N67-39831

X-554-66-283

NASA TMX 60547

PROJECT
GEMINI

GODDARD REAL TIME PROGRAMMING SYSTEM

VOLUME I
INTRODUCTION

MARCH 1965

GODDARD SPACE FLIGHT CENTER
GREENBELT, MD.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

FOR OFFICIAL USE ONLY

THIS SERIES OF VOLUMES DESCRIBES IN DETAIL THE GODDARD REALTIME PROGRAMMING SYSTEM USED TO SUPPORT THE GEMINI, GT-3 AND GT-4 MANNED MISSIONS.

THE VOLUMES REPRESENT OUR FIRST ATTEMPT AT LARGE SCALE COMPUTERIZED DOCUMENTATION. IT HAS BEEN A LEARNING PROCESS AND WE FEEL THE TECHNIQUE HAS GREAT POSSIBILITIES. ALTHOUGH THE ANTICIPATED ECONOMIES WERE NOT REALIZED ON THIS FIRST ATTEMPT, WE FEEL WITH THE EXPERIENCE GAINED, FUTURE AUTOMATED DOCUMENTATION TASKS CAN BE ACCOMPLISHED MORE ECONOMICALLY THAN BY USING CONVENTIONAL TECHNIQUES.

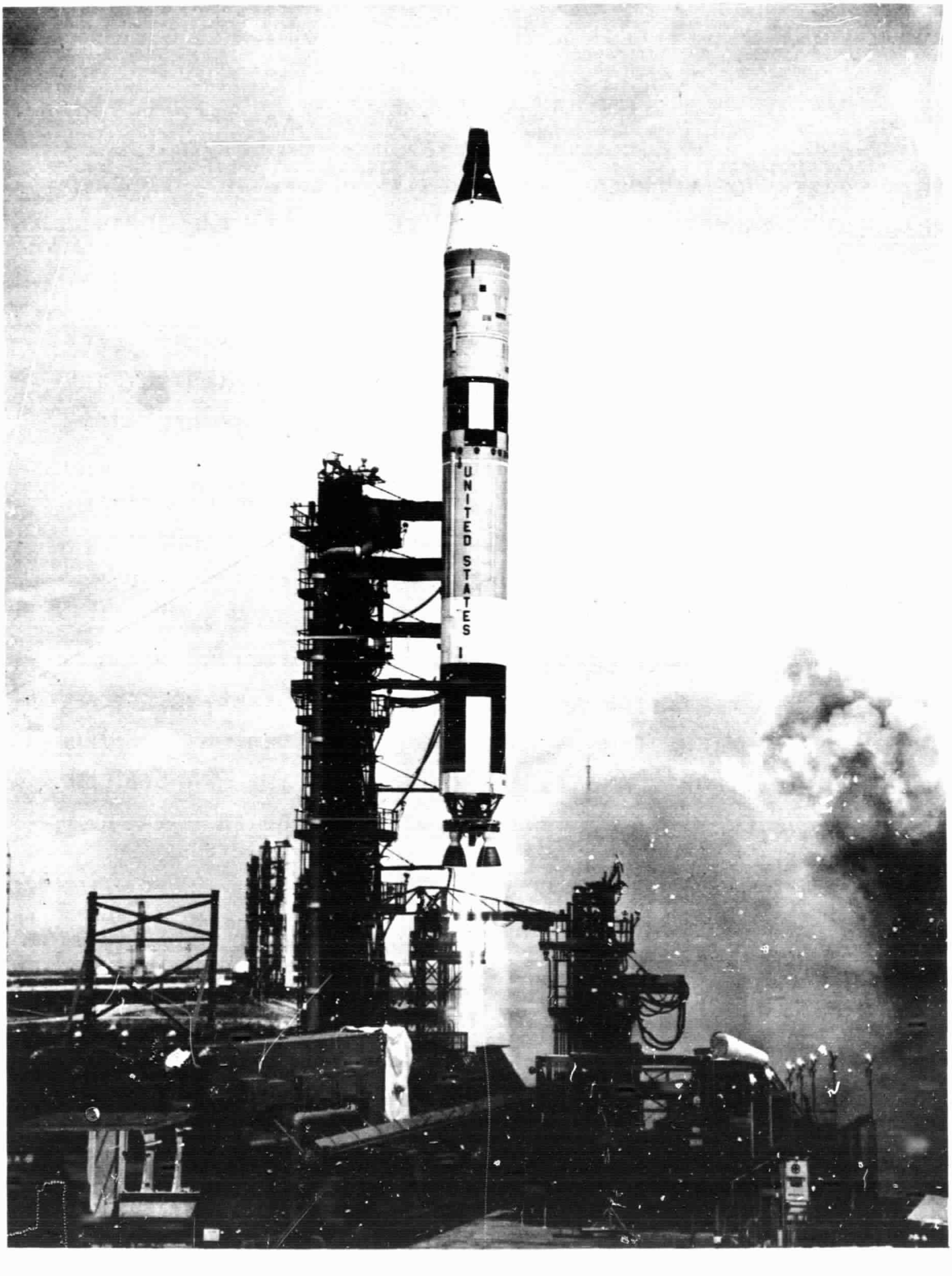
FURTHER WE FEEL THAT COMPUTERIZED DOCUMENTATION PERMITS REALTIME DOCUMENTATION OF THE COMPUTER PROGRAMMING EFFORT INCLUDING FLOW CHARTING. THIS WAS DEMONSTRATED IN OUR LATEST AIMP EFFORT, AND IS A SOLUTION TO THE PROBLEM OF KEEPING DOCUMENTATION CURRENT WITH COMPUTER PROGRAM DEVELOPMENT.

PREPARED BY IBM FOR

DATA OPERATIONS BRANCH
MANNED FLIGHT OPERATIONS DIVISION
TRACKING AND DATA SYSTEMS DIRECTORATE
NASA-GODDARD

RELEASED BY J. J. Donegan

J. J. DONEGAN, HEAD
DATA OPERATIONS BRANCH



Frontispiece. Gemini-Titan II Vehicle

X-554-66-283

Project
GEMINI

GODDARD
REAL TIME PROGRAMMING
SYSTEM

Volume I
Introduction

prepared for
National Aeronautics and Space Administration
Contract No. NAS 5-9762

March 1965

by
Federal Systems Division
International Business Machines Corporation

GODDARD REAL TIME PROGRAMMING SYSTEM

INDEX OF VOLUMES

FOREWORD

PROJECT GEMINI WAS ESTABLISHED BY THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) AS ITS SECOND MAN-IN-SPACE PROGRAM TO CARRY FORWARD THE MANNED SPACE MISSION STARTED BY PROJECT MERCURY AND TO PROVIDE THE KNOW-HOW NEEDED TO ENSURE A SUCCESSFUL MANNED LUNAR LANDING IN PROJECT APOLLO.
IN PROJECT GEMINI, NASA WILL CONDUCT A SERIES OF SPACE FLIGHTS THAT WILL MEASURE THE PHYSIOLOGICAL ASPECTS OF EXPOSING MEN TO SPACE ENVIRONMENT FOR PROLONGED PERIODS, PROVIDE EXPERIENCE IN SPACE-CRAFT CONTROL, AND PERFECT RENDEZVOUS AND DOCKING TECHNIQUES WITH OTHER SPACE VEHICLES IN FLIGHT.

THE GODDARD SPACE FLIGHT CENTER (GSFC), LOCATED AT GREENBELT, MARYLAND, IS RESPONSIBLE FOR PROVIDING PRIME (REAL TIME) COMPUTING SUPPORT FOR THE GEMINI SPACE FLIGHTS THROUGH THE GT-3 (GEMINI TITAN-3) MISSION, AND TO PROVIDE BACKUP SUPPORT FOR THE MANNED SPACECRAFT CENTER AT HOUSTON, TEXAS FOR LATER MISSIONS.

THIS VOLUME IS ONE OF A SERIES OF FOUR MANUALS THAT DESCRIBE THE GSFC REAL TIME COMPUTING SYSTEMS AS DEVELOPED FOR MISSION SUPPORT THROUGH THE GT-3 MISSION. THE FOUR VOLUMES IN THIS SERIES ARE -

VOLUME 1, INTRODUCTION
VOLUME II, MONITOR AND I/O PROGRAMS
VOLUME III, REAL TIME PROCESSORS
VOLUME IV, NON-REAL TIME PROGRAMS

THE PAGE IMPRESSIONS USED FOR PHOTO-OFFSET PRINTING OF THE TEXT AND FLOWCHARTS OF THIS SERIES OF MANUALS WERE PRODUCED BY AN IBM 1401 COMPUTER, WHICH WAS ALSO USED TO CONTROL THE PAGE AND LINE FORMAT. DUE TO CERTAIN LIMITATIONS IN THIS METHOD OF PRODUCTION, SOME FLOWCHARTS, TABLES AND ILLUSTRATIONS WERE PRE- PARED IN WHOLE OR IN PART, USING CONVENTIONAL TYPE- WRITER/LINE ART METHODS.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

APPENDIXES

C

VOL I INTRODUCTION

1. INTRODUCTION

THE FOUR PROCESSOR MANUALS IN THIS SERIES DESCRIBE IN DETAIL THE GODDARD REAL TIME SYSTEM (GRTS) COMPUTER PROGRAMS AND EQUIPMENT USED IN SUPPORT OF GEMINI SPACE FLIGHTS THROUGH THE GT-3 MISSION. THE MATERIAL CONTAINED IN THIS SERIES WAS TAKEN DIRECTLY FROM A SET OF PROGRAMMER WORKBOOKS WHICH GSFC MAINTAINS AND UPDATES TO RECORD THE DEVELOPMENT - THE REVISION OF EXISTING PROGRAMS AND THE PREPARATION OF NEW PROGRAMS TO MEET MISSION REQUIREMENTS - AND STATUS OF THE REAL TIME SYSTEM. THESE WORKBOOKS, WHICH PROVIDE A READILY AVAILABLE SYSTEM REFERENCE AND SERVE TO COORDINATE THE OVERALL PROGRAMMING EFFORT, ARE PREPARED AND UPDATED BY AN AUTOMATED DOCUMENTATION SYSTEM THAT REFLECTS SYSTEM CHANGES, DELETIONS, AND ADDITIONS ON A NEAR REAL-TIME BASIS. SINCE THIS SERIES OF MANUALS COVERS ONLY THE FIRST THREE GEMINI MISSIONS, THEY REFLECT THE CONTENTS OF THE PROGRAMMER WORKBOOKS THROUGH THAT PERIOD.

1.1 ORGANIZATION OF VOLUMES

THIS VOLUME, INTRODUCTION, CONTAINS GENERAL BACKGROUND INFORMATION, COLLECTS IN ONE VOLUME CERTAIN INFORMATION APPLICABLE TO ALL VOLUMES, AND EXPLAINS BRIEFLY THE ORGAINIZATION OF THE MANUALS. A TYPICAL GEMINI MISSION PROFILE IS GIVEN WHICH INCLUDES A GENERAL DESCRIPTION OF THE SPACECRAFT AND BOOSTER, A BREAKDOWN OF OF THE MISSION OBJECTIVES, GENERAL COUNTDOWN PROCEDURES, AND DETAILED DESCRIPTIONS OF THE VARIOUS MISSION PHASES. ALSO INCLUDED ARE GENERAL DESCRIPTIONS OF THE FOLLOWING -

* THE TRACKING AND DATA ACQUISITION NETWORKS UTILIZED DURING THE MISSIONS.

* THE GSFC MISSION SUPPORT EQUIPMENT AND DATA PROCESSING METHODS.
* THE GSFC OPERATING PROCEDURES, INCLUDING ACTIVITIES BEFORE, DURING, AND AFTER AN ACTUAL OR SIMULATED MISSION.
* THE GEMINI PROGRAMMING SYSTEM, INCLUDING MONITOR, LAUNCH/ABORT, ORBIT/REENTRY, AND UTILITY AND SUPPORTING PROGRAMS.
* THE CADFISS (COMPUTATION AND DATA FLOW INTEGRATED SUBSYSTEM) TESTS USED TO CHECK THE ABILITY OF THE MANNED SPACE FLIGHT NETWORK TO PROVIDE MISSION SUPPORT.

APPENDIX A DESCRIBES THE AUTOMATED DOCUMENTATION SYSTEM USED TO DYNAMICALLY RECORD THE DEVELOPMENT OF THE REAL-TIME SYSTEM AND, CONSEQUENTLY, TO PRODUCE THE PAGE IMPRESSIONS FOR THIS SERIES OF MANUALS. THE GEMINI COORDINATE SYSTEMS AND CONVERSIONS, MATHEMATICAL TERMINOLOGY, AND VARIOUS RELATED DATA ARE DESCRIBED IN APPENDICES B THROUGH E. APPENDIX F, IS A COMPREHENSIVE LISTING THAT DEFINES ALL THE TERMS AND ABBREVIATIONS USED IN THIS SERIES. APPENDIX G, INDEX TO PROGRAMS, LISTS ALPHABETICALLY ALL THE PROGRAMS IN THE SYSTEM AND GIVES THE TITLE AND LOCATION, BY VOLUME AND PAGE, OF EACH PROGRAM LISTED.

THE THREE REMAINING PROCESSOR MANUALS ARE ESSENTIALLY A LOGICAL COLLECTION OF PROGRAM DESCRIPTIONS THAT DECRIBE WHAT EACH COMPUTER PROGRAM DOES AND HOW IT DOES IT. THE BREAKDOWN OF THESE VOLUMES AND THE MATERIAL COVERED IN EACH ARE AS FOLLOWS -

VOLUME II, MONITOR AND I/O PROGRAMS

THIS VOLUME CONTAINS A COLLECTION OF THOSE PROGRAMS

USED TO SUPERVISE (INTEGRATE AND CONTROL) THE REAL-TIME COMPUTER PROCESSING OPERATIONS. IN BRIEF, THESE PROGRAMS PERFORM THE NECESSARY PREPROCESSING NECESSARY TO ENABLE REAL-TIME DATA TO BE PROCESSED, PROVIDE THE HOUSEKEEPING FOR THE REAL-TIME PROCESSOR PROGRAMS, AND DETERMINE AT ANY INSTANT THE PRIORITY SCHEDULE WHICH MUST BE OBSERVED TO SATISFY THE COMPUTATIONAL REQUIREMENTS OF THE REAL-TIME SYSTEM.

VOLUME III, REAL-TIME PROCESSORS

THIS VOLUME DESCRIBES THOSE PROGRAMS THAT PROVIDE THE ACTUAL PROCESSING OF REAL-TIME INPUT. THESE PROGRAMS ARE QUEUED BY THE MONITOR AND I/O PROCESSORS AND INCLUDE THE LAUNCH/ABORT AND ORBIT/REENTRY PROCESSORS WHICH PERFORM THE MATHEMATICAL COMPUTATIONS NECESSARY TO DRIVE ON-LINE MISSION DISPLAYS THAT PERMIT SURVEILLANCE OF MISSION PERFORMANCE, AND PROVIDE RECORDS FOR MISSION ANALYSIS.

VOLUME IV, NON REAL-TIME PROCESSORS

THIS VOLUME CONTAINS THE EXTERNAL AND SIMULATION PROGRAMS USED TO COMPLIMENT THE REAL-TIME SYSTEM FOR SUCH ACTIVITIES AS PREPARATION OF SYSTEM LOG TAPES, CORE DUMPING OPERATIONS, ANALYSIS OF PROGRAM OUTPUT, AND MISSION SIMULATION. THE EXTERNAL PROGRAMS, WHICH MAY BE USED BEFORE, DURING, OR AFTER A MISSION, INCLUDE THE SHARE OPERATING SYSTEM, THE UTILITY PROGRAMS, AND THE SUPPORT PROGRAMS. THE SIMULATION PROGRAMS PRETEST THE REAL-TIME PROGRAMMING SYSTEM IN AN ENVIRONMENT THAT APPROACHES A REAL-TIME MISSION, BUT ARE NOT USED DURING AN ACTUAL MISSION.

1.2 FORMAT

THE FORMAT OF THE GEMINI PROCESSOR MANUALS WAS DEVISED TO ACCOMMODATE THE REQUIREMENTS OF AN AUTOMATED DOCUMENTATION SYSTEM (DESCRIBED IN APPENDIX A) WHICH WAS DEVELOPED TO IMPLEMENT A REAL-TIME DOCUMENTATION SCHEME FOR THE GSFC COMPUTER PROGRAMS. THIS FORMAT IS BASICALLY IDENTICAL IN ALL THE PROCESSOR MANUALS (EXCEPT VOLUME 1). EACH MANUAL IS COMPRISED OF A COLLECTION OF PROGRAM DESCRIPTIONS ARRANGED IN A LOGICAL ORDER (I.E., CHRONOLOGICALLY BY SYSTEM USAGE) AND VARIOUS RELATED APPENDICES. NO SYSTEM OF HIERARCHY OR SECTION/PARAGRAPH SUBORDINATION IS USED, AND EACH PROGRAM IS TREATED INDIVIDUALLY, CONSISTING OF DESCRIPTIVE TEXT FOLLOWED BY FLOWCHARTS.

EACH PROGRAM IS NUMBERED CHRONOLOGICALLY AS IT APPEARS IN THE VOLUME, CONTAINS AN ABBREVIATED (OR MNEMONIC) TITLE WITH ITS DERIVATION FOLLOWED BY A STATEMENT OF THE PROGRAM'S FUNCTION AND USE WITHIN THE OVERALL SYSTEM. WITH SOME POSSIBLE VARIATIONS, THE REMAINING SECTIONS OF EACH DESCRIPTION CONFORMS TO THE FOLLOWING BREAKDOWN -

INPUT - DESCRIBES THE METHODS OF ENTERING THE PROGRAM, THE POINTS FROM WHICH ENTRY IS MADE AND, IF APPLICABLE, EXPLAINS THE INPUT ITEM. ALL INPUTS ARE LISTED UNDER SUBHEADS ACCORDING TO TYPE - I.E., TABLES, CONSTANTS, COMMUNICATION CELLS, ETC.

OUTPUT - DESCRIBES THE METHODS OF EXIT, AND THE CONDITIONS UNDER WHICH EACH EXIT IS USED. THE OUTPUTS ARE LISTED IN THE SAME MANNER AS THE INPUTS.

METHOD - CONTAINS A DISCUSSION OF THE SIGNIFICANT POINTS OF THE PROGRAM AND HOW IT PERFORMS ITS FUNCTION. INCLUDED ARE FORMULAS USED, MATHEMATICAL TECHNIQUES, BASIC PROGRAM PHILOSOPHY, ERROR CONDITIONS AND RECOVERY PROCEDURES, RELATED SUBROUTINES, AND OTHER ESSENTIAL INFORMATION.

THE PROGRAM FLOWCHARTS THAT ACCOMPANY EACH PROGRAM DESCRIPTION ARE OF TWO TYPES - (1) GENERAL SYSTEM FLOW, WHICH SHOWS THE LOCATION AND GENERAL FORMAT OF DATA AT EACH STEP AS IT IS MOVED OR PROCESSED THROUGH THE SYSTEM (OR GROUP OF PROGRAMS) - AND (2) LOGIC FLOW, WHICH REPRESENTS THE CODING LOGIC OF THE INDIVIDUAL PROGRAM AND SHOWS THE DECISIONS MADE AND THE OPERATIONS PERFORMED BY THE PROGRAM. THE FLOWCHARTS THAT REPRESENT LOGIC FLOW WERE PREPARED BY THE AUTOMATED DOCUMENTATION SYSTEM WHICH AUTOMATICALLY PRINTS THE FLOWCHART BLOCKS AND INSERTS THE COMMENTS. HOWEVER, SOME OF THE FLOWCHARTS THAT REPRESENT SYSTEM DATA FLOW WERE PREPARED USING CONVENTIONAL TYPE-WRITER/LINE ART METHODS BECAUSE THE GENERAL STRUCTURE OF THESE CHARTS WAS NOT ADAPTABLE TO THE REQUIREMENTS OF THE AUTOMATED SYSTEM. FOR AN UNDERSTANDING OF THE FLOW-CHART CONVENTIONS AND FORMS USED IN THESE MANUALS, REFER TO APPENDIX A, AUTOMATED DOCUMENTATION SYSTEM. THIS APPENDIX ALSO DESCRIBES THE SYSTEM COMPUTER REQUIREMENTS, METHODS OF INPUT, AND LIMITATIONS IN THE FLOWCHARTING TECHNIQUE.

PRECEDING PAGE BLANK NOT FILMED.

VOL I INTRODUCTION

2. GEMINI MISSION PROFILE

GSFC WILL DIRECTLY SUPPORT GEMINI NON-RENDEZVOUS MISSIONS GT- 1 THROUGH GT-3, AND WILL BACK UP HOUSTON FOR LATER MISSIONS. EACH GEMINI SPACECRAFT WILL BE LAUNCHED BY A TITAN II BOOSTER.

THE TITAN II IS A LIQUID-FUELED, TWO-STAGE VEHICLE, TEN FEET IN DIAMETER, WITH TWO MAIN ENGINES IN THE FIRST STAGE AND ONE ENGINE IN THE SECOND. EACH STAGE HAS ITS OWN FUEL AND OXIDIZER TANKS. FIRST STAGE THRUST IS APPROXIMATELY 430,000 POUNDS, SECOND STAGE IS APPROXIMATELY 100,000 POUNDS. THIS VEHICLE HAS THE CAPABILITY OF PLACING 6,000 POUNDS INTO A 100 MILE (NAUTICAL) EARTH ORBIT. DURING LAUNCH, THE FIRST STAGE IS DETACHED AT THE END OF THE FIRST BURN.

THE GEMINI SPACECRAFT IS A TWO-MAN CAPSULE, ESSENTIALLY BALLISTIC, BUT WITH SOME ATMOSPHERIC LIFT CAPABILITY. THIS LIFT WILL BE USED TO PARTIALLY GUIDE THE SPACECRAFT DURING REENTRY BY USING BANK AND ROLL TO ACHIEVE CONTROLLED REENTRY FLIGHT, ALTHOUGH THE DEGREE OF CONTROL WILL BE LIMITED. IN THE SPACECRAFT THE TWO ASTRONAUTS SIT SIDE-BY-SIDE, WITH A SMALL WINDOW PROVIDED FOR EACH ASTRONAUT FOR VISUAL MONITORING OF DOCKING PROCEDURES AND OTHER OBSERVATIONS.

SOME OF THE SPACECRAFT SUBSYSTEMS ARE SIMILAR TO THOSE USED ON PROJECT MERCURY. NEW SUBSYSTEMS TO BE CHECKED OUT INCLUDE ELECTRICAL POWER, GUIDANCE, PROPULSION, RENDEZVOUS, AND RECOVERY. THE ELECTRICAL POWER SUBSYSTEM WILL USE FUEL CELLS, WITH BATTERIES FOR EMERGENCY BACKUP AND FOR USE DURING REENTRY. THE GUIDANCE SUBSYSTEM INCLUDES A DIGITAL COMPUTER, A MANUAL DATA INSERTION

UNIT, AN INERTIAL MEASUREMENT UNIT, AND A CHANGE-IN-VELOCITY INDICATOR. THE PROPULSION SUBSYSTEM, CALLED THE ORBITAL ATTITUDE AND MANEUVERING SYSTEM (OAMS), USES STORABLE LIQUID PROPELLANTS AND A VARIETY OF JETS AND THRUSTERS TO CONTROL SPACECRAFT ATTITUDE AND TO EFFECT ORBIT CHANGES. THE RENDEZVOUS SUBSYSTEM ESSENTIALLY IS A RADAR DESIGNED TO PICK UP THE TARGET VEHICLE IN ORBIT AT A DISTANCE OF OVER 100 NAUTIAL MILES AND GUIDE THE GEMINI SPACECRAFT TO IT. RADAR MEASUREMENTS INCLUDE RANGE, AZIMUTH, AND ELEVATION ANGLE. THE RECOVERY SUBSYSTEM WILL INVOLVE THE USE OF AN INFLATABLE-WING PARAGLIDER IN SOME OF THE LATER MISSIONS.

2.1 MISSION OBJECTIVES

BRIEFLY, THE THREE GEMINI NON-RENDEZVOUS MISSIONS ARE AS FOLLOWS -

- GT-1 A ONE-ORBIT, UNMANNED, ORBITAL FLIGHT TO EVALUATE THE TITAN II BOOSTER, THE SPACECRAFT, AND THE GROUND SUPPORT SYSTEMS.
- GT-2 A 19-MINUTE, UNMANNED, SUBORBITAL FLIGHT TO QUALIFY THE HEAD PROTECTION AND RECOVERY SYSTEMS AND TO PROBE THE PROBLEM OF REENTRY COMMUNICATION BLACKOUT.
- GT-3 A THREE-ORBIT, MANNED MISSION TO VALIDATE THE GEMINI GROUND SUPPORT SYSTEMS, THE PERFORMANCE OF A TWO-MAN CREW IN SPACE, AND THE CONTROLLED REENTRY PRINCIPLE. ALSO, IT WILL DETERMINE THE READINESS OF THE SPACECRAFT FOR LONGER MISSIONS.

IN ADDITION TO THE ABOVE PRIMARY MISSIONS, VARIOUS SCIENTIFIC EXPERIMENTS AND MEASUREMENTS AND ENTRY TECHNIQUES WILL BE MADE IN THE COURSE OF THE FLIGHTS.

A TYPICAL GEMINI LAUNCH PROCEEDS AS FOLLOWS - THE TITAN II MAIN ENGINES ARE IGNITED AND, WHEN PROPER THRUST IS ACHIEVED, THE TITAN II IS RELEASED AND BEGINS TO RISE. WHEN IT HAS RISEN TWO INCHES ABOVE THE LAUNCH PAD, LIFT-OFF IS SIGNALLED. AT THE END OF FIRST STAGE THRUST, THE MAIN ENGINES ARE CUT OFF, AND THE FIRST STAGE IS SEPARATED, THEN THE SECOND STAGE ENGINE IS IGNITED. AT A PRESCRIBED TIME, THE SECOND STAGE ENGINE IS CUT OFF, AND THE SPACECRAFT IS SEPARATED FROM THE TITAN II.

AN UNSUCCESSFUL GEMINI LAUNCH WILL RESULT IN AN ABORT, WHICH IS BROADLY CLASSIFIED AS MODE I, MODE II, OR MODE III ABORT. MODE I ABORT CAN OCCUR FROM LIFTOFF UNTIL AN ALTITUDE OF APPROXIMATELY 70,000 FEET IS REACHED, AND INVOLVES THE USE OF SEAT EJECTION FOR ASTRONAUT ESCAPE. THE MAXIMUM RANGE FROM THE LAUNCH PAD OF THE RECOVERY POINT IS ABOUT 30 NAUTICAL MILES. MODE II ABORT CAN OCCUR FROM ABOUT ONE AND ONE-HALF MINUTES AFTER LIFTOFF UNTIL ABOUT FIVE MINUTES AFTER LIFTOFF AND WILL BE ABOVE 70,000 FEET WITH VELOCITY LESS THAN APPROXIMATELY 21,000 FEET/SECOND. ESCAPE IS ACHIEVED BY FIRING THE SPACECRAFT RETROROCKETS IN SALVO TO SEPARATE FROM THE BOOSTER, AND RECOVERY IS WITHIN 1,500 NAUTICAL MILES OF THE LAUNCH PAD. MODE III ABORT OCCURS NORMALLY WITHIN ABOUT SIX MINUTES AFTER LIFTOFF, AND NORMALLY WILL BE ABOVE 500,000 FEET ALTITUDE WITH A VELOCITY IN EXCESS OF 21,000 FEET/SECOND. THE SPACECRAFT IS SEPARATED FROM THE BOOSTER BY FIRING THE OAMS AND IS PLACED IN THE NORMAL REENTRY ATTITUDE, THEN THE RETROROCKETS ARE FIRED. RECOVERY WILL BE OVER 1,500 NAUTICAL MILES FROM THE LAUNCH PAD.

NORMAL REENTRY WILL START WITH THE JETTISONING OF SOME SPACECRAFT EQUIPMENT (SUCH AS THE OAMS), ORIENTATION TO THE PROPER ATTITUDE, AND FIRING THE RETROROCKETS.

SEVERAL MODES CAN BE USED FOR REENTRY. ONE INVOLVES REVERSING A PREDETERMINED BANK ANGLE AT A TIME DETERMINED BY THE ON-BOARD COMPUTER. ANOTHER INVOLVES A ROLL PROGRAM. IN CASE OF EMERGENCY ABORT AFTER ACHIEVING ORBIT, THE ASTRONAUTS WILL HOLD TO ONE PRESCRIBED BANK ANGLE UNTIL IMPACT.

2.2 GENERAL COUNTDOWN

THE GODDARD REAL TIME SYSTEM PERFORMS THE FOLLOWING GENERAL FUNCTIONS IN SUPPORT OF A TYPICAL GEMINI NON-RENDEZVOUS MISSION -

A) CHECKS THE THREE COMPUTER SYSTEMS (IBM 7094) AT GSFC

B) BERMUDA PERFORMS IN-HOUSE TESTS

C) PERFORMS MISSION CONTROL CENTER/GSFC INTERFACE TESTS

D) PERFORMS CADFISS CHECKS OF CAPE KENNEDY AND PATRICK AIR FORCE BASE RADARS

E) PERFORMS MISSION CONTROL CENTER/BERMUDA INTERFACE TESTS

F) PERFORMS CADFISS SHORT ROLL CALL

G) LOADS OPERATIONAL PROGRAM IN COMPUTERS

H) LOADS AND RUNS DATA FLOW ON COMPUTERS

I) CYCLES AWAITING LIFTOFF

J) LIFTOFF

K) MAKES GO/NO-GO DECISIONS

L) MAKES ORBIT PARAMETER DETERMINATIONS

M) MAKES REENTRY CALCULATIONS

N) PERFORMS POST-MISSION CALCULATIONS

2.3 CADFISS ROLL CALL

THE COMPUTATION AND DATA FLOW INTEGRATED SUBSYSTEM (CADFISS) TEST PROGRAM EVALUATES THE READINESS OF THE WORLD-WIDE MANNED SPACE FLIGHT NETWORK TO SUPPORT A MANNED SPACEFLIGHT MISSION. IT ALSO PROVIDES ON-LINE INFORMATION TO INDICATE THE TYPE OF ANY FAILURE OF THE RADARS OR THE DIGITAL FLOW EQUIPMENT, AND DETERMINES THE DEGREE TO WHICH THE COMPUTER-RELATED PORTIONS OF THE SYSTEM HAVE FULFILLED THEIR DESIGN REQUIREMENTS.

SYSTEMS TESTED INCLUDE THE DIGITAL COMMAND SYSTEM AND THE PULSE CODE MODULATED TELEMETRY SYSTEM. TESTS INCLUDE COMMUNICATIONS TESTS, RADAR BORESIGHT AND RANGE TARGET TESTS, BORESIGHT ACQUISITION AID SLAVE TESTS, AND RADAR SLEW TESTS. THE TESTS ARE UNDER THE AUTOMATIC CONTROL OF THE GSFC COMPUTERS.

CADFISS ROLL CALL IS THE SYSTEMATIC CALLING UP AND CHECKING OUT OF EACH STATION IN THE MANNED SPACE FLIGHT NETWORK. THIS IS DONE AT LEAST ONCE A WEEK AND WHENEVER REQUIRED TO SUPPORT A LAUNCH OR TO CHECK OUT A FACILITY.

2.4 LAUNCH

THE LAUNCH PHASE INCLUDES TWO SUBPHASES - NORMAL LAUNCH AND HOLD. THE NORMAL LAUNCH SUBPHASE EXTENDS FROM LIFTOFF UNTIL ABOUT 15 SECONDS AFTER SECOND STAGE CUTOFF. THE HOLD SUBPHASE EXTENDS FROM THE END OF THE NORMAL LAUNCH SUBPHASE UNTIL THE FLIGHT DYNAMICS OFFICER AT THE MISSION CONTROL CENTER (MCC) AT CAPE KENNEDY PLACES A SWITCH INTO EITHER THE ORBIT OR THE ABORT POSITION. A NOMINAL SEQUENCE IS AS FOLLOWS -

TIME	EVENT
00 00 00	LIFTOFF
00 05 14	ABORT MODE CHANGEOVER (AMC)
00 05 39	SECOND STAGE CUTOFF (SSCO)
00 05 56	B-GE, IP 3600, AND BERMUDA HIGH SPEED DATA EVALUATED BY GSFC COMPUTERS, VELOCITY RATIO, FLIGHT PATH ANGLE, AND OTHER PARAMETERS DETERMINED, GO/NO-GO RECOMMENDATIONS MADE
00 05 59	SPACECRAFT SEPARATION, ORBIT ATTITUDE AND MANEUVERING SYSTEM (OAMS) IGNITED TO APPLY NECESSARY ACCELERATION FOR PHYSICAL SEPARATION
00 06 12	OAMS SYSTEM SHUTDOWN
-- -- --	ORBIT PHASE ENTERED

2.4.1 NORMAL LAUNCH SUBPHASE

HIGH SPEED TRACKING DATA FROM THE BURROUGHS-GENERAL ELECTRIC (B-GE) GUIDANCE SYSTEM COMPUTER AND THE IMPACT PREDICTOR 3600 (IP 3600) COMPUTER AT CAPE KENNEDY ARE RECEIVED AND PROCESSED AT GSFC. HIGH SPEED DATA FROM THE BERMUDA RADARS IS ALSO PROCESSED AFTER SECOND STAGE CUT-OFF.

RESULTS ARE TRANSMITTED EVERY ONE-HALF SECOND TO MCC FOR EVALUATION. THE GSFC COMPUTERS PROVIDE MCC WITH SUCH CRITICAL INFORMATION AS SPACECRAFT ALTITUDE, VELOCITY RATIO, FLIGHT PATH ANGLE, AND PREDICTED IMPACT LATITUDE AND LONGITUDE FOR IMMEDIATE ABORT CONDITIONS.

AT THE USUAL TERMINATION OF THE NORMAL LAUNCH SUB-PHASE, THE GSFC COMPUTERS GIVE GO/NO-GO RECOMMENDATIONS FOR FLIGHT CONTINUATION BASED ON DATA FROM THE VARIOUS SOURCES. RECOMMENDED TIME OF RETROFIRE AND OTHER PERTI-

NENT SPACECRAFT PARAMETERS ARE ALSO SENT TO MCC AT THIS TIME.

THE HOLD SUBPHASE IS THEN ENTERED. HOWEVER, IT IS POSSIBLE UNDER CERTAIN CONDITIONS FOR THE MISSION TO GO FROM THE NORMAL LAUNCH SUBPHASE DIRECTLY TO THE ABORT PHASE.

2.4.2 HOLD SUBPHASE

AT THIS TIME THE FLIGHT DYNAMICS OFFICER AT MCC QUICKLY BUT CAREFULLY EVALUATES THE VARIOUS PARAMETERS DISPLAYED AND DECIDES TO EITHER ABORT THE MISSION OR TO ALLOW IT TO CONTINUE. IF HE DECIDES TO ABORT, HE MUST DO SO QUICKLY IF HE HOPES TO HAVE THE SPACECRAFT LAND IN THE ATLANTIC OCEAN RATHER THAN IN AFRICA.

THE DISPLAYS PRESENTED TO THE FLIGHT DYNAMICS OFFICER ARE HELD CONSTANT UNTIL HE HAS HAD TIME TO EVALUATE THEM THOROUGHLY, HENCE THE TERM 'HOLD PHASE.' HE HAS THE OPTION TO UPDATE THE DISPLAYS BASED ON DATA COMING FROM RADARS TRACKING THE SPACECRAFT (OR BY EXTRAPOLATING FROM THE LAST GOOD DATA RECEIVED) WHEN HE SO DESIRES. ONCE HE HAS MADE HIS DECISION, HE CAUSES THE GSFC COMPUTERS TO ENTER EITHER THE ABORT PHASE OR THE ORBIT PHASE BY PLACING A SWITCH IN THE APPROPRIATE POSITION.

2.5 ABORT

A PREMATURE TERMINATION OF A MISSION IS TERMED AN ABORT. THE VARIOUS PROCEDURES FOLLOWED IN THE EVENT OF AN ABORT ARE BROKEN DOWN AS FOLLOWS -

MODE I. THE ASTRONAUTS EJECT FROM THE SPACECRAFT AND DESCEND TO EARTH BY PARACHUTE. THIS METHOD IS USED WHEN IT IS IMPOSSIBLE TO

SEPARATE THE SPACECRAFT FROM THE BOOSTER. THIS SITUATION EXISTS FROM LIFTOFF UNTIL THE BOOSTER/SPACECRAFT CONFIGURATION REACHES AN ALTITUDE OF ABOUT 70,000 FEET.

MODE II. FOR A CONSIDERABLE TIME AFTER REACHING 70,000 FEET ALTITUDE, IT IS STILL IMPOSSIBLE TO SEPARATE THE SPACECRAFT FROM THE BOOSTER USING THE OAMS. IF AN ABORT BECOMES NECESSARY, SEPARATION IS ACHIEVED BY SIMULTANEOUSLY FIRING ALL FOUR RETROROCKETS. THIS EMERGENCY RETRO-ROCKET SALVO (ERS) IMPARTS AN ACCEL-ERATION IN A POSIGRADE SENSE, AND THE ASTRONAUTS DESCEND IN THE SPACECRAFT.

MODE III. ONCE THE DYNAMICS OF THE FLIGHT ARE SUCH THAT THE OAMS IS SUFFICIENT FOR SEPA-RATION, THE FIRING MECHANISM OF THE RETROROCKETS IS CHANGED FROM THE SALVO FIRING METHOD TO A RIPPLE FIRING METHOD. AN ASTRONAUT WILL NORMALLY DO THIS WHEN HE RECEIVES WORD FROM MCC THAT THE VELOCITY RATIO IS ABOVE 0.8. THE GSFC COMPUTERS ARE INFORMED OF THIS CHANGE OF ABORT MODE (AMC) BY A SWITCH OPERATED ON THE SPACECRAFT COMMUNICATOR'S CONSOLE. IF AN ABORT OCCURS, THE TIME OF FIRING THE RETROROCKETS WILL HAVE A LARGE EF-FECT ON IMPACT POINT PREDICTION.

AN ABORT IS ALSO CLASSIFIED AS A LOW ABORT IF IT OCCURS PRIOR TO AMC, OR AS A HIGH ABORT IF IT OCCURS AFTER AMC. THERE IS NO HOLD PHASE IN THE EVENT OF A LOW

ABORT. THE FLIGHT DYNAMICS OFFICER DIRECTS THE GSFC COMPUTERS TO ENTER THE ABORT PHASE DIRECTLY FROM THE NORMAL LAUNCH SUBPHASE. AFTER AMC THERE IS ALWAYS A HOLD SUBPHASE PRIOR TO ENTERING EITHER THE ABORT OR THE ORBIT PHASES.

2.5.1 LOW ABORT SUBPHASE

HIGH SPEED DATA FROM RADARS TRACKING THE SPACECRAFT ARE UTILIZED FOR PROCESSING, IF AVAILABLE. THESE DATA COME FROM THE BERMUDA RADARS AND FROM THE IP 3600 COMPUTERS AT CAPE KENNEDY. IT IS ALSO POSSIBLE TO EXTRAPOLATE THE TRAJECTORY FROM THE LAST GOOD DATA PROCESSED DURING THE LAUNCH PHASE.

THE TIME AND LATITUDE AND LONGITUDE OF THE PREDICTED IMPACT POINT OF THE SPACECRAFT UNDER VARIOUS LIFT OPTIONS AND OTHER PERTINENT PARAMETERS ARE COMPUTED EVERY SIX SECONDS FOR TRANSMISSION TO MCC.

THE FLIGHT DYNAMICS OFFICER MAY DIRECT THE GSFC COMPUTERS TO ENTER THE REENTRY PHASE AT ANY TIME AFTER THE LOW ABORT PHASE HAS BEGUN BY REQUESTING THAT A MANUAL INSERTION TO THAT EFFECT BE MADE TO THE COMPUTERS.

2.5.2 HIGH ABORT SUBPHASE

WHEN THE FLIGHT DYNAMICS OFFICER DIRECTS THAT THE ABORT PHASE BE ENTERED FROM THE HOLD PHASE, HE SPECIFIES WHICH DATA SOURCE IS TO BE USED (B-GE, IP 3600, OR BERMUDA) TO DETERMINE THE TRAJECTORY. NO FURTHER RADAR DATA IS USED DURING THE ABORT PHASE.

THE TIME AND LATITUDE AND LONGITUDE OF THE PREDICTED IMPACT POINT OF THE SPACECRAFT, THE RETROFIRE TIME (EITHER THE RECOMMENDED TIME OF THE ACTUAL TIME OF RETROFIRE AS REPORTED BY TELEMETRY), AND OTHER PERTINENT PARA-

METERS ARE COMPUTED EACH SIX SECONDS FOR TRANSMISSION TO MCC.

POSITION INFORMATION IS PREDICTED FOR THE RANGE STATIONS AND SENT TO THEM AS TTY MESSAGES TO ENABLE ACQUISITION AIDS AND RADARS AT OBSERVING SITES TO ACQUIRE THE SPACECRAFT SHORTLY AFTER IT APPEARS OVER THE LOCAL HORIZON. THE FIRST ACQUISITION DATA MESSAGES SENT ARE DERIVED FROM A TRAJECTORY IN WHICH IT IS ASSUMED THAT THE RETROROCKETS WILL BE FIRED AT THE TIME RECOMMENDED BY THE GSFC COMPUTERS. LATER MESSAGES UTILIZE THE FIRING TIME OF THE RETROROCKETS AS RECORDED BY INCOMING TELEMETRY FROM THE SPACECRAFT.

ONCE THE FLIGHT DYNAMICS OFFICER HAS SATISFIED HIMSELF THAT HE KNOWS THE RETROFIRE CONDITIONS AS WELL AS POSSIBLE, HE CAUSES THE GSFC COMPUTERS TO ENTER THE RE-ENTRY PHASE BY DIRECTING THAT AN APPROPRIATE MANUAL INSERTION BE MADE.

2.6 ORBIT

THE ORBIT PHASE IN THE GODDARD REALTIME COMPUTING PROGRAM BEGINS WHEN THE DECISION TO COMMIT THE SPACECRAFT TO ORBIT IS COMMUNICATED TO GODDARD BY THE FLIGHT DYNAMICS OFFICER BY MEANS OF A MANUALLY INSERTED BIT IN THE TELEMETRY DATA.

DURING ORBIT, POSITION DATA OBTAINED FROM SITE RADARS IS COMBINED WITH PREVIOUS RADAR DATA WHICH IS STORED IN THE COMPUTERS AT GSFC TO DEFINE PRESENT SPACECRAFT POSITION AND VELOCITY, AND TO PREDICT FUTURE SPACECRAFT POSITIONS. POSITION INFORMATION IS PREDICTED FOR ALL RANGE STATIONS AND TRANSMITTED TO THEM AS TTY MESSAGES TO ENABLE ACQUISITION AID AND RADARS AT EACH SITE TO ACQUIRE THE SPACECRAFT SHORTLY AFTER IT APPEARS

OVER THE LOCAL HORIZON.

A SPECIAL PROBLEM IN THE GEMINI MISSIONS FOR THE GSFC COMPUTERS IS THE CAPABILITY OF THE SPACECRAFT TO CHANGE ITS ORBIT, REQUIRING THE REAL TIME PROGRAM TO RECOMMEND AND SUPPORT THE SPACECRAFT MANEUVERS AND TO SUPPLY POSITION AND VELOCITY INFORMATION FOR ORBIT NAVIGATION AND PRE-RETROFIRE UPDATES. THE INFLIGHT CALCULATIONS PERFORMED BY THE GEMINI ONBOARD COMPUTER ARE DUPLICATED AT GSFC TO ENABLE THE MANNED SPACE FLIGHT NETWORK TO PREDICT AND TRACK SUBSEQUENT ORBITAL CHANGES.

WHILE IN FLIGHT THE SPACECRAFT TRANSMITS TELEMETRY INFORMATION TO EACH TRACKING STATION WHEN IN RANGE OF THE STATION. THE STATIONS THEN COMPOSE AND TRANSMIT A SUMMARY OF THE MESSAGES TO GSFC.

THE GSFC COMPUTERS ALSO CONTINUOUSLY CALCULATE IMPACT POINTS AHEAD OF THE SPACECRAFT IN THE EVENT AN EMERGENCY ABORT OCCURS DURING ORBIT.

TO PREPARE FOR REENTRY, THE TIME TO FIRE RETRO-ROCKETS (GMTRC) IS CALCULATED BY THE GSFC COMPUTERS FOR A PREDETERMINED IMPACT POINT. THE LANDING AREAS ARE SELECTED PRIOR TO STARTING THE MISSION, BUT CAN BE UPDATED DURING THE MISSION. THE PLANNED LANDING AREA FOR THE PRESENT ORBIT IS DISPLAYED UNTIL A FEW MINUTES PRIOR TO GMTRC FOR THAT AREA, AT WHICH TIME THE LANDING AREA FOR THE SUCCEEDING ORBIT IS DISPLAYED. A CONTINGENCY LANDING AREA WILL BE DISPLAYED BASED ON SOME VARIABLE DELTA T BEFORE THE CURRENTLY DISPLAYED GMTRC, AND MAY BE OVERRIDDEN BY A MANUAL INPUT UNTIL THE GMTRC FOR THE NEXT CONTINGENCY LANDING AREA OCCURS. THE MANUAL INPUT MAY BE A PLANNED LANDING AREA OR A CONTINGENCY LANDING AREA INPUT.

EACH TIME A PLANNED LANDING AREA GMTRC IS COMPUTED, THE PRE-RETROFIRE UPDATE QUANTITIES FOR THAT TIME ARE COMPUTED AND STORED SO THAT THEY CAN BE TRANSMITTED TO A REMOTE COMMAND SITE BY TTY AT THE REQUEST OF THE FLIGHT CONTROLLER (RETRO OFFICER). HOWEVER, IF A MANUAL INPUT FOR A PLANNED LANDING AREA OCCURS, THERE WILL BE TWO SETS OF PRE-RETROFIRE UPDATE QUANTITIES COMPUTED AND STORED, BOTH READY FOR TRANSMISSION AT THE FLIGHT CONTROLLER'S REQUEST. THUS, WHEN THE FLIGHT CONTROLLER REQUESTS A TRANSMISSION FROM GSFC TO THE REMOTE COMMAND SITE VIA TTY, HE MUST SPECIFY WHICH SET OF QUANTITIES IS TO BE TRANSMITTED.

FOR THE NON-RENDEZVOUS MISSIONS, THE GEMINI ONBOARD COMPUTER REQUIRES TWO TYPES OF UPDATES - ORBIT NAVIGATION UPDATES AND PRE-RETROFIRE UPDATES. ORBIT NAVIGATION UPDATES REQUIRE TIME-TAGGED POSITION AND VELOCITY INPUTS. PRE-RETROFIRE UPDATES REQUIRE TIME-TAGGED POSITION AND VELOCITY INPUTS AND THE LATITUDE AND LONGITUDES OF THE ASSOCIATED TARGET LANDING POINT. THE TIME REFERENCE SYSTEM (TRS) IN THE SPACECRAFT AND THE DIGITAL COMMAND SYSTEM (DCS) IS SUCH THAT THE TIME TAG IS A TIME-TO-GO QUANTITY RATHER THAN ELAPSED TIME OR GMT.

2.7 REENTRY

WHEN THE DECISION IS MADE TO END A MISSION, DESCENT IS INITIATED BY MANEUVERING THE SPACECRAFT TO THE DESIRED ATTITUDE AND FIRING THE RETROROCKETS AS PRECISELY AS POSSIBLE AT THE CALCULATED MOMENT. ENTRY INTO THIS PHASE WILL BE ACCOMPLISHED THROUGH THE MANUAL INSERTION OF THE NUMBER OF RETROROCKETS FIRED, THE TIME OF FIRING, AND THE SPACECRAFT ATTITUDE. THUS, THE COMPUTERS WILL BE INSTRUCTED TO INITIATE REENTRY PHASE PROCESSING ONLY UPON A

FLIGHT CONTROLLER REQUEST THAT IS BASED UPON THE KNOWLEDGE THAT RETROFIRE HAS OCCURRED. HOWEVER, THE MANUAL INPUTS OF THE RETROFIRE CONDITIONS ARE NOT LIMITED TO THOSE STATED ABOVE.

THE LOGICAL SEQUENCE INITIATED BY THE MANUAL INSERTION OF THE RETROFIRE CONDITIONS IS AS FOLLOWS -

A) LOW SPEED DATA RECEIVED DURING THE RETROFIRE PERIOD WILL BE SEPARATED INTO THREE CATEGORIES - (1) ORBIT DATA (PRE-RETROFIRE), (2) THRUST DATA (DURING RETROFIRE), AND (3) REENTRY DATA (POST-RETROFIRE).

B) THE LAST ACCEPTED TIME, POSITION, AND VELOCITY PRIOR TO RETROFIRE WILL BE INTEGRATED UP TO THE TIME OF RETROFIRE.

C) ANY THRUST DATA RECEIVED WILL NOT BE USED IN POST-RETROFIRE COMPUTATIONS.

D) REENTRY COMPUTATIONS WILL BEGIN WITH INTEGRATION OF THE POSITION AND VELOCITY VECTORS THROUGH RETROFIRE USING THE MANUALLY INSERTED RETROFIRE CONDITIONS.

E) TOUCHDOWN (IMPACT) POINTS FOR ZERO LIFT TRAJECTORY AND MAXIMUM LIFT TRAJECTORY WILL BE COMPUTED BY NUMERICAL INTEGRATION IN ORDER TO DETERMINE THAT THE TARGET IS WITHIN THE LANDING FOOTPRINT THE COMPUTATIONS WILL BE ANCHORED TO CONDITIONS AT THE END OF THE RETROROCKET THRUSTING PERIOD.

F) APPROPRIATE BACKUP GUIDANCE AND CONTROL QUANTITIES WILL BE COMPUTER GENERATED.

SEVERAL METHODS ARE AVAILABLE FOR COMPUTING NOMINAL TRAJECTORIES, AND THE METHOD TO BE USED WILL BE CHOSEN TO SUIT CIRCUMSTANCES AS THE FLIGHT CONTROLER'S JUDGEMENT

DICTATES. EACH METHOD WILL BE ASSOCIATED WITH A NUMERICAL CODE TO BE USED AS A MANUAL INPUT. THE INSERTION OF THE NUMERICAL CODE WILL ESTABLISH THE MODE OF COMPUTATION FOR GENERATING THE NOMINAL TRAJECTORY. THE MEANING OF THE CODE WILL APPLY EQUALLY WELL TO EITHER ORBIT OR REENTRY PHASE COMPUTATIONS.

SEMI-AUTOMATIC TARGET LOGIC WHICH PROVIDES FOR BOTH AUTOMATIC AND MANUAL INITIATION OF THE NUMBER OF COMPUTER ACTIONS TO CHOOSE A TARGET WILL BE INCLUDED IN THE REAL TIME PROGRAM.

2.8 PULSE CODE MODULATION SYSTEM

THE PULSE CODE MODULATION SYSTEM (PCM SYSTEM) IS A TELEMETRY SYSTEM USED TO TRANSMIT DESIRED DATA FROM THE GEMINI SPACECRAFT TO THE GROUND STATIONS. GSFC IS RESPONSIBLE FOR PROCESSING TELEMETRY SUMMARY MESSAGES FOR THE GEMINI NON-RENDEZVOUS MISSIONS. THE RESULT OF THIS PROCESSING IS ANOTHER TELEMETRY SUMMARY MESSAGE WHICH IS BROADCAST TO ALL THE NETWORK SITES.

SUMMARIES MAY BE RECEIVED AT ANY TIME FROM PRE-LAUNCH TO THE COMPLETION OF THE MISSION. DATA WILL BE RECEIVED IN THE FOLLOWING ORDER UNTIL A FIRM ORBIT HAS BEEN ESTABLISHED - RADAR DATA, GEMINI SYSTEMS DATA, AND GEMINI COMPUTER DATA.

THE INPUTS TO GSFC WILL CONSIST OF LOW SPEED TTY MESSAGES WITH THE GEMINI SYSTEMS DATA IN TTY CODE, BINARY FORM, REPRESENTING EIGHT-BIT BINARY WORDS. THESE EIGHT-BIT BINARY WORDS REPRESENT 0 TO 100 PERCENT OF FULL SCALE VALUES. THE ONBOARD GEMINI COMPUTER DATA AND THE ONBOARD TIMING DATA WILL ALSO BE IN TTY CODE, BINARY FORM, REPRESENTING 24-BIT BINARY WORDS. THESE 24-BIT BINARY WORDS REPRESENT DECIMAL VALUES.

THE OUTPUTS TO THE NETWORK WILL CONSIST OF LOW SPEED TTY MESSAGES CONTAINING THE SAME DATA THAT WAS RECEIVED, BUT CONVERTED TO ENGINEERING UNITS. THE TTY MESSAGES WILL BE REBROADCAST AS REQUESTED IN THE MESSAGE HEADERS, EITHER TO THE ENTIRE NETWORK OR TO THE ORIGINATOR AND THE MCC ONLY.

2.8.1 GEMINI SYSTEMS DATA

EACH REMOTE TRACKING SITE WILL HAVE AN ON-SITE COMPUTER WHICH BUFFERS THE PCM TELEMETRY DATA TRANSMITTED FROM THE SPACECRAFT. ON EACH PASS OF THE SPACECRAFT OVER A SITE, A MINIMUM OF TWO NORMAL TELEMETRY SUMMARY MESSAGES ARE SENT. THESE ARE TRANSMITTED AFTER THE RADARS LOSE TRACK TO AVOID INTERFERENCE WITH THE RADAR DATA. ONE MESSAGE GIVES THE STATUS OF THE GEMINI SYSTEMS AT THE TIME OF ACQUISITION OF THE SIGNAL. THE OTHER MESSAGE GIVES THE STATUS AT THE TIME OF THE LOSS OF THE SIGNAL. IF ANY IRREGULARITIES IN THE NORMAL MESSAGES ARE DETECTED, ADDITIONAL TELEMETRY SUMMARIES MAY ALSO BE TRANSMITTED. THERE ARE SEVERAL TELEMETRY SUMMARY FORMATS WHICH MAY BE SENT. THE NUMBER OF CONTINGENCIES MAY VARY WITH EACH MISSION UP TO A MAXIMUM OF EIGHT.

THE PROCESSING REQUIRED ON THE GEMINI SYSTEMS DATA IS THE CONVERSION OF THIS DATA FROM PERCENT OF FULL SCALE VALUES TO ENGINEERING UNITS. EACH PARAMETER HAS A CORRESPONDING CALIBRATION CURVE WITH WHICH THE CONVERSION TO ENGINEERING UNITS WILL BE ACCOMPLISHED. THE OCCASION MAY ARISE WHERE A BIAS (SHIFT) MAY HAVE TO BE APPLIED TO A CALIBRATION CURVE DURING A MISSION. UPON CONVERSION TO ENGINEERING UNITS, THE DATA WILL BE REFORMATTED AND BROADCAST TO THE NETWORK.

2.8.2 GEMINI COMPUTER DATA

THE ON-BOARD GEMINI COMPUTER TELEMETRY SUMMARY MESSAGE IS ALSO SENT TO GSFC FOR REFORMATTING. THIS MESSAGE HAS FIVE SUBFORMATS WHICH ARE USED DURING DIFFERENT PHASES OF THE GEMINI MISSION. THIS MESSAGE IS SENT ONLY ONCE FOR EACH PASS. THE GEMINI COMPUTER DATA IS NOT SENT IN REAL TIME AND IS NOT REQUIRED FROM EVERY SITE. ONCE THE ORBIT EPHEMERIS HAS BEEN ESTABLISHED, RADAR DATA MAY BE TRANSMITTED AFTER THE SIGNAL IS LOST. NO SET SEQUENCE FOR TRANSMISSION IS ESTABLISHED, BUT WILL BE DECIDED ON THE BASIS OF REQUIREMENTS AS THE MISSION PROGRESSES.

THE ON-BOARD COMPUTER DATA WILL REQUIRE A SOMEWHAT DIFFERENT ROUTINE THAN THAT USED FOR THE GEMINI SYSTEMS DATA. THE GEMINI COMPUTER DATA IS ORIGINALLY IN DECIMAL FORM, RATHER THAN PERCENT OF FULL SCALE. EACH PARAMETER MUST BE SCALED BY SOME PREDETERMINED CONSTANT TO OBTAIN THE CORRECT MAGNITUDE AND UNITS. (THESE SCALING FACTORS ARE SIMILAR TO THE CALIBRATION CURVES, EXCEPT THERE IS ONLY ONE FOR EACH COMPUTER WORD.) THE GEMINI COMPUTER DATA IS THEN REFORMATTED AND SENT TO THE MISSION CONTROL CENTER ONLY.

2.9 DIGITAL COMMAND SYSTEM

THE DIGITAL COMMAND SYSTEM (DCS) IS A UNIT DESIGNED TO TRANSFER DIGITAL DATA FROM THE REAL TIME COMPUTING COMPLEX AT GSFC TO THE GEMINI SPACECRAFT RAPIDLY AND WITH HIGH DEGREE OF RELIABILITY. DCS UNITS ARE INSTALLED AT SEVERAL REMOTE SITES. DATA FROM GSFC TO THE SPACECRAFT IS SENT TO A REMOTE SITE DCS UNIT, THENCE TO THE SPACECRAFT AS IT PASSES OVER THE STATION. SELECTED DATA FROM THE SPACECRAFT IS SENT TO GSFC BY THE PCM TELEMETRY SYSTEM TO

THE NEAREST GROUND STATION, AND THEN TO GSFC VIA TTY.

EACH DCS UNIT INCLUDES SIX SUBSYSTEMS - INPUT, MEMORY CONTROL, ADDRESS DISPLAY, CLOCK, VELOCIMETER, AND TRANSMIT. INPUTS MAY BE TTY, HIGH SPEED DATA LINK, ON-SITE COMPUTER, OR MANUAL, AND ARE CONTROLLED BY THE SELECT SWITCH ON THE DCS MAIN CONTROL PANEL. OUTPUT IS A PHASE-MODULATED RADIO SIGNAL AT A FREQUENCY OF 406-549 MC. MODES OF OPERATION ARE INPUT, DISPLAY, TEST, AND TRANSMIT.

EACH ON-SITE DCS IS LINKED TO THE PCM TELEMETRY SYSTEM THROUGH A TELEMETRY OUTPUT BUFFER. THE BUFFERED INFORMATION PASSED FROM THE SPACECRAFT TO THE DCS THROUGH THE TELEMETRY BUFFER IS MAP, TR CLOCK DOWN LINKED, AND VELOCIMETER DOWN LINKED. DCS UPLINK CLOCK DATA INCLUDES TIME TO RETROFIRE (TR) CLOCK DATA, TIME TO RESET (TX) CLOCK DATA, AND TIME TO FUNCTION (TF) CLOCK DATA. CLOCK DATA IS GENERATED WITHIN THE DCS BY MANUAL INSERTION (THE CLOCK INSERT THUMBWHEEL ON THE DCS MAIN CONTROL PANEL) AND SUBSEQUENT UPDATING BY THE GEMINI TIME STANDARD EQUIPMENT.

THE DCS INPUT FORMAT FOR TTY DATA IS A 23-CHARACTER (OCTAL) WORD PRECEDED BY A FIGURES/LETTERS INTERLOCK AND A START CODE, AND FOLLOWED BY A STOP CODE. DATA WILL BE ADMITTED TO THE INPUT SUBSYSTEM ONLY IF A FIGURES CODE HAS BEEN RECEIVED. ONLY ONE FIGURES CODE NEED BY TRANSMITTED AT THE START OF A DCS MEMORY LOADING OPERATION SINCE THIS INTERLOCK WILL REMAIN OFF UNTIL A LETTERS CODE IS RECEIVED. THE START CODE IS TWO LEFT PARENTHESES WHICH ALLOWS THE DATA FOLLOWING IT TO ENTER THE INPUT SUBSYSTEM. THE STOP CODE IS ONE RIGHT PARENTHESIS, AND IS REQUIRED ON ALL MESSAGES OF LESS THAN 23 CHARACTERS. A MAXIMUM LENGTH (23 CHARACTERS) MESSAGE

WILL CAUSE AN END OF WORD AUTOMATICALLY.

THE MESSAGE FORMAT FOR TTY INPUT TO THE DCS IS AS FOLLOWS -

TTY CHARACTERS (OCTAL)	BITS	FUNCTION
1-6	16	ROW PARITY
7	3	COLUMN PARITY
8-11	10	MEMORY ADDRESS
12	3	VEHICLE ADDRESS
13	3	SYSTEM ADDRESS
14-23	1-29	COMMAND WORD (GEMINI)

THE DCS OUTPUT DATA TO THE GEMINI SPACECRAFT IS CONTAINED IN A 40-BIT WORD IN THE FOLLOWING FORMAT -

BITS	FUNCTION
1-3	VEHICLE ADDRESS
4-6	SYSTEM ADDRESS
7-35	COMMAND WORD
36	PARITY (NOT TRANSMITTED)
37-40	BIT COUNT (NOT TRANSMITTED)

2.10 POST MISSION ANALYSIS

POST MISSION ANALYSIS UTILIZES A GROUP OF PROGRAMS CALLED THE POSTFLIGHT REPORTER, WRITTEN IN FORTRAN II, WHICH PRODUCES SUMMARY REPORTS OF PERTINENT RECORDED DATA ON GEMINI MISSIONS FOR THE EXPRESS PURPOSE OF POSTFLIGHT ANALYSIS.

DURING A GEMINI MISSION, REAL OR SIMULATED, SPECIAL TAPES ARE USED TO LOG CERTAIN DATA IN REAL TIME. THESE LOG TAPES ARE USED AS INPUT TO A SPECIAL PROGRAM (KARL) WHICH READS IN SCALE FACTORS, SORTS OUT THE DESIRED DATA, AND RECORDS ITS OUTPUT ON TAPES A4 AND B4. FROM THE

SORTED A4 AND B4 TAPES, THE POSTFLIGHT REPORTER PRODUCES FOUR OUTPUT TAPES - A3 FOR DISTANCE COMPUTATIONS AND PROGRAM DIAGNOSTICS, B1 FOR DATA REJECTED FROM THE PROGRAM, B2 FOR A CONDENSED (QUICKLOOK) REPORT, AND C3 FOR A THREE-DAY REPORT.

PRECEDING PAGE BLANK NOT FILMED.

3. TRACKING, DATA ACQUISITION, AND INPUTS TO GSFC

3.1 TRACKING NETWORKS

TWO TRACKING NETWORKS ARE UTILIZED DURING THE GEMINI MISSIONS - NASA'S MANNED SPACE FLIGHT NETWORK (MSFN) AND THE AIR FORCE EASTERN TEST RANGE (ETR).

3.1.1 MANNED SPACE FLIGHT NETWORK

THE MANNED SPACE FLIGHT NETWORK FOR GEMINI IS COMPOSED OF TRACKING AND DATA ACQUISITION FACILITIES A-ROUND THE WORLD, A MISSION CONTROL CENTER (MCC) AT CAPE KENNEDY, AND A COMPUTING AND COMMUNICATIONS CENTER AT GODDARD. (SEE FIGURE 3-1 AND TABLE 3-1.) STARTING WITH GT-4, THE MISSION CONTROL CENTER AT HOUSTON, TEXAS, WILL BE USED FOR THE FLIGHT CONTROL AND COMPUTING FUNCTIONS PREVIOUSLY PERFORMED AT THE CAPE KENNEDY MCC AND AT GODDARD.

THE MSFN CONSISTS OF SEVEN PRIMARY LAND SITES, SIX OTHER LAND SITES, AND TWO SHIPS. THE LAND SITES ARE AS FOLLOWS -

PRIMARY	OTHER
CAPE KENNEDY AND ETR	KANO, NIGERIA
BERMUDA	TANANARIVE, MALAGASY
GRAND CANARY ISLAND	CANTON ISLAND
CARNARVON, AUSTRALIA	POINT ARGUELLO, CALIF.
HAWAII	WHITE SANDS, N. M.
GUAYMAS, MEXICO	EGLIN AFB, FLORIDA
CORPUS CHRISTI, TEXAS	

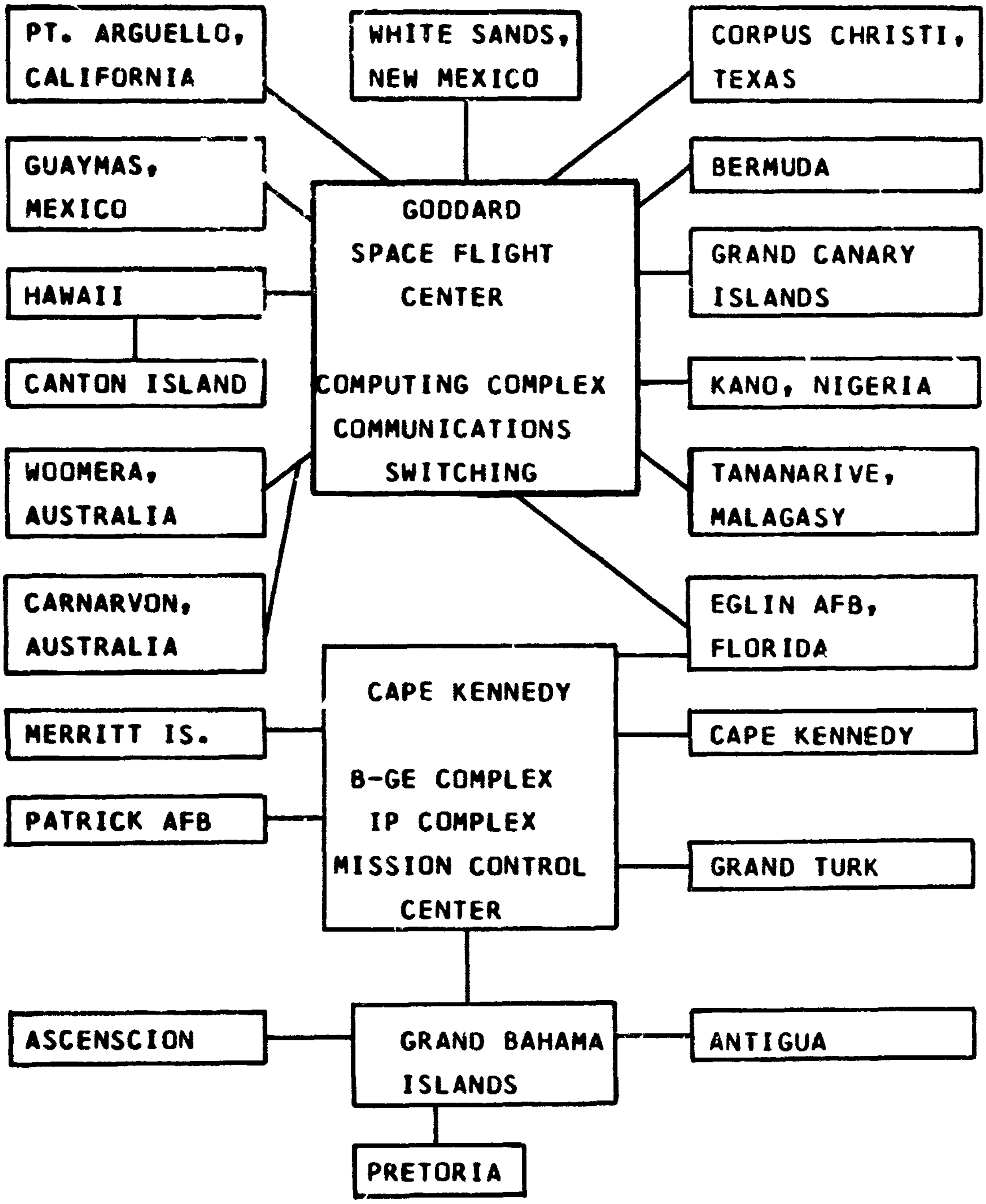


FIGURE 3-1. MANNED SPACE FLIGHT NETWORK BASIC COMMUNICATION LINKS

TABLE 3-1. MANNED SPACE FLIGHT NETWORK STATION ID.

INT. STA. NO.	NAME OF STATION	SITE TYPE	EARTH SECTOR	DCC SUB-CHANNEL (OUT)	SITE NAME IN STA. BLOCK
1	MERRITT ISLAND	TPQ-18	18	11	MLA
2	GRAND BAHAMA IS.	TPQ-18	1	11	GBI
3	RANGE TRACKER	FPS-16	15	11	RTK
4	BERMUDA	FPS-16	1	10	BDA
5	BERMUDA	VERLORT	1	10	BDA
6	GRAND CANARY IS.	VERLORT	[illegible]	11	CYI
7	CARNARVON	FPQ-6	10	10	CRO
8	WOOMERA	FPS-16	11	11	WOM
9	HAWAII	FPS-16	15	11	HAW
10	HAWAII	VERLORT	15	11	HAW
11	POINT ARGUELLO	FPS-16	17	11	CAL
12	POINT ARGUELLO	VERLORT	17	11	CAL
13	GUAYMAS	VERLORT	17	10	GYM
14	WHITE SANDS	FPS-16	17	11	WHS
15	CORPUS CHRISTI	VERLORT	18	10	TEX
16	EGLIN	FPS-16	18	11	EGL
17	CARNARVON	VERLORT	10	10	CRO
18	GRAND TURK IS.	TPQ-18	1	10	GTK
19	ASCENSION	TPQ-18	4	10	ASC
20	PATRICK	FPQ-6	18	11	PAT
21	PRETORIA	FPS-16	6	11	PRE
22	ANTIGUA	FPQ-6	2	10	ANT
23	ROSE KNOT	TELEMETRY	16	10	RKV
24	KANO	TELEMETRY	5	11	KNO
25	TANANARIVE	TELEMETRY	7	11	TAN
26	COASTAL SENTRY	TELEMETRY	8	11	CSQ
27	CANTON ISLAND	TELEMETRY	14	11	CTN

3.1.2 GSFC RESPONSIBILITIES

GODDARD HAS RESPONSIBILITY FOR THE OPERATION, MAINTENANCE, MODIFICATION, AND AUGMENTATION OF TRACKING AND DATA ACQUISITION FACILITIES IN THE MSFN. IN ADDITION, GODDARD OPERATES THE OVERALL NASA COMMUNICATIONS NETWORK (NASCOM) WHICH LINKS 89 WORLD-WIDE STATIONS INTO ONE NETWORK. THE COMMUNICATIONS CENTER AT GODDARD IS A SWITCHING AND RELAY CENTER CAPABLE OF ACCEPTING MESSAGES FROM ALL SITES AND AUTOMATICALLY RELAYING THEM TO THE MCC. IN ADDITION, ANY SITE CAN WORK THROUGH THE CENTER TO ALL OTHER SITES, AND DATA FROM RADAR STATIONS CAN BE RELAYED DIRECT TO THE GODDARD COMPUTERS. MESSAGES MAY ALSO BE RELAYED FROM THE CONTROL AND SPACE FLIGHT COMMUNICATIONS CENTERS TO ANY SITE OR TO ALL SITE SIMULTANEOUSLY. THE CENTER ALSO PROVIDES MEMORY FOR MESSAGE STORAGE, ANALYZES LINE READINESS, AND PROVIDES ROUTINE SYSTEM STATUS INFORMATION.

3.1.3 VOICE COMMUNICATIONS

THE NETWORK'S VOICE COMMUNICATIONS ARE ALSO CONTROLLED AND SWITCHED FROM GODDARD. A SWITCHBOARD SYSTEM WITH MULTIPLE DUAL-OPERATING CONSOLES ENABLES ONE OPERATOR TO DEVOTE FULL ATTENTION TO ANY SPECIAL MISSION CONFERENCES. THIS SYSTEM IS CALLED STATION CONFERENCING AND MONITORING ARRANGEMENT II (SCAMAII). BOTH POINT-TO-POINT CONNECTIONS AND CONFERENCE ARRANGEMENTS ARE POSSIBLE.

3.1.4 TRACKING RADARS

FOUR TYPES OF RADARS ARE PRIMARILY USED AT THE MSFN SITES - VERLORT, FPS-16, TPQ-18, AND FPQ-6. THE VERLORT HAS GREATER RANGE CAPABILITY THAN THE FPS-16, BUT THE FPS-16 IS MORE ACCURATE AT CLOSE RANGE. THE FPQ-6 HAS

BOTH GREATER RANGE AND MORE ACCURACY THAN THE OTHER TWO. FOR A SITE HAVING TWO TYPES OF RADARS, THE NORMAL TRACKING AND DATA TRANSMISSION PROCEDURE IS AS FOLLOWS. THE VERLORT STARTS ITS ACTIVE TRACKING FIRST, AND A MANUAL SWITCH IS USED TO SELECT THE DATA FOR TTY TRANSMISSION. AS THE SPACECRAFT COMES WITHIN RANGE OF THE FPS-16 OR FPQ-6 RADAR, THE SWITCH IS TURNED TO SELECT FPS-16 (FPQ-6) WHILE THE VERLORT CONTINUES TRACKING. WHEN THE SPACECRAFT GOES OUT OF FPS-16 (FPQ-6) RANGE, THE DATA TRANSMITTER IS SWITCHED BACK TO VERLORT. ALL THE DATA TRANSMITTED, AS WELL AS VERLORT DATA FOR THE ENTIRE RANGE, IS RECORDED ON PAPER TAPE IN 5-CHANNEL CODE. IF THE INITIAL TRANSMISSION OF DATA IS UNSATISFACTORY, GODDARD MAY REQUEST RETRANSMISSION. IN THIS CASE, A SITE EQUIPPED WITH BOTH VERLORT AND FPS-16 (FPQ-6) RADARS TRANSMITS ONLY THE VERLORT DATA FOR THE ENTIRE RANGE.

3.2 CAPE KENNEDY INSTALLATIONS

3.2.1 B-GE COMPLEX

THE B-GE COMPLEX INCLUDES A GENERAL ELECTRIC GUIDANCE SYSTEM AND A BURROUGHS A-1 COMPUTER. THE GE GUIDANCE SYSTEM SUPPLIES ATLAS OR TITAN II MISSILE RAW DATA TO THE BURROUGHS A-1 COMPUTER, WHICH COMPUTES PARAMETERS USED IN SPACECRAFT GUIDANCE AND FLIGHT EVALUATION. A MILGO HIGH SPEED BUFFER AND RETRANSMITTER ACCEPTS 24-BIT PARALLEL DATA TRANSFERS FROM THE BURROUGHS A-1 COMPUTER, AND ACCEPTS A SERIAL TRANSFER OF THE DATA FROM THE MCC TELEMETRY EVENT BUFFER. THE BUFFER AND RETRANSMITTER SERIALLY RETRANSMITS ALL DATA TO GSFC WITH DUPLEXED TRANSMITTERS OVER TWO LINES, AND RETRANSMITS SELECTED DATA BACK TO THE MCC OVER ONE LINE. RETRANS-

MISSION IS AT 1003 BITS/SECOND. THE TIME BETWEEN START OF RETRANSMISSIONS, UNDER BURROUGHS COMPUTER CONTROL, IS 500 MILLISECONDS.

3.2.2 IP BUILDING

THE IP COMPUTERS IN THE IP (IMPACT PREDICTOR) COMPUTER BUILDING ACCEPTS AND PROCESSES RAW DATA FROM THE AIR FORCE EASTERN TEST RANGE (ETR) RADARS. A MILGO HIGH SPEED BUFFER AND RETRANSMITTER ACCEPTS 36-BIT PARALLEL TRANSFERS FROM THE IP COMPUTER, AND ACCEPTS THE SERIAL TRANSFER OF DATA FROM THE MCC TELEMETRY EVENT BUFFER. THE BUFFER AND RETRANSMITTER SERIALLY RETRANSMITS ALL DATA TO GSFC WITH DUPLEXED TRANSMITTERS OVER TWO LINES AT 1003 BITS/SECOND. THE TIME BETWEEN THE START OF TRANSMISSIONS IS APPROXIMATELY 400 MILLISECONDS.

3.2.3 MISSION CONTROL CENTER

DURING LAUNCH, BUFFERING AND TRANSMITTING EQUIPMENT AT THE MISSION CONTROL CENTER (MCC) ACCEPTS DATA FROM THE SPACECRAFT TELEMETRY RECEIVER AND, TOGETHER WITH EVENT OR OVERRIDE SIGNALS FROM SEVERAL DISPLAY CONSOLES, TRANSMITS THE DATA VIA HIGH-SPEED CIRCUITS TO THE B-GE COMPLEX AND THE IP BUILDING FOR PROCESSING AND RETRANSMISSION TO GSFC.

DURING ORBIT AND REENTRY PHASES, RAW RADAR BUFFERING AND TRANSMITTING EQUIPMENT RECEIVES DATA FROM THE ETR RADARS AND FORMATS IT FOR TRANSMISSION OVER 100 WORD/MINUTE TTY CIRCUITS TO THE GSFC COMPUTERS. DATA IS PROCESSED AT GSFC AND THEN RETURNED TO THE MCC FOR ANALYSIS AND DISPLAY.

DATA RECEIVERS AT THE MCC ACCEPT THE GSFC DATA OVER TELEPHONE LINES AND CONVERT THESE SIGNALS TO DIGITAL IN-

FORMATION. BUFFER REGISTERS STORE RECEIVED INFORMATION UNTIL IT CAN BE DISPLAYED. DIGITAL-TO-ANALOG CONVERTERS PROVIDE ANALOG REPRESENTATIONS OF THE DIGITAL QUANTITIES FOR THE X-Y PLOTBOARDS. SWITCHING EQUIPMENT ENABLES DATA FROM EITHER THE GSFC COMPUTERS OR THE B-GE COMPUTER TO BE SELECTED FOR DISPLAY ON THE PLOTBOARDS AND DISPLAY CONSOLES.

3.3 BERMUDA COMPLEX

TWO RADARS AT BERMUDA PRODUCE DATA FOR USE BY THE GSFC COMPUTERS, AN FPS-16 (MODIFIED) -RADAR AND A VERLORT RADAR.

THE FPS-16 (MODIFIED) RADAR PRODUCES 17 BITS OF AZIMUTH, 17 BITS OF ELEVATION, 25 BITS OF RANGE, AND AN ON-TRACK BIT EVERY TENTH OF A SECOND, AND SENDS THIS DATA TO A MILGO 4008-T RADAR DATA TRANSMITTER. THE RADAR DATA TRANSMITTER REFORMATS THIS DATA WITH 20 BITS OF TIME AND A 1-SECOND MARK FROM THE LOCAL TIME STANDARD, AND SERIALLY TRANSMITS IT BY THE FREQUENCY SHIFT KEYING (FSK) METHOD TO THE MILGO 1013-1A RADAR BUFFERS AT 1000 BITS/ SECOND. THE SAME FPS-16 (MODIFIED) RAW DATA, PLUS A C-BAND BEACON IDENTIFICATION TO TELL IF THE RADAR IS TRACKING THE GEMINI SPACECRAFT OR THE AGENA TARGET VEHICLE, IS RETRANSMITTED BY A MILGO 165 DIGITAL-TO-TTY CONVERTER AS A 38-CHARACTER TTY MESSAGE AT 100 WORDS/ MINUTE EVERY SIX SECONDS TO THE RADAR DATA CONTROL UNIT. THIS UNIT CONTROLS THE SELECTION OF THE TRANSMITTER THAT OUTPUTS TO GSFC OVER THE 100 WORD/MINUTE TTY CIRCUIT.

THE VERLORT RADAR PRODUCES 16 BITS OF AZIMUTH, 16 BITS OF ELEVATION, 19 BITS OF RANGE AND AN ON-TRACK BIT EVERY TENTH OF A SECOND. THIS DATA IS SENT IN PARALLEL TO A SECOND MILGO 4008-T RADAR DATA TRANSMITTER. THE TRANS-

MITTER REFORMATS THIS DATA WITH 20 BITS OF TIME AND A 1-SECOND MARK FROM THE LOCAL TIME STANDARD AND SERIALLY TRANSMITS THIS DATA BY THE FSK METHOD TO THE BERMUDA RADAR BUFFERS (MILGO 1013-1A) AT 1000 BITS/SECOND. THE SAME VERLORT RAW DATA, PLUS AN S-BAND BEACON IDENTIFICATION TELLING IF THE RADAR IS TRACKING THE GEMINI SPACECRAFT OR THE AGENA TARGET VEHICLE, IS SENT IN PARALLEL TO A SECOND MILGO 165 DIGITAL-TO-TTY CONVERTER WHICH RETRANSMITS IT AS A 34-CHARACTER TTY MESSAGE AT 100 WORDS-MINUTE EVERY SIX SECONDS TO RADAR DATA CONTROL UNIT.

THE MILGO 1013-1A BERMUDA RADAR BUFFERS RECEIVE VERLORT AND FPS-16 RADAR DATA FROM THE MILGO 4008-T DATA TRANSMITTERS. THE INCOMING DATA IS MERGED WITH INDEPENDENT-TONE DATA, IS PROPERLY FORMATTED, COMBINED WITH THE CONTROL AND ERROR CODE DATA, AND SENT BY THE RADAR BUFFER TO THE BELL 201A DATA TRANSMITTERS (SUBSETS 201A) FOR ENCODING AND TRANSMISSION OVER LANDLINE AND SUBMARINE CABLE TO GSFC. TWO INDEPENDENT DATA CHANNELS ARE PROVIDED IN THE RADAR BUFFER, EACH TRANSFERRING TO ITS OWN DATA TRANSMITTER AND TRANSMISSION LINE. IDENTICAL DATA IS PROCESSED BY EACH BUFFER CHANNEL.

3.4 DATA ACQUISITION AND INPUTS TO GSFC

THE COMMAND POINT AND HEADQUARTERS OF THE GEMINI PROJECT (UP TO GT-3) IS THE MISSION CONTROL CENTER (MCC) AT CAPE KENNEDY. (COMMENCING WITH THE GT-4 MISSION, CONTROL WILL BE FROM THE MCC, HOUSTON TEXAS.) CONTROLLERS, AEROMEDICAL SPECIALISTS, AND OTHER PERSONS HAVING SPECIALIZED RESPONSIBILITIES PERFORM THEIR DUTIES IN THE CONTROL CENTER. DECISIONS AFFECTING THE ASTRO-

NAT'S SAFETY AND THE STATUS OF THE FLIGHT ARE MADE HERE. FROM THE CONTROL CENTER DISPLAY CONSOLES, PLOTBOARDS, STRIP CHARTS, AND MAPS, PROJECT PERSONNEL ARE ABLE TO DERIVE INFORMATION TO AID IN EVALUATING THE MISSION'S PROGRESS AND TO INITIATE THE NORMAL OR EMERGENCY COMMANDS NECESSARY TO ENSURE THE BEST POSSIBLE LEVEL OF MISSION SUCCESS.

THE FUNCTIONS AT CAPE KENNEDY ARE NOT ALL ASSOCIATED DIRECTLY WITH THE MCC AND VEHICLE LAUNCH OPERATIONS. SOME CAPE ACTIVITIES AND FUNCTIONS ARE CHANNELED THROUGH INTERMEDIATE STEPS BEFORE THEY CAN BE EMPLOYED DIRECTLY IN CONTROL CENTER OPERATIONS. CONTINUOUSLY UPDATED POSITION AND VELOCITY PARAMETERS, THE TIME AT WHICH RETROFIRE MUST OCCUR TO BRING THE SPACECRAFT DOWN IN A PREDESIGNATED RECOVERY ZONE, AND MANY OTHER CRITICAL CONTROL QUANTITIES ARE DETERMINED FROM MANY SOURCE INPUTS BY THE GODDARD IBM 7094 COMPUTERS AND TRANSMITTED OVER HIGH-SPEED LINES TO THE CONTROL CENTER AT CAPE KENNEDY. THE 7094'S SUPPLY CALCULATED VALUES NEEDED TO SUPPORT ALL FUNCTIONS OF THE OVERALL GEMINI OPERATION. THESE VALUES DRIVE DISPLAY DEVICES OF ALL TYPES, PROVIDE ACQUISITION DATA TO ENABLE CONTINUOUS TRACKING OF THE SPACECRAFT, AND MAINTAIN GROUND SYSTEM COORDINATION THROUGHOUT ALL PHASES OF THE FLIGHT.

SEVERAL DATA GATHERING, PROCESSING, AND TRANSMITTING SYSTEMS AT CAPE KENNEDY AND ITS DOWNRANGE COMPLEX FEED INFORMATION TO THE COMPUTING CENTER AT GODDARD TO BE PROCESSED AND ROUTED BACK TO THE CONTROL CENTER AND THE OTHER STATIONS OF THE WORLDWIDE SITE NETWORK. THESE EQUIPMENT ARRAYS TRACK THE VEHICLE/SPACECRAFT IN ITS FLIGHT (ESSENTIALLY DURING ONLY THE PERIOD FROM LIFTOFF UNTIL INSERTION INTO ORBIT), CONSTANTLY TAKE POSITIONAL

MEASUREMENTS, RECEIVE TELEMETERED SIGNALS FROM THE VEHICLE/SPACECRAFT CONCERNING MISSION SUBPHASES AND ASTRONAUT/VEHICLE/SPACECRAFT CONDITIONS, AND PASS THIS ACCUMULATED DATA AT HIGH SPEED TO THE IBM 7094 COMPUTERS.

