November 25, 1968
R-SE-L-070-008

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

SATURN V
FLIGHT PROGRAM DEVELOPMENT

"FOR INFORMATION ONLY"

Prepared For

SYSTEMS ENGINEERING OFFICE
MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

By

THE BOEING COMPANY
HUNTSVILLE, ALABAMA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO NASA

MSFC - Form 2846 (December 1966)

SATURN V FLIGHT PROGRAM DEVELOPMENT

070-008

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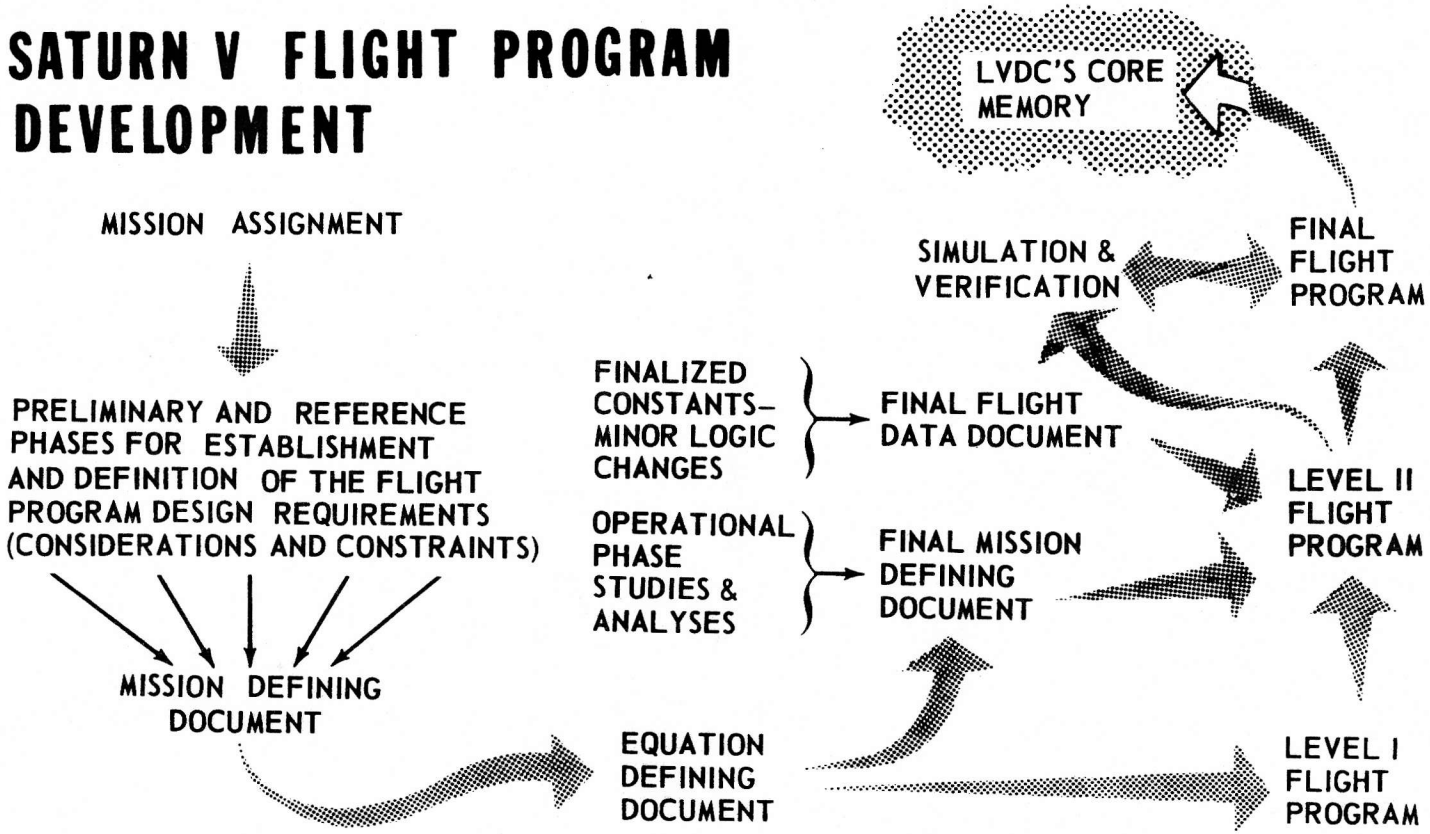


070-008-001
SATURN V FLIGHT
PROGRAM DEVELOPMENT

The Saturn V Flight Program development can be broken down into two distinct phases, separated by issuance of a Mission Defining Document. Leading up to the Mission Defining Document are the generalities; the ground rules, guidelines, and objectives; and preliminary and reference material on which to base and plan specifics. With the issuance of the Mission Defining Document, operational data becomes necessary; specific vehicle characteristics and capabilities are important; equations are recorded for a vehicle performing a mission; and the actual flight program software is prepared and documented.

