), FM/FM, and PCM telemetry subsystems. Furthermore, the System Time Code Word input can be provided to the 160A via the TDP.

The GP-I will provide one 8-bit words output (with odd parity) per channel sample to the TDP. The FM/FM subsystem will emit up to 64 channels of analogue-value inputs to the TDP. (A manually programmable plugboard permits sampling of 64 analog channels at a maximum combined rate of 40 kc and a minimum sampling rate of 5 cps). In turn, the TDP, via the CSU, outputs the digitized FM/FM samples to the computer with 8-bit words.

The PCM will be made available, in 8-bit words per 12-bit 160A. A 12-bit control word is available to the 160A (undetermined at present).

The 160A can select one to four TLM inputs to the TDP or outputs by programmed execution of the appropriate function select code.

3.1.7 1200-Bit-per-Second High-Speed Data Line

A limited amount of information can be exchanged between the Tracking Station data processing subsystem and STA over the High-Speed Data line, which will be a fully duplexed 1200-bits-per-second data line.

It will be terminated, functionally, in a single Computer Communication Converter at each end. The STA CCC will interface with a single Bird Buffer 160A. The Tracking Station CCC will interface with the T&C and TLM 160A's. Every 160A will be able to send or receive over the line. The CCC will interrupt the site 160A using it on line 40, whenever a new word is to be sent or received. A status word will permit the interrupt routine to verify which function is required. The 160A will be able to disable the CCC interrupts when a transmission has been completed.

A word from STA will cause an interrupt only in the Tracking Station 160A for which the word is intended.

3.1.8 Select and Cross-Connect Unit (S&CCU)

To give the data subsystem maximum flexibility, a S&CCU will be included in each system. This will allow the equipment configuration to be modified to meet any contingency which might arise. Functionally, the S&CCU's will be passive patchboards for interconnecting the interfacing equipment.

3.2 DATA SUBSYSTEM EQUIPMENT CONFIGURATION

At this time, one 160A complex is assigned to tracking and commanding and one 160A complex is assigned to telemetry. The tracking 160A complex interfaces with the IOB and the CCC via the S&CCU; the telemetry 160A complex interfaces with the TDP and the CCC via the S&CCU units, as shown in (Fig. 1) (The two computers can be used interchangeably when desired). The basic constraints are: (a) both 160A complexes are to consist of the same set of equipment and are to interface in the same way with the CCC and the S&CCU, (b) the data rates over the IOB, TDP, CCC must be acceptable to 160A programs and hardware, and (c) the interrupt assignments must be suitable for the diagnostic and operational programs.

3.3 GENERAL ASPECTS OF FM/FM TELEMETRY PROCESSING

The pass telemetry program will be designed to accept program modules to process any one four sources of telemetry data, FM/FM, GP-1a, GP-1 b and PCM . The following discussion applies only to FM/FM.

The TDP accepts up to 64-analog inputs from the FM/FM ground station. These 64 inputs are scanned sequentially, under the control of a manually programmable plugboard, at rates from 40 kc to 50 cps or from 4 kc to 5 cps. Basically, there is a train of 40-kc pulses, which can be used to sample one analog input at 40 kc. This 40-kc train is divided into two 20-kc trains, interlaced to alternate one pulse from each train. The two 20-kc trains could be used to sample any two analog inputs alternately, each at 20 kc for a total data rate of 40 kc. Similarly, the two 20-kc trains are divided down to four 10-kc trains, a pulse occurring from each of the four trains, in order. Thus exactly two of the four 10-kc trains overlap each of the 20-kc trains. For example, one of the 20-kc trains and one or both of the non-overlapping 10-kc trains can be used to sample analog inputs. This, in principle, is carried down to 50 cps. Not all "phases" of lower rates are present. The output of this sampling process is a sequential string of samples, each narrow enough to occur at a total 40 kc, whatever the actual rate