3.4.1 EASTERN TEST RANGE RADAR

RADAR FACILITIES OF THE PRE-EXISTING CAPE KENNEDY DOWNRANGE COMPLEX SERVE AS PRIME SOURCES OF DATA DURING THE EARLY STAGES OF A GEMINI MISSION. AS IS THE CASE FOR OTHER CAPE KENNEDY DATA-SOURCE COMPONENTS, CAPE KENNEDY RADARS ARE UTILIZED MOST EFFECTIVELY DURING THE LAUNCH PHASE OF THE MISSION. FOUR SPECIFIC TRACKING SYSTEMS ARE USED -

TRACKING SYSTEM	LOCATION
AZUSA	CAPE KENNEDY
MISTRAM	CAPE KENNEDY
AN/FPS-16	CAPE KENNEDY
AN/FPS-16	GRAND BAHAMA ISLAND
AN/FPS-16	PRETORIA
FPQ-6	ANTIGUA
TPQ-18	GRAND TURK, ASCENSION

3.4.1.1 LAUNCH

DURING LAUNCH, EACH SITE TAKES RANGE, AZIMUTH, AND ELEVATION MEASUREMENTS ON THE LAUNCH VEHICLE/SPACECRAFT, REFERENCED TO THAT PARTICULAR RADAR INSTALLATION. THESE ACCUMULATED VALUES ARE SENT BY A HIGH-SPEED, REAL-TIME DATA TRANSMISSION SYSTEM TO THE IP (IMPACT PREDICTOR) BUILDING AT CAPE KENNEDY WHERE THEY ARE ACCEPTED AS INPUTS FOR PROCESSING BY THE IP COMPUTER. THE COMPUTER-SMOOTHED POSITION/TIME/VELOCITY COORDINATES, FROM AZUSA AND C-BAND SOURCES, ARE INTERLEAVED WITH TELEMETRY IN-

FORMATION, A TIME TAG, AND A SITE IDENTIFICATION CODE IN THE IP HIGH-SPEED MESSAGE TO THE GODDARD CENTER.

AN AZUSA BEACON LOCATED IN THE GEMINI LAUNCH VEHICLE ALSO TRANSMITS SIGNALS AS INPUTS TO THE IP COMPUTER FOR VEHICLE TRACKING AND IMPACT PREDICTION. THUS, TWO SEPARATE SETS OF INFORMATION MAY BE CHANNELED (ONE AT A TIME) THROUGH IP FACILITIES DURING THE LAUNCH PERIOD - IP-PROCESSED AZUSA DATA AND IP-PROCESSED C-BAND DATA. AFTER SPACECRAFT SEPARATION AZUSA DATA IS NO LONGER AVAILABLE TO GODDARD.

3.4.1.2 ORBIT AND REENTRY.

RADAR DATA FROM DOWNRANGE SITES PLAYS ITS MOST SIGNIFICANT ROLE DURING THE LAUNCH PHASE. THE EFFECTIVE APPLICATION OF CAPE KENNEDY RADAR INFORMATION CEASES AT SPACECRAFT INSERTION INTO ORBIT - AFTER INITIAL ORBITAL PARAMETERS ARE ESTABLISHED BY THE GODDARD 7094 COMPUTERS FROM CAPE KENNEDY DATA. DATA FLOW FROM THE RADARS THROUGH THE IP COMPUTER TO GODDARD CONTINUES AFTER LAUNCH, BUT THIS INFORMATION IS IGNORED IN FAVOR OF READINGS FROM OTHER WORLDWIDE TRACKING STATIONS.

DURING ORBIT, THEIR DOWNRANGE RADARS FUNCTION AS NORMAL TRACKING NETWORK UNITS - THEY ACQUIRE THE SPACECRAFT ON EACH PASS OF THE NORMAL FLIGHT. RANGE AZIMUTH, AND ELEVATION MEASUREMENTS ARE TAKEN AS DURING LAUNCH, BUT THIS INFORMATION IS TRANSMITTED DIRECTLY TO GODDARD OVER LOW-SPEED TTY LINES INSTEAD OF THE IP HIGH-SPEED ROUTE. SENT AT A ONE-SAMPLE-EVERY-SIX-SECONDS SPEED, THE TTY MESSAGES CONTAINING POSITION INFORMATION ARE TIME TAGGED AND IDENTIFIED BY SITE.

THE DOWNRANGE RADAR READINGS BECOME CRITICALLY IMPORTANT DURING SPACECRAFT REENTRY AND RECOVERY IN A NOR-

MAL MISSION SITUATION SINCE THE PLANNED LANDING AREA IS WITHIN RANGE OF ONE OR MORE OF THE DOWNRANGE SITES. INFORMATION ROUTED AT LOW SPEED FROM EACH DOWNRANGE STATION DIRECTLY TO GODDARD IS EMPLOYED BY THE IBM 7094 COMPUTERS TO MAINTAIN REENTRY DISPLAYS AT CAPE KENNEDY.

3.4.2 IMPACT PREDICTOR COMPUTER

THE IP COMPUTERS, LOCATED IN THE IP BUILDING AT CAPE KENNEDY, UTILIZE AZUSA BEACON AND CAPE KENNEDY, GRAND BAHAMA ISLAND, OR ANTIQUA ISLAND RAW RADAR INPUTS OF RANGE, AZIMUTH, AND ELEVATION. UTILIZING COMPONENTS OF THE LAUNCH MONITOR SUBSYSTEM, THE COMPUTER MAKES ITS MOST IMPORTANT CONTRIBUTIONS TO MISSION SUCCESS IN REAL TIME DURING THE LAUNCH PERIOD.

IN ADDITION TO THE COMPUTER, THE IP BUILDING CONTAINS EQUIPMENT FOR ACCEPTING TELEMETRY DATA FROM THE MCC TO BE SENT TO GODDARD, AND FOR ACCEPTING EITHER CALCULATED POSITION AND VELOCITY INFORMATION FROM THE IMPACT PREDICTOR FROM THE DOWNRANGE C-BAND RADAR STATIONS. FACILITIES FOR BUFFERING AND RETRANSMITTING SELECTED DATA BY HIGH-SPEED LINES TO THE GODDARD CENTER ARE ALSO PROVIDED.

3.4.2.1 LAUNCH

FROM RAW-RADAR RANGE, AZIMUTH, AND ELEVATION INPUTS IN REAL TIME DURING LAUNCH, THE IP COMPUTER CONTINUALLY CALCULATES TRAJECTORY ALTITUDE OF APOGEE AND THE POINT WHERE THE VEHICLE WOULD IMPACT IF THRUST TERMINATED AT THAT INSTANT. THESE RESULTS ARE DISPLAYED TO THE RANGE SAFETY OFFICER AT CAPE KENNEDY TO ENABLE HIM TO EVALUATE THE PERFORMANCE OF A LAUNCH OPERATION. IN ADDITION, POSITION AND VELOCITY PARAMETERS ARE SENT OVER TWO HIGH-

SPEED LINES AS INPUTS FROM THE IMPACT PREDICTOR TO THE GODDARD COMPUTING AND COMMUNICATIONS CENTER.

THE IP FURNISHES PROCESSED DATA FROM THE C-BAND TRACKING SYSTEMS, DEPENDING ON WHICH DATA IS CHOSEN DURING THE LAUNCH PHASE. SELECTION OF THE TRACKING INFORMATION TO BE TRANSMITTED TO GODDARD IS UNDER CONTROL OF MCC OPERATORS. FROM THIS REAL-TIME PROCESSING OF RAW RADAR QUANTITIES, THE IP COMPUTER PRODUCES POSITION AND VELOCITY VECTORS DESCRIBING THE TRAJECTORY OF THE LAUNCH VEHICLE. BASED ON GEOCENTRIC INERTIAL COORDINATES, THE POSITION AND VELOCITY RATES ARE REDEFINED AT EACH COMPUTING INTERVAL AND TIME TAGGED WITH RANGE TIME.

SWITCHING OPTIONS BETWEEN THE IP COMPUTER AND ANY ONE OF THE OTHER ELEMENTS OF CAPE KENNEDY'S TRACKING SYSTEM GIVES RADAR AND DATA PROCESSING FLEXIBILITY TO THE GEMINI MISSION. A SIMULTANEOUS INPUT TO THE IBM 7094'S FROM THE B-GE TRACKING AND GUIDANCE SYSTEM FURTHER ENSURES THE AVAILABILITY OF RELIABLE INFORMATION DURING LAUNCH.

IP MESSAGES RECEIVED AT A TWO-PER-SECOND RATE BY GODDARD CONTAIN CALCULATED POSITION AND VELOCITY VECTORS, TELEMETRY INFORMATION FROM BOTH THE LAUNCH VEHICLE AND THE SPACECRAFT, AND CHECKSUM PARITY NOTATIONS TO VALIDATE TRANSMISSION ACCURACY. ADDED TO TRACKING VALUES ON THE IP MESSAGE, THE SIGNALS DERIVED FROM TELEMETRY SOURCES ARE TIME MULTIPLEXED IN REAL TIME ONTO THE TWO HIGH-SPEED TRANSMISSION LINES TO GODDARD.

IF A LAUNCH ABORT IS COMMANDED FROM THE GEMINI CONTROL CENTER, C-BAND DATA RATHER THAN IP AZUSA INFORMATION IS NORMALLY ACCEPTED BY THE GODDARD 7094'S. THESE ARE THE VECTORS FROM WHICH THE TIME FOR RETROFIRE AND THE IMPACT POINT ARE CALCULATED. IF IP C-BAND RADAR

DATA IS NOT AVAILABLE OR IS NOT SATISFACTORY, THE 7094'S APPLY PREVIOUS IP (OR B-GE) DATA TO COMPUTE THE ABORT LANDING POINT. SUCH BACKUP DATA IS NECESSARY SINCE, DURING LAUNCH ABORT, ONLY LAUNCH VEHICLE TRACKING VALUES ARE AVAILABLE. VEHICLE VELOCITY IS INCREMENTED BY POSIGRADE ROCKET FIRING IN THIS CASE, AND IP-PROCESSED QUANTITIES ARE ACCEPTED UNTIL RETROFIRE SIGNALS ARE RECEIVED, AT WHICH TIME THE REENTRY PHASE IS ENTERED.

THE CAPE KENNEDY EQUIPMENT WHICH RECEIVES, COMBINES, AND TRANSMITS COLLATED IP MESSAGES TO THE GODDARD COMPUTING AND COMMUNICATIONS CENTER IS THE HIGH-SPEED INPUT BUFFER AND DUAL DATA RETRANSMITTER. WITH AN EFFECTIVE EMPLOYMENT LASTING PRIMARILY DURING LAUNCH, THE DEVICE SIMULTANEOUSLY ACCEPTS TWO INPUTS, ONE FROM THE MISSION CONTROL CENTER TELEMETRY EVENT TRANSMITTING BUFFER, THE OTHER FROM THE IP COMPUTER. IT RETRANSMITS THE DATA AT 1003 BITS PER SECOND TO GODDARD. TIME BETWEEN THE START OF TRANSMISSIONS IS APPROXIMATELY 400 MILLISECONDS.

3.4.2.2 ORBIT AND REENTRY

AS PREVIOUSLY MENTIONED, THE IP COMPUTER PLAYS ITS MOST IMPORTANT ROLE DURING THE GEMINI FLIGHT'S LAUNCH AND INSERTION PHASE. THE IMPACT PREDICTOR'S DATA COLLECTING, PROCESSING, AND TRANSMITTING FUNCTIONS DO NOT STOP AFTER LAUNCH BUT, AS THE SPACECRAFT BEGINS ITS ORBITAL FLIGHT AND AS LOW-SPEED MESSAGES BEGIN TO ARRIVE FOR PROCESSING BY GODDARD, THE NEED FOR CAPE KENNEDY HIGH-SPEED INPUTS TO THE IBM 7094'S CEASES. AT THE SPACECRAFT'S INSERTION INTO ORBIT, THE IP ESTABLISHES INITIAL ORBITAL ELEMENTS FROM DOWNRANGE-ACQUIRED RADAR RANGE, AZIMUTH, AND ELEVATION MEASUREMENTS. FROM THEN ON AND FOR THE REMAINDER

OF THE MISSION, IP HIGH-SPEED MESSAGES ARE NOT USED BY THE GODDARD CENTER.

3.4.3 BURROUGHS-GENERAL ELECTRIC (B-GE) GUIDANCE SYSTEM COMPUTER

THIS SPECIAL-PURPOSE COMPUTER, OPERATING WITH RADAR AND TELEMETRY DATA RECEIVED FROM THE LAUNCH VEHICLE, TRACKS A BEACON IN THE VEHICLE, CHECKS FLIGHT TRAJECTORY, AND GENERATES THE COMMANDS NECESSARY TO ACHIEVE OPTIMUM LAUNCH AND INSERTION PERFORMANCE. AS PART OF THE LAUNCH PHASE GUIDANCE SYSTEM, IT PLAYS AN EXTREMELY CRITICAL ROLE IN GEMINI MISSION LAUNCH SEQUENCE MONITORING AND CONTROL. THE B-GE SYSTEM IS EQUIPPED TO TRACK THE LAUNCH VEHICLE, NOT THE SPACECRAFT, THEREFORE, IT DETERMINES MISSION FLIGHT AND SPEED PROFILES ONLY UNTIL A FEW SECONDS AFTER SPACECRAFT SEPARATION OCCURS.

THE B-GE BUILDING, WHICH HOUSES THE COMPUTER, CONTAINS EQUIPMENT CAPABLE OF RECEIVING DATA FROM THE COMPUTER AND OF RETRANSMITTING IT TO THE GSFC CENTER AND OTHER PROJECT ACTIVITIES WHICH UTILIZE B-GE INFORMATION.

FOR ALL PURPOSES AFFECTING MISSION EVALUATION AND CONTROL, THE COMPUTER IS OPERATIONAL ONLY DURING LAUNCH WHEN IT CONVERTS RAW TRACKING VALUES INTO COMPUTED POSITION AND VELOCITY VECTORS (GEOCENTRIC INERTIAL COORDINATE SYSTEM REDEFINED IN TIME AT EACH PROCESSING CYCLE) DESCRIBING THE LAUNCH VEHICLE'S TRAJECTORY. THESE QUANTITIES, AND TIME-OF-TRANSMISSION NOTICES, ARE SENT CONTINUALLY IN REAL TIME OVER TWO HIGH-SPEED (1000 BITS PER SECOND) DATA CIRCUITS TO THE GODDARD COMPUTING AND COMMUNICATIONS CENTER, WHERE THEY ARE PROCESSED TO OBTAIN PERTINENT INFORMATION FOR DISPLAY AND MISSION CONTROL PURPOSES.

CERTAIN VALUES DERIVED FROM SPACECRAFT AND VEHICLE TELEMETRY SIGNALS, AND FROM OTHER SOURCES, ARE ADDED TO THE TRACKING MESSAGE SENT TO GODDARD BY TIME-MULTIPLEXING THEM ONTO THE HIGH-SPEED LINES. THESE ESSENTIAL QUANTITIES, CALLED DISCRETES, ARE CONTAINED IN A MESSAGE WORD WHICH 1) INDICATES THE STATUS OF MISSION SUBPHASES - LIFTOFF, FIRST STAGE ENGINE CUTOFF AND SECOND STAGE ENGINE CUTOFF (SECO) - AND 2) INDICATES WITH DATA FLAGS THE QUALITY OF THE CONSTANTLY UPDATED STATUS OF B-GE CALCULATIONS. A CHECKSUM INDICATION, ALSO CONTAINED IN B-GE-TO-GODDARD INFORMATION, IS RECEIVED BY THE IBM 7094 COMPUTERS TO VALIDATE MESSAGE ACCURACY AND DATA BIT TOTALS.

ELAPSED TIME READINGS FOR SEVERAL EVENTS ARE CONTINUOUSLY TRANSMITTED TO GODDARD DURING THE LAUNCH PERIOD. ALSO REQUIRED IS AN UPDATING INTERVAL (DETERMINED BY THE B-GE SYSTEM) WHICH IS TRANSMITTED BY TELETYPE BEFORE LIFTOFF AND MANUALLY INSERTED INTO THE GODDARD COMPUTERS. AS PREVIOUSLY MENTIONED, THE B-GE TRACKING AND GUIDANCE SYSTEM ENSURES THE AVAILABILITY OF RELIABLE INFORMATION DURING LAUNCH. THUS, IF B-GE DATA TRANSMISSION FAILS OR IS DETERMINED TO BE INACCURATE FOR ANY REASON, IP MESSAGES CAN BE SELECTED TO SUPPLY BACKUP POSITION/TIME/VELOCITY VALUES.

THE GODDARD IBM 7094 COMPLEX COMPUTES A COMPLETE SET OF INFORMATION FROM EITHER IP OR B-GE INPUT DATA, THE DESIRED DATA INPUT TO THE IBM 7094'S IS SELECTED AT THE MISSION CONTROL CENTER AND THE SUBSEQUENT CHOICE TRANSMITTED TO GODDARD. ADDITIONALLY, PARTICULAR PORTIONS OF B-GE OUTPUT ARE CHANNELED BY REMOTE MEANS DIRECTLY TO DISPLAY DEVICES AT THE CONTROL CENTER RATHER THAN TO THE MAIN COMPUTING CENTER. A TWO-INCH LIFTOFF NOTIFICATION TELEMETERED FROM THE LAUNCHING PAD IS SENT TO GODDARD AND

TO MISSION CONTROL CENTER DIGITAL DISPLAY CONSOLES. TRACKING DATA ACCUMULATED BY THE B-GE COMPUTER AND INFORMATION FROM THE MISSION CONTROL CENTER'S TELEMETRY EVENT TRANSMITTING BUFFER ENTERS A HIGH-SPEED INPUT BUFFER AND DUAL DATA RETRANSMITTER DIRECTLY FROM THE TWO SOURCES. HERE THE B-GE MESSAGES ARE COMPOSED AND COMMITTED TO THE TWO HIGH-SPEED LINES TO BE TRANSMITTED IN SERIAL FORM TO THE COMPUTING CENTER AT GODDARD. CONTROLLED BY THE B-GE SYSTEM, INTERVALS BETWEEN STARTS OF CONSECUTIVE TRANSMISSIONS ARE USUALLY 500 MILLISECONDS, WITH 100 MILLISECONDS BETWEEN THE FINISH OF ONE AND THE START OF THE NEXT.

3.4.4 TELEMETRY

TELEMETRY SIGNALS FROM THE LAUNCH PAD, THE LAUNCH VEHICLE, AND THE SPACECRAFT INDICATE THE STATUS OF MISSION SUBPHASES AND CERTAIN CRITICAL EVENTS WHICH HAPPEN, OR FAIL TO HAPPEN, DURING A GEMINI FLIGHT. THESE SIGNALS, PICKED UP BY TELEMETRY RECEIVERS AND CONVERTED TO FORMS USEFUL FOR DISPLAY INTERPRETATION AND AS INPUTS TO THE GODDARD IBM 7094 COMPUTERS, ARE EXTREMELY IMPORTANT INDICATORS OF EVENTS AND CONDITIONS REGARDING THE SPACECRAFT AND THE VEHICLE, THE ASTRONAUT'S STATE OF BEING, AND OTHER FACTORS VITAL TO A SUCCESSFUL MISSION.

3.4.4.1 LAUNCH

TELEMETRY INFORMATION FROM CAPE KENNEDY IS OF GREATEST IMPORTANCE DURING THE MISSION'S LAUNCH PHASE, I.E., FROM VEHICLE LIFTOFF UNTIL SPACECRAFT INSERTION OR PASSAGE BEYOND CAPE KENNEDY RADAR RANGE. DURING THIS PERIOD, VIRTUALLY ALL REAL-TIME DATA ENTERING THE GODDARD COMPUTERS IS RECEIVED FROM COLLECTING, PROCESSING, AND

TRANSMITTING EQUIPMENT AT CAPE KENNEDY.

TELEMETRY SIGNALS ARE TRANSMITTED FROM THREE SOURCES - LAUNCHING PAD, LAUNCH VEHICLE, AND THE SPACECRAFT. FOR EXAMPLE, THE SPACECRAFT TELEMETRY RECEIVER LOCATED AT CAPE KENNEDY ACCEPTS A NUMBER OF TELEMETERED MISSION PARAMETERS FROM A TELEMETRY TRANSMITTER IN THE SPACECRAFT. FROM THESE SIGNALS, OR ''MESSAGES,'' CONCERNING THE ASTRONAUT'S CONDITION, SPACECRAFT ENVIRONMENT AND EQUIPMENT, AND THE STATUS OF SELECTED DISCRETE EVENTS, GEMINI COMPUTATIONAL FACILITIES UTILIZE ONLY THAT LAUNCH DATA CONCERNING SPACECRAFT EQUIPMENT AND ''ONE-TIME'' EVENTS. AEROMEDICAL FACTS OF INTEREST, AND OTHER OCCURRENCES, ARE DISPLAYED DIRECTLY TO THOSE PERSONS CHARGED WITH SPECIFIC ASPECTS OF THE MISSION NOT PERTINENT TO LAUNCH CONTROL COMPUTATION.

TELEMETRY EVENT SIGNALS ARE RECEIVED FROM THE SPACECRAFT/VEHICLE AND ARE EITHER TRANSMITTED DIRECTLY TO THE GODDARD CENTER OR PROCESSED/DISPLAYED AND THEN SENT TO GODDARD. (CERTAIN TELEMETRY EVENT VALUES ARE ALSO MANUALLY INSERTED INTO THE IBM 7094 COMPUTERS. THEY ARE DISCUSSED LATER IN THIS SECTION.) THE TELEMETRY EVENT QUANTITIES ARE -

TELEMETRY EVENT	SOURCE
TWO-INCH LIFTOFF	LAUNCH PAD
FIRST STAGE ENGINE CUTOFF	B-GE COMPUTER
FIRST STAGE SEPARATION	LAUNCH VEHICLE T/M
SECOND STAGE ENGINE CUTOFF COMMAND (SECO)	B-GE COMPUTER
SPACECRAFT SEPARATION (SPS)	SPACECRAFT T/M
OAMS IGNITED	SPACECRAFT T/M

C

ABORT SEQUENCE INITIATED	SPACECRAFT T/M
RETROGRADES FIRED (1, 2, OR 3)	MISSION CONTROL CENTER
DATA SOURCE SELECTED BY GODDARD COMPUTERS	MISSION CONTROL CENTER
ORBIT PHASE	MISSION CONTROL CENTER
ABORT PHASE	MISSION CONTROL CENTER

A DUPLEXED TELEMETRY EVENT TRANSMITTING BUFFER UNIT LOCATED IN THE TEL-3 BUILDING AT CAPE KENNEDY RECEIVES TELEMETRY SYSTEM DATA FROM THE CAPE'S TLM-18 TELEMETRY-RECEIVING ANTENNAS, FROM OTHER TELEMETRY RECEIVERS AND DEMODULATORS, AND FROM DATA TRANSMISSION EQUIPMENT AT THE DOWNRANGE SITES. GRAND BAHAMA ISLAND DETERMINES WHICH DOWNRANGE TELEMETRY INFORMATION IS TO BE RECEIVED AT THE TEL-3 BUILDING. EITHER GRAND BAHAMA OR GRAND TURK TELEMETRY IS THEN FORWARDED ACCORDING TO ITS RELATIVE STRENGTH. TAPE RECORDS ARE KEPT OF THE RECEIVED SIGNALS AT BOTH LOCATIONS TO ALLOW POSTMISSION EXAMINATION.

EACH OF THE DUPLEXED UNITS IN THE TELEMETRY EVENT TRANSMITTING BUFFER TRANSMITS SPACECRAFT ELAPSED TIME, RETROFIRE SETTING, AND OTHER SINGLE EVENT AND HUMAN-DECISION DATA TO ONE OF TWO POINTS. ONE OF THE DUPLEXED BUFFERS SERIALLY TRANSMITS INFORMATION TO THE B-GE COMPLEX. THE OTHER BUFFERS SEND DATA TO THE IP BUILDING. EITHER BUFFER IS CAPABLE OF TRANSMITTING TO B-GE OR IP RECEIVING FACILITIES.

TELEMETRY INFORMATION IS ADDED TO B-GE POSITIONAL VALUES AND IP SMOOTHED DATA THROUGH EACH (B-GE AND IP) BUILDING'S RESPECTIVE INPUT BUFFER AND DUAL DATA RETRANS-

MITTER. THE RESULTANT MESSAGES CONTAINING B-GE TM AND IP TM DATA ARE SENT OVER TWO PAIRS OF HIGH-SPEED LINES TO THE GODDARD IBM 7094 COMPUTERS FOR REAL-TIME PROCESSING.

3.4.4.2 ORBIT

CAPE TELEMETRY INFORMATION TRANSMITTED WITH RADAR DATA FROM B-GE AND IP FACILITIES IS, AS OTHER HIGH-SPEED CAPE KENNEDY INPUTS TO GODDARD, IGNORED BY THE IBM 7094'S IN FAVOR OF OTHER TELEMETRY INPUTS DURING THE SPACE-CRAFT'S ORBITAL FLIGHT. THE GRAND BAHAMA ISLAND AND GRAND TURK ISLAND DOWNRANGE SITES, HOWEVER, ASSUME ROLES AS NORMAL TELEMETRY RECEIVING STATIONS DURING THIS PERIOD. TELEMETRY SUMMARIES CONSISTING OF READINGS CONCERNING THE CONDITION OF THE ASTRONAUT AND THE SPACECRAFT ARE COM-POSED AT EACH SITE BY INTERPRETING DISPLAYED TELEMETRY DATA AND CONVERTING THIS INFORMATION INTO SHORT TTY MESSAGES. THE MESSAGES ARE SENT AT A 60-WORDS-PER-MINUTE RATE DIRECTLY TO THE COMMUNICATIONS CENTER AT GODDARD.

3.4.4.3 REENTRY

NORMAL SPACECRAFT REENTRY TAKES PLACE IDEALLY WITH-IN TELEMETRY RECEPTION RANGE OF CAPE KENNEDY DOWNRANGE STATIONS. UNDER NORMAL CIRCUMSTANCES (OR UNDER EMERGENCY CONDITIONS IF THE FLIGHT ABORTS IN THE AREA), TTY TELE-METRY SUMMARY MESSAGES FROM THE DOWNRANGE SITES INCLUDE INFORMATION CONFIRMING THAT RETROROCKETS HAVE BEEN FIRED, THE TIME AT WHICH EACH ROCKET WAS FIRED, AND, IF POSSIBLE, SPACECRAFT ATTITUDE ANGLE AT THE TIME OF EACH FIRING.

RETROFIRE INFORMATION CANNOT BE OBTAINED IN REAL TIME UNLESS IT OCCURS DIRECTLY OVER A STATION. HOWEVER, THERE IS NO REQUIREMENT FOR THIS DATA ON AREAL-TIME

BASIS. IN A NORMAL REENTRY, THE TIME TO RETROFIRE IS COMPUTED AND SET PRIOR TO ACTUAL FIRING. IF AN EARLY REENTRY IS NECESSARY FOR ANY REASON, TELEMETRY MESSAGES FROM REMOTE SITES BECOME ESPECIALLY IMPORTANT TO SPACECRAFT IMPACT PREDICTION AND SAFE RECOVERY.

3.4.5 GEMINI TRACKING SITES

RADARS LOCATED THROUGHOUT THE WORLDWIDE TRACKING NETWORK ACCURATELY ''READ'' AND PINPOINT THE SPACECRAFT'S POSITION FROM THE TIME THE VEHICLE IS LAUNCHED UNTIL THE SPACECRAFT'S RETURN TO EARTH. BEACON SIGNALS CONSTANTLY TRANSMITTED FROM THE SPACECRAFT ARE AUTOMATICALLY TRACKED BY HIGH-PRECISION RADARS TO ESTABLISH RANGE, AZIMUTH, AND ELEVATION MEASUREMENTS RELATIVE TO EACH SITE. THE ACCUMULATED POSITION PARAMETERS ARE FORWARDED TO THE GODDARD IBM 7094 COMPUTERS TO BE COMBINED WITH OTHER TRACKING READINGS AND BE PROCESSED. FROM THIS INPUT FLOW OF TRACKING DATA, THE IBM 7094 COMPUTERS DETERMINE AND CONTINUOUSLY UPDATE THE SPACECRAFT'S PRESENT POSITION AND PREDICTED FLIGHT PATH. THE PREDICTED FLIGHT PATH INFORMATION IS RELAYED FROM GODDARD TO THE NEXT RADAR SITE UNDER THE SPACECRAFT'S PATH TO ENABLE THAT SITE TO POINT ITS RADAR AT THE SPACECRAFT - ''ACQUIRE'' THE SPACECRAFT - AS IT MOVES TOWARD THE SITE. THE GEMINI TRACKING REQUIREMENT IS, THEREFORE, LARGELY A CONTINUING CHAIN OF DATA-ROUTING FUNCTIONS-FROM THE RADAR TO THE COMPUTER AND ON TO THE NEXT RADAR, REPEATED OVER AND OVER DURING THE MISSION. THE GROUND SYSTEM PROVIDES CONTINUOUS HIGH-SPEED TRACKING DURING LAUNCH AND INSERTION - TO ENABLE THE SYSTEM'S COMPUTER COMPLEXES TO ESTABLISH INITIAL ORBIT TRAJECTORY PARAMETERS. DURING ORBITAL FLIGHT AN INTERMITTENT LOW-SPEED FLOW OF TRACKING

VALUES IS REQUIRED TO COMPUTE SPACECRAFT POSITION AND SPEED AND TO CALCULATE THE OPTIMUM TIME TO BEGIN REENTRY. CONTINUOUS RADAR DATA IS PROVIDED, IF POSSIBLE, TO THE COMPUTERS DURING THE REENTRY PORTION OF THE FLIGHT TO ACCURATELY LOCATE WHERE THE SPACECRAFT WILL IMPACT. PRINCIPAL TYPES OF PRECISION TRACKING RADARS ARE AN/FPS-16, AN/FPQ-6 AND VERLORT - ALL USED IN PROJECT GEMINI TRACKING. ALL RADAR-EQUIPPED RANGE STATIONS EXCEPT EGLIN AIRFIELD, FLORIDA, EMPLOY ONE OR BOTH OF THESE TYPES. (AT EGLIN A MODIFIED AN/MPQ-31 S-BAND UNIT HAS THE SAME EFFECTIVE CHARACTERISTICS AS, AND OPERATES AS, VERLORT RADAR.) THE VERLORT RADAR IS A RELATIVELY WIDE-ANGLE, LONG-RANGE S-BAND RADAR WHICH, IN ADDITION TO ACQUIRING DATA ON ITS OWN, IS USED TO GUIDE THE AN/FPS-16 OR FPQ-6 RADAR IN ACQUIRING THE SPACECRAFT. THE AN/FPS-16 IS A NARROW-BEAM, SHORT-RANGE C-BAND DEVICE OF VERY HIGH ACCURACY. VERLORT HAS A RANGE OF 1000 NAUTICAL MILES (700 NAUTICAL MILES IS CONSIDERED THE RADAR=S OPTIMUM USABLE RANGE) AND THE AN/FPQ-16, A 500-NAUTICAL MILE RANGE. BOTH RADARS ARE INCORPORATED INTO THE ACQUISITION SYSTEM AS UNITS CAPABLE OF BOTH DIRECTING AND BEING DIRECTED. IN ADDITION TO THE SPECIALIZED CAPE KENNEDY AND GODDARD CENTERS (EACH DISCUSSED ELSEWHERE IN THIS VOLUME), THE TRACKING NETWORK CONSISTS OF 14 RANGE STATIONS POSITIONED AROUND THE GLOBE NEAR THE GROUND TRACK OF THE SPACECRAFT. THESE REMOTE SITES MAKE RADAR OBSERVATIONS OF SPACECRAFT POSITION, COMMUNICATE BY VOICE WITH THE ASTRONAUT, RECEIVE TELEMETRY SIGNALS FROM THE SPACECRAFT, AUTOMATICALLY SET A RETROTIMER FOR FIRING THE RETROROCKETS, AND COMMUNICATE NECESSARY INFORMATION TO AND FROM GODDARD AND THE CONTROL CENTER AT CAPE KENNEDY.

FOUR STATIONS ARE EQUIPPED WITH BOTH TYPES OF RADAR-BERMUDA, HAWAII, POINT ARGUELLO, AND EGLIN AIR FORCE BASE. EQUIPPED WITH ONLY AN/FPS-16 RADARS ARE THREE SITES - WOOMERA, WHITE SANDS, AND CAPE KENNEDY (CONSIDERED HERE AS ONE SITE). FOUR SITES - GRAND CANARY ISLAND, GUAYMAS, AND CORPUS CHRISTI - HAVE ONLY VERLORT RADAR, AND FOUR - KANO, ZANZIBAR, CANTON ISLAND, AND ONE SHIP - HAVE NO TRACKING RADARS. THE SHIP 'RANGE TRACKER' HAS C-BAND FPS-16.

WITH THE EXCEPTION OF EGLIN AIR FORCE BASE AND WHITE SANDS, ALL STATIONS RECEIVE TELEMETRY INFORMATION FROM THE SPACECRAFT WHICH INDICATES ENVIRONMENTAL CONDITIONS, THE STATUS OF CERTAIN SPACECRAFT SYSTEMS, AND OTHER EVENTS. SHORTLY AFTER THE SPACECRAFT PASSES OUT OF LOCAL RADAR RANGE, AND AFTER THE FINAL POSITION/VELOCITY MESSAGE OF EACH PASS IS SENT, EACH SITE COMPOSES AND TRANSMITS A SUMMARY OF TELEMETRY READINGS TO GODDARD. THE MESSAGE IS SENT VIA LOW-SPEED (SIX CHARACTERS PER SECOND) TTY AND IS LESS THAN ONE MINUTE LONG.

AT GODDARD, APPLICABLE TELEMETRY QUANTITIES FROM EACH SITE ARE EXTRACTED FROM THE MESSAGE AND INSERTED MANUALLY BY PUNCHED PAPER TAPE INTO THE TWO IBM 7094 COMPUTERS.

METEROLOGICAL INFORMATION FROM EACH NETWORK STATION IS ALSO TRANSMITTED TO GODDARD BY TTY LINES AT LEAST ONE HOUR PRIOR TO LIFTOFF. THESE MESSAGES CONTAIN SITE SURFACE TEMPERATURE IN DEGREES CENTIGRADE, SURFACE AIR PRESSURE IN MILLIBARS, AND SURFACE WATER VAPOR PRESSURE. PREFLIGHT RADAR CALIBRATION DATA REFLECTING BIAS ERRORS FROM BORESIGHT TESTS IS ALSO SENT FROM EACH TRACKING SITE TO THE COMPUTING CENTER.

3.4.5.1 LAUNCH

FROM LIFTOFF UNTIL SPACECRAFT INSERTION INTO ORBIT, CAPE KENNEDY AND BERMUDA RADARS TRACK THE VEHICLE/SPACECRAFT AND SUPPLY THE BITS OF DATA NECESSARY FOR REAL-TIME COMPUTATION. THESE TWO STATIONS ALONE ARE OPERATIVE UNTIL THE FLIGHT ENTERS A SUSTAINED ORBIT.

IT IS AFTER A SUITABLE ORBIT IS ATTAINED THAT DATA FLOW FROM RADAR SITES OTHER THAN BERMUDA/CAPE KENNEDY COMMENCES. THEN, AS THE SPACECRAFT MOVES AROUND THE EARTH, THE SEQUENTIAL FEEDING OF RADAR QUANTITIES FROM WORLDWIDE STATIONS BEGINS INTO THE GODDARD IBM 7094 COMPUTERS.

3.4.5.2 ORBIT

GEMINI GROUND TRACKING SITES MAKE THEIR BIGGEST CONTRIBUTIONS TO MISSION CONTROL AND COMPUTATION DURING THE ORBITAL PHASE. AS THE SPACECRAFT PROGRESSES IN ITS GLOBAL FLIGHT, EACH SITE, ONE AFTER ANOTHER, 'SEES' THE SPACECRAFT FOR A TIME AND THEN LOSES IT TO THE NEXT SITE ALONG THE GROUND TRACK. THIS ROTATING, SITE-TO-SITE GATHERING OF THE DATA REQUIRED FOR COMPUTATIONS ENSURES RELATIVELY UNINTERRUPTED MONITORING OF SPACECRAFT POSITION AND SPEED. WHERE THE SPACECRAFT IS AT PRESENT IS DETERMINED SO ITS FUTURE POSITION AT ANY GIVEN MOMENT CAN BE PREDICTED.

DURING EACH PASS OF THE SPACECRAFT OVER A RADAR SITE, RANGE, AZIMUTH, AND ELEVATION MEASUREMENTS ARE TAKEN FOR AS LONG AS THE SPACECRAFT REMAINS WITHIN EFFECTIVE RANGE. THE INFORMATION FROM THE RADAR IS PROCESSED THROUGH CONVERSION EQUIPMENT AT THE SITE AND TRANSFORMED INTO A TTY FORMAT FOR TRANSMISSION TO GODDARD AT A LOW-SPEED RATE OF 60 OR 100 WORDS PER MINUTE (SIX

OR TEN CHARACTERS PER SECOND INTO THE COMPUTER).

EACH TTY SAMPLE, OR FRAME, INCLUDES AZIMUTH, RANGE, AND ELEVATION MEASUREMENTS, TIME-OF-TRANSMISSION TAGS, AND STATION AND TYPE-OF-RADAR IDENTIFICATION. TIME IS SPECIFIED IN GREENWICH MEAN TIME (GMT) IN HOURS, MINUTES, AND SECONDS.

FROM THE SITE-TRANSMITTED RAW RADAR INFORMATION, THE IBM 7094 COMPLEXES DETERMINE THE INSTANTANEOUS POSITION OF THE SPACECRAFT, THE PROJECTED CONTINUED PATH OF FLIGHT, THE RESULTING LANDING POINT FOR AN EMERGENCY REENTRY INITIATION AT THAT MOMENT, THE TIME TO FIRE RETROROCKETS TO BRING THE SPACECRAFT DOWN IN THE NEXT RESCUE AREA, AND THE TIME TO FIRE RETROROCKETS FOR A NORMAL LANDING.

FROM STATIONS EQUIPPED WITH BOTH VERLORT AND C-BAND RADARS, VERLORT DATA IS TRANSMITTED FIRST AS THE SPACE-CRAFT BEGINS ITS TRIP OVER THAT SITE. C-BAND RADAR TAKES OVER WHEN IT SATISFACTORILY LOCKS - ON AS THE SPACECRAFT MOVES NEARER THE SITE, AND VERLORT DATA IS SENT AGAIN AS THE SPACECRAFT COMPLETES ITS TRANSIT AND FADES FROM C-BAND RANGE. RANGE, AZIMUTH, AND ELEVATION VALUES FROM BOTH RADARS ARE ACCUMULATED DURING A PASS, BUT ONLY IN-FORMATION FROM THE RADAR BEST SUITED TO ACQUIRE DATA AT A PARTICULAR RANGE (SHORT OR LONG) IS USED FOR MISSION OPERATION PURPOSES. INFORMATION FROM THE ENTIRE PASS COVERAGE IS RECORDED ON PAPER TAPE. IF THE INITIAL TRANS-MISSION SERIES IS UNSATISFACTORY GODDARD MAY REQUIEST RETRANSMISSION. DATA FROM THE TWO RADAR TYPES AT A SITE EQUIPPED WITH BOTH IS NEVER TRANSMITTED SIMULTANEOUSLY.

3.4.5.3 REENTRY

DURING THE REENTRY PHASE - UNDER EITHER NORMAL CIRCUMSTANCES OR EMERGENCY ABORT CONDITIONS - IT IS, OF COURSE, EXTREMELY VITAL THAT COMPUTED SPACECRAFT POSITION IS CONFIRMED BY RADAR MEASUREMENTS UNTIL RECOVERY. FROM TTY-CARRIED RADAR INPUTS FROM THE REMOTE SITES, THE IBM 7094'S CONTINUE TO REPEAT LANDING POINT COMPUTATIONS UNTIL THE MOMENT OF IMPACT. RANGE STATION RADARS SUPPLY LOCATION INFORMATION FOR COMPUTER CONVERSION INTO TRAJECTORY PARAMETERS FOR THIS PHASE EXACTLY AS FOR THE ORBITAL PERIOD CALCULATIONS.

IF THE SPACECRAFT IMPACTS IN ONE OF THE PLANNED WESTERN ATLANTIC OCEAN RECOVERY ZONES, CAPE KENNEDY AND BERMUDA RADAR DATA - COLLECTING AND PROCESSING FACILITIES ARE ABLE TO MONITOR THE LANDING MOST EFFECTIVELY. THIS IS THE IDEAL NORMAL-MISSION ARRANGEMENT, SINCE THESE ACTIVITIES ARE EQUIPPED TO HANDLE LANDING CONTROL COMPUTATIONS IN NEAR-REAL TIME AND OTHER SITES ARE NOT.

3.4.6 MANUAL INPUT

DATA FED MANUALLY INTO THE GODDARD IBM 7094'S CONSISTS OF THAT INFORMATION SO IMPORTANT IN CONTENT TO THE SUCCESS OF THE MISSION THAT THE MESSAGES ARE SET ASIDE TO BE TREATED WITH SPECIAL PRIORITY BY GEMINI CONTROL PERSONNEL. MANUALLY INSERTED DATA BECOMES AN ALL-IMPORTANT SOURCE OF BACKUP INFORMATION IF AUTOMATICALLY-TRANSMITTED AND PROCESSED QUANTITIES FAIL TO INDICATE SEVERAL CRITICAL FACTS CONCERNING THE FLIGHT.

CONSTANTLY-CHANGING FLIGHT FACTORS SUCH AS SPACECRAFT POSITION AND VELOCITY REQUIRE CONTINUOUS PROCESSING AND PLOTTING DURING A MISSION, CERTAIN OTHER INPUTS TO THE COMPUTERS DO NOT. THESE LATTER QUANTITIES - MANUAL

INPUTS - REPRESENT THE OCCURRENCE OF SINGLE, EXTREMELY IMPORTANT EVENTS WHICH TAKE PLACE ONCE (DISCRETES, THE DECISION TO CONTINUE THE MISSION, RETROFIRE INFORMATION) AND PARTICULARLY PRECISE CLOCK READINGS(TIME OF RETRO-FIRE, SPACECRAFT CLOCK SETTINGS). INFORMATION SUCH AS THIS, ARRIVING AT THE COMPUTING CENTER BY ANY OF THE VARIOUS GEMINI HIGH-AND LOW-SPEED COMMUNICATION MEANS, IS PUNCHED ONTO PAPER TAPE TO BE THEN INSERTED MANUALLY INTO THE IBM 7094 COMPUTERS.

TWO ESPECIALLY IMPORTANT MESSAGES WHICH BECOME SO VALUABLE TO COMPUTATION AND CONTROL IF NORMAL AUTOMATIC CHANNELS FAIL, OR GENERATE AND TRANSMIT ERRONEOUS DATA, ARE (1) THE GREENWICH MEAN TIME (GMT) OF TWO-INCH LIFTOFF AND (2) THE DECISION TO ENTER EITHER THE ABORT PHASE OR THE ORBIT PHASE GO/NO-GO RECOMMENDATION) FOLLOWING LAUNCH. WHEN NEEDED AS BACKUP INPUTS INTO THE GODDARD COMPUTERS, THESE MESSAGES, AS ALL MANUAL INPUT QUANTITIES, ARE PUNCHED ONTO TAPE IN A PRESCRIBED FORMAT AND FED TO A PAPER TAPE READER TO BE INSERTED INTO THE DATA COMMUNICATIONS CHANNEL, AND THEN INTO THE COMPUTERS.

NEEDED BY THE IBM 7094'S DURING THE PERIOD WHEN THE MISSION PROCEEDS FROM THE ABORT PHASE INTO REENTRY OR FROM ORBIT INTO REENTRY ARE THE NUMBER OF RETROROCKETS FIRED (ONE, TWO, THREE, OR FOUR) AND THE GMT OF EACH RETROFIRING. ANY NETWORK STATION, INCLUDING THOSE WITH TELEMETRY-RECEPTION FACILITIES ONLY, CAN CONFIRM THAT RETROROCKETS HAVE FIRED. THE TIME OF FIRING OF EACH ROCKET IS NOTED TO THE NEAREST SECOND (IN GMT, AS MENTIONED) AND TRANSMITTED BY 60-WORD-PER-MINUTE TTY TO GODDARD TO BE FED THROUGH THE DCC'S PAPER TAPE INPUT SUB-CHANNEL INTO THE COMPUTER. IF POSSIBLE TO DETERMINE, SPACECRAFT ATTITUDE ANGLES AT ALL THREE FIRINGS ARE ALSO

TRANSMITTED.

APPROXIMATELY 20 QUANTITIES AND NOTATIONS, DERIVED IN THE ORBIT PERIOD FROM TELEMETRY SIGNALS OBSERVED DURING SPACECRAFT TRANSIT OVER A SITE, ARE INCORPORATED IN SUMMARY INTO A STANDARD FORMAT AND TRANSMITTED TO GODDARD AFTER THE SPACECRAFT LEAVES LOCAL RADAR/TELEMETRY RANGE. THIS SUMMARY MESSAGE IS DISPATCHED AT A 60-WORDS-PER-MINUTE RATE IMMEDIATELY FOLLOWING THE LAST RADAR DATA TRANSMISSION FOR THAT ORBIT.

IN NORMAL OPERATION A CLOCK IN THE SPACECRAFT TRIGGERS A MECHANISM TO FIRE THE RETROROCKETS. THE PROPER CLOCK SETTING IS CONTINUOUSLY CALCULATED BY THE COMPUTERS AT GODDARD. IF A CLOCK RESET IS REQUIRED BECAUSE OF ERRORS IN CLOCK RATE OR ORBIT PERIOD, OR BECAUSE OF AN IMPENDING LANDING, GODDARD SENDS A NEW SETTING TO THE COMMAND STATION NEAREST THE SPACECRAFT AND THAT STATION AUTOMATICALLY RESETS THE TIMER AS THE SPACECRAFT PASSES OVER.

3.4.7 WWV TIMING SIGNALS

THE CONCEPT OF COMPUTATIONAL CONTROL AS REPRESENTED BY PROJECT GEMINI DEMANDS A STANDARDIZED TIME BASE AS A COORDINATING REFERENCE POINT FOR ALL ACTIVITIES WITHIN THE SCOPE OF THE PROJECT. SUCH CONTROL IN ESTABLISHING AND MAINTAINING THE RELATIONSHIPS BETWEEN TIME ON THE GROUND AND TIMES INDICATED ON CLOCKS IN THE SPACECRAFT CANNOT BE COMPROMISED IN ACHIEVING A SUCCESSFUL MISSION.

FROM THE STANDPOINT OF SYSTEM COORDINATION AND CONTROL IN REAL TIME, TIMING SIGNALS ARE AMONG THE MOST IMPORTANT AND PRECISE DATA INPUTS INTO THE GODDARD IBM 7094 COMPUTERS. IN ADDITION TO SERVING AS THE VITAL, ACCURATE GUIDELINES ON WHICH THE COMPUTERS' INTERNAL

PROCESSING SEQUENCES ARE BASED, THE TIME SIGNALS ARE THE BASIC REFERENCE POINTS NEEDED TO KEEP RANGE STATION, CONTROL CENTER, AND COMPUTING AND COMMUNICATIONS CENTER ACTIVITES IN SYNCHRONISM. TO MAINTAIN SIMULTANEOUSLY - EXACT CLOCK READINGS AT NETWORK SITES AND THE GEMINI CENTERS, THE PRIMARY TIME - CHECK AND CONTROL SIGNALS DISTRIBUTED FOR OVERALL PROJECT COORDINATION EMANATE FROM THE SAME SOURCE - NATIONAL BUREAU OF STANDARDS RADIO STATION, WWV, WASHINGTON, D.C.

TIMING PULSES BROADCAST FROM WWV ARE ACCEPTED INTO GODDARD IBM 7094 INPUT DEVICES MUCH THE SAME AS OTHER GEMINI GROUND SYSTEM INPUT DATA QUANTITIES. AS THE KEY TO THE EXTERNAL AND INTERNAL TIMING COORDINATION NECESSARY FOR GODDARD COMPUTATIONAL OPERATIONS, THE SIGNALS 'CLOCK' IBM 7094 ACTIVITES AND PROVIDE EXTERNAL TIMING INPUTS TO THOSE CONTROL FUNCTIONS WITHIN THE COMPUTERS WHICH TRIGGER COMPUTING PROCESSES AT SPECIFIED INTERVALS.

THE BASIC TONE BURSTS TRANSMITTED TO GODDARD ARE SENT BY WWV EVERY MINUTE. FOR PROJECT GEMINI PURPOSES, AN AUTOMATIC TIMING CAPABILITY IS FURNISHED TO THE COMPUTERS FROM THE GEMINI TIMING SYSTEM THROUGH A REAL TIME INPUT/ OUTPUT DATA-ROUTING DEVICE, THE DATA COMMUNICATIONS CHANNEL (DCC).

THE SIGNALS FURNISHED THROUGH THREE SPECIFIED SUB-CHANNELS OF THE 32-SUBCHANNEL DCC ARE USED IN DATA PROCESSING OPERATIONS TO -

1) INCREMENT A MEMORY LOCATION EVERY 8-1/3 MILLISECONDS,
2) ACT, IF NEEDED, AS AN INTERVAL CLOCK BY INTER-RUPTING A PROGRAM AFTER A SPECIFIED NUMBER OF EITHER 1/2 SECOND OR 8-1/3 MILLISECOND INCRE-MENTS (UP TO A MAXIMUM OF 255 INTERVALS),

3) SYNCHRONIZE, WITH A WWV PULSE GENERATOR ATTACHED TO THE SUBCHANNEL, ONE-MINUTE SIGNALS FROM THE DCC TO THE COMPUTER WITH THE WWV ONE-MINUTE PULSE (ACCURATE TO THE MILLISECOND).

4. GSFC MISSION SUPPORT EQUIPMENT

THE GSFC MISSION SUPPORT EQUIPMENT CONSISTS OF THREE IBM 7094 DATA PROCESSING SYSTEMS AND VARIOUS PERIPHERAL AND COMMUNICATIONS EQUIPMENT. (SEE FIGURE 4-1.)

4.1 IBM 7094 DATA PROCESSING SYSTEMS

ALL THREE IBM 7094 DATA PROCESSING SYSTEMS (A,B, AND C) CAN BE RECEIVING THE SAME INPUT DATA AND PERFORMING THE REQUIRED CALCULATIONS, WITH ONE NORMALLY PROVIDING OUTPUT. THIS ARRANGEMENT ALLOWS ONE IBM 7094 TO BE ON-LINE, ONE TO BE IN STANDBY STATUS, AND THE THIRD TO BE DOWN FOR REQUIRED MAINTENANCE.

EACH IBM 7094 DATA PROCESSING SYSTEM CONFIGURATION (FIGURE 4-2) IS IDENTICAL TO THE OTHER TWO, AND INCLUDES THE FOLLOWING EQUIPMENT -

QUANTITY	EQUIPMENT NUMBER	DESCRIPTION
1	7606	MULTIPLEXOR
2	7302	CORE STORAGE
1	7109	ARITHMETIC SEQUENCE UNIT
1	7110	INSTRUCTION PROCESSING UNIT (CPU)
1	7608	POWER CONVERTER
1	7618	POWER CONTROL
1	7607-1	DATA CHANNEL (A)
2	7607-II	DATA CHANNELS (B AND C)
1	7909	DATA CHANNEL (D)
1	716	PRINTER

QUANTITY	EQUIPMENT NUMBER	DESCRIPTION
1	721	CARD PUNCH (SYSTEM ''C'' ONLY)
1	7223	CARD READER
14	729-IV	TAPE DRIVES
1	7631-II	FILE CONTROL UNIT
1	1301	FILE (DISK STORAGE)
1	7151	CONSOLE CONTROL UNIT
1		PROGRAM CONTROL CONSOLE
1	7281-I	DATA COMMUNICATIONS CHANNEL (F)
1	7281-II	DATA COMMUNICATIONS CHANNEL (E)

4.1.1 7302 CORE STORAGE

ALL DATA MUST BE PLACED IN STORAGE BEFORE THEY CAN BE PROCESSED BY THE COMPUTER. EACH 7302 CORE STORAGE UNIT CAN HOLD 32,768 BINARY WORDS (OR 163,840 CHARACTERS IN BINARY CODED DECIMAL-BCD).

4.1.2 CPU

THE CPU CONSISTS OF THE 7109 ARITHMETIC UNIT AND THE 7110 INSTRUCTION PROCESSING UNIT. THE CPU CONTAINS THE FOLLOWING -

A) AN INSTRUCTION COUNTER, WHICH TELLS THE COMPUTER THE LOCATION OF THE NEXT INSTRUCTION TO BE PERFORMED.

B) AN INSTRUCTION BACKUP REGISTER - A 36-POSITION REGISTER USED DURING INSTRUCTION OVERLAP OPERATIONS.

C) AN ADDRESS REGISTER, WHICH RECEIVES ITS INFORMATION FROM THE STORAGE REGISTER OR INSTRUCTION BACKUP REGISTER AT THE BEGINNING OF A STORAGE REFERENCE CYCLE.

D) AN INSTRUCTION REGISTER, WHICH HOLDS INSTRUCTIONS TO MAKE ROOM IN THE STORAGE REGISTER FOR DATA THAT MAY BE REQUIRED BY THE INSTRUCTION.

E) A STORAGE REGISTER OF 36 POSITIONS, WHICH STORES INFORMATION THAT COMES TO THE CPU FROM CORE STORAGE PRIOR TO ROUTING TO OTHER REGISTERS.

F) ADDERS, USED TO ADD NUMBERS (37 POSITIONS TO ALLOW FOR OVERFLOW).

G) AN ACCUMULATOR REGISTER (AC) OF 38 POSITIONS USED TO HOLD ONE FACTOR DURING ARITHMETIC OPERATIONS AND TO RECEIVE RESULTS FROM ADDERS.

H) A MULTIPLIER-QUOTIENT REGISTER (MQ) OF 36 POSITIONS, WHICH CONTAINS THE MULTIPLIER IN MULTIPLICATION OPERATIONS AND RECEIVES THE QUOTIENT IN DIVISION.

I) A SENSE INDICATOR REGISTER, 36 POSITIONS, USED TO STORE WORDS FOR USE IN CALCULATION, OR FOR MATCHING OR COMPARING RESULTS.

J) SEVEN 15-POSITION INDEX REGISTERS USED FOR ADDRESS MODIFICATION.

K) A TAG REGISTER, WHICH HOLDS THE TAG FIELD OF THE INSTRUCTION BEING EXECUTED.

L) INDEX ADDERS (15-POSITIONS) - USED IN STORING, LOADING, CHANGING AND MODIFYING INDEX REGISTERS.

THE CPU PERFORMS SUCH OPERATIONS AS ADDITION, SUBTRACTION, MULTIPLICATION, DIVISION, SHIFTING, TRANSFERRING, COMPARING, AND STORING. IT ALSO HAS THE ABILITY TO TEST VARIOUS CONDITIONS ENCOUNTERED DURING PROCESSING AND TO TAKE ACTION CALLED FOR BY THE RESULT.

A REGISTER IS A DEVICE CAPABLE OF RECEIVING INFORMATION, HOLDING IT, AND TRANSFERRING IT AS DIRECTED BY CONTROL CIRCUITS.

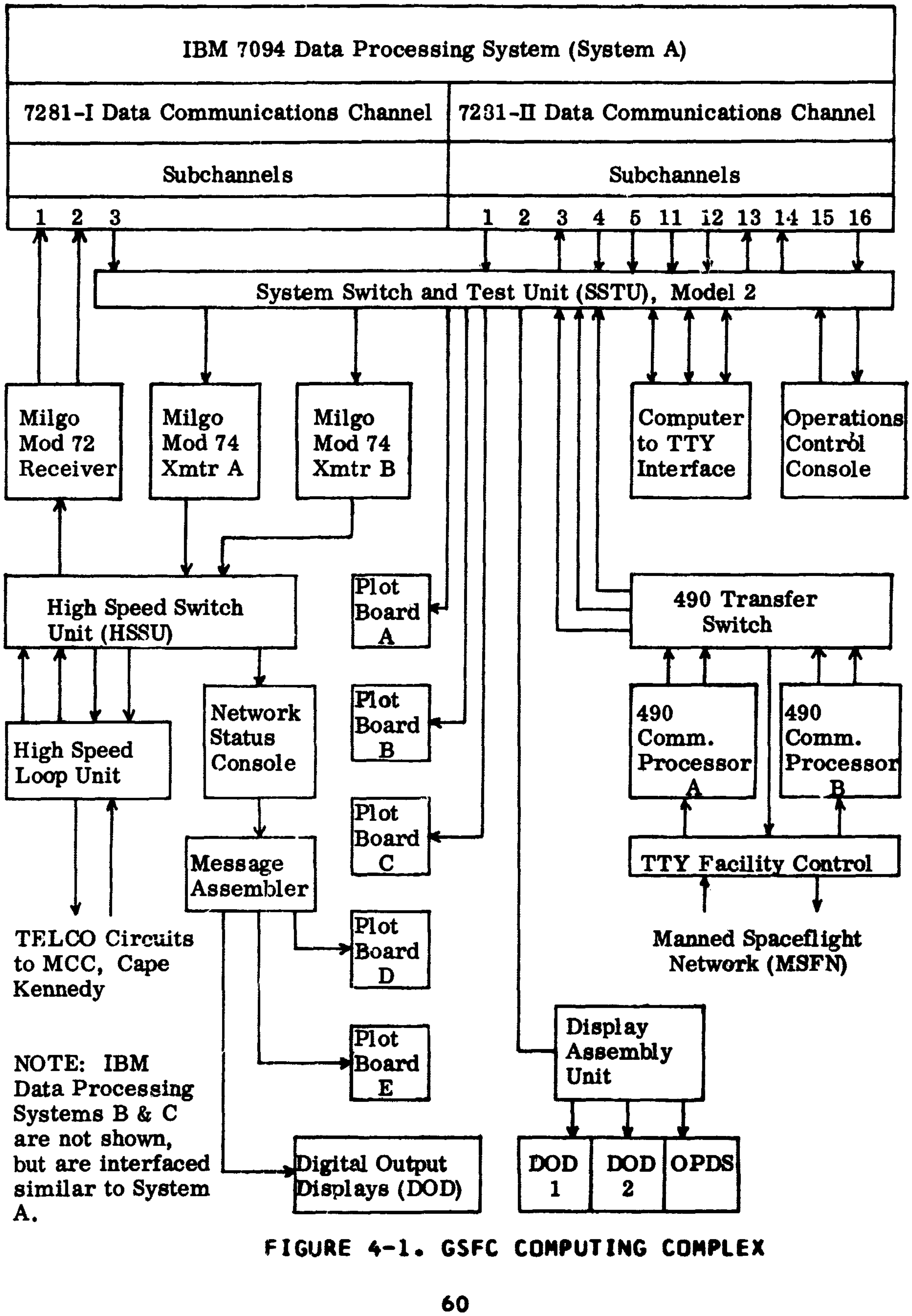


FIGURE 4-1. GSFC COMPUTING COMPLEX

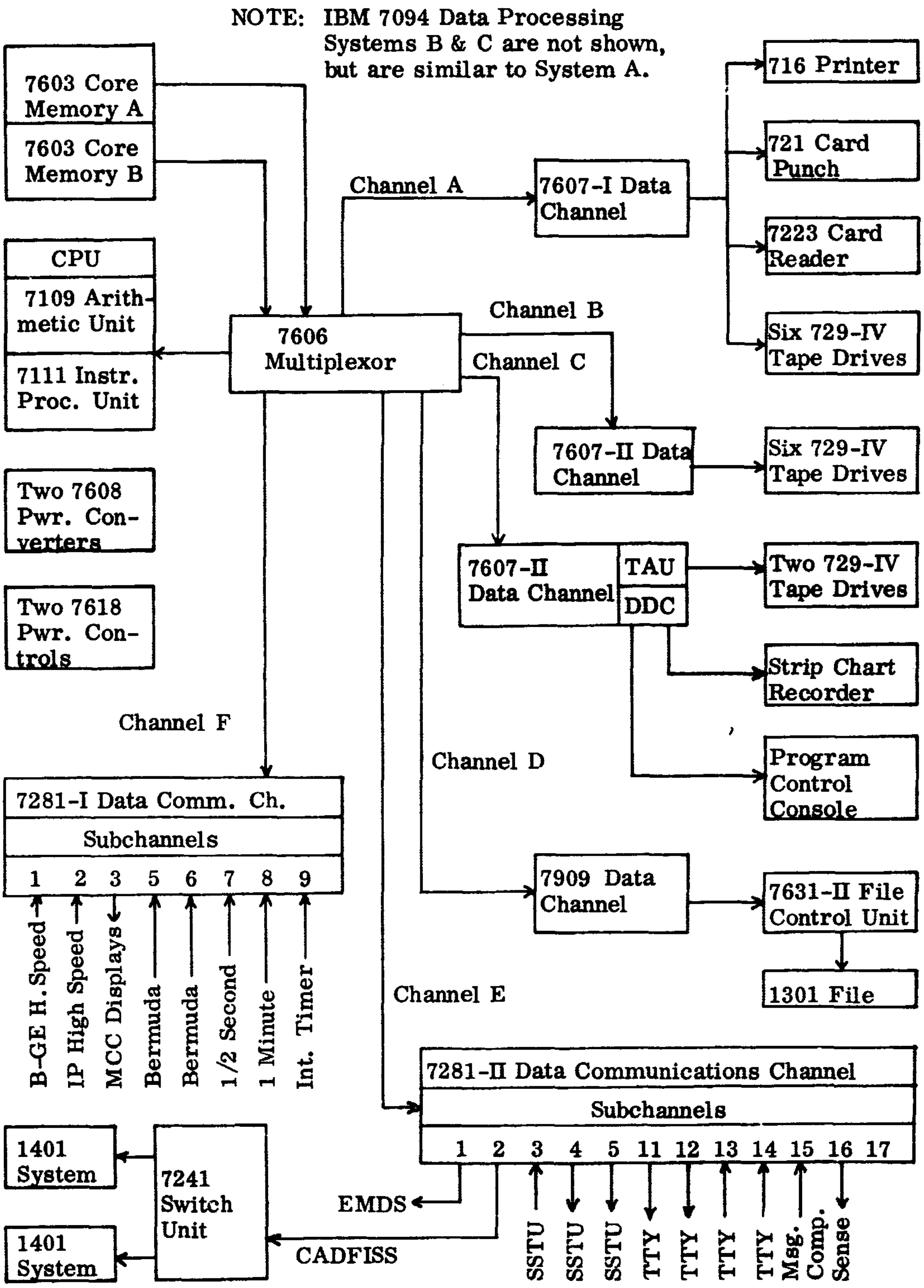


FIGURE 4-2. GSFC IBM 7094 DATA PROCESSING SYSTEM (SYSTEM A ONLY)

4.1.3 DATA CHANNELS

BOTH THE 7607 AND THE 7909 DATA CHANNELS USE A COMMAND WORD TECHNIQUE FOR DATA TRANSMISSION. WITH THIS, CONTROL OF AN INPUT-OUTPUT OPERATION PASSES FROM THE CPU TO THE DATA CHANNEL ITSELF, WHICH FREES THE CPU TO PROCEED WITH ITS OWN STORED PROGRAM. THE COMMAND WORD IS USED TO TRANSFER CONTROL, AND THE DATA CHANNELS CONTAIN REGISTERS AND COUNTERS TO EXERCISE THIS CONTROL. THE CHANNEL PERFORMS COMMAND DECODING, ASSEMBLY OF DATA BYTES INTO WORDS, AND DISASSEMBLY OF WORDS INTO BYTES.

THE 7607 AND 7909 DATA CHANNELS ATTACH TO THE 7606 MULTIPLEXOR, AND CONTROL DATA TRANSMISSION BETWEEN THE 7094 D.P.S. AND THE I/O DEVICES (SEE FIGURE 4-2.) IN ADDITION, THE 7909 DATA CHANNEL CAN INSTRUCT AND SELECT THE 7631 FILE CONTROL UNIT AND PERFORM LIMITED COUNTING AND TESTING OPERATIONS INDEPENDENTLY OF THE CPU OR OF OTHER DATA CHANNEL ACTIVITY. HOWEVER, THE CPU CAN STILL SUPERVISE 7909 OPERATION.

DATA BEING TRANSMITTED BETWEEN CORE STORAGE AND ANY I/O DEVICE MUST PASS THROUGH A DATA CHANNEL. THE OPERATION OF A DATA CHANNEL IS INITIATED BY THE EXECUTION OF TWO INSTRUCTIONS IN THE CPU. ONCE STARTED, THE CHANNEL OPERATES INDEPENDENTLY OF THE MAIN PROGRAM BEING EXECUTED BY THE CPU.

PROGRAMS FOR A CHANNEL OPERATION ARE STORED IN CORE STORAGE JUST AS ARE INSTRUCTIONS EXECUTED BY THE CPU. TO DISTINGUISH BETWEEN PROGRAMS, DATA EXECUTED IN THE CPU ARE TERMED 'INSTRUCTIONS,' DATA EXECUTED BY THE DATA CHANNEL ARE 'COMMANDS,' AND DATA EXECUTED BY THE ADAPTER ARE 'ORDERS.'

ALL TRANSMISSION IS IN 36-BIT WORD PARALLEL FASHION. THE DATA CHANNEL CAN SIGNAL OR INTERRUPT PROCESSING BY

TRAPPING THE COMPUTER PROGRAM, BUT DATA CHANNELS MAY BE INDIVIDUALLY OR COLLECTIVELY PREVENTED FROM CAUSING TRAPS UNTIL THE PROGRAM IS ABLE TO HANDLE THEM.

4.1.4 716 PRINTER

THE 716 PRINTER IS EQUIPPED WITH 120 ROTARY-TYPE WHEELS WHICH ROTATE TO POSITION THE CHARACTER DESIRED. EACH WHEEL HAS 48 CHARACTERS AND CAN PRINT AT THE RATE OF 150 LINES PER MINUTE. PRINTING FORMAT IS CONTROLLED BY THE ARRANGEMENT OF THE INFORMATION IN STORAGE AND BY A CONTROL PANEL ON THE PRINTER.

4.1.5 721 CARD PUNCH

THE 721 CARD PUNCH CAN PUNCH 100 CARDS PER MINUTE WITH DECIMAL, ALPHABETIC, BCD, OR ANY SPECIAL CHARACTER CODE. THIS UNIT IS INSTALLED ONLY IN THE ''C'' COMPUTING SYSTEM.

CUSTOMER ENGINEERS - THESE ENGINEERS MAINTAIN THE GODDARD COMPUTER COMPLEX WHICH CONSISTS OF THE FOLLOWING EQUIPMENT -

A) THREE IBM 7094 COMPUTERS INCLUDING ASSOCIATED TAPE DRIVES, CARD READERS, PRINTERS, AND CARD PUNCHER.

B) THREE DATA COMMUNICATIONS CHANNELS AND ASSOCIATED CIRCUITRY.

TO ACCOMPLISH THEIR TASKS, THE CUSTOMER ENGINEERS USE THE FOLLOWING TO CHECK THE OPERATION OF THIS EQUIPMENT -

A) 7094 DIAGNOSTIC PROGRAM 9S51 - MEMORY CHECK

B) 7094 DIAGNOSTIC PROGRAM 9M51 - MAIN FRAME CHECK

C) 7094 DIAGNOSTIC PROGRAM 9C51 - CARD READER CHECK

D) DDC DIAGNOSTIC PROGRAM - ONE MINUTE CLOCK CHECK

E) DCC DIAGNOSTIC PROGRAM - 60-CYCLE CLOCK CHECK

F) DCC DIAGNOSTIC PROGRAM - HIGH-SPEED LOOP CHECK

G) TTY INPUT AND OUTPUT CHECK

COMPUTATION AND DATA FLOW INTEGRATED SUBSYSTEM (CADFISS) GROUP - CADFISS TESTING, DIRECTED FROM THE GODDARD COMPLEX, CONSISTS OF DYNAMICALLY EXERCISING ALL THOSE UNITS OF THE GEMINI GROUND SYSTEM WHICH HAVE AN OPERATIONAL RELATIONSHIP TO THE COMPUTERS. THIS RELATIONSHIP IS DEFINED AS THE AVENUES OF DIRECT DATA FLOW FROM EACH POINT OF DATA INITIATION TO POINTS OF INTERMEDIARY AND ULTIMATE DATA USE.

A) CADFISS ROLL CALL

THE CADFISS ROLL CALL IS PERFORMED TO BRING INTO THE NETWORK ALL THE SITES THAT WILL BE IN OPERATION FOR THE MISSION. THE ROLL CALL IN EFFECT SENDS A CUE TO EACH SITE, AND THE SITE UPON RECEPTION OF THE CUE TRANSMITS CERTAIN DATA TO GODDARD WHICH IS USED FOR SITE RADAR CALIBRATION CHECKS, DATA FLOW CHECKS, ERROR CORRECTION EQUIPMENT CHECKS, ETC.

B) SIMULATED FLIGHT TEST

THE PROGRAM GROUP SIMULATED FLIGHT TEST IS PERFORMED AFTER THE CADFISS ROLL CALL. THIS TEST INTEGRATES THE NETWORK IN A SIMULATED MISSION. THE SIMULATED MISSION IS INITIATED AT THE CAPE BY FIRST SUPPLYING DATA TO THE GEMINI PROGRAM SYSTEM OF A SIMULATED TRAJECTORY. THE PROGRAM SYSTEM THEN TAKES THE DATA SUPPLIED, PROJECTS AN ORBIT, SENDS ACQUISITION DATA TO THE SITES, AND EXPECTS TO RECEIVE FROM EACH OF THE SITES ADDITIONAL DATA TO UPDATE AND CORRECT THE ORBIT

PREDICTIONS.

4.1.6 729-IV TAPE DRIVE

THESE ARE USED AS THE PRINCIPAL INPUT/OUTPUT MEDIUM OF THE IBM 7094 SYSTEM. THEY ARE USED FOR STORAGE OF INTERMEDIATE RESULTS AND PERMANENT STORAGE FOR LARGE FILES OF DATA. THE TAPE IS PLASTIC, ONE-HALF INCH IN WIDTH, COATED ON ONE SIDE WITH A MAGNETIC OXIDE MATERIAL. UP TO 2400 FEET OF TAPE MAY BE WOUND ON THE 10 1/2-INCH DIAMETER PLASTIC REEL.

INFORMATION IS RECORDED MAGNETICALLY IN SEVEN PARALLEL CHANNELS ALONG THE LENGTH OF THE TAPE, SIX TO RECORD INFORMATION AND THE SEVENTH AS A CHECK BIT. EACH SIX BIT GROUP AND ITS CHECK BIT ARE RECORDED IN A COLUMN ACROSS THE TAPE FROM THE FIRST CHANNEL TO THE SEVENTH. THE COLUMNS ARE LIKE RUNGS ON A LADDER, AND 556 SUCH GROUPS CAN BE RECORDED ON EACH INCH OF TAPE ON THE IBM 729-IV. THE CODING USED IS BINARY CODED DECIMAL (BCD), IN WHICH CHANNEL 1 IS THE CHECK BIT, CHANNELS 2 AND 3 THE ZONE BITS, AND CHANNELS 4-7 THE NUMERICAL BITS. TAPE SPEED IS 112.5 INCHES PER SECOND. AN END OF FILE (EOF) IS AN 8 3/4-INCH GAP (NO RECORDS) FOLLOWED BY A TAPE MARK (00 11 11 BITS PLUS CHECK BIT). CHECK BITS ARE ALSO WRITTEN LONGITUDINALLY.

4.1.7 7631-II FILE CONTROL UNIT

THE 7631-II FILE CONTROL UNIT PROVIDES FOR CONNECTION OF THE 1301 DISK STORAGE UNIT TO THE 7909 DATA CHANNEL.

4.1.8 1301 DISK STORAGE

THE 1301 AS USED AT GSFC CONTAINS TWO MODULES OF

DISK ASSEMBLIES, MOUNTED ONE ABOVE THE OTHER ON A COMMON VERTICAL SHAFT. EACH MODULE CONSISTS OF 25 MAGNETICALLY COATED DISKS, TWO FEET IN DIAMETER, AND AN ACCESS MECHANISM WITH 24 ACCESS ARMS. EACH DISK SURFACE HAS 250 TRACKS. THE DISKS ARE MOUNTED 1/2 INCH APART ON THE VERTICAL SHAFT WHICH ROTATES AT 1400 RPM. EACH DISK IS MADE OF THIN METAL AND COATED ON BOTH SIDES WITH A MAGNETIC RECORDING MATERIAL. DATA ARE STORED AS MAGNETIC SPOTS ON EACH SURFACE OF THE DISK. TOTAL STORAGE CAPACITY IS 55,920,000 BITS. TWO READ-WRITE HEADS ARE MOUNTED ON EACH ACCESS ARM, ONE TO SERVICE THE UPPER AND ONE THE LOWER AS IT PASSES BETWEEN TWO DISKS. THE ARMS ARE MOUNTED TOGETHER, SO WHILE ONE MAY BE READING OR WRITING, OTHERS MUST WAIT. THIS PERMITS IMMEDIATE ACCESS TO SPECIFIC AREAS OF INFORMATION. TRANSMISSION OF DATA TO AND FROM DISK STORAGE IS ACCOMPLISHED BY DATA CHANNEL COMMANDS. DISK CONTROL OPERATIONS THAT DO NOT REQUIRE DATA TRANSMISSION ARE ACCOMPLISHED BY SENDING AN ORDER TO THE 7631-II FILE CONTROL UNIT WHERE IT IS DECODED AND EXECUTED.

4.1.9 CONSOLE CONTROL UNIT

THE CONSOLE CONTROL UNIT PROVIDES EXTERNAL CONTROL OF THE DATA PROCESSING SYSTEM. KEYS TURN CONSOLE POWER ON OR OFF, START OR STOP OPERATION, AND CONTROL VARIOUS DEVICES IN THE SYSTEM.

FORTY SENSE LIGHTS ARE ON THE CONSOLE. THEY ARE PROGRAM-CONTROLLED (SLN AND SLF INSTRUCTIONS).

A GROUP OF 36 SWITCHES CORRESPONDING TO THE 36 BIT POSITIONS OF A WORD ARE PROVIDED ON THE CONSOLE. A SWITCH PLACED IN THE UP POSITION CORRESPONDS TO A 1. DOWN CORRESPONDS TO A 0. THE INSTRUCTION ENTER KEYS

CAUSES THE NUMBER ENTERED INTO THESE SWITCHES TO REPLACE THE CONTENTS OF THE MQ REGISTER. A RESET SWITCH ON THE IBM 7151 CONSOLE CONTROL UNIT RESTORES ALL INPUT SWITCHES TO THE ZERO STATE.

4.2 PERIPHERAL EQUIPMENT

4.2.1 HIGH-SPEED DATA RECEIVERS, MILGO MODEL 72

FOUR DATA RECEIVERS ARE USED AT GODDARD. TWO RECEIVERS ACCEPT THE DUPLEXED, SERIAL TRANSMISSION OF DATA FROM THE B-GE COMPLEX, AND TWO RECEIVERS ACCEPT THE SAME TYPE OF TRANSMISSION FROM THE IP COMPLEX. EACH RECEIVER BUFFERS THE INCOMING DATA UNTIL EIGHT BITS ARE RECEIVED FROM EACH DATA LINE. THE TWO DUPLEXED 8-BIT DATA FRAMES FROM EACH SOURCE ARE THEN MADE AVAILABLE TO A SUBCHANNEL OF THE DATA COMMUNICATIONS CHANNEL (DCC). THE 7094 ACCEPTS DATA AS IT IS ASSEMBLED (8-BIT PARRALLEL TRANSFERS), THUS ENABLING THE RECEIVER TO ACCEPT DATA CONTINUALLY AT 1003 BITS PER SECOND (BPS). IN THIS MANNER, DUPLICATE FRAMES OF DATA FROM THE B-GE COMPLEX AND FROM THE IP COMPLEX ARE AVAILABLE TO THE THREE GSFC 7094'S.

4.2.2 DIGITAL-TO-ANALOG CONVERTERS AND PLOTBOARDS A,B,C, MILGO MODELS 1576B AND 3010

THREE PLOTBOARDS AT GODDARD ARE DRIVEN BY THREE 4-CHANNEL DIGITAL-TO-ANALOG (D/A) CONVERTERS. EACH PLOTBOARD IS AN X-Y PLOTTER WITH A PLOTTING AREA OF 30 INCHES BY 30 INCHES. EACH PLOTBOARD HAS TWO CARRIAGES AND MAKES TWO INDEPENDENT X-Y PLOTS. ONE PEN ON EACH CARRIAGE REMAINS IN CONTACT WITH THE BOARD, EXCEPT DURING LONG MOVEMENTS. EACH PLOTBOARD AND ASSOCIATED D/A CONVERTER CAN BE CONNECTED TO ANY OF THE THREE COMPUTER DCC'S THROUGH

SWITCHING IN THE SYSTEM SWITCH AND TEST UNIT, CONTROLLED AT THE OPERATIONS CONTROL CONSOLE (OCC). EACH COMPUTER, THROUGH ITS DCC, SERIALLY SUPPLIES 48 BITS TO SHIFT REGISTERS IN THE D/A'S. FROM THE SHIFT REGISTER, DATA IS TRANSFERRED IN PARALLEL TO A STORAGE REGISTER, WHICH DRIVES THE D/A'S AND PLOTBOARD.

4.2.3 OPERATIONS CONTROL CONSOLE, IBM

THE OPERATIONS CONTROL CONSOLE (OCC) IS USED AS A MONITOR AND SWITCHING CONTROL UNIT FOR REAL-TIME DATA PROCESSED BY THE THREE IBM 7094 COMPUTERS. CONTROLS AND INDICATORS ARE PROVIDED ON THE FRONT PANEL OF THE CONSOLE TO ACCOMPLISH THE MONITORING AND SWITCHING FUNCTIONS.

4.2.3.1 SENSE LIGHTS. THE UPPER PANEL OF THE CONSOLE HAS THREE ROWS OF FORTY INDICATORS EACH. THIRTY-SIX INDICATORS IN EACH ROW ARE ACTIVATED FROM THE SENSE OUTPUTS OF COMPUTERS A, B, AND C, RESPECTIVELY. THE INFORMATION DISPLAYED BY THESE INDICATORS IS THE SAME AS THAT DISPLAYED ON THE PROGRAM CONTROL CONSOLES AND IS UNDER PROGRAM CONTROL.

4.2.3.2 CONTROL FUNCTIONS AND INDICATORS. THE FOLLOWING SWITCH ACTIONS AND INDICATIONS ARE ON THE OCC -

A) POWER ON-OFF - CONTROLS POWER TO OCC.
B) PROGRAM CONTROL CONSOLE DISABLED - DISABLES THE MANUAL ENTRY OPERATIONS OF THE INDICATED PCC.
C) MISSION MODE - MODE OF OPERATION NORMALLY USED DURING MISSIONS REQUIRING FULL TRIPLEX CAPABILITY FOR MAXIMUM SUPPORT. THE STANDBY COMPUTER CAN BE CONNECTED TO THE STANDBY DATA TRANSMITTER, MODEL 74. HOWEVER, THE OPERATIONAL PROGRAM

WILL NOT OUTPUT HIGH SPEED DATA (2000 BPS) FROM S/C 3 DUE TO THE COMPUTER STATUS BIT. TTY DATA OUTPUT IS NOT AVAILABLE FROM THE STANDBY COMPUTER.

D) MULTIPLE-MISSION MODE - MODE OF OPERATION WHICH ALLOWS MORE FLEXIBILITY IN THE SELECTION AND USE OF THE COMPUTERS. MULTIPLEXED TTY DATA (4800 BPS) OUTPUTS ARE AVAILABLE FROM ALL THREE COMPUTERS TO THE COMMUNICATION PROCESSORS. THE STANDBY COMPUTER MAY BE CONNECTED TO THE STANDBY DATA TRANSMITTER, MOD 74, AND HIGH SPEED (2000 BPS) DATA OUTPUT WILL BE AVAILABLE FROM THE OPERATIONAL PROGRAM.

E) TRANSMITTER-SELECT ENABLED - ALLOWS THE INTERCHANGE OF MODEL 74 TRANSMITTERS.

F) INDICATOR TEST A,B,C - TESTS THE INDICATOR LIGHTS ON THE UPPER PANEL.

G) INDICATOR TEST PANEL - TESTS THE INDICATOR LIGHTS ON THE LOWER PANEL.

H) TRANSMITTER ACTIVE A-B - INDICATES WHICH TRANSMITTER IS SENDING DATA TO THE SOUTHBOUND DATA LINES.

I) COMPUTER TO STRIP CHART RECORDER - SELECTS ONE OF SIX COMBINATIONS OF COMPUTERS TO STRIP CHARTS.

J) COMPUTER TO PLOTBOARD SELECTION - SELECTS ONE OF SIX COMBINATIONS OF COMPUTERS TO PLOTBOARDS A,B,C.

K) COMPUTER STATUS - ALLOWS SELECTION OF COMPUTERS IN THE MISSION AND MULTIPLE-MISSION MODE TO BE ACTIVE, STANDBY, OR AVAILABLE. IN THIS GROUP THERE ARE INDICATORS SHOWING WHEN EACH COMPUTER

IS NOT READY AND UNDER CONTROL OF MAINTENANCE PERSONNEL.

L) SELECT AVAILABLE COMPUTER FOR CP - ENABLE A,B,C SELECTS AN AVAILABLE COMPUTER. MULTIPLEXED TTY SUBCHANNELS (4800 BPS) ARE CONNECTED TO THE COMMUNICATIONS PROCESSORS.

M) ALARM AUDIBLE RESET - TURNS OFF THE AUDIBLE ALARM SET BY ANY SENSE LIGHT 36-CONTACT CLOSURE.

N) MA ALARM RESET - TURNS OFF THE AUDIBLE AND VISUAL ALARM SET BY MISSING OR IMPROPER END OF WORD OR ODD-EVEN SUBFRAME CONTROL SIGNALS AS DETECTED WITHIN THE MESSAGE ASSEMBLER.

O) SDCU TRANSMITTER ENABLE - ENABLES THE SELECTION OF THE HIGH SPEED OUTPUT OF THE SDCU TO BE TRANSFERRED TO THE MOD 72 RECEIVERS FOR LOOP-BACK TESTING AND TO THE SOUTHBOUND HIGH SPEED TELEPHONE LINES TO MCC.

P) SELECT COMPUTER TO DAU-ENABLE,A,B,C - ENABLES THE SELECTION OF ONE COMPUTER FOR OUTPUT TO THE DISPLAY ASSEMBLER UNIT (DAU).

Q) DAU ALARM/RESET - RESETS THE OCC AUDIBLE ALARM WHEN ACTIVATED BY AN ALARM CONDITION IN THE DAU.

4.2.4 SYSTEM SWITCH AND TEST UNIT, IBM

THE SYSTEM SWITCH AND TEST UNIT (SSTU) CAN SWITCH CERTAIN I/O DATA AMONG THE THREE IBM 7094 COMPUTERS CONTROLLED BY THE OCC OR CAN ISOLATE ANY OF THE THREE COMPUTER SYSTEMS FROM ITS I/O DATA SOURCE. MAINTENANCE CAN THEN BE PERFORMED ON THE ISOLATED IBM 7094 WITHOUT INTERFERING WITH ANY OTHER COMPUTER. THE CONTROL OF SWITCHING OR AVAILABILITY OF AN IBM 7094 FOR MAINTENANCE IS FROM THE OCC. THE SSTU HAS TWO MAIN UNITS - A HIGH-

SPEED SWITCH UNIT, LOCATED IN THE ODR B CABINET, AND A CONTROL AND LOW-SPEED DATA UNIT.

THE SSTU HAS AN OPERATOR'S PANEL AND ALSO DUPLICATES THE STATUS INDICATIONS OF THE OCC. IT ALSO HAS CONTROLS AND INDICATORS FOR MAINTENANCE USE.

THE OPERATOR'S PANEL HAS THE FOLLOWING CONTROLS AND INDICATORS -

A) POWER ON-OFF - CONTROLS POWER TO SSTU.

B) TEST INDICATORS - TESTS INDICATOR LIGHTS ON PANEL.

C) MODE INDICATORS - INDICATE MISSION OR MULTIPLE-MISSION STATUS AS SET BY OCC.

D) COMPUTER STATUS INDICATORS - DUPLICATES STATUS LIGHTS ON OCC.

E) TRANSMITTER SELECTION - INDICATES ENABLE TO SWITCH TRANSMITTER AS FOLLOWS -
A OR B ACTIVE SWITCH CHANGES TRANSMITTER STATUS.
A OR B STANDBY INDICATOR SHOWS STANDBY TRANSMITTER.

F) COMPUTER TO STANDBY TRANSMITTER - A,B,C SELECTION SWITCHES CONNECT A COMPUTER TO STANDBY TRANSMITTER AND INDICATES SELECTION.

G) AVAILABLE COMPUTER FOR CP - INDICATES AVAILABLE COMPUTER SELECTIONS FOR CADFISS OUTPUT TO COMMUNICATIONS PROCESSOR.

H) TELETYPEWRITER OUTPUT DISABLED - INDICATES THAT THE ACTIVE TTY OUTPUT CIRCUIT HAS A CONTINUOUS MARKING CONDITION IMPOSED ON IT ON LOSS OF 48V.

I) COMPUTER TO DAU A,B,C - INDICATES WHICH COMPUTER IS SELECTED FOR OUTPUT TO THE DAU AND THAT THE DAU IS IN OPERATIONAL STATUS.

THE MAINTENANCE PANEL HAS THE FOLLOWING CONTROLS AND INDICATORS -

A) MAINTENANCE SELECTION A,B,C - PLACES COMPUTER INTO MAINTENANCE, LOCKS OUT OCC SELECTION.

B) RELEASE FROM MAINTENANCE A,B,C - ALLOWS OCC TO TAKE CONTROL OF COMPUTER.

C) HIGH-SPEED DATA LOOP TEST, ISOLATE AND RELEASE - DISCONNECTS OR CONNECTS NORTHBOUND DATA LINES TO MODEL 72 RECEIVER AND ALLOWS LOOPBACK.

D) ISOLATE TELETYPEWRITER A,B,C - DISCONNECTS THE TWO LOW SPEED TTY INPUTS AND THE TWO LOW SPEED TTY OUTPUTS TO ANY COMPUTER IN NOT READY STATUS AND ALLOWS TEST SWITCHING.

E) RELEASE FROM ISOLATE A,B,C - RECONNECTS TTY INPUTS AND OUTPUTS AND REMAINS SELECTED FOR MAINTENANCE STATUS.