As shown by the slide, a mission assignment is made and preliminary and reference phase studies are conducted for establishment and definition of the flight program design requirements. These are assembled into a Mission Defining Document from which an Equation Defining Document is prepared. Simultaneously with release of an EDD, preparation is begun on an initial (level I) flight program. More firm data is realized from operational phase studies and analyses based on the specific vehicle and mission, resulting in changes to the initiated flight program. Incorporation of this data results in a level II flight program. Simulations of the vehicle and its flight are conducted to verify the flight program. The finalized constants and any minor logic changes are incorporated, and the flight program is verified and loaded into the magnetic core memory of the Launch Vehicle Digital Computer. The vehicle now possesses the instructions which will control the LVDC, and consequently the vehicle flight, from seconds before liftoff until the separation of the Instrument Unit from the launch vehicle payload.

(1), (2), (3), (4), (5)

FLIGHT PROGRAM FUNCTIONS

THE FLIGHT PROGRAM IS DEFINED AS THE SET OF INSTRUCTIONS WHICH CONTROLS THE LAUNCH VEHICLE DIGITAL COMPUTER (LVDC) OPERATION FROM SECONDS BEFORE LIFTOFF UNTIL THE END OF THE LAUNCH VEHICLE MISSION. THESE INSTRUCTIONS ARE STORED IN CORE MEMORY WITHIN THE LVDC.

THE FLIGHT PROGRAM CONSISTS OF INFORMATION RELEVANT TO THE FOLLOWING FUNCTIONS:

- NAVIGATION
- GUIDANCE
- ATTITUDE CONTROL
- EVENT SEQUENCING
- DATA MANAGEMENT
- GROUND COMMAND PROCESSING
- HARDWARE EVALUATION

070-008-002
FLIGHT PROGRAM
FUNCTIONS

The flight program is defined as the set of instructions which controls the Launch Vehicle Digital Computer (LVDC) operation from seconds before liftoff until the end of the launch vehicle mission. These instructions are stored in core memory within the LVDC.

The flight program consists of information necessary to perform many functions during the launch vehicle mission. These functions include: navigation, guidance, attitude control, event sequencing, data management, ground command processing, and hardware evaluation. Specific definition of these functions depends on mission objectives.

The flight program is designed to operate successfully in the presence of stage failure conditions. Each external signal which starts a computer time base after guidance reference release is backed up by an alternate means which signifies occurrence of the specific event. Moreover, the program prevents premature initiation of time bases by appropriate logic, even if an erroneous start-time-signal is received.

(8), (11), (12), (13)

FLIGHT PROGRAM OPERATIONAL ELEMENTS

THE FLIGHT PROGRAM MAY BE DIVIDED INTO THE FOLLOWING OPERATIONAL ELEMENTS:

- POWERED FLIGHT MAJOR LOOP
- ORBITAL FLIGHT PROGRAM
- MINOR LOOP
- INTERRUPTS & FLIGHT SEQUENCING
- TELEMETRY & COMMUNICATIONS

The flight program can be divided into five operational elements. These are the powered flight major loop, the orbital flight program, the minor loop, interrupts, and telemetry.

1. The powered flight major loop contains guidance and navigation calculations, timekeeping, and all repetitive functions which do not occur on an interrupt basis.

2. The orbital flight program consists of an executive routine concerned with IU equipment evaluation during orbit and a telemetry time-sharing routine to be employed while the vehicle is over receiving stations. In addition, all navigation, guidance, and timekeeping computations are carried out on an interrupt basis keyed to the minor loop in the orbital flight program.

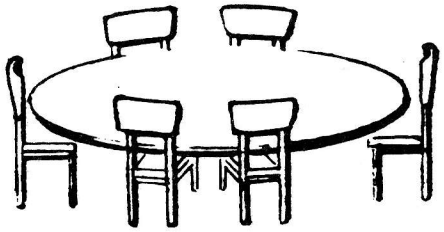
3. The minor loop contains the platform gimbal angle and accelerometer sampling routines and the control system computations.