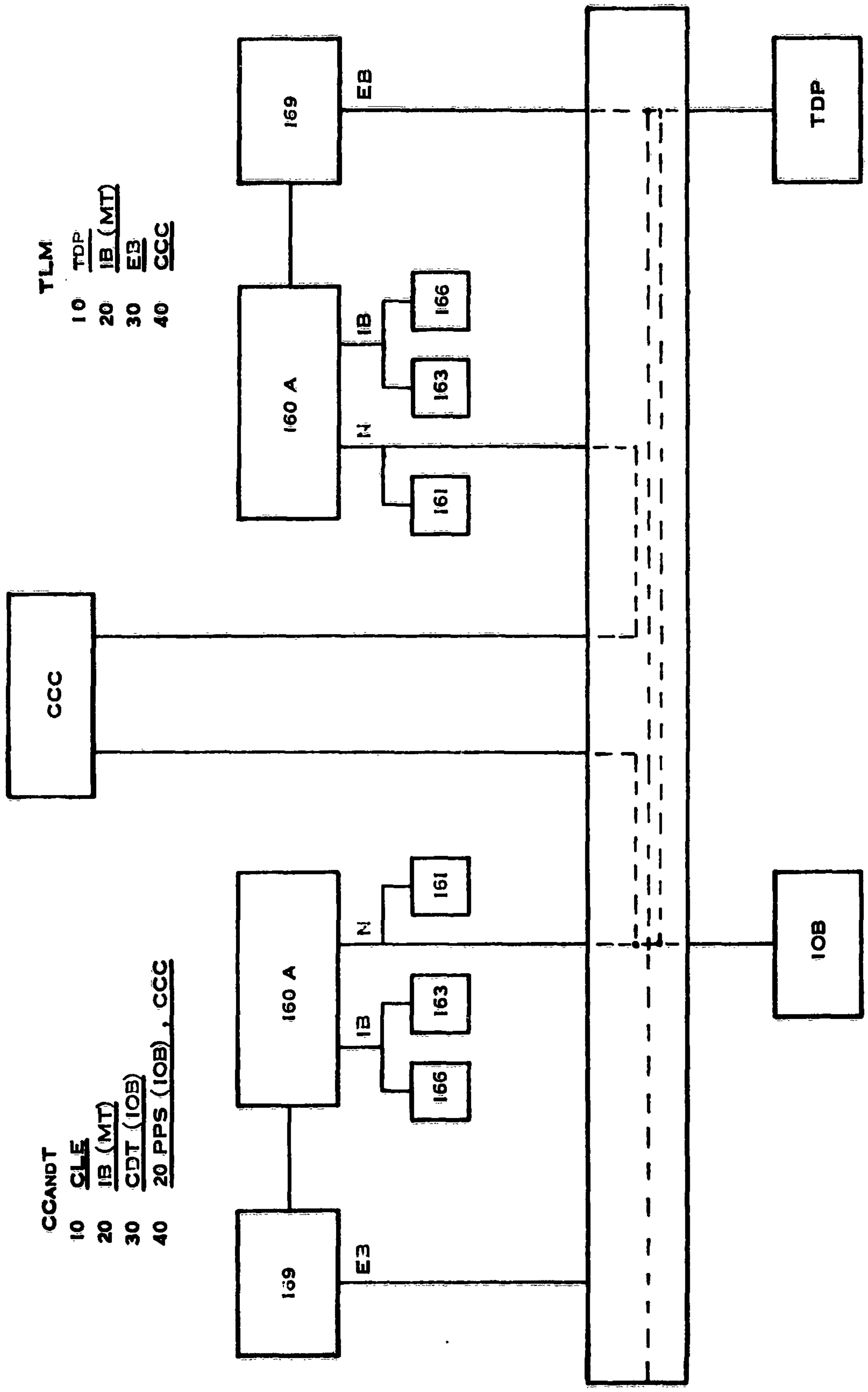

Fig. 3-1 Tentative MSAP Tracking Station Data Subsystem Configuration

may be. This sequential string is gated into an analog-to-digital converter, and each sample is converted into an eight-bit number. When the FM/FM telemetry has been selected, by the computer program, each such digitized sample causes interface logic to transfer the sample into the 160A. The plugboard output cycle repeats every 20 or 200 milliseconds (depending on a range switch), and the data entered into the 160A during that period is called a master frame. Once per frame, a frame sync bit is recorded in a high-order bit. One of the telemetry data words is marked, in a high-order bit, as having occurred first after the 1 pps signal.

Finally, the analog outputs of the FM/FM ground station are of two kinds, continuous and decommutated. Continuous outputs are emitted by FM/FM channels (via subcarrier discriminators); decommutated outputs are emitted by PAM/FM/FM channels (via a subcarrier discriminator and decommutator; the 2 decomms, in this case, are 90-point units with 30 sample and hold circuits.)

3.3.1 General Aspects of Commanding

The Data Processing Subsystem at each tracking station supports analog and digital commanding systems by accepting commands and control data from STC, accepting operator directives via the SOC and remote consoles, generating analog or digital command data for the command transmitting equipment, receiving status data (accept, reject, echo check error, verification error, no verification) from the transmitting equipment and the telemetry ground station, and presenting status data to the history tape, SOC or remote consoles, and STC.

In detail, there are 8 submodes of commanding: (a) analog manual, (b) analog manual repetitive, (c) analog manual long, (d) analog computer auto, (e) digital single, (f) digital repetitive, (g) MCDU, and (h) digital computer auto.

Analog Commanding. Analog manual commanding is performed by hardware which provides the capability of generating 15 unique commands. These commands are represented by 15 combinations of tone relay closures which are used by the external modulating equipment. Command number selector switches on operating consoles select the particular command desired. The command number is then converted by a matrix circuit in the CLE to one of the 15 possible 2 out of 6 relay combinations when the transmit switch is depressed. The system has the capability of working in three distinct modes: single, repetitive and long.

The analog single mode of operation will cause the CLE to present the selected pair of relay closures to the pulse coder for one second each time the transmit switch is operated. This command is then cleared until the next transmission command is received.

Repetitive transmission operations will cause the CLE to present the selected pair of relay closures to the pulse coder for one second and then withdraw them for one second. This sequence will be repeated until the transmission counter of the CLE reaches a console selected repetitive level. A stop repetitive momentary switch is included in the system; when operated, it causes the repetitive operation to be terminated and the Repetitive Mode switch to be released. The sequence may be restarted by depressing the repetitive mode switch and then depressing the transmit switch.

Long transmission mode selection will cause the CLE to present the selected pair of relay closures to the pulse coder continuously until the transmit switch closure is withdrawn.

In all three modes described above, initiation of each command causes an operational hardware status check, approximately 300 msec after the transmission begins. The condition of each of (a) verification and (b) echo check, at that time, causes output signals that will either allow the CLE equipment to continue operations or establish an error condition that must be overriden by manual intervention. These status bits are also available to the computer for recording.

For analog commanding, the 160A commanding module provides recording and reporting functions. The recording function will result in a history tape which includes the commanding operations. The reporting function will provide a real-time report of command operations to the STC via the 75-computer word-per-second lines that are available at the stations.