F) ISOLATION COMMUNICATIONS PROCESSOR A,B,C - ISOLATES THE INPUT LINES OF ANY COMPUTER IN NOT READY STATUS FROM THE COMMUNICATIONS PROCESSOR AND ALLOWS LOOP TESTING.

G) RELEASE COMMUNICATION PROCESSOR A,B,C - RECONNECTS THE INPUT LINES TO THE COMMUNICATION PROCESSOR AND REMAINS SELECTED FOR MAINTENANCE STATUS.

H) LOOP CHANNEL 1 (CP), A,B,C - LOOP CHANNEL 2 (CP), A,B,C - ALLOWS CONNECTING OF EITHER 4800 BPS OUTPUT SUBCHANNEL OF AN ISOLATED COMPUTER TO THE 4800 BPS INPUT SUBCHANNEL.

4.2.5 DATA TRANSMITTER, MILGO MODEL 74

THERE ARE TWO IDENTICAL MODEL 74 TRANSMITTERS AT GODDARD. EITHER CAN BE SELECTED AT THE SSTU TO RECEIVE

DATA FROM THE HIGH-SPEED (1000 BPS) OUTPUT DCC SUBCHANNEL OF THE ACTIVE COMPUTER. IN THE ACTIVE TRANSMITTER, BINARY DATA IS CONVERTED INTO A 2-FREQUENCY SIGNAL BY A FREQUENCY SHIFT KEYER (FSK). THERE ARE FOUR FSK'S THAT SEND THE DATA OVER FOUR HIGH-SPEED TELEPHONE LINES TO THE MCC AT 1000 BITS/SEC EACH.

DURING DIFFERENT MISSION PHASES THE 440-BIT ODD FRAME DATA IS ALWAYS FOLLOWED BY THE 440-BIT EVEN FRAME DATA. TRANSMISSION IS AS FOLLOWS - DURING LAUNCH AND ABORT, A 440-BIT DATA FRAME IS TRANSMITTED EVERY ON-HALF SECOND. DURING ORBIT, A 440-BIT DATA FRAME IS TRANSMITTED EVERY SIX SECONDS. DURING REENTRY, A 440-BIT DATA FRAME IS TRANSMITTED EVERY THREE SECONDS. THE STANDBY TRANSMITTER CAN BE DRIVEN BY ONE OF THE REMAINING COMPUTERS TO DRIVE THE LOCAL DISPLAYS OR CAN BE USED FOR LOOP TESTS.

4.2.6 OPERATIONAL DATA RECORDERS

4.2.6.1 OPERATIONAL DATA RECORDER A, MILGO MODEL 1585. OPERATIONAL DATA RECORDER A (ODR A) IS A MAGNETIC TAPE UNIT USED TO RECORD AND PLAY BACK TONE BURST SIGNALS FROM SEVEN DATA CHANNELS. THE SIGNALS RECORDED CONSIST OF THE INPUT SIGNALS FROM MCC TO THE FOUR DATA RECEIVERS, B-GE, IP, AND BERMUDA RADAR INPUT FROM CHANNELS 1 AND 2.

4.2.6.2 OPERATIONAL DATA RECORDER B, MILGO MODEL 1585. THE ODR B IS IDENTICAL WITH THE ODR A EXCEPT FOR THE DATA CHANNEL ASSIGNMENTS. THE SIGNALS RECORDED ARE FROM THE ACTIVE MILGO MODEL 74 DATA TRANSMITTER (ALL FOUR OUTPUTS). THE ODR B PLAYS BACK THROUGH THE ACTIVE MODEL 74. CONTROL OF PLAYBACK IS ON THE DATA TRANSMITTER.

4.2.7 DATA RECEIVERS, BELL DATA SUBSETS 201A

TWO BELL DATA SUBSETS ARE USED TO RECEIVE SERIAL DATA TRANSMISSIONS FROM BERMUDA. A THIRD DATA RECEIVER IS ALSO USED TO RECEIVE WTR (WESTERN TEST RANGE) DATA FROM POINT ARGUELLO. WTR TO GSFC TRANSMISSION TERMINATES AT A DATA RECEIVER AT GSFC FROM WHERE IT CAN BE PATCHED TO EITHER INPUT BUFFER. THE DATA IS RECEIVED IN 2-BIT BYTES (DIBITS), WHICH HAVE BEEN-PHASE-SHIFTED BY AN AMOUNT DEPENDING ON THE DIBIT COMBINATION - 00=45 DEGREES, 01=135 DEGREES, 10=225 DEGREES, 11=315 DEGREES. DATA IS RECOVERED BY MEASURING THE PHASE ANGLE BETWEEN EACH RECEIVED DIBIT COMBINATION AND THE PRECEDING COMBINATION (USING A 90 DEGREE REFERENCE). PAIRS OF BITS ARE IDENTIFIED SIMULTANEOUSLY, BUT ARE TRANSFERRED FROM THE SUBSET SERIALLY. MESSAGES ARE IDENTIFIED WITH START OF WORD (SOW) AND END OF WORD (EOW) SIGNALS.

4.2.8 RADAR BUFFER, MILGO MODEL 1013-4A

BERMUDA MESSAGES ARE RECEIVED FROM EACH BELL 201A SUBSET AND PASSED TO THE BERMUDA RADAR BUFFER, WHERE THE INCOMING MESSAGES ARE AMPLIFIED, DECODED, AND TRANSFERRED BY THE BUFFER TO THE IBM DCC 7281 MOD 1, SUB, CHANNEL 5 AND 6. THE BUFFER ALSO GENERATES AND TRANSFERS AN ERROR CODE FOR THE COMPUTER TO IDENTIFY VALID TRANSMISSIONS. TWO INDEPENDENT CHANNELS ARE PROVIDED IN THE BUFFER. EACH CHANNEL NORMALLY RECEIVES DATA FROM A SEPARATE SUBSET AND TRANSFERS DATA TO THE SAME DCC SUBCHANNEL OF THE THREE COMPUTERS. SAMPLE AND EOM SIGNALS ARE PROVIDED BY EACH BUFFER CHANNEL TO EACH DCC CHANNEL TO CONTROL SENSING OF TRANSFERRED DATA AND TO RESET INPUT DATA TRANSFER-COUNTERS.

A MESSAGE DECODER AMPLIFIES AND DECODES INCOMING DATA AND SEPARATES THE MESSAGE INTO THREE PARTS - SOW, DATA, AND EOW. THE THREE OUTPUTS ARE SUPPLIED TO A TIMING AND CONTROL UNIT TO GENERATE TIMING SIGNALS AND TO CONTROL DATA TRANSFERS. THE DATA OUTPUT IS PASSED THROUGH AN ERROR-CODE GENERATOR TO FORM AN INDEPENDENT 16-BIT ERROR CODE FOR THE 160 DATA BITS OF THE BERMUDA MESSAGE. OUTPUT DATA IS STORED IN THE GENERATOR UNTIL THE PROPER TIME FOR COMPARING THE LOCALLY GENERATED ERROR CODE WITH THE ERROR CODE RECEIVED IN THE RADAR MESSAGE. THE OUTPUT DATA IS THEN TRANSFERRED SERIALLY INTO A 16- BIT RECEIVING REGISTER FOR TRANSMISSION TO THE DCC. AFTER THE RECEIVING REGISTER IS FILLED, THE DATA IS TRANSFERRED IN PARALLEL TO THE DCC SUBCHANNELS. A TOTAL OF TWELVE 16-BIT TRANSFERS ARE MADE FOR EACH MESSAGE FROM A BUFFER CHANNEL TO ITS ASSOCIATED DCC SUBCHANNEL. MESSAGE DATA IS CONTAINED WITHIN THE FIRST 11 TRANSFERS. THE TWELFTH TRANSFER CONTAINS ONLY THE GODDARD-GENERATED ERROR CODE.

4.2.9 MESSAGE ASSEMBLER, IBM

THE MESSAGE ASSEMBLER, UNDER CONTROL OF A DATA SOURCE SWITCH ON THE NETWORK STATUS CONSOLE, RECEIVES COMPUTER OR ODR SERIAL DATA FOR TRANSMISSION IN ACCORDANCE WITH THE GODDARD OUTGOING MESSAGE FORMAT. THE DATA CAN COME FROM THE ACTIVE OR STANDBY TRANSMITTER, AND ANY ONE OF THE GODDARD OUTGOING TELEPHONE LINES DRIVEN FROM THE ACTIVE TRANSMITTER CAN BE MANUALLY SELECTED VIA ISOLATION AMPLIFIERS. (SEE FIGURE 4-2.) SPECIFICALLY, THE UNIT PERFORMS THE FOLLOWING -

A) IT ASSEMBLES GROUPS OF DATA AND DISTRIBUTES THEM TO PROPER DISPLAYS VIA A TIME-SHARED DATA

BUS. AN INTERNAL PLUGBOARD FACILITY ALLOWS CONTROL OF REQUIRED DATA GROUP LENGTH AND GROUP COUNT FOR DATA ROUTING. A START OF WORD (SOW) TONE BURST IS TRANSMITTED AT THE START OF EACH SUBFRAME MESSAGE FROM THE MODEL 74 HIGH-SPEED DATA TRANSMITTER. FACILITIES ARE INCORPORATED TO DELAY THIS SOW BURST BY AN AMOUNT, DELTA T, IN ACCORDANCE WITH EXISTING REQUIREMENTS SPECIFIED FOR THE DATA DELAY CAPABILITY IN THIS UNIT.

B) IT MAKES A REMOTE SELECTION (AT THE NETWORK STATUS CONSOLE) OF INPUT TO THE D/A CONVERTERS WHICH DRIVE THE X-Y RECORDERS.

C) IT OPERATES THE COUNT CLOCK. THIS INCLUDES COUNTDOWN AND COUNTUP FACILITIES AND RESET, PRESET, HOLD, AND PROCEED CONTROLS. THE COUNT CLOCK OPERATES FROM MINUS 99 DAYS, 23 HOURS, 59 MINUTES, 59 SECONDS, TO PLUS 99 DAYS, 23 HOURS, 59 MINUTES, 59 SECONDS.

D) IT OPERATES A CLOCK REGISTER THAT CAN BE MANUALLY PRESET AND STEPPED BY A ONE PPS SIGNAL (DERIVED FROM THE TIME STANDARD SYSTEM) TO DRIVE THE GMT CLOCK.

4.2.10 DIGITAL OUTPUT DISPLAYS, IBM

THIS UNIT ACCEPTS DIGITAL DATA (IN BCD MODE) FROM THE MESSAGE ASSEMBLER AND DISPLAYS IT IN ALPHANUMERIC FORM. DISPLAYED CHARACTERS ARE 1-3/8 INCHES HIGH AND ARE GROUPED TO FACILITATE RAPID IDENTIFICATION OF ASSOCIATED DISPLAY QUANTITIES. ALL CHARACTERS ARE LEGIBLE FROM 60 DEGREES TO EITHER SIDE.

THE FOLLOWING DIGITAL DATA IS DISPLAYED -

A) FLIGHT DYNAMICS DISPLAYS
   1) (V/V_R)/VELOCITY
   2) GAMMA/APOGEE ALTITUDE
   3) INCLINATION ANGLE/$V-V_{GO}$
   4) GO/NO-GO
   5) ALTITUDE
   6) ORBIT CAPABILITY
   7) ORBIT NUMBER
   8) PERIGEE ALTITUDE

B) RETROFIRE DISPLAYS
   1) EMERGENCY (MANUAL INSERTION AND CONTINGENCY)
      GMTRC
      ESTRC
   2) END-OF-THIS-ORBIT (NEXT PRIMARY RECOVERY AREA)
      GMTRC
      ESTRC
   3) GMTRS
   4) RECOVERY AREA

C) RECOVERY DISPLAYS
   1) GMTLC
   2) LONGITUDE (WITH PLUS OR MINUS INDICATOR)
   3) LATITUDE (WITH PLUS OR MINUS INDICATOR)

D) DATA SOURCE LIGHTS
   1) B-GE MOD III
   2) B-GE MISTRAM
   3) IP AZUSA
   4) IP MISTRAM
   5) IP FPS-16
   6) IP FPQ-6
   7) BERMUDA

8) BERMUDA SOLUTION

E) GO NO-GO RECOMMENDATION DISPLAYS

1) B-GE

2) IP

3) BERMUDA

F) DIGITAL COUNT CLOCK WITH HOLD/PROCEED INDICATIONS

DIGITAL GMT CLOCK

GTRS/TRLC

G) PROPULSION DISPLAYS

1) YAW

2) PITCH/BANK ANGLE

3) DELTA T_{pc} /DELTA T_{pi}

4) GMTPC/GMTPI/GMTRB

5) DELTA V

4.2.11 DIGITAL-TO-ANALOG CONVERTER, MILGO MODEL 1646

THIS UNIT RECEIVES DATA FROM THE MESSAGE ASSEMBLER AND CONVERTS THE 80 DATA BITS (PARALLEL) INTO EIGHT 10-BIT BYTES. THE 10-BIT BYTES ARE CONVERTED TO EIGHT CHANNELS OF ANALOG OUTPUT VOLTAGE TO DRIVE PLOTBOARDS D AND E.

4.2.12 PLOTBOARDS D AND E, MILGO MODEL 3010

PLOTBOARDS D AND E ACCEPT ANALOG VOLTAGES FROM THE MODEL 1646 D/A CONVERTER AND DISPLAY CERTAIN INFORMATION IN CARTESIAN COORDINATES. ONE PEN ON EACH ARM PLOTS THE ANALOG INFORMATION WHILE THE OTHER PEN MAKES TIMING MARKS ADJACENT TO THE PLOTTED CURVE. THE PENS HOLD THEIR POSITIONS WHILE THE INPUT DATA IS CHANGING. IN THE EVENT OF LARGE DEVIATIONS FROM PRESET LIMITS ON EITHER THE ARM OR PEN CARRIAGE ON SUCCESSIVE MESSAGE INPUTS, THE AFFECTED

PENS ARE LIFTED FROM THE PLOTTING SURFACE. THE INFORMATION DISPLAYED IS THE SAME AS THE MCC AND IS SELECTED FROM THE NETWORK STATUS CONSOLE.

4.2.13 NETWORK STATUS CONSOLE, IBM

THE NETWORK STATUS CONSOLE (NSC) PROVIDES THE FOLLOWING --

A) SWITCHES TO CONTROL STATUS LIGHTS ON THE NETWORK STATUS DISPLAY PANEL. THE SWITCHES ARE LAID OUT IN THE PATTERN OF THE LIGHTS ON THE NETWORK STATUS DISPLAY.

B) FIVE PLOTBOARD DATA SOURCE PUSHBUTTONS CONTROL DATA TO EACH PLOTBOARD -

PLOTBOARD D - PLOTS 1,2,3,4, AND WALL MAP
PLOTBOARD E - PLOTS 1,2,3,4, AND WALL MAP

C) COUNT CLOCK AND GMT CLOCK RESET AND CONTROL SWITCHES

D) DIGITAL OUTPUT DISPLAY TEST CONTROL SWITCHES

E) CIRCUITRY TO ENABLE FLASHING OF THE SITE COLOR LIGHT

F) PROVISION FOR TWO SETS OF TWO TELEPHONE JACKS, EACH SET CONTROLLED BY ONE OF THE TWO CALL DIRECTOR SYSTEMS MOUNTED IN THE CONSOLE

G) CONTROL PANEL LAYOUT DESIGNED SO THAT TWO OPERATORS MAY HAVE ACCESS TO CONTROLS

H) THE NETWORK STATUS DISPLAY REPORT LIGHT CONTROLLED BY A 3-WAY SWITCH ON THE NSC.

SWITCH POSITIONS ARE -

POSITION 1 - REPORT LIGHT OFF- ALL STATUS LIGHTS OFF

POSITION 2 - REPORT LIGHT OFF - STATUS LIGHTS UNAFFECTED

POSITION 3 - REPORT LIGHT RED - STATUS LIGHTS UNAFFECTED

I) TWO 5-POSITION SWITCHES MOUNTED ON THE CONSOLE PANEL TO SELECT ONE OF THE FOUR HIGH-SPEED LINES FOR LOCAL DISPLAY AND TO SELECT A DIFFERENT LINE FOR REMOTE DISPLAY. THE FIFTH POSITION OF EACH SWITCH DISCONNECTS THE CORRESPONDING DISPLAY FROM THE INPUT LINES.

J) A STANDBY DATA SOURCE BUTTON PERMITS THE NSC OPERATOR TO SELECT THE STANDBY TRANSMITTER AS AN ALTERNATE DATA SOURCE FOR THE MESSAGE ASSEMBLER. A NORMAL DATA SOURCE BUTTON SELECTS THE ISOLATED, HIGH-SPEED, SOUTHBOUND DATA FROM THE ACTIVE TRANSMITTER FOR INPUT TO THE MESSAGE ASSEMBLER.

4.2.14 NETWORK STATUS DISPLAY, IBM

THIS DISPLAY INDICATES THE STATUS OF ALL SITES COMPRISING THE MSFN TRACKING RANGE BY MEANS OF COLORED LIGHT DISPLAYS. WHEN A SITE DESIGNATION FLASHES GREEN, THAT SITE HAS ESTABLISHED CONTACT WITH THE CAPSULE. THE STATUS OF THE EQUIPMENT (RADAR IDENTIFICATION, TELEMETRY, ACQUISITION, COMMAND CONTROL, TTY, COMPUTERS, AND VOICE LINK) LOCATED AT EACH SITE IS INDICATED BY THE FOLLOWING COLOR CODE -

A) RED - EQUIPMENT IS NOT OPERATIONAL AND NOT EXPECTED TO BE OPERATIONAL AT SHOT TIME.

B) AMBER - EQUIPMENT IS NOT OPERATIONAL, BUT IS EXPECTED TO BE OPERATIONAL AT SHOT TIME.

C) GREEN - EQUIPMENT IS OPERATIONAL.

ALL STATUS LIGHTS ARE CONTROLLED FROM SWITCHES ON THE NSC.

4.2.15 HIGH-SPEED DATA-LOOP TEST UNIT, IBM

THIS UNIT IS NOT USED FOR NORMAL OPERATION, BUT RATHER FOR SPECIAL GODDARD COMPUTER TESTS. IT IS SPECIFICALLY DESIGNED TO CONNECT THE OUTPUT OF THE DATA TRANSMITTERS (MILGO MODEL 74) TO THE DATA RECEIVERS (MILGO MODEL 72) WITH THE PROPER ATTENUATION.

4.2.16 RESIDUAL PLOTTERS, SANBORN MODEL 356-5480 AND D/A CONVERTERS, MILGO MODEL 1646-5A

THE A,B,AND C COMPUTERS AT GODDARD HAVE A DIRECT DATA CONNECTION INSTALLED IN THE 7607-II DATA CHANNEL C WHICH PERMITS THE CONNECTION OF A MILGO MODEL 1646-5A D/A CONVERTER TO THE IBM 7094 DATA PROCESSING SYSTEM. TRANSFER OF DATA BETWEEN THE D/A CONVERTERS AND THE 7094 IS THE SAME AS WITH STANDARD OUTPUT UNITS. TWO 4-CHANNEL D/A CONVERTERS IN THE MODEL 1646-5A ARE CONNECTED TO SELECTED DIRECT DATA CONNECTIONS BY A SWITCH CONTROLLED FROM THE OPERATIONS CONTROL CONSOLE (OCC). THE ANALOG OUTPUT FROM THE D/A CONVERTER IS CONNECTED TO A 4-CHANNEL STRIP CHART RECORDER, SANBORN MODEL 356-5480.

4.2.17 PROGRAM CONTROL CONSOLES, IBM

THERE ARE THREE PROGRAM CONTROL CONSOLES AND EACH HAS A DIRECT DATA CONNECTION FOR ENTERING INFORMATION INTO ITS ASSOCIATED 7094 COMPUTER. THE CONSOLE CONSISTS OF TWO FUNCTIONAL SECTIONS - MANUAL SWITCHES SECTION AND OUTPUT STATUS INDICATORS SECTION.

4.2.17.1 MANUAL ENTRY SWITCHES SECTION. THIS SECTION CONSISTS OF 36 MANUAL ENTRY SWITCHES, OR DATA ENTRY KEYS. EACH SWITCH HAS THREE POSITIONS DESIGNATED AS 1,2, AND 3. THE DATA MESSAGE ENTERED INTO THE COMPUTER CONSISTS OF

36-BIT WORD TRANSFERS. WORD 1 CONSISTS OF THOSE SWITCHES SET TO POSITION 1. WORD 2 CONSISTS OF THOSE SWITCHES SET TO POSITION 3. WHEN A SWITCH IS SET TO POSITION 1, A ONE IS PLACED IN WORD 1 AND A ZERO IN WORD 2. SIMILARLY, WHEN A SWITCH IS SET TO POSITION 2, A ZERO IS PLACED IN BOTH WORDS 1 AND 2. DATA MESSAGES ENTER THE COMPUTER PROCESSOR UNDER DIRECT DATA INTERRUPT CONTROL. DATA TRANSFERS ARE EXECUTED VIA THE AUTOMATIC/MANUAL INTERRUPT KEYS AS FOLLOWS -

A) AUTOMATIC MODE - THIS MODE OF OPERATION MEANS THAT WHEN ONE OF THE 36 ENTRY SWITCHES IS CHANGED TO A POSITION OTHER THAN POSITION 2, A PROGRAM INTERRUPT IS IMMEDIATELY INITIATED.

B) MANUAL MODE - IN THIS MODE OF OPERATION THE DATA ENTERS THE COMPUTER AFTER SEVERAL SWITCH SETTINGS HAVE BEEN MADE AND THE INTERRUPT KEY HAS BEEN DEPRESSED. THE INTERRUPT SIGNAL IS ENABLED BY A CONTROL SWITCH ON THE OCC.

4.2.17.2 OUTPUT STATUS INDICATORS SECTION. THIS SECTION CONSISTS OF 36 STATUS INDICATORS CONTROLLED BY THE OUTPUT FROM SUBCHANNEL 16 OF THE IBM 7281-II DCC OF THE ASSOCIATED COMPUTER AND ARE UNDER PROGRAM CONTROL. THERE IS AN AUDIBLE AND VISUAL ALARM STATUS CONTROLLED BY SENSE RELAY 36-CONTACT CLOSURE.

4.2.18 DATA COMMUNICATIONS CHANNEL ADAPTER, IBM 7276 MOD 1

THERE ARE THREE DATA COMMUNICATIONS CHANNEL ADAPTERS, AND EACH IS CONNECTED TO THE INPUT AND OUTPUT TTY SUBCHANNELS OF A 7281 MODEL 1 DCC ASSOCIATED WITH ONE OF THE IBM 7094 COMPUTERS. EACH ADAPTER CONTAINS 18 INPUT

TTY SIGNAL CONVERTERS AND 6 OUTPUT TTY CONVERTERS -

A) INPUT TTY SIGNAL CONVERTER - EACH INPUT TTY SIGNAL CONVERTER IS A SOLID-STATE DEVICE THAT ACCEPTS SERIAL 7.42-UNIT BAUDOT CODE SIGNALS AT 60, 75, OR 100 WPM FROM INCOMING TTY LINES AND CONVERTS THEM TO PARALLEL SIGNALS FOR TRANSFER TO AN ASSOCIATED 7281 MODEL 1 INPUT TTY SUB-CHANNEL.

B) OUTPUT TTY SIGNAL CONVERTER EACH OUTPUT TTY SIGNAL CONVERTER IS A SOLID-STATE DEVICE THAT ACCEPTS PARALLEL SIGNALS FROM A 7281 MODEL 1 OUTPUT TTY SUBCHANNEL AND CONVERTS THEM TO 7.42 UNIT CODE TTY SIGNALS FOR TRANSMISSION SERIALLY AT 60, 75, OR 100 WPM TO AN ASSOCIATED OUTPUT TTY DEVICE.

C) SENSE OUTPUT STATUS CIRCUITRY EACH 7276 MOD 1 DCC ADAPTER HAS CIRCUITRY THAT CONVERTS FIVE 8-BIT WORDS FROM THE DCC :81 MODEL 1 SENSE OUT-PUT SUBCHANNEL 31 INTO A 40-BIT PARALLEL OUTPUT THAT DRIVES THE 40 STATUS INDICATOR DISPLAY LIGHTS ON THE OPERATIONS CONTROL CONSOLE AND PROGRAM CONTROL CONSOLE. THIS SENSE OUTPUT CIR-CUITRY IS ALSO USED FOR AN INTERNAL LOOP CHECK OF THE 7276 MOD 1 CHANNELS WHEN IN TEST MODE.

4.2.19 SIMULATION DATA CONTROL UNIT, IBM

THE SIMULATION DATA CONTROL UNIT (SDCU) PROVIDES THE COORDINATE CONVERSION COMPUTER WITH A HIGH AND LOW SPEED INTERFACE TO THE GODDARD REAL TIME SYSTEM. THE HIGH SPEED INTERFACE NORMALLY ALLOWS THE COORDINATE CON-VERSION COMPUTER TO ACCEPT INERTIAL DATA FROM THE GEMINI MISSION SIMULATOR (MCC) FOR COORDINATE CONVERSION AND TO

TRANSMIT SIMULATION DATA PERTINENT TO THE LAUNCH PHASE OF A GEMINI MISSION TO THE IBM 7094 COMPUTER COMPLEX. ACCESS TO EITHER THE MISSION CONTROL CENTER OR THE 7094 COMPUTER AT GSFC IS MADE POSSIBLE BY THE LINE SWITCHING CAPABILITY WITHIN THE HIGH SPEED INTERFACE. THE LOW SPEED INTERFACE PROVIDES THE COORDINATE CONVERSION COMPUTER WITH THE FACILITY TO SUPPLY RADAR COORDINATE DATA (TTY) PERTAINING TO THE ORBIT AND REENTRY PHASE OF THE GEMINI MISSION TO THE IBM 7094 REAL-TIME COMPLEX.

THE SDCU CONSISTS OF THE FOLLOWING UNITS -

A) HIGH-SPEED DATA RECEIVER AND BUFFER (2)
B) HIGH-SPEED DATA BUFFER AND TRANSMITTER (2)
C) TTY PARALLEL TO SERIAL CONVERTERS (4)
D) TTY SERIAL TO PARALLEL CONVERTERS (2)
E) HIGH-SPEED DIGITAL DATA CONTROL PANEL (1)
F) HIGH-SPEED DIGITAL DATA SELECTOR (1)

4.2.19.1 HIGH-SPEED DATA RECEIVER AND BUFFER. THIS UNIT ACCEPTS SERIAL DATA THAT HAS BEEN TRANSMITTED OVER 3 KC TELEPHONE LINES FROM MCC OR GSFC. THIS DATA IS BUFFERED INTO A 24-BIT PARALLEL FORMAT FOR TRANSFER TO A PARALLEL INPUT CHANNEL OF THE COORDINATE CONVERSION COMPUTER.

4.2.19.2 HIGH-SPEED DIGITAL DATA CONTROL PANEL. THIS PANEL ENABLES THE COORDINATE CONVERSION COMPUTER TO ACCESS THE HIGH-SPEED LINES BETWEEN GSFC AND MCC. THE ENABLE FUNCTION IS UNDER MANUAL CONTROL.

4.2.19.3 HIGH-SPEED DIGITAL DATA SELECTOR. THIS SELECTOR PROVIDES COMPLETE FLEXIBILITY FOR THE HIGH-SPEED DATA INTERFACE WITH THE COORDINATE CONVERSION COMPUTER VIA THE HIGH-SPEED LINES BETWEEN GSFC AND MCC. EACH RECEIVER

AND TRANSMITTER HAS ACCESS TO ANY OF THE FOUR NORTHBOUND LINES OR TO ANY OF THE FOUR SOUTHBOUND LINES. EACH RECEIVER AND TRANSMITTER CAN ALSO BE ISOLATED FROM THE HIGH-SPEED LINES.

4.2.19.4 TTY PARALLEL TO SERIAL CONVERTER. THIS CONVERTER RECEIVES DIGITAL INFORMATION AND CONTROL SIGNALS FROM CHARACTER OUTPUT BUFFERS OF THE COORDINATE CONVERSION COMPUTER. THIS INFORMATION IS ACCEPTED FIVE BITS AT A TIME IN PARALLEL FORMAT AND CONVERTED INTO 7.42-UNIT CODE TTY SIGNALS FOR TRANSMISSION AT 60 OR 100 WPM.

4.2.19.5 TTY SERIAL TO PARALLEL CONVERTER. THIS CONVERTER RECEIVES SERIAL 7.42-UNIT CODE TTY SIGNALS AT 60 OR 100 WPM AND CONVERTS THESE SIGNALS TO 5-BIT PARALLEL DATA FOR TRANSFER TO A CHARACTER INPUT BUFFER OF THE COORDINATE CONVERSION COMPUTER.

4.2.19.6 SIMULATION DATA CONTROL UNIT HIGH-SPEED BUFFER AND DATA TRANSMITTER. THE SIMULATION DATA CONTROL UNIT HIGH-SPEED BUFFER AND DATA TRANSMITTER RECEIVES DIGITAL INFORMATION AND CONTROL SIGNALS FROM A COORDINATE CONVERSION COMPUTER PARALLEL OUTPUT CHANNEL. THE HIGH-SPEED BUFFER AND DATA TRANSMITTER ACCEPTS THIS DIGITAL INFORMATION 24 BITS AT A TIME IN A PARALLEL FORMAT, SERIALIZES THIS DATA, AND CONVERTS IT INTO KEYED TONE BURSTS (FREQUENCY SHIFT KEYING) WHICH SHALL BL TRANSMITTED OVER 3 KC TELEPHONE VOICE LINES. IN NORMAL OPERATION, THE HIGH-SPEED BUFFER AND DATA TRANSMITTER WORKS IN CONJUNCTION WITH AN FSK DATA RECEIVER AT GSFC OR MCC.

4.2.20 OPERATIONAL DATA RECORDER (ODR)

THIS ODR PROVIDES RECORD CAPABILITY FOR HIGH-SPEED DATA ENTERING THE SDCU RECEIVERS DURING REAL-TIME OPERATION. IT ALSO PROVIDES PLAYBACK CAPABILITY FOR REAL-TIME OPERATION WHEN THE HIGH-SPEED LINES ARE NOT AVAILABLE.

4.2.21 COORDINATE CONVERSION COMPUTER, COMPUTER CONTROL COMPANY

THE COORDINATE CONVERSION COMPUTER (CCC) IS A SMALL, FAST, HIGHLY VERSATILE PROCESSOR DESIGNED FOR APPLICATIONS INVOLVING CONTROL, MONITORING, AND COMPUTAIONS REQUIRED IN A WIDE RANGE OF PROCESSES. MOST INTERNAL OPERATIONS ARE PERFORMED IN 10 MICRO SECONDS OR LESS, INCLUDING EXCESS TIME. THE COMPUTER OPERATIONS INCLUDE ADDITION, SUBTRACTION, MULTIPLICATION, DIVISION, DATA TRANSFERS, AND A VARIETY OF LOGICAL, JUMP, AND INDEXING OPERATIONS. INCLUDED AS PART OF THE COMPUTER ARE INDEX REGISTERS, PAPER TAPE READER, PAPER TAPE PUNCH, INPUT/OUTPUT TYPEWRITER, MAGNETIC TAPE UNITS, EXTERNAL SENSE LINES, OUTPUT CONTROL LINES, INTERRUPT LINES, CHARACTER INPUT/OUTPUT BUFFERS, 24-BIT PARALLEL INPUT CHANNELS, AND 24-BIT PARALLEL OUTPUT CHANNELS.

THE APPLICATION OF THIS COMPUTER AT GSFC IS ONE IN WHICH REAL-TIME INERTIAL DATA FROM MCC (AT 1003 BITS PER SECOND) IS RECEIVED AND, WITHIN SIX SECONDS, IS VALIDATED, RECORDED, REFORMATTED, AND RETRANSMITTED AT 100 WPM TO THE GODDARD IBM 7094 COMPUTER COMPLEX AS RADAR COORDINATE DATA (RANGE, AZIMUTH, ELEVATION).

4.2.22 REMOTE COUNT CLOCK

THE REMOTE COUNT CLOCK PROVIDES THE ''C'' COMPUTER AREA AND THE COORDINATE CONVERSION COMPUTER AREA WITH A VISUAL DISPLAY OF THE GMT AND COUNT CLOCKS. THEY OPERATE IN PARALLEL WITH THE GMT AND COUNT CLOCKS ON THE DIGITAL OUTPUT DISPLAY.

PRECEDING PAGE BLANK NOT FILMED.

5. GSFC DATA PROCESSING

5.1 INPUT/OUTPUT TRANSMISSION

DURING A GEMINI MISSION, THE MOST CRITICAL DATA MUST BE PROCESSED IN REAL TIME. REAL-TIME DATA IS READ INTO AND OUT OF THE COMPUTER STORAGE AREA SIMULTANEOUSLY WITH CENTRAL PROCESSOR OPERATION AND WITH THE OPERATION OF OTHER INPUT/OUTPUT EQUIPMENT. EIGHT INPUT-OUTPUT CHANNELS, IDENTIFIED A THRU H, CAN BE AVAILABLE WITH A IBM 7094 COMPUTER. GODDARD COMPUTERS USE CHANNELS A,B, AND C FOR ON-LINE COMMUNICATION AND CHANNEL F FOR REAL-TIME TRANSMISSION. A REAL-TIME TRANSMISSION DEVICE, THE IBM 7281-I DATA COMMUNICATION CHANNEL (DCC), IS USED WITH CHANNEL F TO MAKE REAL-TIME OPERATION POSSIBLE.

5.1.1 DATA COMMUNICATION CHANNEL

THE DCC AIDS IN SOLVING PROJECT GEMINI OPERATIONAL CONTROL PROBLEMS BY PROVIDING THE CAPABILITY FOR THE TOTAL COMPUTAION AND COMMUNICATIONS NETWORK TO OPERATE IN REAL TIME. THE MERIT OF THE DCC IN THE GEMINI PROJECT LIES IN ITS INVALUABLE CONTRIBUTION AS THE EQUIPMENT RESPONSIBLE FOR FUNNELING THE HUGE FLOW OF INFORMATION THROUGH THE IBM 7094 COMPUTER. SIMPLY STATED, THE DCC AUTOMATICALLY ACCEPTS INPUTS FROM A LARGE NUMBER OF DATA SOURCES, PLACES THE INFORMATION QUANTITIES DIRECTLY AT THE DISPOSAL OF THE COMPUTER, AUTOMATICALLY ACCEPTS CALCULATED OUTPUT DATA FROM THE COMPUTER AND MAKES THAT INFORMATION IMMEDIATELY AVAILABLE FOR TRANSMISSION TO MANY DESTINATIONS. THE DCC, THUS, ENHANCES THE EFFICIENCY OF THE COMPUTER-GEMINI PROGRAMMING SYSTEM DATA PROCESSING OPERATIONS TAKE PLACE AT NO SACRIFICE TO INTERNAL COM-

PUTER TIME.

TWO OF THE THREE IBM 7094 COMPUTERS (ONE COMPUTER IS IN STANDBY) LOCATED AT THE GODDARD COMPUTING AND COMMUNICATIONS CENTER ARE EACH CONNECTED BY A DCC TO RADAR SITES AND SOURCES COMPRISING THE REAL-TIME TRACKING AND INSTRUMENTATION SYSTEM. ALL INFORMATION TRANSMITTED TO GODDARD PASSES INTO THE COMPUTER THROUGH THE DCC'S. AFTER PROCESSING TAKES PLACE, THE OUTPUT QUANTITIES ARE THEN TRANSMITTED THROUGH THE DCC'S TO THE COMMAND CENTERS AND REMOTE STATION. EMPLOYING THE DCC'S ENABLES THE COMPUTER TO TRANSMIT AND RECEIVE DATA AUTOMATICALLY-REAL-TIME COMPUTATIONS PROCEED SIMULTANEOUSLY WITH DATA TRANSMISSION.

TO MAINTAIN DATA PROCESSING IN REAL-TIME AND TO ENSURE THAT NO DATA QUANTITIES ARE LOST DURING TRANSMISSION, THE DCC'S ''STACK UP'' DATA IN COMPUTER CORE STORAGE AS IT IS RECEIVED. WHEN SUFFICIENT DATA HAS BEEN ENTERED THROUGH THE DCC'S, COMPUTER PROCESSING OPERATIONS ARE INTERRUPTED. THE COMPUTER THEN EXTRACTS THE DCC-CHANNELED CORE STORAGE INFORMATION AND MOVES IT FROM THE STORAGE BUFFER TO THE PROCESSOR BLOCK. AT THIS POINT, THE COMPUTER MAY (1) PROCESS THE INFORMATION, (2) RETURN TO THE EXACT POINT AT WHICH PREVIOUS CALCULATIONS WERE INTERRUPTED, OR (3) INITIATE A NEW PROGRAM.

WHEN AN INTERRUPT OCCURS, CENTRAL PROCESSING IS TAKEN FROM THE MAIN PROGRAM AND GIVEN TO THOS INSTRUCTIONS IN LOWER CORE STORAGE SPECIFIED BY THE PARTICULAR INTERRUPT. AFTER THE COMPUTER HAS SERVICED THE INTERRUPT AND HAS SATISFIED THE RESULTING CONDITIONS IMPOSED BY THE SYSTEM, THE PRE-INTERRUPT PROCESSING STATE OS RESTORED (INSOFAR AS POSSIBLE, BECAUSE AN IMMEDIATE CONSEQUENCE OF THE INTERRUPT MAY BE AN ALTERATION IN THE PROCESSING SEQUENCE OR DATA FLOW) AND PROCESSING CONTROL IS RETURNED

TO THE MAIN PROGRAM AT THE EXACT POINT FROM WHICH IT WAS EXEMPTED.

THIRTY-TWO SUBCHANNELS ON THE DCC'S CONNECT THE 7094 COMPUTER TO EXTERNAL DATA SOURCES WHICH ARE LINKED TOGETHER THROUGHOUT THE GEMINI GROUND COMMUNICATIONS SYSTEM. A MULTIPLEXER-SEQUENCER WITHIN THE DCC'S EXAMINES SUBCHANNELS IN TURN, GIVES PRIORITY TO THE HIGHER-SPEED SUBCHANNEL AS REQUIRED, REQUESTS PROGRAM INTERRUPTS, AND PROVIDES CONTROL NEEDED FOR SUBCHANNEL OPERATION. SUBCHANNEL INTERRUPTS OCCUR ONLY WHEN THE SEQUENCER IS POSITIONED AT THAT PARTICULAR SUBCHANNEL.

SUBCHANNELS MAY BE TURNED ON (ACTIVATED) OR TURNED OFF (DEACTIVATED) INDEPENDENTLY WITH THE INSTRUCTIONS FROM THE MAIN PROGRAM. SUBCHANNELS MUST BE ACTIVATED TO TRANSFER DATA OR INITIATE PROGRAM INTERRUPTS (TRAPS). FURTHER, A MAIN PROGRAM INSTRUCTION MUST ENABLE THE DCC FOR TRAPPING BEFORE AN INTERRUPT REQUEST IS HONORED. IF THE DCC IS DISABLED, TRAPS ARE REMEMBERED AND EXECUTED WHEN ENABLED. DISABLING THE DCC HAS NO EFFECT THEREFORE ON DATA TRANSMISSION UNLESS THERE IS A WAITING TRAP. WHEN ANY OF THE SUBCHANNELS REQUESTS A TRAP, ALL DCC DATA TRANSFERS ARE STOPPED UNTIL THE TRAP IS GRANTED. (SEE FIGURE 5-1.)

AT ANY GIVEN TIME IN THE MISSION, IT MAY BE ESSENTIAL THAT A PROGRAM OR A ROUTINE BE COMPLETED WITHOUT INTERRUPTION. IN PROGRAMMING TERMINOLOGY SUCH A PROGRAM WOULD ''RUN DISABLED,'' I.E., IT WOULD BEGIN WITH AN INSTRUCTION TO DISABLE THE DCC (AND ALL OTHER DATA CHANNELS). NORMAL DATA TRANSFER THROUGH THE DCC WILL CONTINUE IN THIS CASE. HOWEVER, IF AN INPUT BUFFER AREA IS FILLED OR AN OUTPUT BUFFER AREA IS EMPTIED, THE PARTICULAR SUBCHANNEL INVOLVED WILL REQUEST AN INTERRUPT. AT

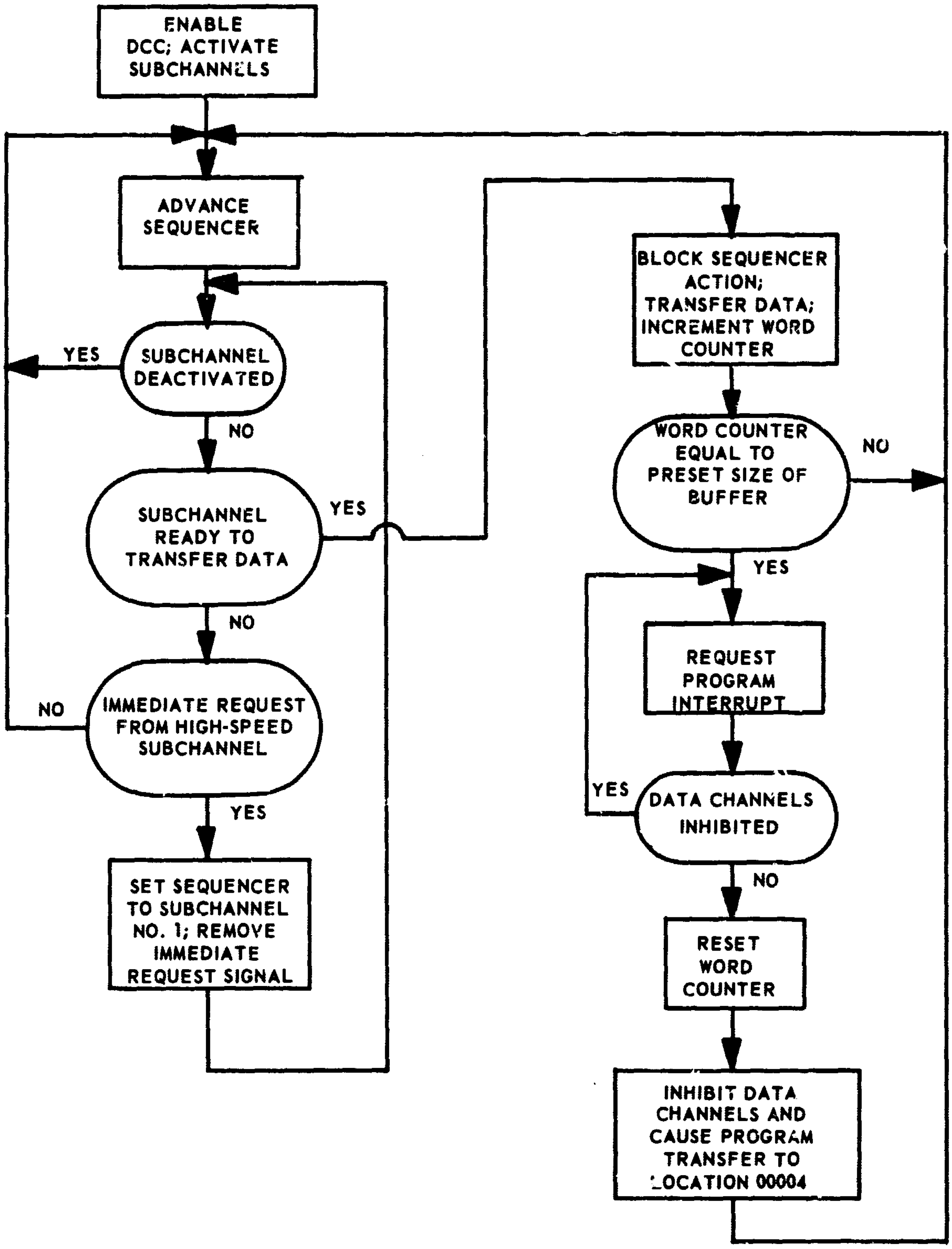


FIGURE 5-1. SIMPLIFIED DCC LOGIC FLOW

THIS POINT THE DCC BECOMES INHIBITED AND ALL DATA TRANSFER CEASES. (DATA COULD BE LOST TO THE SYSTEM IF A PROGRAM'S PRIORITY DEMANDS UNINTERRUPTED EXECUTION, ALTHOUGH IN ACTUAL USAGE THE SPEED OF THE IBM 7094 COMPUTER VIRTUALLY PRECLUDES THE LOSS OF DATA IN THIS MANNER.) THE TRAP IS REMEMBERED AND, AFTER THE ROUTINE IS COMPLETED, AN ENABLING INSTRUCTION IS GIVEN, THE TRAP REQUEST IS GRANTED, AND THE TRANSFER OF DATA BY THE DCC CONTINUES. THEREFORE, THE DCC MAY INTERRUPT THE MAIN PROGRAM ONLY TO THE EXTENT THAT THE MAIN PROGRAM ALLOWS. THE DCC CONTROLS THE TRANSMISSION OF DATA, AND THE MAIN PROGRAM CONTROLS THE ACTION OF THE DCC.

5.1.2 DATA CHANNELS A,B, AND C

THE INPUT OF REAL-TIME DATA OCCURS THROUGH THE DCC. TO PROVIDE MAXIMUM VERSATILITY IN THE OPERATIONAL TRACKING PROGRAM, THE IBM 7094 DATA CHANNELS A, B, AND C ARE UTILIZED TO PERFORM THE FOLLOWING FUNCTION -

A) WRITE THE GEMINI SYSTEM TAPE, INITIALLY LOAD THE FIRST PHASE OF THE GEMINI PROGRAMMING SYSTEM FOR LAUNCH, AND LATER LOAD THE NEW PROGRAMS REQUIRED FOR THE ORBIT AND REENTRY PHASES AND, IF NECESSARY, THE PROGRAMS REQUIRED FOR ORBITAL RESTARTS.

B) LOAD THE STATION CHARACTERISTICS TAPE INTO COMPUTER CORE STORAGE DURING THE PRELAUNCH INITIALIZATION OF THE GEMINI PROGRAMMING SYSTEM.

C) WRITE AND MAINTAIN A RESTART TAPE WITH THE PROPER PARAMETERS FOR ORBITAL AND REENTRY RESTARTS AND FOR THE PHASE CHANGE FROM ORBIT TO REENTRY.

D) PROVIDE THE GEMINI PROGRAMMING SYSTEM WITH PREPARAED MESSAGES FOR ON-LINE PRINTING THROUGH-OUT THE MISSION.

E) PROVIDE, FOR POSTFLIGHT ANALYSIS, A PERMANENT LOG TAPE RECORD OF ALL INPUT-OUTPUT TRANSMISSION VIA THE DCC AND OF ALL ON-LINE MESSAGE PRINT-OUTS.

TO PROMOTE MAXIMUM EFFICIENCY OF TAPE INPUT-OUTPUT (AND ON-LINE PRINTER) OPERATIONS AND TO ENSURE MINIMUM DELAY OF THE CENTRAL PROCESSING UNIT, THE SIMULTANEOUS INPUT-OUTPUT/COMPUTE CAPABILITY OF THE IBM 7094 SYSTEM IS USED FOR ALL DATA CHANNEL OPERATIONS WHILE THE GEMINI PROGRAMMING SYSTEM IS OPERATING IN REAL TIME. THAT IS, NO DATA CHANNEL COMMANDS ARE GIVEN WHICH WOULD LOGICALLY DISCONNECT AN INPUT-OUTPUT DEVICE AT THE TERMINATION OF TRANSMISSION WITHOUT AN ACCOMPANYING DATA CHANNEL TRAP. THIS REQUIRES TWO PROGRAMS FOR EVERY INPUT-OUTPUT TRANSMISSION PROCESS - THE MONITOR PROCESSOR (MYXXXX) WHICH INITIATES THE TRANSMISSION AND THE MONITOR TRAP PROCESSOR (MTXXXX) WHICH SERVICES THE TRAP FOLLOWING THE COMPLETION OF TRANSMISSION.

WHEN TWO OR MORE TRANSMISSION PROCESSORS SHARE THE SAME DATA CHANNEL, CERTAIN RESTRICTIONS MUST BE OBSERVED. PRIOR TO INITIATING TRANSMISSION THE PROCESSOR MUST -

A) SUPPRESS EVERY OTHER PROCESSOR WHICH MAY IN-ITIATE TRANSMISSION OVER THE SAME DATA CHANNEL.

B) SET THE LOW-CORE TRAP CONTROL LOCATION WITH A TRANSFER INSTRUCTION ADDRESSED TO THE TRAP PROCESSOR APPROPRIATE FOR THE DATA TRANSMITTED.

C) SUPPRESS ITSELF, IF NECESSARY, TO PREVENT SUCCESSIVE ENTRY AND TRANSMISSION UNTIL AFTER THE TRAP PROCESSOR HAS SIGNALED THE COMPLETION

OF THE CURRENT TRANSMISSION CYCLE.

5.1.3 DCC SUBCHANNEL ASSIGNMENTS

OF THE 32 SUBCHANNELS ON THE DCC, THE GEMINI PROGRAMMING SYSTEM USES 30. THE SPECIFIC FUNCTION OF THE INDIVIDUAL SUBCHANNELS IS DESCRIBED IN THE FOLLOWING PARAGRAPHS. THE UNDERSCORED SUBCHANNEL NUMBER PRECEDING THE EXPLANATION REFERS TO THE SEQUENCER POSITION AND, SINCE THE SEQUENCER EXAMINES EACH SUBCHANNEL SEQUENTIALLY, IT REFERS ALSO TO EACH SUBCHANNEL'S RELATIVE PRIORITY.

SUBCHANNEL 1 - HIGH-SPEED INPUT SUBCHANNEL THAT RECEIVES DATA FROM THE B-GE COMPUTER AT CAPE KENNEDY. AS ITS PRIORITY INDICATES, THIS SUBCHANNEL TRANSMITS DATA OF EXTREME IMPORTANCE. THE B-GE COMPUTER RECEIVES TRACKING INFORMATION FROM THE LAUNCH VEHICLE ONLY, THEREFORE, DATA PERTINENT TO SPACECRAFT TRACKING TERMINATES WITH SPACECRAFT SEPARATION.

SUBCHANNEL 2 - HIGH-SPEED INPUT SUBCHANNEL THAT RECEIVES DATA FROM THE AN/FPS-16 RADARS AT CAPE KENNEDY AND THE DOWNRANGE STATIONS. A MANUAL SELECTOR SWITCH AT THE CAPE ROUTES THE TRANSMISSION OF IP-PROCESSED AN/FPS-16 OR AZUSA QUANTITIES TO GODDARD. THE HIGH-SPEED TRANSMISSION TO GODDARD OF CAPE KENNEDY RADAR INFORMATION EFFECTIVELY STOPS AT THE TIME OF SPACECRAFT INSERTION.

SUBCHANNEL 3 - HIGH-SPEED OUTPUT SUBCHANNEL THAT TRANSMITS GODDARD-PROCESSED DATA TO CAPE KENNEDY WHERE IT IS USED TO DRIVE CONTROL CENTER DISPLAYS. THIS OUTPUT LINE IS USED CONTINUOUSLY THROUGHOUT THE MISSION.

SUBCHANNEL 4 - HIGH-SPEED OUTPUT SUBCHANNEL THAT TRANSMITS DATA TO THE LOCAL DIGITAL-TO-ANALOG CONVERTORS WHERE IT IS USED TO DRIVE GODDARD DISPLAYS. THIS OUTPUT LINE IS IN CONTINUOUS USE THROUGHOUT THE MISSION.

SUBCHANNELS 5 AND 6 - HIGH-SPEED INPUT SUBCHANNELS THAT RECEIVE DATA FROM BOTH THE VERLORT AND AN/FPS-16 RADARS AT BERMUDA. THE DUPLEXED TRANSMISSION HAS BOTH TYPES OF DATA IN THE SAME MESSAGE, AND TRANSMISSION RATE IS AT 2000 BITS PER SECOND.

SUBCHANNEL 7 - A ONE-HALF SECOND TRAP SUBCHANNEL THAT PROVIDES A PROGRAM INTERRUPT EVERY ONE-HALF SECOND. SINCE MUCH OF THE COMPUTER'S OUTPUT TRANSMISSION IS BASED ON A TIME PERIOD, THE INCREMENTING (OR DECREMENTING, IF A COUNTDOWN METHOD IS USED) OF CORE STORAGE LOCATIONS FOR EACH HALF-SECOND TRAP ENABLES THE COMPUTER TO KEEP COUNT OF TIME AND TO DELIVER OUTPUT ON SPECIFIED SCHEDULES. THE CONTINUOUS FUNCTIONING OF THE HALF-SECOND TRAP IS ESSENTIAL IN A REAL TIME SYSTEM. ALTHOUGH THE SIX HIGH-SPEED SUBCHANNELS HAVE HIGHER PRIORITY, THE MAXIMUM TIME REQUIRED TO SERVICE THESE, UNDER THE WORST POSSIBLE CONDITIONS, WOULD NOT INTERFERE WITH THE HALF-SECOND TIME COUNT.

IN SYNCHRONIZATION WITH THE OPERATION OF SUBCHANNEL 7, CORE STORAGE LOCATION IS INCREMENTED FROM 0 TO 59 TO KEEP COUNT OF THE NUMBER OF ELAPSED 8-1/3 MILLISECOND PERIODS SINCE THE LAST ON-HALF-SECOND TRAP (60 INTERVALS OF 8-1/3 MILLISECONDS SPAN A HALF SECOND). AFTER THE 60TH INTERVAL THE CELL IS RESET TO ZERO. THE CELL ENABLES THE COMPUTER TO DEFINE MORE PRECISELY THE CHRONOLOGY OF EVENTS ON THE TAPED LOGGING RECORD. ALSO, THE SIGN BIT OF THIS STORAGE CELL INDICATES WHETHER THE COMPUTER IS OR IS NOT TRANSMITTING EXTERNALLY. WHEN THE SIGN OF THIS CELL IS POSITIVE, THE COMPUTER IS TRANSMITTING ON LINE. THE BIT IS CONTROLLED FROM THE OUTPUT STATUS CONSOLE.

SUBCHANNEL 8 - THE WWV TRAP SUBCHANNEL RECEIVES A PULSE FROM THE NATIONAL BUREAU OF STANDARDS RADIO STATION

WWV EVERY MINUTE. THIS SIGNAL INITIATES A PROGRAM INTERRUPT WHICH ENABLES THE COMPUTER TO INCREMENT A CELL CONTAINING A ONE-MINUTE COUNT AND TO ASCERTAIN THE ACCURACY OF THE COMPUTER'S INTERNAL TIME COUNT.

SUBCHANNEL 9 - THE INTERVAL TIMER SUBCHANNEL PROVIDES AN INTERNAL TIME WHICH IS SET BY PLACING THE DESIRED INTERVAL IN A SPECIFIED CELL. AN INTERRUPT IS PRODUCED WHEN THE SPECIFIED INTERVAL HAS ELAPSED.

SUBCHANNEL 10 - LOW-SPEED OUTPUT 1 (TTY SUBCHANNEL X) SELECTS AND TRANSMITS TTY ACQUISITION DATA TO THE FOLLOWING STATIONS - BERMUDA, ATLANTIC SHIP, HAWAII, GUAYMAS, AND CORPUS CHRISTI.

SUBCHANNEL 11 - LOW-SPEED OUTPUT 22 (TTY SUBCHANNEL Y) SELECTS AND TRANSMITS TTY ACQUISITION DATA TO THE FOLLOWING STATIONS - CAPE KENNEDY, GRAND CANARY ISLAND, KANO, ZANZIBAR, COASTAL SENTRY QUEBEC SHIP, MUCHEA, WOOMERA, CANTON ISLAND, POINT ARGUELLO, WHITE SANDS, AND EGLIN.

SUBCHANNEL 12- STANDY FOR SUBCHANNELS 11 AND 12.

SUBCHANNEL 13 - NOT USED.

SUBCHANNEL 14 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA (RANGE, AZIMUTH AND ELEVATION) AND TELEMETRY SUMMARIES FROM THE CAPE KENNEDY, GRAND BAHAMA ISLAND, AND THE SAN SALVADOR ISLAND TRACKING STATIONS.

SUBCHANNEL 15 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA FROM THE BERMUDA TRACKING STATION.

SUBCHANNEL 16 - ALTERNATE LOW-SPEED ROUTE FOR RADAR DATA AND TELEMETRY SUMMARIES FROM THE GRAND CANARY ISLAND TRACKING STATION.

SUBCHANNEL 17 - LOW-SPEED INPUT THAT RECEIVES ADMINISTRATIVE TRAFFIC OR SERVES AS THE ALTERNATE RADAR DATA AND TELEMETRY SUMMARY ROUTE FROM THE BERMUDA

TRACKING STATION.

SUBCHANNEL 18 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA AND TELEMETRY SUMMARIES FROM THE GRAND CANARY ISLAND TRACKING STATION AND TELEMETRY SUMMARIES ONLY FROM THE TANANARIVE AND KANO TRACKING STATIONS.

SUBCHANNEL 19 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA AND TELEMETRY SUMMARIES FROM THE WOOMERA, CARARVON, AND THE HAWAII TRACKING STATIONS, AND TELEMETRY SUMMARIES ONLY FROM THE CANTON ISLAND TRACKING STATION.

SUBCHANNEL 20 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA AND TELEMETRY SUMMARIES FROM THE POINT ARGUELLO TRACKING STATION.

SUBCHANNEL 21 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA FROM THE WHITE SANDS TRACKING STATION.

SUBCHANNEL 22 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA FROM THE EGLIN AIR FIELD TRACKING STATION.

SUBCHANNEL 23 - LOW-SPEED INPUT THAT RECEIVES TELEMETRY SUMMARIES FROM THE ROSEKNOT VICTOR (RKV) SHIP.

SUBCHANNEL 24 - LOW-SPEED INPUT THAT RECEIVES TELEMETRY SUMMARIES FROM THE COASTAL SENTRY QUEBEC (CSQ) SHIP, AND RADAR DATA AND TELEMETRY SUMMARIES FROM THE WOOMERA AND CARNARVON TRACKING STATIONS.

SUBCHANNEL 25 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA AND TELEMETRY SUMMARIES FROM THE HAWAII TRACKING STATION.

SUBCHANNEL 26 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA AND TELEMETRY SUMMARIES FROM THE GUAYMAS TRACKING STATION.

SUBCHANNEL 27 - LOW-SPEED INPUT THAT RECEIVES RADAR DATA AND TELEMETRY SUMMARIES FROM THE CORPUS CHRISTI TRACKING STATION.

SUBCHANNEL 28 - LOW-SPEED INPUT THAT RECEIVES TELE-

METRY SUMMARIES FROM CAPE KENNEDY.

SUBCHANNEL 29 - LOCAL INSERTION OF RADAR DATA.

SUBCHANNEL 30 - THE PAPER TAPE INPUT SUBCHANNEL FOR ALL MANUALLY-INSERTED MESSAGES. MANUAL INPUT INFORMATION INCLUDES - THE GMT OF TWO-INCH LIFT-OFF, A MESSAGE INDICATING THAT EITHER ABORT OR ORBIT HAS BEEN ENTERED BY THE SPACECRAFT, THE NUMBER OF RETROROCKETS FIRED AND THE TIME OF FIRING, RANGE AND VELOCITY VECTORS FOR INTEGRATION, AND SPACECRAFT CLOCK INFORMATION. THE MESSAGES ARE PUNCHED ON PAPER TAPE AND INSERTED INTO THE COMPUTER VIA SUBCHANNEL 30.

SUBCHANNEL 31 - THE SENSE OUTPUT SUBCHANNEL TRANSMITS FIVE 8-BIT WORDS FROM CORE STORAGE TO THE OPERATIONS CONTROL CONSOLE. EACH BIT CONTROLS ONE OF 40 INDICATOR LIGHTS ON THE OPERATIONS CONTROL CONSOLE AND PROGRAM CONTROL CONSOLE. A 1 TURNS ON A PARTICULAR INDICATOR, AND A ZERO TURNS IT OFF.

SUBCHANNEL 32 - NOT USED.

(TABLE 5-1 LISTS THE SEQUENCE POSITION, THE STARTING LOCATION IN CORE, AND THE SIZE OF EACH BUFFER AREA FOR DEVICES CONNECTED TO THE DCC.)

TABLE 5-1. STORAGE LAYOUT AND SEQUENCER NUMBERING, GSFC COMPUTER COMPLEX (SHEET 1 OF 2)

TYPE OF DEVICE AND NUMBER	SEQUENCER POSITION	OCTAL ADD. OF BUFFER (1ST WORD)	ADD. IN DEC.	SIZE OF BUFF.	OPEN WORDS AT END OF BLOCK
HIGH-SPEED	1	07400	3840	24	8
INPUT NO. 1		07440	3872	24	8
HIGH-SPEED	2	07500	3904	24	8
INPUT NO. 2		07540	3936	24	8
HIGH-SPEED	3	07600	3968	32	0
OUTPUT NO. 1					
HIGH-SPEED	4	07640	4000	32	0
OUTPUT NO. 2					
HIGH-SPEED	5	07000	3584	24	8
INPUT BDA NO.1					
HIGH-SPEED	6	07700	4032	24	8
INPUT BDA NO.2					
ONE-HALF SECOND	7	07127	3671	1	0
TRAP					
WWV TRAP	8	----	---	--	-
INTERVAL TIMER	9	07126	3670	1	0
TTY OUTPUT NO.1	10	07120	3664	6	0
TTY OUTPUT NO.2	11	07130	3672	6	2
TTY OUTPUT NO.3	12	07310	3784	6	2
OPEN	13	07320	3792	6	2
TTY INPUT NO.1	14	07160	3696	6	2
TTY INPUT NO.2	15	07170	3704	6	2
TTY INPUT NO.3	16	07200	3712	6	2

TABLE 5-1. STORAGE LAYOUT AND SEQUENCER NUMBERING, GSFC COMPUTER COMPLEX (SHEET 2 OF 2)

TYPE OF DEVICE AND NUMBER	SEQUENCER POSITION	OCTAL ADD. OF BUFFER (1ST WORD)	ADD. IN DEC.	SIZE OF BUFF.	OPEN WORDS AT END OF BLOCK
TTY INPUT NO.4	17	07210	3720	6	2
TTY INPUT NO.5	18	07220	3728	6	2
TTY INPUT NO.6	19	07230	3736	6	2
TTY INPUT NO.7	20	07240	3744	6	2
TTY INPUT NO.8	21	07250	3752	6	2
TTY INPUT NO.9	22	07260	3760	6	2
TTY INPUT NO.10	23	07270	3768	6	2
TTY INPUT NO.11	24	07300	3776	6	2
TTY INPUT NO.12	25	07310	3784	6	2
TTY INPUT NO.13	26	07320	3792	6	2
TTY INPUT NO.14	27	07330	3800	6	2
PAPER TAPE INPUT (SPARE)	28	07340	3808	6	2
PAPER TAPE INPUT (RADAR)	29	07350	3816	6	2
PAPER TAPE INPUT (NON-RADAR)	30	07360	3824	6	10
SENSE OUTPUT	31	07040	3616	5	
OPEN	32				

NOTE - ALL FIXED DCC LOCATIONS ARE BETWEEN 07000(OCT) AND 07740(OCT).

5.2 INPUTS TO GSFC

REAL-TIME INPUT TO THE GODDARD COMPUTER COMPLEX CONSISTS OF HIGH-SPEED TELEPHONE LINES, TTY LINES, AND PAPER TAPE INPUT. HIGH-SPEED LINES SUPPLY GODDARD WITH PROCESSED DATA AND HUMAN DECISIONS FROM CAPE KENNEDY AND BERMUDA DURING THE LAUNCH AND ABORT PHASES, TTY LINES SUPPLY RAW RADAR DATA DURING ORBIT AND REENTRY PHASES, AND PAPER TAPE AND PROGRAM CONTROL CONSOLE EQUIPMENT, LOCATED AT GODDARD, PROVIDES THE MEANS OF ENTERING DISCRETE EVENT INFORMATION AND TRACKING STATION CHARACTERISTICS.

5.2.1 HIGH-SPEED INPUT

DATA FROM THE B-GE AND THE IP COMPLEXES AT CAPE KENNEDY IS RECEIVED AT GODDARD OVER DUPLEXED HIGH-SPEED TELEPHONE LINES.

THE AZUSA II AND MISTRAM DATA ARE USED BY THE IP COMPUTERS TO CONTINUOUSLY PREDICT BOOSTER IMPACT POINTS DURING BOOSTER POWERED FLIGHT. AFTER SECOND STAGE CUT-OFF, FPS-16 OR FPQ-6 RADAR INPUT CAN BE MANUALLY SELECTED FOR USE BY THE IP COMPUTER. THE B-GE GUIDANCE SYSTEM FUNCTIONS ONLY DURING BOOSTER POWERED FLIGHT AND DOES NOT GIVE SPACECRAFT POSITION DATA AFTER SPS.

IN ADDITION TO HIGH-SPEED DATA LINES FROM THE CAPE, THERE ARE TWO HIGH-SPEED DATA LINES CONTAINING MULTIPLEX VERLORT AND FPS-16 RAW RADAR DATA FROM THE BERMUDA COMPLEX. THE BERMUDA RADARS START TRACKING THE SPACECRAFT BEACON AT APPROXIMATELY ABORT MODE CHANGEOVER (AMC) AND CONTINUE TRACKING UNTIL LOSS OF SIGNAL (LOS). THE GODDARD COMPLEX UTILIZES THIS HIGH-SPEED DATA UNTIL THE ORBIT PHASE IS ENTERED.

THE HIGH-SPEED B-GE AND IP INPUTS ARE FED DIRECTLY

TO THE DCC OF THE GODDARD COMPUTERS IN 16-BIT BYTES. THE DCC THEN PLACES THE FIRST EIGHT BITS (1 THROUGH 8) IN THE HIGH-ORDER BUFFER AND THE SECOND EIGHT BITS (9 THROUGH 16) IN THE LOW-ORDER BUFFER, BOTH RIGHT-JUSTIFIED. THE HIGH-SPEED DATA FROM BERMUDA IS ALSO FED DIRECTLY INTO THE DCC IN 16-BIT BYTES, BUT IN THIS CASE THE DCC PLACES THE FIRST EIGHT BITS (1 THOUGH 8) IN THE FIRST STORAGE LOCATION, THE SECOND EIGHT BITS (9 THROUGH 16) IN THE SECOND STORAGE LOCATION, AND SO ON. WITH BOTH METHODS, AFTER TWENTY-FOUR 8-BIT BYTES HAVE BEEN TRANSFERRED TO THE APPROPRIATE CORE LOCATION, THE DCC CAUSES AN INTERRUPT OF THE COMPUTER PROGRAM. THE APPROPRIATE TRAP PROCESSING ROUTINE IS EXECUTED.

5.2.2 LOW-SPEED TTY DATA

DURING EACH PASS OF THE SPACECRAFT OVER A RADAR SITE, POSITION INFORMATION (RANGE, AZIMUTH, AND ELEVATION) IS SENT TO GODDARD VIA TTY EVERY SIX SECONDS WHILE THE SPACECRAFT IS WITHIN RANGE. TIME IS SPECIFIED IN GREENWICH MEAN TIME IN HOURS, MINUTES, AND SECONDS. NEGATIVE ELEVATION ANGLES OF OBSERVATIONS BELOW THE HORIZONTAL PLANE APPEAR IN COMPLEMENTED FORM ($-10^{\circ} = 350^{\circ}$ $-8^{\circ} = 352^{\circ}$, ETC.).

AT GODDARD, 13 TTY RADAR INPUT LINES PRESENT TTY CHARACTERS TO SUBCHANNELS 16 TO 28 OF THE DCC AT A RATE OF SIX CHARACTERS PER SECOND. CHANNEL 14, WHICH CARRIES TTY INPUT OF RADAR DATA FROM CAPE KENNEDY, AND CHANNEL 15, WHICH PROVIDES THE SIMILAR INPUT FROM BERMUDA, AND 17, 19, AND 28 OPERATE AT 100-WPM. THE DCC ACCEPTS ONE 5-BIT CHARACTER AT A TIME AND PLACES IT IN THE LOW ORDER POSITIONS (31 TO 35) OF ONE 7094 WORD, ACCORDING TO THE CHANNEL ADDRESS REGISTER OF THAT LINE, AND THEN INCRE-

MENTS THE CHANNEL ADDRESS REGISTER BY 1. WHEN SIX CHARACTERS HAVE BEEN PLACED IN SIX CONSECUTIVE LOCATIONS OF STORAGE, THE DCC RESETS THE CHANNEL ADDRESS REGISTER OF THIS LINE AND CAUSES AN INTERRUPT IN THE PROGRAM. THE PROGRAM PICKS UP THE TTY CHARACTERS, EACH WITH A LEADING ZERO BIT, PACKS THEM INTO A 36-BIT WORD, AND STORES THE WORD IN A 10-WORD BLOCK SET ASIDE FOR THIS PARTICULAR LINE. WHEN THIS BLOCK IS FILLED, DATA IS PRESENTED TO THE INPUT PROGRAM FOR PROCESSING.

5.2.3 PAPER TAPE INPUT

CERTAIN DISCRETE QUANTITIES CAN BE MANUALLY INSERTED INTO THE GODDARD COMPUTERS BY PAPER TAPE. THESE QUANTITIES ARE MONITORED FROM THE INCOMING VOICE OR TTY CIRCUITS, REPUNCHED IN A PRESCRIBED FORMAT, AND INSERTED IN THE PAPER TAPE READER, A MULTIPLE TRANSMITTER DISTRIBUTOR (MXD) CONNECTED TO THE DCC SUBCHANNELS 29 AND 30 AT A 100-WPM RATE.

THE FOLLOWING QUANTITIES CAN BE INSERTED AS INDICATED -

A) GMT OF LIFTOFF, RECEIVED VIA VOICE FROM CAPE KENNEDY DURING LAUNCH.

B) GMT OF FIRING RETROROCKETS RECEIVED BY VOICE FROM MCC.

C) THE WORDS ABORT AND ORBIT, WHICH CAN BE INSERTED TO CHANGE THE PROGRAM PHASE IN CASE OF TLM MESSAGE FAILURE.

D) $\overline{R}/\overline{V}$, AND T, TO REDEFINE A NEW ORBIT TABLE.

E) LONGITUDE AND LANDING ORBIT NUMBER, AT THE REQUEST OF THE RETROFIRE CONTROLLER.

F) THE TIME (DELTA T) BETWEEN THE ACTUAL LIFTOFF AND THE VECTOR MESSAGE TIME, CONTAINING THE

FIRST INDICATION OF DISCRETE LIFTOFF IN THE B-GE TO GODDARD MESSAGE.

G) RETRO WEIGHTS.

H) ORBIT DETERMINATION-ORBIT LIFETIME.

I) DIFFERENTIAL CORRECTION OF ARC LENGTH OF BASE FOR EQUAL DISTRIBUTION.

5.2.4 IBM 7094 - NASCOM 490 LOW SPEED DATA TRANSFER AT GSFC

LOW SPEED TTY DATA IS TRANSMITTED FROM THE NASCOM 490 COMMUNICATIONS PROCESSOR AT GSFC TO THE GSFC 7094 COMPUTERS AT THE SAME SPEED AS RECEIVED FROM THE INCOMING NETWORK TTY LINES TO THE 490 - 60-WPM OR 100-WPM. TTY DATA ORIGINATED BY THE 7094 COMPUTERS IS TRANSMITTED TO THE 490 AT 100 WPM.

ALL INCOMING DATA TO THE 490 FORMATED JJ, LETTERS, CARRIAGE RETURN, LINE FEED, LETTERS, IS ROUTED TO THE 7094 COMPUTERS.

PROGRAMMING OF THE 490 ENSURES THAT ALL DATA DIRECTED TO THE 7094 COMPUTERS IS TRANSFERRED FROM THE 490 TO THE 7094'S, REGARDLESS OF THE CONDITION (INCOMPLETE OR GARBLED) OF THE DATA WHEN RECEIVED BY THE 490.

INCOMING DATA TO THE 490 FOR TRANSFER TO THE 7094 COMPUTERS AT GSFC IS FORMATED TO BEGIN WITH JJ, LETTERS, CARRIAGE RETURN, LINE FEED, LETTERS. THE END-OF-MESSAGE FUNCTION EMPLOYED IS FIGURES, H, LETTERS.

5.3 DATA PROCESSING

5.3.1 LAUNCH

DURING LAUNCH, THE GSFC 7094 COMPUTING CYCLE IS 500 MILLISECONDS, WHICH CORRESPONDS TO THE NOMINAL MESSAGE

FRAME REPETITION TIME FROM THE B-GE COMPLEX. THE IP DATA IS RECEIVED AT A MESSAGE FRAME REPETITION TIME OF 400 MILLISECONDS. THEREFORE, IN EVERY FOURTH GSFC 7094 COMPUTER CYCLE, THE FOURTH IP MESSAGE IS DISCARDED IN FAVOR OF THE FIFTH. THE BERMUDA DATA IS RECEIVED AT THE RATE OF ONE OBSERVATION FROM VERLORT AND FPS-16 EVERY 100 MILLISECONDS. THE DATA FROM THE HIGH-SPEED SOURCES IS EDITED FOR TRANSMISSION ERRORS, AND INFORMATION FOR THE DATA QUALITY MONITOR IS COMPUTED FROM BOTH B-GE AND IP DATA. A DATA SOURCE-SELECT SIGNAL FROM MCC DETERMINES WHICH DATA SOURCE WILL BE USED FOR COMPUTATIONS AND, CONSEQUENTLY, FOR DIGITAL AND PLOTBOARD DISPLAYS.

LAUNCH COMPUTATIONS, WHICH CONTINUE FROM LIFTOFF TO BEYOND RADAR RANGE OF CAPE KENNEDY, CAN BE DIVIDED INTO THE FOLLOWING THREE PHASES -

A) LIFTOFF (LO) TO ABORT-MODE CHANGEOVER (AMC).

B) AMC TO POWER-CUTOFF + 15 SECONDS.

C) POWER-CUTOFF + 15 SECONDS TO ABORT OR ORBIT.

IN EACH PHASE, CONTINUOUS CALCULATIONS OF IP AND TIME-FOR-RETROFIRE ARE MADE FOR USE IN A POSSIBLE ABORT. THE GEMINI COORDINATE SYSTEM IS USED FOR IMPACT PREDICTIONS. CONSEQUENTLY, B-GE AND IP DATA ARE TRANSFORMED TO THE GEMINI COORDINATE SYSTEM.

COMPUTATIONS ARE MADE FOR THE FOLLOWING DISPLAY UNITS DURING NORMAL LAUNCH FROM LITFTOFF TO END OF DATA COLLECTION (ONE-HALF SECOND COMPUTATION CYCLE) -

A) PLOTBOARD 1 - γ VS V/V_R IN THREE SCALES -

FOR V/V_R LESS THAN 0.19

V/V_R GREATER THAN 0.9

B) PLOTBOARD 2

PLOTS THE FOLLOWING VARIABLES -

S = CROSSRANGE DISTANCE - FORMERLY $Y-Y_{NOM}$

D = DOWNRANGE DISTANCE

H = HEIGHT OF SPACECRAFT ABOVE SPHERICAL EARTH $(R-\bar{R})$

PLOTS S VS D WITH THE LEFT ARM AND H VS D WITH THE RIGHT ARM. TWO SCALES ARE PLOTTED FOR D LESS THAN 60 AND D GREATER THAN 60 MILES.

C) PLOTBOARD 4

LATITUDE AND LONGITUDE OF MINIMUM DELAY IMPACT POINT ARE PLOTTED WITH THE LEFT ARM. THE RIGHT ARM REMAINS OFF SCALE AT MAXIMUM VALUES UNTIL ABORT MODE CHANGEOVER (AMC) IS RECOGNIZED. (AMC SHOULD OCCUR AT V/V_R OF .8, APPROXIMATELY 315 SECONDS, ELAPSED TIME.) AFTER AMC, TWO IMPACT POINTS ARE COMPUTED AND DISPLAYED. THE LEFT ARM CONTINUES TO PLOT THE MINIMUM DELAY IMPACT POINT AND THE RIGHT ARM PLOTS THE MAXIMUM DELAY IMPACT POINT.

D) STRIP CHARTS -

PLOTS $\gamma - \gamma_{NOM}$ AND $V/V_R - V/V_{RNOM}$ FOR B-GE AND IP. OUTPUT TO STRIP CHARTS ENDS AT END OF DATA COLLECTION PERIOD.

E) DIGITAL OUTPUT DISPLAY AT GSFC

DATA SOURCES ARE -

B-GE (TRACKING THE BOOSTER)

IP AZUSA (TRACKING THE BOOSTER)

IP MISTRAM (TRACKING THE BOOSTER)

IP FPQ-6 (TRACKING THE SPACECRAFT)

IP FPQ-16 (TRACKING THE SPACECRAFT)

BERMUDA (TRACKING THE SPACECRAFT).

F) RECOVERY AREA

999A IS DISPLAYED UNTIL A RECOVERY AREA HAS BEEN COMPUTED, I.E., UNTIL GO/NO-GO COMPUTATION.

G) MISSING DATA

IN THE EVENT OF MISSING DATA, COMPUTATIONS ARE MADE ON THE LAST GOOD VECTOR, AND ONLY γ AND V/V_R ARE UPDATED. THE OTHER DISPLAYS REMAIN CONSTANT.

COMPUTATIONS ARE MADE FOR THE FOLLOWING DISPLAY UNITS DURING THE AVERAGE VECTOR PHASE, FROM INITIATION OF GO/NO-GO TO SETTING THE ABORT/ORBIT SWITCH (5-SECOND COMPUTATION CYCLE) -

A) PLOTBOARDS 1 AND 2

NO CHANGE FROM NORMAL LAUNCH

B) PLOTBOARD 4

THE LEFT ARM CONTINUES TO PLOT THE MINIMUM-DELAY IMPACT POINT.

THE RIGHT ARM PLOTS THE IMPACT POINT WHICH WILL RESULT IF THE SELECTED SOURCE GMTRC IS OBSERVED.

C) DIGITAL OUTPUT DISPLAY AT GSFC

1) IF A BOOSTER SOURCE IS SELECTED AT INITIATION OF GO/NO-GO COMPUTATIONS, THE FIRST GO/NO-GO RECOMMENDATION DISPLAYED IS THAT OF THE SELECTED BOOSTER SOURCE, FOLLOWED APPROXIMATELY TWO SECONDS LATER BY THE NON-SELECTED BOOSTER SOURCE RECOMMENDATION. IF BERMUDA DATA IS AVAILABLE, THE BERMUDA RECOMMENDATION WILL APPEAR TWO SECONDS LATER.

2) IF BERMUDA IS THE SELECTED SOURCE AT THE INITIATION OF GO/NO-GO COMPUTATION, ITS RECOMMENDATION APPEARS FIRST, FOLLOWED BY B-GE AND IP AT APPROXIMATELY 2-SECOND INTERVALS.

3) THE GO/NO-GO RECOMMENDATION ON THE FLIGHT DYNAMICS CONSOLE REFLECTS THE RECOMMENDATION OF THE SELECTED SOURCE.

4) IF BOTH GO AND NO-GO LIGHTS ARE DISPLAYED,

EITHER THERE HAS BEEN NO DATA ON THIS LINE DURING THE COLLECTION PERIOD OR THE VECTORS RECEIVED DO NOT FALL WITHIN SPECIFIED EDIT LIMITS.

5) NORMALLY, THE INITIAL GO/NO-GO SEQUENCE IS DONE WITH BOOSTER SOURCES. HOWEVER, AN IP SPACECRAFT SOURCE MAY BE USED, RESULTING IN NO RECOMMENDATION AND LIGHTING OF BOTH GO AND NO-GO LIGHTS.

6) GMTRC AND ESTRC FOR THE SELECTED BOOSTER SOURCE ARE DISPLAYED AS GMTRC AND ESTRC - NEXT EMERGENCY AREA. GMTRC AND ESTRC FOR THE NON-SELECTED BOOSTER SOURCE ARE DISPLAYED UNDER NEXT PRIMARY AREA IF B-GE OR IP IS THE SELECTED SOURCE. IF BERMUDA IS THE SELECTED SOURCE, GMTRC AND ESTRC, BASED ON BDA DATA, ARE DISPLAYED IN THE NEXT EMERGENCY AREA SLOTS, AND NEXT PRIMARY AREA IS SET TO ZERO.

AFTER THE INITIAL GO/NO-GO SEQUENCE AND UNTIL BERMUDA IS SELECTED, ALL OUTPUTS EXCEPT THE BDA GO/NO-GO DECISION REMAIN CONSTANT FOR DISPLAY PURPOSES. SELECTED SOURCE MAY BE CHANGED FROM B-GE TO IP AND BACK TO B-GE TO STUDY THE OUTPUTS AT THE TIME OF THE GO/NO-GO SEQUENCE. IF BERMUDA DATA WAS NOT AVAILABLE AT THE TIME OF THE INITIAL GO/NO-GO SEQUENCE AND IS LATER AVAILABLE, A GO/NO-GO RECOMMENDATION WILL BE DISPLAYED. IF IP IS SELECTED AFTER BERMUDA HAS BEEN SELECTED AT LEAST ONCE, THE IP RECOMMENDATION ON THE DIGITAL DISPLAY BOARD IS SUBJECT TO REVISION DUE TO COMPUTATIONS ON IP SPACECRAFT DATA. IF AN IP BOOSTER SOURCE IS SELECTED AFTER THE INITIAL GO/NO-GO SEQUENCE, SPACECRAFT DATA IS DISPLAYED AND MISSING

DATA IS INDICATED.

INCLINATION ANGLE IS REPLACED BY - DELTA V(G), FOLLOWING THE INITIAL GO/NO-GO SEQUENCE WHERE DELTA V_G , IS THE INCREASE IN VELOCITY REQUIRED IN ORDER TO OBTAIN A 1.5 ORBIT CAPABILITY. THE QUANTITY IS DISPLAYED AS $V-V_{GO}$ AND IS POSITIVE IF 1.5 ORBITS CAN BE ACHIEVED.

DELTA V, DISPLAYED ON THE PROPULSION PANEL, IS COMPUTED AS FOLLOWS -

A) V(ACTUAL) - V(INSERTION), IF V(ACTUAL) IS GREATER THAN V(INSERTION)

B) V(ACTUAL) - V(INSERTION), IF V(ACTUAL) IS LESS THAN OR EQUAL TO V(INSERTION)

C) V(EO) - DELTA V(E) - V(INSERTION), IF V(ACTUAL) IS LESS THAN OR EQUAL TO V(INSERTION) AND DELTA V(E) IS GREATER THAN OR EQUAL TO ZERO.

THE PROPULSION PANEL DISPLAYS ARE WHITE WHEN DELTA V IS POSITIVE AND RED WHEN DELTA V IS NEGATIVE.

GMTPC, DISPLAYED ON THE PROPULSION PANEL, IS THE TIME AT WHICH THRUST SHOULD BE TERMINATED IF V(GO) IS TO BE ACHIEVED. IT IS COMPUTED ONCE EVERY 5 SECONDS. GMTPC IS 0, IF V(ACTUAL) - V(GO) IS POSITIVE.

DELTA T_{pc} IS DISPLAYED UNDER DELTA T_{pi} $/T_{pc}$ DURING AVERAGE-VECTOR PHASE.

DELTA T_{pc} IS UPDATED EVERY SECOND.

IF NO NEW AVERAGE VECTOR IS AVAILABLE ON THE SELECTED LINE, THE LAST GOOD VECTOR IS INTEGRATED FORWARD EACH COMPUTING CYCLE ACCORDING TO THE THRUST SWITCH.

5.3.2 ABORT PHASE

GEMINI PROCESSING PROVIDES FOR EITHER A HIGH ABORT OR LOW ABORT. IN BOTH CASES, COMPUTATIONS ARE DONE ON A

SIX-SECOND CYCLE.

IN ORDER FOR THE PROGRAM TO ENTER THE LOW ABORT PHASE, THE FOLLOWING CONDITIONS MUST BE MET - ABORT MODE 3 (AM3) MUST NOT HAVE OCCURRED AND ASTRONAUT ACTUATED ABORT (AAA) AND ABORT PHASE STARTED (ABS) SIGNALS MUST HAVE BEEN RECEIVED. UNDER THESE CONDITIONS, THE VECTOR FROM LAUNCH PHASE IS SAVED FOR FUTURE REENTRY PROCESSING AND CONTROL IS GIVEN TO THE ABORT PROGRAM.

THE VALID SOURCES DURING LOW ABORT PHASE CONSIST OF THE SPACECRAFT SOURCES, IP FPQ-6, IP FPS-16, BDA FPS-16, AND BDA VERLORT. ANY OTHER SOURCE WILL RESULT IN A MISSING DATA INDICATION ALONG WITH THE FORCE SELECTION OF IP FPS-16.

HIGH ABORT PHASE WILL NOT BE ENTERED UNTIL THE GO/NO-GO RECOMMENDATION HAS BEEN COMPLETED, AT WHICH TIME THE AVERAGE VECTOR FROM THE SELECTED SOURCE, UPDATED TO THE NEXT WHOLE MINUTE, IS TURNED OVER TO THE ABORT PROGRAM AS THE ABORT DEFINING VECTOR. ONCE HIGH ABORT PHASE HAS BEEN ENTERED, ONLY THE TELEMETRY DATA IS PROCESSED. IMMEDIATELY UPON ENTRY TO THE ABORT PROGRAM, AN ORBIT TABLE AND A REENTRY TABLE BASED UPON THE GMTRC FROM LAUNCH ARE GENERATED. DISPLAYS ARE DRIVEN FROM THESE TABLES UNTIL THE RETROFIRE SIGNALS ARE RECEIVED VIA TELEMETRY, AT WHICH TIME A NEW REENTRY TABLE IS GENERATED.

IN BOTH THE HIGH AND LOW ABORT, ONLY A MANUALLY INSERTED TIME OF RETROFIRE WILL CAUSE THE PROGRAM TO LEAVE ABORT PHASE AND ENTER THE REENTRY PHASE. AT THIS TIME IN LOW ABORT THE ORIGINAL ABORT DEFINING VECTOR SAVED FROM THE LAUNCH PHASE IS TURNED OVER TO REENTRY. IN HIGH ABORT, THE VECTOR IN THE ORBIT TABLE ASSOCIATED WITH THE MANUALLY INSERTED TIME OF FIRING IS TURNED OVER TO THE REENTRY PROGRAM.