4. An interrupt routine permits interruption of the normal program operation to free the LVDC for priority work. Several subroutines or secondary functions are available to the main program. They are utilized at specific times within the main loop or at certain phases of the flight. Other interrupt operations may occur at any time within the program. Actually, the minor loop is an interrupt operation which will occur at intervals of 25 times per second during powered flight. (i.e. every 40 milliseconds the main program is interrupted while gimbal angle readings, accelerometer samplings, and control system routines are processed).

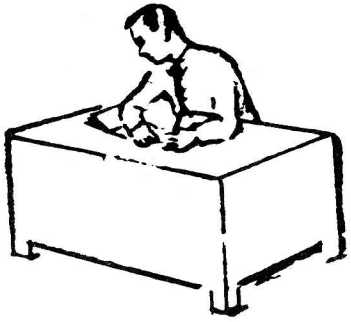
5. A programmed telemetry feature is provided as a method of monitoring LVDC and LVDA operations. The telemetry routine transmits specified information and data to the ground via IU telemetry equipment. In orbit, telemetry data must be stored at times when the vehicle is not within electromagnetic range of a ground receiving station. This operation is referred to as data compression. The stored data will be transmitted later, on a time-shared basis with real-time telemetry, when range conditions are favorable.

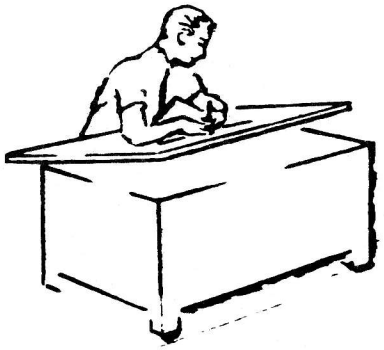
(8), (11), (12), (13)

PRELIMINARY MISSION STUDIES AND CONSTRAINTS

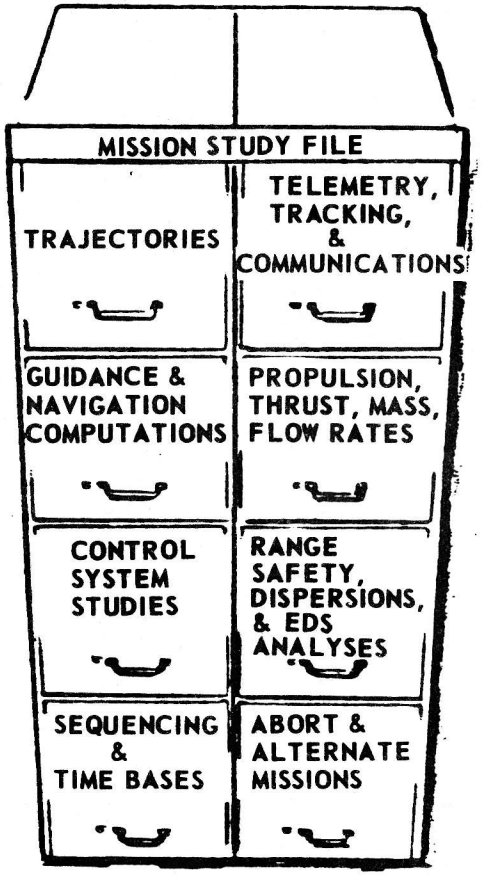


NASA HEADQUARTERS PREPARES A "MISSION ASSIGNMENT DOCUMENT"





FLIGHT MECHANICS PANEL PRODUCES "PRELIMINARY MISSION CONSTRAINTS"



INDIVIDUAL MSFC LABORATORIES GENERATE FLIGHT PROGRAM DESIGN REQUIREMENTS

070-008-004
PRELIMINARY MISSION
STUDIES AND CONSTRAINTS

The Saturn V Flight Program development for any given launch vehicle and mission occurs over approximately a two year period. It begins with NASA Headquarters providing a "Mission Assignment Document" stating objectives and guidelines.

The Flight Mechanics Panel produces "Preliminary Mission Constraints" which, in turn, provides limitations on targeting, guidance, and launch azimuth. This makes possible the establishment of mission design requirements (considerations and constraints) from the separate MSFC laboratories.

Preliminary and reference phase studies done by the individual MSFC organizations and contractors generate general flight program design requirements (considerations and constraints impacting everything associated with a vehicle and its mission). These flight program design requirements are arrived at by numerous studies and analyses, including:

R-AERO
1. Trajectories --resulting in planned flight path
2. Guidance computations--resulting in equations, presettings
3. Range safety, abort and alternate mission plans
4. Tracking and communication coverage, aerodynamic coefficient.