In the analog computer auto mode, SOC selection of analog block number (via command number select switches) and transmit cause the 160A commanding module to obtain successive eight-bit command numbers and output them to the CLE at the appropriate analog command rate (one per 2 seconds). Each command number is converted into the command in the CLE. Initiation of each command causes a (hardware) status check, similar to that of analog manual single. The result of this status check either permits or inhibits transmission of subsequent commands in the block, if any. One special feature of analog computer auto is the capability of generating either standard analog commands from a command block, or monitoring and generating special intermediate command functions, when required, for 698BK.

Digital Commanding. Digital commands are generated in the CLE as bit-serial pulse trains representing binary zeros and ones. These pulses are used, in several commanding systems, to modulate the transmitted RF carrier. The vehicle receiving such a pulse train will restore it to the command function code and will use this code to activate the required command sequences. The following basic functions must be performed by the 160A commanding module: control, data manipulation, error analysis, and reporting and recording.

Digital commands are always selected and initiated by a console, formatted, checked for status upon completion of each command transmission, and reported and recorded upon completion of each attempted command operation. Also, in every mode, a reject level may be selected which causes automatic retransmission of the command until it is accepted or the reject level is reached.

The modes of digital commanding are: (a) digital single (SOC), (b) digital repetitive (SOC), (c) digital single (remote), (d) digital repetitive (remote), (e) MCDU, and (f) digital computer auto.

In digital single (SOC), SOC selection of command number, reject level and transmit causes the 160A commanding module (ACM) to obtain, format, indicate to SOC, output (until accepted by vehicle the number of times given in the repetitive level), status check, and report and record a digital command.

Remote single and remote repetitive are similar to SOC single and SOC repetitive, respectively.

In the MCDU mode, MCDU selection of a command number causes the CLE to output a command to the ACM. The ACM senses a new command in this data input, and formats and outputs this command to the CLE. Output of this command is reinitiated upon completion, if the same command is still on the MCDU input lines. No status checking occurs. The ACM report occurs only upon selection of a new command or a new mode.

In the computer auto mode, SOC selection of block number via command number select switches, reject level and transmit, cause the ACM to obtain, format, indicate to SOC, output and status check the first command in the block. The command is transmitted until it is accepted or the reject level is reached. If the reject level is reached without an acceptance, transmission of this block is terminated. It can be restarted by overriding the error condition and reselecting transmit. If the block includes additional commands, as soon as each is accepted, the ACM proceeds to the next. Upon successful termination of the block, or an error stop, report and record occurs. If selected auto computer stop can cause a recoverable pause between command transmission, in an attempted computer auto sequence, release of computer auto sequence to continue, from the point of initiation of the pause. If, however, a new command block number is selected while computer auto stop is operated, the newly selected sequence will be initiated if transmit is selected. Before selecting transmit, or while in an error stop, selection of command advance causes the ACM to advance to the next command (this is accompanied by a count of the commands discarded in the reject level display, which is reset upon selection of transmit). ("Illegal command selected" is displayed if the command advance is operated after the last command in the selected block.)

The ACM formats all digital commands for transmission in one-bit-per-interrupt-10 format by an interrupt subroutine which also inputs accept/verify and echo-check bits after transmission of each command bit. Upon completion of each command, the ACM examines the accept/verify and echo-check data to determine operational command status Status results are (a) "accepted", (b) "rejected", and (c) "simultaneous command echo-check error and accept." Status conditions (a) and (b) cause error conditions in all digital modes.

The ACM indicates to SOC the operational process of the period in which a command is being attempted by sending command in progress accept, reject, no accept or reject, spoof error, and command error, as they develop.

The ACM reports every period in which a command was attempted in near-real-time, as appropriate to the mode. The report includes command number (this implies both mode and command function), time at start of command transmission attempt, report number (accumulated count of command operations), report status indicators (operational command status), and additional operational data (including echo check image, where applicable).

The ACM records essentially the same material on the history tape.

3.3.2 General Aspect of Tracking

The major tracking functions are to provide antenna pointing data for acquisition and tracking, report (to STC) and record two sets of antenna encoder data.

Antenna pointing data is accepted from STC, recorded, interpolated to 20 pps, provided to the selected antenna under SOC or stored schedule data control, and indicated on the SOC and printer.

Two sets of antenna encoder and status data are accepted at 1 pps, recorded, reported to STC at STC-selected rate, and (edited and) printed.

3.4 TRACKING AND COMMAND DATA SUBSYSTEM CONFIGURATION AND USAGE

A T&C 160A complex will perform tracking and commanding functions at a site. For this function a CDC-160A Computer will be connected to a CDC-169 Auxiliary Memory Unit, a CDC-161 Typewriter, a CDC-162 Magnetic Tape Unit, a CDC-166-2-B Printer, a Philco Input/Output Buffer (via a select and cross-connect unit), and a Computer Communications Converter (CCC).

The auxiliary memory supplies an additional 8-k memory and an external buffer channel. The typewriter will be used for minimal operator input/output (not in real-time).

The magnetic tape unit is required to make tape reels available for the following:

a. Program library

b. Acquisition T&C data

c. History tape (2 tape handlers required for continuous duty cycle).

The printer is to print processed data, if required, and program status messages and alarms.

The IOB will permit the 160A program to communicate with the system operator's console, the system time code word, the vehicle time code word, the time offset of these two, the digital terminals (antenna encoder outputs and status) the command logic equipment, the acquisition servos, and the checkout system.

The computer communication converter will allow the STA bird buffer to send messages to either site 160A, and allow either site 160A to send messages to STA, over a full duplex 1200-bit per second line. The CCC will also provide a mode for communication between the T&C and the TLM computers.

3.4.1 Input Output Channel and Interrupt Assignments

An analysis of the programming problem for this data processing complex has resulted in assignment of the IOB, and the normal channel and the magnetic tape, the typewriter, and printer unit to the internal 160A buffer channel.