5.3.3 ORBIT PHASE

TWO MACRO PROGRAMMING SYSTEMS COMPRISE THE ORBIT PHASE. THE FIRST, KNOWN AS THE ORBIT PREDICTION MACRO SYSTEM, HAS THE PRIME FUNCTION OF DEVELOPING AN OUTPUT TABLE OF PREDICTED POSITIONS AND CORRESPONDING VELOCITIES OF THE SPACECRAFT DURING FLIGHT. INPUT CONSISTS OF A SET OF ORBITAL ELEMENTS, OR PARAMETERS, USED IN THE SOLUTION OF EQUATIONS TO DETERMINE THE ORBIT OF THE S/C.

THE SECOND SYSTEM, KNOWN AS THE DIFFERENTIAL CORRECTION MACRO SYSTEM, HAS AS ITS MAIN PURPOSE THE DETERMINATION OF THE INSTANTANEOUS ORBIT PARAMETERS. THE INPUT TO THIS SYSTEM CONSISTS OF EDITED RADAR OBSERVATIONS AND AN ORBIT PREDICTION TABLE COVERING THE TIME INTERVAL SPANNING THE OBSERVATIONS AND BASED ON THE PREVIOUS SET OF ORBIT PARAMETERS. A SERIES OF CORRECTIONS TO THE ORBIT ELEMENTS ARE CALCULATED WHICH, WHEN ADDED TO THE PREVIOUS ELEMENTS, PRODUCE THE INSTANTANEOUS ORBIT ELEMENTS.

THE RAW RADAR INFORMATION RECEIVED BY TTY IS EDITED, AND THE BEST SET OF OBSERVATIONS IS CHOSEN BEFORE PROCESSING BY DIFFERENTIAL CORRECTION TAKES PLACE. DURING ORBIT, THE COMPUTING CYCLE IS SUCH THAT COMPLETE DISPLAY DATA (TWO FRAMES) IS SENT TO THE MCC EVERY 12 SECONDS.

5.3.4 REENTRY PHASE

IN THE REENTRY PHASE, THE ORBIT DIFFERENTIAL CORRECTION PROCESS IS USED FOR OBSERVATIONS ABOVE 450,000 FEET TO IMPROVE PREDICTIONS OF THE REENTRY TRAJECTORY. NO OBSERVATIONS PRIOR TO THE TIME OF RETROROCKET BURNOUT ARE INCLUDED. NUMERICAL DIFFERENTIAL CORRECTION IS UTILIZED WHEN OBSERVATIONS BELOW 450,000 FEET ARE INCLUDED IN THE CORRECTION PROCESS. EACH TIME AN UPDATED REENTRY TRAJECTORY IS ESTABLISHED, THE PREDICTED LANDING POINT OF

THE SPACECRAFT IS COMPUTED. DURING REENTRY, THE COMPUTING CYCLE IS SUCH THAT COMPLETE DISPLAY DATA (TWO FRAMES) IS SENT TO THE MCC EVERY SIX SECONDS.

5.4 GSFC OUTPUT

OUTPUT INFORMATION, EXCEPT DOWNRANGE AND CROSSRANGE DISTANCE, IS COMPUTED IN THE GEMINI COORDINATE SYSTEM AND IS APPLICABLE TO THE PARTICULAR INPUT SOURCE DURING ALL PHASES OF THE MISSION. FOR DOWNRANGE AND CROSSRANGE DISTANCE, THESE COORDINATE SYSTEMS ARE TRANSFORMED TO A TOPOCENTRIC SYSTEM WITH THE ORIGIN AT THE PAD.

THE FUNCTION OF THE OUTPUT SECTION IS TO CONVERT COMPUTED ORBITAL DATA INTO THE FORMATS REQUIRED FOR TRANSMISSION TO MCC, RADAR SITES, GODDARD, AND BERMUDA. THE OUTPUT IS TRANSMITTED BY THE DATA COMMUNICATIONS CHANNEL AS DESCRIBED IN THE FOLLOWING PARAGRAPHS.

5.4.1 TTY DATA

THE TTY LINES TRANSMIT DATA AT THE RATE OF SIX OR TEN CHARACTERS PER SECOND (CPS), RIGHT-JUSTIFIED, WITH ONE CHARACTER PER 7094 WORD. THE DATA IS IN 5-CHANNEL, TELETYPEWRITER CODE, AND WITHIN THE 7094 WORD THE CHARACTER IS RIGHT-JUSTIFIED. DATA BLOCKS ASSOCIATED WITH THE TTY LINES ARE SIX WORDS LONG.

5.4.2 HIGH-SPEED DATA

THE HIGH-SPEED OUTPUT LINES TRANSMIT DATA AT 1000 BPS, WITH 8 BITS PER 7094 WORD AND RIGHT-JUSTIFIED. THE LOW-ORDER BITS ENTER THE CHANNEL FIRST. THE BLOCKS ASSOCIATED WITH THE HIGH-SPEED OUTPUT LINES ARE 32 WORDS LONG, BUT THE TRAP INDICATING END OF TRANSMISSION OCCURS EITHER WHEN THE 32ND WORD HAS BEEN TRANSMITTED OR WHEN

A WORD IS TRANSMITTED THAT CONTAINS A 1 IN THE SIGN POSITION.

5.4.3 DISPLAY DATA

THE INFORMATION DISPLAYED AT CAPE KENNEDY AND GODDARD IS TRANSMITTED VIA THE DCC OVER THE HIGH-SPEED LINES AS FOLLOWS. AN ODD DATA FRAME FOLLOWED BY AN EVEN DATA FRAME (TWO DATA FRAMES) IS TRANSMITTED EVERY SECOND DURING LAUNCH AND ABORT, 5 TIMES A MINUTE DURING ORBIT, AND 10 TIMES A MINUTE DURING REENTRY. THE TIMING IS CONTROLLED BY A CLOCK INTERRUPT, OR TRAP, WHICH INDICATES WHEN A NEW FRAME OF DATA IS TO BE TRANSMITTED. GODDARD PLOTS LAUNCH DEVIATIONS AND ORBITAL PHASE RESIDUALS.

5.5 DESTINATIONS OF GODDARD-PROCESSED DATA

5.5.1 CAPE KENNEDY

THE MISSION CONTROL CENTER, HEADQUARTERS AND FOCAL POINT FOR OVERALL GEMINI OPERATIONS UP TO AND INCLUDING GT-3, HOUSES THE CHARTS, PLOTBOARDS, CONSOLES, METERS, AND MAPS ON WHICH ARE DISPLAYED THE INFORMATION QUANTITIES VITAL TO MISSION EVALUATION AND CONTROL. COMMAND PERSONNEL, FLIGHT CONTROLLERS, AEROMEDICAL TECHNOLOGISTS AND OTHERS WHO MONITOR GEMINI ACTIVITIES READ,INTERPRET, AND ANALYZE THE DISPLAYED DATA,APPLYING THE RESULTS TO THEIR PARTICULAR AREAS OF PROJECT RESPONSIBILITY.

INFORMATION ENTERS THE CONTROL CENTER FROM MANY SOURCES. THIS SECTION OF THE DOCUMENT, HOWEVER,IS CONCERNED ONLY WITH THOSE DISPLAY QUANTITIES WHICH ORIGINATE AT THE GODDARD COMPUTING AND COMMUNICATIONS CENTER'S IBM 7094 COMPUTER COMPLEX.

PROCESSED DATA FROM THE IBM 7094 COMPUTERS IS TRANS-

MITTED AT 1000 BITS PER SECOND OVER HIGH-SPEED LINES TO CAPE KENNEDY. ACCEPTED AT THE MISSION CONTROL CENTER AND CHANNELED TO THE PROPER DISPLAY DEVICES, THE IBM 7094-CALCULATED VALUES FROM GODDARD ENABLE FLIGHT MONITORING IN NEAR-REAL TIME. COMPUTED DATA IS SENT TO FOUR STRIP CHARTS,FOUR PLOTBOARDS, A WALL MAP,CLOCKS, AND DIGITAL DISPLAYS.

PROCESSED OUTPUT INFORMATION FOR MISSION CONTROL CENTER DISPLAY PURPOSES IS CALCULATED BY THE GODDARD IBM 7094 COMPUTERS AT HALF-SECOND INTERVALS. DATA FROM ONLY ONE COMPUTER IS TRANSMITTED TO CAPE KENNEDY. THE OPERATIONS CONTROL CONSOLE AT GODDARD ALLOWS SELECTION OF THE COMPUTER FROM WHICH DATA IS TO BE SENT.

HIGH-SPEED DATA TRANSMITTERS SEND COMPUTED VALUES TO CAPE KENNEDY AT 1000 BITS PER SECOND. A MESSAGE CONSISTS OF TWO DATA FRAMES. AN ODD DATA FRAME FOLLOWED BY AN EVEN DATA FRAME. EACH FRAME IS APPROXIMATELY 440 BITS LONG.

DATA RECEIVERS AT THE CONTROL CENTER ACCEPT THE GSFC GENERATED BINARY MESSAGES AND CHANNEL THE INFORMATION INTO COMPARATOR AND RECEIVING REGISTER UNITS. HERE THE INCOMING DATA IS BUFFERED AND STORED BEFORE BEING FED TO THE VARIOUS DISPLAYS. FROM THE REGISTERS, DATA QUANTITIES ARE ROUTED THROUGH A SWITCH UNIT WHICH SELECTS AND FEEDS INFORMATION TO THE PROPER DISPLAYS. DIGITAL-TO-ANALOG CONVERTERS PROVIDE ANALOG REPRESENTATIONS TO THE PLOTBOARDS.

5.5.1.1 PLOTBOARDS. FIVE PLOTBOARDS LOCATED IN THE MISSION CONTROL CENTER ARE USED TO CHART DATA DURING ALL PHASES OF THE MISSION. EACH BOARD IS A 30-BY 30-INCH DUAL -ARM (FOUR PENS, TWO PENS PER ARM) DISPLAY MARKED WITH A 1024 BY 1024 GRID. DATA PAIRS ARE CON-

VERTED, SCALED, AND APPLIED AS X-Y PLOT POINTS. EACH QUANTITY CONSISTS OF TEN BITS. DIFFERENT INFORMATION IS DISPLAYED AND DIFFERENT OVERLAYS ARE USED DURING LAUNCH ABORT, ORBIT, AND REENTRY PERIODS OF FLIGHT.

DURING THE LAUNCH PHASE, DATA BASED ON EITHER IBM 7094-PROCESSED B-GE OR IP (AZUSA OR C-BAND) INPUT IS SENT FROM GODDARD OVER HIGH-SPEED LINES TO THE CONTROL CENTER. MESSAGES ARE ACCEPTED BY THE BOARDS AT A TWO-PER SECOND FREQUENCY.

GODDARD COMPUTER OUTPUT TO MISSION CONTROL CENTER PLOTBOARDS DURING THE ORBIT AND REENTRY PHASES ARE DERIVED FROM IBM 7094-PROCESSED RADAR SITE RANGE, AZIMUTH, AND ELEVATION MEASUREMENTS. AGAIN, INFORMATION FROM ONLY ONE COMPUTER IS TRANSMITTED. EACH MESSAGE, SENT AT A FREQUENCY OF FIVE MESSAGES PER MINUTE, CONSISTS OF TEN BITS FOR EACH SMOOTHED COORDINATE.

PLOTBOARD 1 - DURING LAUNCH, BOARD 1 PLOTS SPACE CRAFT FLIGHT-PATH ANGLE VERSUS THE RATIO OF INERTIAL VELOCITY TO REQUIRED VELOCITY. THREE DIFFERENT SCALES MARKED WITH APPROPRIATE LIMITS ARE EMPLOYED AS BOARD OVER LAYS DURING LAUNCH.

DURING ABORT, BOARD 1 PLOTS LONGITUDE AND LATITUDE OF IMPACT POINT, MINIMUM LIFT, AND MAXIMUM LIFT.

DURING ORBIT, BOARD 1 PLOTS APOGEE ALTITUDE AND LATITUDE OF PERIGEE VERSUS ELAPSED TIME.

DURING REENTRY, THIS BOARD SHOWS LATITUDE AND LONGITUDE OF IMPACT POINT, MINIMUM LIFT, AND MAXIMUM LIFT.

PLOTBOARD 2 - BOARD 2 CARRIES TWO PLOTS DURING THE LAUNCH PERIOD. SPACECRAFT ALTITUDE VERSUS DOWNRANGE DISTANCE IS CHARTED ON THE BOTTOM OF THE BOARD (THIS QUANTITY IS ALSO DISPLAYED IN THE EVENT OF A LAUNCH ABORT), AND CROSSRANGE DEVIATION VERSUS DOWNRANGE DIS-

TANCE IS DISPLAYED SIMULTANEOUSLY ON A SEPARATE SCALE ON THE UPPER PORTION OF THE OVERLAY. ALL QUANTITIES ARE DISPLAYED IN NAUTICAL MILES.

TWO PLOTS APPEAR ON BOARD 2 DURING ORBITAL FLIGHT. SPACECRAFT ALTITUDE ABOVE AN OBLATE EARTH, AS A FUNCTION OF ELAPSED TIME, IS DEPICTED ON THE LOWER PART OF THE BOARD. ON THE UPPER PORTION OF THE BOARD IS DISPLAYED THE DIFFERENCE BETWEEN THE SEMIMAJOR AXIS OF THE ORBIT AND THE AVERAGE RADIUS OF THE EARTH, AS A FUNCTION OF ELAPSED TIME.

DISPLAYED ON BOARD 2 DURING A NORMAL REENTRY IS SPACE CRAFT ALTITUDE, AS A FUNCTION OF TIME.

PLOTBOARD 3 - A VARIETY OF PARAMETERS IS DISPLAYED ON BOARD 3 DURING LAUNCH AND HOLD. HOWEVER, QUANTITIES FURNISHED TO THE PLOTBOARD DURING THIS PHASE COME DIRECTLY FROM THE B-GE COMPUTER AND ARE NOT PERTINENT TO A GODDARD DATA FLOW DESCRIPTION.

BOARD 3 DISPLAYS SPACECRAFT ALTITUDE VERSUS SPACE CRAFT VELOCITY DURING ABORT, ORBIT, AND REENTRY.

PLOTBOARD 4 - BOARD 4 DISPLAYS IMPACT POINT COMPUTATIONS MADE AT GODDARD DURING A NORMAL LAUNCH AND IN THE EVENT OF AN ABORTED LAUNCH. THE BOARD'S OVERLAY IS A MAP OF THE ATLANTIC OCEAN AREA SHOWING LAND AND WATER MASSES AND RECOVERY AREAS.

PLOTTED DURING LAUNCH ARE THE LATITUDES AND LONGITUDES OF IMPACT POINT, ASSUMING THAT 1) THE RETROROCKETS WILL FIRE IN 30 SECONDS (MINIMUM DELAY) AND 2) THE RETROROCKETS WILL FIRE AT 450,000 FEET (MAXIMUM DELAY).

BOARD 4 DISPLAYS TWO ITEMS DURING ORBIT, THE LATITUDE AND LONGITUDE OF PRESENT SPACECRAFT POSITION AND THE COMPUTED IMPACT POINT FOR RETROFIRE IN 30 SECONDS.

DURING ABORT AND REENTRY, SPACECRAFT PRESENT POSITION AND THE PREDICTED IMPACT POINT ARE SHOWN.

5.5.1.2 WALL MAP. LOCATED IN THE OBSERVERS' AND VISITORS' AREA OF THE MISSION CONTROL CENTER IS A LARGE (50 FEET LONG) WALL MAP OF THE WORLD. IT DISPLAYS THE LOCATIONS OF ALL GEMINI RANGE STATIONS AND THE GROUND TRACK OF THE SPACECRAFT.

AS THE GEMINI MISSION PROGRESSES, A MINIATURE LIGHTED SPACECRAFT MOVES ALONG THE TRACK, INDICATING THE ACTUAL PRESENT POSITION OF THE SPACECRAFT. A SMALL, MOVING LIGHT AHEAD OF THE SPACECRAFT INDICATES, DURING ABORT AND REENTRY, THE LATITUDE AND LONGITUDE OF THE REFINED IMPACT POINT OR, DURING ORBIT, IMPACT POINT IF THE RETROROCKETS ARE FIRED IN 30 SECONDS.

5.5.1.3 STRIP CHART. A HIGH-SPEED MULTICHANNEL (SIX RECORDING PENS) STRIP CHART, CALLED THE DATA QUALITY MONITOR, IS USED AT THE MCC DURING THE LAUNCH PHASE. THIS DEVICE ENABLES AN OPERATOR TO DETERMINE WHICH SETS OF INFORMATION ARE MOST VALID FOR PRESENTATION TO GEMINI DISPLAY EQUIPMENT. SELECTABLE PAPER SPEEDS AND SEVERAL CONTROL SWITCHES AND ASSOCIATED INDICATORS ALLOW THE OPERATOR TO CHOOSE FROM RECORDER THE BEST DATA TO BE ROUTED TO OPERATIONS DISPLAYS. A LAMP FOR EACH OF THE FOUR B-GE GENERATED DATA FLAGS INDICATES THE QUALITY OF B-GE OUTPUT VALUES.

THE SIX PENS ARE DRIVEN BY DATA FROM THREE SOURCES, EACH CHARTING TWO ITEMS OF INFORMATION.

THE DISPLAYED QUANTITIES ARE

A) THE DIFFERENCE BETWEEN FLIGHT-PATH ANGLE AND NOMINAL FLIGHT-PATH ANGLE.

B) THE DIFFERENCE BETWEEN VELOCITY RATIO AND NOMINAL VELOCITY RATIO.

THE QUANTITIES ARE BASED ON -

A) B-GE TRANSMITTED DIRECTLY FROM THE BURROUGHS COMPUTER.

B) B-GE DATA PROCESSED AND TRANSMITTED BY THE GODDARD COMPUTERS.

C) GODDARD 7094 PROCESSED INFORMATION FROM IP AZUSA OR C-BAND DATA.

EACH ITEM CONSISTS OF TEN BITS TRANSMITTED TO THE DISPLAY REGISTER TWICE EACH SECOND.

5.5.1.4 DIGITAL DISPLAYS. COMPUTED INFORMATION FROM THE GSFC IBM 7094'S IS ROUTED AT HIGH SPEED TO MCC DIGITAL DISPLAYS LOCATED VARIOUSLY ON THE FLIGHT DYNAMICS OFFICER'S CONSOLE, THE RETROFIRE CONTROLLER'S CONSOLE, THE RECOVERY STATUS MONITOR CONSOLE, AND A WALL DIGITAL DISPLAY.

DIGITAL VALUES ARE SENT TO THE DISPLAY REGISTER TWICE PER SECOND DURING THE LAUNCH PHASE. TO AVOID FLICKER, THE QUANTITIES ARE UPDATED BY THE COMPUTER ONLY ONCE EACH SECOND. ALL DIGITAL DISPLAY VALUES ARE TRANSMITTED FROM GODDARD AT A FREQUENCY OF FIVE PER MINUTE DURING ORBIT. DURING REENTRY, DATA QUANTITIES ARE ROUTED FROM GODDARD TO CAPE KENNEDY AT A TEN PER MINUTE RATE.

<u>FLIGHT DYNAMICS OFFICER'S CONSOLE</u> - SIX DIGITAL DISPLAYS ARE LOCATED ON THIS IMPORTANT CONTROL CONSOLE. FOR REFERENCE PURPOSES IN TEXT THESE DIGITAL INDICATORS ARE DESIGNATED DISPLAYS 1, 2, 3, 4, 5, AND 6.

A) DISPLAY 1 INDICATES DURING LAUNCH AND ABORT THE GO/NO-GO RECOMMENDATION OF THE GODDARD

COMPUTERS TO CONTINUE OR ABORT THE MISSION.

B) DISPLAY 2 INDICATES SPACECRAFT ALTITUDE IN NAUTICAL MILES AND TENTHS OF NAUTICAL MILES DURING THE ENTIRE MISSION, FROM LAUNCH TO IMPACT.

C) DISPLAY 3 INDICATES FLIGHT-PATH ANGLE IN DEGREES TENTHS, AND HUNDREDTHS OF DEGREES DURING LAUNCH AND REENTRY, AND DENOTES APOGEE HEIGHT IN HUNDREDTHS AND TENTHS OF NAUTICAL MILES DURING ORBIT.

D) DISPLAY 4 INDICATES SPACECRAFT INCLINATION ANGLE IN DEGREES AND TENTHS OF DEGREES DURING LAUNCH AND ORBIT.

E) DISPLAY 5 INDICATES ORBIT LIFETIME REMAINING FROM THE TIME OF THE LAST PASS OVER CAPE KENNEDY. THIS QUANTITY, PREDICTED AT INSERTION AND UPDATED DURING ORBITAL FLIGHT, REGISTERS FROM 0 TO 999.

F) DISPLAY 6 INDICATES THE RATIO OF SPACECRAFT INERTIAL VELOCITY TO REQUIRED VELOCITY DURING LAUNCH. AFTER INSERTION INTO ORBIT AND FOR THE REMAINDER OF THE FLIGHT, DISPLAY 6 INDICATES ACTUAL SPACECRAFT VELOCITY.

RETROFIRE CONTROLLER'S CONSOLE - LOCATED ON THIS CONSOLE ARE NINE DIGITAL DISPLAYS, NUMBERED IN TEXT FOR REFERENCE PURPOSES. ALL TIME DISPLAYS ARE REPRESENTED IN HOURS, MINUTES, AND SECONDS.

A) DISPLAY 1 INDICATES DURING ABORT AND ORBIT THE GREENWICH MEAN TIME(GMT) TO RETROFIRE TO LAND IN AN EMERGENCY ABORT AREA.

B) DISPLAY 2 PRESENTS DURING LAUNCH, FROM 20 SECONDS AFTER STAGING, THE COMPUTED GMT TO RE-

TROFIRE IN THE NEXT RECOVERY AREA AND, DURING ABORT AND ORBIT, THE ELAPSED SPACECRAFT TIME FOR RETROFIRE TO LAND IN THE NEXT RECOVERY AREA.

C) DISPLAY 3 INDICATES DURING ORBIT THE GMT OF RETROFIRE COMPUTED FOR THE END OF THE PRESENT ORBIT.

D) DISPLAY 4 INDICATES DURING ORBIT THE ELAPSED SPACECRAFT TIME FOR RETROFIRE TO LAND AT THE END OF THE PRESENT ORBIT.

E) DISPLAY 5 DISPLAYS DURING ORBIT THE GMT TO RETROFIRE TO LAND IN THE NORMAL IMPACT AREA.

F) DISPLAY 6 INDICATES DURING ORBIT THE ELAPSED SPACECRAFT TIME TO RETROFIRE COMPUTED FOR THE NORMAL IMPACT AREA FOLLOWING A MISSION.

G) DISPLAY 7 PRESENTS DURING ORBIT THE GMT OF RETROFIRE BASED ON THE PRESENT SPACECRAFT SETTING, AND DISPLAYS DURING REENTRY THE ELAPSED GROUND TIME SINCE RETROFIRE.

H) DISPLAY 8 INDICATES DURING ORBIT THE INCREMENTAL SPACECRAFT TIME FOR RETROFIRE COMPUTED FOR THE NEXT EMERGENCY RECOVERY AREA.

I) DISPLAY 9 INDICATES FOR THE ENTIRE MISSION THE NUMBER OF THE ORBIT, AND THE PRESENTLY DESIGNATED RECOVERY AREA (NUMBERED TO TWELVE).

RECOVERY STATUS MONITOR CONSOLE - THE DIGITAL DISPLAYS LOCATED ON THIS CONSOLE INDICATE -

A) THE COMPUTED GMT OF IMPACT IN HOURS AND MINUTES DURING ABORT, ORBIT, AND REENTRY.

B) THE COMPUTED LONGITUDE AND LATITUDE IN DEGREES AND MINUTES FOR THE ABORT LANDING POINT (DURING ABORT), THE NORMAL END-OF-MISSION IMPACT POINT

(DURING ORBIT) AND THE REFINED IMPACT POINT (DURING REENTRY).

WALL DIGITAL DISPLAY - DISPLAYED IN GMT HOURS, MINUTES, AND SECONDS DURING THE LAUNCH AND ABORT PHASES IS THE GROUND TIME REMAINING UNTIL RETROFIRE. DURING REENTRY THIS DISPLAY INDICATES THE GROUND TIME REMAINING UNTIL IMPACT.

PRESENTED ON THE WALL DISPLAY DURING ORBIT IS THE CURRENT ORBIT NUMBER.

5.5.2 GEMINI TRACKING SITES

THE GODDARD IBM 7094 COMPUTER TRANSMITS PREDICTED POSITION COORDINATES TO REMOTE RADAR STATIONS TO ENABLE THEM TO INITIATE TRACKING (ACQUIRE) THE SPACECRAFT ON RADAR AS IT COMES INTO LOCAL RANGE. THESE COMPUTED QUANTITIES-THE ACQUISITION MESSAGE-ARE PREPARED AND TRANSMITTED OVER LOW-SPEED (60 OR 100 WORDS PER MINUTE) TTY LINES INTERMITTENTLY DURING THE MISSION.

INCOMING LOW-SPEED TRAFFIC (ACQUISITION AND PREADVISORY MESSAGES AND MISCELLANEOUS COMMUNICATIONS) APPEARS IN PRINTED-PAGE FORM ON A RECEIVING-ONLY (RO) TTY WRITER AT EACH STATION. INFORMATION IS FED FROM THE DATA ACQUISITION CONSOLE'S MASTER ACQUISITION BUS TO THE SITE'S RADAR(S), INDICATING THE EXACT DIRECTION THE RADAR SHOULD BE POINTED TO PICK UP THE SPACECRAFT AS IT BEGINS ITS OVERHEAD PASS.

SOMETIME BEFORE THE VEHICLE/SPACECRAFT IS LAUNCHED, MESSAGES CONTAINING THE FOLLOWING INFORMATION ARE SENT FROM THE COMPUTING AND COMMUNICATIONS CENTER TO THE TRACKING STATIONS -

A) AN EPHEMERIS TABLE (TABLE OF EXPECTED SPACECRAFT POSITION AT REGULAR TIME INTERVALS) PREPARED

IN ADVANCE FROM ORBIT COMPUTATIONS WITH ALLOWANCES MADE FOR EXPECTED UNCERTAINTIES IN INSERTION PARAMETERS.

B) THE ESTIMATED TIME OF LAUNCH, UPDATED PERIODICALLY AS A PART OF THE PRE-LAUNCH PROCEDURES.

C) THE ACTUAL TIME OF LAUNCH (AFTER FIRING, IN THIS CASE) IN GREENWICH MEAN TIME IN HOURS, MINUTES, AND SECONDS.

(NOTE - THE ONLY ACQUISITION DATA SENT TO RANGE SITES DURING THE LAUNCH PERIOD IS THAT INFORMATION TRANSMITTED TO BERMUDA.)

REMOTE SITE RADARS ACCOMPLISH THEIR MOST IMPORTANT FUNCTION - KEEPING TRACK OF THE SPACECRAFT'S POSITION - DURING THE MISSION'S ORBITAL PHASE. COMPUTED POSITIONAL VALUES FROM THE GODDARD COMPLEX, TRANSMITTED TO THE SITES OVER LOW-SPEED TTY LINES, LET RANGE RADARS FIND THE SPACECRAFT AND MAINTAIN POSITION READINGS WHEN ORBITAL FLIGHT BRINGS IT INITIALLY INTO EFFECTIVE TRACKING DISTANCE.

ACQUISITION MESSAGES CONTAIN THE 7094-PREDICTED SLANT RANGE, AZIMUTH, AND ELEVATION OF THE SPACECRAFT FROM THE SITE AT FOUR DIFFERENT TIMES (GMT-REFERENCED), THE TIMES WHEN THE SPACECRAFT WILL BE LOCATED AT APPROXIMATELY 1, 10, AND 30 DEGREES ELEVATION ABOVE THE HORIZON, AND THE TIME OF THE COMPUTED CLOSEST APPROACH OF THE SPACECRAFT TO THE SITE.

THREE ACQUISITION MESSAGES PER ORBIT ARE TRANSMITTED FROM GODDARD TO EACH SITE. THE TTY TRANSMISSION OF COORDINATES AND THE SPACECRAFT'S EXPECTED TIME OF ARRIVAL TAKES LESS THAN ONE MINUTE.

A PREADVISORY TTY MESSAGE, ROUTED FROM THE CONTROL CENTER THROUGH GODDARD, MAY BE RECEIVED BY A SITE

APPROXIMATELY ONE MINUTE BEFORE ESTIMATED ACQUISITION TIME. SUCH A MESSAGE INFORMS THE STATION OF ANY SIGNIFICANT TRENDS REPORTED FROM PREVIOUS SITES, AND MAY INSTRUCT THE SITE TO MAKE SPECIAL OBSERVATIONS DURING SPACECRAFT TRANSIT OVER THAT STATION. MOST OF THIS INFORMATION CONCERNS THE CONDITION OF THE ASTRONAUT.

ACQUISITION MESSAGES TRANSMITTED DURING REENTRY MAINTAIN THE SAME FORMAT.

5.5.3 GODDARD DISPLAYS

THREE DIGITAL DISPLAYS, FIVE PLOTBOARDS, A PROGRAM CONTROL CONSOLE, AN OPERATIONS CONTROL CONSOLE, AND AN OPTICAL PROJECTION DISPLAY SYSTEM ARE USED AT GODDARD TO MONITOR GEMINI MISSION PROGRESS AND EVALUATE THE OPERATIONAL STATUS OF THE THREE IBM 7094 COMPUTER COMPLEXES. THESE DISPLAY AND CONTROL DEVICES, USED DURING ALL PHASES OF THE MISSION AND FOR POSTFLIGHT ANALYSIS, ACCEPT 7094-PROCESSED DATA AT 1000 BITS PER SECOND (TO THE PLOTBOARDS) AND AT 100 WORDS PER MINUTE (TO THE PROGRAM CONTROL CONSOLE). (SEE FIGURE 5-2)

THE TWO-PEN PLOTBOARDS MEASURE 30 INCHES BY 30 INCHES. EACH BOARD IS EMPLOYED WITH ONE OF THE TWO COMPUTERS. POSITION COORDINATES (X-Y) SMOOTHED BY EACH PLOTTER'S ASSOCIATED COMPUTER ARE PRESENTED ON THE PARALLELED BOARDS SO OPERATORS CAN MONITOR SPACECRAFT POSITION AND, IN CASES OF QUESTIONABLE CALCULATED DATA, EVALUATE AND SELECT THE MOST VALID PROCESSED INFORMATION.

PROGRAM CONTROL CONSOLES, ONE FOR EACH OF THE THREE COMPUTERS, PROVIDE THE MEANS TO ENTER OR OVERRIDE TELEMETRY DATA (E.G., LIFTOFF, BECO). THE PCC HAS THIRTY-SIX 3-POSITION DATA ENTRY SWITCHES AND 40 INDICATOR LIGHTS. THE SWITCHES PRESENT DATA TO THE COMPUTER IN

TWO 36-BIT WORDS. THE USE OF EACH WORD IS DETERMINED BY THE COMPUTER. THE INDICATOR LIGHTS PROVIDE 40 SEPARATE INDICATIONS ADDRESSABLE BY THE COMPUTER AND ALLOW THE PROGRAMMER TO DISPLAY UP TO 40 BITS OF INFORMATION FROM EITHER A SINGLE EVENT OR A MULTIPLE OCCURRENCE.

DATA CAN BE READ OUT OF THE PCC EITHER AUTOMATICALLY OR MANUALLY. IN THE MANUAL MODE, THE DESIRED 1'S AND 0'S ARE SET UP WITH THE 36 ENTRY SWITCHES AND THE CYCLE IS INITIATED WITH THE INTERRUPT PUSHBUTTON. IN THE AUTOMATIC MODE, THE READ-IN CYCLE IS INITIATED AND BOTH WORDS ARE READ IN WHENEVER ONE OF THE 36 ENTRY SWITCHES IS MOVED FROM THE CENTER POSITION. A SWITCH IN THE UP POSITION READS A 1 IN WORD ONE AND A 0 IN WORD TWO, CONVERSELY, AND ENTRY SWITCH IN THE DOWN PISITION READS A 1 IN WORD TWO AND A 0 IN WORD ONE. A ZERO IS READ IN FOR BOTH WORDS WHEN THE CENTER POSITION IS USED.

OPERATIONS CONTROL CONSOLE PROVIDES THE SWITCHING FACILITY FOR TRIPLEX COMPUTER OPERATION. THE CONSOLE HAS THE FOLLOWING FUNCTIONAL CAPABILITIES -

A) SWITCH COMPUTER OUTPUT-MISSION AND NON-MISSION MODES

B) SWITCH RESIDUAL PLOTTERS

C) DISPLAY PROGRAM STATUS

D) SWITCH LOCAL PLOTBOARDS AMONG COMPUTERS

E) PROVIDE VOICE COMMUNICATIONS

F) ENABLE SWITCH FOR 1) ACTIVE/STANDBY STATUS FOR HIGH-SPEED DATA TRANSMITTERS AND 2) PROGRAM CONTROL CONSOLE INTERRUPT CONTROLS

G) TEST FACILITY FOR CHECKING INDICATORS

H) ENABLE CADFISS SELECTION

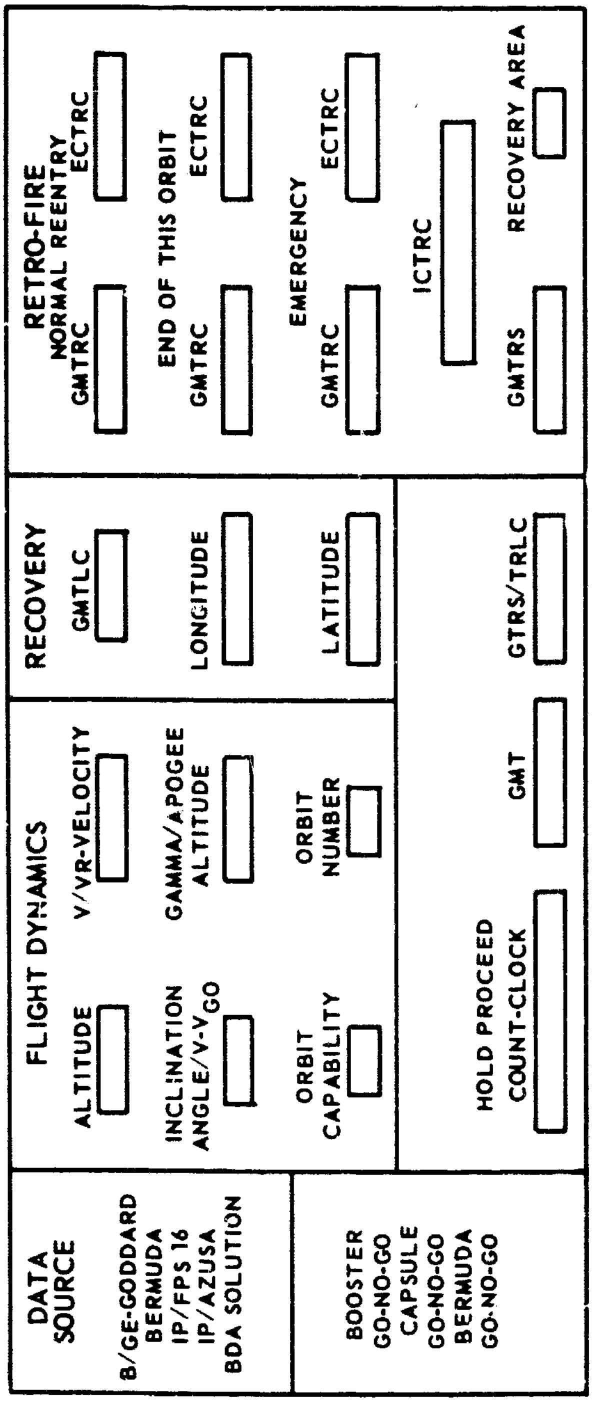


FIGURE 5-2. GSFC DIGITAL DISPLAYS

6. GSFC OPERATING PROCEDURES

THIS SECTION DEALS WITH GODDARD ACTIVITIES BEFORE, DURING, AND AFTER REAL-TIME OR SIMULATED REAL-TIME OPERATION OF THE GEMINI COMPUTING SYSTEM. DISCUSSIONS INCLUDE DETAILED PROCEDURES TO AID COMPUTER AND PERIPHERAL EQUIPMENT OPERATORS IN PERFORMING THEIR DUTIES PRETESTING AND REAL-TIME GEMINI SYSTEM OPERATION.

6.1 GENERAL

PREMISSION PROCEDURES AT GOODARD INVOLVE LAST MINUTE SYSTEM CHECKS AND PROGRAM LOADING INTO THE COMPUTERS. DURING THE MISSION, THE COMPUTER OPERATIONAL DIRECTOR AND HIS STAFF CONSTANTLY MONITOR OPERATIONS AND MAINTAIN CONTACT WITH THE GEMINI CONTROL CENTER. AFTER THE MISSION, THE POSTFLIGHT PEPORTER PROGRAM ANALYZES LOG TAPE DATA - DATA IS DECODED AND THEN COMPILED AND ARRANGED FOR A MORE COMPLETE ANALYSIS.

6.1.1 PREMISSION OPERATION

APPROXIMATELY ONE MONTH BEFORE A GEMINI MISSION, FLIGHT CONTROLLERS AT CAPE KENNEDY BEGIN MONITORING PROGRAM SYSTEM TESTS. THESE TESTS ARE KNOWN AS ''NETWORK DRILLS,'' AND THEY ACCOMPLISH TWO PURPOSES - 1) TRAIN ALL PERSONNEL IN THEIR DESIGNATED OPERATIONS AND ENSURE THEIR BECOMING FAMILIAR WITH ALL ASPECTS OF THE JOB TO BE PERFORMED - AND 2) TEST THE ABILITY OF EACH OF THE PARTICIPATING SITES TO PERFORM ITS DESIGNATED JOB IN THE OVERALL SYSTEM TEST.

6.1.2 MISSION OPERATION

THE COMPUTER OPERATIONAL DIRECTOR AT GODDARD IS RESPONSIBLE FOR MISSION SUPPORT OPERATIONS IN THE COMPUTE ROOM. A CHIEF OPERATOR IS RESPONSIBLE FOR TAPE LOADING IN THE A, B, AND C COMPUTERS. TWO PROGRAM MONITORS, BRIEFED ON THE EXPECTED (NOMINAL) SEQUENCE OF EVENTS AND ON-LINE MESSAGES, OBSERVE THE ON-LINE MESSAGES AND MONITOR THE PLOTBOARDS. THE CAPE COORDINATOR IS ALSO DIRECTLY INVOLVED WITH COMPUTER OPERATIONS. HE IS RESPONSIBLE FOR COMMUNICATING WITH FLIGHT CONTROLLERS AT CAPE KENNEDY AND COORDINATING GODDARD ACTIVITIES WITH THE CAPE DURING A COUNTDOWN. THE CAPE COORDINATOR ALSO MANS THE OUTPUT STATUS CONSOLE DURING COUNTDOWN AND MISSION PERIODS.

6.1.3 POSTMISSION OPERATION

IMMEDIATELY AFTER A MISSION, THE LOG TAPE IS PRESERVED AND HIGH-SPEED INPUT AND OUTPUT ARE DUMPED. POST-FLIGHT REPORT, WHICH IS CAPABLE OF REPORTING FOR ANY PHASE AND FOR ANY NUMBER OF LOG TAPES, PREPARES A SUMMARY OF PERTINENT LOG TAPE INFORMATION. LOG TAPE DATA IS DECODED, AND APPLICABLE INFORMATION IS COMPILED 24 HOURS AFTER GODDARD IS RELEASED FROM REAL-TIME COMPUTING.

6.2 MISSION SUPPORT GROUPS

MISSION SUPPORT GROUPS ARE DIVIDED INTO TWO CATEGORIES - THOSE ASSOCIATED WITH THE OPERATIONAL PROGRAM AND THE COMPUTERS AND THOSE CONCERNED WITH COMMUNICATIONS AND MONITORING ACTIVITIES.

6.2.1 PROGRAMMING AND RELATED GROUPS

THESE GROUPS OPERATE, TEST, OR MAINTAIN THE COMPUTER AND ITS SUPPLEMENTAL EQUIPMENT. GROUPS IN THIS CATEGORY

INCLUDE - OPERATIONAL PROGRAMMING GROUP, KINGSTON ENGINEERS (MILGO MAINTENANCE), CUSTOMER ENGINEERS (IBM 7094 AND DCC MAINTENANCE), AND THE CADFISS (COMPUTATION AND DATA FLOW INTEGRATED SUBSYSTEM) GROUP.

OPERATIONAL PROGRAMMING GROUP - THIS GROUP IS RESPONSIBLE FOR DEVELOPING AND TESTING THE GEMINI PROGRAM SYSTEM AND FOR OPERATING THE SYSTEM BEFORE, DURING AND AFTER THE MISSION. IN ADDITION, THIS GROUP LOADS THE PROGRAM INTO THE SYSTEM, MONITORS ITS OPERATION, AND PERFORMS POSTFLIGHT ANALYSIS.

KINGSTON ENGINEERS (MILGO MAINTENANCE) - THE KINGSTON ENGINEERS MAINTAIN THE MILGO EQUIPMENT - AMPEX TAPE RECORDERS, DATA TRANSMITTERS AND RECEIVERS, AND PLOTBOARDS - AND PERFORM DETAILED EQUIPMENT CHECKS AND PARTICIPATE IN CADFISS TESTING. THEY ARE AVAILABLE DURING COUNTDOWN AND MISSION PERIODS AND ARE DIRECTLY RESPONSIBLE TO THE GODDARD PREFLIGHT DIRECTOR BEFORE LIFTOFF AND TO THE GODDARD OPERATIONS DIRECTOR AFTER LIFTOFF. THE FOLLOWING LISTS IN MORE DETAIL THE DUTIES OF THE KINGSTON ENGINEERS -

A) THE ENGINEERS TURN ON POWER TO THE HIGHT-SPEED EQUIPMENT AND CONTACT CAPE KENNEDY BY PHONE TO TEST THE HIGH-SPEED LINES USING SAMPLE SIGNALS.

B) THE DATA SIGNALS ARE THEN TESTED TO INSURE NO LINES ARE OPEN - THAT AMPLITUDE OF SIGNAL EXISTS, AND THAT ALL EQUIPMENT IS OPERATING. IF TROUBLE IS FOUND IN THE HIGH-SPEED LINES, A.T. AND T. IS NOTIFIED BY CALLING THE TROUBLE BOARD IN WASHINGTON, D.C., AND ALSO THE FAX CONTROLLER AT GODDARD.

C) A DIAGNOSTIC HIGH-SPEED INPUT PROGRAM IS ENTERED INTO THE COMPUTER, AND THE TWO HIGH-SPEED INPUT

RECEIVERS, THE TRANSMITTER AT THE CAPE, THE DATA LINES, AND THE ASSOCIATED EQUIPMENT ARE CHECKED. THE INPUT IS COMPARED WITH A KNOWN PATTERN AND RESULTS PRINTED ON THE COMPUTER'S PRINTER.

IF TROUBLE EXISTS, THE ENGINEERS WITH THE ASSISTANCE OF THE COMPUTER CAN COMPARE THE INPUT BIT FOR BIT. IT IS COMPARED FOR BIT PICK-UP OR DROP-OUT. THE TROUBLE IS THEN DIAGNOSED AND REPAIRED.

D) THE DIAGNOSTIC HIGH-SPEED OUTPUT PROGRAM IS ENTERED INTO THE COMPUTER TO CHECK THE HIGH-SPEED TRANSMITTER AT GODDARD AND THE RECEIVERS AT THE CAPE. TESTS ARE PREFORMED IN A SIMILAR MANNER AS ABOVE.

E) THE HIGH-SPEED OUTPUT PROGRAM IS ALSO USED TO OPERATE THE DISPLAYS AT THE CAPE AND PERFORM TEST ON THE X-Y RECORDERS (PLOTBOARDS) AT GODDARD. THIS IS NECESSARY FOR CALIBRATION OF THE RECORDERS.

6.2.2 COMMUNICATIONS GROUP

THE GSFC GEMINI COMMUNICATIONS GROUP, HEADED BY THE COMMUNICATIONS DIRECTOR, IS RESPONSIBLE FOR ESTABLISHING GROUND COMMUNICATIONS PROCEDURES, COORDINATING SPECIALIZED NETOWRK USER PROCEDURAL REQUIREMENTS, CONFIRMING THE SUPPORT CAPABILITY OF THE COMMUNICATIONS NETWORK, ESTABLISHING AND PUTTING INTO EFFECT MISSION AND/OR ASSOCIATED TEST SCHEDULES, AND MAINTAINING AND IMPROVING NETWORK EFFICIENCY.

THE COMMUNICATIONS LIAISON COORDINATOR IS DIRECTLY RESPONSIBLE FOR THE SUPERVISION OF THE INTERFACE BETWEEN COMPUTER AND COMMUNICATIONS NETWORKS. HE RELAYS THE ORDERS AND RECOMMENDATIONS OF THE COMMUNICATIONS DIRECTOR

TO THE COMPUTER OPERATIONAL DIRECTOR AND MONITORS THE ACTIVITIES IN THE COMPUTER AREA TO ENSURE THAT THE ORDERS ARE PROPERLY EXECUTED.

6.3 PERSONNEL DUTIES

AS NOTED IN THE FOREGOING DESCRIPTION OF MISSION OPERATIONS, MANY FUNCTIONS MUST BE PERFORMED AND COORDINATED TO IMPLEMENT AND SUPPORT THE COMPUTER OPERATIONS. A SUMMARY OF THE OVERALL DUTIES OF PERSONNEL DIRECTLY INVOLVED IN THE TESTING AND OPERATION OF THE GEMINI PROGRAM SYSTEM IS PRESENTED BELOW.

6.3.1 CADFISS TEST DIRECTOR

THE DUTIES OF THE CADFISS TEST DIRECTOR ARE TO -

A) SECURE FROM OPERATIONS DIRECTOR A DETAILED COUNTDOWN PROCEDURE.

B) CONTACT AND REMAIN IN VOICE COMMUNICATION WITH THE FLIGHT DIRECTOR AT THE CAPE.

C) INSURE THAT EACH TEAM PERFORMS ITS DESIGNATED TASK AT THE APPOINTED TIME AS DESCRIBED IN THE COUNTDOWN PROCEDURES.

D) REPORT TO THE OPERATIONS DIRECTOR THE RESULTS OF ALL REQUIRED FUNCTIONS.

E) PROVIDE COORDINATION BETWEEN THE CAPE AND GSFC FOR EACH TASK PERFORMED.

F) RELAY TO THE OPERATIONS DIRECTORS ANY CHANGE IN PROCEDURES AS REQUIRED BY THE CAPE OR AT GSFC.

G) RECONFIRM THE EXTENT TO WHICH ALL GEMINI SITES WILL BE ABLE TO PARTICIPATE IN EXERCISES.

H) KEEP A WRITTEN RECORD OF ALL OPERATIONS AS PERFORMED AND THE RESULTS OF THESE TESTS.

I) HAVE ABSOLUTE CONTROL OF OPERATIONS IN THE

COMPUTER AREA WHEN ACTING AS TEST DIRECTOR.

J) KEEP THE FLIGHT DIRECTOR AT THE CAPE INFORMED AS TO PROGRESS OF MISSION AS DETERMINED AT GSFC.

K) INFORM COMPUTER-COMMUNICATIONS COORDINATOR OF EXPECTED TIMES THAT TTY COMMUNICATION WILL OCCUR.

L) MONITOR OPERATOR'S CONTROL CONSOLE AND SELECT DESIRED COMPUTER IN CASE TROUBLE DEVELOPS ON ONE.

6.3.2 MESSAGE MONITORS

THE TENTATIVE DUTIES OF THE MESSAGE MONITOR ARE TO -

A) MONITOR THE COMPUTERS IN THEIR SEQUENCE OF OPERATION.

B) RECOGNIZE THE SERIES OF EVENTS THAT OCCUR AND ARE PRINTED, E.G., ''LIFT-OFF HAS OCCURRED.''

C) COMPARE THE EVENTS WITH KNOWN INFORMATION TO DETERMINE IF ANY DEFICIENCIES EXIST.

D) INFORM THE TEST DIRECTOR OF THE TIME THAT EVENTS OCCUR, THE COMPUTER'S PROGRESS, AND THE EXPECTED RESULTS.

6.3.3 COMPUTER-COMMUNICATION COORDINATOR

THE TENTATIVE DUTIES OF THE COMPUTER-COMMUNICATIONS COORDINATOR ARE TO -

A) COORDINATE ACTIVITIES BETWEEN THE CADFISS DIRECTOR AND THE COMMUNICATIONS NETWORK.

B) INFORM TEST DIRECTORS OF STATUS, AND SUBSEQUENTLY ANY CHANGE IN STATUS, OF COMMUNICATIONS NETWORK.

C) RELAY TO COMMUNICATIONS ANY CHANGE IN STATUS OF COMPUTER OPERATIONS.

D) INSURE THAT THE TTY MESSAGE MONITORS IN COMPUTER AREA ARE READY TO HANDLE ALL TRAFFIC.

E) MONITOR THE MESSAGES TRANSMITTED AND RECEIVED FROM REMOTE SITES, AS TO COMPLETENESS OF MESSAGE, CORRECT FORMAT, AND SUCCESSFUL COMPLETION.

F) RELAY BOTH TO COMPUTER TEST DIRECTOR AND COMMUNICATIONS ANY DISCREPANCIES IN MESSAGES.

G) GIVE THE TEST DIRECTORS, ANY MESSAGES REFERRING TO STATUS OF NET, COUNTDOWN, ETC., WHICH PRINTS ON THE MESSAGE MONITORS.

6.3.4 OPERATORS

THE TENTATIVE DUTIES OF THE OPERATORS ARE TO -

A) INSURE THAT AN ADEQUATE SUPPLY OF PAPER, BLANK TAPES, AND LABEL-ON TAPE IS READILY AVAILABLE.

B) OBTAIN FROM FILES ALL NECESSARY TAPES AND PROGRAMS TO PERFORM OPERATION.

C) HAVE AVAILABLE UTILITY PROGRAMS AND OPERATING NOTES IN CASE AN EMERGENCY STOP OCCURS.

D) BECOME FAMILIAR WITH COMPLETE OPERATING PROCEDURES OF ALL SUBSYSTEM TESTS AND OPERATIONAL PROGRAMS RUN DURING A GEMINI OPERATION.

E) MONITOR OPERATION OF COMPUTER FOR POSSIBLE TAPE ERRORS, UNLISTED STOPS, EQUIPMENT MALFUNCTION, ETC.

F) ADEQUATELY LABEL ALL MATERIAL - PAPER, PLOTS, TAPES, ETC. WITH INFORMATION RELATIVE TO OPERATION.

G) PREPARE A LIST OF ALL MATERIAL AND GIVE TO TEST DIRECTOR FOR FUTURE REFERENCE.

H) PROVIDE, AT REQUEST OF TEST DIRECTOR, PROVISIONS FOR MAKING QUICK ANALYSIS OF LOGGED DATA.

I) HAVE PRINTED ANY TAPES WHERE OPERATION REQUIRES AN EARLY PRINTOUT.

J) BECOME FAMILIAR WITH OPERATION OF OPERATIONAL DATA RECORDER AND PLOTBOARDS.

6.3.5 ENGINEERS

THE TENTATIVE DUTIES OF THE ENGINEERS ARE TO -

A) INSURE RELIABILITY OF EQUIPMENT.

B) PERFORM DESIGNATED TESTS AT APPOINTED TIMES.

C) INFORM TEST DIRECTOR ON STATUS OF EQUIPMENT.

D) PROVIDE TO TEST DIRECTOR AN ESTIMATE OF REPAIR TIME, IF NECESSARY.

E) MONITOR EQUIPMENT AT REQUEST OF TEST DIRECTOR.

F) LOG ALL PERTINENT DATA REGARDING OPERATION OF EQUIPMENT.

G) MONITOR HIGH-SPEED LINES FOR PROPER OPERATION.

6.4 DATA CHANNEL AND COMPUTER CONTROL OPERATION

REAL-TIME DATA IS INPUT TO THE IBM 7094 COMPUTERS THROUGH DATA CHANNELS A, B, AND C.

6.4.1 DATA CHANNEL A

THE GEMINI SYSTEM TAPE (A1) IS THE BASIC COMPUTER PROGRAM FOR PROJECT GEMINI. THIS PROGRAM, WHEN LOADED INTO CORE STORAGE, CONTROLS ALL PROCESSING AND INPUT/OUTPUT OPERATIONS THROUGHOUT THE MISSION. DECISIONS ARE MADE BY THE GEMINI PROGRAM ON THE BASIS OF COMPUTATIONAL RESULTS. VARIOUS SIGNIFICANT EVENT INPUTS SUCH AS GMT OF LIFTOFF ARE GIVEN TO, AND RECOGNIZED BY, THE SYSTEM, AND COMPUTER ACTION IS TAKEN ACCORDING TO THE INFORMATION PRESENTED.

THIS PROGRAM IS THE HEART OF THE COMPUTING SYSTEM FOR THE GEMINI LAUNCH MONITOR SUBSYSTEM, AND CONTAINS

WITHIN ITSELF THE ABILITY TO RECOGNIZE FROM INPUT DATA THE VARIOUS PHASES OF THE MISSION AND TO DIRECT DATA PROCESSING AND TRANSMITTING AS THE MISSION DICTATES.

THE SYSTEM TAPE IS COMPOSED OF THREE FILES. THE FIRST FILE IS A LOADING PROGRAM AND HAS THE SOLE FUNCTION OF READING THE SECOND FILE INTO CORE STORAGE. THE SECOND FILE CONTAINS THE MAIN PROGRAM WHICH INCLUDES SOME SECTIONS USED ONLY IN THE LAUNCH/ABORT PHASE. THE THIRD FILE CONSISTS OF ADDITIONS TO THE LAUNCH/ABORT PROGRAM TO PROVIDE FOR THE ORBIT AND REENTRY PHASES.

THE AVAILABLE CORE STORAGE IS INSUFFICIENT TO CONTAIN THE ENTIRE PROGRAM AT ANY ONE TIME. TWO ROUTINES (EDIT AND DIFFERENTIAL CORRECTION) NOT USED IN THE LAUNCH PHASE ARE READ INTO CORE STORAGE AFTER LAUNCH, REPLACING LAUNCH ROUTINES WHICH ARE NO LONGER NEEDED. THE MAIN PROGRAM IN CORE STORAGE IS CHANGED ONLY IN THE INTERPHASE STAGE OF THE MISSION.

THE SYSTEM IS LOADED FROM TAPE AT SOME TIME PRIOR TO LAUNCH. THE GMT AT WHICH INITIALIZATION IS DESIRED IS ENTERED OCTALLY WITH THE COMPUTER'S CONSOLE KEYS (HOURS IN THE DECREMENT AND MINUTES IN THE ADDRESS). THE SIGN KEY IS DEPRESSED WITHIN 60 SECONDS PRIOR TO THE TIME THUS ENTERED. AT THE NEXT SUCCEEDING EXACT MINUTE THE WWV TRAP OCCURS AND THE CORRECT GMT IS READ FROM THE KEYS AND WRITTEN INTO CORE STORAGE. WHEN THIS HAPPENS, THE ON-LINE PRINTER PRINTS OUT TWO MESSAGES - NORMAL OPERATION BEGUN AND THE WWV ENTERED IS (GMT) XX HRS XX MINS XX SECS.

THE COMPUTER COMES TO A PROGRAMMED HALT. THE START BUTTON MUST BE PRESSED AND THE STATION CHARACTERISTICS TAPE, PREVIOUSLY UPDATED, WILL BE READ INTO CORE STORAGE AND BECOME A PART OF THE GEMINI COMPUTER PROGRAM. AN ON-LINE PRINTOUT DESIGNATES THAT THE OPERATION HAS BEEN

SUCCESSFULLY COMPLETED.

INITIALIZATION IS NOW COMPLETE AND THE PROGRAM BEGINS PROCESSING AND TRANSMITTING DATA. IT CYCLES AS IT AWAITS INITIAL INPUT DATA FROM CAPE KENNEDY.

THE ON-LINE CARD READER IS USED IN UPDATING THE STATION CHARACTERISTICS TAPE (DESCRIBED BELOW). THIS OPERATION IS PART OF THE COUNTDOWN PROCEDURES AND TAKES PLACE TWO OR MORE HOURS PRIOR TO LAUNCH.

THE ON-LINE CARD READER IS NOT USED WHILE THE ACTUAL MISSION IS IN PROGRESS.

THE STATION CHARACTERISTICS TAPE (A7) IS PREPARED FROM METEROLOGICAL DATA SUPPLIED TO GODDARD FROM EACH TRACKING STATION SEVERAL HOURS BEFORE LAUNCH. CONSISTING OF READINGS OF THE ATMOSPHERIC TEMPERATURES, WATER VAPOR PRESSURE, TOTAL PRESSURE, AZIMUTH ANGLE OF THE BORESIGHT TOWER, AND THE ELEVATION ANGLE OF THE BORESIGHT TOWER AT EACH SITE, THIS INFORMATION IS PUNCHED ON CARDS AND READ BY THE ON-LINE CARD READER TO PRODUCE THE STATION CHARACTERISTICS TAPE. THE DATA FROM THE VARIOUS STATIONS IS NOW LOADED INTO THE CORRESPONDING STATION CHARACTERSTICS BLOCK IN CORE MEMORY, AND BECOMES PART OF THE COMPUTER'S STORED KNOWLEDGE OF EACH PARTICULAR STATION.

THE INFORMATION SUPPLIED FROM THE STATION CHARACTERISTICS TAPE PROVIDES CORRECTIONS TO THE RADAR VALUES FROM THE SITES. ONCE READ INTO CORE STORAGE, ONLY THE NEED TO RESTART THE SYSTEM REQUIRES THAT THIS TAPE BE USED AGAIN.

THE MESSAGE TAPE (A6) PROVIDES THE ON-LINE PRINTER THE CARD IMAGES FOR ON-LINE MESSAGE PRINTS OF OVER 270 PREPARED ALPHABETIC MESSAGES (AN ON-LINE PRINTOUT MUST BE PREPARED IN A CARD IMAGE FORMAT). EACH MESSAGE CONSISTS OF ONE RECORD AND IS IDENTIFIED BY A RECORD NUMBER.

MESSAGES ARE OF THREE TYPES - TIME (E.G., ''THE FOLLOWING NUMBER OF MINUTES HAS PASSED), EVENT (E.G., ''NORMAL OPERATION BEGUN''), AND INSTRUCTIONS TO THE PROXIMATE OPERATORS (E.G., ''CHANGE LOG TAPE''). MESSAGES MAY ALSO BE CLASSIFIED AS FIXED OR VARIABLE FIELD. THE VARIABLE FIELD MESSAGES (E.G., THE FIRST EXAMPLE GIVEN) REQUIRE THE GENERATION BY THE COMPUTATIONAL PROGRAM OF NUMERICAL DATA IN CARD IMAGE FORMAT TO COMPLETE THE MESSAGE.

THE MESSAGE TAPE MUST BE AVAILABLE AS SOON AS THE SYSTEM IS READ INTO THE COMPUTER AND, SINCE THE ON-LINE MESSAGES PROVIDE IMMEDIATELY ESSENTIAL INFORMATION, THIS TAPE IS IN USE CONTINUOUSLY THROUGHOUT THE MISSION.

THE ON-LINE PRINTER PRINTS THE MESSAGES SUPPLIED BY THE MESSAGE TAPE. INDIRECTLY, THE ON-LINE PRINTER PROVIDES A MEANS OF COMPARING THE TRIPLEXED COMPUTERS. THE COMPUTER SYSTEM RECEIVES THE SAME INPUT DATA AT APPROXIMATELY THE SAME TIME AND PERFORMS THE SAME CALCULATIONS. THEREFORE, THE ON-LINE MESSAGE PRINTOUTS SHOULD OCCUR ALMOST SIMULTANEOUSLY. ANY SIGNIFICANT TIME GAP WOULD BE CAUSE FOR IMMEDIATE CONCERN.

6.4.2 DATA CHANNEL B

THE LOG TAPES (B6, B7) CHRONOLOGICALLY RECORD FOR POSTMISSION ANALYSIS ALL INPUT/OUTPUT DATA TRANSMITTED THROUGH THE DATA COMMUNICATIONS CHANNEL. NOT ALL INFORMATION TO ENTER THE DCC IS INTENDED FOR PROCESSING - SUCH INFORMATION (REROUTED TO THE MISSION CONTROL CENTER) IS LOGGED, NONETHELESS. TAPE B7 IS USED ONLY IF B6 BECOMES FILLED.

THE RESTART TAPE (B9) RECORDS SPECIFIC KEY COMPUTER PARAMETERS. THESE PROVIDE A COMPUTATIONAL CONTINUITY

SUFFICIENT TO RESTART THE SYSTEM OR ENABLE THE SYSTEM TO CHANGE PHASE FROM ORBIT TO REENTRY.

A RESTART COULD BECOME NECESSARY IN THE EVENT OF MACHINE MALFUNCTION OF IF THE MANUAL OVERRIDE OPTION IS ACCEPTED. IN THE CHANGE FROM ORBIT TO REENTRY THERE IS TIME LAG BETWEEN THE EVENT AND THE COMPUTER'S COGNIZANCE OF THAT EVENT. DURING THIS TIME LAG THE COMPUTER HAS BEEN PROCESSING REENTRY DATA FOR THE ORBITAL PHASE. WHEN THE COMPUTER IS INFORMED OF THE TIME OF PHASE CHANGE, THE RESTART TAPE SUPPLIES THE LAST PARAMETERS VALID PRIOR TO RETROROCKET FIRING.

6.4.3 DATA CHANNEL C

THE RESERVE RESTART TAPE RECORDS, IN PARALLEL, ON TAPE C9 THOSE PARAMETERS RECORDED ABOVE THE TAPE B9.

6.4.4 COMPUTER CONSOLE KEYS

AT SOME TIME BEFORE LIFTOFF, GREENWICH MEAN TIME (GMT) MUST BE READ INTO THE GEMINI PROGRAMMING SYSTEM TO PROVIDE A STANDARD TIME BASE.

DURING THE FINAL STAGES OF COUNTDOWN, THE LAUNCH PROGRAM, NOW LOADED IN CORE MEMORY, COMES TO A PROGRAMMED COMPUTER HALT. THE GMT AT WHICH INITIALIZATION IS DESIRED IS MANUALLY SET IN THE CONSOLE'S ENTRY KEYS-HOURS IN THE DECREMENT, MINUTES IN THE ADDRESS. WITHIN 60 SECONDS OF THE TIME THUS SET, THE SIGN KEY OF THE CONSOLE MUST BE DEPRESSED. WHEN THE NEXT WWV ONE-MINUTE TRAP OCCURS, THE SYSTEM READS THE GMT FROM THE KEYS INTO CORE STORAGE.

AFTER GMT IS SUCCESSFULLY RECEIVED, THE ON-LINE PRINTER PROVIDES TWO MESSAGES - ''NORMAL OPERATION BEGUN'' AND ''THE WWV TIME ENTERED IS (GMT) XX HRS XX MINS XX SECS.''

UNLESS AN EMERGENCY SITUATION SHOULD REQUIRE A PROGRAM RESTART, THE CONSOLE KEYS ARE NOT USED AFTER GMT HAS BEEN SUCCESSFULLY ENTERED.

6.4.5 SENSE SWITCHES

TEST PATTERNS FROM THE CAPE RADARS ARE RECEIVED JUST BEFORE LIFTOFF AND ARE PROCESSED AND TRANSMITTED TO THE MISSION CONTROL CENTER. IF LIFTOFF IS DELAYED SEVERAL MINUTES, A CONSIDERABLE AMOUNT OF THE LOG TAPE COULD BE FILLED WITH THE TEST PATTERN DATA. THIS DATA HAS NO VALUE FOR POSTMISSION ANALYSIS AND, WITH SENSE SWITCH 1 DOWN (ON), DATA RECEIVED ON SUBCHANNELS 1 AND 2, AND TRANSMITTED ON SUBCHANNEL 3, IS NOT LOGGED.

6.4.6 OPERATIONS CONTROL CONSOLE

THE OPERATIONS CONTROL CONSOLE (OCC) IS A SYSTEM MONITORING DEVICE COMMON TO THE THREE COMPUTERS. IT PROVIDES FOR THE SELECTION OF ONE COMPUTER TO TRANSMIT OUTPUT DATA TO BOTH THE MISSION CONTROL CENTER AND TO THE WORLDWIDE TRACKING NETWORK. WHEN MISSION MODE IS SELECTED, TRANSMISSION OF HIGH-SPEED DATA WILL BE FROM THE ACTIVE COMPUTER AND LOW-SPEED DATA WILL BE FROM THE STANDBY COMPUTER. ANY COMPUTER MAY DRIVE ANY ONE OF THE THREE LOCAL PLOTBOARDS (ONLY ONE PLOTBOARD AT A TIME MAY BE SELECTED).

THE OPERATIONS CONTROL CONSOLE ALSO CONTAINS STATUS LIGHTS TO INDICATE MAJOR CONDITIONS FOR EACH COMPUTER. THE UPPER PANEL OF THE CONSOLE HAS 120 INDICATORS, 40 OF WHICH ARE ACTIVATED FROM THE SENSE OUTPUT OF EACH COMPUTER. THE INFORMATION DISPLAYED BY THESE INDICATORS IS THE SAME AS THAT DISPLAYED ON THE PROGRAM CONTROL CONSOLES AND IS UNDER PROGRAM CONTROL.

6.4.7 PROGRAM CONTROL CONSOLE

THE PROGRAM CONTROL CONSOLE (PCC) PROVIDES THE OPERATOR WITH A MEANS OF FORCING OR OVERRIDING CERTAIN DISCRETE EVENTS. THE PCC USES 36 THREE-POSITION DATA ENTRY SWITCHES AND 40 INDICATOR LIGHTS. THE PURPOSE OF THE ENTRY SWITCHES IS TO PRESENT DATA TO THE COMPUTER IN THE FORM OF TWO 36-BIT WORDS. THE INDICATOR LIGHTS PROVIDE 40 SEPARATE INDICATIONS ADDRESSABLE BY THE COMPUTER. THE LIGHTS ALLOW THE PROGRAMMER TO DISPLAY UP TO 40 BITS OF INFORMATION FROM EITHER A SINGLE EVENT OR MULTIPLE OCCURRENCE.

DATA CAN BE READ OUT OF THE PCC BOTH MANUALLY AND AUTOMATICALLY. IN THE MANUAL MODE, THE DESIRED 1'S AND 0'S ARE SET UP ON THE 36 LEVER SWITCHES FOR WORDS 1 AND 2. THE READ-IN CYCLE IS INITIATED BY DEPRESSING THE INTERRUPT PUSHBUTTON. IN THE AUTOMATIC MODE, THE READ-IN CYCLE IS INITIATED AND BOTH WORDS ARE READ-IN WHENEVER ONE OF THE 36 LEVER SWITCHES IS MOVED FROM THE CENTER POSITION. A LEVER SWITCH IN THE UP POSITION IS READ IN AS A 1 IN THAT BIT POSITION OF WORD 1. A LEVER SWITCH IN THE DOWN POSITION IS READ IN AS A 1 IN THAT BIT POSITION OF WORD 2. A ZERO IS READ IN FOR ALL SWITCHES IN THE OFF POSITION. NOTE THAT IF A 1 IS PRESENT IN A BIT POSITION IN WORD 1, THEN A 0 WILL AUTOMATICALLY BE PRESENT IN THAT BIT POSITION IN WORD 2. CONVERSELY, IF A 1 IS PRESENT IN WORD 2, THE CORRESPONDING BIT POSITION IN WORD 1 WILL BE 0.

6.5 PROGRAM SYSTEM OPERATING PROCEDURES

TWO DIFFERENT MODES OF OPERATION EXIST IN THE GEMINI PROGRAM SYSTEM - REAL-TIME OPERATION, WHEN THE SYSTEM OPERATES IN THE REAL ENVIRONMENT, AND SIMULATED

OPERATION, WHEN THE SYSTEM OPERATES IN AN EXTERNAL ENVIRONMENT SIMULATED BY THE SIC PROGRAM. IN THE LATTER MODE, A RESTART FEATURE IS PROVIDED.

6.5.1 JOB TAPE PREPARATION

JOB TAPES MUST BE GENERATED BEFORE ANY REAL-TIME OR SIMULATED SYSTEM RUN. JOB TAPES CONSIST OF A SYSTEM COMPILATION PLUS MODIFICATIONS SUCH AS CORRECTIONS TO, OR EXPANSION OF, THE SYSTEM. IN SOME CASES, MODIFICATIONS NECESSARY TO CONVERT A NORMAL OPERATIONAL SYSTEM TO OR FROM A SIMULATED OPERATIONAL SYSTEM ARE ALSO INCLUDED.

SYSTEM TAPE GENERATION USES THE UTILITY ROUTINE MXMRGE TO COMBINE THE MODIFICATION DECKS WITH THE COMPILATION DECKS (SQUOZE TAPE). THE MXMRGE RUN OUTPUT IS A TAPE HAVING AN IDENTICAL FORMAT WITH ANY SOS JOB DECK. THIS TAPE PROVIDES THE INPUT (A3) FOR THE SOS LOAD-AND-GO (LG) RUN. THE SOS LG OUTPUT IS AN ABSOLUTE BINARY, SELF-LOADING SYSTEM TAPE.

TAPE ASSIGNMENTS FOR JOB TAPE PREPARATION ARE AS FOLLOWS -

MERGE	A1	A2	A3	A5	A6
			BLANK	MOD DECK OR BLANK	
SOS L AND G	SOS SYSTEM	BLANK HIGH DENSITY	SOS INPUT TAPE		H.D. BLANK

B1	B2	B3	B4	B8 SQUOZE	C1 UTILITY WITH MXMRGE	C6
BLANK	BLANK	BLANK	UTILITY WHEN AVAIL.	H.D. BLANK		H.D. BLANK

TAPES A3, A5, B8, AND C1 MUST BE PREPARED AND READY BEFORE INITIATING MXMRGE.

THE STEP-BY-STEP PROCEDURE FOR SYSTEM TAPE PREPARATION IS AS FOLLOWS --

A) ENTER MXMRGE KEY SETTING, AS SUPPLIED BY THE PROGRAMMER, IN THE CONSOLE.

B) USING EITHER A C1 MXMRGE CALL CARD OR AN MXMRGE DECK, CLEAR AND LOAD THE MXMRGE PROGRAM FROM C1. PLACE THE PROGRAMMER'S MOD DECK BEHIND THE C1 CALL CARD (OR MXMRGE DECK) UNLESS TAPE A5 IS USED. IN THIS CASE, SET THE SIGN KEY TO THE UP POSITION.

C) WHEN A CALL CARD IS USED, THE FOLLOWING ON-LINE PRINTOUT OCCURS AFTER MXMRGE IS LOADED - MXMRGE, MERGS MODS WITH SQUOZE.

D) WITH SUCCESSFUL RUNS, MXMRGE PROVIDES THE FOLLOWING PRINTOUTS -

''TOTAL COMMON MODS X''

''ONE JOB HAS BEEN WRITTEN ON A3. SQUOZE AND MOD COUNTS WILL FOLLOW.''

''TOTAL SQUOZE RECORDS FROM B8 S. TOTAL MOD CARDS Y.''

''ONE JOB HAS BEEN WRITTEN ON A3. SQUOZE AND

MOD COUNTS WILL FOLLOW.''
''TOTAL SQUOZE RECORDS FROM B8 Q. MOD CARDS Z
GOOD MORNING. PLEASE RESET ENTRY KEYS FOR FIRST
JOB THEN PRESS START.''
THE SUM OF THE NUMBERS X + Y + Z SHOULD ALMOST
EQUAL THE NUMBER OF CARDS IN THE MODIFICATION
DECK. A SIGNIFICANT DIFFERENCE INDICATES A MERGING ERROR. SQUOZE RECORD COUNTS S AND Q ALWAYS
HAVE THE SAME VALUES FOR ANY COMPILATION.

E) RESET THE ENTRY KEYS FOR SOS. NORMALLY, A 3 IS PLACED IN THE ENTRY KEYS ADDRESS, SPECIFYING 3 GEMINI TAPES. ALSO, WET UP THE FOLLOWING TAPES - A1, A2, A6, B1, B2, B3, AND B4.

F) CHANGE B8 TO A BLANK.

G) DEPRESS THE START PUSHBUTTON TO CALL IN SOS FROM A1 TO PROCESS THE A3 INPUT TAPE. IF CHANNEL A DOES NOT HAVE A FULL COMPLEMENT OF TAPE DRIVES, CHANGE A5 TO A6.
IF THE MODIFICATION DECK WAS ON A5 BEFORE MERGING, HOWEVER, SAVE A5 UNTIL SOS HAS COMPLETED.

H) SOS INPUT IS FROM A3. ITS OUTPUT IS A BINARY TAPE ON B1 (OR ON B3 FOR THE SECOND JOB IN DUAL COMPILATION). A SUCCESSFUL SOS RUN YIELDS THE FOLLOWING ON-LINE PRINTOUTS -

```
    JOB    XXXXXX
    LG
                                  ERROR MESSAGES, IF
                                  ANY
    XXXXXX <--------------------- (FROM JOB CARD)
UNDEF SYMBOLS IN TEXT
    YYYYYY
    -----
    -----
    -----
    -----
    -----
    ZZZZZ
ORIGIN IN MONITOR
    GO
**UNDEFINED SYMBOLS BETWEEN, AND INCLUDING, THE
        FOLLOWING TWO SYMBOLS ARE
*QDEFN ENTRIES
    AAAAAA
    BBBBBB
GEMINI MONITOR SYSTEM TAPE WRITER
THIS PROGRAM EDITS ERASE 1 OR IB MONITOR AND
WRITES IT ON THE GEMINI SYSTEM TAPE (A6)
SET ERASE 1 OF IB MONITOR TO BI AND SET A A6 FOR THE
    GEMINI SYSTEM TAPE
PRESS START TO BEGIN JOB.
```

I) IGNORE THE MESSAGE BEGINNING WITH ''SET ERASE 1, ETC.'' AFTER WRITING IS COMPLETED, CONTROL RE-

TURNS TO SOS FOR THE SECOND JOB. A SUCCESSFUL RUN PRODUCES AN ON-LINE PRINTOUT SIMILAR TO JOB 1.

J) AFTER THE SECOND JOB IS COMPLETED, CHECK FOR THE FOLLOWING PRINTOUT -

GEMINI SYSTEM TAPE SUCCESSFULLY WRITTEN
PRESS START TO COMPARE TAPES

A SUCCESSFUL COMPARISON CAUSES THE FOLLOWING PRINTOUT -

COMPARISON SUCCESSFUL

MOST MERGE ERRORS RESULT FROM THE MODIFICATION DECK SETUP OR MERGE ENTRY KEY SETTING. OCCASIONALLY, A TAPE REDUNDANCY PRODUCES AN ERROR. THE ABSENCE OF A FIELD CARD CAUSES MERGING ERRORS. IF THE PRINTOUT ''PERMANENT READ ERROR HAS OCCURRED'' IS PRESENT, CHECK THE KEY SETTINGS AND RESTART MXMRGE FROM THE BEGINNING. THE PRINTOUT ''THE FOLLOWING MOD OVERLAPS ANOTHER'' INDICATES AN ERROR IN THE PROGRAMMER'S MODIFICATION DECK, ALTHOUGH THIS PRINTOUT CAN OCCUR BECAUSE OF A MODIFICATION DECK READING ERROR. REMERGE, AND, IF THE PRINTOUT REPEATS CONTINUE PROCESSING, IGNORE THE OVERLAP UNLESS OTHER INSTRUCTIONS ARE GIVEN. NO PAUSE CARD IN THE MODIFICATION DECK BLOCKS THE PRINTOUT SHOWN IN D PREVIOUSLY, BUT THE MXMRGE OPERATIONS ARE NOT OTHERWISE AFFECTED.

FOLLOWING A REDUNDANCY IN READING THE FIRST FEW RECORDS ON A3 DURING THE SOS RUN, THE MERGE KEY SETTINGS MAY PROBABLY BE INCORRECT. THIS TYPE OF ERROR PARALLELS READING A DEFECTIVE TAPE. THEREFORE, CHECK BOTH POSSIBILITIES BEFORE ABANDONING THE JOB. SOMETIMES SOS UNCOVERS REDUNDANCIES ON B1, B2, OR B3. THE SOS STOP FOR REDUNDANCY IS 77202 (OCT). IN THIS CASE, REWIND A3, A1, AND A2, REPLACE THE DEFECTIVE TAPE, DEPRESS THE CLEAR

PUSHBUTTON, AND DEPRESS THE LOAD TAPE PUSHBUTTON.

WHEN THE SYSTEM TAPE WRITER ENCOUNTERS A REDUNDANCY, THE CHANNEL IS IDENTIFIED BY AN ON-LINE MESSAGE. DEPRESS SS4, AND MAKE SEVERAL ATTEMPTS TO OVERCOME THE REDUNDANCY BEFORE ABANDONING THE TAPE. WITH SS2 DOWN, THE GEMINI TAPE WRITER AUTOMATICALLY ATTEMPTS TO OVERCOME A REDUNDANCY, REJECTING THE TAPE ONLY IF THE REDUNDANCY REPEATS 20 SUCCESSIVE TIMES.

THE GEMINI TAPE WRITER COMPARES B AND C CHANNEL TAPES WITH THAT ON CHANNEL A. ONE NC COMPARE NEGATES USE OF THAT TAPE. COMPLETE DISAGREEMENT INDICATES ANY OF THE TAPES INVOLVED CAN BE USED WITH EQUAL CHANCE OF SUCCESS.

6.5.2 OPERATIONAL PROGRAM PROCEDURES

THE NORMAL OPERATIONAL PROGRAM PROCEDURAL STEPS ARE-

A) PREPARE AND READY THE FOLLOWING TAPES -

1) A1 - JOB TAPE
2) A5 - MESSAGE TAPE
3) A6 - MESSAGE TAPE
4) A8 - STATION CHAR. TAPE
5) A9 - AUX. STATION CHAR. TAPE
6) B6 - LOG TAPE
7) B7 - USED WHEN B6 IS FULL
8) B8 - JOB TAPE
9) B9 - RESTART TAPE
10) C6 - JOB TAPE (C6 FROM SOS)
11) C9 - RESTART TAPE (DUPLICATE OF B9)

B) ARRANGE THE SENSE SWITCHES (SS) AS NEEDED -

1) SS 1--IN THE UP POSITION NORMAL LOGGING ON B6. IN THE DOWN POSITION LOGGING IS SUPPRESSED ON B6.

2) SS 2--IN THE UP POSITION END OF TRANSMISSION BY A STATION INITIATES A DIFFERENTIAL CORRECTION. IN THE DOWN POSITION, IF THE DECREMENT AND/OR THE ADDRESS CONTAIN A CORE STORAGE BLOCK NUMBER IN THE CORRESPONDING KEY POSITIONS, AN END OF TRANSMISSION BY THE STATIONS INVOLVED INITIATES A DIFFERENTIAL CORRECTION. IF THE KEY DECREMENT AND ADDRESS FIELDS CONTAIN ALL ZEROS, THE D.C. PROGRAM IS BYPASSED.

3) SS 3--THE UP POSITION IS THE NORMAL POSITION. IN THE DOWN POSITION MANUAL INSERTION OF PAPER TAPES IS ACCEPTED.

4) SS 4--THE UP POSITION IS THE NORMAL POSITION. IN THE DOWN POSITION IT IS USED IN CONJUNCTION WITH THE ENTRY KEYS. IF THE SIGN KEY IS DOWN, A D.C. IS FORCED IMMEDIATELY. IF KEYS 24-29 CONTAIN A VALID OCTAL CORE STORAGE BLOCK NUMBER, THESE STATIONS ARE DELETED FROM ALL FUTURE D.C.'S. IF KEYS 12-17 AND/OR 6-11 CONTAIN A VALID OCTAL CORE STORAGE BLOCK NUMBER, THESE STATIONS ARE REINSERTED INTO FUTURE D.C.'S. ALL THREE OPERATIONS MAY BE DONE SIMULTANEOUSLY.

5) SS 5--THE UP POSITION IS THE NORMAL POSITION. IN THE DOWN POSITION IT IS USED IN CONJUNCTION WITH THE ENTRY KEYS. IF KEYS 24-29 AND/OR 30-35 CONTAIN A VALID OCTAL STATION NUMBER, THIS STATION IS PLACED IN A MODE ACCEPTABLE FOR TRANSMISSION. IF KEYS 6-11 AND/OR KEYS 12-17 CONTAIN A VALID

OCTAL STATION NUMBER, TRANSMISSION BY THIS STATION IS REJECTED.

6) SS 6--IN THE UP POSITION SIGNIFIES AMPEX AND PAPER TAPES TIME TAGS ARE GMT. IN THE DOWN POSITION SIGNIFIES AMPEX AND PAPER TAPES ARE IN DELTA T TIME (ELAPSED TIME).

C) SET THE COMPUTER TO THE 65K MODE AND THE CORE BLANK SWITCH TO A. IT IS NOT NECESSARY TO HAVE THREE JOB TAPES, BUT FOR A RUN THAT GOES BEYOND LAUNCH, AN A6 AND C6 ARE REQUIRED BECAUSE, WHEN THE NEXT PHASE IS REACHED, THE APPROPRIATE PROGRAM IS READ FROM C6.

D) CLEAR AND LOAD TAPE, THEREBY READING THE JOB TAPES INTO CORE. IF A JOB TAPE IS NOT READY WHEN THE OPERATION BEGINS, IT IS NOT LOADED. ONCE THE PROGRAM IS LOADED, IT SELECTS ALL THE OTHER TAPES REQUIRED AND REWINDS THEM. IF ONLY A LOAD AND DUMP IS DESIRED, MESSAGE TAPES ARE NOT NECESSARY BECAUSE A BLANK TAPE CAN BE USED TO SATISFY THE REWIND INSTRUCTION. AFTER THE RE-WIND IS COMPLETED, TRAP CONTROL AND COMMAND TRAPS ON CHANNELS A, B, AND C ARE ENABLED.

E) ENTER TIME IN THE ENTRY KEYS -

1) SIGN KEY - DOWN TO ENTER TIME, BUT OTHER KEYS MUST BE SET FIRST

2) KEYS 1-5 - ORBIT NUMBER FOR RESTART (MUST BE ZERO FOR LAUNCH RUN)

3) KEYS 6-17 - CURRENT TIME (GMT), IN HOURS AND MINUTES

4) KEYS 18-35 - RESTART TIME (HOURS, MINUTES, AND SECONDS). MUST BE ZERO FOR LAUNCH RUN

F) DEPRESS THE START PUSHBUTTON-STATION CHARACTER-

ISTICS TAPE A7 IS READ, AND THE GEMINI PROGRAM IS RUNNING.

G) ENTER TIME IN THE FOLLOWING MANNER -

1) GMT HOURS OCTALLY NOTED IN KEYS 6-11

2) GMT MINUTES OCTALLY NOTED IN KEYS 12-17 TIME IS RECOGNIZED WHEN THE SIGN KEY IS PLACED IN THE DOWN POSITION. ON THE FOLLOWING MINUTE TRAP FROM THE DCC, THE PROGRAM READS THE KEYS, PRINTS THE STARTING TIME ON-LINE, AND WAITS TO START CYCLING.

H) DEPRESS THE START PUSHBUTTON TO START CYCLING.

I) START THE AMPEX DRIVE AFTER THE STATION CHARACTERISTICS TAPE IS SUCCESSFULLY READ. WHEN THE LIFTOFF SIGNAL IS RECEIVED, WHICH IS INDICATED ON THE PCC, THE PLOTBOARD BEGINS TO PLOT, AND THE DISPLAYS ARE UPDATED EACH HALF-SECOND. PLOTBOARD 1 IS DISPLAYED DURING LAUNCH. ALL HIGH-AND-LOW-SPEED INPUT AND HIGH-SPEED OUTPUT IS LOGGED ON B6. IN ADDITION TO TELEMETRY DATA, THE PCC ALSO INDICATES THE SELECTED DATA SOURCE.

J) AT INSERTION-INTO-ORBIT TIME, THE C6 JOB TAPE IS SELECTED TO READ IN THE ORBIT PROGRAMS. AT THIS POINT, THE BERMUDA RADAR DATA TAPE MAY BE ENTERED VIA THE ASR. WITH IGNITION OF THE ORBIT PHASE INDICATOR, STOP THE AMPEX TAPE.

K) PLOTBOARD 5 (WORLD MAP) IS DISPLAYED DURING THE ORBIT PHASE, WITH THE DISPLAYS BEING UPDATED EVERY SIX SECONDS. UPON ENTERING THE ORBIT PHASE -

1) ENTER PAPER TAPE DATA AS APPROPRIATE.

2) MONITOR THE MACHINE INDICATORS VERY CLOSELY, REPORTING ANY INDICATION IMMEDIATELY.

3) REPLACE B6 WHEN LOGGING STARTS ON B7.

L) EACH TIME A NEW VECTOR IS GENERATED, IT IS WRITTEN ON B9 AND C9 WITH A TIME TAG. THIS ACTION ENABLES A RESTART SHOULD AN ERROR OCCUR. THIS CAPABILITY IS ESSENTIAL FOR MANNED MISSIONS.