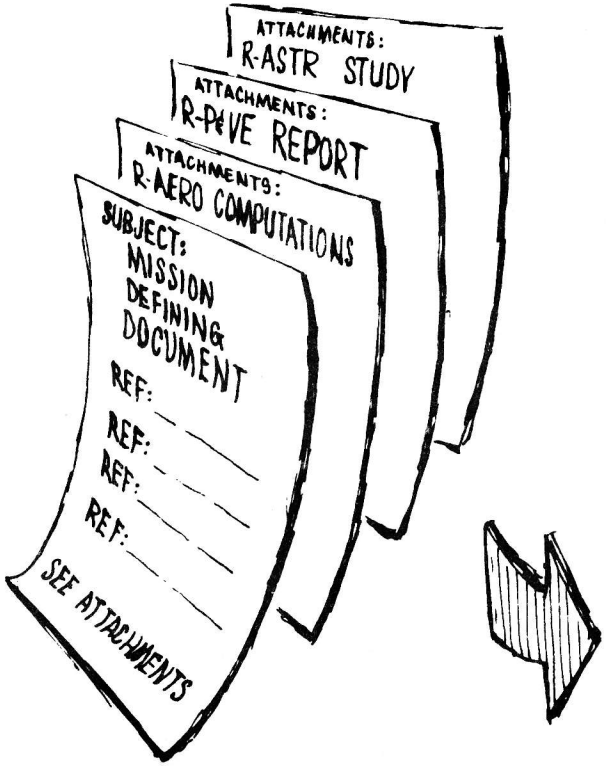
R-ASTR
1. Navigation equations, integration routines
2. Control system data--resulting in sample rates, gains
3. Sequencing--resulting in listing of timed events

I-MO MCC Telemetry Requirements

R-P&VE Propulsion data, thrust, mass, flow rates, C.G.

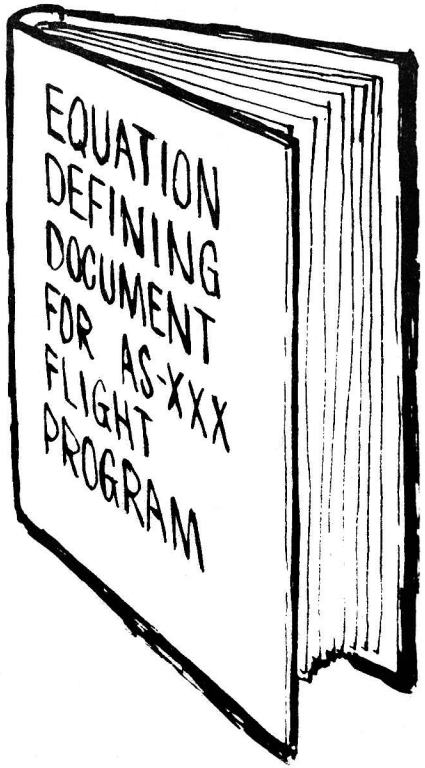
(1), (2), (3), (4), (5)

LEVEL I FLIGHT PROGRAM DEVELOPMENT

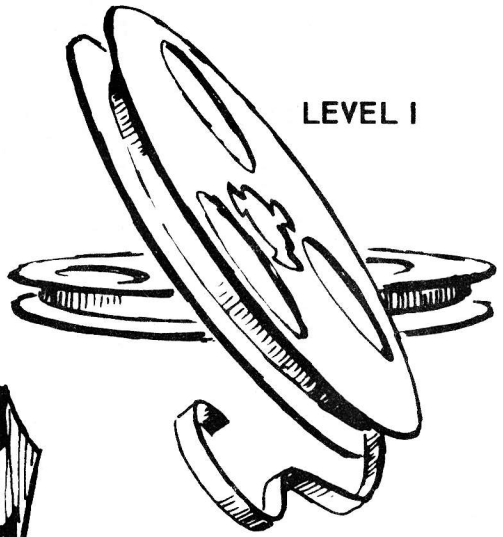


MISSION DEFINING DOCUMENT IS ASSEMBLED BY ASTRIONICS FROM DESIGN REQUIREMENT AND MISSION OBJECTIVE STUDIES & ANALYSES

EQUATION DEFINING DOCUMENT IS PREPARED BY IBM AND SHOULD CONTAIN ALL THE INFORMATION NECESSARY TO PREPARE A FLIGHT PROGRAM



LEVEL I



LEVEL I (INITIAL) FLIGHT PROGRAM PREPARED (INITIATED BY IBM AT THE SAME TIME THE EDD IS DELIVERED)

The design requirements are provided to Astrionics, who is responsible for the implementation of these requirements into a Saturn V flight program and has contracted with IBM to accomplish this end.