The interrupt assignment is based on relative importance of the various I/O functions, their rates, and the maximum permissible delays in responding to each interrupt line. On this basis, the following assignments have been made. The console interrupt (line 10) will be an external interrupt.

These interrupts will be allowed during any part of the data processing cycle (except during non-buffered I/O transfer) in order to meet I/O timing requirements. The output data transferred in these I/O functions will be prepared in the data processing cycle.

The four 160A interrupts employed in the proposed programming system and the manner in which the T&C computer will use them are outlined below:

Interrupt 10. When ready to take the command bit, the CLE will generate an interrupt 10, which will inform the program that the CLE has an echo return on the last bit transmitted and is ready for another bit. The program either will send another bit, or, if there are no more valid bits in the particular command being transmitted, will send the no level indicator and will disable the CLE interrupt. This interrupt line has the highest priority because of the stringent time tolerances of the CLE.

Interrupt 20. Interrupt 20, an internal signal of the 160A, is generated to inform the program that an internal buffer operation is completed and that the internal buffer I/O channel is available for another operation.

Interrupt 30. The computer digital terminal generates this signal when two 12-bit CDT words are ready for the 160A. Each of the two CDT's will supply a 12-bit word at each interrupt.

Interrupt 40. This signal is generated by either the CCC or the 20-pps IOB timing signal. In response, the interrupt routine will request a status word from the CCC. This status report will inform the program if the CCC caused the interrupt. If the interrupt was CCC-generated, the status word will inform the routine whether to input or output a word (from or to STA) or input a word from the TLM computer. If the 20-pps IOB signal caused the interrupt, the routine will output antenna pointing data to the antenna acquisition servo equipment and input and output data (SOC, CLE) which have the least strict time schedules. This data will include control signals from the SOC push-buttons, status data to the SOC displays, tone command information from the CLE, the system and vehicle timing data from the timing logic devises. The IOB will furnish a status word to the 160A designating one of the 20-pps interrupts as the 1-second signal.

3.5 TELEMETRY DATA SUBSYSTEM CONFIGURATION AND USAGE

A TLM 160A complex will perform telemetry functions at a site. For this, a CDC-160A Computer will be connected to a CDC-169 Auxiliary Memory Unit, a CDC-161 Typewriter, a CDC-163 Magnetic Tape Unit, a CDC-166-2-B Printer, a Philco Telemetry Data Processor (via a select and cross-connect unit), and a computer communication converter.

The auxiliary memory supplies an additional 8-k memory and an external buffer channel.

The typewriter will be used for operator input/output in non-real-time functions.

The magnetic tape unit is required to make tape reels available for the following:

a. Master Program tape with write lock-out

b. Prepass messages

c. History tape handlers required for continuous duty cycle.

The printer will be used for real-time printout of selected processed telemetry data (for STC) prepass message abstracts, schedules, program status messages and alarms, and administrative test.

The TDP permits the 160A program to select any one of four telemetry inputs (GP-1-a, GP-1-b, FM/FM, PCM) one of STCW, input control and output control and has the ability to send TLM data to the T&C 160A.

3.5.1 Input/Output Channel and Interrupt Assignments

An analysis of the programming problem for this data processing complex has resulted in assignment of the CCC to the normal channel; the CDC-161, CDC-163-4 and CDC-166-2-B to the internal buffer channel.

The interrupt assignment is based on the relative importance of the various input/output functions, their rates, and the maximum permissible delays in responding to each interrupt line.

These interrupts will be allowed during any part of the data processing cycle, but not during non-buffered input/output transfers. The output data transferred will be prepared in the data processing cycle.

The three 160A interrupt lines used in the telemetry programming system, and the manner in which the TLM computer will use them, are outlined below.

Interrupt 10. This indicates that the 1-second timing pulse has been received. This interrupt will be used as the timing signal during non-real-time operations.

Interrupt 20. When a buffered data transfer to magnetic tape, typewriter, or the printer, is completed, the internal buffer will interrupt on line 20.

Interrupt 30. This indicates that the pre-set external buffer area has been filled with 1 second's data. This is the timing signal during real-time operations.

Interrupt 40. When the CCC has a word, from STA, for the TLM 160A, or when the TLM 160A has previously sent a word to STA, and a next word, if any, should now be sent, the CCC will interrupt the TLM/ 160A on line 40.

SECTION 4

DATA SUBSYSTEM PROGRAMMING

4.1 GENERAL DESIGN SPECIFICATIONS

The Operational Program will consist of the following types of subprograms:

a. Acquisition and tracking data processing subprograms

b. Telemetry data processing subprogram

c. Command data processing subprograms

d. Station control and data display processing subprogram

e. Interstation message generation, handling, and interpretation subprograms

f. Executive/Control subprograms (which interface the above subprograms, the 160A operator and any data-specific operational decisions)

g. Latitude crossing and time-early/time-late.

h. A reasonableness check of track data.

i. Utility and housekeeping subprograms.

The computer subprograms to be developed shall be general-purpose, and shall not be station-peculiar or satellite-peculiar, except as necessary to satisfy the following specific requirements:

a. The operation and performance of computer programs shall be compatible with equipment installed in SCF remote stations under the multi-satellite equipment augmentation development, and shall be consistent with peculiarities of configuration between different stations where these exist.

4.2 DESIGN SPECIFICATIONS, TRACKING AND COMMANDING OPERATIONAL PROGRAM (TACOP)

TACOP is a general purpose tracking and commanding operation program for processing and controlling vehicle tracking, vehicle commanding, and station operational and inter-station data.

TACOP will provide tracking and command data processing in both directions between selected antennas and the STA.