ONCE THE PROGRAM HAS ENTERED THE ORBIT PHASE, THE SECOND TYPE OF REAL-TIME RUN, A RESTART IN ORBIT, CAN BE EXECUTED. THERE ARE TWO TYPES OF RESTART - 1) A RESTART FROM TAPE USING THE B9 AND C9 TAPES ALREADY GENERATED FROM ANOTHER RUN - 2) A BLANK RESTART. FOR THE FORMER, IF ONLY ONE RESTART TAPE IS AVAILABLE, PUT IT ON C9. PUT A BLANK ON B9 WITH AN EOF AT THE BEGINNING OF THE TAPE TO INDICATE ONLY ONE RESTART TAPE. ENTER TIME AS FOLLOWS -

A) RESTARTING ORBIT NUMBER - OCTUALLY NOTED IN KEYS 1-5

B) GMT HOURS - OCTALLY NOTED IN KEYS 6-11 (CURRENT TIME)

C) GMT MINUTES - OCTALLY NOTED IN KEYS 12-17 (CURRENT TIME)

D) GMT HOURS - OCTALLY NOTED IN KEYS 18-23 (RESTART TIME)

E) GMT MINUTES - OCTALLY NOTED IN KEYS 24-29 (RESTART TIME)

F) GMT SECONDS - OCTALLY NOTED IN KEYS 30-35 (RESTART TIME)

FOR A BLANK RESTART, TIME IS ENTERED IN THE SAME MANNER, EXCEPT THE RESTART TIME IS 1 SECOND, RATHER THAN SOME SPECIAL TIME. TAPES B9 AND C9 ARE PROVIDED WITH EOF'S AT THEIR BEGINNING. WHEN AN ATTEMPT IS MADE TO READ THEM, THE PRINTOUT ''NEITHER RESTART TAPE CAN BE READ.... INSERT PAPER TAPES'' OCCURS. PLACE SS 3 IN THE DOWN

POSITION, AND INSERT THE LIFTOFF TAPE TWICE FOLLOWED BY THE VECTOR TAPE, ALSO TWICE. OPERATION CONTINUES IDENTICALLY WITH A RESTART FROM TAPE.

6.5.3 DUMPING THE REAL-TIME SYSTEM

DUMPING THE REAL-TIME SYSTEM MUST BE CONSIDERED IN TWO WAYS - 1) DUAL COMPILATION DUMPING AND 2) MULTIPLE COMPILATION DUMPING. FOR THE FORMER, IF THE REAL-TIME PROGRAM IS RUNNING, PLACE SS6 AND KEY 2 IN THE DOWN POSITION. THIS CONFIGURATION IS SENSED BY THE PROGRAM, CAUSING CONTROL TO TRANSFER TO 77777 (OCT). THIS LOCATION, IN TURN, CAUSES A CONTROL TRANSFER TO THE DUMP PROGRAM MOENDS. SHOULD IT BE IMPOSSIBLE TO TRANSFER AUTOMATICALLY 77777(OCT), EFFECT IT MANUALLY. IF THIS LOCATION IS CLEARED, LOOK UP THE MOENDS LOCATION, AND MANUALLY TRANSFER TO THAT LOCATION.

UPON ENTERING MOENDS, AN EOF IS WRITTEN ON THE LOG TAPE. IT THEN IS REWOUND AND UNLOADED. FOLLOWING THIS ACTION, THE RESTART TAPES ARE GIVEN EOF'S. TAPE SCANNING IS THEN PERFORMED IN THE FOLLOWING ORDER -

A) B5 - BLANK (L.D.)
B) B4 - DUMP UTILITY TAPE
C) B2 - BLANK (L.D. CORES FOR JOB 1)
D) B0 - BLANK (L.D. CORES FOR JOB 2)
E) B1 - BLANK (L.D. DICTIONARY FOR JOB 1)
F) A1 - JOB TAPE (TO WRITE DICTIONARIES)
G) B3 - BLANK (L.D. DICTIONARY FOR JOB 2)

AT THE FIRST HPR, DIAL THE JOB TAPE OFF AND THE SOS TAPE ON A1. NOTE THE SOS TAPE USED TO BUILD THE JOB TAPES MUST NOW BE USED. DEPRESS THE START PUSHBUTTON, CAUSING AN EOF TO BE WRITTEN ON B2 FOLLOWED BY A REWIND OF B1 AND B2. OUTPUT IS ON A2. AT THE NEXT HPR, DEPRESS THE START

TO DUMP JOB 2 PUSHBUTTON. AN EOF IS WRITTEN ON B0 FOLLOWED BY A REWIND OF B0 AND B3. BECAUSE THERE IS NO END OF TAPE TEST FOR A2, WRITING PAST THAT POINT TERMINATES THE DUMP. THE FINAL STOP IS 173(OCT).

FOR MULTIPLE COMPILATION DUMPING, DUMP PROGRAM ENTRY IS IDENTICAL WITH DUAL COMPILATION DUMPING. TAPE SELECTION IS AS FOLLOWS -

A) B5 - BLANK (L.D.)
B) B4 - DUMP UTILITY TAPE
C) B2 - BLANK (L.D. CORES FOR ALL JOBS)
D) A1 - JOB TAPE
E) B1 - BLANK (L.D. DICTIONARY FOR ALL JOBS)

WHEN THE FIRST HPR IS REACHED, DIAL THE SOS ON A1 AND THE JOB TAPE TO A0 (DO NOT REWIND). THE NEXT STOP IS THE FINAL SOS STOP, 173(OCT).

6.5.4 LOGGING PROGRAMS

UPON COMPLETION OF AN OPERATIONAL RUN, EITHER SIMULATED OR UNSIMULATED, THE LOG TAPE(S) PRODUCED ARE INTERPRETED BY THE ROUTINES HSIN7, MXHSPR, AND MXPRLG.

OPERATOR'S PROCEDURES FOR THESE ROUTINES ARE -

A) HSIN7 (DECODE HIGH-SPEED INPUT
  1) PREPARE AND READY THE FOLLOWING TAPES -
    (A) A3-BLANK-BCD OUTPUT TAPE
    (B) A4-IF BINARY OUTPUT REQUIRED (SS1 DOWN)
    (C) B6-LOG TAPE
    (D) C1-UTILITY TAPE
  2) PLACE C1 CALL CARD IN CARD READER
  3) CLEAR AND LOAD CARDS
  4) AT PROGRAM STOP, SET ADDRESS OF KEYS AS FOLLOWS -
    (A) ENTRY KEY 35-B-GE DATA SELECTED

(B) ENTRY KEY 34-IP DATA SELECTED
(C) ENTRY 33-BERMUDA RADAR DATA IN RADIANS
(D) ENTRY KEY 33-BERMUDA RADAR DATA IN DEGREES
(E) ENTRY KEY 31-END JOB

5) DEPRESS START KEY
6) AT END OF JOB WRITE END OF FILE ON TAPE A3, REWIND AND HAVE PRINTED

B) MXHSPR (DECODE HIGH-SPEED OUTPUT)

1) PREPARE AND READY THE FOLLOWING TAPES -
(A) A5-OUTPUT TAPE
(B) B6-LOG TAPE
(C) B7-BLANK (SAME AS C6)
(D) C6-INTERMEDIATE TAPE (HIGH DENSITY IF POSSIBLE)
(E) C7-UTILITY TAPE

2) PLACE C1 CALL CARD IN CARD READER
3) DEPRESS CLEAR AND LOAD CARD BUTTON. THE JOB FINISHES WITH THE ON-LINE PRINTING OF THE FOLLOWING MESSAGES -
JOB COMPLETE-PRESS START FOR COMPLETION.
4) DEPRESSING THE START BUTTON AT THIS POINT WRITES 4 END OF FILES ON TAPE A5 AND REWINDS AND UNLOADS ALL TAPES USED. IF MORE THAN ONE LOG TAPE IS TO BE PROCESSED THEIR OUTPUTS CAN BE BATCHED BY CLEARING THE MACHINE AFTER THE END OF JOB MESSAGE IS PRINTED, WRITING END OF FILE ON TAPE A5, AND RELOADING THE PROGRAM WITH THE LOG TAPE ON B6.

C) MXPRLG (DECODE LOW-SPEED OUTPUT)

1) PREPARE AND READY THE FOLLOWING TAPES -

(A) B6-B6 LOG TAPE AS INPUT

(B) A2-BLANK

(C) C1-UTILITY TAPE

2) PLACE C1 CALL CARD IN CARD READER

3) DEPRESS CLEAR AND LOAD CARDS

4) WHEN THE PROGRAM STOPS, SET THE KEYS CORRESPONDING TO THE SUBCHANNELS DESIRED, I.E., KEYS 14 THROUGH 31 FOR CHANNELS 14 THROUGH 31. SENSE LIGHTS INDICATE THE NUMBER OF CHANNELS TO BE PROCESSED.

5) DEPRESS THE START KEY

6) FINAL HALT -

(A) HALT 10536. WRITE END OF FILE ON TAPE A2

(B) PRINT PROGRAM CONTROL

(C) PROGRAM DOES NOT REWIND TAPE A2

6.5.5 INSERTING PAPER TAPE MESSAGES

PAPER TAPE MESSAGES ARE INSERTED IN THE FOLLOWING MANNER -

A) SET THE TOP SWITCH OF THE TAPE READER TO THE FREE POSITION.

B) DEPRESS THE RED BUTTON.

C) RAISE THE CLAMP AND INSERT THE PAPER TAPE.

D) PLACE THE CLAMP ON THE PAPER TAPE.

E) SET THE K-K · T-TSWITCH TO THE T POSITION.

F) SET THE TEST-LINE SWITCH TO THE LINE POSITION.

G) SET THE SWITCH ON TOP OF THE TAPE READER TO THE RUN POSITION.

H) IF THE PAPER TAPE DOES NOT MOVE, DEPRESS THE KEYBOARD SEND KEY.

I) AFTER THE TAPE IS READ AND THE READER STEPS,

SET THE TOP SWITCH TO THE FREE POSITION.

J) DEPRESS THE RELEASE PUSHBUTTON AND REMOVE THE TAPE.

6.5.6 PUNCHING PAPER TAPES

PAPER TAPES ARE PUNCHED IN THE FOLLOWING MANNER.

A) PLACE THE TEST-LINE SWITCH IN THE TEST POSITION.

B) SET THE K-K·T-T SWITCH TO THE T POSITION.

C) USING THE SPACE BAR, SPACE A FEW INCHES OF BLANK TAPE.

D) DEPRESS THE FIGS KEY.

E) WITH THE FIGS KEY DEPRESSED, DEPRESS THE REPT KEY FOR AT LEAST SIX FIGURE SHIFTS.

F) DEPRESS THE SLASH KEY.

G) TYPE THE RETROFIRE MESSAGE CODE - 080808.

H) TYPE A SLASH (/).

I) TYPE, THREE TIMES, THE NUMBER OF RETROS FIRED.

J) TYPE A SLASH (/).

K) TYPE, THREE TIMES, THE RETROFIRE TIME, WITH EACH TIME SEPARATED BY A SLASH.

L) DEPRESS THE CTRS KEY.

M) WITH THE LTRS KEY DEPRESSED, DEPRESS THE REPT KEY AT LEAST 14 TIMES.

N) FEED PAPER TAPE (TAPE PRINTS CAN BE CHECKED).

O) SET THE TEST-LINE SWITCH TO THE LINE POSITION.

P) SET SS 3 TO THE DOWN POSITION AND FEED THIS MESSAGE INTO THE COMPUTER TWICE.

Q) IF ACCEPTED, REPEAT THE MESSAGE FEED ONCE.

R) PLACE SS 3 IN THE UP POSITION.

6.6 OTHER EQUIPMENT

IN ADDITION TO THE IBM 7094'S AND DDC'S, GODDARD OPERATORS MUST BE FAMILIAR WITH THE OPERATION OF OTHER EQUIPMENT. PROCEDURES ASSOCIATED WITH SOME OF THESE EQUIPMENTS ARE GIVEN IN THE FOLLOWING PARAGRAPHS.

6.6.1 AMPEX RECORDER (ODR)

THE AMPEX RECORDER IS SIMILAR IN OPERATION TO A TAPE RECORDER. IT RECORDS LAUNCH DATA FROM THE CAPE (B-GE AND/OR IP) AND FROM BERMUDA ON 7 CHANNEL TAPE WHICH CAN BE PLAYED BACK LATER TO SIMULATE LAUNCH. THIS RECORDER IS OPERATED IN THE FOLLOWING MANNER -

A) DEPRESS THE POWER PUSHBUTTON.
B) DEPRESS THE LOW SPEED PUSHBUTTON.
C) DEPRESS THE FAST FORWARD PUSHBUTTON TO SPACE THE TAPE TO THE DESIRED RECORD.
D) DEPRESS THE DRIVE PUSHBUTTON TO START THE TAPE.
E) DEPRESS THE STOP PUSHBUTTON WHEN FINISHED.

6.6.2 BERMUDA BUFFER

THE BERMUDA BUFFER DECODES BERMUDA RADAR MESSAGES AND PRESENTS THEM TO THE DCC ON SUBCHANNELS FIVE AND SIX. THE BUFFER IS USED ONLY WHEN THE AMPEX RECORDER IN USE HAS BERMUDA DATA. OPERATION OF THE BERMUDA BUFFER IS AS FOLLOWS -

A) DEPRESS THE POWER PUSHBUTTON.
B) DEPRESS THE PLAYBACK CONFIRM PUSHBUTTON.

6.6.3 OPERATIONS CONTROL CONSOLE (OCC)

THE OPERATIONS CONTROL CONSOLE IS PROVIDED TO FACILITATE COMPUTER OUTPUT SWITCHING, RESIDUAL PLOTTER SWITCHING, PROGRAM STATUS INDICATIONS, LOCAL PLOTBOARD

SWITCHING, VOICE COMMUNICATIONS, INTERNAL TEST FACILITIES, AND CADFISS SELECTION. CONTROLS AND INDICATORS ARE AS FOLLOWS -

A) MODE SELECT MISSION - USED DURING A LINE MISSION TO CONTROL OUTPUT DATA SWITCHING OF DCC SUBCHANNELS 3, 10, 11, AND 12. POSITIONS ON THIS SWITCH ARE ACTIVE STATUS, STANDBY STATUS, AVAILABLE STATUS, AND NOT READY STATUS. ALL POSITIONS APPLY TO THE SELECTED COMPUTER.

B) MODE SELECT NON-MISSION - USED DURING SIMULATION AND CADFISS MISSION TO CONTROL OUTPUT DATA SWITCHING OF DCC SUBCHANNEL 3 AND SUBCHANNELS 10, 11, AND 12 FOR EACH COMPUTING COMPLEX. POSITIONS ON THIS SWITCH AND THEIR APPLICATION ARE IDENTICAL WITH THE MISSION MODE COUNTERPARTS.

C) COMPUTER TO STRIP CHART RECORDER - ENABLES SELECTION OF ANY ONE OF THESE COMPUTERS FOR EACH PLOTTER.

D) COMPUTER TO PLOTBOARD - ENABLES SELECTION OF ANY ONE OF THESE COMPUTERS FOR EACH PLOTBOARD.

E) TRANSMITTER ACTIVE AB - ENABLES ACTION - STANDBY SWITCHING OF THE DATA TRANSMITTER IN THE MISSION MODE ONLY. A SELECT SIGNAL ALLOWS ONE SWITCH OF THE TRANSMITTER POSITION. CONFIRMATION RESETS THIS SWITCH.

F) PROGRAM STATUS INDICATORS - THREE SETS OF 40 INDICATORS ARE PROVIDED, ONE SET FOR EACH COMPUTER. EACH SET IS CONTROLLED BY THE DCC SUBCHANNEL 31 OUTPUT. INDICATOR DEFINITIONS ARE -

COMPUTER WORD	INDICATORS CORRESPOND TO MACHINE WORD BITS 28-35	LOWER CORE LOCATIONS
1	1-8	07040
2	9-16	07041
3	17-24	07042
4	25-32	07043
5	33-40	07044

G) ALARMS - AN AUDIBLE ALARM IS PROVIDED WHICH WORKS IN CONJUNCTION WITH AN AUDIBLE RESET PUSHBUTTON INDICATOR. ACTIVATION OF ANY OF THE PROGRAM STATUS INDICATORS TRIGGERS THE ALARM AND LIGHTS THE RESET PUSHBUTTON INDICATOR. THE ALARM STOPS AND THE INDICATOR TURNS OFF UPON DEPRESSING THE ALARM RESET PUSHBUTTON.

H) SELECT STANDBY COMPUTER CADFISS ENABLES ABC - A TWO-POSITION SWITCH ALLOWING (1) A CADFISS TTY OUTPUT SELECTION AND (2) A RETURN TO NORMAL OF THE TTY OUTPUTS.

6.6.4 PROGRAM CONTROL CONSOLE (PCC)

THE PCC FACILITATES INSERTION AND DELETION OF TELEMETRY EVENTS AND CORE STORAGE BLOCKS CONTAINING RADAR DATA. DC'S MAY BE FORCED BY THE PCC. PCC OPERATION IS AS FOLLOWS -

A) ENABLES PCC FROM OCC.

B) DEPRESS MANUAL MODE PUSHBUTTON.

C) SET DESIRED KEYS.

D) DEPRESS INTERRUPT PUSHBUTTON.

6.6.5 TAPE RECORDER, MODEL 1585

OPERATION OF THE MODEL 1585 TAPE RECORDER IS AS FOLLOWS -

A) PLACE THE DESIRED TAPE ON THE LOWER HUB AND LOCK THE REEL ON BY TURNING THE WINGS COUNTERCLOCKWISE.

B) THREAD TAPE AS SHOWN BY THE DIAGRAM ON THE RECORD.

C) PUSHBUTTON OPERATION -

(1) POWER ON PUSHBUTTON - DEPRESS POWER ON PUSHBUTTON TO APPLY POWER TO THE RECORDER (A LIGHT TURNS ON TO INDICATE EITHER HIGH SPEED OR LOW SPEED). DEPRESSING THE POWER ON PUSHBUTTON AGAIN SHUTS OFF POWER AND EXTINGUISHES ALL LIGHTS.

2) LOW SPEED PUSHBUTTON - IF HIGH-SPEED LIGHT IS ON, THE HIGH-SPEED LIGHT GOES OUT AND THE LOW-SPEED LIGHT COMES ON WHEN THIS PUSHBUTTON IS DEPRESSED. THE RECORDER IS THEN IN LOW SPEED.

(3) REWIND PUSHBUTTON - DEPRESS THE REWIND PUSHBUTTON, AND TAPE MOVES FROM THE UPPER REEL TO THE LOWER REEL AT HIGH SPEED. WHEN THE DESIRED SECTION OF THE TAPE HAS BEEN REACHED, DEPRESS THE STOP PUSHBUTTON.

(4) FAST FORWARD PUSHBUTTON - DEPRESS THE FAST FORWARD PUSHBUTTON, AND TAPE MOVES FROM THE UPPER REEL TO THE LOWER REEL AT HIGH SPEED. WHEN THE DESIRED SECTION OF THE TAPE HAS BEEN REACHED, DEPRESS THE STOP PUSHBUTTON.

(5) DRIVE PUSHBUTTON - DEPRESS THE DRIVE PUSH-BUTTON, AND TAPE MOVES FROM THE LOWER REEL TO THE UPPER REEL AT LOW SPEED. THIS CONDITION IS USED FOR PLAY BACK OF RECORDED TAPES. WHEN PLAYBACK IS COMPLETED, DEPRESS THE STOP PUSHBUTTON.

(6) RECORD PUSHBUTTON - DEPRESSING THE RECORD PUSHBUTTON STARTS THE RECORDING PROCESS.

D) SELECT THE DESIRED RECORD ON THE TAPE. THIS MAY BE DONE BY THE USE OF THE FAST FORWARD, REWIND, OR DRIVE PUSHBUTTONS TO MOVE THE TAPE TO THE DESIRED RECORD.

E) ON THE RECEIVER, MAKE SURE THAT THE OPERATE TEST SWITCHES ON BOTH THE IP AND B-GE RECEIVERS ARE IN THE OPERATE POSITION.

F) ON THE TRANSMITTER,SET THE TEST-CONTROL-MONITOR-SELECT SWITCH TO THE OPERATE POSITION.

G) ON THE TRANSMITTER, SET THE RECORDER CONTROL INPUT SELECT SWITCH TO THE DESIRED POSITION.

(1) RECORDER OPERATION SWITCH SHOULD ALWAYS BE LEFT IN THE OPERATE POSITION UNLESS PLAYBACK IS REQUIRED.

(2) IP-OUTPUT OF THE TAPE RECORDER 1 IS SENT TO THE INPUT OF THE IP RECEIVER AND IS PROCESSED BY THAT RECEIVER.

(3) B-GE-OUTPUT OF THE TAPE RECORDER IS SENT TO THE INPUT OF THE B-GE RECEIVER AND IS PROCESSED BY THAT RECEIVER.

(4) IP-B-GE-OUTPUT OF THE TAPE RECORDER 1 IS SENT TO THE INPUTS OF BOTH THE IP AND B-GE RECEIVER AND IS PROCESSED BY BOTH RECEIVERS.

FOR THE OUTPUT TAPE RECORDER, THE PROCEDURE IS IDENTICAL WITH STEPS A) THROUGH D) ABOVE. IN ADDITION, SET THE OPERATE TEST SWITCH ON THE RECEIVER TO THE OPERATIVE POSITION FOR BOTH IP AND B-GE DATA, AND SET THE OUTPUT SELECT SWITCH ON THE TRANSMITTER TO PLAYBACK.

6.6.6 AMERICAN TELEPHONE AND TELEGRAPH COMPANY, AUTOMATIC SEND/RECEIVE UNIT

OPERATION OF AMERICAN TELEPHONE AND TELEGRAPH COMPANY, AUTOMATIC SEND/RECEIVE UNIT IS AS FOLLOWS -

A) SET LINE/TEST SWITCH TO LINE POSITION.
B) SET K-KT-T SWITCH TO KT.
C) SET SWITCH ON TAPE FEED UNIT TO FREE.
D) PUSH BUTTON ON TOP OF FEED UNIT TO RAISE CLAMP.
E) PLACE 5-HOLE PUNCHED TAPE ON FEED UNIT MAKING SURE THAT SPROCKET ENGAGES FEED HOLES AND THAT TWO OF THE 5 CHANNELS LIE TO REAR OF SPROCKET AND 3 TOWARD FRONT.
F) CLAMP TAPE IN POSITION.
G) SET SWITCH ON TAPE FEED UNIT TO RUN. (THE INPUT MESSAGE AT THIS POINT ENTERS THE SYSTEM).
H) PRESS SEND KEY.
I) TO STOP OPERATION, SET SWITCH ON FEED UNIT TO STOP.
J) TO REMOVE TAPE, PUSH BUTTON ON TOP OF FEED UNIT TO RAISE CLAMP.

6.7 GODDARD COUNTDOWN PROCEDURES

TABLE 6-1 CONTAINS THE GT-3 COUNTDOWN PROCEDURE. THE COUNTDOWN IS LIMITED TO SPECIFICALLY DESIGNATED ACTIVITIES WHICH MUST OCCUR IN A PRESCRIBED ORDER BOTH ONE DAY BEFORE LAUNCH AND ON THE DAY OF LAUNCH. THE GODDARD REFERENCES IN THE COUNTDOWN PERTAIN TO PERSONNEL IN THE COMPUTER ROOM ONLY. THE PRESENTATIONS ARE MADE IN TERMS OF TIME (T-0 IS THE TIME OF LAUNCH IN MINUTES, AND IS THE STANDARD UPON WHICH ALL OTHER TIME REFERENCES ARE BASED), AND THE PERSON RESPONSIBLE FOR EXECUTING THE ACTION.

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 1 OF 19)

T-TIME (MIN) BE- GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						THE FOLLOWING TESTS WILL BE RUN ON THE DAY BEFORE LAUNCH.	
			CNV GSC			TRAJECTORY RUNS LIVE FROM IP AND B/GE FOR FIDO. THESE WILL BE CONDUCTED AS SPECI- FIED BY THE FLIGHT DYNAMICS OFFICER.	
						TEST =1 BURROUGHS DATA VIA GSFC 1. CAPCOM. - GIVE 20 SEC. COUNT WITH LIFTOFF ON HIS MARK. 2. FIDO - GIVE 5 SEC. COUNT, SWITCH TO B COMPUTER AT T EQUALS ONE MIN. GIVE 5 SEC COUNT, RETURN TO COMPUTER A AT T EQUALS TWO MIN.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 2 OF 19)

T-TIME (MIN) BE- GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						3. CAPCOM. - AT T EQUAL 2 MIN. 36 SEC. USE OVERRIDE TO GIVE TOWER ROCKETS FIRED AND TOWER SEPA- RATION.	
						4. FIDO - GIVE 5 SEC COUNT AND SWITCH TO COM- PUTER B AT T EQUAL ONE MIN. GIVE 5 SEC COUNT-RETURN TO COMPUTER A AT T EQUAL 4 MIN.	
						5. CAPCOM. AT T EQUAL 4 MIN. 57 SEC USE OVERRIDE TO GIVE CAP. SEP.	
						TEST =2. - BURROUGHS DATA DIRECT.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 3 OF 19)

T-TIME (MIN) BE- GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						1. CAPCOM. - GIVE T/M EVENTS AS IN TEST =1. TEST =3. - IP/7094 DATA. 1. SAME AS TEST=1 UP TO TIME OF C. O. 2. CAPCOM. - AT T EQUAL 4 MIN. 56 SEC. USE OVERRIDE TO GIVE SECO-IF NOT AVAILABLE USE ABORT OVER-RIDE. AT T EQUAL 4 MIN. 57 SEC. USE OVERRIDE TO GIVE CAP. SEP. TEST =4. - BURROUGHS AND IP/7094 DATA. 1. DATA SELECT SELECT IP/7094	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 4 OF 19)

T-TIME (MIN) BE- GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						2. CAPCOM. -SAME TEST =1.	
						3. FIDO-REQUEST SWITCH TO GE VIA GSFC AT APPROXIMATELY T EQUAL 40 SEC.	
						TEST =5. IP/7094 DATA.	
						1. FIDO - TEST RUN WITH COMPUTER A.	
						2. CAPCOM - GIVE LIFTOFF AFTER 20 SEC. COUNT. TOWER ROCKETS FIRED AND TOWER SEP. AT NORMAL TIME. AT T EQUAL 3 MIN. GIVE ABORT OVERRIDE TO EVENT. GIVE DECO OVERRIDE	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 5 OF 19)

T-TIME (MIN) BE- GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						AND CAP. SEP. AT NORMAL TIME. TEST =6. - BURROUGHS DATA VIA GSFC. 1. SAME AS TEST = 5 EXCEPT THAT SECO OVERRIDE GIVEN AT T EQUAL 3 MIN. INSTEAD OF ABORT OVERRIDE. TEST =7. -IP/7094 DATA. 1. FIDO - RUN WITH COMPUTER A. 2. CAPCOM - GIVE LIFTOFF AFTER 20 SEC. COUNT AT T EQUAL 2 MIN. 36 SEC. GIVE TOWER SEP. TO NO EVENT. AT T EQUAL 4 MIN) 57 SEC. GIVE	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 6 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						THE FOLLOWING OVERRIDES - A. SECO TO EVENT B. TOWER ROCKETS FIRED TO EVENT. C. CAP. SEP. TO EVENT	
						TEST =8 BURROUGHS DATA VIA GSFC. 1. FICO-RUN WITH COMPUTER B. 2. BURROUGHS-AT T EQUAL 4 MIN. 46 SEC. STOP TRANSMISSION OF ALL DATA TO GSFC. 3. CAPCOM - AT T EQUAL 4 MIN. 57 SEC. GIVE CAP. SEP. OVERRIDE TO EVENT.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 7 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
475	365	110					
			GSC			CUSTOMER ENGINEERS PERFORM THE FOLLOW-ING TESTS ON BOTH COMPUTERS AND ASSO-CIATED EQUIPMENT. 1.9S51 H+ L 7094 CORE MEMORY 2.9M51 7094 MAIN FRAME 3.9T51 7094 MAGNETIC TAPE 4.DCC CE TEST CLOCKS (.5 SEC + ONE MIN.) 5.GSFC LOOP TEST - USE CANARY PERFO-RATOR OUTPUT TAPE ON ASR 140, 141 TO	GSC PRE-FLT DIRECTOR

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 8 OF 19)

T-TIME (MIN) BEGIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						CHECK DCC SUB CHAN 29, 30	
						6.TEST 7 BYPASS LOOP ALL TTY CHANS. CHECK THAT NO CHANS. ARE OMITTED.	
						7.OPERATIONAL PROGRAM CYCLE THRU 3 WWV ONE MINUTE TRAPS.	
475							
			GSC			TEST TAPE-TO-CARD EQUIPMENT AND PATCH SYSTEMATIC TO WHS.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 9 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
395	335	60					
			MCC			RCA ENGINEERS PER-FORM IN HOUSE CHECK OF ALL LMSS EQUIPMENT AT CNV.	
370	340	30					
			CNV	AMR MCC IP	IPD FP-6	RADARS 1.16, 3.16 AND 5.16 TRANSMITTER TRANSMIT STATIC PAT-TERNS TO MCC RADAR RECEIVER AND IP 7094 BUFFER FOR SIGNAL ALIGNMENT. ADJUST ISOLATION AMPLIFIERS AT IP7090 COMPLEX.	AMR/ IP BUFFER R-TTY
365							
			GSC			PATCH FP6 ACROSS GD1431.	
365	350	15	GSC			KINGSTON ENGINEERS PERFORM IN HOUSE CHECK OF ALL MCC EQUIPMENT AT GSC + VOICE CHECK FP3, FP6/1431 + CALIBRATE AND LOAD PLOTBOARDS.	GSC PRE-FLT DIRECTOR

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 10 OF 19)

T-TIME (MIN) BEGIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
360							
			BDA			IBM SITE MANAGER REPORT STATUS OF ALL TRACKING AND COMPUTER EQUIPMENT TO GSC COMPUTER PER-FLIGHT DIRECTOR VIA SCAMMA.	
350	320	30					
			GSC			BDA HIGH-SPEED INTERFACE. BDA RADAR BUFFER PATTERNS	GSC
			BDA			BDA 4008T PATTERNS TO GSC BDA RADAR STATIC PATTERN TO GSC (IF IT IS AVAILABLE). 1. STANDARD TIME 2. FPS-16 TIME 3. VERLORT TIME	PRE-FLT DIRECTOR
335	245	90					
			GSC			HIGH SPEED INTERFACE CHECKS BETWEEN GSC AND CNV	GSC PRE-FLT DIRECTOR

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 11 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
			CNV	IP		A. IP7094 BFR PATTERNS TO GSC-DUPLEX	
				B-GE		B. B/GE BUFFER PATTERNS TO GSC DUPLEX.	
				MCC		C. CAPCOM CHECK TO GSC - DUPLEX.	
						D. GSC HIGH SPEED TRANSMITTER PATTERNS TO MCC.-GSC TO USE KINGSTON HIGH SPEED.	
						DIAGNOSTIC PROGRAM ON ITEMS A THRU C.	
335	215	120					
			GSC BDA			TTY INPUT-OUTPUT CHECKS.	BDA GSC PRE-FLT DIRECTOR COMP. OP.
275	245	30					
			CNV	MCC		CALIBRATE PLOTBOARDS AND LOAD CADFISS PLOT BOARD CHARTS.	PLOT
270	245	25					
						TEST PATCHES EQUIPMENT	GSC PRE-FLT

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 12 OF 19)

T-TIME (MIN) BEGIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
245	235	10					
			GSC			LOAD AND CYCLE CADFISS ROLL CALL PROGRAM FOR SHIPS	CADFISS TEST CONDUCTOR
245	225	20					
			CNV	MCC IP B-GE	FP=3 FP=6	PERFORM FINAL PREPARATIONS FOR ROLL CALL TEST AS FOLLOWS A. SET EQUIPMENT TO OPERATE CONDITION AND UNSEAT DIGITAL JUNCTION PLUGBOARD B. RELOAD PLOTBOARDS AND PLACE IN OPERATE POSITION. C. SET MES, CAPCOM, RETRO, AND DQM SWITCHES FOR ROLL CALL TEST=26. D. SELECT HIGH SPEED DATA LINES AT 408	SUPPORT/DATA SEL

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 13 OF 19)

T-TIME (MIN) BEGIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						BIT RECEIVING REGISTERS AND SELECT DESIRED REGISTER FOR INITIAL DATA.	
245	215	30					
			GSC			PATCH FOLLOWING TTY EQUIPMENT AS SPECIFIED. A. ROTR 15 TO CIRCUIT 7005-20. B. ROTR 17 TO CIRCUIT USAF-02. C. ROTR 16 TO CIRCUIT 7005-10. D. RO 147 TO CIRCUIT 7005-17. E. RO 146 TO CIRCUIT 7005-17. F. AST 140 TO CIRCUIT 7005-11. G. AST 141 TO CIRCUIT 7005-02. (NOTE ABOVE PATCHES SUBJECT TO CHANGE	COMM. CO-ORD.

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 14 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						PRIOR TO F. MINUS 12 DAY).	
235	225						
						CADFISS TEST FOR SHIPS.	
235	215	20					
			ALL			FINAL PREPARATIONS FOR ROLL CALL TEST WITH ALL SITES.	CADFISS TEST CON-DUCTORS
230	215	15					
			BDA			PREPARE FOR CADFISS SHORT ROLL CALL HIGH AND LOW SPEED	COMP. OP.
225							
			CNV	AMR		RADAR 1.16, 3.16 AND 5.16 M/O AND LOCKED ON BORESIGHT TOWERS.	AMR
				IP		IP COMPUTER READY FOR ROLL CALL AT T-215	IP
				B-GE		B-GE COMPUTER READY FOR ROLL CALL AT T-215	B-GE

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 15 OF 19)

T-TIME (MIN) BEGIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
225							
			CNV			FP=3 STATUS REPORTS TO FIDO. FDIR	AREA SUP-ERSIVORS/
			GSC			FP=3 GSC STATUS RE-PORT TO FIDO FOR RE-LAY TO NSM.	PRE-FLT DIRECTOR
220							
			CNV	MCC	FDIR	CNV AND GSC STATUS REPORTS TO NSM.	FIDO.
216							
			GSC		FP=3	COMMENCE 60 SECOND COUNT FOR START OF CADFISS ROLL CALL TEST WITH ALL SITES.	CADFISS TEST CON-DUCTOR
			CNV	MCC		PLACE DIGITAL JUNC-TION PLUGBOARD IN SEATED POSITION.	DATA SEL.
215							
			ALL			BST 101, 107, 108 COMPLETE. REPORT TO NSM ALL PROBLEMS AF-FECTING CADFISS SHORT ROLL CALL.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 16 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
215			CNV	MCC		BRF MESSAGE ON NET-WORK COUNT. INCLUDES ESTIMATE OF CADFISS R. C. START TIME.	
215			BDA			PARTICIPATE IN CADFISS SHORT ROLL CALL. HIGH AND LOW SPEED	BDA GCC/ VERLORT/ FPS16/ DATA/ COMP. OP.
215	150	55	ALL			CADFISS ROLL CALL TEST WITH ALL SITES. INCLUDING HIS. TAN. RUNS IF TIME ALLOWS. DUPLEX COMPUTERS. DATA LIVE FROM IP AND B/GE NOTE. BRF MES-SAGE REQUESTING CADFISS RE-RUNS READS, CADFISS ROLL CALL FAILED UR SITE ON TEST -- AND TEST -- REQUEST YOU CHECK AND	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 17 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
						PREPARE FOR RE-RUN AT -----Z.	
210							
			GSC			START REAL TIME CADFISS REPORTS TO NSM.	
210	150	60					
			GSC		FP=6	GSC REPORTS TEST PROGRESS REPORT TO NSM AT MCC.	CADFISS TEST CON-DUCTOR.
160			ALL			RELEASE SITE STATUS MSG TO MCC/GSC.	
150	145	5					
			GSC			LOAD DUPLEX COMPU-TERS FOR TRAJECTORY RUN FROM B-GE AND IP COMPUTER LIVE AND HIGH SPEED BDA, LOW SPEED BDA, LOW SPEED CYI.	COMP. OP.
145							
			MCC			BRF MESSAGE ON NET-WORK COUNT. INCLUDES RELEASE OF TTY NET-WORK FROM CADFISS RESTRICTION.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 18 OF 19)

T-TIME (MIN) BE-GIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
145	115	30					
			GSC CNV BDA CYI	 IP B-GE		LIVE TRAJECTORY CONFIDENCE CHECK DUPLEX	SYSTEMS TEST CONDUCTOR
115							
			GSC			TTY CIRCUIT CHECK. PREPARATION FOR DATA FLOW TEST AT T-95 MIN.	
115	95	20					
			GSC			DATA FLOW PREPARATIONS.	
115	65	50					
			GSC BDA			KE OPTIONAL TIME.	
95	65	30					
			GSC			PERFORM RADAR DATA FLOW TEST, CUES 41 + 42 AND ALL RADAR SITES EXCEPT CNV.	NSM/CAD-FISS TEST DIRECTOR
65							
			CNV	MCC		BRF MESSAGE TO RELEASE NETWORK FROM COMPLETED DATA FLOW TEST.	

TABLE 6-1. GODDARD COUNTDOWN PROCEDURE
(SHEET 19 OF 19)

T-TIME (MIN) BEGIN	END	INT	LOCATION SITE CODE	AREA	COMM LOOP	ACTION	POSITION RESPONSE
65	55	10					
			GSC			LOAD AND RUN B/GE DATA LINK TEST	
55	50						
						LOAD OPERATIONAL PROGRAM DUPLEX	COMP. OP.
50	20	30					
			GSC			TRAJECTORY RUN FROM GSC ODR, OR LIVE CONFIDENCE RE-RUN OF T-145 TRAJECTORY.	
20							
			GSC			LOAD OPERATIONAL PROGRAM DUPLEX.	
15							
			GSC	CMPR		OPERATIONAL PROGRAM IS LOADED INTO COMPUTER A AND B IS CYCLING AT T-15 MIN.	NASA REP COMP. OP.
12							
			BDA			CHECK RADAR DIALS FOR BORESITE COORD.	
00							
			GSC	CMPR		MISSION COMPUTATIONS. POST FLIGHT ANALYSIS. SUPPORT TERMINATED.	COMP. OP

PRECEDING PAGE BLANK NOT FILMED.

VOL I INTRODUCTION

7. GEMINI REAL TIME PROGRAMMING SYSTEM

7.1 GENERAL

PROJECT GEMINI PROGRAMMING IS THE CONTINUOUS DEVELOPMENT OF AN EFFICIENT AND RELIABLE COMPUTATIONAL SYSTEM CAPABLE OF PERFORMING REAL-TIME TRACKING AND PROCESSING FUNCTIONS NECESSARY TO SUPPORT MANNED ORBITAL SPACE FLIGHTS. THE PROGRAMMING SYSTEM MUST ALLOW CONSTANT MONITORING OF THE SPACECRAFT'S FLIGHT WHILE PROVIDING THE MISSION CONTROL CENTER AT CAPE KENNEDY WITH PROCESSED DATA ESSENTIAL FOR COMPLETE MISSION SURVEILLANCE AND CONTROL.

7.1.1 CONCEPT OF REAL-TIME CONTROL

REAL-TIME CONTROL IS A PROGRAMMING FUNCTION THAT PERMITS THE INTERRUPTION OF INTERNAL COMPUTER OPERATIONS TO PROCESS DATA WHICH MUST BE ACCEPTED IMMEDIATELY AND, AFTER PROCESSING IS COMPLETED, RETURN CONTROL TO THE MAIN PROGRAM AT THE INTERRUPTED POINT.

THE CONCEPT OF REAL-TIME CONTROL AS IT APPLIES TO PROJECT GEMINI INVOLVES THE REAL-TIME GATHERING OF DATA, THE PROCESSING OF THIS INFORMATION, AND THE TRANSMITTING AND DISPLAYING OF THE COMPUTED QUANTITIES. THIS APPLICATION OF THE CONCEPT REPRESENTS A TRULY SOPHISTICATED SYSTEM BECAUSE THE WORLDWIDE FLOW OF INFORMATION (FROM DATA SOURCES, THROUGH THE COMPUTER, TO THE DISPLAYS) TAKES PLACE WITHOUT HUMAN INTERVENTION.

REAL-TIME POSITION/TIME/VELOCITY INPUT DATA IS USED IN COMPUTATIONS WHICH PREPARE A VARIETY OF OUTPUT QUANTITIES FOR DISPLAY ON STRIP CHARTS, PLOTBOARDS, WALL MAPS, AND OTHER RECORDING DEVICES. AN EXTENSIVE RADAR TRACKING

SYSTEM MAINTAINS COVERAGE OF THE SPACECRAFT'S TRAJECTORY, THUS OFFERING RELIABLE AND EXACT DATA TO BE PROCESSED AS INFORMATION FOR CONTROL FUNCTIONS. COMPLEX CALCULATIONS POINT SPACECRAFT POSITION AT ALL TIMES, ALLOWING COMMANDS TO BE SENT TO THE SPACECRAFT AT PRECISE POINTS IN ITS ORBIT. EXACT CONTROL CAN BE ACCOMPLISHED ONLY WITH A WORLDWIDE NETWORK OF TRACKING SITES, COMPUTERS, AND COMMAND AND COMMUNICATIONS CENTERS CONNECTED IN A REAL-TIME INFORMATION SYSTEM.

7.1.2 COMPUTER PROGRAMS

DATA PROCESSING IN PROJECT GEMINI IS THE APPLICATION OF ADVANCED COMPUTER PROGRAMMING TECHNIQUES TO SOLVE PROBLEMS INVOLVED IN CONTINUOUSLY MONITORING THE ORBITAL POSITION OF A MANNED SPACECRAFT. ALL PREDICTIONS OF THE SPACECRAFT'S FUTURE LOCATION, INCLUDING IMPACT POINT, AS WELL AS ALL LOGICAL DECISIONS AFFECTING THE MISSION, ARE DEPENDENT ON PROCESSING DATA IN REAL TIME. UNPRECEDENTED PROBLEMS WHICH REQUIRED RADICALLY NEW SOLUTIONS WERE ENCOUNTERED DURING THE DEVELOPMENT OF A REAL-TIME SYSTEM FOR PROJECT MERCURY. ONE SOLUTION WAS THE DEVELOPMENT OF A REAL-TIME TRANSMISSION DEVICE, THE DATA COMMUNICATIONS CHANNEL (DCC) TO ENABLE THE TRANSMISSION OF VAST QUANTITIES OF REAL-TIME DATA DIRECT LY INTO COMPUTER CORE STORAGE. ANOTHER SOLUTION, AND PERHAPS THE MOST RADICAL, WAS THAT NECESSARY TO PRODUCE A PROGRAM CAPABLE OF PERFORMING COMPLEX DATA PROCESSING REQUIRED TO SUPPORT THE GEMINI MISSION.

UNLIKE ORDINARY PROGRAMMING IN WHICH THE FLOW OF THE PROCESS CAN BE PREDICTED BEFORE EXECUTION, THE GEMINI PROGRAMMING SYSTEM INVOLVES FACTORS NOT UNDER PROGRAM CONTROL. HENCE, THE PROGRAM SYSTEM MUST CONTROL ITS OWN

FLOW IN RESPONSE TO OUTSIDE EVENTS WHICH ARE CHANNELED TO THE IBM 7094 THROUGH THE DCC. THE MONITOR PROGRAM MUST DECIDE WHAT TO DO NEXT ON THE BASIS OF WHAT HAS HAPPENED IN THE PAST AND WHAT MUST HAPPEN IN THE FUTURE.

MANY TIMES SEVERAL PROCESSING FUNCTIONS WILL BE COMPETING WITH ONE ANOTHER FOR THE COMPUTER'S TIME. AT ANY TIME, EACH MUST BE SATISFIED WITHOUT SACRIFICE OF OTHERS, THAT IS, THE COMPUTER MUST DELIVER SEVERAL COMPETING QUANTITIES ON A RIGOROUS SCHEDULE. PRODUCING OUTPUT ON THIS SCHEDULE WOULD BE A DIFFICULT TASK EVEN IF THE INCOMING DATA WERE ARRIVING SMOOTHLY AT REGULAR INTERVALS. HOWEVER,WHEN INPUT IS NOT ONLY IRREGULAR BUT NOT EVEN SCHEDULED, THE SYSTEM MUST BECOME CONSIDERABLY MORE COMPLEX.

DATA MUST BE ABSORBED BY THE SYSTEM WITHOUT PRODUCING ERRORS OR DELAYS. ALSO, SINCE ERRORS MAY ARISE IN COMPUTATIONS, THE SYSTEM MUST EITHER BE ABLE TO DETECT AND CORRECT THESE ERRORS OR DETECT AND INDICATE THEM TO PERSONNEL. IF THE ERRORS CANNOT BE CORRECTED AUTOMATICALLY, THE SYSTEM MUST BE CAPABLE OF RESTARTING WITH A MINIMUM OF MANUAL ASSISTANCE AND QUICKLY ADJUST TO REAL-TIME COMPUTATIONS. TO FUNCTION ON A CONTINUOUS BASIS, THE SYSTEM MUST BE CONSCIOUS OF ITS CHANGING RESPONSIBILITIES THROUGHOUT THE MISSION. IT MUST, FOR EXAMPLE, BE PREPARED TO MODIFY ITS DATA REQUIREMENTS DEPENDING ON THE RESULTS OF PREVIOUS COMPUTATIONS. FINALLY, THE VARIOUS PROGRAMS INVOLVED MUST BE CLOSELY INTEGRATED AND COORDINATED, WHILE THE SYSTEM ITSELF REMAINS EXTREMELY FLEXIBLE AND ADAPTABLE TO CHANGE.

THE PROGRAMS WHICH, WHEN ASSEMBLED AND COMPILED, COMPOSE THE GEMINI PROGRAMMING SYSTEM CAN BE BROADLY CLASSIFIED AS MONITOR AND PROCESSING PROGRAMS. AS THE

NAMES IMPLY, THE MONITOR PROGRAMS PROVIDE SYSTEM SUPERVISION, AND THE PROCESSING PROGRAMS PERFORM MATHEMATICAL COMPUTATIONS.

7.2 MONITOR I/O PROGRAMS

7.2.1 GEMINI MONITOR SCHEME

PROJECT GEMINI OPERATIONAL PROGRAMS MUST ACCOMPLISH THREE TASKS WHICH ARE ALL FAIRLY SYNCHRONOUS IN TIME - THEY MUST ACCEPT INPUT WHICH ARRIVES ON AN ASYNCHRONOUS SCHEDULE, PERFORM CERTAIN COMPUTATIONS ON THE INPUT INFORMATION, AND PROVIDE OUTPUT QUANTITIES AT SPECIFIED TIME INTERVALS. TO MEET THESE THREE REQUIREMENTS AND ENSURE A SMOOTH, OVERALL GEMINI DATA PROCESSING EFFORT, THE MONITOR CONTROL PROGRAM SUPERVISES THE PROCESSORS BY COORDINATING COMPUTATION ACCORDING TO THE ARRIVAL OF INPUT DATA, CALCULATIONS TO BE PERFORMED AND OUTPUT QUANTITIES NEEDED. MONITOR ESTABLISHES THE CONSTANTLY CHANGING PROCESSING PRIORITIES ON THE BASIS OF INPUT, COMPUTATIONAL, AND OUTPUT CONDITIONS.

CONTROL OF THE GEMINI PROGRAM DEPENDS ON INPUT DATA, ON THE RESULTS OF COMPUTATIONS BY THE PROGRAM ITSELF, AND ON A PRESET PRIORITY TABLE WHICH IS CAPABLE OF CONTINUOUS, EFFECTIVE MODIFICATION. IN NON-REAL-TIME COMPUTER PROGRAMS,CONTROL NORMALLY PROCEEDS ALONG THE LINES OF FLOW PRESCRIBED BY THE PROGRAM BEING EXECUTED. WHEN REAL-TIME TRAPPING IS INTRODUCED INTO THE SYSTEM, CONTROL IS NO LONGER RESTRICTED TO THE PRESET LINE OF FLOW. IN TRAPPING MODES, A SIGNAL IS GENERATED WHEN A SPECIFIC CONDITION IS MET. ON RECEIPT OF THE SIGNAL, CONTROL IMMEDIATELY TRANSFERS TO A PREDETERMINED LOCA-

TION REGARDLESS OF THE PRESENT LINES OF FLOW WHICH WOULD OTHERWISE HAVE BEEN USED.

IN REAL-TIME PROCESSING SYSTEMS, THERE ARE THREE STATES IN WHICH THE COMPUTER MAY BE OPERATING - IT MAY BE ENABLED, DISABLED, OR INHIBITED. WHEN THE COMPUTER IS ENABLED, TRAPS MAY OCCUR. WHEN DISABLED OR INHIBITED, TRAPS CANNOT OCCUR EVEN THOUGH AN INTERRUPT SIGNAL HAS BEEN RECEIVED. THE COMPUTER MAY BE ENABLED OR DISABLED BY EXECUTING THE APPROPRIATE INSTRUCTION. THE INHIBITED STAGE, HOWEVER, IS NOT ENTERED THROUGH PROGRAMMING. WHEN A TRAP OCCURS, THE COMPUTER IS IMMEDIATELY INHIBITED AND AND SUBSEQUENT TRAPS ARE PROHIBITED UNTIL THE COMPUTER IS RE-ENABLED BY THE PROGRAM.

ALL INPUT/OUTPUT DATA TRANSMISSION OCCURS THROUGH THE DATA COMMUNICATIONS CHANNEL AND OTHER DATA CHANNELS SIMULTANEOUSLY WITH THE EXECUTION OF THE MAIN PROGRAM. ONLY WHEN AN INPUT BUFFER IS FILLED, AN OUTPUT BUFFER EMPTIED, A HALF-SECOND INTERVAL ELAPSES, OR THE ONE-MINUTE PULSE FROM WWV OCCURS, MUST THE PRESENT COMPUTER PROGRAM BE INTERRUPTED. THIS SITUATION GIVES RISE TO THE PRIMARY CONTROL MECHANISM IN THE GEMINI MONITOR, THE PROGRAM TRAP.

WHEN THE GEMINI PROGRAM SYSTEM IS EXECUTING ANY OF THE NON-TRAP PROCESSORS, TWO POSSIBILITIES EXIST - THE PROCESSOR MAY BE COMPLETED OR A TRAP MAY INTERRUPT AND TAKE CONTROL FROM THE PROCESSOR. IF THE COMPUTER IS ENABLED FOR TRAPPING ON A GIVEN DATA CHANNEL, ALL TRAP REQUESTS ON THAT CHANNEL ARE HONORED IMMEDIATELY. THE TRAP MAY BE NECESSARY TO ACCEPT INPUT TRANSMISSION OR TO TERMINATE OUTPUT TRANSMISSION, OR THE TRAP MAY BE THE RESULT OF A TIMING SIGNAL. THE TRAP PROCESSOR, OPERATING WHILE THE COMPUTER IS INHIBITED FROM TRAPPING, GENERATES CON-

TROL INFORMATION FOR THE MONITOR CONTROLLER PROGRAMS AND, IF NECESSARY, THE TRAP PROCESSOR RELOCATES DATA. AFTER RELOCATING DATA, CONTROL PASSES FROM THE TRAP PROCESSOR TO THE BASIC PRIORITY ROUTINE, MOPRIO.

IF THE NON-TRAP PROCESSOR HAD BEEN COMPLETED WITHOUT INTERRUPTION, CONTROL WOULD ALSO RETURN TO MOPRIO. WHEN ANY TRAP OR ORDINARY PROCESSOR IS COMPLETED, CONTROL ALWAYS RETURNS TO MOPRIO.

7.2.2 GENERAL DESCRIPTION OF MONITOR

BECAUSE THE GEMINI PROGRAMMING SYSTEM AND, IN PARTICULAR, THE GEMINI MONITOR CONCEPT OF REAL-TIME PROCESSING IS UNIQUE, A GENERAL DESCRIPTION OF TRAPPING LOGIC IS PROVIDED IN THE FOLLOWING PAGES TO ENABLE THE READER TO CORRELATE SYSTEM PROCESSING WITH SYSTEM CONTROL. TO SUPPORT THE DESCRIPTION, A FLOWCHART OF THE MONITOR CONCEPT AND AN ASSORTMENT OF WORD FORMAT TABLES USED IN THE MONITOR SYSTEM ARE SHOWN IN FIGURE 7-1 AND TABLES 7-1 AND 7-2.

WHEN A TRAP OCCURS AND TAKES CONTROL FROM A PROCESSO PROGRAM, THE COMPUTER IS INHIBITED AND DCC LOGIC STORES THE NUMBER OF THE SUBCHANNEL INITIATING THE TRAP IN THE DECREMENT OF LOCATION 00003. ALSO, THE DCC SETS UP THE NECESSARY RETURN TO THE INTERRUPTED PROGRAM BY STORING THE CONTENTS OF THE LOCATION COUNTER IN THE ADDRESS PORTION OF THE SAME LOCATION. CONTROL THEN TRANSFERS TO THE REAL-TIME CHANNEL MAIN CONTROLLER PROGRAM, MORTCC.

EVERY DCC PROGRAM INTERRUPT IS SERVICED BY MORTCC TO -

A) SAVE EXISTING COMPUTER CONDITIONS.

B) TRANSFER CONTROL TO THE APPROPRIATE TRAP PROCESSOR.

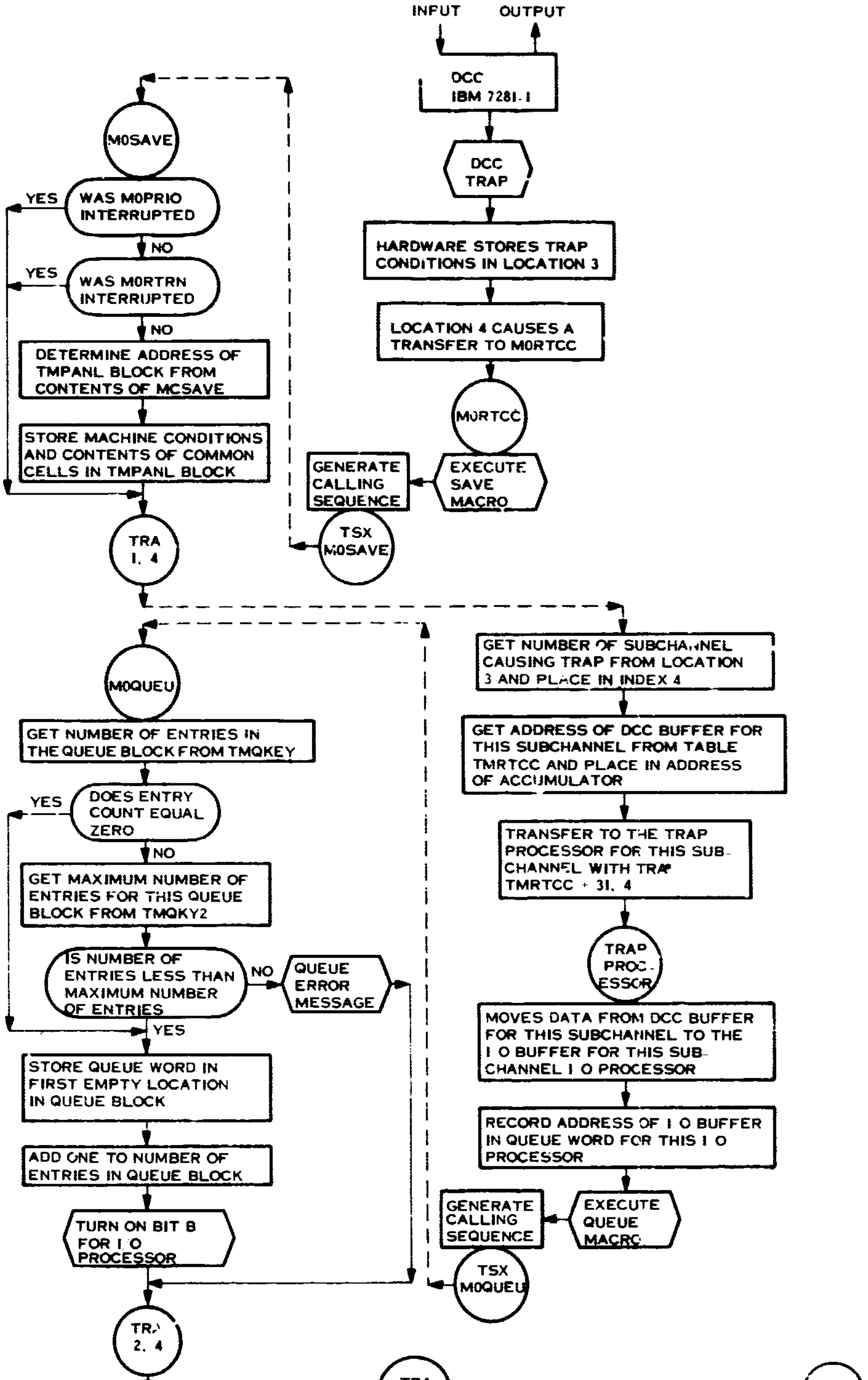


FIGURE 7-1. GEMINI REAL TIME PROGRAMMING MONITOR SYSTEM (SHEET 1 OF 3)

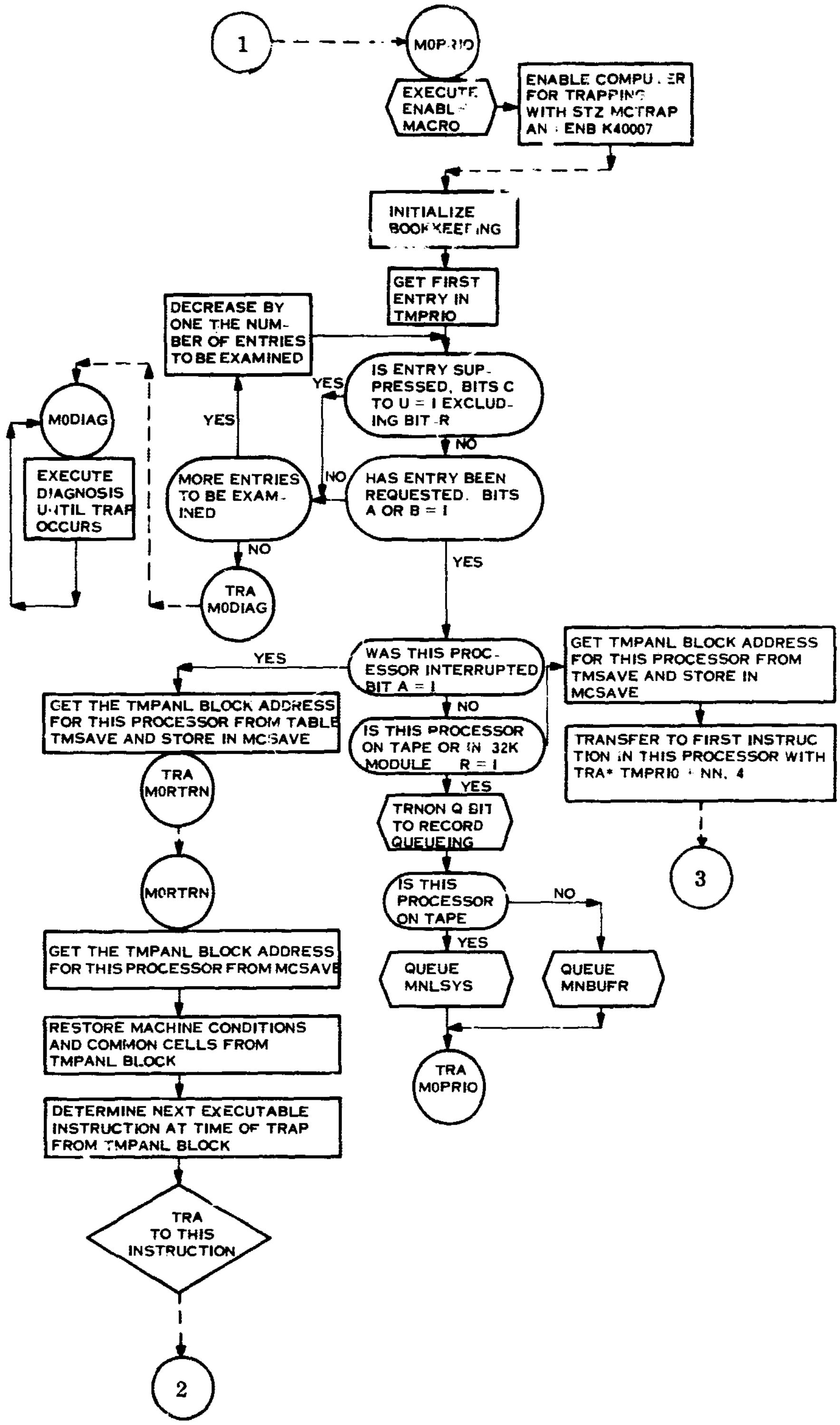


FIGURE 7-1. GEMINI REAL TIME PROGRAMMING MONITOR SYSTEM (SHEET 2 OF 3)

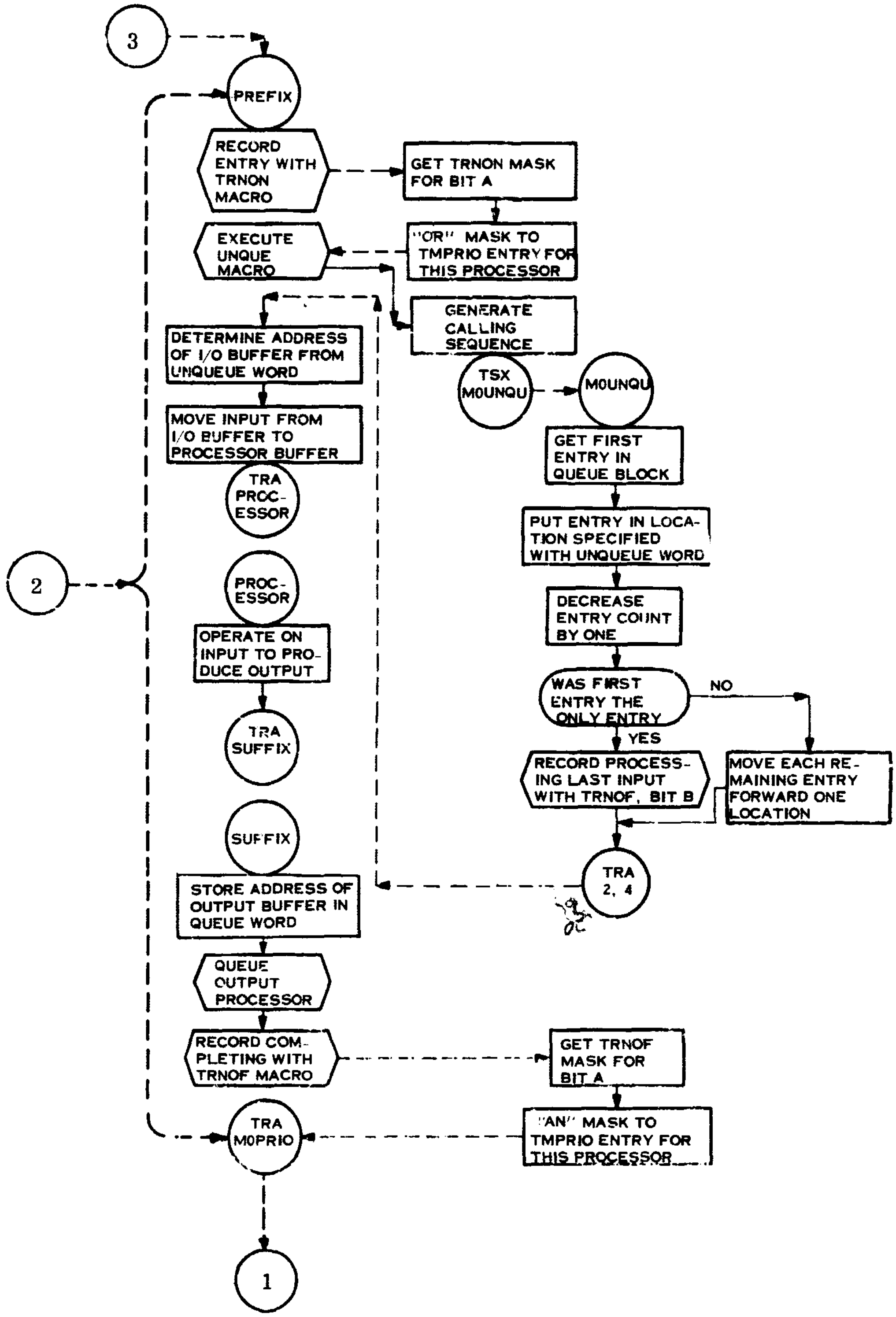


FIGURE 7-1. GEMINI REAL TIME PROGRAMMING MONITOR SYSTEM (SHEET 3 OF 3)

TABLE 7-1. WORD FORMAT TABLES

MCSAVE WORD FORMAT

BITS	CONTENTS
21-35	THE BASE ADDRESS OF THE 14-WORD STORAGE AREA IN TABLE TMPANL
3 - 17	ROUTINE NUMBER

INPUT FORMAT TO M0QUEU

BITS	CONTENTS
3-17	PROCESSOR MONITOR NUMBER
21-35	LOCATION CONTAINING THE ADDRESS OF THE I/O BUFFER

TMQKY2 WORD FORMAT

BITS	CONTENTS
3-17	MAXIMUM NUMBER OF ENTRIES FOR THIS QUEUE BLOCK

TMQKEY WORD FORMAT

BITS	CONTENTS
3-17	CURRENT NUMBER OF ENTRIES IN THIS QUEUE BLOCK
21-35	ADDRESS OF THIS QUEUE BLOCK

TMRTCC WORD FORMAT

BITS	CONTENTS
3-17	ADDRESS OF THE DCC BUFFER ASSOCIATED WITH THIS SUB-CHANNEL
21-35	ADDRESS OF THE TRAP PROC-ESSOR FOR THIS SUBCHANNEL

LOCATION 3

BITS	CONTENTS
5-9	NUMBER OF THE SUBCHANNEL RESPONSIBLE FOR THE TRAP
21-35	CONTENTS OF THE LOCATION COUNTER AT THE TIME OF THE TRAP

TMPRIO WORD FORMAT

BITS	CONTENTS
S-20	BITS A THROUGH U
21-35	ADDRESS OF FIRST INSTRUC-TION IN PROCESSOR

TMSAVE WORD FORMAT

BITS	CONTENTS
21-35	ADDRESS OF THE FOURTEEN WORD SAVE BLOCK IN TMPANL

TMREFR WORD FORMAT

BITS	CONTENTS
2	CONTAINS A ONE IF THE ROU-TINE IS ON TAPE
21-35	LOCATION OF ENTRY IN TMPRIO

TMFRPR WORD FORMAT

BITS	CONTENTS
21-35	PROCESSOR MONITOR NUMBER

INPUT FORMAT TO M0UNQU

BITS	CONTENTS
3-17	PROCESSOR MONITOR NUMBER
21-35	ADDRESS OF LOCATION INTO WHICH FIRST ENTRY IN QUEUE BLOCK IS TO BE STORED

TABLE 7-2. WORD FORMAT ENTRIES

LOCATION 3

BITS	CONTENTS
5-9	1
21-35	27500

UNQUEUE WORD

BITS	CONTENTS
3-17	10 (MNHSGB)
21-35	ADDRESS OF LOCATION Y

QUEUE WORD

BITS	CONTENTS
3-17	10 (MNHSGB)
21-35	ADDRESS OF LOCATION X

LOCATION X

BITS	CONTENTS
21-35	ADDRESS OF THE I/O BUFFER INHSGB

QUEUE BLOCK QHSGB

BITS	CONTENTS
21-35	ADDRESS OF THE I/O BUFFER INHSGB

BUFFERS

TMHSGB	BSS	20
INHSGB	BSS	20
OUTBUF	BSS	20

TMPANL

TMPANL	BSS	742

ORDERED BY SUBCHANNEL NUMBER
DCC REFERENCE TABLE
TMRTCC

SYMBOLIC LOCATION	DCC BUFFER	TRAP PROCESSOR	SUBCHANNEL NO.
TMRTCC	TMSENS	MTSENS	31
+ 28	TMHSOD	MTHSOD	3
+ 30	TMHSGB	MTHSGB	1
+ 31		MTERTC	0

MCSAVE

BITS	CONTENTS
21-35	ADDRESS OF TMPANL + 126

QUEUE BLOCK QSTRP

BITS	CONTENTS
21-35	ADDRESS OF BUFFER OUTBUF

ORDERED BY OPERATIONAL PRIORITY

TMPRIO
MONITOR PRIORITY TABLE

SYMBOLIC LOCATION	BITS S, 1, 2 . . . 20 A, B, C . . . U	PROCESSOR ADDRESS
TMPRIO	. . . . . .	MYHSOD
+ 4	1, 1, 0 . . . 0	MPHSGB
+ 7	0, 1, 0 . . . 0	MPSTRP
+ 52	0, 0, 0 . . . 0	MYINIT

TMFRPR
MONITOR PRIORITY REFERENCE TABLE

SYMBOLIC LOCATION		PROCESSOR MONITOR NUMBER
TMFRPR		15 (MNHSOD)
+ 4		10 (MNHSGB)
+ 7		35 (MNSTRP)
+ 52		27 (MNINIT)

ORDERED BY PROCESSOR MONITOR NUMBER

TMREFR
MONITOR REFERENCE TABLE

PROCESSOR MONITOR NUMBER	SYMBOLIC LOCATION	ORDER OF PRIORITY
1 (MNMESS)	TMREFR	TMPRIO+21
. . . .	. . . .	. . . .
10 (MNHSGB)	+ 9	TMPRIO+4
35 (MNSTRP)	+ 34	TMPRIO+7
53 (MNSRST)	+ 52	TMPRIO+24

TMSAVE
MONITOR SAVE TABLE

SYMBOLIC LOCATION		LOCATION IN TMPANL BLOCK
TMSAVE		TMPANL
. . . .		. . . .
+ 9		TMPANL + 126
+ 34		TMPANL + 476
+ 52		TMPANL + 728

ORDERED BY PROCESSOR MONITOR NUMBER

TMQKEY
MONITOR QUEUE TABLE

SYMBOLIC LOCATION	NO. OF ENTRIES	QUEUE BLOCK ADDRESS
TMQKEY	2	QMESS
. . . .	. . .	. . . .
+ 9	0	QHSGB
+ 34	0	QSTRP
+ 52	10	QSRST

TMQKY2 MONITOR QUEUE TABLE LENGTH

SYMBOLIC LOCATION	LENGTH OF QUEUE BLOCK
TMQKY2	5
. . .	. . .
+ 9	7
+ 34	1
+ 52	12

MORTCC ENSURES THE SAVING OF MACHINE CONDITIONS WITH THE SAVE MACRO WHICH GENERATES THE CALLING SEQUENCE TO THE MAIN CONTROLLER SAVE PROGRAM, MOSAVE (SEE FIGURE 7-1). BEFORE STORING MACHINE CONDITIONS, HOWEVER, MOSAVE DETERMINES IF THE TRAP TOOK CONTROL FROM EITHER THE MAIN CONTROLLER PRIORITY PROGRAM, MOPRIO, OR THE MAIN CONTROLLER RETURN PROGRAM, MORTRN (MACHINE CONDITIONS ARE NOT SAVED IN EITHER INSTANCE). AFTER TESTING FOR THESE TWO CONDITIONS, MOSAVE STORES THE CONTENTS OF THE AC, MQ, AND INDEX REGISTERS (IR) IN A 14-WORD BLOCK IN TABLE TMPANL. IN TMPANL, 14-WORD STORAGE AREAS ARE PROVIDED FOR EACH PROCESSOR PROGRAM LISTED IN THE PRIORITY TABLE TMPRIO. BASE ADDRESSES FOR EACH STORAGE AREA ARE CONTAINED IN THE COMMUNICATION CELL MCSAVE, LOADED BY MOPRIO (SEE TABLE 7-1).

AFTER MACHINE CONDITIONS ARE STORED BY MOSAVE IN TMPANL, CONTROL RETURNS TO MORTCC (SEE FIGURE 7-1). MORTCC EXAMINES LOCATION 00003 TO DETERMINE WHICH DCC SUBCHANNEL CAUSED THE TRAP AND THEN PLACES THAT SUBCHANNEL NUMBER IN IR4. WITH THE CONTENTS OF IR4, MORTCC USES THE REAL-TIME CHANNEL REFERENCE TABLE, TMRTCC, TO DETERMINE -

A) WHICH SUBCHANNEL BUFFER CONTAINS THE INPUT.

B) WHICH TRAP PROCESSOR RECEIVES CONTROL.

AFTER OBTAINING THIS INFORMATION, MORTCC PLACES THE SUBCHANNEL NUMBER IN THE DECREMENT OF THE AC AND THE SUBCHANNEL'S DCC BUFFER LOCATION IN THE ADDRESS. CONTROL THEN TRANSFERS TO THE APPROPRIATE TRAP PROCESSOR WHICH PERFORMS AS FOLLOWS-

A) MOVES INPUT DATA FROM THE DCC BUFFER TO AN INPUT OUTPUT BUFFER (THIS RELEASES THE DCC FOR NEW INPUT).

B) QUEUES THE APPROPRIATE INPUT-OUTPUT PROCESSOR THAT DATA IS AVAILABLE WITH THE QUEUE MACRO.

BEFORE EXECUTING THE QUEUE MACRO, HOWEVER, THE TRAP PROCESSOR BUILDS A QUEUE WORD CONTAINING 1) THE BASE ADDRESS OF THE INPUT-OUTPUT BUFFER RECEIVING THE DATA FROM THE DCC BUFFER AND 2) THE MONITOR NUMBER OF THE INPUT-OUTPUT PROCESSOR BEING QUEUED. USING THIS QUEUE WORD, THE TRAP PROCESSOR EXECUTES THE QUEUE MACRO WHICH, IN TURN, GENERATES A CALLING SEQUENCE TO THE MAIN CONTROLLER QUEUE PROGRAM, MOQUEU. MOQUEU RECORDS IN A QUEUE BLOCK THE CONTENTS OF THE LOCATION SPECIFIED IN THE ADDRESS FIELD OF THE QUEUE WORD GENERATED BY THE TRAP PROCESSOR. QUEUE BLOCKS ARE PROVIDED TO ALLOW STACKING OF INPUT DATA TO PRESERVE ANY DATA WHICH CANNOT BE ACCEPTED, OR DISPOSED OF, BECAUSE OF A TEMPORARY MACHINE CONDITION. AS EACH ENTRY IS PLACED IN THE QUEUE BLOCK, THE CURRENT NUMBER OF ENTRIES FOR THAT BLOCK IS UPDATED IN A TABLE CALLED TMQKEY. IN ADDITION TO THE NUMBER OF ENTRIES, TMQKEY ALSO CONTAINS IN ITS ADDRESS FIELD THE BASE ADDRESS OF THE FIRST ENTRY IN THE QUEUE BLOCK (SEE TABLE 7-1). AFTER EACH ENTRY, THE CURRENT ENTRY COUNT IN TMQKEY IS COMPARED TO A PREDETERMINED NUMBER CONTAINED IN A SECOND TABLE CALLED TMQKY2. IF THE QUEUE BLOCK IS NOT FULL WHEN NEW DATA ARRIVES, THE NEW DATA IS STORED IN THE FIRST AVAILABLE LOCATION, AND THE COUNT OF THE CURRENT NUMBER OF ENTRIES IS INCREASED BY ONE. IF THE QUEUE BLOCK IS FULL, DATA WILL BE LOST. AFTER THE CONTENTS OF THE QUEUE WORD ARE STORED IN THE QUEUE BLOCK, MOQUEUE NOTIFIES THE APPROPRIATE INPUT-OUTPUT PROCESSOR OF WAITING INPUT. NOTIFICATION IS ACCOMPLISHED USING A TURN-ON PROCEDURE WHICH SETS A 1 IN THE B-BIT POSITION OF THE TMPRIO ENTRY FOR THE SELECTED PROCESSOR.

PROCESSORS ARE REFERENCED FROM THE MONITOR PRIORITY TABLE TMPRIO WHICH CONTAINS AN ENTRY FOR EACH PROCESSOR, ORDERED BY ASSIGNED PRIORITY. IN A DYNAMIC SYSTEM PRIORITY MAY, AND OFTEN DOES, CHANGE AS VARIOUS PHASES OF THE PROGRAM ARE ENTERED. TO FACILITATE PRIORITY MODIFICATION, A COMMON REFERENCE WAS ESTABLISHED BETWEEN MOQUEU AND TMPRIO. THIS REFERENCE IS THE INTERMEDIATE TABLE TMREFR. TMREFR CONTAINS AN ENTRY FOR EACH PROCESSOR LISTED IN TMPRIO, WITH ENTRIES ORDERED BY MONITOR NUMBER INSTEAD OF ASSIGNED PRIORITY. MOQUEU, THEREFORE, CAN REFERENCE TMREFR BY MONITOR NUMBER, WHICH NEVER CHANGES, TO OBTAIN THE LOCATION OF THE DESIRED PROCESSOR IM TMPRIO IN THE EVENT PRIORITY HAS BEEN MODIFIED. AFTER THE DESIRED INPUT-OUTPUT PROCESSOR IS NOTIFIED BY MOQUEU, CONTROL TRANSFERS TO MOPRIO AND THE FOLLOWING OPERATIONS ARE INITIATED -

A) THE COMPUTER IS ENABLED FOR TRAPPING.

B) CONTROL IS GIVEN TO THE PROPER PROCESSOR.

ENABLING THE COMPUTER IS NECESSARY BECAUSE IT WAS INHIBITED AUTOMATICALLY BY THE DCC TRAP. INHIBITING ENSURES COMPLETE PROCESSING OF ONE TRAP BEFORE A SECOND IS INITIATED. MOPRIO ENABLES THE COMPUTER FOR SUBCHANNEL TRAPPING WITH THE EXECUTION OF THE ENABLE MACRO, QENBA. THIS MACRO FIRST SETS THE COMMUNICATION CELL MCTRAP TO ZERO AND THEN EXECUTES THE ENB INSTRUCTION, USING THE CONSTANT K40007.

REGARDING THE SECOND ABOVE CITED FUNCTION FOR MOPRIO (TRANSFERRING CONTROL TO THE PROPER PROCESSOR), MOPRIO EXAMINES EACH PROCESSOR IN ORDER OF ITS ASSIGNED PRIORITY AND, WHEN CERTAIN PROGRAM CONDITIONS ARE FULFILLED, GIVES CONTROL TO A PROCESSOR PROGRAM. IN OPERATION, MOPRIO TESTS EACH ENTRY IN THE PRIORITY TABLE (TMPRIO) TO DETER-

MINE IF THAT ENTRY HAS BEEN SUPPRESSED. (SUPPRESSION IS IN EFFECT PRIORITY MODIFICATION.) INDICATION OF PROCESSOR BEING SUPPRESSED IS FOR A 1 TO BE CONTAINED IN ANY BIT POSITION C THROUGH U, EXCEPT BIT POSITIONS Q AND R. IF A PROCESSOR HAS BEEN SUPPRESSED, THE NEXT ENTRY IS EXAMINED AUTOMATICALLY. MOPRIO REPEATS THIS PROCEDURE FOR ALL ENTRIES IN TMPRIO UNTIL ONE IS ENCOUNTERED THAT IS UNSUPPRESSED.

AFTER THE SUPPRESSION BITS FOR AN ENTRY HAVE BEEN TESTED AND A PROCESSOR SELECTED, MOPRIO TESTS THE A-AND B- POSITIONS FOR THAT ENTRY - A 1 IN BIT POSITION A INDICATES THE PROCESSOR HAS BEEN INTERRUPTED, A 1 IN BIT POSITION B INDICATES THE PROCESSOR HAS BEEN QUEUED. IF ZEROS ARE CONTAINED IN BIT POSITIONS A AND B, THE NEXT SUCCESSIVE ENTRY IN TMPRIO IS EXAMINED.

IF THE A-BIT CONTAINS A 1, MOPRIO RETURNS CONTROL TO THE INTERRUPTED PROCESSOR THROUGH THE MAIN CONTROLLER RETURN PROGRAM, MORTRN. THIS PROGRAM RESTORES THE MACHINE CONDITIONS STORED IN THE 1-WORD BLOCK IN TMPANL EXACTLY AS THEY WERE AT THE TIME OF THE TRAP AND RETURNS CONTROL TO THE PROCESSOR AT THE POINT OF INTERRUPTION (SEE FIGURE 7-1). BEFORE MOPRIO TRANSFERS CONTROL, HOWEVER, IT LOADS MCSAVE WITH THE STARTING LOCATION OF THE BLOCK IN TMPANL CONTAINING THE MACHINE CONDITIONS. MCSAVE IS LOADED FROM THE INTERMEDIATE TABLE TMFRPR, DEVELOPED TO ALLOW ACCURATE REFERENCING OF TABLE TMSAVE BY MOPRIO WHEN PRIORITY CHANGES. TMFRPR LISTS PROCESSOR ENTRIES ORDERED BY ASSIGNED PRIORITY (EACH ENTRY CONTAINS THE PROCESSOR MONITOR NUMBER). TMFRPR, THEREFORE, CAN BE REFERENCED BY MOPRIO TO DETERMINE MONITOR PROGRAM NUMBERS WHICH REMAIN UNCHANGED THROUGHOUT PROCESSING OPERATIONS. USING THE MONITOR NUMBER, MOPRIO CAN CORRECTLY LOAD MCSAVE FROM

TABLE TMSAVE.

IF THE B-BIT OF AN ENTRY CONTAINS A 1, IT INDICATES THE PROCESSOR HAS BEEN QUEUED. MOPRIO THEN TESTS THE R-BIT OF THE SAME ENTRY TO DETERMINE WHETHER THE REQUESTED PROCESSOR IS AN A-CORE OR IS IN AN INTERMEDIATE BUFFER AREA. IF THE R-BIT OF THE ENTRY CONTAINS A ZERO, THE PROCESSOR IS IN A-CORE - A 1 INDICATES INTERMEDIATE STORAGE. IF THE PROCESSOR IS IN A-CORE, MCSAVE IS LOADED BY MOPRIO, AND CONTROL IS TRANSFERRED TO THE FIRST INSTRUCTION IN THAT PROGRAM.

IF THE R-BIT CONTAINS A 1, MOPRIO EXAMINES BIT POSITION 2 OF THE TMREFR ENTRY TO DETERMINE WHICH INTERMEDIATE STORAGE AREA IS BEING USED - I.E., TAPE OR THE 32K BUFFER MODULE. IF BIT POSITION 2 CONTAINS A 1, TAPE STORAGE IS INDICATED, AND MOPRIO QUEUES THE MONITOR SYSTEM TAPE LOADING PROCESSOR, MYLSYS. IF BIT POSITION 2 IS ZERO, THE PROCESSOR IS IN THE 32K BUFFER MODULE, AND MOPRIO QUEUES THE MONITOR BUFFER PROCESSOR, MYBUFR. WHEN BOTH BIT POSITIONS A AND B CONTAIN 1'S, A-POSITION HAS HIGHER PRIORITY.

IF ALL ENTRIES ARE TESTED AND NO REQUEST ARE PRESENT, MOPRIO TRANSFERS CONTROL TO THE MONITOR DIAGNOSTIC ROUTINE, MODIAG, MODIAG RETAINS CONTROL UNTIL A PROGRAM INTERRUPT OCCURS.

WHEN A PROCESSOR IS IN INTERMEDIATE STORAGE, IT IS NECESSARY TO QUEUE EITHER MYLSYS OR MYBUFR - IT IS ALSO NECESSARY TO TURN ON THE Q-BIT (SUPPRESSION BIT) FOR THAT PROCESSOR'S ENTRY IN TMPRIO. MYLSYS AND MYBUFR ARE OF A LOW PRIORITY AND, UNLESS THE PROCESSOR IS SUPPRESSED, A PROGRAM LOOP WOULD RESULT. THAT IS, MOPRIO WOULD QUEUE EITHER MYLSYS OR MYBUFR, RETURN TO EXAMINE THE FIRST ENTRY IN TMPRIO, AND THEN QUEUE MYLSYS OR MYBUFR AGAIN.

WITH THE Q-BIT SET, HOWEVER, MOPRIO IS FORCED TO PASS THE ENTRY AND EVENTUALLY EXAMINE ENTRIES FOR MYLSYS AND/OR MYBUFR IN WHICH THE B-BIT IS ON. MYLSYS OR MYBUFR BRINGS THE PROCESSOR INTO A-CORE, TURNS OFF THE R-BIT IN THE ENTRY TO NOTIFY MOPRIO THAT THE PROCESSOR IS NOW IN A-CORE, AND TURNS OFF THE Q-BIT TO UNSUPPRESS THE PRO-CESSOR (ALLOWS MOPRIO TO EXAMINE THE A- AND B-BIT POSI-EXAMPLE IS PRESENTED OF THE GEMINI PROGRAMMING SYSTEM IN OPERATION. THE EXAMPLE ASSUMES THAT A VEHICLE HAS BEEN LAUNCHED, THAT INPUT DATA IS BEING RECEIVED OVER SUB-CHANNEL 1, AND THAT THE LOCATION COUNTER INDICATES 27,500. TABLE 7-2 SHOWS THE ACTUAL CONTENTS OF THE VARIOUS TABLES PRESENTED IN TABLE 7-1 AS THEY APPEAR DURING DIFFERENT PHASES OF THE PROCESSING OPERATION.

WHEN THE TRAP OCCURS, THE DCC STORES A 1 IN BITS 5 TO 9 OF LOCATION 00003 AND STORES THE CONTENTS OF THE LOCATION COUNTER (27500) IN THE ADDRESS OF THE SAME LOCA-TION. THE DCC NOW TRANSFERS CONTROL TO LOCATION 00004. THE CONTENTS OF THIS LOCATION CAUSE A TRANSFER TO MORTCC SAVES MACHINE CONDITIONS WITH THE SAVE MACRO. THE SAVE MACRO TRANSFERS CONTROL TO MOSAVE WITH THE CALLING TIONS).

THE MONITOR DESCRIPTION TO THIS POINT CONCERNS SYS-TEM CONTROL LOGIC FOR SELECTING A PROCESSOR PROGRAM TO ACT ON INPUT DATA IN REAL TIME. BEFORE CONTINUING, IN-TRODUCTION MUST BE MADE TO THE TWO TYPES OF PROCESSOR PROGRAMS CONTAINED IN THE GEMINI SYSTEM.