4.2.1 TACOP Program Design

The TACOP program is divided into pre-pass, real-time and post-pass programs. The real-time programs will be further subdivided into preacquisition, pass, and fade routines.

4.2.2 Pre-Pass Functions of TACOP

Pre-pass functions are those concerned with accepting scheduling and operational data for specific vehicle passes from STA and organizing this and station data files for operational use.

TACOP will accept, store, communicate to operators, and control the responses to messages between tracking stations and STA via the 75 wps line, which contains the following information:

a. Configuration of tracking system. For example, patchboard numbers, vehicle numbers, TACOP options

b. Callout of flight specific subroutines which will be used during this pass

c. Initial information for real-time processing, including data format options, and rates

d. The program must be capable of receiving and storing this data for several vehicles and passes in order that pre-pass messages be kept as short as possible.

TACOP will provide print-outs of all or selected parts of the pre-pass messages or administrative text on the CDC-166-2-B Printer under control of data insertion via the CDC-161 Typewriter.

During pre-pass, the preacquisition phase of the real-time program, and, hence, the entire real-time program, will be activated. This includes merging of pre-pass information. It is initialized by dialing in the vehicle number of the SOC and typing in the revolution number via the typewriter if necessary. A printout on the printer will announce this transition, and any other necessary details.

TACOP will permit a pre-pass system checkout which is simulation of real-time operation.

4.2.3 Pre-Pass Processing Program Design

The pre-pass program will be used to input and process pre-pass messages from STA to be responded to, to be stored on magnetic tape for future use and, if required, for historical purposes. These pre-pass messages will include antenna pointing data, command data, mode options, and commanding parameters for a specific vehicle or vehicles.

The pre-pass program will include provision for transmission of administrative text between tracking stations and STA. Input will be converted to printer format and sent over the high-speed data line to the printer at the far end.

When system checkouts are complete, and the pre-pass program is read-in, the program will establish communication with STA. Messages will be exchanged to insure that the proper STA computer is connected and ready to transmit pre-pass messages. Each message will be verified, as required, and will be acknowledged. The program will produce a record on magnetic tape for each vehicle pass. Each file will be identified with a vehicle number for easy reference by the real-time program.

The antenna pointing data received will be expanded by linear interpolation (if necessary) into the one-point per second values expected by the real-time program. Pointing and command data will be written in short records on magnetic tape for quick retrieval in real-time.

The accuracy of the command data received will be verified by retransmitting all of the command information back to STA. STA will acknowledge that complete verification was achieved, or will retransmit the correct command data again until it can be verified, or will request operator action after three failures.

A complete file on tape will consist of a vehicle identification record, records of vehicle specific information, and records arranged by revolution number that contain operational parameters, antenna pointing data, and command data.

The pre-pass program will cycle, inputting messages for vehicles in vehicle and pass time order, and record this data on magnetic tape, until a few minutes before the selected ETA reaches zero. The program will have options to terminate this phase by manual intervention and/or a loss of transmission from STA; thereupon, a print-out will announce transition to real-time or post-pass.

The program will accept an operator directive to print a schedule of all vehicles and pass times contained on the pre-pass tape.

4.2.4 Real-Time Functions of TACOP

Real-time is entered from the pre-pass phase, and terminated when the vehicle fades, or when the pass is otherwise terminated.

TACOP will accept digital data via the IOB from the station operator's console, the command logic equipment, the vehicle time code word and offset, the computer digital terminals, the system time code word, and equipment status. TACOP will also accept data from the computer communications converter and will accept command verification data from the TLM 160A.

TACOP will perform the following functions as required or modified by the pre-pass data:

a. Use pointing, commanding and mode data from STA.

b. Time tag and record actual tracking data from antennas and complete command histories on magnetic history tape

c. Interface with the SOC and the 166 Printer operators

d. Interface with command verification data from the TLM 160A

e. Communicate with STA for tracking data, commanding data and shared data line control.

Under real-time control from STA, via the shared 75 wps line, the following functions must be controlled:

a. Selection of required tracking antenna data and required reporting rate for the shared 75 wps line to STA

b. Acceptance and verification of a limited quantity of commanding data for immediate use.

TACOP will output pointing data to the acquisition servo via the IOB; command data to the CLE via the IOB; control and status data to the SOC via the IOB; tracking and commanding history to the magnetic tape; command summaries to STA via the CCC; and alarms and milestone to the operators via the 166 printer and the SOC.

4.2.5 Real-Time Processing Program Design for Pre-Acquisition

The preacquisition routine will be read into the 160A by operator signal to the other programs. When current vehicle number and revolution number have been inserted into the program from a schedule or SOC and typewriter, the program will search the pre-pass tape for the data file for this vehicle and revolution. If the appropriate data files is found, a Buffer area will be filled. If the file is not found, the program will print an alarm and ask for a new pass identification. The same process may be used for the next vehicle. The program updates the SOC displays and/or a printed schedule as required.

The routine will initiate and continually monitor communications with STA. When communication has been established with STA, the routine will insure that site and STA have the same pass identification. Any difficulty in data transmission or conflict in pass identification will be indicated by printing an alarm. The routine will then generate the pointing data for the initial one-second and make it available, under SOC control, to the acquisition servo. The routine will have the ability to add or subtract a typewriter input delta time to the time associated with the initial antenna pointing data.

The routine will have the capability to reload the pre-pass program. This option might be needed if STA should have updated information on an impending pass to replace stored data on the pre-pass tape. Included with this would be the option to record this data on the history tape.

The transition from preacquisition to pass can occur only after the vehicle and revolution have been entered, any parameters necessary for data handling functions during the pass will have been supplied, and necessary pointing and commanding data that is available will have been obtained.

4.2.6 Real-Time Processing Program Design (PASS)

During a pass, the PASS program performs the following:

a. Supplies pointing data under SOC Control

b. Accepts and formats antenna (encoder) inputs for history

c. Selects and formats antenna encoder data for STA, if required

d. Records a complete command function and station history

e. Performs digital commanding under SOC control, STA pre-pass message, or limited STA control

f. Report Command operations to STC.

g. Accepts and displays appropriate SOC data, at TS and STC.

h. Computes latitude crossing and a measure of time early/time late.

During tracking, the STA pointing data for the current vehicle is used to put out 20 pps (interpolated) pointing data to the acquisition servo. The 1 pps pointing data is stored on magnetic tape before the pass and is buffered in from this magnetic tape in real-time as needed.

The position and status data from two antenna systems can be read into the CDC-160A. Both sets of data will be recorded on the history tape and both or either can be selected for STA real-time messages. The STA selections can be modified, upon receipt of a message for this purpose, from STA in real-time.

Manual analog command functions are controlled by the SOC and the CLE. These functions are available to the TACOP, via the IOB, for recording on the history tape. An analog auto-computer mode initiated by the SOC and controlled by TACOP is also available.

Digital commanding is performed under control of station consoles and TACOP. Generally, command data is received from the STA during pre-pass, but may be received to a limited extent in real-time. These commands will also be time-tagged and recorded on the history tape when they are used. Where the need for vehicle-specific data formatting exists individual command modules will be used.

The TACOP Real-Time program is arranged as a set of interrupt subroutines, data processing routines and a central processing control loop.

The interrupt subroutines acknowledge and satisfy real-time demands for data transfers with other equipment systems. These are set up to meet response time limitations and to interface properly with the basic processing loop. In general, the quick-reaction interrupt routines merely respond to the interrupt, exchange data with the I/O involved, and leave a flag (gate) set in the processing control loop. Another interrupt subroutine provides for break-in by a higher priority interrupt subroutine. This routine has been setup to handle the extensive exchange of data with the SOC, which must be interruptable to permit the quick reaction interrupt routines to meet their deadlines.

The central processing control loop examines, in turn, each of the gates set by interrupt routines or by processing routines as requests for processing functions. The entire processing control loop is interruptable, but will be traversed at sufficient speed for all deadlines to be met.

4.3 TELEMETRY OPERATIONAL PROGRAM (TLMOP)

4.3.1 TLMOP Design Objectives

a. TLMOP is a general-purpose, operational program for processing, compressing, formatting and control of telemetry data

b. TLMOP will provide a general-purpose framework capable of accepting vehicle and/or pass specific subroutines, and will provide for processing each type of telemetry data acceptable to the TDP

c. TLMOP will, where possible, be general and non-satellite-specific in nature, and its basic requirements will be a generalized set of present satellite program requirements. Projected satellite requirements will be included where possible.

d. TLMOP will be modular in form, with each module based on a specific function, with minimum interaction between modules. TLMOP will be designed for simplicity and ease of maintenance.

4.3.2 Pre-pass Functions of TLMOP

The pre-pass period permits a scheduled interaction between the tracking station and the STA in which control and technical data necessary to direct the tracking station operations during one or more subsequent passes is transmitted and acknowledged.

TLMOP will accept and store in pre-pass, messages from STA, via the shared 75-wps line, containing the following information.

a. Configuration of the entire TLM system; for example, TDP patchboard number, vehicle number, type of TLM data routines

b. Callout of flight-specific subroutines which will be used during a referenced pass

c. Initializing information for the real-time program, including data commutation patterns, channels for initial selection, corresponding algorithms and parameters

d. TLMOP will accept, sort, and store this data for several vehicle passes at any scheduled contact.

TLMOP will provide printouts on the 166 printer, of all or part of the pre-pass data, as specified on the 161 typewriter.

The real-time program can be activated by operator input of the necessary information using the CDC-161 typewriter, on semi-automatically by reference to a stored schedule. The semi-automatic method will inform the operator as to what operation is scheduled and begin real-time operation upon receipt of permission via the CDC-161 typewriter.

TLMOP will provide for a system checkout which is a simulation of real-time operation.

4.3.3 TLMOP Program Design

TLMOP is divided into pre-pass, real-time, and post-pass functions. Administrative text will be printed at all times, within the constraints of the system.

The processing programs accept, edit, process, format and output the various data in order to create timely data for all real-time equipment, the pre-pass and history tapes, and operator print-outs. The functions of the processing programs occur at various rates (depending on the type and rate of telemetry input data, etc.)

In general, each of pre-pass, pass and post-pass is a processing program with a cyclic control routine with provision for passage to any of the other phases.

4.3.4 TLMOP Pre-Pass Processing Program Design

The pre-pass program will be used to input and process pre-pass messages which will specify telemetry type and period of use, points to be selected, applicable compression algorithms and parameters, parameters for verification functions, if any, and miscellaneous requirements.

After the pre-pass program has been read into the 160A and initiated, the program will attempt to establish communication with STA at the appropriate time under control of the store schedule or operator. Messages will be exchanged to insure that the proper STA 160A (Bird Buffer) is connected and ready to exchange pre-pass messages. Each part of each message will be verified, as appropriate, and acknowledged.

TLMOP will produce a file on magnetic tape for each vehicle. Each file will contain, at the beginning, several telemetry processing schemes. These schemes will have an associated mode number, such that a nominal processing scheme can be specified if vehicle number and mode number are named. Following these records are pass specific records ordered by revolution number. These "pass specific" records will specify which processing scheme is to be used on a pass and will also contain which changes, if any, are to be made in the processing scheme.