THE FIRST TYPE OF PROCESSOR PROGRAM IS THE SINGLE PROGRAM TYPE. THE SECOND TYPE CONSISTS OF THE PROCESSOR PROGRAM PLUS PREFIX AND SUFFIX PROGRAMS. PREFIX AND SUF-FIX PROGRAMS ARE ADDED TO CERTAIN PROCESSOR PROGRAMS TO SUPPLY MONITOR ENTRY AND EXIT FUNCTIONS.

THE TWO MAIN FUNCTIONS OF THE PREFIX PROGRAM ARE TO-

A) RECORD THE PROCESSOR(S ENTRY IN TMPRIO (TURN ON A-BIT TRNON MACRO).

B) LOCATE INPUT DATA (EXTRACT INFORMATION FROM QUEUE WORD USING UNQUE MACRO).

THE TRNON MACRO RECORDS THE PROCESSOR'S ENTRY IN TMPRIO. THE UNQUE MACRO LOCATES INPUT DATA FOR THE PROCESSOR. UNQUE GENERATES A CALLING SEQUENCE FOR THE PROCESSOR, USING THE MONITOR NUMBER OF THE PROCESSOR PROGRAM ALONG WITH THE LOCATION INTO WHICH THE FIRST ENTRY IN THE QUEUE BLOCK IS TO BE STORED. THE MAIN CONTROLLER UNQUEU PROGRAM IS ENTERED FROM THE UNQUE MACRO AND PLACES THE CONTENTS OF THE FIRST LOCATION OF THE PROCESSOR QUEUE BLOCK IN THE LOCATION SPECIFIED BY THE CALLING SEQUENCE. IF MORE THAN ONE ENTRY IS IN THE QUEUE BLOCK, REMAINING ENTRIES ARE MOVED FORWARD ONE LOCATION AND THE ENTRY COUNT IS REDUCED BY ONE. IF ONLY ONE ENTRY IS PRESENT, MOUNQU TURNS OFF THE B-BIT IN TMPRIO TO INDICATE THAT THE FINAL SET OF DATA IS BEING PROCESSED. PROGRAM CONTROL IS TRANSFERRED FROM MOUNQU TO THE PREFIX PROGRAM TO MOVE INPUT DATA FROM THE I/O BUFFER TO THE PROCESSOR'S INTERNAL BUFFER. AFTER THE TRANSFER, CONTROL IS GIVEN TO THE PROCESSOR. THE PROCESSOR PROGRAM PERFORMS THE COMPUTATIONAL OPERATIONS AND THEN TRANSFERS CONTROL TO THE SUFFIX PROGRAM.

SUFFIX PROGRAMS ARE ENTERED FROM THEIR ASSOCIATED PROCESSORS TO PERFORM EXIT FUNCTIONS. INCLUDED IN THE EXIT FUNCTIONS IS TO QUEUE THE APPROPRIATE OUTPUT PROCESSOR PROGRAM WITH RESULTS OF THE PRECEDING OPERATION USING MOQUEU.

MOQUEU IS ENTERED FROM THE SUFFIX PROGRAM TO PROVIDE THE QUEUEING FUNCTIONS. AFTER THE QUEUE WORD FOR THE OUTPUT PROCESSOR IS ESTABLISHED (THE QUEUE MACRO IS EXECU-

TED AND GIVES THE LOCATION OF THE OUTPUT BUFFER AND MONITOR NUMBER OF THE NEXT PROCESSOR), MOQUEU THEN RETURNS CONTROL TO THE SUFFIX PROGRAM. THE SUFFIX PROGRAM TURNS OFF THE A-BIT IN TMPRIO AND RETURNS CONTROL TO MOPRIO.

7.2.3 EXAMPLE OF MONITOR CONTROL

TO SUMMARIZE THE PRECEDING DESCRIPTION, A DETAILED SEQUENCE -

```
TSX     MOSAVE, 4
PZE     RETURN
```

MOSAVE STORES THE CURRENT MACHINE CONDITION IN THE 14-WORD BLOCK BEGINNING AT TMPANL + 126 (OBTAINED FROM MCSAVE) AND TRANSFERS CONTROL TO MORTCC WITH TRA 1,4. MORTCC PLACES THE NUMBER OF THE SUBCHANNEL CAUSING THE TRAP (BITS 5-9 OF LOCATION 00003) IN IR4, THE CONTENTS OF THE DECREMENT OF TMRTCC + 31, 4 IN THE AC8 AND TRANSFERS CONTROL TO THE TRAP PROCESSOR MTHSBG -

```
TRA*    TMRTCC + 31, 4
```

MTHSBG MOVES THE INPUT DATA FROM THE DCC BUFFER INTO THE INPUT-OUTPUT BUFFER, INHSBG, AND RECORDS THE STARTING LOCATION IN THE I/O BUFFER IN A QUEUE WORD FOR THE APPROPRIATE I/O PROCESSOR. THE QUEUE MACRO BUILDS THE QUEUE WORD WITH THE INSTRUCTION QUEUE MNHSGB, LOCATION X, AND GIVES CONTROL TO MOQUEU AS FOLLOWS -

```
TSX     MOQUEUE, 4
PZE     LOCATION X, ,MNHSGB
PZE     RETURN
```

WHERE -

A) LOCATION X WILL CONTAIN PZE INHSBG

B) MNHSGB EQU 10

MOQUEU REFERENCES LOCATION TMQKEY + MNHSG - 1 FOR

THE NAME OF THE QUEUE BLOCK AND THE CURRENT NUMBER OF ENTRIES IN THE BLOCK. TMQKEY + 9 IS DETERMINED TO BE THE REFERENCED LOCATION AND INDICATES THERE ARE NO ENTRIES IN THE QUEUE BLOCK QHSGB. THEREFORE, TMQKEY IS NOT REFERENCED (SEE TABLE 7-2). MOQUEUE INCREASES THE ENTRY COUNT BY ONE AND STORES THE CONTENTS OF LOCATION X (THE ADDRESS INHSGB IN THE FIRST LOCATION OF THE QUEUE BLOCK (QHSGB). MOQUEUE NOTIFIES IOHSGB OF WAITING INPUT BY TURNING ON THE B-BIT OF THE PROCESSOR'S ENTRY IN TMPRIO AS FOLLOWS -

```
     CAL      TMNMSK - 1 + B           **B EQU 2
     ORS*     TMREFR + MNHSGB - 1       **MNGSGB EQU 10
```

WHICH IS -

```
     CAL           TMNMSK + 1
     ORS*          TMREFR + 9
     TMNMSK + 1  EQU                   K20000000000
     TMREFR + 9  PZE                   TMPRIO + 4
```

MOQUEU COMPLETES THE QUEUEING BY RETURNING CONTROL TO THE TRAP PROCESSOR WITH TRA 2, 4, AND THE TRAP PROCESSOR (MTHSGB) TRANSFERS CONTROL TO MOPRIO.

THIS COMPLETES THE QUEUEING PROCESS AND THE RELOCATING OF INPUT DATA, CONTROL IS NOW RETURNED TO THE MAIN PROGRAM, THE COMPUTER IS ENABLED, AND TMPRIO IS SEARCHED FOR THE REQUESTED PROCESSOR WITH THE HIGHEST PRIORITY.

MOPRIO ENABLES THE COMPUTER WITH THE QENBA MACRO WHICH SUPPLIES THE FOLLOWING -

```
     STZ      MCTRAP
     ENB      K40007
```

MOPRIO NOW EXAMINES EACH ENTRY, STARTING WITH THE HIGHEST PRIORITY, TO SELECT A QUEUED PROCESSOR PROGRAM (BITS A OR B ON). THE FIFTH ENTRY (TMPRIO + 4) HAS BITS A AND B ON AND THE SUPPRESSION BITS OFF AND, THEREFORE, IS SELECTED. BIT A INDICATES THE PROCESSOR WAS INTERRUPTED,

AND BIT B INDICATES A QUEUE (SET BY MTHSGB). MCSAVE IS SET AS FOLLOWS, AND CONTROL IS TRANSFERRED TO MORTRN TO EXECUTE THE RETURN TO LOCATION 27,500 -

```
CLA     TMFRPR + 41, 4   (TMPRPR + 4)
PAC     0, 4             COMPLEMENT OF DECIMAL 10
CLA     TMSAVE - 1, 4    (TMSAVE + 9)
STA     MCSAVE           (ADDRESS TMPANL + 126)
```

MORTRN RESTORES MACHINE CONDITIONS EXISTING AT THE TIME OF THE TRAP FROM THE CONTENTS OF THE 14-WORD BLOCK BEGINNING AT LOCATION TMPANL + 126. THIS BLOCK ALSO PROVIDES THE CONTENTS OF THE LOCATION COUNTER AT THE TIME OF INTERRUPT (27,500).

MORTRN RETURNS CONTROL TO IOHSGB AND, ON COMPLETION, IOHSGB TRANSFERS CONTROL TO ITS SUFFIX, MFHSGB. BECAUSE THE SUFFIX PROGRAM IS PRESENTED IN MORE DETAIL LATER IN THIS DESCRIPTION, IT IS SUFFICIENT TO SAY AT THIS TIME THAT THE SUFFIX TURNS OFF THE A-BIT IN TMPRIO + 4 AND TRANSFERS CONTROL TO MOPRIO. MOPRIO REPEATS THE EXAMINATION OF ENTRIES AND AGAIN SELECTS TMPRIO + 4 BECAUSE THE B-BIT IS ON FOR THIS ENTRY. BEFORE GIVING CONTROL TO IOHSGB, MOPRIO DETERMINES THAT THE PROCESSOR IS IN A-CORE. MCSAVE IS THEN LOADED IN THE SAME MANNER AS WHEN CONTROL WAS RETURNED TO THE POINT OF INTERRUPTION. NOTE THAT THIS IS THE SECOND TIME IOHSGB IS ENTERED. THE FIRST ENTRY OCCURRED BECAUSE THE PROGRAM HAD BEEN INTERRUPTED. THE SECOND ENTRY OCCURRED BECAUSE THE PROGRAM WAS QUEUED. ON THE SECOND ENTRY, THE PREFIX FOR IOHSGB IS ENTERED AND THE TRNON MACRO IS EXECUTED -

```
TRNON   A, MNHSGB
```

THE MACRO CAUSES THE FOLLOWING INSTRUCTIONS TO BE SUPPLIED -

```
CAL     TMNMSK + A - 1
```

```
     ORS*    TMREFR + MNHSGB - 1
```

INPUT DATA IS THEN LOCATED WITH THE UNQUEU MACRO -

```
     UNQUE   MNHSGB, LOCATION Y
```

THIS MACRO SUPPLIES THE FOLLOWING SEQUENCES AND CAUSES A TRANSFER TO MOUNQU -

```
     TSX     MOUNQU, 4
     PZE     LOCATION Y, MNHSGB
     PZE     RETURN
```

MOUNQU REMOVES THE FIRST ENTRY (ADDRESS OF INHSGB BUFFER) IN THE IOHSGB QUEUE BLOCK (QHSGB) AND STORES THIS ENTRY IN LOCATION Y AS FOLLOWS -

```
     CLA*    TMQKEY + MNHCGB - 1      (TMQKEY + 9)
     SLW*    1, 4                     (LOCATION Y)
```

MOQNQU THEN DECREASES THE ENTRY COUNT BY ONE AND TESTS FOR ZERO. IN THIS EXAMPLE, THE COUNT IS ZERO AND, CONSEQUENTLY, THE 8-BIT IN TMPRIO + 4 IS TURNED OFF AS FOLLOWS -

```
     CLA     TMFMSK + 8-1
     ANS*    TMREFR + MNHSGB - 1      (TMREFR + 9)
```

THE 8-BIT IS TURNED OFF TO INDICATE THAT IOHSGB IS PROCESSING THE LAST SET OF INPUT. MOUNQU RETURNS CONTROL TO MPHSGB WITH -

```
     TRA     2, 4
```

MPHSGB REFERENCES LOCATION Y FOR THE ADDRESS OF THE BUFFER INHSGB, MOVES THE INPUT FROM THE BUFFER TO IOHSGB'S INTERNAL BUFFER, AND TRANSFERS CONTROL TO IOHSGB. IOHSGB EDITS THE INPUT DATA, STORES THE RESULTS IN THE OUTPUT BUFFER, OUTBUF, AND TRANSFERS CONTROL TO ITS SUFFIX, MFHSGB. MFHSGB NOTIFIES THE STRIP-CHART PROCESSOR CCSTRP OF INPUT WITH THE INSTRUCTION -

```
     QUEUE   MNSTRP, LOCATION Z
```

THE QUEUE MACRO SUPPLIES THE FOLLOWING -

```
     TSX     MOQUEU, 4
     PZE     LOCATION Z, , NNSTRP
     PZE     RETURN
```

WHERE -

A) LOCATION Z CONTAINS PZE OUTBUF

B) MNSTRP EQU 35

MOQUEU STORES THE CONTENTS OF LOCATION Z (ADDRESS OF OUTBUF) IN THE QUEUE BLOCK QSTRP, TURNS ON THE B-BIT IN TMPRIO + 7, AND RETURNS CONTROL TO MFHSGB. MFHSGB RECORDS COMPLETION OF IOHSGB PROCESSING BY TURNING OFF THE A-BIT IN TMPRIO + 4, USING THE TRNOF MACRO, AND THEN RETURNS CONTROL TO MOPRIO -

```
     TRNOF   A, MNHSGB
```

MOPRIO, ON EXAMINING ENTRIES, FINDS THE B-BIT ON IN TMPRIO + 7 AND LOADS MCSAVE WITH THE ADDRESS TMPANL + 476. MOPRIO THAN TRANSFERS CONTROL TO THE PREFIX MPSTRP TO ENTER THE STRIP-CHART PROCESSOR CCSTRP. CCSTRP COMPLETES ITS PROCESSING OF OUTPUT DATA FROM IOHSGB AND TRANSFERS CONTROL TO THE SIFFIX MFSTRP. MFSTRP STORES THE OUTPUT FROM CCSTRP IN THE DCC OUTPUT BUFFER TMHSOD, AND ACTIVATES SUBCHANNEL 3 AS FOLLOWS -

```
     CLA     K10000
     ORS     MCACTV
     QPSLF
```

THE QPSLF MACRO EXECUTES THE ACTIVATE SENSE LINE PROGRAM MYPSLF WHICH ACTIVATES SUBCHANNEL 3 (ORS INSTRUCTION PLACES A 1 IN BIT POSITION 3 OF MCACTV-SEE FIGURE 7-1). IMMEDIATELY ON BEING ACTIVATED, SUBCHANNEL 3 INITIATES TRANSMISSION FROM THE DCC BUFFER TMHSOD TO THE CONTROL CENTER AT THE CAPE. AFTER ALL DATA HAS BEEN TRANSMITTED, THE COMPUTER IS TRAPPED BY SUBCHANNEL 3, AND THE DCC GIVES CONTROL TO THE TRAP PROCESSOR MTHSOD.

MTHSOD RECORDS THE FACT THAT TRANSMISSION OCCURRED AND DEACTIVATES SUBCHANNEL 3 AS FOLLOWS -

```
     CLA      K67777
     ANS      MCACTV
     QPSLF
```

MYPSLF DEACTIVATES SUBCHANNEL 3 (MCACTV NOW CONTAINS A ZERO) AND RETURNS CONTROL TO MOPRIO.

PROCESSING FOR THIS EXAMPLE IS NOW COMPLETE SINCE AL QUEUES SET AS A RESULT OF THE PROCESSING HAVE BEEN SATISFIED. MOPRIO EXAMINES THE TMPRIO TABLE FOR THE NEXT QUEUED PROCESSOR. MAIN PROGRAM PROCESSING TAKES PLACE AND CONTINUES UNTIL A TRAP OCCURS AND THE REAL-TIME TRAPPING LOGIC IS REPEATED.

RETURNING TO THE ORGINAL ASSUMPTION THAT IOHSGB WAS EDITING A SET OF INPUT WHEN THE DCC (SUBCHANNEL NUMBER ONE) TRAPPED THE COMPUTER, THE FOLLOWING SEQUENCE OF EVENTS OCCURRED. (THEY ARE LISTED TO ILLUSTRATE THE USE OF SUPPRESSION.) -

A) MORTCC SAVED THE MACHINE CONDITIONS BY EXECUTING THE SAVE MACRO AND THEN TRANSFERRED CONTROL TO MTHSGB.

B) MTHSGB MOVED THE INPUT FROM TMHSGB INTO INHSGB, QUEUED IOHSGB WITH THE QUEUE MACRO, AND THEN TRANSFERRED CONTROL TO MOPRIO.

C) MOPRIO RETURNED CONTROL TO IOHSGB BY TRANSFERRING TO MORTRN.

D) MORTRN RESTORED THE MACHINE CONDITIONS AND RETURNED CONTROL TO IOHSGB AT THE POINT OF INTERRUPT.

E) IOHSGB RESUMED THE EDITING PROCESS AT THE POINT OF INTERRUPT, STORED THE EDITED RESULTS IN BUFFER OUTBUF, AND THEN TRANSFERRED CONTROL TO ITS

SUFFIX MFHSGB. THIS ASSUMES THAT THE POINT OF INTERRUPT LIES WITHIN THE COMPUTATIONAL PROGRAM IOHSGB.

F) MFHSGB QUEUED CCSTRP WITH THE EDITED RESULTS (CONTAINED IN OUTBUF) AS INPUT, TURNED OFF (WITH THE TRNOF MACRO) THE A BIT IN TMPRIO + 4, AND WOULD THEN RETURN CONTROL TO MOPRIO UNLESS SUPPRESSED. TO ALLOW CONTROL TO BE RETURNED TO MOPRIO AT THIS POINT WOULD BE INCORRECT BECAUSE MOPRIO WOULD RETURN CONTROL TO IOHSGB (THROUGH THE PREFIX MPHSGB) WHICH WOULD DESTROY THE CURRENT CONTENTS (FIRST SET OF EDITED RESULTS) OF OUTBUF WHEN IOHSGB STORED THE SECOND SET OF EDITED RESULTS IN OUTBUF. TO AVOID MOPRIO GIVING CONTROL TO IOHSGB BEFORE IT GIVES CONTROL TO CCSTRP, THE SUFFIX MFHSGB TURNS ON ONE OR MORE OF THE SUPPRESSION BITS IN TMPRIO + 4 TO CAUSE MOPRIO TO EVENTUALLY EXAMINE TMPRIO + 7 (I.E., THE ENTRY FOR CCSTRP) WHICH HAS THE B-BIT ON. CONTROL, THEREFORE, IS TRANSFERRED TO MPSTRP. MPSTRP WOULD UNQUEUE THE QUEUE BLOCK QSTRP (CONTAINS THE ADDRESS OF OUTBUF), TRANSFER THE CONTENTS OF OUTBUF TO AN INTERNAL CCSTRP BUFFER, AND TRANSFER CONTROL TO CCSTRP. CCSTRP WOULD MAKE THE NECESSARY CALCULATIONS AND TRANSFER TO ITS SUFFIX, MFSTRP. MFSTRP WOULD PLACE THE RESULTS OF THE CALCULATIONS IN THE DCC BUFFER TMSHOD, ACTIVATE SUBCHANNEL 3, TURN OFF THE SUPPRESSION BITS IN TMPRIO + 4 (THAT WERE TURNED ON BY MFHSGB), TURN OFF THE A-BIT IN TMPRIO + 7, AND RETURN CONTROL TO MOPRIO. THEN IT WOULD BE PERMISSABLE FOR MOPRIO TO GIVE CONTROL TO

IOHSGB AND THEREBY REINITIATE THE CYCLE.

THE PRECEDING EXAMPLE IS HYPOTHETICAL AND IS ACCURATE ONLY TO THE EXTENT THAT IT DEMONSTRATES THE FUNCTIONS OF THE VARIOUS SEGMENTS OF THE GEMINI MONITOR SYSTEM.

7.3 LAUNCH/ABORT PROGRAMS

STANDARD RADAR TTY MESSAGES, MANUAL INSERTION MESSAGES, BURROUGHS-GENERAL ELECTRIC MESSAGES, AND THE IP PROCESSED AZUSA OR AN/FPS-16 RADAR MESSAGES ARE EACH SUPPLIED TO A SEPARATE INPUT PROCESSOR. ALTHOUGH THESE PROCESSORS DIFFER IN METHOD AND DETAIL, THE BASIC FUNCTION OF EACH IS COMMON TO ALL FOUR - THEY EXAMINE INPUT DATA FOR CONFORMANCE TO SPECIFIED CRITERIA AND CONVERT THE ACCEPTABLE INFORMATION FROM THE FORM IN WHICH IT ENTERS THE COMPUTER TO THE FORMAT PRESCRIBED FOR THE COMPUTATIONAL PROCESSOR WHICH THE DATA IS TO SUPPLY. ALL INPUT DATA CONTAINS INTERNAL INFORMATION WHICH ENABLES THE PROCESSOR TO DETECT, THROUGH CERTAIN VALIDITY TESTS, THE PRESENCE OF TRANSMISSION ERRORS AND OTHER EQUIPMENT ERRORS.

THE FOLLOWING EXAMPLES ILLUSTRATE SOME OF THE FUNCTIONS PERFORMED BY INPUT PROCESSORS - THE RADAR TELETYPE INPUT PROCESSOR CONVERTS ANGLES FROM MILS TO RADIANS, AND RANGE FROM YARDS TO EARTH RADIUS VALUES. THE MANUAL INSERTION INPUT PROCESSOR ACCEPTS FROM PAPER TAPE THE TTY MESSAGE REPRESENTATION AND CONVERTS IT INTO IBM 7094 COMPUTER WORDS. THE HIGH-SPEED INPUT PROCESSORS DETERMINE WHETHER THE PREFERRED B-GE DATA IS ACCEPTABLE OR IF THE IP PROCESSED AN/FPS-16 DATA SHOULD BE USED FOR COMPUTATION. THE HIGH-SPEED INPUT PROCESSORS SEGREGATE DIS-

CRETE EVENT SIGNALS FROM RADAR INFORMATION.

THE HIGH-SPEED INPUT PROCESSORS, WHICH ACCOUNT FOR ALL INPUT DATA DURING THE LAUNCH/ABORT PHASE, ARE NOT USED THEREAFTER BECAUSE HIGH-SPEED INPUT DATA IS RECEIVED ONLY FROM THE CAPE KENNEDY TRACKING COMPLEX. LOW-SPEED DATA ACCOUNTS FOR ALL OF THE INPUT INFORMATION DURING ORBIT, REENTRY, AND ANY ABORT OUTSIDE THE RANGE OF THE CAPE RADARS.

THE LOW-SPEED OUTPUT PROCESSOR ACCEPTS COMPUTED DATA AND CONVERTS IT INTO THE STANDARD FORM FOR TTY ACQUISITION MESSAGES. THE SAME LOW-SPEED OUTPUT PROCESSOR IS USED FOR ALL PHASES. THE HIGH-SPEED OUTPUT PROCESSOR RECEIVES COMPUTED DATA AND CONVERTS IT INTO THE FORMAT NECESSARY TO DRIVE THE CAPE KENNEDY AND GODDARD DISPLAYS. THE GODDARD HIGH-SPEED OUTPUT PROCESSOR MUST SERVICE ONLY ONE DISPLAY, THE LOCAL PLOTBOARD, AND IS USED FOR ALL PHASES, ALTHOUGH DIFFERENT QUANTITIES ARE PLOTTED IN DIFFERENT PHASES. THE DISPLAYS AT THE MISSION CONTROL CENTER - THE VARIOUS PLOTBOARDS, STRIP CHARTS, DIGITAL AND CLOCK DISPLAYS - ARE THE PRIMARY MEANS OF MONITORING THE MISSION. THE HIGH-SPEED OUTPUT PROCESSOR FOR THE CAPE DISPLAYS DURING LAUNCH/ABORT IS DIFFERENT FROM THAT USED DURING ORBIT AND REENTRY.

THE MAIN PROCESSORS RECEIVE THE CONVERTED, VALIDATED DATA FROM THE INPUT PROCESSORS AND, USING THE LAUNCH/ABORT SUBROUTINES, COMPUTE THE FOLLOWING -

A) LATITUDE AND LONGITUDE OF THE PRESENT SPACECRAFT POSITION.

B) TABLES OF POSITION AND VELOCITY VECTORS AS A FUNCTION OF ALTITUDE AND TIME FOR BOTH ELLIPTIC AND CIRCULAR ORBITS.

C) LATITUDE AND LONGITUDE OF IMPACT FOR DIFFERENT

CONDITIONS OF ABORT.

D) ORBIT OR ABORT RECOMMENDATION.

E) RETROFIRE TIME CORRECTION.

F) CHANGE IN POSITION AND VELOCITY DUE TO RETRO-FIRE.

G) VALUES FOR THE MISSION CONTROL CENTER STRIP CHART.

7.4 ORBIT/REENTRY PROGRAMS

THE ORBIT PHASE BEGINS AFTER THE SPACECRAFT HAS BEEN INSERTED INTO ORBIT AND A GO-AHEAD COMMAND HAS BEEN GIVEN BY THE MISSION CONTROL CENTER. THE REENTRY PHASE BEGINS AT THE TIME THE SPACECRAFT RETROROCKETS ARE FIRED AND CONTINUES UNTIL IMPACT.

PROGRAMS FOR THE ORBIT PHASE OF THE GEMINI MISSIONS WILL HAVE THE CAPABILITY TO ACCURATELY DEFINE, PREDICT, AND CORRECT ORBIT PARAMETERS IN REAL TIME. ONE PROGRAM WILL SIMULATE SPACECRAFT THRUSTING. ANOTHER WILL COMPUTE AND RECOMMEND THE SPACECRAFT MANEUVERS REQUIRED TO ACHIEVE DESIRED CHANGES IN ORBIT. OUTPUTS WILL BE SPACE-CRAFT ORIENTATION, EXPRESSED IN PITCH AND YAW, AND THE THRUST DURATION REQUIRED TO OBTAIN THE DESIRED TRAJEC-TORY. RETROFIRE TIME WILL BE COMPUTED AS THE FIRING TIME TO PLACE THE SPACECRAFT ON THE TARGET AREA LONGITUDE BY USING APPROXIMATELY 40 PERCENT OF THE DOWNRANGE CAPABIL-ITY. NAVIGATION COMMANDS WILL BE COMPUTED FOR EACH OF TWO POSSIBLE NAVIGATION MODES WHICH THE SPACECRAFT ON-BOARD COMPUTERS MIGHT SELECT FOR THE REENTRY TRAJECTORY -

A) MODE 1 ASSUMES THAT THE SPACECRAFT WILL HOLD A PREDETERMINED BANK ANGLE (APPROXIMATELY 60 DE-GREES) AND, AT THE COMPUTER-RECOMMENDED TIME,

WILL ROLL TO THE NEGATIVE OF THAT ANGLE AND HOLD THIS NEW BANK ANGLE UNTIL IMPACT.

B) MODE 2 WILL REQUIRE A COMPUTED BANK ANGLE AND A TIME TO INITIATE SPACECRAFT ROLLING TO LAND AT A SPECIFIED IMPACT POINT.

DATA FROM STATIONS OBSERVING THE SPACECRAFT DURING THRUSTING MANEUVERS WILL BE HANDLED AS SPECIAL CASES IN THE DIFFERENTIAL CORRECTION PROGRAM. THE DATA WILL BE SORTED INTO PRE-THRUST, THRUST, AND POST-THRUST GROUPS. PRE-THRUST DATA WILL BE USED TO UPDATE THE ORBIT TO THE TIME WHEN THRUSTING BEGINS. POST-THRUST DATA WILL BE USED TO DEFINE THE ORBIT AFTER THE COMPLETION OF THRUSTING. LATE REPORTING STATIONS POSE ANOTHER SPECIAL CASE BECAUSE THE TIME TAGS OF THE OBSERVATION WILL HAVE TO BE COMPARED WITH THRUSTING TIMES BEFORE THE DATA CAN BE USED.

THROUGHOUT THE MISSION, TELEMETRY QUANTITIES FROM AROUND THE NETWORK WILL BE PROCESSED AND TRANSMITTED AS TELEMETRY SUMMARY MESSAGES. THIS PROCESSING WILL INVOLVE THE CONVERSION OF ''PERCENT FULL'' QUANTITIES TO ENGINEERING UNITS.

THE LIFTING AND BANKING CAPABILITY OF THE SPACECRAFT, TOGETHER WITH A COMPUTER CAPABILITY ON BOARD THE VEHICLE, WILL ENLARGE THE GROUND-BASED COMPUTER PROGRAM CONSIDERABLY. THE GSFC PROGRAM WILL HAVE TO KNOW OR BE ABLE TO DETERMINE, AT THE TIME OF REENTRY, WHICH NAVIGATION MODE IS BEING USED. THE LIFT REGION OF THE TRAJECTORY WILL IMPOSE NEW REQUIREMENTS ON THE EXISTING DIFFERENTIAL CORRECTION PROGRAMS. A DATA SMOOTHING TECHNIQUE MAY BE NEEDED IN PLACE OF, OR AS A SUPPLEMENT TO, DIFFERENTIAL CORRECTION DURING THE LIFT REGION OF REENTRY.

VOL I INTRODUCTION

A MODEL OF THE SPACECRAFT ON-BOARD COMPUTATION WILL BE REQUIRED IN THE GROUND COMPUTER TO PROVIDE THE GROUND-BASED COMPUTATIONAL BACKUP CAPABILITY REQUIRED DURING REENTRY.

TWO TYPES OF UPDATING INFORMATION WILL BE PROVIDED TO THE ON-BOARD COMPUTER - ORBIT NAVIGATION UPDATES AND PRE-RETROFIRE UPDATES. FOR ORBIT NAVIGATION UPDATING, A TIME AT WHICH THE UPDATE INFORMATION IS TO APPLY WILL BE FURNISHED TO GSFC DURING THE MISSION BY THE RETROFIRE OFFICER AT CAPE KENNEDY. THE TIME WILL BE INSERTED INTO THE COMPUTER, WHICH WILL THEN COMPUTE AND SEND TO SPECIFIED REMOTE STATIONS, VIA TTY CIRCUITS, A SET ORBIT PARAMETERS (X, Y, Z, X, Y, Z IN EARTH-CENTERED INERTIAL COORDINATES) WHICH WILL APPLY AT THE SPECIFIED TIME.

CONTROL LOGIC FOR HANDLING CONTINGENCY SITUATIONS WILL BE DEVELOPED, SUCH AS INABILITY OF THE SPACECRAFT TO LAND IN THE DESIGNATED TARGET AREA. IN SUCH A CASE, AN ALTERNATE TARGET AREA WILL BE SELECTED, AND NAVIGATION COMMANDS RECOMPUTED.

PRE-RETROFIRE UPDATE COMPUTATIONS WILL BE INITIATED BY MANUALLY INSERTING THE LONGITUDE AND LATITUDE OF A LANDING AREA REQUESTED BY THE CAPE KENNEDY RETROFIRE OFFICER. COMPUTER OUTPUTS WILL CONSIST OF A COMPUTED TIME TO FIRE RETROROCKETS TO LAND IN THE REQUESTED AREA AND A SET OF ORBIT PARAMETERS DEFINING THE TRAJECTORY AT THE COMPUTED RETROFIRE TIME.

THE MAIN PROCESSORS EDIT AND SMOOTH THE INPUT DATA AND PERFORM THE MATHEMATICAL COMPUTATIONS NECESSARY TO GENERATE ACQUISITION ORBITAL TRACKING, REENTRY IMPACT POINT, AND OTHER OUTPUT INFORMATION. THE PRIMARY FUNCTION OF DATA PROCESSING AFTER INSERTION IS TO DEFINE AND REFINE PRECISELY THE SPACECRAFT'S ORBIT AND PREPARE IN-

FORMATION RELEVANT TO A NORMAL OR ABNORMAL REENTRY.

THE MATHEMATICS OF ORBITAL COMPUTER PROCESSING INVOLVES SOLVING BY NUMERICAL METHODS THE FORMULAS DERIVED FROM THE BASIC NEWTONIAN EQUATIONS OF MOTION. THE NUMERICAL METHODS EMPLOYED INCLUDE COWELL'S NUMERICAL INTEGRATION FOR EXTRAPOLATION AND CORRECTION OF ORBITAL PARAMETERS AND THE DIFFERENTIAL CORRECTION, CONVERSION, AND PARTIAL COEFFICIENT CALCULATION PROGRAMS. TO MINIMIZE THE EFFECTS OF RADAR VALUES FROM STATIONS WHOSE INPUT DATA IS CONSIDERED (ON THE BASIS OF PAST RESULTS) LESS RELIABLE, ANOTHER PROCESSOR SUPPLIES COMPARATIVE WEIGHTS TO THE INPUTS FROM EACH SITE.

THE POSITION OF THE SPACECRAFT RELATIVE TO THE 18 EARTH SECTORS IS CHECKED EVERY MINUTE DURING ORBIT. EACH TIME THE SPACECRAFT ENTERS A NEW SECTOR, A PROCESSOR PROVIDES THE NECESSARY INFORMATION FROM THE SPACECRAFT POSITION TABLES TO GENERATE ACQUISITION DATA FOR DESIGNATED SITES.

OTHER PROGRAMS CONTINUOUSLY COMPUTE AND COMPARE THE VARIOUS CLOCK SETTINGS, THE MOST IMPORTANT OF WHICH IS THE SPACECRAFT CLOCK SETTING FOR RETROFIRE--TO PLACE THE IMPACT POINT WITHIN A DESIGNATED RECOVERY AREA. AFTER RETROFIRE, THE PROCESSORS CONTINUE TO COMPUTE THE SPACECRAFT POSITION TABLES UNTIL THE FLIGHT TERMINATES.

PRECEDING PAGE BLANK NOT FILMED.

8. UTILITY AND SUPPORTING PROGRAMS

THE COMPLEXITY OF THE GEMINI PROGRAMMING SYSTEM NECESSITATED THE DEVELOPMENT OF SPECIALIZED PROGRAMS, I.E., PROGRAMS OTHER THAN MONITOR AND PROCESSOR PROGRAMS AND IN ADDITION TO THE EXTERNAL SHARE OPERATING SYSTEM (SOS) AND THE SIMULATION PROGRAMS. THESE PROGRAMS ''OUTSIDE'' THE SYSTEM HAVE BEEN DEVELOPED TO - 1) AID IN SOLVING RECURRING COMPUTATIONAL PROBLEMS, SUCH AS SQUARE ROOT DERIVATIONS, 2) AID IN MAINTAINING SYSTEM PROGRAMS, SPECIFICALLY TO WRITE AND UPDATE SYSTEM TAPES, 3) ANALYZE LOG TAPES, AND 4) PROVIDE CORE DUMPING FUNCTIONS.

8.1 GENERAL

THE SUPPORT PROGRAMS FOR THE GODDARD REAL-TIME SYSTEM CONSIST OF POST-MISSION PROGRAMS, SIMULATION PROGRAMS, AND EXTERNAL PROGRAMS. THESE PROGRAMS ARE USED APART FROM THE GEMINI OPERATIONAL PROGRAMS TO RUN LIMITED SYSTEM CHECKS, TO MAKE DETERMINATIONS NOT OTHERWISE DONE, AND TO RECALCULATE DESIRED PARAMETERS AND VALUES NOT OTHERWISE RECORDED.

8.2 EXTERNAL PROGRAMS

EXTERNAL PROGRAMS ARE NEITHER MONITOR NOR PROCESSOR PROGRAMS, BUT ARE COMPLEMENTARY TO THE OPERATIONAL GODDARD REAL-TIME PROGRAMMING SYSTEM AND MAY BE ENTERED BEFORE, DURING, OR AFTER THE MISSION TO COMPILE THE GEMINI PROGRAM, WRITE THE OPERATIONAL SYSTEM TAPE, OR DUMP SELECTED PORTIONS OF CORE. THE EXTERNAL PROGRAMS (VO UME IV, PART 1) INCLUDE THE SHARE OPERATING SYSTEM, THE UTILITY PROGRAMS, AND THE SUPPORT PROGRAMS.

8.2.1 SHARE OPERATING SYSTEM

THE SHARE OPERATING SYSTEM (SOS), WITH MODIFICATIONS, IS THE STANDARD PROGRAMMING SYSTEM FOR PROJECT GEMINI. SOS IS USED BECAUSE OF ITS ADAPTABILITY TO THE VARYING CONDITIONS IMPOSED UPON A REAL TIME SYSTEM.

8.2.1.1 SOS COMPILER. THE SOS COMPILER TRANSLATES, COMPILES, AND ASSEMBLES. IT PROCESSES SYMBOLIC RECORDS, LIBRARY ROUTINES, AND PREVIOUSLY COMPILED PROGRAMS COMBINED WITH SUBSEQUENT SYMBOLIC PROGRAMS TO PRODUCE A TIGHTLY ENCODED (SQUOZE) BINARY DECK.

THE COMPILER USES SCAT (SHARE COMPILER, ASSEMBLER, AND TRANSLATOR), AN EXTENSION OF THE SOS SYMBOLIC LANGUAGE. SCAT FORMAT, ARITHMETIC EXPRESSIONS, VARIABLE FIELD EXPRESSIONS, SPECIAL CHARACTERS, MACHINE INSTRUCTIONS, PSEUDO-INSTRUCTIONS, AND MACRO INSTRUCTIONS ARE DETAILED IN VOLUME IV, PART 1.

8.2.1.2 SOS PRODUCED PROGRAM. THE SOS LISTING FACILITIES PROVIDE A MEANS OF OBTAINING NECESSARY INFORMATION WHEN MAKING PROGRAM MODIFICATIONS. THESE LISTINGS ARE IN SYMBOLIC FORM AS THIS IS THE MOST USEFUL METHOD FOR DETERMINING NECESSARY CHANGES, AND ARE ASSIGNED A NUMBER FROM ONE OR TWO REFERENCE SYSTEMS. THE NUMBERING SYSTEMS ARE CALLED RELATIVE AND ALTER, AND ARE USED TO REFER TO WORDS IN A PROGRAM. A RELATIVE NUMBER IS AN INTEGER WHICH INDICATES THE POSITION OF A MACHINE WORD RELATIVE TO A PRECEDING WORD HAVING A LOCATION SYMBOL - ALTER NUMBERS ARE NUMBERS FOR THE SYMBOLIC CARDS IN A SOURCE PROGRAM DECK.

8.2.1.3 SOS MODIFY AND LOAD. THE MAIN FUNCTIONS PERFORMED BY MODIFY AND LOAD ARE (1) THE MODIFICATION OF A SQUOZE PROGRAM ON THE BASIS OF SYMBOLIC INFORMATION SUPPLIED WITHIN THE SQUOZE DECK AND (2) LOADING THE MODIFIED VERSION OF A PROGRAM INTO STORAGE IN PREPARATION OF EXECUTION OF THE PROGRAM. MODIFY AND LOAD CAN ALSO PREPARE A NEW SQUOZE DECK INCORPORATING SYMBOLIC MODIFICATIONS, PREPARE A SYMBOLIC LISTING OF A PROGRAM FROM A SQUOZE DECK WITH NO MODIFICATIONS, AND PREPARE AN ABSOLUTE BINARY VERSION OF A PROGRAM.

MODIFICATIONS ARE MADE BY UTILIZING FOUR SCAT PSEUDO-OPERATIONS AS FOLLOWS -

NAME	PURPOSE
CHANGE	DELETES AND INSERTS WORDS USING RELATIVE ADDRESSES FROM A SYMBOLIC LOCATION.
ALTER	DELETES AND INSERTS EQUIVALENTS OF SYMBOLIC SOURCE PROGRAM CARDS INSTEAD OF MACHINE WORDS.
SYMBOL	PERMITS ASSIGNMENT OF A LOCATION SYMBOL TO A WORD WITHOUT REQUIRING THE DELETION AND SUBSEQUENT INSERTION OF THE WORD.
ASSIGN	DEFINES OR REDEFINES SYMBOLS.

8.2.1.4 SOS DEBUGGING MACROS. DEBUGGING MACROS PERMIT INVESTIGATION OF THE CONTENTS OF STORAGE OR CONTROL PANEL DURING EXECUTION OF A PROGRAM. THEY ARE USED DURING THE DEVELOPMENT PHASES OF A PROGRAM AND ARE REMOVED AFTER DEBUGGING HAS BEEN COMPLETED. THE DEBUGGING MACROS CAN BE THOUGHT OF AS EXTENSIONS OF THE SCAT PSEUDO-OPERATIONS AND, AS SUCH, CAN BE INSERTED INTO THE PROGRAM EITHER WHILE CODING OR AS MODIFICATIONS DURING MODIFY AND LOAD. DEBUGGING MACROS CAN BE INFORMATION

MACROS, WHICH REQUEST INFORMATION OUTPUT, MODAL MACROS, WHICH SPECIFY THE FORMAT OF THE OUTPUT, AND CONDITIONAL MACROS, WHICH PERMIT OUTPUT SELECTIVITY.

8.2.1.5 SOS MONITOR. THE SOS MONITOR IS A SUPERVISORY PROGRAM WHICH CONTROLS THE PROCESSING OF PROGRAM DECKS AND THEIR ASSOCIATED CONTROL CARDS (JOB DECKS). THE CONTROL CARDS DIRECT THE SOS MONITOR TO -

A. COMPILE A PROGRAM (LISTING AND SQUOZE DECK AS OUTPUT).
B. MODIFY AND LOAD A SQUOZE DECK FOR EXECUTION.
C. MODITY AND PUNCH A SQUOZE DECK TO PUNCH A CLEAN (NO MODIFICATIONS) SQUOZE DECK.
D. PRODUCE A LISTING OF A SQUOZE DECK WITH OR WITHOUT MODIFICATIONS.
E. PERMIT THE USE OF DEBUGGING MACROS.

8.2.2 SOS MODIFIED FOR GEMINI

TO ADAPT SOS FOR USE IN PROJECT GEMINI, CHANGES WERE MADE TO THE STANDARD SOS. THESE CHANGES, PLUS GEMINI SOS TAPE FEATURES AND GEMINI SOS LIMITATIONS, ARE GIVEN IN VOLUME IV, PART 1.

8.2.2.1 INCORPORATION OF GEMINI PROGRAMMER MACROS INTO SOS AS SYSTEM MACROS. THE GEMINI SOS SYSTEM TAPE DOES NOT INCLUDE ANY OF THE PROGRAMMER MACROS OF THE GODDARD REAL-TIME PROGRAMMING SYSTEM. THEREFORE, THE DEFINITION OF EACH MACRO MUST BE INSERTED AS MODIFICATION DURING EACH EXECUTION RUN IF ANY CHANGE OR ALTER INSERTS A USE OF THAT MACRO. HOWEVER IT IS POSSIBLE TO INCORPORATE THESE MACROS INTO SOS SO THEY CAN BE AVAILABLE WITHOUT RE-DEFINITION AT MODIFY AND LOAD TIME.

8.2.2.2 COMPONENTS OF THE GEMINI SOS PROGRAMMING SYSTEM. THE COMPLETE GEMINI SOS PROGRAMMING SYSTEM CONSISTS OF -

A. THE GEMINI SOS SYSTEM TAPE, WHICH INCLUDES THE NEW YORK SOS SYSTEM TAPE WITH GRTS MODIFICATIONS.
B. THE SOS LIBRARY TAPE (GEMINI LIBRARY TAPE PLUS THE REGULAR LIBRARY TAPE).
C. ONE CARD DECK USED TO WRITE AND UPDATE THE GEMINI SYSTEM TAPE.
D. TWO CARD DECKS OF COLUMN BINARY SQUOZE CARDS, ONE WITH GRTS MODIFICATIONS FOR GEMINI AND ONE FOR SHARE OR THE NEW YORK SOS.
E. A FOLDER OF LISTINGS FOR THE SELECTIONS TO SOS.

8.2.2.3 GEMINI SOS TAPE. USING SYMBOLIC CONTROL CARDS FOR THE BINARY PROGRAMS WHICH COMPRISE SOS, THE SOS TAPE-WRITER PROGRAM, IBWR1, WRITES THE COMPLETE SOS SYSTEM TAPE. THE SYSTEM TAPE THEN MAY BE PLACED, DUPLICATED, OR EDITED BY THE SELF-LOADING EDITING PROGRAM, IBWR2.

8.2.2.4 SOS LIBRARY TAPE. THE SOS LIBRARY TAPE CONSISTS OF UTILITY COMPUTATIONAL SUBROUTINES WHICH ARE, IN EFFECT, PROGRAMMING AIDS THAT REDUCE THE AMOUNT OF PROGRAMMER CODING NEEDED TO INCLUDE A SPECIFIC MATHEMATICAL PROCESS IN A PROGRAM. TO ALLOW VARIOUS PROGRAMS OF THE GODDARD REAL-TIME PROGRAMMING SYSTEM TO SHARE SOME LIBRARY PROGRAMS, IT WAS NECESSARY TO RECODE THESE LIBRARY PROGRAMS TO PROTECT INTERMEDIATE OR TEMPORARY RESULTS FROM PROGRAM INTERRUPTS AND SUBSEQUENT ENTRY INTO THE LIBRARY PROGRAM BEFORE THE INTERRUPTED PASS COULD BE COMPLETED. THIS RECODING NECESSITATES THE MAINTENANCE OF

TWO LIBRARY TAPES, THE REGULAR SOS LIBRARY TAPE AND THE GEMINI SOS LIBRARY TAPE. ON THE REGULAR SOS LIBRARY TAPE EACH PROGRAM CONTAINS ITS OWN TEMPORARY STORAGE. THE GEMINI SOS LIBRARY TAPE PROGRAMS ARE AS FOLLOWS -

NAME	PURPOSE
U1SICO	COMPUTES THE SINE OR COSINE OF AN ANGLE.
U1EXPE	COMPUTES THE VALUE OF THE NATURAL EXPONENTIAL FUNCTION E .
U1SQRT	COMPUTES THE SQUARE ROOT OF A NUMBER.
U1LOGE	COMPUTES THE NATURAL LOGARITHM OF A NUMBER.
U1ATAB	COMPUTES THE ARC TANGENT OF THE QUOTIENT A DIVIDED BY B.
U1ATNA	COMPUTES THE ARC TANGENT OF A NUMBER.
U1ASCO	COMPUTES THE ARC SINE OR THE ARC COSINE OF A NUMBER.
U1TACO	COMPUTES THE TANGENT OR THE COTANGENT OF AN ANGLE.
U1FXPT	CONVERTS A NUMBER FROM FLOATING-POINT TO FIXED-POINT FORMAT.
U1FLPT	CONVERTS A NUMBER FROM FIXED-POINT TO FLOATING FORMAT.
U3DOTP	COMPUTES THE DOT (INNER) PRODUCT OF TWO REAL 3-DIMENSIONAL VECTORS.
U3XPRO	COMPUTES THE CROSS (OUTER) PRODUCT OF TWO REAL 3-DEMENSIONAL VECTORS.
U3MATM	COMPUTES THE PRODUCT OF TWO MATRICES.
UA1LSC	CONVERTS AN INERTIAL POSITION VECTOR INTO VALUES OF RANGE, AZIMUTH, AND ELEVATION.
U7INTP	PERFORMS A 6-POINT LAGRANGIAN INTERPOLATION TO DETERMINE INTERMEDIATE VALUES OF RADIUS OR RADIUS AND VELOCITY VECTORS.
U3VMAG	GENERATES THE MAGNITUDE OF A GIVEN VECTOR.

U3UNTV	GENERATES THE UNIT VECTOR OF A GIVEN VECTOR.
C9RVTH	PREDICTS POSITION AND VELOCITY OF SPACECRAFT ASSUMING ELLIPTICAL MOTION AND NO DRAG.
C9ASKE	SOLVES KEPLER'S EQUATION M = E - SIN E.
LBRWR	PREPARES A LIBRARY TAPE OF UTILITY SUBROUTINES FOR USE WITH GEMINI SOS.

8.2.3 UTILITY PROGRAMS

UTILITY PROGRAMS COMPLEMENT MONITOR AND COMPUTATIONAL PROGRAMS. THEY ARE SERVICE PROGRAMS WHICH PRODUCE INPUT TAPES, PROCESS OUTPUT TAPES, AND SATISFY VARIOUS SPECIALIZED NEEDS.

MANY UTILITY PROGRAMS ARE RECORDED ON A C1 UTILITY TAPE TO PROVIDE AVAILABILITY OF UTILITY PROGRAMS AS NEEDED. EACH SUCH UTILITY PROGRAM APPEARS ON THE C1 TAPE AS A SINGLE RECORD, LOADING INSTRUCTIONS ARE AT THE BEGINNING OF EACH RECORD.

PROGRAM SELECTION AND LOADING FROM THE C1 UTILITY TAPE IS ACCOMPLISHED WITH THE USE OF A CALL CARD. THE INFORMATION CONTAINED ON THIS TYPE OF CARD POSITIONS THE TAPE TO THE DESIRED RECORD AND INITIATES THE LOADING ACTION. BEFORE POSITIONING AND AFTER LOADING, A CALL CARD REWINDS THE C1 TAPE. ONCE LOADED, EACH PROGRAM IS IDENTIFIED ON THE ON-LINE PRINTER BEFORE ITS OPERATION.

THE UTILITY PROGRAMS ARE AS FOLLOWS -

NAME	PURPOSE
MXCHER	READS B6 LOG TAPE, SELECTS AND PREPARES FOR OFF-LINE PRINTING IN OCTAL INPUT-OUTPUT DATA IDENTIFIED WITH SELECTED DCC SUB-CHANNEL NUMBERS.
MXPOCL	READS B6 LOG TAPE, PREPARES RECORDED INFORMATION FOR OFF-LINE PRINTING IN OCTAL.

MXILCO	INTERPRETS AND FORMATS FOR OFF-LINE PRINTING THE REAL-TIME CORED OUTPUT RECORDED ON B6 LOG TAPE BY MTCOR AND MSCORE.
COLBER	MAINTAINS AND MANIPULATES SYMBOLIC DECKS IN LARGE-SCALE COMPUTING SYSTEMS USING SOS.
CORMAP	RECORDS ON A2 SELECTED LINES FROM AN SOS LISTING.
MXNDKT	PREPARES A LISTING FOR THE USE OF IN-PROCESS, READY, AND SUPPRESSION INDICATORS FOR THE GEMINI COMPILATIONS.
SQZSUM	REPRODUCES COLUMN-BINARY SQUOZE CARDS WITH THE CHECKSUM CORRECTED.
KEYS	EXAMINES A PROGRAM LISTING TAPE AND PRINTS OUT EACH INSTRUCTION WHICH HAS A DIRECT ADDRESS EQUAL TO THE LOCATION ENTERED IN THE CONSOLE KEYS.
LOWCOR	EXAMINES A PROGRAM LISTING AND RECORDS EACH INSTRUCTION WITH A DIRECT ADDRESS LESS THAN 0040.
COMPAR	COMPARES CORRESPONDING RECORDS FROM TWO PROGRAM LISTINGS AND RECORDS THE LOCATIONS OF THOSE WHICH ARE NOT IDENTICAL.
SUMARY	ANALYZES THE SQUOZE TAPE OF ANY SOS-ASSEMBLED PROGRAM AND ESTIMATES THE ALLOWABLE NUMBER OF MODIFICATIONS IN THAT PROGRAM FOR AN SOS EXECUTION RUN.
PAPTAP	PREPARES PAPER TAPES IN TTY CODING FOR THE GEMINI TRACKING PROGRAM.
MXTHLG	EXAMINES THE MXPRLG OUTPUT TAPE FOR LOW-SPEED TTY DATA RECEIVED FROM GEMINI RADAR STATIONS AND UNPACKS, CONVERTS, AND FORMATS IT FOR OFF-LINE PRINTING.

HSIN7	EXAMINES THE LOG TAPE FOR HIGH-SPEED IP 7094, B-GE, OR BERMUDA RADAR INPUT MESSAGES.
MXHSPR	EXAMINES THE LOG TAPE FOR HIGH-SPEED OUTPUT DATA TRANSMITTED TO CAPE KENNEDY AND UNPACKS SCALES, AND ARRANGES THE DATA FOR OFF-LINE PRINTING.
MXHSGP	EXAMINES THE LOG TAPE FOR HIGH-SPEED OUTPUT DATA TRANSMITTED TO CAPE KENNEDY AND UN-PACKS, SCALES, AND ARRANGES THE DATA FOR OFF-LINE PRINTING IN GEMINI FORMAT.
MXPRLG	EXTRACTS KEY-SELECTED INPUT AND OUTPUT DATA FROM THE LOG TAPE FOR OFF-LINE PRINTING IN A SPECIALIZED FORMAT.
MXHSPL	DISPLAYS ON THE GSFC PLOTBOARD THE DATA FROM THE LOG TAPE USED DURING A PREVIOUS GODDARD REAL-TIME PROGRAMMING SYSTEM RUN TO DRIVE PLOTBOARDS 1 THROUGH 4 AND THE WALL MAP IN THE MISSION CONTROL CENTER.

8.2.4 SUPPORTING PROGRAMS

THE GEMINI SUPPORTING PROGRAMS PERFORM ALL FUNCTIONS NECESSARY FOR OBJECT PROGRAM EXECUTION THAT CANNOT BE PERFORMED DURING THE MISSION. BASICALLY, SUPPORTING PROGRAMS PRODUCE THE DEBUG GEMINI SYSTEM TAPES. SINCE THEY ARE NOT PART OF THE REAL-TIME TRACKING SYSTEM, THEY ARE USED EITHER BEFORE OR AFTER EACH REAL-TIME OPERATION.

THE SUPPORT PROGRAMS ARE AS FOLLOWS -

NAME	PURPOSE
MXMRGE	MERGES SYMBOLIC CARDS INTO SQUOZE DECK (ON TAPE) TO PRODUCE A JOB TAPE.
MXLOAD	LOADS INTO CORE THE PROGRAMS AND TABLES NEEDED BY THE GEMINI OPERATIONAL SYSTEM FOR

LAUNCH DATA PROCESSING.

MXDEFN AUTOMATICALLY EXTENDS THE DEFINITION OF SPECIFIED SYMBOLS AMONG ''N'' SEPARATELY COMPILED JOBS DURING PROGRAM EXECUTION.

SETORG COMMUNICATES COMMON INFORMATION BETWEEN JOBS 1 AND 2 DURING DUAL COMPILATION.

MTTEST LOCATES PROGRAM ERRORS.

WRTB4T WRITES AND PERMITS MODIFICATIONS TO THE FIRST THREE FILES ON THE B4 TAPE WHICH CONTAIN PROGRAMS USED TO WRITE THE OPERATIONAL GEMINI SYSTEM TAPE.

ISODMP PRODUCES A SYMBOLIC DUMP OF THE GEMINI OPERATIONAL SYSTEM.

SGENDX PREPARES FOR A SYSTEM DUMP BY READING THE DUALDP DUMP PROGRAM (A SUBROUTINE OF ISODMP) AND THE SOS SNAP FILE.

CORING INITIALIZES THE SOS SNAP PROGRAM SO THAT FILES FROM DIFFERENT COMPILATIONS MAY BE SNAPPED ON DIFFERENT TAPES.

MXWMOT PREPARES THE MESSAGE TAPE FOR THE GODDARD REAL-TIME PROGRAMMING SYSTEM.

UOSTCH GENERATES THE STATION CHARACTERISTICS TAPE FOR THE GODDARD REAL-TIME PROGRAMMING SYSTEM.

UOSTUP INSERTS, DELETES, AND CHANGES STATION BLOCKS ON THE STATION CHARACTERISTICS TAPE.

8.2.5 SHARE OPERATING SYSTEM (SOS)

SHARE IS AN ORGANIZATION FORMED BY USERS OF THE IBM-704/709/7090/7094 DATA PROCESSING SYSTEMS FOR THE EXCHANGE OF PROGRAMMING INFORMATION AND THE MUTUAL DEVELOPMENT OF PROGRAMMING STANDARDS. THE SHARE OPER-

ATING SYSTEM (SOS) IS A PRIMARY MACHINE LANGUAGE PROGRAMMING SYSTEM USED WITH IBM 704/709/7090/7094 COMPUTERS.

TO CODE VARIOUS PARTS OF THE GEMINI PROJECT SIMULTANEOUSLY, CERTAIN RESTRICTIONS HAD TO BE PLACED ON EACH PROGRAMMER SO THE JOINT PROGRAMMING EFFORTS COULD BE COMPILED WITHOUT DIFFICULTY. THIS NECESSITATED THE ESTABLISHMENT OF SPECIAL FEATURES TO GUIDE THE PROGRAMMER IN WRITING PROGRAMS -

A) A SPECIAL NOTATION FOR EACH SECTION OF THE GEMINI PROGRAM.

B) A SPECIAL NOTATION FOR COMMUNICATION BETWEEN PROGRAMMERS.

C) A SPECIAL CODING FOR MACHINE HARDWARE OPERATION.

D) THE USE OF SIX-CHARACTER SYMBOLS, COMMUNICATION CELLS, AND CONSTANTS.

CERTAIN CONSTANTS, SUCH AS THE ROTATIONAL SPEED OF THE EARTH, HAD TO BE ESTABLISHED, THESE VALUES WERE DETERMINED BY NASA AND CONFIRMED BY DR. HERGET OF THE CINCINNATI OBSERVATORY.

MATHEMATICIANS HAD TO BE CONSISTENT IN THEIR USAGE OF GREEK LETTERS TO DESIGNATE THE VARIOUS UNITS OF SPACE AND TIME. THERE WAS ALSO A NEED FOR CONSISTENCY IN DEFINING THE COORDINATE SYSTEMS TO BE USED THROUGHOUT ALL PROGRAMS AND IN DEFINING THE CONVERSION OF LOCAL COORDINATE SYSTEMS TO SPHERICAL, AND VICE VERSA. FURTHERMORE, BECAUSE CERTAIN ROUTINES WOULD BE USED TO A GREAT EXTENT IN GEMINI SYSTEM CODING, A LIBRARY TAPE WAS DEVELOPED TO ENSURE CONSISTENCY AND EASE OF CODING.

THE USE OF SOS OFFERS THE FOLLOWING ADVANTAGES -

A) RELATIVE EASE IN ALTERATION OF PROGRAMS DURING THE CODING AND TESTING STAGES.

B) CONTROL OVER THE ALLOCATION OF STORAGE.

C) EXECUTION OF VARIOUS PROGRAMS WHICH ARE IN DIFFERENT STAGES OF DEVELOPMENT.

D) CONTROL OVER INDIVIDUAL DATA (REAL-TIME INPUTS), AN ABSOLUTE NECESSITY.

E) INCORPORATION OF COMMON LIBRARY SUBROUTINES.

SOS ALSO PROVIDES THE ADVANTAGES OF SYMBOLIC ASSEM-- BLY AND ELIMINATES THE DISADVANTAGES OF OTHER ASSEMBLY SYSTEMS. CHANGES IN SYMBOLIC FORM CAN BE MADE IN LITTLE MORE TIME THAN IT TAKES TO LOAD BINARY PUNCHED CARDS. DEBUGGING INFORMATION CAN BE LISTED IN SYMBOLIC FORM RATHER THAN IN ACTUAL LANGUAGE, AS WAS PREVIOUSLY REQUIRED.

OTHER PROVISIONS OF SOS INCLUDE -

A) THE USE OF MNEMONIC OPERATION CODES (INCLUDING A LARGE GROUP OF PSEUDO-OPERATIONS).

B) ARBITRARILY CHOSEN LOCATION SYMBOLS.

C) RELATIVE AND COMPLEX ADDRESSING.

D) THE DEFINITION OF SPECIAL-PURPOSE MACRO-INSTRUC- TIONS FOR USE IN A GIVEN PROGRAM.

ALTHOUGH SOS IS ACTUALLY AN INTEGRATED SYSTEM, IT HAS, FOR CONVENIENCE AND EASY REFERENCE, BEEN DIVIDED INTO THE FOLLOWING SUBSYSTEMS -

A) THE SHARE COMPILER-ASSEMBLER-TRANSLATOR (SCAT), SUBDIVIDED INTO -

1) COMPILER

2) LISTER

3) MODIFY AND LOAD

B) THE DEBUGGING SYSTEM (PROGRAM TESTING AND COR- RECTION), WHICH INCLUDES THE SNAP AND SNAPTRAN PROGRAMS.

C) THE INPUT-OUTPUT SYSTEM.

D) MONITOR

8.2.5.1 SHARE COMPILER-ASSEMBLER-TRANSLATOR (SCAT). THIS SUBSYSTEM CONSISTS OF THREE DIFFERENT PARTS - COMPILER, LISTER, AND MODIFY AND LOAD. THESE THREE PARTS TOGETHER PERFORM ALL THE FUNCTIONS ASSOCIATED WITH SYMBOLIC ASSEMBLY. IN ADDITION, SCAT PRODUCES SYMBOLIC LISTINGS, PERFORMS ALL THE MECHANICS OF INCORPORATING MODIFICATIONS INTO A PROGRAM, AND LOADS PROGRAMS FOR EXECUTION.

COMPILER

THE COMPILER ASSEMBLES THE FIRST PART OF A SYMBOLIC SOURCE PROGRAM. THIS FUNCTION CONSISTS OF READING SYMBOLIC CARDS, TRANSLATING THE INFORMATION, AND PRODUCING A COMPACT BINARY-CODED-SYMBOLIC (SQUOZE) FORM OF THE PROGRAM. THE SQUOZE FORM OF THE PROGRAM CONTAINS ALL THE INFORMATION, INCLUDING REMARKS CARDS AND COMMENTS FROM INSTRUCTION CARDS, SUPPLIED IN THE SOURCE PROGRAM.

THE SQUOZE DECK PRODUCED BY THE COMPILER MAY BE USED IN EITHER OF TWO WAYS -

A) IT MAY BE USED WITH A SYMBOLIC DECK AND OTHER SQUOZE DECKS AS INPUT TO SUBSEQUENT COMPILER PASSES AND THEN INCORPORATED WITH THE SYMBOLIC DECK TO FORM ONE OUTPUT SQUOZE PROGRAM. THIS FEATURE MAKES IT POSSIBLE TO WRITE A PROGRAM IN PARTS AND TO DEBUG EACH PART BEFORE COMBINING THEM.

B) IT MAY BE USED AS INPUT TO MODIFY AND LOAD, WHICH COMPLETES ASSEMBLY AND LOADS THE PROGRAM FOR EXECUTION.

ANOTHER POWERFUL TOOL OF THE COMPILER IS THE MACRO-OPERATION CONCEPT. THE COMPILER IS BUILT TO RECOGNIZE A

LARGE, FIXED NUMBER OF MACRO-OPERATIONS. IT ALSO ACCEPTS AND TEMPORARILY RETAINS DEFINITIONS OF MACRO-OPERATIONS GIVEN BY THE PROGRAMMER. IN EITHER CASE, IT GENERATES AND INSERTS INTO THE PROGRAM THE SEQUENCE OF MACHINE WORDS SPECIFIED BY ANY ONE OF THESE MACRO-OPERATIONS IN A MACRO-INSTRUCTION.

LISTER

THE SCAT LISTER IS ACTUALLY A PART OF THE MODIFY AND LOAD PROGRAM. HOWEVER, SINCE THE LISTER IS USED BY THE COMPILER AS WELL AS BY MODIFY AND LOAD, AND BECAUSE KNOWLEDGE OF CERTAIN FEATURES OF THIS LISTING PRODUCED BY SCAT ARE REQUIRED FOR AN UNDERSTANDING OF MODIFY AND LOAD, THE LISTER IS CONSIDERED SEPARATELY HERE.

THE LISTER PROVIDES THE COUNTERPART OF PROGRAM ASSEMBLY LISTING. THE LISTINGS PRODUCED INCLUDE ALL THE SYMBOLIC INFORMATION, REMARKS, AND COMMENTS FROM THE ORIGINAL SOURCE PROGRAM DECK AS MODIFIED BY SUBSEQUENT CHANGES. A MACHINE LANGUAGE PROGRAM IS ALSO GENERATED BY THE LISTER.

MODIFY AND LOAD

MODIFY AND LOAD COMPLETES THE ASSEMBLY OF INPUT, INCORPORATES SYMBOLIC MODIFICATIONS (IF INCLUDED WITH THE INPUT), AND LOADS THE PROGRAM INTO STORAGE FOR EXECUTION. INPUT TO MODIFY AND LOAD CONSISTS OF A SQUOZE PROGRAM AND, WHEN NECESSARY, SYMBOLIC CARDS WHICH INDICATE CHANGES TO BE MADE IN THE PROGRAM.

MODIFY AND LOAD ALSO OFFERS THE FOLLOWING FEATURES -

A) A NEW SQUOZE PROGRAM INCORPORATING SYMBOLIC CHANGES CAN BE PREPARED WHEN DESIRED (A NEW LISTING OF THE PROGRAM IS ALSO PREPARED).

B) AN ABSOLUTE BINARY DECK CAN BE PUNCHED FROM A SQUOZE PROGRAM.

C) A NEW LISTING OF A PROGRAM IN SQUOZE FORM CAN BE PREPARED WHEN REQUIRED.

8.2.5.2 THE DEBUGGING SYSTEM. THE DEBUGGING SYSTEM CONSISTS OF A GROUP OF CLOSED SUBROUTINES AND THEIR ASSOCIATED MACRO-INSTRUCTIONS WHICH MAY BE WRITTEN INTO A PROGRAM AT STRATEGIC POINTS OR INCLUDED AS PROGRAM CHANGES THROUGH MODIFY AND LOAD. THESE SUBROUTINES SUPPLY THE INSTRUCTIONS NECESSARY TO PRINT OUT SYMBOLIC INFORMATION WHICH AIDS IN DEBUGGING.

8.2.5.3 INPUT-OUTPUT SYSTEM. THE INPUT-OUTPUT SYSTEM CONSISTS OF A SET OF MACRO-INSTRUCTIONS WHICH GENERATES IN A PROGRAM THE INSTRUCTIONS NECESSARY FOR SEVERAL TYPES OF INPUT AND OUTPUT. THESE MACRO-INSTRUCTIONS ARE GENERAL-PURPOSE TYPES AND ARE INTENDED TO BE INTERSPERSED WITH MACHINE INSTRUCTIONS, AS NECESSARY, TO ACHIEVE SPECIAL PURPOSE INPUT-OUTPUT FOR A GIVEN JOB.

8.2.5.4 MONITOR-SUPERVISORY CONTROL. MONITOR IS THE CONTROL FUNCTION OF THE SOS SYSTEM. THERE ARE TWO SOMMONLY USED MONITORS IN USE WITH SOS INSTALLATIONS, THE ''SHARE'' OF ''MOCK-DONALD'' MONITOR, OPERATING AS A THREE-PHASE MONITOR, AND THE IB-MONITOR, A SINGLE-PHASE MONITOR. PROJECT GEMINI USES THE IB VERSION, AND ALL SUBSEQUENT REFERENCES TO THE SOS MONITOR THROUGHOUT GEMINI DOCUMENTATION IMPLIES THE IB VERSION OF THE SOS MONITOR. INPUT TO THE MONITOR PROGRAM CONSISTS OF ONE OR MORE JOB DECKS. A JOB DECK IS A PROGRAM DECK (SYMBOLIC, SQUOZE, OR ANY COMBINATION OF THE TWO) WITH CONTROL CARDS

WHICH INDICATE THE FUNCTIONS TO BE PERFORMED ON THE PROGRAM, E.G., COMPILE, LIST, LOAD, ETC. THIS DECK IS PROCESSED BY SOS AND IS CONTROLLED WHILE IN PROCESS BY THE MONITOR AS SPECIFIED IN THE CONTROL CARDS IN THE JOB DECK.

WHEN A JOB DECK IS USED AS INPUT, MONITOR READS THE CONTROL CARDS, DETERMINES THE SEGMENT OF SOS REQUIRED FOR PROCESSING THE DECK, AND LOADS THE REQUIRED PART. CONTROL IS THEN TRANSFERRED TO THE PROCESSOR LOADED BY MONITOR. THAT PROGRAM THEN PROCESSES INPUT UNTIL THE END OF THE JOB DECK IS REACHED, A NEW CONTROL CARD IS ENCOUNTERED, OR AN ERROR OCCURS. WHEN THE END OF THE DECK IS REACHED OR A NEW CONTROL CARD IS ENCOUNTERED, THE MONITOR IS REINITIALIZED AND THE PROCESS IS REPEATED. IF AN ERROR OCCURS, THE MONITOR PRINTS A MESSAGE INDICATING THE ERROR, AND, IF POSSIBLE, CONTINUES PROCESSING THE JOB. IF IT 2S NOT POSSIBLE FOR THE MONITOR TO CONTINUE, IT SKIPS TO THE NEXT JOB.

8.2.5.5 MODIFICATIONS TO SOS FOR PROJECT GEMINI. AN IMPORTANT POINT TO MENTION HERE IS THE NEED FOR MODIFICATION TO A SYSTEM (SOS) TO MEET THE REQUIREMENTS FOR THE GEMINI PROGRAMMING SYSTEM. SOS IS A DYNAMIC PROGRAMMING SYSTEM MAINTAINED BY THE IBM APPLIED PROGRAMMING DEPARTMENT FOR USERS OF THE IBM 709/7090/7094 DATA PROCESSING SYSTEMS. THE SHARE ORGANIZATION CONTINUALLY REVIEWS SOS WITH A VIEW TOWARD CORRECTING KNOWN OR SUSPECTED ERRORS, AND MAKING IMPROVEMENTS TO AID ITS MEMBER USERS WITH THEIR CHANGING NEEDS. SHARE ACCORDINGLY RECOMMENDS CHANGES TO IBM APPLIED PROGRAMMING, AND AS CHANGES ARE INCORPORATED INTO THE SYSTEM, THEY ARE DISSEMINATED BY THE SHARE DISTRIBUTION AGENCY IN THE FORM

OF ''DISTRIBUTIONS.''

IN ORDER TO INCORPORATE CERTAIN SPECIAL FEATURES IN A TIMELY MANNER, I.E., WITHOUT NECESSARILY WAITING FOR SHARE TO PROMULGATE THEM, A SYSTEMS AND STANDARDS SUB-GROUP OF THE IBM PROGRAMMING STAFF FOR PROJECT GEMINI WAS ENGAGED TO MAKE LOCAL MODIFICATIONS TO SOS. THIS INVOLVED PERFORMING THE NECESSARY TESTS AND GENERATION OF TAPES. TO ACCOMPLISH THIS TESTING AND TAPE PREPARATION IN TIME FOR THE GEMINI SHOTS, IT WAS SOMETIMES NECESSARY TO FOREGO INCLUSION OF THE MOST RECENT CHANGES FROM SHARE. THUS PROJECT GEMINI, AS IS THE CASE WITH MOST SYSTEM USERS, DEVELOPED A SYSTEM TAPE DIFFERING IN DETAILS FROM THE STANDARD SHARE DISTRIBUTED SOS TAPE.

THE GEMINI SOS SYSTEM CONSISTS OF -

A) SEVERAL COPIES OF THE GEMINI SOS TAPE.

B) TWO SOS LIBRARY TAPES AND THEIR DUPLICATES - REGULAR SOS LIBRARY AND GEMINI SOS TAPE.

C) THE NEW YORK SOS SYSTEM TAPE AND DUPLICATES - LABELED SHARE SOS TAPE.

D) THE COMPLETE SYSTEM IN ABSOLUTE BINARY CARDS, USED TO WRITE THE GEMINI SOS TAPE, AND ANOTHER ABSOLUTE BINARY DECK, USED TO WRITE THE SHARE SOS TAPE.

E) EACH COMPLETE SYSTEM (GEMINI AND SHARE) IN COLUMN-BINARY SQUOZE CARDS WITH APPROPRIATE MODIFICATIONS.

F) LISTINGS FOR THE SECTIONS OF THE SOS SYSTEM. ALSO BCD TAPES FROM WHICH DUPLICATE LISTINGS MAY BE PRINTED.

8.2.6 DUAL COMPILATIONS

A PRIMARY OBSTACLE TO SYSTEMS GROWTH INVOLVED THE

LIMITATIONS INHERENT IN THE SOS CONTROL SYSTEM. AN ORGANIC SYSTEM, SOS UNDERGOES CONTINUOUS MODIFICATION AND DEBUGGING AND MANY CHANGES HAVE BEEN AND ARE BEING MADE IN TAILORING SOS TO THE UNIQUE REQUIREMENTS OF THE GEMINI PROGRAM. HOWEVER, UTMOST CARE HAS BEEN TAKEN TO AVOID CREATING AN SOS SYSTEM WHICH DIFFERS RADICALLY FROM THAT MAINTAINED BY IBM THROUGH THE SHARE ORGANIZATION. THE BASIC PHILOSOPHY FOLLOWED IN TAILORING SOS FOR THE GEMINI SYSTEM SUPPORT REQUIRES THAT (1) THE NORMAL ACTION OF SOS FOR ALL JOBS OTHER THAN THE GEMINI SYSTEM WILL NOT BE ALTERED OR INTERFERED WITH, (2) PRIMARY CONSIDERATION WILL BE GIVEN TO CONFINING ALL GEMINI MODIFICATIONS TO THE COMPARATIVELY SIMPLE IB MONITOR SECTION OF SOS, AND (3) WHENEVER EITHER OR BOTH OF THE FIRST TWO RULES CANNOT BE APPLIED, MODIFICATION OF SOS WILL BE SIMPLIFIED AND CENTRALIZED BY DYNAMIC MODIFICATIONS AND/OR THE ESTABLISHMENT OF COMMUNICATION REGIONS BETWEEN THE GEMINI SYSTEM PREPROCESSORS, POSTPROCESSORS, AND SOS.

COMPARATIVELY MINOR CHANGES HAVE MOST OFTEN BEEN INCORPORATED AS NEED DICTATED, ALTHOUGH WHEN DIFFICULTY RESULTED FROM SOS'S REJECTION OF A 'MODIFY, LOAD, AND GO' MODIFICATION DECK, ONLY TWO SOLUTIONS HAVE BEEN AVAILABLE - (1) REDUCING THE SIZE OF THE MODIFICATION DECK AS A TEMPORARY MEASURE OR (2) RECOMPILING AS A MORE PERMANENT SOLUTION. ALTHOUGH BOTH SOLUTIONS WERE USED, NEITHER WAS COMPLETELY DESIRABLE. REDUCING THE SIZE OF THE MODIFICATION DECK OFTEN PRECLUDED FULL SCALE SYSTEM TESTING OF MAJOR CHANGES IN THE OPERATIONAL PROGRAM. INCORPORATING THE MODIFICATIONS INTO A COMPILATION MAY FORCE USAGE OF SOME CHANGES WITHOUT SUFFICIENT TESTING, AND WHILE THE RECOMPILATION SCHEME SOLVED TEMPORARY

PROBLEMS, IT SIMULTANEOUSLY REDUCED THE MODIFICATION LIMITS OF THE GENERATED GEMINI SYSTEM.

HOWEVER, SOME SOS LIMITS ARE APPARENTLY IMMUTABLE. ESPECIALLY NOTABLE IS THE TERMINAL LIMIT OF 32,768 SYMBOLIC CARDS (TAPE RECORDS) BEYOND WHICH COMPILATION IS IMPOSSIBLE. SOS SIMPLY HAS NOT BEEN DESIGNED TO SUPPORT A SYSTEM OF THE MAGNITUDE ATTAINED BY THE GEMINI PROGRAM AND NO ALTERNATIVE SYSTEM OFFERED THE SPECIFIC ADVANTAGES OF SOS-DEBUGGING AIDS, SYMBOLIC CORE DUMPS, EASE OF MODIFICATION, AND THE BASIC MACHINE LANGUAGE NECESSARY TO CODE EFFICIENTLY A REAL-TIME PROGRAM.

TO CONTINUE PROGRAMMING IN SOS, A MAJOR MODIFICATION OR EXTENSION IN SYSTEM'S TECHNIQUES WOULD BE REQUIRED. IF THE GEMINI PROGRAMMING SYSTEM COULD BE SECTIONED AND EACH RESULTING SECTION COMPILED AS A SEPARATE JOB, THE LIMITATIONS OF SOS COULD BE PRORATED OVER A NUMBER OF JOBS SUFFICIENT TO MINIMIZE, AND EFFECTIVELY ELIMINATE, THE SIGNIFICANT INHERENT LIMITS OF SOS. SUCH A DIVISION WOULD REQUIRE A COMMON MODE OF COMMUNICATION TO ENSURE INTERJOB COMPATIBILITY IN RECONSTRUCTING FROM THE SEPARATE JOBS THE COMPLETE GEMINI PROGRAM FOR SYSTEM TESTING. THE FEASIBILITY OF THIS APPROACH HAS BEEN DEMONSTRATED BY THE DUAL COMPILATION TECHNIQUES.

WHILE IN THEORY ANY DIVISION PRODUCING JOBS WHICH WERE APPROXIMATELY EQUIVALENT IN TERMS OF SOS LIMITATIONS COULD BE MADE, IN PRACTICE, CONSIDERABLE PRACTICAL ADVANTAGE COULD BE REALIZED BY A STRATEGIC ORDERING OF THE TWO JOBS AND THE ROUTINES WITHIN EACH JOB. THE FOLLOWING PRINCIPLES HAVE BEEN DESIGNED TO FACILITATE THE EXTENSION OF THE DUAL COMPILATION SYSTEM TO A MULTIPLE COMPILATION SYSTEM IN WHICH A COMPLETELY GENERALIZED DEFINITION OF PARAMETERS WOULD ALLOW THE BASIC

STRUCTURE TO SUPPORT A REAL-TIME SYSTEM OF ANY SIZE.

THE MONITOR CONCEPT OF COMMUNICATION CELLS AND TABLES FOR INTER-REFERENCE BLENDED IDEALLY WITH THE TWO JOB DIVISION. THESE CELLS AND TABLES BECAME THE PRIMARY CONCERN OF THE COMMON AREA, I.E., THAT PART OF THE COMPILATIONS WHICH IS IDENTICAL IN BOTH JOBS. ORIGINALLY, THE COMMON AREAS OF BOTH COMPILATIONS CONTAINED THE FOLLOWING - THE SYSTEM LOADER, THE ERROR-CORRECTION CODE WRITING AND READING SUBROUTINES, THE SYSTEM TAPE WRITER, THE MONITOR SUBROUTINES, THE MONITOR CONTROLLERS, NON-MONITOR SUBROUTINES SHARED BY ONE OR MORE ORDINARY PROCESSORS, COMMUNICATION CELLS, QUEUE TABLES, THE DATA COMMUNICATION CHANNEL'S INPUT AND OUTPUT BUFFER TABLES, CONSTANTS, MONITOR TABLES, AND LIBRARY SUBROUTINES. MUCH OF WHAT WAS ORIGINALLY LOCATED WITHIN THE COMMON AREA TO FACILITATE THE CHANGE FROM THE SINGLE TO THE DUAL COMPILATION MODE CAN BE AND IS BEING MOVED OUT. IN TERMS OF THE OPERATIONAL PROGRAM, ONLY DATA (COMMUNICATION CELLS, TABLES AND CONSTANTS) NEED BE KEPT IN COMMON. OBVIOUSLY, MODIFICATION CAPABILITIES ARE ENHANCED BY MINIMIZING THE COMMON AREA. (THE TERM 'COMMON AREA' REFERS SOLELY TO THE SYMBOLIC AND SQUOZE TAPES, AND HAS NO NECESSARY CONNECTION WITH THE ACTUAL CORE STORAGE ALLOCATIONS ALTHOUGH CERTAIN IMPLICATIONS ARE VALID.)

FUNDAMENTAL TO THE OPTIMUM ORDERING OF PROGRAMS WITHIN SEPARATELY COMPILED JOBS AND THE JOBS THEMSELVES WAS THE SUBSEQUENT USAGE OF THE GENERATED ABSOLUTE SYSTEM TAPES. SEVERAL PROGRAMS INCLUDED IN THE GEMINI COMPILATION ARE NOT PART OF THE OPERATING (TRACKING) PROGRAM AND FUNCTION EITHER AS PREPROCESSORS OR POSTPROCESSORS. THESE PROGRAMS--MXDEFN, MXSTW1, MXLOAD, DUALDP, AND CORING--HAVE BEEN EITHER CREATED FOR THE DUAL COMPILA-

TION SYSTEM OR GREATLY MODIFIED FOR APPLICATION TO THE DUAL COMPILATION SYSTEM.

A) MXDEFN-PROVIDES FOR INTERJOB CONTROL TRANSFERS.

B) MXSTW1-WRITES THE ABSOLUTE, ERROR-CORRECTED, SELF-LOADING GEMINI SYSTEM TAPE.

C) MXLOAD-INITIALLY LOADS PHASE I OF THE GEMINI PROGRAM SYSTEM.

D) DUALDP-INITIALIZES THE GEMINI PROGRAM SYSTEM FOR DUMPING AFTER A RUN.

E) CORING-GENERATES SOS CORE MACROS FOR EITHER TOTAL OR SELECTIVE DUMPING.

THESE PROGRAMS ARE NEVER USED WHEN THE GEMINI SYSTEM PROGRAM BEGINS CYCLING IN REAL-TIME OPERATIONS. HOWEVER, TO FUNCTION PROPERLY ALL OF THESE PROGRAMS MUST BE GIVEN INFORMATION ABOUT THE COMPILATIONS VIA THE SOS CREATED MODIFY-AND-LOAD TAPES.

8.3 POST-MISSION PROGRAMS

THE POST-MISSION PROGRAMS RECALCULATE CERTAIN FLIGHT PARAMETERS, SUCH AS LAUNCH, ORBIT, AND REENTRY PARAMETERS, AND CALCULATE OTHER PARAMETERS NOT CALCULATED BY THE OPERATIONAL PROGRAMS, I.E., THE STAGNATION HEAT RATE.

THE POST-MISSION PROGRAMS OPERATE AS FOLLOWS - EACH TIME THE GODDARD REAL-TIME SYSTEM IS OPERATED, ON EITHER ACTUAL OR SIMULATED MISSIONS, LOG TAPES ARE MADE TO RECORD THE ENTIRE OPERATION. THE LOG TAPES CONTAIN ALL DATA PRODUCED DURING THE MISSION. THE OPERATIONAL DATA ON THE LOG TAPES, PLUS FIXED GEMINI CONSTANTS PREVIOUSLY ADDED TO THE POST-MISSION PROGRAMS, PROVIDE THE INPUTS NECESSARY TO PERFORM THE POSTFLIGHT CALCULATIONS. THE RESULTS OF THESE CALCULATIONS ARE CALLED POSTFLIGHT REPORTS.

8.3.1 LOG TAPE PROCESSOR

THE OPERATIONAL DATA ON THE LOG TAPES IS FIRST PROCESSED BY THE LOG TAPE PROCESSOR, PROGRAM KARL. KARL READS IN A TABLE OF SCALE FACTORS AND ZERO CONSTANTS AND WRITES THE TABLE ON THE A3 TAPE. KARL THEN CALLS SUBROUTINE SORTER TO SORT THE LOG TAPE. SORTER WRITES THE SORTED HIGH-SPEED OUTPUT ON THE A4 TAPE AND THE SORTED HIGH-SPEED INPUT ON THE B4 TAPE AND RETURNS TO KARL. TO PERFORM ITS FUNCTIONS, SORTER UTILIZES THE FOLLOWING SUBROUTINES -

NAME	PURPOSE
BCTB (BCTB1)	CONVERTS MODIFIED BCD NUMBERS TO FIXED-POINT BINARY NUMBERS.
BCTBI (BCTBJ)	CONVERTS MODIFIED BCD NUMBERS TO FIXED-POINT BINARY NUMBERS.
HILKE	CONVERTS AND SCALES HIGH-SPEED OUTPUT FROM GRANULAR VALUES TO SIGNIFICANT STANDARD VALUES.
HMSCS	CONVERTS MODIFIED BCD NUMBERS REPRESENTING TIME IN HOURS, MINUTES, AND SECONDS TO BINARY NUMBERS REPRESENTING THE SAME TIME IN FIXED POINT SECONDS.
HMSTS	CONVERTS MODIFIED BCD NUMBERS REPRESENTING TIME TO BINARY NUMBERS REPRESENTING THE SAME TIME IN FIXED-POINT SECONDS.
REUN	ENTERS, WHEN KARL IS FINISHED, ''END OF FILE'' ON ALL TAPES USED BY KARL AND ITS SUBROUTINES, THEN REWINDS AND UNLOADS THESE TAPES.

8.3.2 POSTFLIGHT REPORTER

THE POSTFLIGHT REPORTER CONSISTS OF A MONITOR PROGRAM PLUS RELATED SUBROUTINES. THE POSTFLIGHT MONITOR MAKES LOGICAL DECISIONS AND DIRECTS THE FUNCTIONING OF THE POSTFLIGHT SUBROUTINES. THIS MONITOR IS UNRELATED TO AND OPERATES IN A DIFFERENT MANNER FROM THE OPERATIONAL MONITOR PROGRAM.

THE POSTFLIGHT MONITOR RELIES ON EXTERNAL AND INTERNAL CONTROLS. INTERNALLY, IT USES COMMON, A BLOCK OF 4572 (OCT) LOCATIONS IN HIGH-ORDER CORE STORAGE, TO FACILITATE THE EXCHANGE OF DATA AMONG ITS SUBROUTINES. EXTERNALLY, MONITOR REQUIRES THE USE OF CONTROL DATA CARDS AND SENSE SWITCHES TO EXERCISE THE VARIOUS OPTIONS OF THE PROGRAM. ALL OUTPUT FROM MONITOR IS PLACED IN COMMON AND MAY BE PRINTED ON-LINE AND WRITTEN ONTO TAPE. THE MONITOR OUTPUT DATA IS USED TO WRITE THE POSTFLIGHT REPORTS.

MONITOR INVESTIGATES FOUR FLIGHT PHASES - LAUNCH, ABORT, ORBIT, AND REENTRY - FOR STATED PERIODS OF TIME AND SELECTS THE DATA REQUIRED FOR THE SPECIFIED REPORTS. DISCRETE EVENT OCCURRENCES ARE ALSO REPORTED.