The pre-pass program will have the capability to edit an old pre-pass tape, and merge selected old and new data to produce a new pre-pass tape.

The pre-pass program will receive successive pre-pass messages for the appropriate vehicles by vehicle number and ETA order, recording this data on magnetic tape, until directed to enter the next real-time program. Failure of STA transmissions will be indicated to the operator.

The pre-pass program will, upon direction, print out a schedule of all vehicles and ETA's contained on the pre-pass tape.

The final action of the pre-pass program will be to load the pass or post-pass program into the 160A upon operator direction.

4.3.5 Real-Time Functions of TLMOP

Real-time may be entered from pre-pass upon ETA = 2 minutes or operator direction, and may extend until ETT = 0 and loss of telemetry antenna lock or operator termination of the pass (and may conclude with a transition to pre-pass phase).

TLMOP will accept digital telemetry data from any one of the following sources:

a. The TDP scanner and digitizer, which accepts up to 64 points

b. Digitized PAM data from either of the two GP-1's

c. PCM data can be patched (at the TDP) to be bit-serial or 10-bit parallel.

TLMOP will respond to direction to select and process a different source of telemetry data, but will not handle two sources simultaneously. TLMOP will accept or supply the following data.

a. The system time code-word

b. Control words to and from the TDP

c. Control data from and compressed telemetry data to STA via the computer communication converter. Control data may include modification of selected type of telemetry (source) points or selected algorithms and parameters.

TLMOP will perform the following processing on the input digital telemetry data (as specified by the pre-pass message):

a. Time-tag with STCW, as necessary, and store as much as possible of the raw telemetry input data on (magnetic) history tape

b. Sort and process a subset of the telemetry input data for transmission to STA, as specified in the pre-pass message.

c. Locate and time-tag, if required, command verifications appearing in the raw telemetry input, and output each verification to the 166 printer and T&C 160A (if required, for TACOP), and STA.

d. Time-tag TLM points, if required, to a time resolution equal to 5/data rate.

e. Keep maximum possible accuracy of processed telemetry data, within STA direction and data subsystem limitations.

Processing and compression of telemetry input data is to include the following as required by STA in the pre-pass or real-time messages:

a. Reasonableness checks; to include examination of some or all of master frame and subframe syncs, decommutator sync signals and reasonableness check on data

b. Smoothing data to reduce effects of noise. Rejection of noise spikes outside limits specified by STA.

c. Compression of acceptable data, to reduce the load on the shared 75-wps line to STA, and report step function steps, periodic time-tagged values, time of event, and others as required.

TLMOP will respond to real-time control, from STA, via the shared 75-wps line and allow the following:

a. The selection of a new source of telemetry input

b. Addition of more telemetry points or deletion of previously-selected telemetry points from a currently-selected telemetry source

c. Change of parameters with respect to a currently-selected telemetry point and algorithm

d. Change of algorithm to be applied to a currently selected point

e. Minimum loss of data processing time, and commanding verification functions.

TLMOP will provide a command verification option, to:

a. Locate command verification in a digital telemetry input stream

b. Compare the command verification received with the desired response

c. Transmit command verification to the 166 printer and TACOP

d. Time-tag receipt of the command verification.

TLMOP will output data as follows:

a. All raw input telemetry data will be recorded on magnetic tape to the extent that the input rate permits.

b. All the processed and compressed data will be sent to STA via the CCC to the extent that sharing the 75-wps line with TACOP will permit (in a format applicable to the algorithm).

c. The compressed data that goes to STC will be converted to 2-decimal digit percent of full scale and displayed on the 166 printer if the output permits. Otherwise, the printout will be in that format peculiar to the algorithm.

d. Command verification shall be located and time-tagged, and sent to the 166 printer, TACOP and STA.

4.3.6 TLMOP Real-Time Processing Program Design

TLMOP will, as directed by STA, select the required telemetry source, and integrate any configuration or mode option data required to implement this selection.

The telemetry source is selected and up to 4000 telemetry points can be input per second over the external buffer channel of the 169 auxiliary memory.

Of course, the entire raw telemetry input is recorded on 163-magnetic tape (assuming no write parity checking).

The data input will be time-tagged with STCW and recorded, as far as input rates permit, on magnetic tape. As directed by STA in pre-pass or real-time, a selected subset of the input points will be accumulated, sorted, and processed.

Sync conditions will be continually monitored. Upon loss of sync, alarms will be printed at site and sent to STC. Continuous attempts will be made to regain sync.

Thereafter, the data selected for futher processing and compression will be smoothed and processed by the selected algorithms as follows:

a. Periodic time-tagged smoothed value (e.g., once per second).

b. Step function detection.

c. Time-tagged maxima/minima and time of event.

d. Trapezoidal integration of smoothed data with respect to time.

e. Others as required.

Sorting out and processing the selected data will be done using (1) subroutines to locate master frame sync and verify master frame sync once per master frame, (2) subroutines using tables of relative address increments to locate data of interest relative to master frame sync and accumulate extracted data for processing, (3) subroutines to select and apply the correct algorithm and parameters for processing each accumulated "point", (4) subroutines to format data for STA transmission, and (5) subroutines to format the compressed value for 166 print-out and initiate print at the appropriate time.

Locating master frame sync requires examining consecutive words in memory for a fixed pattern. For sync patterns less than a word long, the rate of search is a few thousand words every second; for longer patterns, the rate is correspondingly lower.

The sorting can be done via tables which specify relative addresses of data words which pertain to a given identification following each master sync.