INPUTS TO MONITOR ARE THE TAPES PRODUCED BY THE LOG TAPE PROCESSOR, KARL. MONITOR UTILIZES THE FOLLOWING SUBROUTINES TO PROCESS THE INPUTS -

NAME	PURPOSE
ACTORS	SETS UP CONVERSION CONSTANTS IN CORE.
ANTJE	CONTROLS INTEGRATION FOR POSITION AND VELOCITY VECTORS.
AUTHOR	WRITES A LOADER ON A1 TAPE.
CHUMLY	SETS UP BCD OUTPUT BLOCK IN CORE.

DISTAN	COMPUTES DISTANCES TRAVELED BY THE SPACECRAFT BY USING GEOCENTRIC LATITUDE AND LONGITUDE.
DONIN	OBTAINS HIGH-SPEED INPUT DATA.
DONOUT	OBTAINS HIGH-SPEED OUTPUT DATA.
FIXIT	ENSURES THAT AN ANGLE LIES BETWEEN ZERO AND 360 DEGREES.
FIXIT1	ENSURES THAT AN ANGLE LIES BETWEEN ZERO AND TWO PI.
FIXIT2	ENSURES THAT N HOURS LIE BETWEEN THE LIMITS OF ZERO AND 24 (INCLUDING ZERO).
GETME	SUPPLIES TIMES DISCRETE EVENTS.
HRSCNV	CONVERTS FLOATING-POINT TIME IN SECONDS INTO FIXED-POINT HOURS, MINUTES, AND SECONDS.
INITIA	INITIALIZES SYSTEM.
INTEG2	CONTROLS THE LAGR2 SUBROUTINE.
LAUNCH	CALCULATES LAUNCH AND ABORT PARAMETERS FROM HIGH-SPEED INPUT DATA.
ORBIT	CALCULATES ORBIT PARAMETERS FROM ORBIT DISPLAY OUTPUT DATA.
PAMELA	SETS UP A LIST OF GEOPHYSICAL CONSTANTS AND PLACES THEM IN COMMON.
RACNV	CONVERTS ABORT AND REENTRY PARAMETERS FROM THE REENTRY DISPLAY OUTPUT DATA.
RENTER	CALCULATES ABORT AND REENTRY PARAMETERS FROM THE REENTRY DISPLAY OUTPUT DATA.
REUNT	ENTERS ''END OF FILE'' AT END OF POSTFLIGHT REPORTER AND REWINDS AND UNLOADS ALL TAPES USED BY THE PROGRAM.

THE OTHER PROGRAMS USED BY THE POSTFLIGHT REPORTER IN ADDITION TO THOSE USED BY THE POSTFLIGHT MONITOR ARE

AS FOLLOWS -

NAME	PURPOSE
ALAMDA	FINDS THE SUBCAPSULE POSITION (GEODETIC LONGITUDE AND HEIGHT).
ARCCOS	PRODUCES THE RADIAN ANGLE BETWEEN ZERO AND PI RADIANS WHOSE COSINE CORRESPONDS TO THE VALUE GIVEN IN THE CALL STATEMENT ANGLE = ARCCOS (VALUE).
ARCSIN	PRODUCES THE RADIAN ANGLE BETWEEN MINUS ONE-HALF PI AND PLUS ONE-HALF PI WHOSE SINE CORRESPONDS TO THE VALUE GIVEN IN THE CALL STATEMENT ANGLE = ARCSIN (VALUE).
ATMOS	PRODUCES ATMOSPHERIC DENSITY FOR A SPECIFIC HEIGHT.
ATMOS1	PRODUCES IN ENGLISH UNITS THE ATMOSPHERIC DENSITY, KINEMATIC VISCOSITY, AND SPEED OF SOUND AT SPACECRAFT POSITION.
CROSS	COMPUTES VECTOR CROSS PRODUCTS.
CSUBDL	COMPUTES DRAG AND LIFT COEFFICIENTS.
DE	COMPUTES SPACECRAFT ACCELERATION USING THE DIFFERENTIAL EQUATIONS OF MOTION.
DRAG	COMPUTES CONTRIBUTION TO ACCELERATION DUE TO ATMOSPHERIC DRAG.
GECNV	CONVERTS PROCESSED B-GE POSITION AND VELOCITY COMPONENTS TO TRUE INERTIAL COORDINATES.
HEAT	CALCULATES THE STAGNATION HEAT RATE IN ENGLISH UNITS.
IPCNV	CONVERTS PROCESSED IP POSITION AND VELOCITY COMPONENTS TO TRUE INERTIAL COORDINATES.
LARG2	PRODUCES POSITION AND VELOCITY VECTORS FOR A GIVEN TIME BY PERFORMING LAGRANGIAN INTER-

POLATION USING THREE POINTS ON EACH SIDE OF THE GIVEN TIME.

MERCNV CONVERTS POSITION AND VELOCITY COMPONENTS IN THE TRUE INERTIAL COORDINATE FROME TO PAD RECTANGULAR COORDINATES.

NEWTON FINDS THE SPACECRAFT IMPACT POINT USING ITERATION METHODS.

RFLP CALCULATES THE RANGE OF THE SPACECRAFT FROM THE LAUNCH PAD.

RKDP INTEGRATES FOR THE NEXT VECTOR USING THE RUNGE-KUTTA DOUBLE PRECISION METHOD.

SIGNTN DETERMINES THE CORRECT QUADRANT FOR THE ARCTAN ROUTINE.

TAN DERIVES A FUNCTION WHOSE VALUE IS THE TRIGONOMETRIC TANGENT OF THE PARAMETER ANGLE.

8.4 GEMINI SYSTEM SIMULATION-

GEMINI SYSTEM SIMULATION PRETESTS THE PROJECT GEMINI PROGRAMMING SYSTEM IN AN ENVIRONMENT THAT APPROACHES A REAL-TIME MISSION. THE PRINCIPAL OBJECTIVES OF SIMULATION TESTS ARE TO -

A) TEST THE COMPATIBILITY OF THE GEMINI PROGRAMMING SYSTEM WITH THE REAL-TIME MISSION.
B) TEST THE CAPABILITY OF THE PROGRAMMING SYSTEM TO PROCESS DATA FROM A VARIETY OF SITUATIONS.
C) PROVIDE DATA FOR COMPARISONS WITH COMPUTER OUTPUT.
D) AID IN THE SENSITIVITY ANALYSIS OF GEMINI PROGRAMMING PARAMETERS.

FOR THE PURPOSE OF DISCUSSION, SIMULATION PROGRAMS MAY BE GROUPED INTO THREE MAJOR AREAS -

A) DATA PREPARATION PROGRAMS.

B) SIMULATED INPUT-OUTPUT CONTROL PROGRAMS.

C) OPEN AND CLOSED PROGRAMS FOR THE GEMINI PROCESSING CENTER AT GODDARD.

8.4.1 DATA PREPARATION PROGRAMS

PRIOR TO THE ACTUAL OPERATION OF THE GEMINI SIMULATION SYSTEM, THE FOLLOWING TYPES OF DATA MUST BE PREPARED AND RECORDED ON MAGNETIC TAPE TO BE READ AT A QUASI-REAL-TIME RATE INTO THE GODDARD IBM 7094 COMPUTERS -

A) B-GE COMPUTER DATA.

B) IP COMPUTER DATA.

C) TELEMETRY DATA FROM CAPE KENNEDY.

D) C-BAND AND VERLORT RADAR DATA FROM THE TRACKING-SITES.

FOR SIMULATION PURPOSES, A SET OF TIMED POSITION AND VELOCITY VECTORS REPRESENTING A COMPLETE FLIGHT IS CALLED A FLIGHT PROFILE. GIVEN THIS FLIGHT PROFILE, THE DATA PREPARATION PROGRAMS PROVIDE COMPLETE AND ERRORLESS SETS OF READINGS FOR ALL STATIONS AND THEN APPLY PERTURBATIONS TO REPRESENT THREE TYPES OF ERRORS - RANDOM, TRANSMISSION, AND PATHOLOGICAL ERRORS. ERRORS OF ALL THREE CLASSES CAN BE INJECTED INTO THE PROCESSING OPERATION SIMULTANEOUSLY OR IN ANY COMBINATION OF THE AVAILABLE VARIATIONS.

FIGURE 8-1, A GENERAL FLOW CHART, ILLUSTRATES THE DATA FLOW FOR THE DATA PREPARATION PHASE. THIS PHASE ENCOMPASSES THE FOLLOWING FIVE PROGRAMS WHICH ARE USED TO GENERATE BOTH THE DESIRED FLIGHT PATH AND THE RADAR OBSERVATION -

A) OBSERVER PROGRAM - GENERATES A PREDETERMINED ORBIT AS SET BY INPUT PARAMETERS AND FROM THIS

ORBIT PRODUCES RANGE, AZIMUTH, AND ELEVATION (RAE) READINGS FOR ALL STATIONS.

B) SELECTOR PROGRAM - SELECTS THE DESIRED RAE DATA FROM THE OUTPUT OF THE OBSERVER PROGRAM AND ATTACHES RANDOM, TRANSMISSION, BIAS, AND PATHOLOGICAL ERROR CODES TO THIS DATA.

C) SHRED PROGRAM - DETECTS THE CODES ATTACHED TO THE MESSAGE BY THE SELECTOR PROGRAM AND ACTUALLY PERTURBS THE VALUES.

D) SORT PROGRAM - REARRANGES THE MESSAGES IN THE ORDER OF THE TIME SEQUENCE IN WHICH THEY ARE TO ENTER THE COMPUTER.

E) MERGE PROGRAM - COMBINES THE HIGH-SPEED LAUNCH DATA TAPE WITH LOW-SPEED RADAR DATA TAPE.

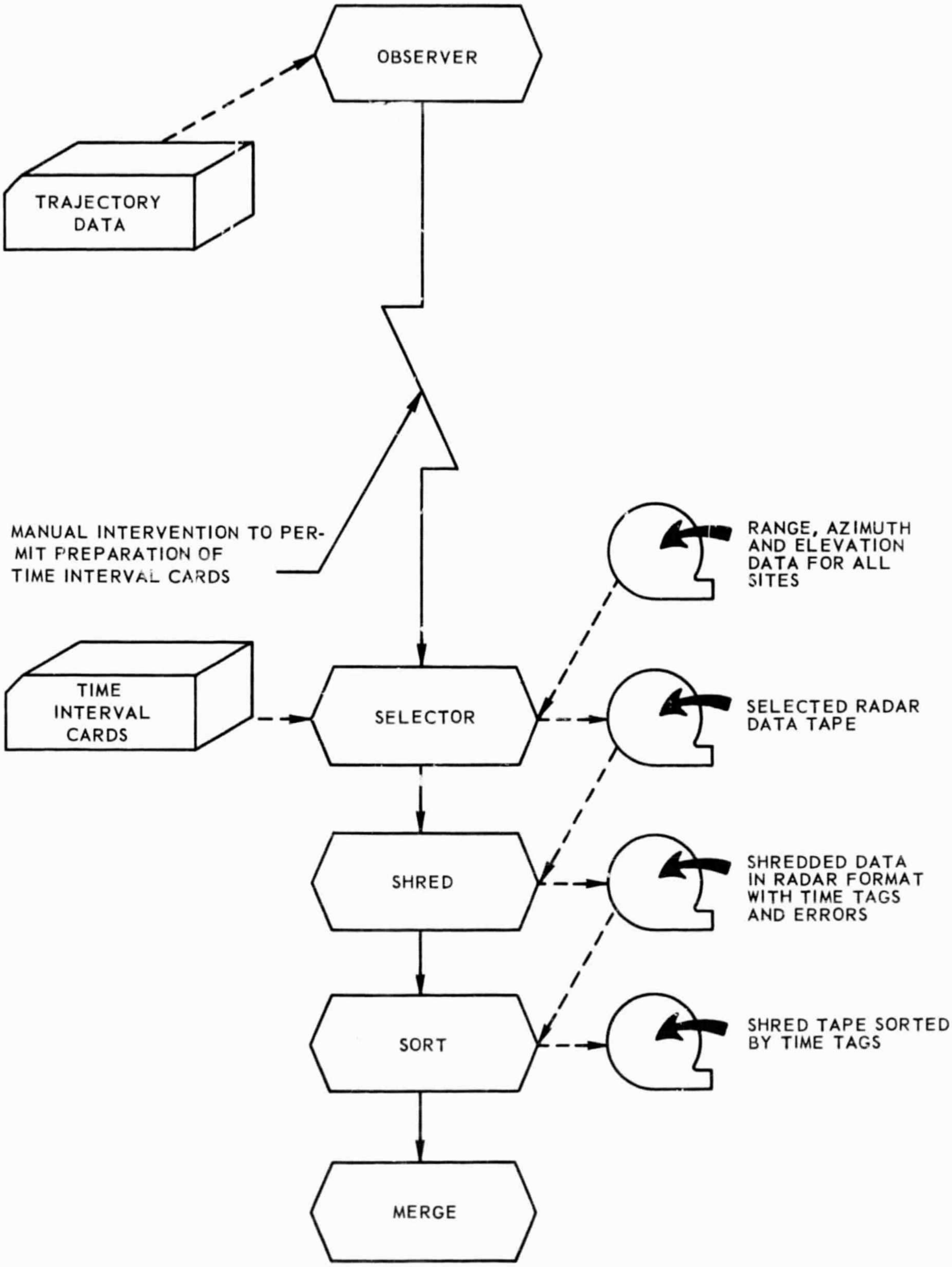


FIGURE 8-1. DATA GENERATION FOR GEMINI SIMULATION SYSTEM

8.4.2 SIMULATED INPUT-OUTPUT CONTROL PROGRAM (SIC)

THE SIC PROGRAM CONTROLS THE FEEDING OF THE DATA PREPARATION PROGRAMS' OUTPUT TO MONITOR. THE INPUT TO SIC IS THE TAPE GENERATED BY THE SORT PROGRAM. SIC PASSES THIS INFORMATION TO MONITOR BY MAINTAINING CONTROL OVER MONITOR AND BY SIMULATING THE DATA COMMUNICATIONS CHANNEL (DCC), THE DEVICE WHICH NORMALLY SUPPLIES INTERRUPTS TO THE GEMINI PROGRAMMING SYSTEM. SIC IS PROVIDED WITH A CLOCK INPUT TO FORCE THE ENTIRE PROGRAM SYSTEM TO OPERATE IN REAL-TIME, SIC THEN FEEDS THE SIMULATED DATA TO THE OPERATIONAL GEMINI PROGRAMS IN STEP WITH THIS CLOCK. THE PROCESS IS SHOWN IN FIGURE 8-2.

THE CLOCK GENERATES A TRAP EVERY MILLISECOND. SIC SERVES AS THE CORRESPONDING TRAP PROCESSOR. EVERY MILLISECOND, THEREFORE, CONTROL IS TRANSFERRED TO SIC, WHICH KEEPS TRACK OF REAL-TIME BY MEANS OF A COMPUTER, INSPECTS THE TIME-OF-ARRIVAL TAGS ON THE INPUT DATA FROM THE SORT TAPE, INSERTS THE DATA IN INPUT BUFFERS WHEN THE TIME TAG AGREES WITH THE CLOCK, AND SIMULATES THE INTERRUPTS WHICH THE DCC WOULD SUPPLY WHEN THE INTERRUPT TAGS SO INDICATE. IF SIC FINDS NO NEED FOR A TRAP AT A GIVEN TIME, IT RETURNS CONTROL TO THE POINT IN THE PROGRAM AT WHICH THE MILLISECOND TRAP OCCURRED. WHEN IT DETERMINES THAT A TRAP IS NEEDED, HOWEVER, SIC SETS UP THE CONDITIONS WHICH WOULD BE ESTABLISHED BY A DCC TRAP IN AN ACTUAL FLIGHT SITUATION AND THEN TRANSFERS TO THE PROPER TRAP PROCESSOR IN THE GEMINI PROGRAMMING SYSTEM. IN THIS MANNER, SIC PERFORMS A COMPLETE SIMULATION OF THE FUNCTIONS OF THE DCC AND OF THE ASSOCIATED INTERRUPTS QUANTIZING TIME TO MILLISECOND INCREMENTS.

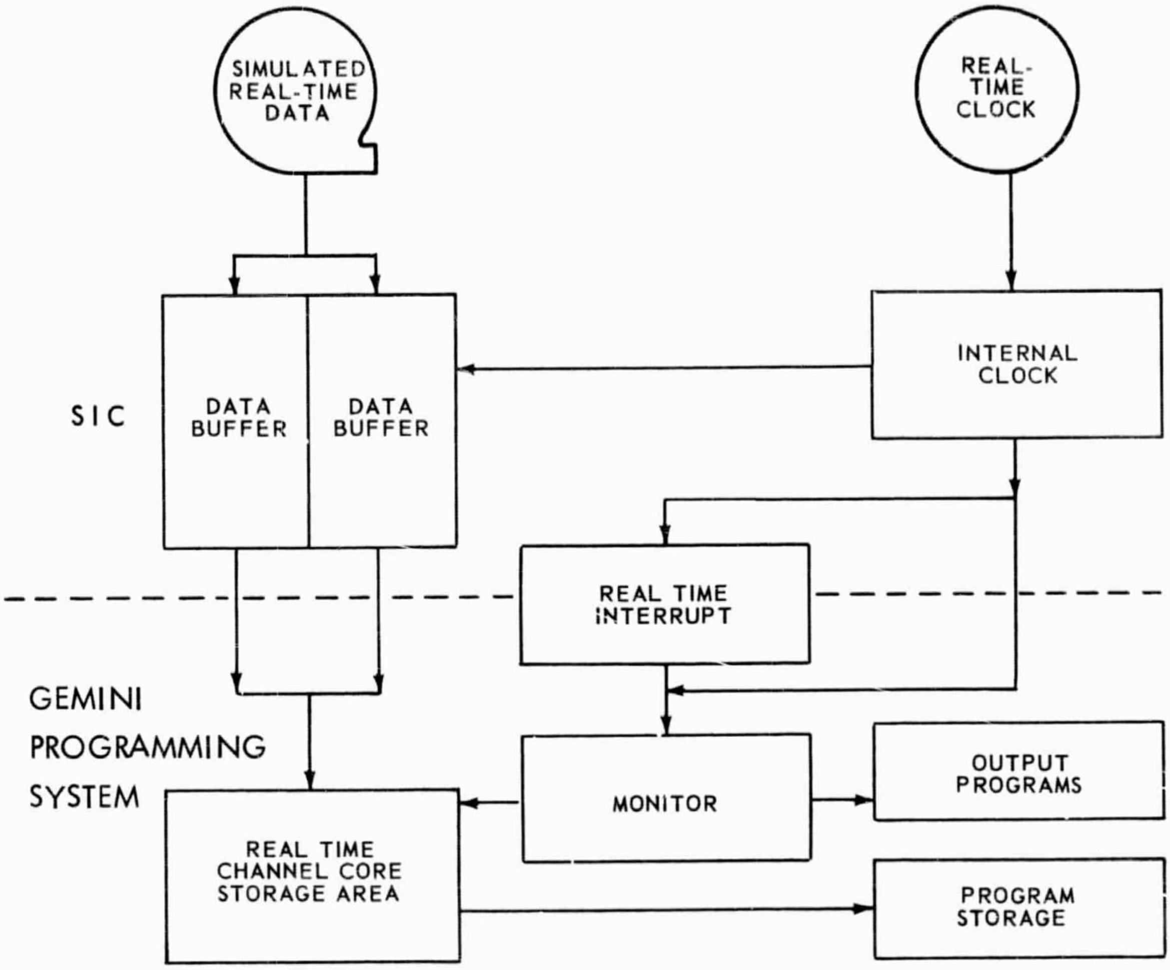


FIGURE 8-2. SIC AND THE GEMINI PROGRAMMING SYSTEM

A FEATURE HAS BEEN ADDED TO SIC WHICH, IN RESPONDING TO A GIVEN MILLISECOND TRAP, WOULD NOT ROB THE GEMINI PROGRAMMING SYSTEM OF TIME NORMALLY AVAILABLE TO IT. THIS FEATURE CONSISTS OF ASSIGNING MILLISECOND INTERVALS ALTERNATELY TO SIC AND TO THE OPERATIONAL GEMINI PROGRAM AS SHOWN BELOW -

SIC	GEMINI	SIC	GEMINI	SIC	GEMINI

0 1 2 3 4 5 6

TIME IN MILLISECONDS

AS SHOWN, SIC OPERATES DURING THE ODD INTERVALS. THE GEMINI PROGRAM OPERATES DURING THE EVEN INTERVALS. IN OPERATION, SIC ADVANCES ITS CLOCK ONE MILLISECOND AFTER EVERY ODD-NUMBERED TRAP, THEN WAITS FOR THE NEXT (EVEN-NUMBERED) TRAP. CONTROL IS TURNED OVER TO GEMINI IMMEDIATELY AFTER THE EVEN-NUMBERED TRAPS. THUS, WHILE COMPUTATION IS PROCEEDING AT HALF-SPEED WITH RESPECT TO REAL-TIME, THE PROGRAM SYSTEM HAS HALF THAT TIME AVAILABLE TO IT AND MUST, THEREFORE, OPERATE AT A REAL-TIME RATE.

ANOTHER FEATURE OF THIS SIMULATION PROCEDURE TAKES ADVANTAGE OF THE FACT THAT THERE ARE PERIODS OF TIME WHEN THERE IS NO WORK TO BE DONE. SUCH A SITUATION EXISTS WHEN SEVERAL MINUTES SEPARATE SUCCESSIVE RADAR TRANSMISSIONS. TO AVOID INEFFICIENT USE OF COMPUTER TIME UNDER THESE CONDITIONS, SIC HAS BEEN DESIGNED TO RECOGNIZE THE IDLE PERIODS AND CAN SPEED UP ITS CLOCK BY INCREMENTS AS LARGE AS HALF A MINUTE AND BRING MONITOR UP TO DATE ON SUCH ADVANCES IN TIME. DURING IDLE PERIODS,

THEREFORE, TIME IS ACCELERATED AND DURING BUSY PERIODS IS ADVANCED AT HALF-SPEED, RESULTING IN THE PROGRAM SYSTEM BEING ALLOTTED HALF THE AVAILABLE TIME. IN THIS CASE, THE OPERATIONAL PROGRAM IS FORCED TO AT LEAST KEEP UP WITH REAL-TIME AND IS PERMITTED TO ACCELERATE WHEN POSSIBLE DURING A SIMULATION RUN.

8.4.3 OPEN AND CLOSED LOOP SIMULATIONS

THE PURPOSE OF OPEN AND CLOSED LOOP SIMULATION PROGRAMS IS TO TRAIN MISSION CONTROL CENTER (MCC) PERSONNEL IN THE PERFORMANCE OF THE FUNCTIONS REQUIRED OF THEM DURING A MISSION. THIS TRAINING ENABLES THE FLIGHT CONTROLLERS AND THEIR TECHNICAL STAFFS TO BECOME THOROUGHLY FAMILIAR WITH THE PROCEDURES TO BE USED DURING BOTH NORMAL AND EMERGENCY OPERATIONS. SUCH TRAINING WILL ALSO FACILITATE THE DEVELOPMENT AND REFINEMENT OF THESE PROCEDURES.

THE OPEN AND CLOSED LOOP PROGRAMS USED DURING SIMULATION ARE AS FOLLOWS -

A) OPEN LOOP SIMULATION, MISSION CONTROL CENTER.

B) CLOSED LOOP SIMULATION, MISSION CONTROL CENTER.

C) CLOSED LOOP SIMULATION, BERMUDA.

THE FOLLOWING PARAGRAPHS CONTAIN GENERAL DISCUSSIONS OF THESE TRAINING SIMULATION APPLICATIONS. IN ADDITION, A DISCUSSION IS INCLUDED CONCERNING THE SPECIAL EQUIPMENT REQUIRED FOR OPEN AND CLOSED LOOP SIMULATIONS.

OPEN LOOP SIMULATION (MCC)

THE OPEN LOOP SIMULATION PROGRAM CAUSES ALL THE DISPLAYS AT THE TWO CONTROL CENTERS TO INDICATE IN REAL-TIME THE STATUS OF A SIMULATED LAUNCH. THIS SIMULATION USES TWO DATA SOURCES - THE FIRST SOURCE CONSISTS OF DIS-

PLAY QUANTITIES GENERATED BY THE B-GE COMPLEX LOCATED AT CAPE KENNEDY. THE SECOND DATA SOURCE IS COMPOSED OF THE DISPLAY QUANTITIES DEVELOPED BY THE IBM 7094 COMPUTERS AT GODDARD AND RELAYED BACK TO THE MISSION CONTROL CENTER. TO PREPARE A SIMULATION RUN FOR A PARTICULAR MISSION (EITHER NORMAL LAUNCH, OR ABORT DURING LAUNCH), IT WAS NECESSARY TO OBTAIN THE FULL SET OF DATA OUTPUT DEVELOPED BY THE B-GE COMPUTER DURING AN ACTUAL LAUNCH. THIS DATA, SUPPLIED BY THE SPACE TECHNOLOGY LABORATORIES (STL), INCLUDES A SET OF DISPLAY QUANTITIES AND POSITION/VELOCITY VALUES OF THE LAUNCH VEHICLE FOR EVERY HALF-SECOND OF FLIGHT.

USING THE DATA PREPARATION PROGRAMS TOGETHER WITH STL DATA, THE GEMINI COMPUTER PROGRAM WAS RUN TO OBTAIN THE DISPLAY QUANTITIES DEVELOPED BY THE GODDARD COMPUTERS. (DATA FLOW BETWEEN GODDARD AND THE MISSION CONTROL CENTER IS SHOWN IN FIGURE 8-3.) THESE QUANTITIES ARE RECORDED ON AN OUTPUT LOG TAPE BY THE GEMINI MONITOR PROGRAM. BOTH SETS OF DISPLAY QUANTITIES, ONE SET PER TRACK, WERE THEN WRITTEN SERIALLY ON AN AMPEX TAPE BY TRANSMITTING THE DATA FROM GODDARD COMPUTERS OVER HIGH-SPEED LINES TO THE MISSION CONTROL CENTER AND RECORDING IT ON THE A-SIMULATOR. THIS TAPE CAN BE PLAYED AT THE MISSION CONTROL CENTER ON THE A-SIMULATOR, CAUSING ALL THE DISPLAYS TO REACT IN THE FASHION DETERMINED BY LAUNCH CONDITIONS. THE DATA MAY ALSO BE SENT DIRECTLY TO THE DISPLAYS FROM THE GODDARD COMPUTERS WITHOUT RECORDING IT ON A-SIMULATOR.

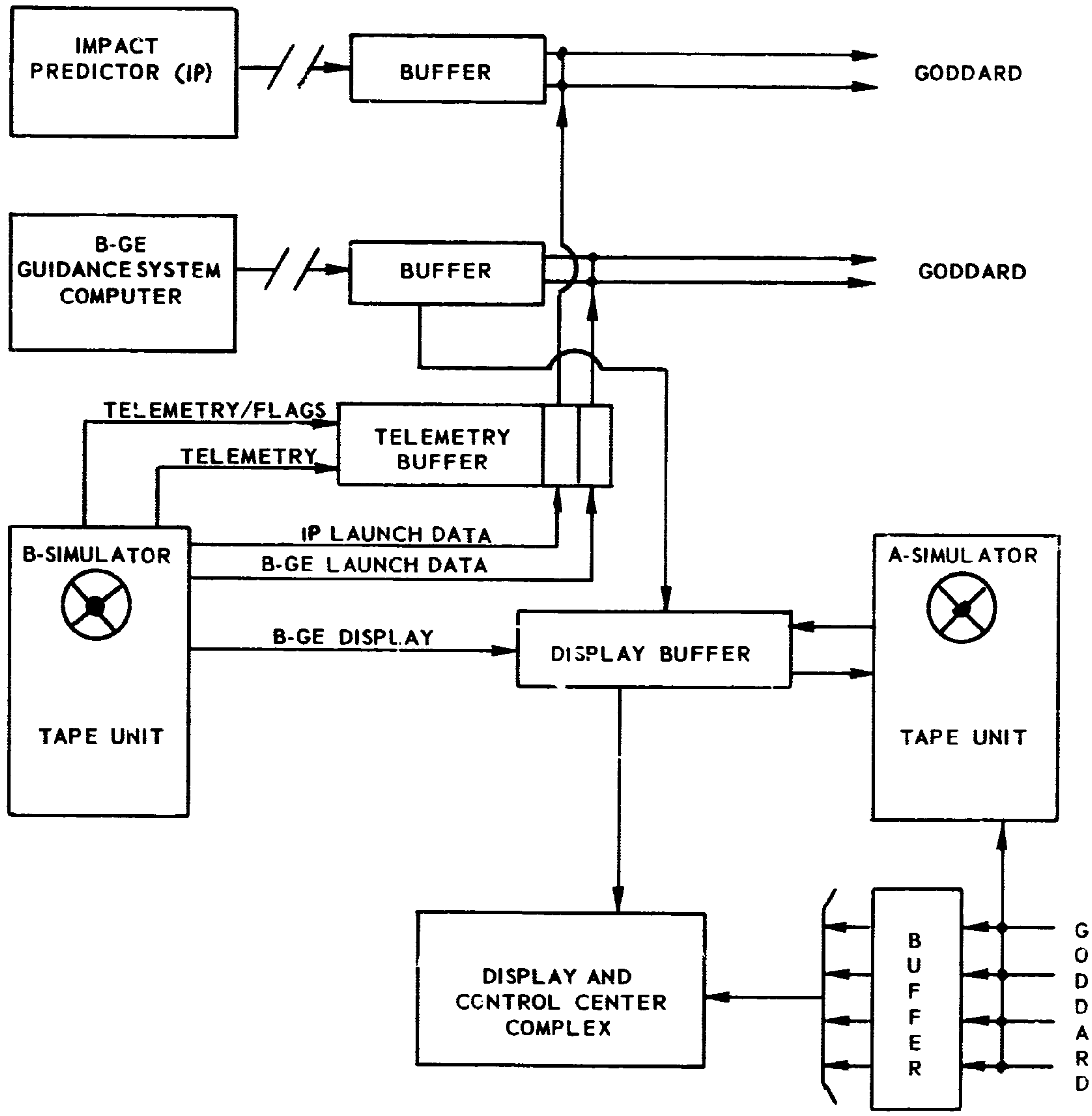


FIGURE 8-3. SIMULATION DATA FLOW BETWEEN MCC AND GSFC

CLOSED LOOP SIMULATION (MCC)

THE CLOSED LOOP SIMULATION PROGRAM WAS DEVELOPED TO PROVIDE FOR A MORE REALISTIC TRAINING DEVICE TO ENABLE THE FLIGHT CONTROLLERS AT THE CONTROL CENTER TO ALTER THE SIMULATED FLIGHT. THIS IS A NECESSARY PART OF AN EFFECTIVE SIMULATION, SINCE THE MAIN FUNCTION OF THE CONTROLLERS IS TO DETERMINE IF THE SPACECRAFT IS TO BE INSERTED INTO THE DESIRED ORBIT OR IF THE LAUNCH SHOULD BE ABORTED. THIS CRITICAL DECISION MUST BE BASED ON THE DISPLAYED PHYSICAL FLIGHT QUANTITIES AND THE DISPLAYED RECOMMENDATIONS MADE BY THE B-GE COMPUTER AND OTHER COMPONENTS OF THE SYSTEM. SUCH DECISION MAKING EXTENDS BEYOND THE LAUNCH PHASE - THE CONTROLLERS MUST MONITOR THE DISPLAYS AND THE SPACECRAFT TELEMETRY AND VOICE COMMUNICATION CHANNELS DURING THE FULL FLIGHT OF THE SPACECRAFT. A DECISION TO CAUSE THE SPACECRAFT TO RE-ENTER THE ATMOSPHERE AND LAND CAN BE MADE AT ANY POINT IN THE ORBIT.

MANY REAL-TIME CLOSED LOOP SIMULATIONS OF THE GEMINI MISSION THAT UTILIZE ALMOST ALL OF THE PHYSICAL AND HUMAN ELEMENTS OF THE GEMINI PROJECT ARE PLANNED.
THIS SIMULATION TECHNIQUE EMPLOYS A SPACECRAFT PROCEDURES TRAINER WHICH CONTAINS TWO ASTRONAUTS, SIMULATED AEROMEDICAL DATA, AND VEHICLE TRACKING AND TELEMETRY DATA WHICH ALL WORK SIMULTANEOUSLY TO PRESENT A TRUE, ALTHOUGH SIMULATED, PICTURE OF A GEMINI LAUNCH. CLOSED LOOP SIMULATION INVOLVES THE PREPARATION OF AN IBM 729 TAPE UNIT TAPE WHICH CONTAINS LAUNCH DATA NORMALLY AVAILABLE TO THE GODDARD IBM 7094 COMPUTERS AND MISSION CONTROL CENTER DISPLAYS. THIS TAPE IS PLAYED AT THE MISSION CONTROL CENTER ON THE B-SIMULATOR, AND THE INFORMATION IS SENT TO GODDARD FOR COMPUTATION. THE DATA IS RECORDED

SERIALLY AT 200 BITS/INCH ON THE AVAILABLE SIX TRACKS OF THE B-SIMULATOR AND IS PLAYED BACK AT 60 INCHES PER SECOND. THE GODDARD COMPUTERS, AND MISSION CONTROL CENTER PERSONNEL, DO NOT KNOW THAT AN ACTUAL LAUNCH HAS NOT TAKEN PLACE. BASED ON THE LAUNCH CHARACTERISTICS CONTAINED ON THE TAPE, A VARIETY OF DIFFERENT SITUATIONS CAN OCCUR -

A) A NORMAL LAUNCH IS SIMULATED AND THE FLIGHT CONTROLLER ALLOWS THE SPACECRAFT TO GO INTO ORBIT.

B) A NORMAL LAUNCH IS SIMULATED BUT THE CONTROLLER CALLS FOR AN ABORT BEFORE INSERTION INTO ORBIT.

C) A LAUNCH WHICH SHOULD ABORT IS SIMULATED AND THE CONTROLLER DOES CALL FOR AN ABORT.

D) A LAUNCH WHICH SHOULD ABORT IS SIMULATED BUT THE CONTROLLER DOES NOT CALL FOR AN ABORT.

IN THE FIRST SITUATION, A), THE COMPUTER SYSTEM AUTOMATICALLY GOES INTO THE ORBIT PHASE AND IS READY TO RECEIVE RADAR MESSAGES FROM THE WORLDWIDE TRACKING SYSTEM. PRECOMPUTED RADAR OBSERVATIONS ARE DEVELOPED BY THE GENERAL SIMULATION PROGRAM FOR THIS MISSION, AND EACH SITE TRANSMITS THE CORRESPONDING MESSAGES TO GODDARD OVER NORMAL COMMUNICATION CHANNELS. THE RADAR MESSAGES ENTER THE COMPUTER AUTOMATICALLY AND ARE PROCESSED BY A PROGRAM WHICH REFINES THE ORBIT. PREPARED FOR EACH SITE IS A SCENARIO FOR THE MISSION WHICH INDICATES THE TIME THE SIMULATED SPACECRAFT WOULD PASS IN AND OUT OF RANGE OF THEIR RADARS. THESE TIMES CORRESPOND TO THE TIMES THE PRECOMPUTED RADAR OBSERVATIONS ARE TRANSMITTED TO THE GODDARD COMPUTERS. (AN INCREMENT WHICH REPRESENTS A DELAY IN TRANSMISSION MAY BE ADDED TO THESE TIMES.) ON COMMAND FROM THE CONTROLLERS, OR FROM INSTRUCTORS

DIRECTING THE SCENARIO, A TELEMETRY MESSAGE IS ENTERED INTO THE COMPUTERS, INFORMING THE PROGRAM THAT THE RETRO-ROCKETS WERE FIRED AT A CERTAIN TIME. THE COMPUTER THEN MONITORS THE SPACECRAFT TO ITS IMPACT POINT. DEPENDING ON THE POINT OF REENTRY, RADAR OBSERVATIONS FOR THIS PORTION OF THE FLIGHT ARE ALSO PRECOMPUTED FOR TRANSMISSION BY THE SITES AT SPECIFIED TIMES. THROUGHOUT THE ORBITAL AND REENTRY STAGES, THE DISPLAYS AT THE MISSION CONTROL CENTER ARE ACTIVATED AS IF A NORMAL ORBITAL FLIGHT IS TAKING PLACE.

IN THE SECOND SITUATION, B), THE COMPUTER RECEIVES AN ABORT SIGNAL AND IMMEDIATELY TRANSFERS TO REENTRY COMPUTATION. THIS ACTION REPRESENTS A WRONG DECISION BY THE CONTROLLER, HOWEVER.

IN THE THIRD SITUATION, C), THE COMPUTER PROCEEDS INTO REENTRY COMPUTATION, AND THE DISPLAYS SHOW THE IMPACT POINT BASED ON THE TIME OF ABORT. SINCE IT IS IMPOSSIBLE TO PREDICT WHEN THE CONTROLLER WILL CALL FOR AN ABORT, NO ADDITIONAL RADAR OBSERVATIONS ARE SENT TO THE COMPUTER AFTER THE ABORT.

IN THE FINAL SITUATION, D), THE DATA TAPE FORCES AN ABORT AFTER A PREDETERMINED TIME HAS PASSED. THIS ALSO REPRESENTS A WRONG DECISION BY THE CONTROLLER.

CLOSED LOOP SIMULATION (BERMUDA)

AS AN ADJUNCT TO THE MCC CLOSED LOOP SIMULATION, A BERMUDA CLOSED LOOP SIMULATOR IS USED TO PROVIDE THE GODDARD COMPUTERS WITH HIGH-SPEED BERMUDA RADAR DATA. THIS PROGRAM IS DESIGNED TO INTRODUCE VERLORT AND AN/FPS-16 RADAR DATA INTO THE GODDARD COMPLEX THROUGH THE RADAR RECEIVER. THE SIMULATION IS RUN AS FOLLOWS - THE PROGRAM USES A BERMUDA SIC INPUT TAPE AND EXTRACTS

VERLORT AND AN/PFS-16 RADAR DATA FROM IT. THIS RADAR DATA IS ARRANGED IN A SPECIAL FORMAT FOR WRITING ON TWO TRACKS OF AN OUTPUT TAPE. THE OUTPUT TAPE IS READ BY THE B-SIMULATOR AT CAPE KENNEDY AND THE SIGNALS PRODUCED ARE RECORDED ALONG WITH TELEMETRY DATA ON THE ONE-INCH TELEMETRY TAPE DRIVE USED BY THE SPACECRAFT TRAINER AT CAPE KENNEDY. THE TAPE IS THEN TRANSPORTED TO BERMUDA WHERE IT IS READ INTO RADAR RECEIVERS WHICH TREAT IT AS RADAR DATA AND FEED IT INTO GODDARD COMPUTERS VIA THE DCC ON SUBCHANNELS 5 AND 6. A SCHEMATIC DIAGRAM OF THIS FLOW OF INFORMATION APPEARS IN FIGURE 8-4.

<u>SPECIAL EQUIPMENT DESCRIPTION</u>

THREE AMPEX TAPE UNITS HAVE BEEN ADAPTED FOR USE IN THE OPEN AND CLOSED LOOP SIMULATION TRAINING PROGRAMS -

A) A-SIMULATION LOCATED AT THE MISSION CONTROL CENTER

B) B-SIMULATION LOCATED AT THE MISSION CONTROL CENTER

C) A-SIMULATOR LOCATED AT BERMUDA

THE A-SIMULATOR AT THE MISSION CONTROL CENTER IS CONNECTED TO THE HIGH-SPEED OUTPUT LINES FROM GODDARD WHICH DRIVE THE CONTROL CENTER PLOTBOARDS (SEE FIGURE 8-5). IN ADDITION, THE A-SIMULATOR IS CONNECTED TO THE B-GE DISPLAY BUFFER. THE TAPE MOUNTED ON THIS UNIT CAN RECORD OR PLAY BACK FROM EITHER OF TWO TRACKS. THE TWO TRACKS CAN BE READ, BUT NOT WRITTEN, SIMULTANEOUSLY. IN THIS MANNER, ANY DISPLAY DATA TRANSMITTED OVER THE HIGH-SPEED LINES FROM GODDARD OR TRANSMITTED INTO THE B-GE DISPLAY BUFFER MAY BE RECORDED ON TAPE FOR SUBSEQUENT PLAYBACK.

THE SECOND TAPE UNIT LOCATED AT THE MISSION CONTROL

CENTER IS THE B-SIMULATOR (SHOWN IN FIGURE 8-5). THIS UNIT READS SIX TRACKS OF A SPECIALLY WRITTEN TAPE. ITS OUTPUT IS CONNECTED TO THE TELEMETRY BUFFER AND THE B-GE DISPLAY BUFFER. THE 1, 2, 4, 8, A, AND B TRACKS CAN BE READ FROM THE TAPF (ALL EXCEPT THE PARITY TRACK) SIMULTANEOUSLY. THE TAPE IS WRITTEN AS ONE CONTINUOUS RECORD SO EACH TRACK CAN REPRESENT A CONTINUOUS STREAM OF DATA. AS EACH TRACK IS READ, AND OUTPUT SIGNAL IS GENERATED. FIGURE 8-6 ILLUSTRATES THE PULSE SHAPES WHICH CAN BE GENERATED BY A SERIES OF ONES AND ZEROES IN ANY TRACK READ BY THE UNIT. IT IS POSSIBLE TO VERY THIS UNIT'S OUTPUT LINE SIGNALS BY PLACING THE PROPER BITS IN THE DESIRED TRACKS.

THE THIRD TAPE UNIT DESIGNED ESPECIALLY FOR THE SIMULATION TRAINING PROGRAM IS THE A-SIMULATOR LOCATED AT BERMUDA. THE TWO TRACKS OF THIS A-SIMULATOR ARE TIED INTO THE AN/APS-16 AND VERLORT RADARS. THE RADAR INFORMATION IS THEN TRANSMITTED TO GODDARD OVER THE BERMUDA HIGH-SPEED LINES.

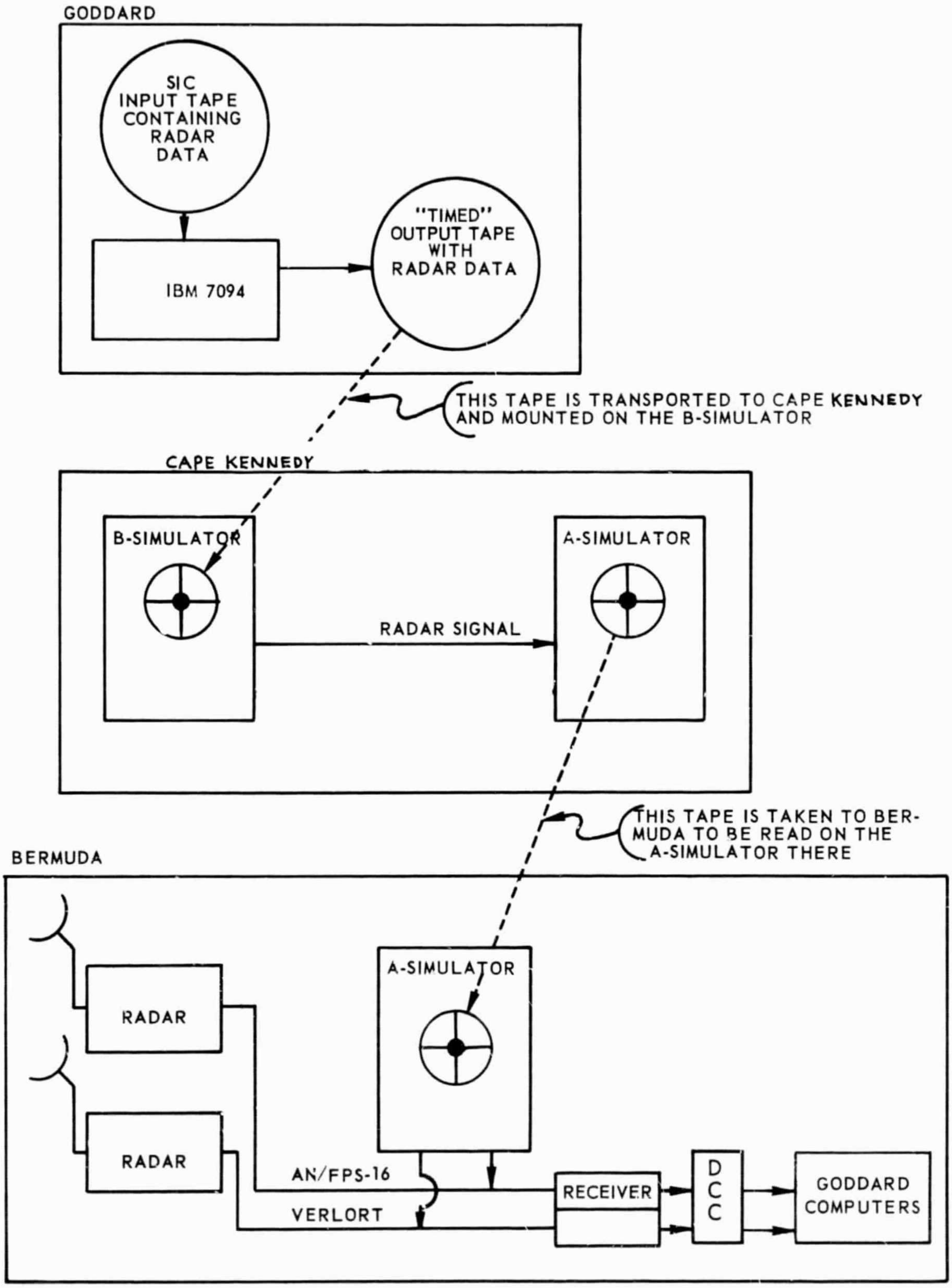


FIGURE 8-4. BERMUDA CLOSED LOOP SIMULATION DATA FLOW

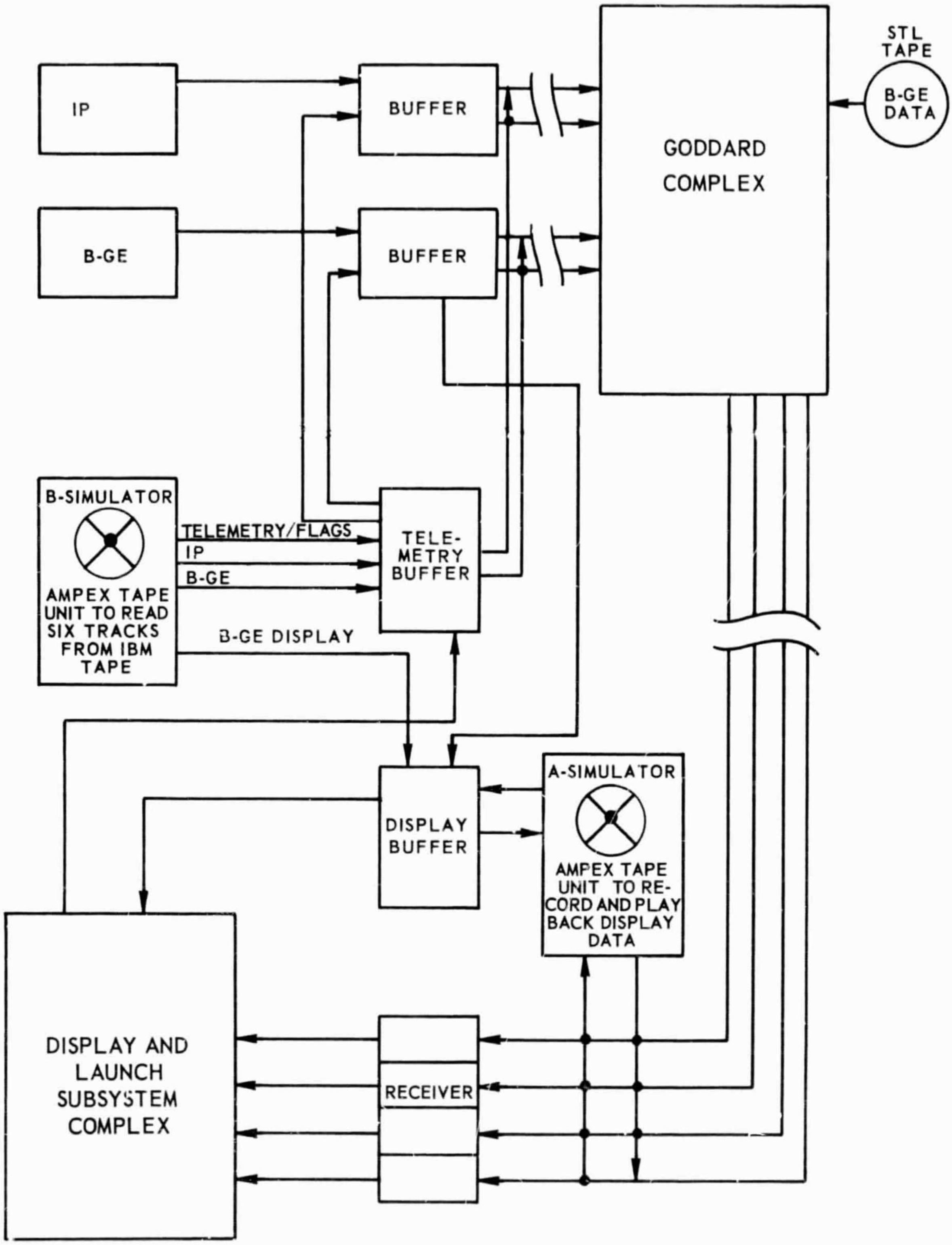


FIGURE 8-5 LAUNCH SUBSYSTEM WITH A- AND B-SIMULATORS

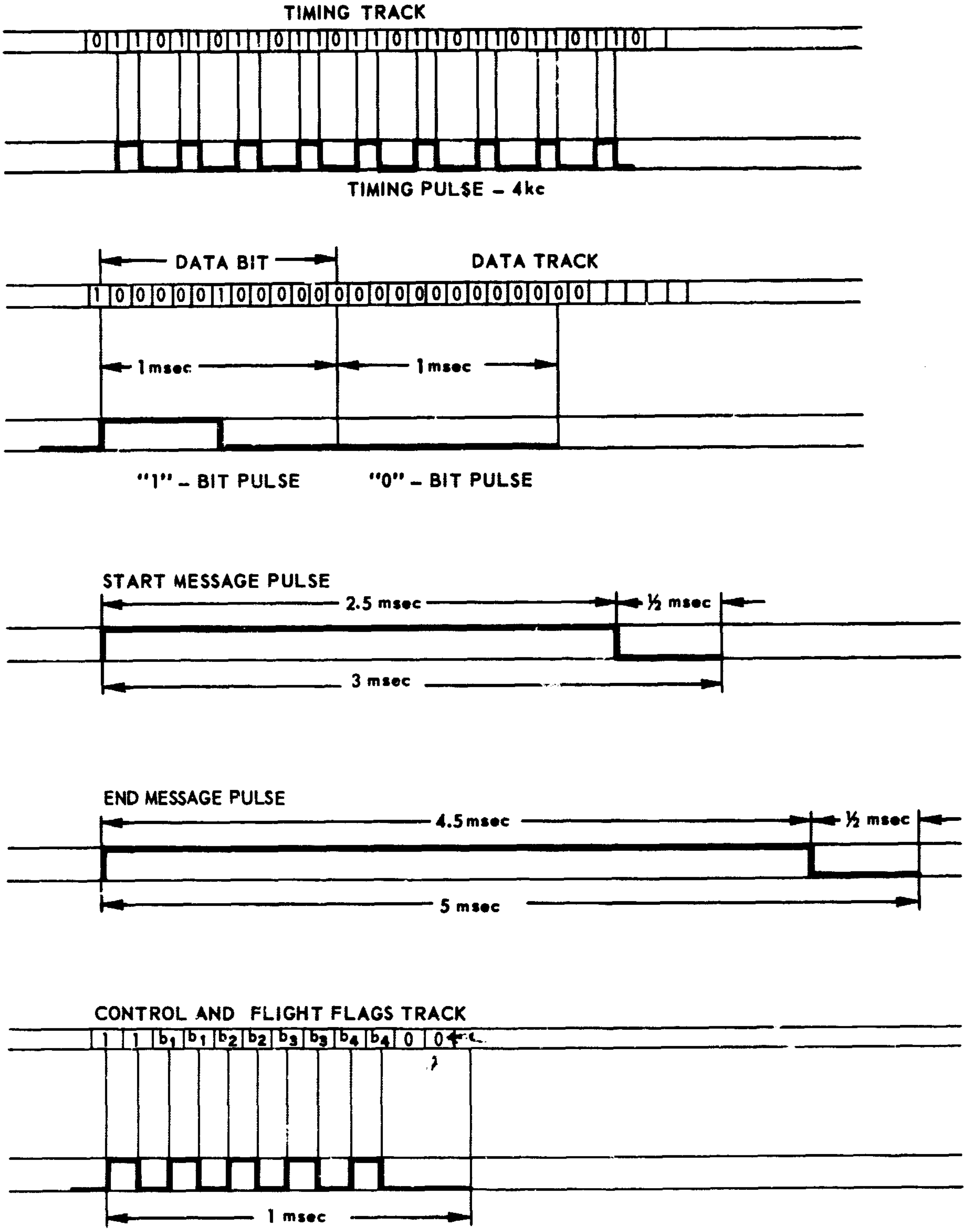


FIGURE 8-6. PULSES GENERATED BY A SERIES OF ONES AND ZEROES

8.4.4 SIMULATION PROGRAMS

THE SIMULATION SYSTEM PROVIDES A DYNAMIC SIMULATION OF THE WORLD-WIDE TRACKING NETWORK BY PERMITTING EXERCISE OF GSFC IBM 7094 COMPUTERS, THE MISSION PROGRAMS, THE CAPE KENNEDY DISPLAYS, AND THE GSFC - CAPE KENNEDY COMMUNICATIONS WITHOUT REQUIRING THE REMOTE SITES OF THE NETWORK TO BE ACTIVATED. THE SYSTEM IS ALSO CAPABLE OF GENERATING NOMINAL OR PREDETERMINED PERTURBED DATA FOR TRANSMISSION FROM THE SITES TO THE GSFC COMPUTERS AT SOME FUTURE TIME WITHOUT REQUIRING THESE COMPUTERS TO BE ACTIVATED DURING THE DATA PREPARATION PHASE. THIS SYSTEM IS CAPABLE OF TRANSMITTING REAL-TIME DATA FROM CAPE KENNEDY TO GSFC AND, WITHIN SIX SECONDS, VALIDATING, RECORDING, REFORMATTING, AND TRANSMITTING THIS DATA TO THE COMPUTERS. REAL TIME RESPONSE IS NECESSARY BECAUSE OF THE ABILITY OF THE GEMINI ASTRONAUTS TO CHANGE THEIR ORBIT.

SIMULATION IS ACCOMPLISHED AS FOLLOWS - THE REACTIONS OF THE ASTRONAUTS IN THE GEMINI MISSION SIMULATOR AT CAPE KENNEDY ARE INTERPRETED BY AN ANALOG COMPUTER. THE RESULTANT DATA IS SENT IN REAL TIME TO THE COORDINATE CONVERSION COMPUTER (CCC) AT GSFC. THE CCC FORMATS THE REAL-TIME DATA DESCRIBING THE MOTION OF THE CAPSULE-POSITION AND VELOCITY VECTORS AND ASSOCIATED TIME. THIS DATA IS AVAILABLE ONLY ONCE, BRIEFLY, AND MUST BE ACCEPTED WHEN PRESENTED, OR LOST. THE DATA IS PERTURBED AS REQUESTED WITH BIAS AND RANDOM ERRORS, RECORDED IN ITS FINAL TTY FORMAT, AND TRANSMITTED TO THE GSFC IBM 7094 COMPUTERS.

DURING A SIMULATION RUN, THE CCC OPERATES IN THE INTERRUPT MODE. EACH INPUT/OUTPUT DEVICE IS EQUIPPED TO CAUSE IN INTERRUPT OF THE PROGRAM IN PROCESS AND TRANS-

FER CENTRAL PROCESSING UNIT CONTROL TO A UNIQUE MEMORY LOCATION. THIS SIGNALS THAT AN INPUT LINE HAS DATA TO BE BROUGHT INTO MEMORY, OR THAT AN OUTPUT LINE HAS COMPLETED ITS PREVIOUS TASK AND IS FREE TO TRANSMIT AGAIN, OR THAT A PREDETERMINED TIME INTERVAL HAS ELAPSED.

RESPONDING TO THESE PROGRAM INTERRUPTS AND FACILITATING THE ABOVE DATA FLOW TO AND FROM MEMORY ARE A GROUP OF TRAP PROCESSORS. PERFORMING THE ACTUAL VALIDATIONS, CALCULATIONS, CONVERSIONS, AND REFORMATTING OF THE DATA ARE THE ORDINARY PROCESSORS, SUBROUTINES, AND MACROS. MONITOR SUPERVISES THE TRAP AND ORDINARY PROCESSORS AND UNITES THEM INTO A SYSTEM CAPABLE OF HANDLING THE REQUIRED DATA FLOW AND COMPUTATIONS WITHIN THE CONSTRAINTS OF TIMING AND MEMORY LIMITATIONS. ALSO USED ARE EXTERNAL, PERIPHERAL, LIBRARY, AND UTILITY SUBROUTINES.

8.4.4.1 MONITOR. MONITOR IS A SET OF ROUTINES WHICH SCAN THE TABLE OF COMPUTATION CYCLE ROUTINES AND SELECT THE ROUTINE OF HIGHEST PRIORITY WAITING TO BE EXECUTED. IT PROVIDES CONTROL LINKAGE BETWEEN THE COMPUTATIONAL CYCLE AND THE TRAP ROUTINES, PRESERVING AND RESTORING THE MACHINE CONDITION AS CONTROL IS TAKEN FROM AND RETURNED TO THE COMPUTATION ROUTINES. MONITOR DECIDES WHAT TO DO NEXT ON THE BASIS OF WHAT HAS HAPPENED IN THE PAST AND WHAT MUST HAPPEN IN THE FUTURE BY CONTINUALLY RESCHEDULING THE ORDER OF EXECUTION OF THE COMPUTATIONAL PROGRAMS ON THE BASIS OF THE INPUT AND OUTPUT CONDITIONS. ALL TRAP AND COMPUTATIONAL CYCLE ROUTINES TRANSFER TO MONITOR UPON THEIR COMPLETION.

THE MONITOR SCANNING PROGRAM, PRIO, DETERMINES AND TRANSFERS CONTROL TO THE REQUIRED COMPUTATIONAL OR NON-

MONITOR PROGRAM AT THE APPROPRIATE ENTRY POINT OR INTERRUPT POINT. PRIO MAKES USE OF THE FOLLOWING FOUR TABLES -

NAME	PURPOSE
MENT	MONITOR ENTRY TABLE
MSTB	MONITOR SAVE TABLE
MRTT	MONITOR RETURN TABLE
PRTB	MONITOR PRIORITY TABLE

8.4.4.2 TRAP PROCESSORS. THE TRAP PROCESSORS SERVICE THE DEMANDS OF THE REAL-TIME ENVIRONMENT WHICH ARE MADE KNOWN TO THE COMPUTER BY PROGRAM INTERRUPTS. A SEPARATE TRAP PROCESSOR IS REQUIRED FOR EACH OF THE 13 INTERRUPT LINES THAT CAN CAUSE A TRAP IN THE CCC. THE 13 TRAP PROCESSORS LISTED IN ORDER OF DESCENDING PRIORITY, ARE AS FOLLOWS -

PRIORITY	NAME	PURPOSE
1	TPAR	PARALLEL INPUT/OUTPUT CHANNEL (NOT USED)
2	THS1	HIGH-SPEED INPUT LINE NO. 1
3	THS2	HIGH-SPEED INPUT LINE NO. 2
4	HIO1	HIGH-SPEED OUTPUT LINE (NOT USED
5	HIO2	HIGH-SPEED OUTPUT LINE (NOT USED)
6	TTY1	TTY OUTPUT LINE NO. 1
7	TTY2	TTY OUTPUT LINE NO. 2
8	TTY3	TTY OUTPUT LINE NO. 3
9	TTYO	TTY INPUT LINE (NOT USED)
10	THSC	HALF-SECOND INTERRUPT
11	TMIN	WWV ONE MINUTE INTERRUPT
12	TLOG	FULLY BUFFERED MAGNETIC TAPE CHANNEL
13	TTOL	STANDARD INPUT/OUTPUT CHANNEL

A)	TYPO	TYPEWRITER OUTPUT
B)	TYPI	TYPEWRITER INPUT
C)	TPTO	PAPER TAPE PUNCH (NOT USED)
D)	TPTI	PAPER TAPE READER (NOT USED)
E)	TPOW	POWER FAILURE

8.4.4.3 ORDINARY PROCESSORS. ORDINARY PROCESSORS PERFORM THE MATHEMATICAL CALCULATIONS AND CONVERSIONS FOR THE PROGRAMMING SYSTEM. THESE PROCESSORS OPERATE INDEPENDENTLY OF THE MONITOR IN THE SAME SENSE THAT THE SUBROUTINES OPERATE INDEPENDENTLY OF THE MAIN PROGRAMS. THAT IS, AN ORDINARY PROCESSOR NEEDS ONLY TO KNOW THE LOCATION OF AVAILABLE INPUT DATA AND THE REQUIRED LOCATIONS FOR STORING THE RESULTING OUTPUT DATA. ORDINARY PROCESSORS, LISTED IN ORDER OF DESCENDING PRIORITY, ARE AS FOLLOWS -

PRIORITY	NAME	PURPOSE
1	HIN1	HIGH-SPEED INPUT FROM LINE NO. 1
2	HIN2	HIGH-SPEED INPUT FROM LINE NO. 2
3	HIOT	HIGH-SPEED OUTPUT (NOT USED)
4	TTYI	TTY INPUT (NOT USED)
5	TTYO	FORMATS TTY OUTPUT.
6	LOGG	INITIATES LOG TAPE WRITING.
7	EDIT	VALIDATES, REFORMATS, AND SCREENS INPUT.
8	CONV	COORDINATES CONVERSION AND DATA PERTURBATION.
9	DIAG	TYPEWRITER AND PAPER TAPE INPUT/OUTPUT AND OTHER MISCELLANEOUS FUNCTIONS.

8.4.4.4 SUBROUTINES. SUBROUTINES ARE STORED IN THE COMPUTER'S MEMORY FOR USE DURING THE REAL-TIME SIMULATION RUN. THE SUBROUTINES ARE USED TO PERFORM BASIC ARITHMETIC FUNCTIONS PECULIAR TO THE SIMULATION PROGRAMMING SYSTEM. THE SUBROUTINES ARE AS FOLLOWS -

NAME	PURPOSE
AKSC	CONVERTS POSITION VECTOR TO R, A, E.
C34W	FORMATS A 34-CHARACTER TTY MESSAGE.
C38W	FORMATS A 38-CHARACTER TTY MESSAGE.
CFOR	CONVERTS FIXED POINT TO TTY CODE.
CHEX	FORMATS A HEXADECIMAL TTY MESSAGE.
	CONVERTS FLOATING POINT TO TTY CODE.
CLOG	MOVES A TTY MESSAGE TO A LOGGING BUFFER.
CORR	APPLIES DEFLECTION CORRECTIONS TO RAW RADAR DATA.
CTIM	FORMATS THE TIME QUANTITY INTO TTY CODE.
CLOG	MOVES A TTY MESSAGE TO A LOGGING BUFFER.
CORR	APPLIES DEFLECTION CORRECTIONS TO RAW RADAR DATA.
CTIM	FORMATS THE TIME QUANTITY INTO TTY CODE.
ECON	REFORMATS THE HIGH-SPEED INPUT DATA.
FACS	COMPUTES THE ARC COSINE OF A NUMBER.
FASN	COMPUTES THE ARC SINE OF A NUMBER.
FGDS	COMPUTES A GREAT CIRCLE DISTANCE.
FLAG	SELECTS THE SIX (OR LESS) SITES CAPABLE OF OBSERVING.
FLFX	CONVERTS INTEGERS FROM FLOATING TO FIXED POINT.
INIT	INITIALIZES THE REAL-TIME SYSTEM.
INTO	CONVERTS A POSITIVE TWO-DECIMAL DIGIT FIXED-POINT BINARY INTEGER TO BCD.

ITIM	CONVERTS BINARY SECONDS TO BCD HOURS-MINUTES-SECONDS.
IVEL	COMPUTES INERTIAL VELOCITY.
MXIN	CONVERTS A POSITIVE EIGHT-DECIMAL-DIGIT. FIXED-POINT BINARY INTEGER TO BCD.
NOTE	TYPES A NOTE TO THE OPERATOR IN NON-REAL-TIME.
RAND	RANDOM NUMBER GENERATOR.
REPT	PROCESSES REAL-TIME REQUESTS FOR ON-LINE STATUS REPORTS.
RMSG	FORMATS AN ON-LINE STATUS REPORT MES-SAGES.
RNGE	APPLIES RANDOM AND BIAS ERRORS TO RAW RADAR DATA.
RSRT	RESTARTS THE SYSTEM.
SAV1	DESIGNATES THE PROPER KEEP MACRO TO SAVE THE MACHINE CONDITION WHEN AN INTERRUPT OCCURS.
SUBL	COMPUTES THE SUBCAPSULE POSITION.
VMAG	CALCULATES THE MAGNITUDE OF A VECTOR.

8.4.4.5 MACROS. MACROS ARE USED IN THE SIMULATION PROGRAMMING SYSTEM TO PERFORM CERTAIN SPECIAL FUNCTIONS, SUCH AS SIGNALLING THAT THE COMPUTER IS ABOUT TO BE ENABLED FOR TRAPPING, AND TO ENABLE IT. MACROS USED IN THE SIMULATION PROGRAMMING SYSTEM ARE AS FOLLOWS -

NAME	PURPOSE
KEEP	CONTAINS THE INFORMATION SAVED WHEN AN INTERRUPT OCCURS AND RESTORES THE SAVED INFORMATION WHEN THE INTERRUPT IS TERMINATED.

MOVE	MOVES THE CONTENTS OF NINE LOCATIONS FROM ONE BLOCK TO ANOTHER.
QENB	SIGNALS THAT THE COMPUTER IS ABOUT TO BE ENABLED FOR TRAPPING, AND ENABLES IT.
QDBL	SIGNALS THAT THE COMPUTER IS ABOUT TO BE DISABLED FROM TRAPPING, AND DISABLES IT.
QOFF	CLEARS THE PRIORITY QUEUE WORD PNOS WHICH CONTAINS THE NUMBER OF THE ORDINARY PROCESSOR ACTUALLY BEING EXECUTED.
SAVE	CALLING SEQUENCES FOR SAV1 SUBROUTINE.
TOFF	TURNS OFF INDICATOR FOR ORDINARY PROCESSOR.
TRON	TURNS ON INDICATOR FOR ORDINARY PROCESSOR.

8.4.4.6 SIMULATION EXTERNAL PROGRAMS. FOUR PROGRAMS WERE DEVELOPED FOR EXECUTION ON THE CCC WHICH ARE NOT PART OF THE GEMINI SIMULATION SYSTEM, BUT WHICH ARE REQUIRED FOR SUPPORT OF THE SYSTEM. THESE FOUR PROGRAMS ARE -

NAME	PURPOSE
CORE	DUMP TO MAGNETIC TAPE.
DDMP	DELETION DUMP.
LIST	PROVIDES SORTED LISTS OF PROGRAM SYMBOLS.
UTL1	CHANGES, PUNCHES, OR TYPES OUT MEMORY.

8.4.4.7 PERIPHERAL PROGRAMS. FIVE PERIPHERAL PROGRAMS ARE REQUIRED TO ASSIST IN RUNNING THE SIMULATION SYSTEM. TWO OF THE PROGRAMS ARE FOR THE GSFC IBM 1401 COMPUTER - THE CARD-TO-PAPER-TAPE PROGRAM PUNCHES AN 8-CHANNEL PAPER TAPE SUITABLE FOR INPUT TO THE CCC ASSEMBLY PRO-

GRAM FROM A SYMBOLIC CARD DECK, AND THE LOG TAPE PROCESSOR PROGRAM (DDPLOG) PROCESSES DATA WRITTEN ON A MAGNETIC LOG TAPE BY THE CCC DURING A GEMINI ORBITAL SIMULATION. THE OTHER THREE PROGRAMS ARE FOR THE GSFC IBM 7094 COMPUTERS. THESE THREE PROGRAMS ARE AS FOLLOWS -

NAME	PURPOSE
CRAM	CONVERTS CCC FLOATING POINT FORMAT TO GSFC IBM 7094 FORMAT.
DBLFL	GENERATES DOUBLE PRECISION FLOATING POINT DATA FROM BCD INPUT.
TODDP	CONVERTS GSFC 7094 FLOATING POINT FORMAT TO CCC FLOATING POINT FORMAT.

8.4.4.8 LIBRARY AND UTILITY SUBROUTINES. LIBRARY AND UTILITY SUBROUTINES ARE PROVIDED FOR THE CCC COMPUTER TO PROVIDE A VARIETY OF MATHEMATICAL AND TAPE MAINTENANCE FUNCTIONS, SUCH AS FLOATING POINT OR DOUBLE PRECISION ADDING, SUBTRACTING, MULTIPLYING, AND DIVIDING AND LOADING, DUMPING, OR UPDATING A TAPE.

PRECEDING PAGE BLANK NOT FILMED.

9. CADFISS

9.1 GENERAL

THE CADFISS TESTS ARE USED TO DETERMINE THE READINESS OF THE MANNED SPACE FLIGHT NETWORK TO PROVIDE MISSION SUPPORT.

THE TESTS ARE A SUPPLEMENT TO REMOTE-SITE TESTING AND PROVIDE A UNIFORM STANDARD OF TESTING AND EVALUATION IN ADDITION TO PROVIDING A MEANS OF TESTING PERTINENT AREAS AND SIMULTANEOUSLY PRESENTING THE RESULT IN REAL-TIME.

CADFISS UTILIZES AN AUTOMATIC PROGRAM CONCEPT - ALL PHASES OF TESTING ARE UNDER CONTROL OF THE COMPUTER PROGRAM. THE IBM 7094 AT GSFC IS THE CENTER OF THE TESTING SYSTEM AND CONTROLS DATA FLOW ACTIVITY BETWEEN REMOTE SITES AND THE GSFC.

INDIVIDUAL TESTS ARE DESIGNED TO EXERCISE THE LAUNCH MONITOR SUBSYSTEM (LMSS) AND LAUNCH TRAJECTORY DATA SYSTEM (LTDS) EQUIPMENT IN A SIMULATED OPERATION THAT PROVIDES A BRIEF CONFIDENCE CHECK OF THE READINESS OF A PARTICULAR PIECE OF EQUIPMENT OR SEGMENT OF THE SYSTEM.

9.2 CADFISS OPERATION

THE TEST PARAMETERS AND CRITERIA, AS WELL AS VARIOUS PATTERNS THAT EXERCISE ALL PERTINENT PHASES OF THE EQUIPMENT BEING TESTED, ARE ENTERED INTO THE IBM 7094 AS PART OF A TEST MODULE. WHEN POSSIBLE, THE REMOTE SITE WILL ACT AS THE DATA SOURCE. HOWEVER, IN DISPLAY TESTS THE IBM 7094 TRANSMITS THE PATTERNS THAT WILL CHECK THE DISPLAY INDICATORS. THIS TYPE OF OPERATION ENABLES

UTILIZATION OF THE NORMAL MISSION DATA FLOW PATH WHILE SITE EQUIPMENT IS TESTED.

THE TESTS ARE CONDUCTED SIMULTANEOUSLY, USING DATA FLOW LINES FROM ALL SITES. WHEN A GROUP OF TESTS UTILIZE ONE DATA LINE, THE TESTS ARE TIME-SEQUENCED BY THE IBM 7094.

TESTING IS INITIATED BY A CUE TO THE REMOTE SITE FROM THE IBM 7094. THE SITE RESPONDS BY SENDING AN ESTABLISHED DATA PATTERN TO THE IBM 7094, WHERE IT IS COMPARED WITH A STORED MODEL RESPONSE. IF NO DATA IS RECEIVED IN THE ALLOWABLE TEST TIME, THE TEST IS TERMINATED.

IF DATA IS RECEIVED AND IDENTIFIED, TEST SCORING WILL COMMENCE. THE CURRENT STATUS OF DATA COMPARISONS IS PRINTED OUT IN REAL-TIME ON A TEST PROGRESS REPORT. THIS REPORT INDICATES THE CRITERIA AND SCORE FOR EACH TEST AND THE CURRENT STATUS OF ALL PHASES OF TESTING (E.G., FAILURE, SUCCESS, NO RESPONSE, INCOMPLETE). THE TEST PROGRESS REPORT INFORMS THE TEST DIRECTOR OF THE TEST STATUS AND AIDS HIM IN READILY IDENTIFYING SYSTEMS FAILURE INDICATORS. SITES ARE NOTIFIED OF TEST STATUS BY TELEPHONE. IN THE EVENT OF FAILURE, CORRECTION PROCEDURES CAN BE INITIATED IMMEDIATELY.

AS EACH TEST IS COMPLETED, THE IBM 7094 AUTOMATICALLY SELECTS THE NEXT TEST TO BE RUN ON A GIVEN CIRCUIT. THIS TESTING CONTINUES UNTIL ALL TESTS HAVE BEEN COMPLETED AND THE RESULTS TABULATED.

THE INPUT DATA IS ALSO LOGGED ON MAGNETIC TAPE AS A DETAILED SUMMARY OF ERROR AND SUCCESS DATA. THIS DATA MAY BE USED TO ASSIST SITE PERSONNEL IN THE SOLUTION OF EQUIPMENT PROBLEMS. THE DATA IS ALSO USED FOR STUDIES AIMED AT VERIFYING THE VALIDITY OF EXISTING TEST PARA-

METERS (WHICH WILL IMPROVE THE QUALITY OF TESTING) AND AT DETERMINING SYSTEM AREAS THAT NEED DESIGN IMPROVEMENTS.

THE CADFISS TESTS ARE USED TO CHECK THE OPERATION OF THE FOLLOWING GENERAL SYSTEMS - RADAR, COMMAND, TELEMETRY, DISPLAY, COMPUTER-TO-COMPUTER VIA HIGH- AND LOW-SPEED LINES, AND COMMUNICATIONS.

9.3 RADAR TESTS

9.3.1 PATTERN TESTS

THE PURPOSE OF THESE TESTS IS TO CHECK THE DATA FLOW BETWEEN THE BERMUDA AND GSFC HIGH SPEED RADAR BUFFERS.

THE DATA USED IN THESE TESTS CONSISTS OF FOUR DIFFERENT STATIC PATTERNS, INSERTED INTO THE BERMUDA RADAR HIGH SPEED BUFFER BY PATCHABLE PLUGBOARDS. THE DATA AND A SPECIAL ERROR CODE ARE TRANSMITTED TO THE GSFC HIGH SPEED BUFFER VIA TWO 2000 BIT/SEC TELEPHONE LINES. BOTH LINES CARRY THE SAME DATA. AN ADDITIONAL ERROR CODE IS GENERATED BY THE GSFC BUFFERS FROM THE RECEIVED DATA. THE DATA PLUS THE TWO ERROR CODES ARE THEN TRANSFERRED TO THE IBM 7094.

THE TEST PROCESSOR ANALYZES THE DATA BY COMPARING THE RECEIVED DATA WITH THE EXPECTED DATA AND TABULATING THE DISCREPANCIES. IT COMPARES THE ERROR CODE GENERATED AT THE BERMUDA BUFFER WITH THAT GENERATED AT THE GSFC BUFFER. CHECKS ARE ALSO MADE ON MISSING MESSAGES AND ON THE TIME RECEIPT OF MESSAGES.

THE TEST PROGRESS REPORT INDICATES THE SCORE FOR THESE TESTS BASED ON THE NUMBER OF FRAMES RECEIVED CORRECTLY, THE NUMBER IN ERROR AND THE NUMBER OF FRAMES MISSING. THIS REPORT ALSO INDICATES THE SECTION OF THE

DATA FRAME THAT FAILED (FPS-16, VERLORT, TIME, SPARE BITS ETC.) AND THE NUMBER OF TIMES THE BERMUDA AND GSFC ERROR CODES DO NOT COMPARE.

THE TEST SUMMARY REPORT GIVES A DETAILED PRINTOUT OF THE DATA SHOWING THE ERRONEOUS BITS, TIME, AND A (PROBABLE FAULT) CODE. THIS CODE IS REFERENCED TO A TABLE THAT GIVES THE PROBABLE AREA OF MALFUNCTION BASED ON AN ANALYSIS OF THE DATA.

9.3.2 BORESIGHT TESTS

THE PURPOSE OF THESE TESTS IS TO DEMONSTRATE THE ABILITY OF EACH RADAR SYSTEM TO -

A) AUTOMATICALLY ACQUIRE A TARGET (BORESIGHT TOWER) WITHIN ITS RASTER SEARCH PATTERN.
B) ORIGINATE CORRECT DATA FOR THE TARGET.
C) ACT AS A SOURCE OF ANGLE TRACKING DATA FOR OTHER ANTENNA PEDESTALS.

THESE TESTS CHECK THE RADAR SYSTEM'S ANGLE TRACKING ABILITY AND ITS ABILITY TO ORIGINATE CORRECT DATA FOR THE BORESIGHT PARAMETERS OF AZIMUTH AND ELEVATION.

SINCE THE DISTANCE (RANGE) FROM THE RADAR ANTENNA TO THE BORESIGHT TOWER IS SMALL, THE BORESIGHT RANGE DATA IS UNIMPORTANT DURING TESTING.

TO BEGIN THE TEST, THE SITE BORESIGHT SIGNAL GENERATOR IS ADJUSTED TO A SPECIFIED SIGNAL LEVEL AND THE RADAR ANTENNA IS POINTED A FEW DEGREES OFF THE BORESIGHT TOWER. THE ANTENNA IS THEN PLACED IN A RASTER SCAN MODE ABOUT THIS POSITION. LOCK-ON OCCURS IN THE NORMAL MANNER AND THE DATA IS TRANSMITTED TO GSFC.

THE TEST PROCESSOR AT GSFC ACCEPTS ALL RECOGNIZABLE DATA AND COMPARES THE PARAMETERS OF AZIMUTH, ELEVATION, AND RANGE AGAINST THE SURVEYED VALUE.

A SCORE INDICATING THE NUMBER OF SUCCESSFUL OR FAILING AZIMUTH PARAMETERS IS INDICATED ON THE TEST PROGRESS REPORT. ONLY THE AZIMUTH SCORE IS DISPLAYED SINCE ONLY ONE SCORE FOR EACH TEST IS ALLOWED ON-LINE. THE TEST WILL BE SCORED A FAILURE IF THE NUMBER OF FAILING FRAMES IN EITHER AZIMUTH, ELEVATION, OR RANGE EXCEEDS THE FAILURE CRITERIA USED IN THE TEST PROCESSOR. IN THE EVENT OF FAILURE, THE LETTERS A, E, OR R WILL BE PRINTED ON-LINE TO INDICATE THE FAILING PARAMETER(S).

THE TEST SUMMARY REPORT DISPLAYS THE RESULTS OF DETAILED ANALYSIS OF THE DATA RECEIVED IN THIS TEST. THE DISPLAY CONSISTS OF THE TOTAL NUMBER OF SAMPLES SCORED FOR EACH PARAMETER AND THE NUMBER OF SUCCESSFUL AND FAILING SAMPLES. ALSO DISPLAYED ARE THE EXPECTED VALUE, THE LIMITS ALLOWED, THE AVERAGE VALUE, AND THE STANDARD DEVIATION.

9.3.3 RANGE TARGET TESTS

THESE TESTS DEMONSTRATE THE CALIBRATION OF THE RANGE RATE ENCODERS, AND, TO A SMALL DEGREE, THE CONDITION OF THE TRANSMITTING AND RECEIVING SYSTEMS. THE RADAR IS LOCKED ON ITS RANGE TARGET AND TRANSMITS DATA CONTAINING THE PARAMETERS OF AZIMUTH, ELEVATION, AND RANGE TO GSFC. SINCE THIS TEST MAINLY CONCERNS THE RANGE SECTION OF THE RADAR SYSTEM, THE LIMITS FOR AZIMUTH AND ELEVATION ARE WIDENED TO PREVENT UNNECESSARY TEST FAILURE.

THE DATA IS PROCESSED AT GSFC IN THE SAME MANNER AS IS PROCESSED FOR THE BORESIGHT TEST.

9.3.4 RADAR SLEW TESTS

THESE TESTS CHECK THE ABILITY OF A RADAR SYSTEM TO GENERATE SMOOTH DIGITAL DATA AS THE ANTENNA AND RANGE SECTION IS SLEWED AT A RATE LIKELY TO BE ENCOUNTERED DURING A SPACECRAFT TRACKING OPERATION.

SEPARATE TESTS ARE USED FOR CLOCKWISE AND COUNTER-CLOCKWISE SLEWS.

SMOOTHNESS OF SLEW IS CHECKED BY PERFORMING A FIRST AND SECOND DIFFERENCE CALCULATION ON THE PARAMETERS OF AZIMUTH, ELEVATION, AND RANGE. TIME IN EACH RADAR FRAME IS CHECKED FOR A SIX-SECOND DIFFERENCE.

THE TEST PROGRESS REPORT INDICATES THE SCORE FOR THE AZIMUTH SINCE ONLY ONE SCORE IS POSSIBLE, BUT FLAG CHARACTERS A, E, R, AND T ARE AVAILABLE IN THE TEST STATUS TO INDICATE FAILURES IN THESE PARAMETERS.

THE TEST SUMMARY REPORT CONTAINS THE RADAR RECEIVED WITH THE CALCULATED FIRST AND SECOND DIFFERENCE FOR AZIMUTH, EVELATION, AND RANGE AND THE FIRST DIFFERENCE FOR AZIMUTH, ELEVATION, AND RANGE AND THE FIRST DIFFERENCE OF TIME. ALSO INDICATED IN THIS REPORT ARE THE STATUS AND SCORES OF THESE PARAMETERS.

9.4 DISPLAY TESTS

DISPLAY TESTING CHECKS THE HIGH SPEED DATA FLOW PATH FROM THE GSFC TO THE MCC, ALL GODDARD-DRIVEN DISPLAYS ARE CHECKED FOR PROPER OPERATION AND THE CORRECT ACCEPTANCE OF DATA. TEST DATA IS ARRANGED INTO 440-BIT ODD AND EVEN SUBFRAMES (BITS 84 AND 85 IDENTIFY ODD OR EVEN). THE TESTING INCLUDES 6054 SUBFRAMES DIVIDED INTO TEST SEQUENCES THAT CONTAIN DATA FOR A PARTICULAR PART OF THE TESTING. THE FIRST 10 SUBFRAMES ARE ALL ZEROS, EXCEPT FOR BITS 84 AND 85, AND THE FIRST SUBFRAME IS

ODD. THESE FIRST 10 SUBFRAMES ARE INITIALIZING SUB-FRAMES THAT RESET ALL DISPLAY DEVICES.

THE FIRST SEQUENCE CONSISTS OF 10 SUBFRAMES. THE IDENTIFICATION BITS IN THE FIRST FIVE CONTAIN ALL ONES, AND THE STRIP CHART BITS CONTAIN 0777 (OCT). OWING TO THE IDENTITY BIT CONFIGURATION, THESE FIVE MESSAGES SHOULD BE DISCARDED, AND THE STRIP CHART SHOULD NOT BE DEFLECTED. A DEFLECTION INDICATES AN EQUIPMENT FAILURE TO REJECT IMPROPERLY IDENTIFIED MESSAGES. THE NEXT FIVE MESSAGES USE ZEROS IN THEIR IDENTIFICATION BITS AND 1577 (OCT) IN THE STRIP CHART BITS. FAILURE TO DISCARD THESE MESSAGES ALSO INDICATES THE INABILITY TO REJECT IMPROPERLY IDENTIFIED MESSAGES.

THE MAIN PORTION OF THE TESTING OCCURS IN TEST SEQUENCES 2 THROUGH 13 WHICH SERVE TO TEST THE DISPLAY DEVICES AT GSFC AND MCC. SEQUENCES 2 THROUGH 12 CONSIST OF 84 SUBFRAMES, EQUALLY DIRECTED ODD AND EVEN, WITH THE ODD SUBFRAME BEING TRANSMITTED FIRST. THE TRANSMISSION RATE IS 500 MILLISECONDS. TEST SEQUENCE 13 CONTAINS 100 SUBFRAMES. AT THE BEGINNING OF TEST SEQUENCE 4, AND ON-LINE PRINTOUT OCCURS INDICATING THAT THE GSFC IS TO SWITCH TRANSMITTERS, THUS BOTH TRANSMITTERS ARE CHECKED. SIMILARLY, AT THE BEGINNING OF TEST SEQUENCE 8 AN ONLINE PRINTOUT OCCURS INDICATING THAT THE MCC SHOULD SWITCH RECEIVING REGISTERS.

TEST SEQUENCE 14 IS IDENTICAL WITH THE INITIAL DE-FLECTION TEST SEQUENCE (SEQUENCE 1), EXCEPT THAT IT SERVICES THE SECOND RECEIVING REGISTER.

TEST DATA IS ALSO USED TO SUPPLY THE GSFC COMPUTER-CONNECTED PLOTBOARDS.

AFTER DISPLAY TESTING IS COMPLETED, A TEST IS PER-FORMED TO OBTAIN A RESPONSE FROM THE SITES INVOLVED IN

THE DISPLAY TESTING. THIS RESPONSE IS A REPORT ON THE SUCCESS OR FAILURE OF THE DISPLAY TESTING.

9.5 MCC-GSFC COMPUTER TESTS

THESE TESTS CHECK THE DATA FLOW FROM THE IP AND B/GE COMPUTERS TO GSFC. THESE TESTS ARE CONDUCTED USING HIGH SPEED DATA.