Selecting the correct algorithm and parameters is done by means of a table of pre-pass and real-time processing control data. This table will identify each telemetry point in the input stream by a simple number (for system use) and include an algorithm number and parameters. All algorithms will include an event output section for inserting events of interest into the CCC buffer area (for STA) and converting to the proper format for the printer.

Print will be initiated every second if any points require tracking station print-out in the previous second. Alphanumeric for alarms and operator information will also be printed each second.

The magnetic tape history subroutine will cause raw telemetry data to be recorded on magnetic tape, to the extent permitted by the input rate. An error in magnetic tape unit operation will cause an attempted rewrite and a printed alarm. A rewrite will cause rewind and selection of the alternate history tape reel.

Additional telemetry processing function performed is the location of command verification data in certain types of telemetry input. These must be located, quality-checked, and compared against required responses. In either outcome, the command verification will be time-tagged and transmitted to the 166 printer and TACOP, if required.

As an executive or control function, an ability to reselect telemetry source, points, algorithms and parameters in real-time, with minimum loss of time and no impairment to the command verification function of TLMOP, is required.

Maximum accuracy will be obtained by using tailored subroutines for all arithmetical functions, since no built-in multiply or divide orders exist in the 160A.

An algorithm to reject noisy points and smooth the remaining data was investigated. The algorithm would have timed events to the exact point at which the event occurred.

The algorithm was coded and run on actual telemetry data furnished by the Air Force. Steps were to be observed in this data. A disadvantage became evident. The algorithm indicated that an event occurred when as few as 4 successive noisy points were encountered. As no check was made on the reasonableness of consecutive points, a succession of noisy points was averaged and the noise was reported as an event. The algorithm was unable to pick out noisy points as noisy. This last is considered to be an extreme disadvantage. It seems difficult to pick the constants needed in the algorithm. In fact, mathematical analysis has indicated that these constants are actually functions of the number of previous points used in the average.

It was decided to operate with an algorithm which, although not as sensitive as the above routine, could distinguish noise. Events are timed to within a 5 point group; that is, the event may be reported 5 telemetry points late. The algorithm uses second differences on successive groups of five points. When the second differences are not below a certain level, the points in that group are discarded as noise. Only points within a group of 5 non-noisy points are used in searching for events. Because of this reasonableness check, only extremely well organized noise will be reported as an event. This algorithm when run on the data described above, reported only a few doubtful points in contrast to the first algorithm which reported many noise bursts as events.

The following algorithms will be included in the operational telemetry program:

1. A four point average algorithm.
2. A moving weighted average algorithm
3. A switch setting algorithm (non-equal increments)
4. A switch setting algorithm (equal increments)
5. A step detection algorithm
6. A binary meter readout algorithm

The four point average takes non-noisy points and forms an average. This average may be reported once per second. Also, it may be reported at a slower rate with intermediate reports if the average exceeds certain prespecified limits. The moving weighted average is $\overline{X}_i = (X_{i-1} + 2X_i + X_{i+1})/4$. This is intended to be used primarily for slow dynamic functions. This average is reported once a second. The switch setting algorithms associate analog levels with discrete settings. As an example, a level between 0% and 40% indicates an off position while 40% to 100% indicates an on position. A setting will be reported periodically and if the switch setting changes. The equal increment algorithm is included to permit up to 10 switch settings per point to be distinguished.

The binary meter readout algorithm converts successive levels of a continuous telemetry channel to a binary number.

The step detection algorithm takes non-noisy points, as specified above, and compares the present level against the last non-noisy average. When the difference between the two levels is above a pre-specified limit, an event is reported.

The processed and compressed data will be reported to the STC over the 75 wps line and printed on the line printer at the tracking site. A simple priority scheme will insure that the more important event reports will take precedence over less important reports during periods of intermittent line difficulties.

The data will be printed at the tracking site in two decimal digit percent of full scale once a second.

The pass function will be terminated if the time to track lapses or by operator intervention via the console jump switches.

4.3.7 Post-Pass Functions of TLMOP

The post-pass program may be entered from pre-pass, and has as its main function to provide processing capabilities (similar to those of the pass program) for data from digital and analog history tapes for transmission to the STA.

Thus, there are two modes of post-pass operation: (1) replay of digital history tape, or (2) replay of analog tapes through the proper ground station.

In either case, the chief modification is that data is not time-tagged with the current STCW, but, where the ground station hardware permits, is time-tagged with the recorded STCW corresponding to the data.

Tracking station configurations and telemetry processing options are specified as in real-time.

If required, necessary control data may be entered via the 161 typewriter, and results displayed only on the 166 printer (that is, with no communication with STA via the 75-wps line).

4.3.8 TLMOP Post-Pass Processing Program Design

Scheduled post-pass operations will begin with location and integration of necessary configuration and control data into a modified real-time program. That is, if a digital magnetic tape history is to be processed, a real-time program corresponding to the original source of telemetry data recorded on the history tape, and modified to buffer in and accept time-tagged telemetry from this history tape, must be organized and entered into the 160A. If an analog ground station history tape is to be replayed, then the appropriate patchboards, must be identified and verified, and a real-time program corresponding to this source and its time-tape must be organized and entered into the 160A.

In either case, the processing of data appears to be identical to real-time, with the provision of post-pass on line modification of telemetry points selected and of algorithms and parameters. Output data generated will be either transmitted to STC or recorded on the local 163. However, since the analog tape recorded STCW replaces real-time STCW in the TDP inputs so that TLMOP no longer has access to actual STCW, then no adherence to schedule in this particular post-pass mode is to be expected.

Operator intervention will terminate post-pass operations. Thereafter, an entry to pre-pass will insure input of actual STCW, when it becomes available, and monitoring of the schedule will resume at that point.

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