THE TRANSMISSION OF HIGH SPEED DATA TO MCC FOR THE DISPLAY TEST SERVES AS A CUE FOR THESE TESTS. THE DATA TRANSMITTED TO GSFC IS COMPARED AGAINST AN EXPECTED PATTERN AND THE ERROR COUNT IS TABULATED FOR DISPLAY ON THE TEST PROGRESS REPORT. SPECIAL PRECAUTIONS ARE TAKEN IN THE TEST PROCESSOR TO ENSURE THAT MISSION MESSAGES AND ERRORS IN TRANSMISSION DO NOT CAUSE AN OUT-OF-SYNC CONDITION BETWEEN THE DATA AND THE EXPECTED PATTERNS. TIMING BETWEEN MESSAGE FRAMES IS ALSO CHECKED TC DETERMINE IF THE TIMING IS OPTIMUM AND IF MESSAGES ARE MISSING.

THE TEST PROGRESS REPORT INDICATES THE NUMBER OF SUCCEEDING, FAILING, AND MISSING DATA FRAMES. THE STATUS OF THE TEST IS INDICATED ALONG WITH VARIOUS FLAGS TO SIGNAL EXCESSIVE FAILURES IN PARAMETERS WITHIN THE DATA FRAME.

THE TEST SUMMARY REPORT DISPLAYS ALL DATA FRAMES CONTAINING ERRORS AND THE EXPECTED PATTERN FOR THE FAILING FRAME. THE FAILING BITS WITHIN THE FRAME WILL BE INDICATED.

9.6 MCC TELEMETRY EVENTS TEST

THIS TEST CHECKS THE MCC TELEMETRY EVENT SWITCHES AND THE DATA TRASMISSION FROM THE TELEMETRY BUFFER AT MCC TO GSFC. THIS IS A DYNAMIC TEST OF THE EVENT SWITCHES.

ONCE THIS TEST IS INITIATED AT GSFC, THE PROGRESS OF THE EVENT CHECKS IS UNDER OPERATOR CONTROL AT MCC. THE TEST PROCESSOR RECOGNIZES A UNIQUE EVENT TO INDICATE THAT THE TEST HAS STARTED AND COMMENCES TABULATION OF THE INCOMING DATA AS THE MCC OPERATOR EXERCISES ALL EVENTS. THE PROCESSOR MONITORS THE TEST TO DETERMINE IF THE OPERATOR IS DEVIATING FROM A SET SEQUENCE AND IF ALL EVENTS HAVE BEEN EXERCISED AT THE COMPLETION OF THE TEST. FAILURE OF ANY OR ALL EVENTS TO CONTAIN THE CORRECT NUMBER OF BITS IS ALSO TABULATED. PRECAUTIONS HAVE BEEN TAKEN IN THIS TEST TO ENSURE THAT EVENT, SEQUENCE, AND DATA TRANSMISSION ERRORS CAN BE TABULATED INDIVIDUALLY, AND THAT A FAILURE IN ONE ITEM CANNOT AFFECT THE SCORING OF ANOTHER.

THE TEST PROGRESS REPORT FOR THIS TEST INDICATES THE NUMBER OF SUCCESSFUL AND FAILING DATA FRAMES BASED ON TRANSMISSION ERRORS AND THE STATUS OF THE TEST.

THE TEST SUMMARY REPORT DISPLAYS EACH FRAME OF DATA CONTAINING AN ERROR AND INDICATES THE TYPE OF FAILURE - I.E., TRANSMISSION, SEQUENCE, OR EVENT. THE FAILING BIT IS ALSO INDICATED.

A TELEMETRY EVENT SUMMARY IS ALSO DISPLAYED AND CONTAINS A TABULATION OF THE NUMBER OF SUCCESSFUL AND FAILING EVENTS. THESE TABULATIONS ARE MADE FOR EACH INDIVIDUAL EVENT.

9.7 TTY COMMUNICATION TEST

THE PURPOSE OF THIS TEST IS TO CHECK THE ABILITY OF THE TTY COMMUNICATIONS LINE AND THEIR ASSOCIATED EQUIPMENT AND TO CARRY DATA BETWEEN GSFC AND THE REMOTE SITES IN THE TRACKING NETWORK.

THE RESULTS OF THIS TEST ARE USED AS A FIGURE OF MERIT FOR SUCCEEDING TESTS USING THE SAME CIRCUITS.

THIS TEST IS ACCOMPLISHED BY TRANSMITTING A SPECIAL TTY TEST PATTERN, CONSISTING OF EITHER 3 OR 50 LINES OF TTY DATA, FROM GSFC TO THE SITE. ON RECEIPT OF THE DATA THE SITE CHECKS IT AGAINST THE EXPECTED PATTERN AND TABULATES THE ERRORS. THIS TABULATED DATA IS THEN SENT TO GSFC VIA A SPECIALLY FORMATTED TTY MESSAGE. THE TEST PROCESSOR INDICATES ON THE TEST PROGRESS REPORT THAT THIS MESSAGE HAS BEEN RECEIVED, AND THEN PRINTS THE TEXT OF THE MESSAGE ON THE TEST SUMMARY REPORT FOR ANALYSIS BY THE TEST DIRECTOR. ON RECEIPT OF THE TEST PATTERN FROM GSFC, THE REMOTE SITE ALSO TRANSMITS A TTY TEST PATTERN TO GSFC. THE TEST PROCESSOR ANALYSES THIS DATA FOR COMMUNICATIONS ERRORS.

THE TEST PROGRESS REPORT FOR THIS TEST INDICATES THE NUMBER OF SUCCESSFUL AND FAILING LINES OF DATA RECEIVED FROM THE SITE AND THE STATUS OF THE TEST.

THE TEST SUMMARY REPORT DISPLAYS THE EXPECTED AND THE ACTUAL RESPONSE AND INDICATES THE CHARACTERS IN ERROR IF MORE THAN SIX GROUPS ARE IN ERROR. IF THERE ARE LESS THAN SIX 6-CHARACTER GROUPS CONTAINING ERRORS, BIT-BY-BIT ANALYSIS WILL BE MADE AND INDICATED ON THE REPORT.

9.8 REPORTING TESTS

THE REPORTING TESTS IN THE CADFISS PROGRAM CONTROL AND MONITOR THE OVERALL TEST SCHEME. THEY REPORT CONDITIONS OF A REMOTE SITE THAT ARE CONTROLLED BY TESTING FROM GSFC.

SOME EXAMPLES OF A REPORTING TEST ARE THE REPORT ON THE DISPLAY TEST AT MCC AND THE REPORT ON THE COMMUNICATION TEST AT THE REMOTE SITE. IN MOST CASES THE TEST PROGRESS REPORT INDICATES THAT REPORTS ARE RECEIVED AND THE TEST SUMMARY REPORT DISPLAYS THE TEXT OF THE REPORT FOR ANALYSIS BY THE TEST DIRECTOR.

9.9 DCS AND PCM TESTS

THE GEMINI TRANSPONDER SIMULATOR, LOCATED AT WALLOPS STATION, TEMPERENCEVILLE, VIRGINIA, IS A PROTOTYPE SIMULATOR USED FOR TESTING AND EVALUATING THE MANNED SPACE FLIGHT NETWORK, DIGITAL COMMAND SYSTEM (DCS), AND THE PULSE CODED MODULATION TELEMETRY SYSTEM (PCM). IT FACILITATES UNIT TESTING OF THE DCS OR PCM AS WELL AS SYSTEM TESTING OF THE DCS AND PCM SYSTEM. THE SYSTEM TEST UTILIZES A REAL TIME CLOSED-LOOP TEST.

PRECEDING PAGE BLANK NOT FILMED.

APPENDIX A. AUTOMATED DOCUMENTATION SYSTEM

A.1 INTRODUCTION

THE AUTOMATED DOCUMENTATION (AUTODOC) SYSTEM AT GSFC PROVIDES AN EASY TO USE METHOD OF PRODUCING AND MAINTAINING THE PROGRAM DOCUMENTATION OF THE GRTS COMPUTING SYSTEM ON A NEAR REAL-TIME BASIS. IN THIS METHOD OF PROGRAM DOCUMENTATION, PROGRAM DESCRIPIIONS ARE PREPARED IN DRAFT FORM, EDITED, AND KEYPUNCHED ONTO UNIT RECORD CARDS WHICH ARE THEN ASSEMBLED INTO DECKS AND FED INTO AN IBM 1401 COMPUTER. THE AUTODOC SYSTEM PROGRAM AUTOMATICALLY PROCESSES THIS INPUT AND PRODUCES PRINTOUTS OF THE PROGRAM DESCRIPTIONS (TEXT AND FLOWCHARTS) IN A SINGLE OPERATION. PHOTO-OFFSET COPIES OF THE PRINTOUTS ARE THEN MADE AND DISTRIBUTED EITHER AS PROGRAMMER WORKING COPIES OR AS FINAL DOCUMENTATION TO REFLECT A PARTICULAR LEVEL IN THE DEVELOPMENT OF THE REAL-TIME SYSTEM - AS IN THE CASE OF THIS SERIES OF MANUALS WHICH REFLECTS THE SYSTEM DEVELOPMENT THROUGH THE GT-3 MISSION.

A.1.1 SYSTEM CAPABILITIES

THE AUTODOC SYSTEM PROVIDES SEVERAL DISTINCT ADVANTAGES TO THE GRTS PROGRAM DOCUMENTATION EFFORT. DOCUMENTATION MAY BE PREPARED AND KEPT CURRENT BY THE SIMPLE INSERTION AND DELETION OF CARDS. FOR EXAMPLE, TO REFLECT A PROGRAM OR SYSTEM CHANGE, TEXT AND/OR FLOWCHARTS ARE ADDED, CHANGED, OR DELETED, BY ADDING, CHANGING, OR REMOVING CARDS, RESPECTIVELY. COPIES OF THE REVISED

PROGRAM ARE PRODUCED BY RERUNNING THE UPDATED DECK ON THE 1401. (DUPLICATE COPIES OF THE PRINTOUTS MAY BE MADE EASILY, WHEN REQUIRED, DURING THE SAME OPERATION.)

AS PART OF THE PROCESSING OF INPUT INFORMATION, THE AUTODOC PROGRAM PERFORMS A PSEUDO EDIT AND PRINTS A DIAGNOSTIC WHICH IS USED PRIMARILY TO DETERMINE THAT NO CODING ERRORS EXIST IN THE FLOWCHART CARDS OF THE INPUT DECK. IN SOME CASES, A CODING ERROR MAY INHIBIT THE FINAL PRINTING OF TEXT AND FLOWCHART -- IN OTHERS, THE PROGRAM DIAGNOSTIC MERELY POINTS OUT ANY UNDESIRABLE CONDITIONS THAT EXIST. IN ADDITION, THE DIAGNOSTIC COMPUTES A READIBILITY FACTOR FOR EACH FLOWCHART PAGE AND A FINAL AVERAGE FOR THE ENTIRE RUN. THIS READIBILITY FACTOR IS USED TO DETERMINE WHETHER A REORDERING OF INFORMATION IS NECESSARY TO REDUCE CLUTTER.

THE AUTOMATIC PRODUCTION OF CAMERA-READY FLOWCHARTS PROVIDED BY THIS SYSTEM AFFORDS CONSIDERABLE SAVINGS IN TIME AND COST OVER CONVENTIONAL METHODS. THE SYSTEM PROGRAM AUTOMATICALLY PRINTS THE FLOWCHART BLOCKS AND INSERTS THE TEXT WITHIN THE BLOCKS. PAGE NUMBERING, CONNECTOR ASSIGNMENTS (INCLUDING ON AND OFF-PAGE VARIATIONS) ARE GENERATED AND, WHEN POSSIBLE, LINES ARE DRAWN BETWEEN BLOCKS TO INDICATE LOGICAL CONNECTIONS. IF THIS IS IMPOSSIBLE, OFF- OR ON-PAGE CONNECTORS, AS REQUIRED, ARE AUTOMATICALLY GENERATED AND PLACED ON THE CHART. FOR OFF-PAGE CONNECTORS, THE PAGE NUMBERS AND COORDINATES OF THE IN-CONNECTOR ARE PRINTED IN THE OFF-PAGE CONNECTOR BLOCK.

WHEN PRODUCING STRAIGHT TEXTUAL INFORMATION, THE PROGRAM OFFERS THE FOLLOWING OPTIONS WHICH CAN BE PERFORMED AUTOMATICALLY -

A. CENTER THE TEXT BEFORE PRINTING.

B. RIGHT JUSTIFY THE TEXT.
C. FULLY JUSTIFY THE TEXT - BY INSERTING BLANKS BETWEEN WORDS SO THAT BOTH EDGES ARE JUSTIFIED.
D. PRINT TEXT AS PUNCHED IN THE CARD.
E. GENERATE LINES ACROSS A PAGE.
F. CREATE A TABLE OF CONTENTS.

A.1.2 RESTRICTIONS AND LIMITATIONS

THE FOLLOWING RESTRICTIONS AND LIMITATIONS INHERENT TO THE AUTODOC SYSTEM IMPOSE SOME DISADVANTAGES TO THE DOCUMENTATION PROCESS -

A. ONLY THE LETTERS OF THE ALPHABET, THE DIGITS 0 THROUGH 9, AND CERTAIN SPECIAL CHARACTERS (SEE SECTION A.2) CAN BE PRINTED BY THE COMPUTER. THEREFORE, TERMINOLOGY THAT INCLUDES SUBSCRIPTS, SUPERSCRIPTS, THE GREEK ALPHABET, ASTRONOMICAL OR OTHER SUCH TERMS USED IN MATHEMATICAL AND ANALYTICAL DERIVATIONS MUST BE OMITTED THROUGHOUT THE AUTOMATIC PROCESSING OPERATION. THIS INFORMATION IS TYPED ONTO THE FINAL PRINTOUTS AFTER ALL PROCESSING HAS BEEN COMPLETED.
B. IN THE GRTS COMPUTING SYSTEM SOME SYSTEM BLOCK DIAGRAMS, TABLES, AND ILLUSTRATIONS BY THEIR NATURE ARE NOT READILY ADAPTABLE TO THE AUTODOC SYSTEM CHARTING REQUIREMENTS AND THEREFORE MUST BE PRODUCED BY CONVENTIONAL TYPEWRITER/LINE ART METHODS.
C. THE SYSTEM ALLOWS ONLY TWO OUTPUT BRANCHES FROM THE DECISION BLOCK IN THE FLOWCHARTING OPERATION. THE PROGRAM ALWAYS LABELS THESE BRANCHES

WITH A YES AND NO - THEREFORE, THE COMMENT WITHIN THE BLOCK MUST BE WORDED TO REFLECT A YES OR NO ANSWER. IF ADDITIONAL OUTPUTS ARE NEEDED, ADDITIONAL BLOCKS MUST BE USED.

D. SYMBOLIC LABELS IN THE FLOWCHARTING OPERATIONS MAY HAVE A MAXIMUM OF 10 CHARACTERS EACH. HOWEVER, ONLY 400 SUCH LABELS MAY BE PROCESSED IN A SINGLE RUN ON THE GSFC 8K COMPUTER. (FOR A 12K OR 16K COMPUTER, THE PROGRAM CAN ACCOMMODATE UP TO 650 OR 900 LABELS PER RUN, RESPECTIVELY.) WHEN IT IS ANTICIPATED THAT MORE THAT 400 LABELS ARE USED IN A DECK, THE DECK MUST BE DIVIDED AND SEPARATE RUNS MADE OF THE SUBSEQUENT SETS OF CARDS. THE PAGE NUMBERING SEQUENCE OF THE PRINT-OUTS FROM THE ADDITIONAL RUNS MAY BE PRESET TO PICK UP THE PAGE COUNT FROM THE LAST PAGE OF THE PREVIOUS RUN.

A.1.3 MACHINE CONFIGURATION

THE AUTODOC SYSTEM AT GSFC UTILIZES AN IBM 1401 8K COMPUTER WITH FOUR MAGNETIC TAPES (THREE WORK TAPES AND A PROGRAM TAPE), A 1402 CARD READER AND A 1403 LINE PRINTER. INPUT TO THE SYSTEM CONSISTS OF A SELF-LOADING PROGRAM TAPE (IBM 1401 -2. 0. 024, TYPE III) AND CARD DECKS COMPOSED OF UNIT RECORD CARDS THAT HAVE BEEN CODED IN THE AUTOCODER LANGUAGE. THE INPUT CARDS CONTAIN THE SOURCE MATERIAL FOR PRINTING THE TEXT AND FLOWCHARTS AND SPECIAL CODING SYMBOLS THAT CONTROL THE OPERATION OF THE SYSTEM PROGRAM.

A.2 PROGRAM OPERATION

TWO DISTINCT MODES OF OPERATION ARE PROVIDED BY THE PROGRAM AS IT ACTS ON THE INPUT DATA. ONE MODE CIRCUMSCRIBES ALL THOSE OPERATIONS RELATING TO FLOWCHARTS AND THE OTHER MODE PROVIDES THE ABILITY TO HANDLE NARRATIVE TEXT, SUCH AS THIS WRITEUP. THE SYSTEM PROGRAM DETERMINES WHICH MODE IT IS OPERATING IN BY EXAMINING EACH INPUT CARD. THE CODING OF THE INPUT CARD DIRECTS THE PROGRAM TO AUTOMATICALLY SWITCH FROM ONE MODE TO ANOTHER. A GIVEN PAGE IS PRINTED IN ONE MODE OR THE OTHER, AND A CHANGE OF MODE CAUSES AN AUTOMATIC SKIP TO ANOTHER PAGE.

A.2.1 CODING

THREE SEPARATE TYPES OF CARDS ARE USED BY THE PROGRAM - CONTROL CARDS, TEXT CARDS, AND FLOWCHART CARDS. THE PREPARATION (CODING) OF THESE CARDS IS DISTINCTLY DIFFERENT FOR THE CONTROL CARDS AND FOR THE TWO MODES OF OPERATION. FOR ALL CODING, HOWEVER, ONLY THE VALID CHARACTERS THAT CAN BE PRINTED BY THE PRINTER MAY BE USED. THE VALID CHARACTERS ARE THE LETTERS OF THE ALPHABET (CAPITAL LETTERS ONLY), THE DIGITS 0 THROUGH 9 AND THE FOLLOWING SPECIAL CHARACTERS -

A. SLASH (/)
B. COMMA (,)
C. EQUALS (=)
D. PERIOD (.)
E. PLUS (+)
F. MINUS OR DASH (-)
G. ASTERISK (*)

H. DOLLAR SIGN ($)
I. LEFT PARENTHESIS (()
J. RIGHT PARENTHESIS ())
K. APOSTROPHE (')

THERE ARE NO COLONS, SEMICOLONS, OR QUESTION MARKS.

A.2.2 CONTROL CARDS

CONTROL CARDS ARE USED TO EXERCISE CERTAIN OPTIONS OVER THE PROGRAM THAT ARE NOT A PART OF ITS AUTOMATIC FUNCTIONS. SOME CARDS ARE USED IN EITHER THE TEXT MODE OR THE FLOWCHARTING MODE AND SOME ARE RESTRICTED TO A SINGLE MODE. THE CONTROL CARDS USED AND THEIR FUNCTIONS ARE -

JOB	THE JOB CARD IS AN OPTIONAL FIRST CARD - THE OPERAND, IF ANY, IS USED AS A PAGE HEADING ON THE TOP OF EACH PAGE OF THE FILE THAT FOLLOWS.
END	THIS CARD IS THE LAST CARD OF AN INPUT SOURCE DECK OF A FILE. IT HAS THE AFFECT OF CAUSING THE PROGRAM TO ENTER THE PRINT CYCLE AFTER COMPLETION OF THE DIAGNOSTIC.
EJECT	THIS CARD HAS THE EFFECT OF IMMEDIATELY TERMINATING THE PAGE IN PROCESS AND SKIPPING TO A NEW PAGE. ITS OPERAND DETERMINES THE PAGE NUMBER THAT WILL BE ASSIGNED TO THE NEXT PAGE ON WHICH PROCESSING BEGINS.
SPACE	CAUSES THE PROGRAM TO SKIP A NUMBER OF TEXT LINES EQUIVALENT TO THE VALUE OF THE

	OPERAND. THIS CARD IS USED IN THE TEXT MODE ONLY.
NONE	THIS OPERATION CAUSES THE PROGRAM TO SKIP A NUMBER OF SEQUENTIAL FLOWCHART BLOCKS EQUIVALENT TO THE VALUE OF THE OPERAND.
COPY	THIS CARD CAUSES THE PROGRAM TO PRINT DUPLICATE COPIES OF THE OUTPUT. THE OPERAND DETERMINES THE NUMBERS OF EXTRA COPIES THAT WILL BE PRINTED.

THE CARD FORMAT FOR ALL CONTROL CARDS IS BASICALLY IDENTICAL - THE OPERATION NAME BEGINS IN COLUMN 16 - AND THE OPERAND BEGINS IN COLUMN 21 FOR JOB, EJECT, SPACE, NONE AND COPY CARDS.

A.2.3 TEXT CARDS

THE CODING FORM USED FOR THE PREPARATION OF INPUT CARDS FOR OPERATION IN THE TEXT MODE IS A STANDARD CODING FORM USED BY THE 1400 SERIES AUTOCODERS (IBM FORM X24-1350-3) OR ANY FORM USING THE SAME BASIC LAYOUT. ALSO, DRAFT MANUSCRIPT PAGES, TYPED OR HANDWRITTEN, OF THE GRTS PROGRAM DESCRIPTIONS ARE CODED DIRECTLY WITHOUT RESORTING TO AN AUTOCODER FORM. FIGURE A-1 IS AN EXAMPLE OF A PAGE OF TEXT THAT HAS BEEN CODED FOR KEYPUNCHING. IN THIS CASE THE KEYPUNCH OPERATOR PLACES AN ASTERISK IN COLUMN 6, TO DIRECT THE PROGRAM TO ENTER THE TEXT MODE, AND BEGINS PUNCHING THE TEXT LINES IN THE COLUMNS INDICATED ON THE PAGE. THE TEXT MODE IS ENTERED WHEN THE PROGRAM SENSES AN ASTERISK IN COLUMN 6 OF THE INPUT CARD.

THE CARD FORMAT FOR CODING CARDS FOR THE TEXT MODE IS AS FOLLOWS -

COLUMN	CODE	FUNCTION
6	*	AN ASTERISK IN THIS COLUMN CAUSES THE PROGRAM TO ENTER THE TEXT MODE. IF THE PROGRAM HAS BEEN OPERATING IN THE FLOWCHART MODE IT WILL SWITCH TO THE TEXT MODE AND SKIP TO A NEW PAGE.
7		IF THIS COLUMN IS BLANK, TEXT IS PRINTED AS IS. OTHERWISE, IF IT CONTAINS A - C, TEXT IS CENTERED BEFORE PRINTING R, TEXT IS RIGHT JUSTIFIED BEFORE PRINTING J, TEXT IS FULLY JUSTIFIED BEFORE PRINTING ANY OTHER CHARACTER IN COLUMN 7 WILL CAUSE A LINE TO BE GENERATED ACROSS THE PAGE CONSISTING OF THE CHARACTER CONTAINED IN THE COLUMN. THIS OPTION ALLOWS LINES TO BE GENERATED ACROSS THE PAGE SUCH AS MIGHT BE USED IN A MEMORY MAP.
8,9	TC	CAUSES THE CONTENTS OF THE CARD TO BE LISTED IN A TABLE OF CONTENTS PAGE AT THE END OF THE ENTIRE RUN WITH THE FINAL PAGE NUMBER ASSIGNMENT.
16 THRU 72		TEXT IS PRINTED AS PUNCHED.

IBM

INTERNATIONAL BUSINESS MACHINES CORPORATION
AUTOCODER CODING SHEET
IBM 1240 - 1401 - 1410 - 1440 - 1460

Form X24-1350-3
Printed in U.S.A.

Program ______
Programmed by ______
Date ______

Identification ______ (76 77 78 79 80)

Sheet ___ of ___

Pg (1–2)	Line (3–5)	Label (6–15)	Operation (16–20)	Operand (21–72)
			TOP	VOL I INTRODUCTION
		*		THE CARD FORMAT FOR CODING CARDS FOR THE TEXT MODE
		*	IS AS	FOLLOWS -
			SPACE	1
		*	COLUMN	CODE FUNCTION
		*	6	* AN ASTERISK IN THIS COLUMN CAUSES THE
		*		PROGRAM TO ENTER THE TEXT MODE. IF THE
		*		PROGRAM HAS BEEN OPERATING IN THE FLOWCHART
		*		MODE IT WILL SWITCH TO THE TEXT MODE AND
		*		SKIP TO A NEW PAGE.
		*	7	IF THIS COLUMN IS BLANK, TEXT IS PRINTED AS
		*		IS. OTHERWISE, IF IT CONTAINS A -
		*		C, TEXT IS CENTERED BEFORE PRINTING
		*		R, TEXT IS RIGHT JUSTIFIED BEFORE
		*		PRINTING
		*		J, TEXT IS FULLY JUSTIFIED BEFORE
		*		PRINTING
		*		ANY OTHER CHARACTER IN COLUMN 7 WILL CAUSE
		*		A LINE TO BE GENERATED ACROSS THE PAGE CON-
		*		SISTING OF THE CHARACTER CONTAINED IN THE
			T	HIS SHEET CODED FOR PAGE 28[illegible] OF VOL II

FIGURE A-1. SAMPLE OF A PROGRAM DESCRIPTION CODED FOR TEXT MODE

A.2.3 FLOWCHART CARDS

THE CODING OF INPUT CARDS FOR THE FLOWCHART MODE REQUIRES THAT FLOWCHARTS BE PREPARED ON A UNIQUE 40-BLOCK MATRIX (FLOWCHARTING WORKSHEET) WHICH HAS BEEN DESIGNED SPECIFICALLY FOR THE AUTODOC SYSTEM. STANDARD FLOWCHARTING SYMBOLS AND CONVENTIONS ARE USED, HOWEVER, WITH VERY LITTLE ADJUSTMENT BEING MADE BY THE PROGRAMMERS. THE FLOW OF DATA IS CHARTED FROM TOP TO BOTTOM OF THE MATRIX AND FROM RIGHT TO LEFT. PSEUDO-BLOCK OPERATIONS ARE USED TO PREDETERMINE WHAT A FLOWCHART PAGE WILL LOOK LIKE, AND SYMBOLIC LABELS ARE USED TO INDICATE AND ACCOMPLISH LOGICAL CONNECTIONS BETWEEN NON-SEQUENTIAL BLOCKS. MNEMONIC OPERATION CODES ARE USED TO SPECIFY BLOCK TYPES AND CONNECTIONS. TEXT INFORMATION DESIRED WITHIN A BLOCK IS CODED IN FREE FORM, WITH THE PROGRAM AUTOMATICALLY PROVIDING THE CENTERING OF TEXT. TABLE A-1 SUMMARIZES THE CHART MODE OPERATION CODES USED IN THE CODING OF FLOWCHARTS. AS SHOWN IN THE TABLE, SOME OPERATIONS HAVE SEVERAL SYNONYMS ANY ONE OF WHICH MAY BE USED AT THE OPTION OF THE PROGRAMMER. THE CARD FORMAT FOR THE FLOWCHART MODE IS AS FOLLOWS -

COLUMN	USE
1 - 5	USED TO SEQUENCE THE INPUT. ANY VALID CHARACTERS LISTED IN SECTION A.2.1 MAY BE USED.
6 - 15	USED FOR THE ASSIGNMENT OF SYMBOLIC LABELS TO FLOWCHART BLOCKS. LABELS MAY BE FROM 1 TO 10 CHARACTERS IN LENGTH, AND ANY VALID CHARACTER MAY BE USED EXCEPT THE ASTERISK IN COLUMN 6.
16 - 20	CONTAINS THE OPERATION CODE FOR THE TYPE OF SYMBOL TO BE DRAWN OR SPECIFIES A LOGICAL

CONNECTION TO SOME OTHER SYMBOL.

21 - 72 NORMALLY CONTAINS TEXT INFORMATION WHICH IS TO BE PLACED INSIDE EACH SYMBOL. TEXT IS LEFT JUSTIFIED WITH ONLY ONE BLOCK BETWEEN WORDS.

FIGURE A-2 IS A DRAFT FLOWCHART PAGE THAT HAS BEEN PREPARED ON THE FLOWCHART MATRIX AND CODED FOR PROCESSING BY THE AUTODOC SYSTEM. THIS FIGURE ILLUSTRATES THE OPERATION CODES THAT SPECIFY THE DRAWING OF A PARTICULAR SHAPED FLOWCHART SYMBOL AND, IN SOME CASES, THE CONNECTIONS TO BE MADE BY THE PROGRAM. FIGURE A-3 ILLUSTRATES THE FLOWCHART SYMBOLS AND VARIOUS OPERATIONS AND LINE DRAWING TECHNIQUES PROVIDED BY THE SYSTEM. THE FLOWCHART SYMBOLS USED ARE -

A. TERMINAL BLOCK
B. PROCESSOR
C. MODIFICATION
D. PREDEFINED PROCESSOR
E. DECISION
F. LINK BLOCK
G. INPUT/OUTPUT
H. ON-PAGE CONNECTOR
I. OFF-PAGE CONNECTOR

AS SHOWN IN FIGURE A-2 THE ABOVE SYMBOLS ARE STANDARD FLOWCHARTING SYMBOLS (IBM FLOWCHARTING TEMPLATE NO. X 20-2020) WHICH ARE FAMILIAR TO THE EXPERIENCED PROGRAMMER AND REQUIRE NO FURTHER DEFINITION. HOWEVER, WHEN ACTED UPON BY THE AUTODOC SYSTEM, THE LINK BLOCK AND OFF-PAGE CONNECTOR SYMBOLS PRODUCE SOME UNUSUAL FEATURES WHICH ARE A DISTINCT ADVANTAGE TO THE READER -

A. THE LINK BLOCK, WHICH IS USED TO INDICATE A

LOGICAL PROGRAM UNIT (I.E., A SUBROUTINE) THAT IS FLOWCHARTED IN DETAIL ELSEWHERE IN THE MANUAL, WILL CONTAIN THE PAGE NUMBER AND COORDINATES OF THE DATA LINK. THE PAGE NUMBER IS LOCATED IN THE CENTER OF THE HORIZONTAL STRIPE AND THE SUBROUTINE COORDINATES ARE GIVEN ABOVE THE STRIPE IN THE RIGHTHAND CORNER OF THE BOX. THE LABEL OF THE SUBROUTINE IS LOCATED IN THE LEFTHAND CORNER ABOVE THE STRIPE.

B. THE OFF-PAGE CONNECTOR SYMBOL WILL CONTAIN THE COORDINATES AND PAGE NUMBER OF ITS IN IN-CONNECTOR. EXAMPLES OF ON-PAGE CONNECTORS ONLY ARE SHOWN IN FIGURE A-3, THESE CONNECTORS GIVE THE COORDINATES OF THE RESPECTIVE IN-CONNECTORS LOCATED ON THAT PAGE. OFF-PAGE CONNECTORS (NOT SHOWN) ARE IDENTICAL EXCEPT THAT THEY CONTAIN THE PAGE NUMBER OF THE IN-CONNECTOR LOCATED BELOW THE COORDINATES.

TABLE A-1. FLOWCHART OPERATION CODES

SYMBOL OPERATIONS		
OPERATION	SYNONYMS	FUNCTION
BLOCK	PROCS, B, P	CAUSES THE PROCESSOR TO DRAW A PROCESS SYMBOL.
MOD	MODFY, M	CAUSES THE PROCESSOR TO DRAW A PROGRAM MODIFICATION SYMBOL.
PREDF		CAUSES THE PROCESSOR TO DRAW A PREDEFINED PROCESS SYMBOL.
Q	DECID	CAUSES THE PROCESSOR TO DRAW A DECISION SYMBOL.
START	STOP, HALT, WAIT, ENTER, EXIT, BEGIN	CAUSES THE PROCESSOR TO DRAW A TERMINAL SYMBOL. THE EXIT SYNONYM OR AN * IN COLUMN 21 CAUSES A BREAK IN LOGIC.
LINK	SUBRT, S, STRIP, CLOSD	CAUSES PROCESSOR TO DRAW A STRIPED PROCESS SYMBOL. OPERAND CONTAINS LABEL OF THE FIRST SYMBOL OF THE SUB-ROUTINE.

TABLE A-1. FLOWCHART OPERATION CODES (CONT'D)

OPERATION	SYNONYMS	FUNCTION
IO	I/O, WRITE, TAPE, TYPE, DISK, DRUM, PRINT, KEY, DISP, CARD PUNCH, DOC	CAUSES PROCESSOR TO DRAW A GENERAL INPUT OUTPUT SYMBOL.
NOTE		NO SYMBOL IS DRAWN. OPERAND TEXT IS PRINTED AFTER CENTERING.

	CONNECTING OPERATIONS	
GOTO	GO TO, G, BRNCH	UNCONDITIONAL CONNECTION TO THE SYMBOL SPECIFIED BY OPERAND.
YES	NO, Y, N	CREATES RIGHT LEG EXIT CONNECTION ON DECISION SYMBOLS.

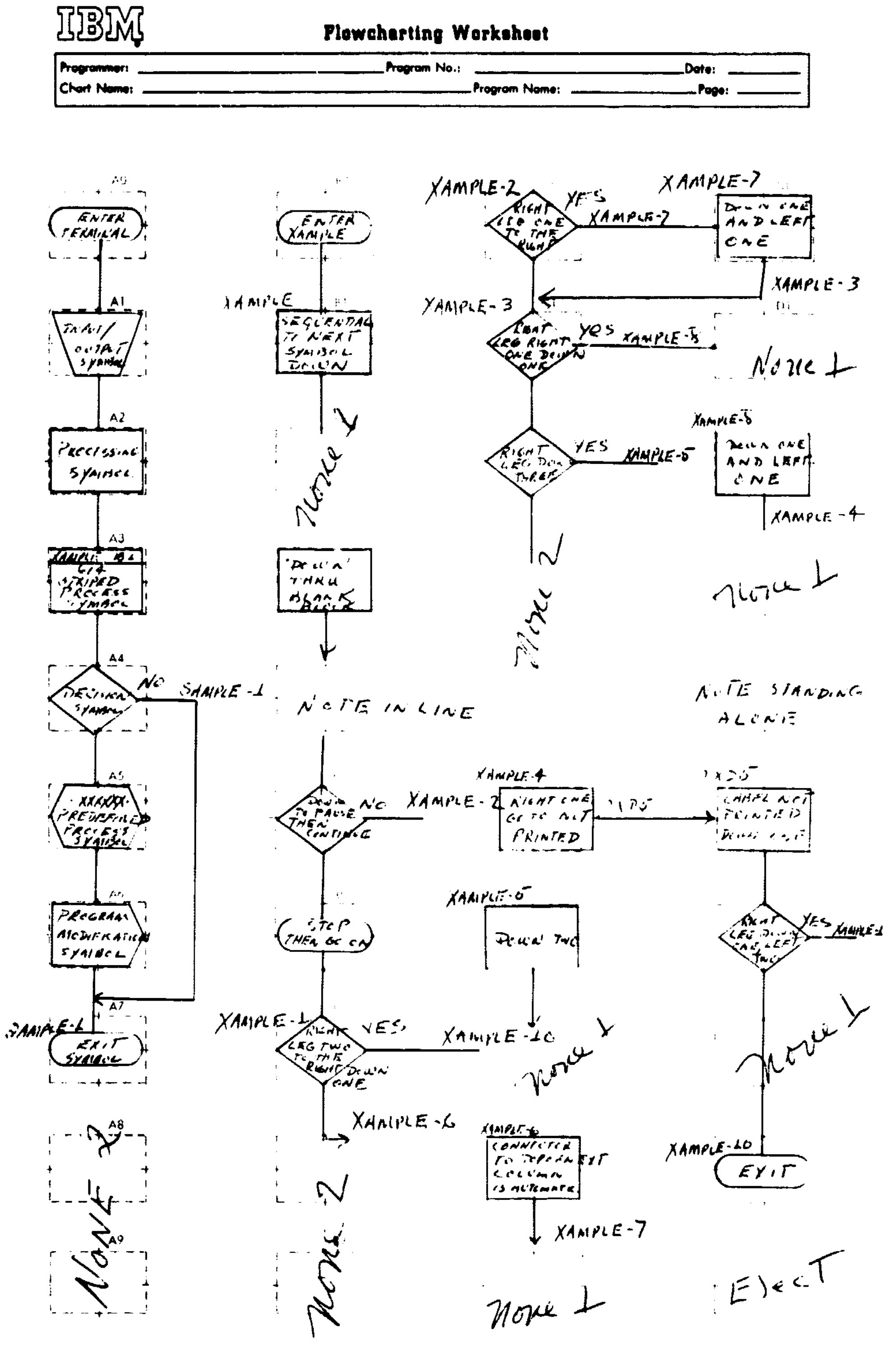


FIGURE A-2. SAMPLE OF A FLOWCHART CODED FOR FLOWCHART MODE

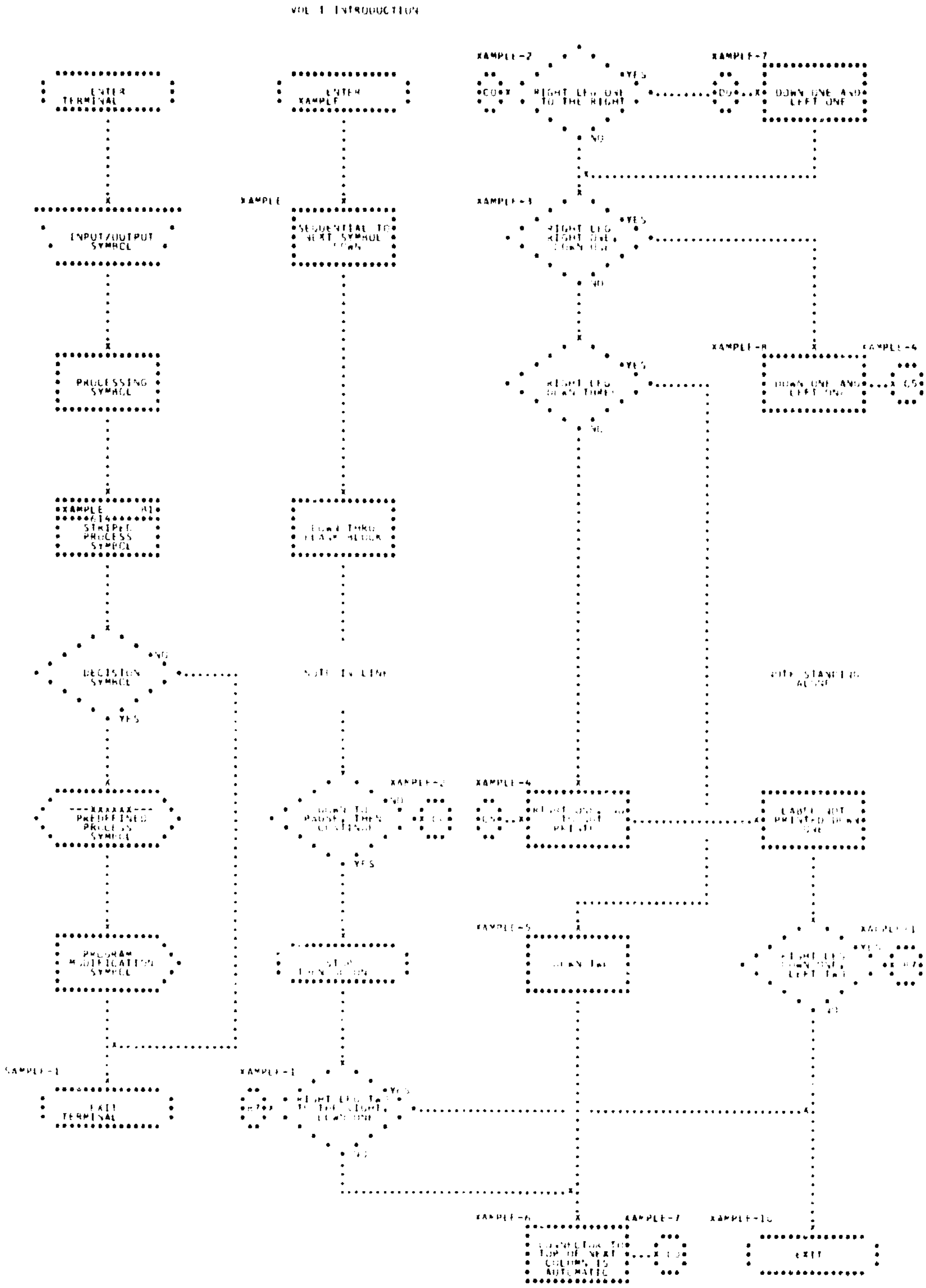


FIGURE A-3. SAMPLE OF A FLOWCHART PRINTED BY AUTODOC PROGRAM

APPENDIX B. COORDINATE SYSTEMS AND CONVERSIONS

There are five coordinate systems used in the Manned Space Flight Network for Gemini flights. These systems, and their coordinates, are as follows:

	Coordinate System	Coordinates
a.	Gemini, or True Cartesian Inertial, Coordinate System	$\overline{\underline{X}}, \overline{\underline{Y}}, \overline{\underline{Z}}$
b.	B-GE Quasi-Inertial	ξ, η, ζ
c.	IP Quasi-Inertial	X, Y, Z
d.	Pad Rectangular	u, v, w
e.	Local Radar	R, A, E

Gemini Coordinate System

The Gemini coordinate system is a right-handed rectangular system with the origin at the earth's center, $\overline{\underline{Z}}$ lying along the earth's polar axis, $\overline{\underline{X}}$ pointing to the first point of Aries (♈ = vernal equinox), and $\overline{\underline{Y}}$ normal to the plane of $\overline{\underline{X}}$ and $\overline{\underline{Z}}$. (See Figure B-1.) In general, data in other coordinate systems are transformed to these coordinates prior to processing. During the Launch Phase, Programs COCO01 and CSCO02 convert B-GE and IP data, respectively, into the Gemini reference system. In the Postflight Reporter, GECNV and IPCNV convert B-GE and IP data, respectively, into the Gemini reference system. In the Postflight Reporter, GECNV and IPCNV convert B-GE and IP data, respectively, into the Gemini system.

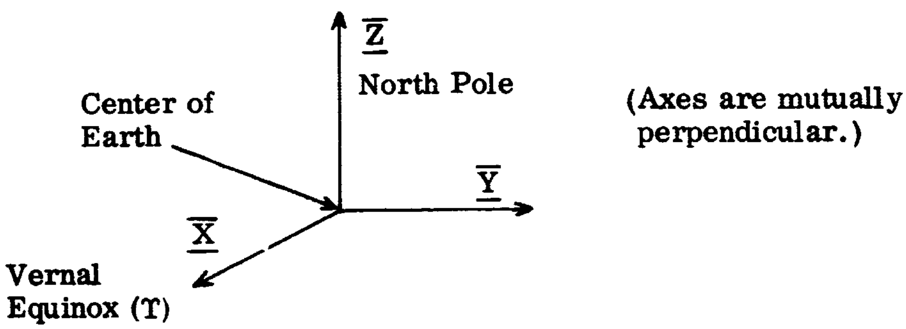


Figure B-1. Gemini Coordinate System

B-GE Coordinate System

This system is a rectangular right-handed set with the origin at the earth's center and the ζ axis always pointing toward the North Pole. (See Figure B-2.) The ξ and η axes are redefined every computing cycle as follows: at midnight preceding launch, the ξ axis lies in the equatorial plane and passes through the meridian of the B-GE radar, and the η axis is normal to the plane of the ζ and ξ axes. Thereafter the $\xi - \eta$ plane is rotated about the ζ axis by $\omega_e t_1$, where ω_e is the angular rotational velocity of the earth and t_1 is the total amount of time which has elapsed since midnight preceding launch. This rotation keeps the ξ axis pointing through the meridian of the B-GE radar.

IP Coordinate System

The IP coordinate system is redefined every computing cycle. The Z axis lies in the earth's polar axis, the X axis is chosen so that at midnight preceding launch it lies in the earth's equatorial plane and passes through the Greenwich meridian, and the Y axis forms a right-handed set with the other two. (See Figure B-3.) Thereafter the X-Y plane is rotated about the Z axis by $\omega_e t_i$, where ω_e is the angular rotational velocity of the earth and t_i is the total time elapsed since midnight preceding launch.

Pad Rectangular Coordinates

This is a rectangular coordinate system with origin at the launch pad. (See Figure B-4.) The u axis points downrange, the w axis is normal to the tangent plane at the pad and is directed away from the surface, and the v axis is normal to the u, w plane and is directed eastward.

Local Radar Coordinates

The local radar system is a spherical system with the origin at the radar. (See Figure B-5.) The elements used are range, slant-range (distance to spacecraft = R), azimuth (angle in local horizontal plane measured clockwise from true north = A), and elevation (angle above local horizontal plane measured in plane

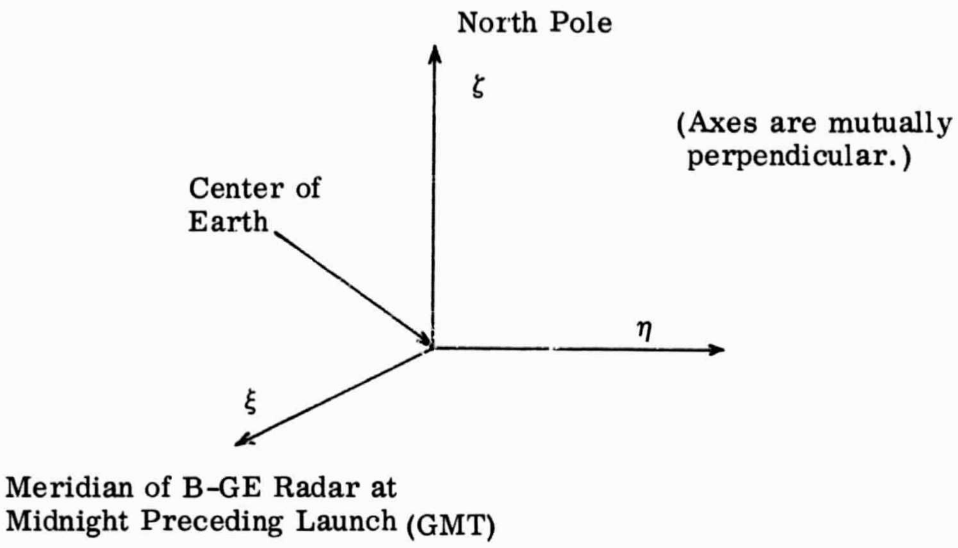


Figure B-2. B-GE Coordinate System

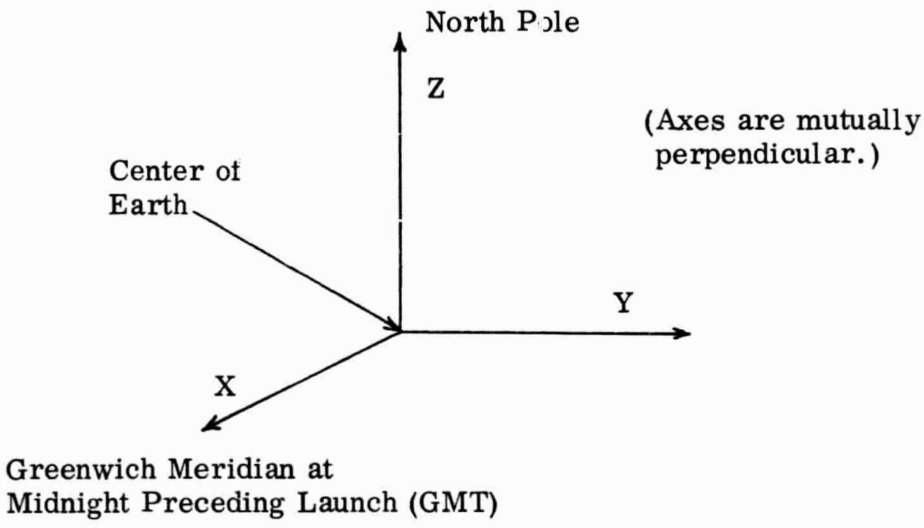


Figure B-3. IP Coordinate System

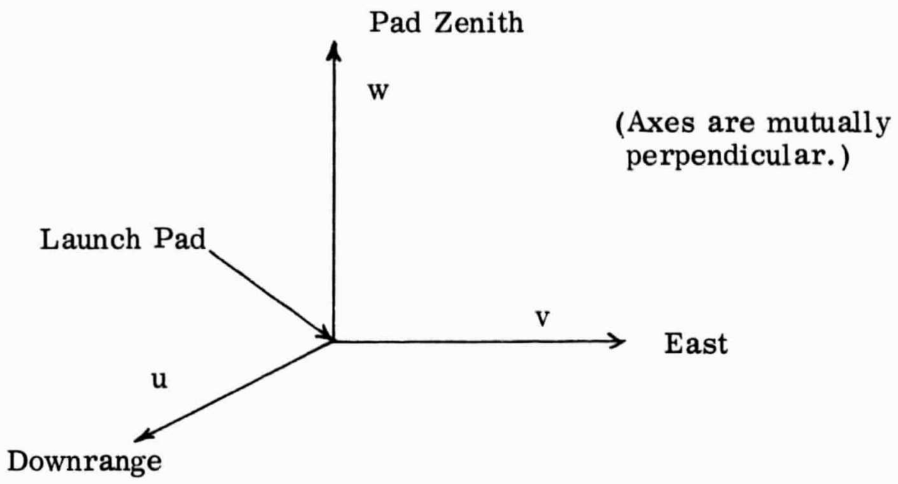


Figure B-4. Launch Pad Coordinate System

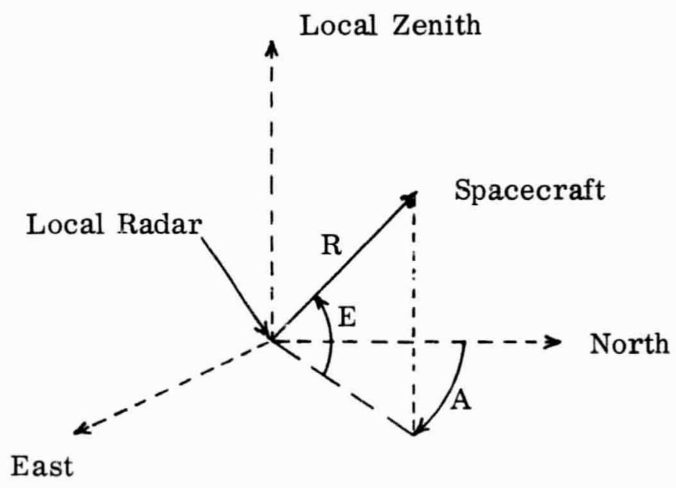


Figure B-5. Local Radar Coordinate System perpendicular to local horizontal plane = E). Launch program CLSTOI converts RAE local radar coordinates to inertial coordinates.

B-GE-to-Gemini Coordinate Conversion

The B-GE and Gemini coordinate systems have a common origin and a common axis (the ζ or $\overline{\underline{Z}}$ axis). Since the Gemini $\overline{\underline{X}}$ axis always points to the first point of Aries (♈), and the B-GE ξ axis points through the meridian of the B-GE radar, coordinate conversion is accomplished by rotating the B-GE system about the common (ζ) axis. (See Figure B-6.)

The angle between the Gemini $\overline{\underline{X}}$ axis and the B-GE ξ axis (ϕ_R) is set initially at midnight (Greenwich time) preceding launch. Thereafter, as the earth rotates, this angle changes by an amount equal to $\omega_e t_i$, where ω_e is the angular rotational velocity of the earth and t_i is the time elapsed since midnight preceding launch. The angle (α) through which the B-GE coordinate system must be rotated to obtain the Gemini coordinate system is given by:

$$-\alpha = \phi_R + \omega_e t_i$$

IP to Gemini Coordinate Conversion

The IP and Gemini coordinate systems have a common origin and a common axis (the Z or $\overline{\underline{Z}}$ axis). Since the Gemini $\overline{\underline{X}}$ axis always points to the first point of Aries (♈), and the IP X axis points through the meridian of Greenwich, coordinate conversion is accomplished by rotating the IP system about the common (Z) axis. (See Figure B-7.)

The angle between the Gemini $\overline{\underline{X}}$ axis and the IP X axis (ϕ_S) is set initially at midnight (Greenwich time) preceding launch. Thereafter, as the earth rotates, this angle changes by an amount equal to $\omega_e t_i$, where ω_e is the angular rotational velocity of the earth and t is the time elapsed since midnight preceding launch. The angle (α) through which the IP coordinate system must be rotated to obtain the Gemini coordinate system is given by:

$$-\alpha = \phi_S + \omega_e t$$

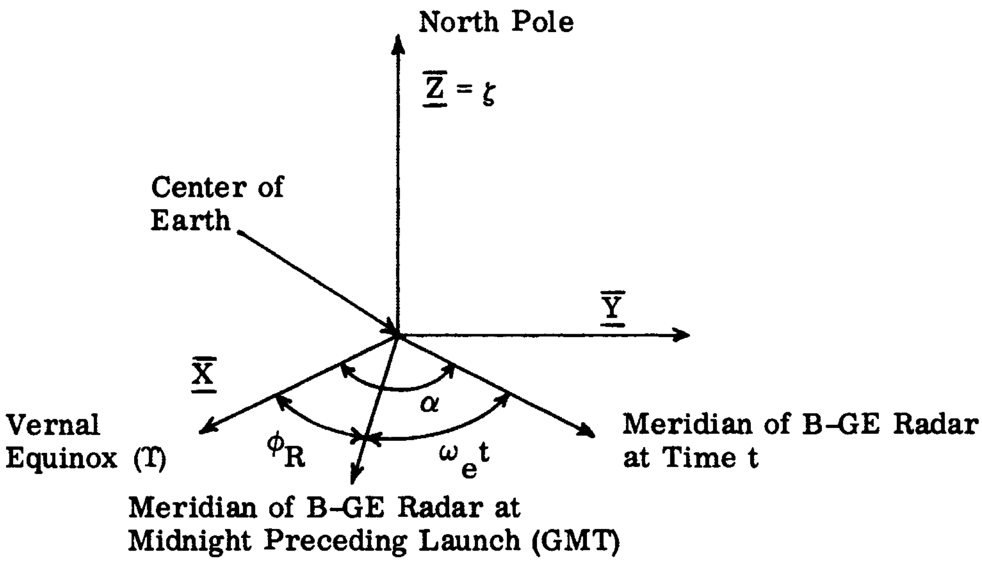


Figure B-6. B-GE to Gemini Coordinate Conversion

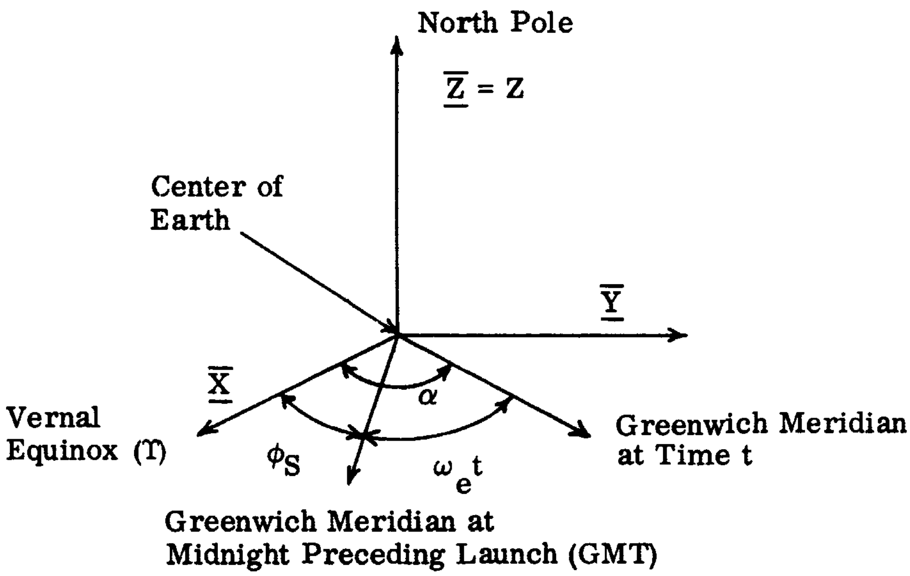


Figure B-7. IP to Gemini Coordinate Conversion

Gemini to Launch Pad Coordinate Conversion

The launch pad coordinate system has its origin at the surface of the earth, thus a combination of rotations and translations is necessary to convert from the Gemini true inertial system to the pad rectangular system. This process consists of four transformations with a new coordinate system resulting from each transformation. (See Figure B-8.)

The first transformation is to rotate the Gemini system about the $\overline{\underline{Z}}$ axis through an angle which is the angular difference between the $\overline{\underline{X}}$ axis and the meridian of the launch pad at time t, measured in the $\overline{\underline{X}}$, $\overline{\underline{Y}}$ (equatorial) plane. This places the $\overline{\underline{X}}$ axis at the meridian of the launch pad; the $\overline{\underline{X}}$ axis is now the $\overline{\underline{X}}'$ axis, and the $\overline{\underline{X}}'$, Z' plane coincides with the meridian plane of the pad.

Next, the origin of the system is moved from the center of the earth to the launch pad, maintaining the new $\overline{\underline{X}}''$, $\overline{\underline{Y}}''$, $\overline{\underline{Z}}''$ axes parallel to the $\overline{\underline{X}}'$, $\overline{\underline{Y}}'$, $\overline{\underline{Z}}'$ axes, respectively. The new $\overline{\underline{X}}''$, $\overline{\underline{Z}}''$ plane still coincides with the meridian plane of the pad.

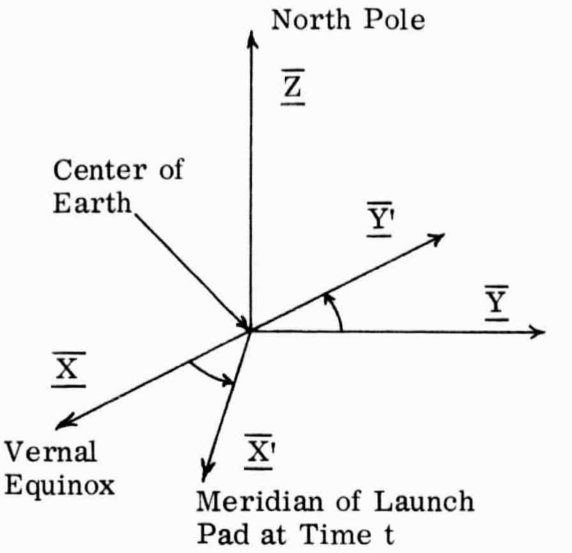
Thirdly, the $\overline{\underline{X}}''$, $\overline{\underline{Z}}''$ axes are rotated about the $\overline{\underline{Y}}''$ axis so that the new $\overline{\underline{Z}}'''$ axis coincides with the local zenith at the launch pad. This leaves the new $\overline{\underline{X}}'''$, $\overline{\underline{Y}}'''$ plane coinciding with the local horizontal plane, and the $\overline{\underline{X}}'''$, $\overline{\underline{Z}}'''$ plane still coinciding with the meridian plane of the pad.

Thus at the end of the third transformation, the origin of the system is at the launch pad, the $\overline{\underline{Z}}'''$ axis is straight up, the $\overline{\underline{X}}'''$ axis points due south and the $\overline{\underline{Y}}'''$ axis points due east.

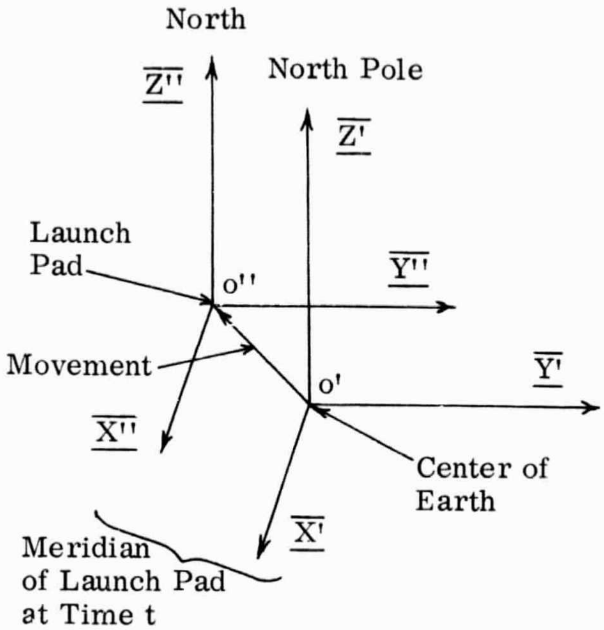
The fourth and final transformation rotates the $\overline{\underline{X}}'''$, $\overline{\underline{Y}}'''$ plane about the $\overline{\underline{Z}}''$ axis in such a manner that the new $\overline{\underline{X}}''''$ axis coincides with the burnout azimuth angle and therefore points downrange. This produces the launch pad coordinate system, where $\overline{\underline{X}}'''' = u$, $\overline{\underline{Y}}'''' = v$, and $\overline{\underline{Z}}'''' = w$.

Local Radar to Gemini Coordinate Conversion

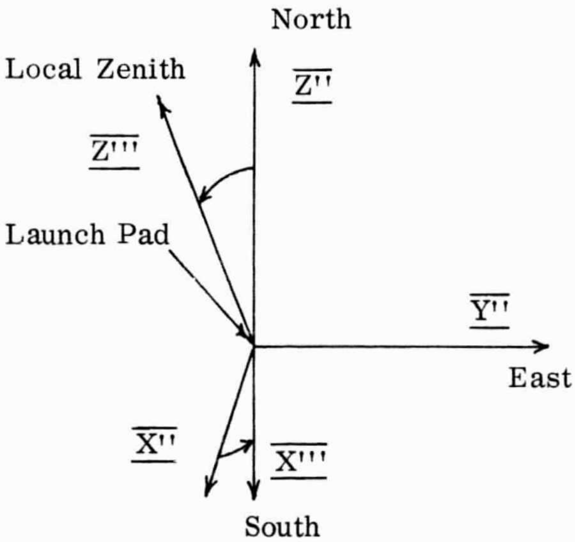
Essentially, this conversion is the reverse of the Gemini to launch pad conversion. First, local radar range (R), azimuth (A), and elevation (E) coordinates are converted to local x, y, and z coordinates, with z pointing to the local zenith, x pointing due east, and y pointing due north. Next, the origin is translated



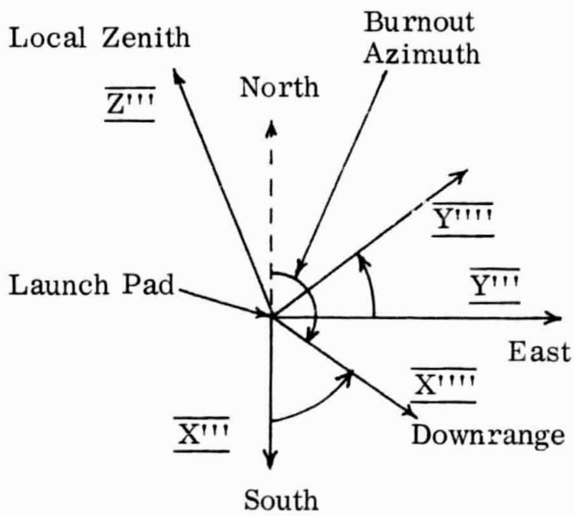
Step 1. Rotate $\overline{X}$, $\overline{Y}$ Plane about $\overline{Z}$ Axis



Step 2. Move Origin to Launch Pad



Step 3. Rotate $\overline{X''}$, $\overline{Z''}$ Plane about $\overline{Y'}$ Axis



Step 4. Rotate $\overline{X'''}$, $\overline{Y'''}$ Plane about $\overline{Z'''}$ Axis

Figure B-8. Gemini to Launch Pad Coordinate Conversion from the local radar to the center of the earth. The y, z plane is then rotated about the x axis until the z axis has the same orientation as the earth's rotational axis (points toward the north pole). Finally, the x, y plane is rotated about the z axis until the x axis points toward the vernal equinox (♈).

C

PRECEDING PAGE BLANK NOT FILMED.

APPENDIX C. MATHEMATICAL TERMINOLOGY

The following alphabetical listing includes selected general astronomical terms, mathematical symbology, and specific Project Gemini reference quantities.

Symbols for Dimensions

A = Angle	K = Temperature	L = Length
M = Mass	T = Temperature	U = Units only (dimensionless)

TERM	DIMENSIONS	SYMBOL	DEFINITION
Acceleration of Gravity	$[LT^{-2}]$	$g(H_0)$	The ratio of the weight of a material particle to its mass.
Apogee			Point on orbit farthest from the geocenter.
Argument of Perigee	[Angle]	ω	The angle between the ascending node and perigee on the celestial sphere.
Ascending Node Unit Vector	[L]	$\overline{N}$	Unit vector directed from geocenter toward ascending node.
Azimuth	[Angle]	A	The bearings of the spacecraft in the horizon plane of the station measured clockwise from north, $0 \leq A < 360^{o}$.
Coefficient of Drag		C_D	A number which relates to the retarding force experienced by a body in motion through fluid.

TERM	DIMENSIONS	SYMBOL	DEFINITION
Date	[T]	$T_{(ref)}$	Equals zero. Reference time is midnight prior to launch.
Density	$[ML^{-3}]$	$\rho(H)$	The ratio of the mass of a homogenous portion of matter to its volume.
Eccentric Anomaly	[Angle]	E_a	The central angle subtending the arc between perigee and the perpendicular projection of the spacecraft's instantaneous position on the major auxiliary circle.
Eccentricity		e	Ratio of the center-to-focus distance to the semimajor axis, a.
Elevation	[Angle]	E	The spacecraft's angular distance above the horizon plane, measured from the station.
Ellipsoid Flattening		f_e	Geophysical constant related to the shape of the geoid.
Ephemeris			A time history tabulation of the position of the orbiting spacecraft with respect to its reference coordinate system.
Eta		η	Orbit element = e sin ω.
First Sum Vector	$[LT^{-1}]$	$`\bar{F}$	First sum vector: $(`F_x, `F_y, `F_z)$
Geocenter			The point of intersection of the polar axis with the equatorial plane.
Geocentric Latitude	[Angle]	ϕ	The angle included between the equatorial plane and a line joining the geocenter and a point on the surface of the earth, measured north or south, $-90^{o} \leq \phi' \leq +90^{o}$

TERM	DIMENSIONS	SYMBOL	DEFINITION
Geodetic Latitude	[Angle]	ϕ	The angle defined by the intersection of a normal to the earth's surface with the equatorial plane, measured south or north, $-90^{o} \leq \phi \leq 90^{o}$.
Geometric Altitude	[L]	H	
Geopotential Altitude	$[L^2T^{-2}]$	Hg	The increase in potential energy of a unit mass lifted from sealevel to a given altitude against the force of gravity.
Geopotential at Base of Layer	$[L^2T^{-2}]$	H_b	
Inclination	[Angle]	i	Dihedral angle between the plane of the equator and the plane of the orbit.
Inertial Coordinate System		ICS	Coordinate system with origin at the geocenter (see X, Y, Z).
Inertial Longitude of Greenwich	[Angle]	λ_0	Hour angle of Greenwich at a reference time, t_0.
Lateral Area	$[L^2]$		Frontal surface area of body; used in drag considerations.
Line of Nodes			The line determined by the intersection of the plane of the orbit of the spacecraft with the earth's equatorial plane.
Local Coordinate System		LCS	Local coordinate system at each radar station.
Longitude	[Angle]	λ	The arc of the equator included between the prime meridian and the meridian of the place, measured eastward $0 \leq \lambda < 360^{o}$.

TERM	DIMENSIONS	SYMBOL	DEFINITION
Longitude of Spacecraft	[Angle]	u	Angle between the ascending node and the instantaneous position of the object, $u = v + \omega$ (mean anomaly of the node).
Longitude of Node	[Angle]	Ω	The arc of the celestial equator included between the vernal equinox and the ascending node, measured eastward.
Longitude of Perigee	[Angle]	Π	Sum of longitude of node plus the argument of perigee. $\Pi = \Omega + \omega$
Mean Anomaly	[Angle]	M_a	Angle between perigee and mean position.
Mean Longitude of Spacecraft	[Angle]	U	$U = \omega + M_a$. Angle between ascending node and mean position.
Mean Motion	$[T^{-1}]$	n	Average rate at which the orbiting spacecraft describes an arc.
Molecular-Scale Temperature	[K]	T_M	Mathematical variable introduced for theoretical reasons.
Normal-to-Orbit Plane	[L]	$\bar{R}$	Unit vector normal to orbit plane; sense determined by orbital angular momentum.
Orbit (parameter or element)			One of a set of quantities which completely describes an orbit.
Perigee			Point on orbit closest to the geocenter.
Perigee Unit Vector	[L]	$\bar{P}$	Unit vector directed from geocenter toward perigee.

TERM	DIMENSIONS	SYMBOL	DEFINITION
Perturbations			Deviations from two-body motion caused by atmospheric drag—the earth's equatorial bulge, etc.
Proportionality Constant (units depend on those of H)		G	
Radius of Earth at Equator	$[L]$	r	
Radius Vector	$[L]$	$\bar{r}$	Radius vector from geocenter to spacecraft in ICS.
Scale—height		H_s	Mathematical variable, negative reciprocal of the altitude derivation of logarithmic pressure.
Sealevel Value of g at Latitude φ (scalar)	$[LT^{-2}]$	g_ϕ	
Sealevel Value of g at Equator (scalar)	$[LT^{-2}]$	g_e	
Second Derivative Vector	$[LT^{-2}]$	$\bar{F}$	Second derivative vector: $(\ddot{X}, \ddot{Y}, \ddot{Z})$
Second Sum Vector	$[L]$	$''\bar{F}$	Second sum vector: $(''F_x, ''F_y, ''F_z)$
Semimajor Axis	$[L]$	a	One-half of the maximum chord of an ellipse.
Sidereal Period	$[T]$	P	Time an orbiting body requires for one complete revolution.
Slant Range	$[L]$	R	Distance from station to spacecraft in LCS. $R \geq 0$.
Slant Range Unit Vector	$[L]$	$\bar{\rho}^*$	Unit vector from station to spacecraft
Slant Range Vector	$[L]$	$\bar{\rho}$	Vector from station to spacecraft

TERM	DIMENSIONS	SYMBOL	DEFINITION
Speed	$[LT^{-1}]$	V	The ratio of distance to unit time.
Station Distance from Geocenter	$[L]$	R_s	
Temperature	$[K]$	T_K	
Temperature Gradient (scalar)	$[KL^{-2}T^{2}]$	L_M	Negative of the "lapse rate"—slope of the altitude—temperature profile.
True Anomaly	[Angle]	v	The angle measured from the center of the orbit in the direction of motion between perigee and the spacecraft position.
Unit Vector along X Axis	$[L]$	$\bar{I}$	
Unit Vector along Y Axis	$[L]$	$\bar{J}$	
Unit Vector along Z Axis	$[L]$	$\bar{K}$	
Value of T_M at Altitude H_b	$[K]$	$(T_M)_b$	
Velocity Vector	$[LT^{-1}]$	$\bar{V}$	Velocity vector in ICS.
Xi		ξ	Orbit element = e cos ω
$\bar{V}$ Component in X Direction	$[LT^{-1}$	V_x	
$\bar{V}$ Component in Y Direction	$[LT^{-1}]$	V_y	
$\bar{V}$ Component in Z Direction	$[LT^{-1}]$	V_z	
X (ICS)	$[L]$	X	ICS axis directed from geocenter toward vernal equinox.
Y (ICS)	$[L]$	Y	ICS axis in earth's equatorial plane forming a righthand set with Z and X axes.
Z (ICS)	$[L]$	Z	ICS axis directed from geocenter toward north celestial pole.

APPENDIX D. GEMINI CONVERSION FACTORS AND GEOPHYSICAL CONSTANTS

National Bureau of Standards Conversion Factors

The conversion factors listed below are constant values which have been established from National Bureau of Standards weights and measures. These basic measurements are the reference standards upon which pertinent computations are based.

Conversion Factor	Value
One international foot	0.3048 meter (exact)
One international nautical mile	1852 meters
One international pound	0.4535923 kilograms
One slug	9.80665 ÷ 0.3048 = 32.17404855 pounds (International Commission on Weights and Measures)
One American Survey foot	0.30480061 meter

Project Gemini Conversion Factors and Geophysical Constants

Conversion Factor/ Constant	Value
Degrees per radian	57.2957795
Feet per Gemini length unit	20,925,738.0
Feet per nautical mile	6076.11548
Feet per statute mile	5280.
Feet/sec per Gemini velocity unit	25,956.272
Gemini length units per Gemini time unit	7905.37572
Gemini mass unit = mass of earth in kilograms	5.975×10^{24}
Harmonic coefficients, second	162.345×10^{-5}
Harmonic coefficient, third	$-.575 \times 10^{-5}$
Harmonic coefficient, fourth	$.7875 \times 10^{-5}$

Conversion Factor/ Constant	Value
KG/M^3 per Gemini density unit = GMU/GML^3	$4.207491926 \times 10^{-5}$
KG/M^3 per Slugs/ft^3	515.378725
Meters per foot	.3048
Meters per Gemini length unit = equatorial radius of earth	6,378,165.0
Nautical miles per Gemini length unit	3443.9336
Pi	3.1415927
Rotation of earth in degrees per minute	.250684452
Rotation of earth in radians per Gemini time unit	$.588337796356 \times 10^{-1}$
Rotation of earth in radians per minute	$.437526906 \times 10^{-2}$
Rotation of earth in radians per second	$.72921151 \times 10^{-4}$
Seconds per Gemini time unit	806.813645
Yards per Gemini length unit	6,975,246.0

APPENDIX E. ORBITAL EPHEMERIS DERIVATIONS

The earth is neither a point source nor a homogeneous body and, therefore, does not reduce to a point attraction. Also, it is a rotating body and is non-spherical; hence, a simple potential function whose various first derivatives yield the components of the force cannot be deduced. This condition causes an expansion in terms of a trigonometric series whose coefficients are Legendre polynomials. The resultant force vector is thereby expressed. The leading coefficient is $\mu = 3.9860266 \times 10^{14}\ m^3/sec^2$. There is not first harmonic; the second harmonic, J_2, is $-1.755 \times 10^{25}\ m^5/sec^2$; H, the third harmonic, is not used; $J_4 = -1.59 \times 10^{-6}\ m^7/sec^2$ is the fourth harmonic.

In general, if ϕ is the potential of the earth's gravitational field at a distance r from its center and at a declination δ, then:

$$\phi = \frac{K_e^2}{r}\left[1 + \frac{1}{3} J_2\left(\frac{a_e}{r}\right)^2 (1-3 \sin^2 \delta) + \frac{1}{5} H\left(\frac{a_e}{r}\right)^3 (3 \sin \delta - 5 \sin^3 \delta) + \frac{1}{30} J_4\left(\frac{a_e}{r}\right)^4 (3 - 30 \sin^2 \delta + 35 \sin^4 \delta) + \ldots\right]$$

where:

K_e = MG

G = universal constant of gravitation

M = mass of the earth

a_e = earth's equatorial radius

Gemini uses the International Ellipsoid which has an a_e value of 6.378165×10^6 meters. The other values of the International Ellipsoid are:

a) Flattening: $f = 1/298.3 = 0.00335233$

b) Rotational speed of the earth: $= .729211508 \times 10^{-4}$ rad/sec

c) Equatorial gravity: $g_e = 9.78034\ m/sec^2$

Using a_e = 637816500 cm., f = 1/298.3, and g_e = 978.034 cm/sec^2, then

$$g = (1 + J_2 + \frac{J_4}{2}) \frac{\mu}{a^2} - a\,\omega^2$$

when ω = 0.0000729211508 rad/sec.

$$J_2 = f(1 - \frac{f}{2}) - (1 - \frac{9f}{7}) \frac{P}{2}$$

and $J_4 = 3f\,(f - \frac{5P}{7})$

(In both of the previous cases, $P = \frac{a^3 \omega^2}{\mu}$.) Therefore:

$$g_e = 978.034 = (1 + f + f^2) \frac{\mu}{a^2} - (a\,\omega^2)(\frac{3}{2} + \frac{3f}{7}).$$

Dividing 978.034 by a, each length becomes units of a = 1. In defining units of time, $T_{(sec)}$ is such that μ = 1, a = 1, and f = 1/298.3. However, when using the above J_2 and J_4 values, T = 806.813645 sec, using $a^3 = \mu T^2$ and solving the following equation:

$$\mu(1 + f + f^2) = 0.0000015334145T^2 + 0.00000000798388T^2.$$

(NOTE: An arithmetic error which yields a new T was noted. However, no change will be made at least until the ultimate spheroid, the DOD spheriod of 1960, is declassified.)

The mass of the earth is the unit of mass in Gemini units and is 5.975 x 10^{24} kilograms.

To correct observed data to a geocentric coordinate frame, and, conversely, to compute acquisition data for each site, the position and coordinate system of each site must be accurately known. The reference system used in specifying geodetic latitude, longitude and altitude is, as specified by Cape Kennedy downrange findings and the U.S. Coast and Geodetic Survey, the Clarke spheriod of 1866.*

---

* a_c = 6378206.4 meters; $1/f_c$ = 294.979; and b_c = 6356583.8 meters.

Page 485 of the American Ephemeris and Nautical Almanac, 1963, refers to the International Ellipsoid of Reference.** The American Ephemeris also provides the following for converting from geodetic latitude, ϕ, to geocentric latitude, ϕ':

$\phi' = \phi - 11' \, 35''.6635 \quad \sin 2\phi + 1''.1731 \quad \sin 4\phi - 0.0026'' \sin 6\phi$. (The notation 11'35".6635 means 11 minutes, 35.6635 seconds of arc.)

Local radius at a given (geodetic) latitude is given by:

$\rho = a(0.998320047 + 0.001683494 \cos 2\phi - 0.000003549 \cos 4\phi + 0.000000008 \cos 6\phi)$

The latter results if there is an expansion and ζ / a is accepted; then it is r-h in Gemini units. Also from the American Ephemeris comes the value for the mean solar day: 1.0027379093 x the mean sidereal day (p. 476).

Since a typical Gemini orbit is a conic section, five quantities define its path; its position at a given instant determines its later position. The equations of motion (three in number) are of second order, each requiring two constants of integration. Thus, six constants are used to specify the motion completely.

When determining the relationship between time and place in orbit, the following elements are used:

a) True anomaly: v

b) Mean daily motion: $\eta \frac{2\Pi}{P}$, when P = sidereal period.

c) Eccentric anomaly E_a: $nt = E_a - e \sin E_a$

d) Mean anomaly: $M_a = nt$. Therefore, $M_a = E_a - e \sin E_a$ (Kepler's equation).

In computing an ephemeris for a nearly circular spacecraft orbit, Herget introduced certain elements to overcome underflows of $e \approx 0$. These "Herget elements" are $\xi = e \cos \omega$ and $\eta = e \sin \omega$.

The classical orbital elements are:

i	=	Inclination
Ω	=	Longitude of ascending node (both i and Ω determine the orbital plane through the center of the earth)
a	=	Semimajor axis (or n = mean daily motion; $n = ka^{-3/2}$.)
e	=	Eccentricity (ϕ = angle of eccentricity; $e = \sin \phi$)
ω	=	Argument of perigee
Π	=	Longitude of perigee = $\omega + \Omega$
T	=	Time (usually at perigee or an epoch, i.e., date ~ mean anomaly)

** $a = 6378388$ meters; $\frac{1}{f} = 297$; and $e^2 = 0.0067226700223333 22$.

PRECEDING PAGE BLANK NOT FILMED.

APPENDIX F. GLOSSARY OF ABBREVIATIONS

ABBREVIATION	MEANING
A	AZIMUTH IN A RANGE, AZIMUTH, ELEVATION SYSTEM
AAA	ASTRONAUT ACTUATED ABORT
APS	ABORT PHASE STARTED
AC	ACCUMULATOR REGISTER
ACME	ATTITUDE CONTROL MANEUVER ELECTRONICS (ONBOARD COMPUTER THAT GENERATES A BANK AND ROLL PROFILE)
AM	ABORT MODE
AMC	ABORT MODE CHANGEOVER (SPACECRAFT REACHES 21,000 FT/SEC)
BCD	BINARY CODED DECIMAL
BDA	BERMUDA
B-GE	BURROUGHS-GENERAL ELECTRIC
CADFISS	COMPUTATION AND DATA FLOW INTEGRATED SUBSYSTEM
CALCOMP	CALIFORNIA COMPANY
CCC	COORDINATE CONVERSION COMPUTER
CET	CAPSULE ELAPSED TIME
CNV	CAPE KENNEDY
CP	COMMUNICATIONS PROCESSOR
CPU	CENTRAL PROCESSING UNIT
D/A	DIGITAL-TO-ANALOG (CONVERTER)
DAU	DISPLAY ASSEMBLER UNIT
DC	DIFFERENTIAL CORRECTION

ABBREVIATION	MEANING
DCC	DATA COMMUNICATIONS CHANNEL
DCS	DIGITAL COMMAND SYSTEM
DELTA V	INCREMENTAL VELOCITY
DELTA T	INCREMENTAL TIME
E	ELEVATION ANGLE IN A RANGE, AZIMUTH, ELEVATION SYSTEM
EGT	ELAPSED GROUND TIME
EGTRC	COMPUTED ELAPSED GROUND TIME SINCE LIFTOFF TO RETROFIRE
EOF	END OF FILE
EOW	END OF WORD
ESTRC	ELAPSED SPACECRAFT TIME FOR RETROFIRE COMPUTER RECOMMENDED
ESTRS	ELAPSED SPACECRAFT TIME OF RETROFIRE, SETTING IN SPACECRAFT CLOCK
ETR	EASTERN TEST RANGE (FORMERLY ATLANTIC MISSILE RANGE)
FIDO	FLIGHT DYNAMICS OFFICER (CAPE KENNEDY
FSK	FREQUENCY SHIFT KEYER
GMT	GREENWICH MEAN TIME
GMTIR	GMT OF TIME TO INITIATE ROLL
GMTLC	GMT OF LANDING, COMPUTED
GMTPC	GMT OF PROPULSION COMPLETION
GMTPI	GMT OF PROPULSION INCREMENT (START MANEUVER)
GMTRC	GMT FOR RETROFIRE, COMPUTED
GMTRS	GMT OF RETROFIRE, BASED ON PRESENT SPACECRAFT SETTING
GO/NO-GO	THE DECISION TO CONTINUE OR ABORT A MISSION.

ABBREVIATION	MEANING
GRTS	GODDARD REAL TIME SYSTEM
GS	GUIDANCE START
GSFC	GODDARD SPACE FLIGHT CENTER
GT	GEMINI/TITAN
GTRS	GROUND TIME REMAINING UNTIL RETROFIRE SETTING IS REACHED
IGS	INERTIAL GUIDANCE SYSTEM
IMU	INERTIAL MEASURING UNIT
I/O	INPUT/OUTPUT
IP	IMPACT PREDICTOR (COMPUTER), CAPE KENNEDY
IR	INDEX REGISTER
LMSS	LAUNCH MONITOR SUBSYSTEM
LO	LIFTOFF
LOS	LOSS OF SIGNAL
MCC	MISSION CONTROL CENTER, CAPE KENNEDY
MDIU	MANUAL DATA INPUT UNIT, DCS SYSTEM
MISTRAM	MISSILE TRAJECTORY MEASUREMENTS SYSTEM (FOR MISSILE RADIO GUIDANCE)
MQ	MULTIPLIER-QUOTIENT REGISTER
MSFN	MANNED SPACE FLIGHT NETWORK
MXD	MULTIPLE TRANSMITTER DISTRIBUTOR
NASCOM	NASA COMMUNICATIONS NETWORK
NI	NUMERICAL INTEGRATION
NSC	NETWORK STATUS CONSOLE
OAMS	ORBITAL ATTITUDE AND MANEUVERING SYSTEM
OCC	OPERATIONS CONTROL CONSOLE
ODR	OPERATIONAL DATA RECORDER
PCC	PROGRAM CONTROL CONSOLE
PCM	PULSE CODED MODULATION (TELEMETRY SYSTEM)

ABBREVIATION	MEANING
R	RANGE IN A RANGE, AZIMUTH, ELEVATION SYSTEM
RO	RECEIVING ONLY
SCAMA	STATION CONFERENCING AND MONITORING ARRANGEMENT
SCAT	SHARE COMPILER, ASSEMBLER, AND TRANSLATOR
S/C	SPACECRAFT
SDCU	SIMULATION DATA CONTROL UNIT
SECO	SECOND STAGE ENGINE CUTOFF
SIC	SIMULATED I/O CONTROL
SOS	SHARE OPERATING SYSTEM
SOW	START OF WORD
SSTU	SYSTEM SWITCH AND TEST UNIT
TC	START TIME FOR ONBOARD COMPUTER REENTRY CALCULATIONS
TF	TIME TO FUNCTION (SPACECRAFT CLOCK DATA)
TLM	TELEMETRY
TM	TELEMETRY
TR	TIME TO RETROFIRE (SPACECRAFT CLOCK DATA)
TRLC	TIME SINCE RETROFIRE OCCURRED
TRS	TIME REFERENCE SYSTEM (SPACECRAFT)
TTY	TELETYPE
TX	TIME TO RESET (SPACECRAFT CLOCK DATA)
USBQP	UNIFIED S-BAND QUALIFICATION PROCESSOR
WTR	WESTERN TEST RANGE (FORMERLY PACIFIC MISSILE RANGE)

APPENDIX G
INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

VOL I INTRODUCTION

INDEX OF PROGRAMS

VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL II MONITOR AND I/O PROGRAMS

INDEX OF PROGRAMS
VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS
VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS
VOL III REAL TIME PROCESSORS

VOL I INTRODUCTION

INDEX OF PROGRAMS

VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS

VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS
VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS
VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS
VOL III REAL TIME PROCESSORS

INDEX OF PROGRAMS
VOL IV NON-REAL TIME PROGRAMS

INDEX OF PROGRAMS
VOL IV NON-REAL TIME PROGRAMS

INDEX OF PROGRAMS

VOL IV NON-REAL TIME PROGRAMS

INDEX OF PROGRAMS
VOL IV NON-REAL TIME PROGRAMS

INDEX OF PROGRAMS

VOL IV NON-REAL TIME PROGRAMS

INDEX OF PROGRAMS
VOL IV NON-REAL TIME PROGRAMS