Astrionics assembles the design requirements by reference under a cover letter referred to as a "Mission Defining Document" and transmits them to IBM for actual preparation of the flight program.

Based on the "Mission Defining Document," IBM prepares an "Equation Defining Document," which should contain all the information necessary to prepare a flight program for storage in the Launch Vehicle Digital Computer (LVDC) core memory.

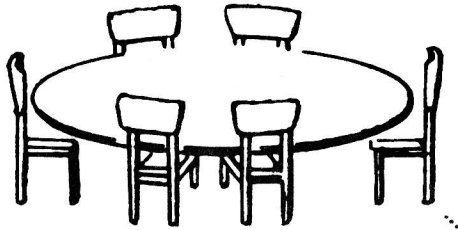
Development of a level I flight program based on the EDD is initiated by IBM at the same time the EDD is delivered to MSFC.

The flight program must be functionally equivalent to the equations and presettings; as originated from the design requirements and mission objectives, as recorded in the appropriate lab studies, and as specified in the EDD. (In actuality, the previous launch vehicle's Equation Defining Document is updated and a copy of the previous vehicle's flight program becomes the level I flight program upon which the current flight program requirements are based.)

(1), (2), (3), (4), (5)

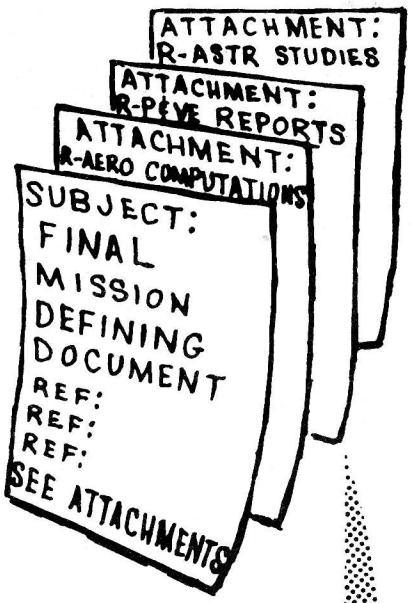
LEVEL II FLIGHT PROGRAM DEVELOPMENT

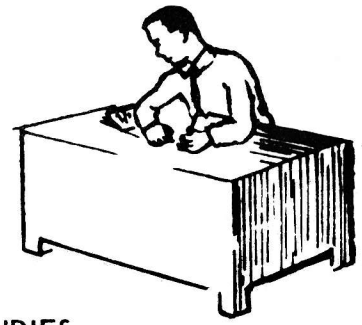
PRELIMINARY DESIGN REVIEW



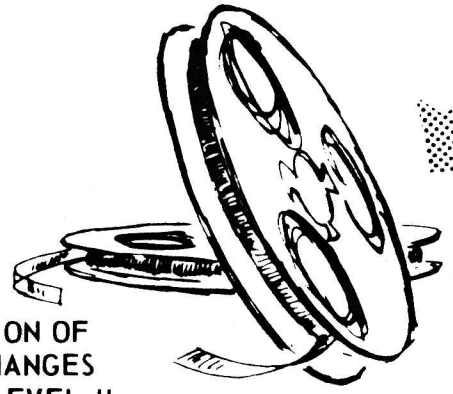
REVIEW DESIGN PHILOSOPHY, LVDC MEMORY UTILIZATION, SCALING REQUIREMENTS, MATH MODEL SIMULATIONS, POSSIBLE PROBLEM AREAS, KNOWN DEVIATIONS FROM ORIGINAL DEFINITION TO ASSURE THAT THE EDD IS A SOUND BASELINE FOR THE FLIGHT PROGRAM.

AFTER MSFC REVIEWS THE EDD, THEY ISSUE A "FINAL MISSION DEFINING DOCUMENT" INCORPORATING LOGIC CHANGES AND UPDATING CONSTANTS REQUIRED IN THE FINAL FLIGHT PROGRAM





OPERATIONAL PHASE STUDIES CONTAINING UPDATED, REFINED, AND PREVIOUSLY MISSING DATA



INCORPORATION OF UPDATING CHANGES RESULTS IN LEVEL II FLIGHT PROGRAM

Astrionics is responsible for reviewing the EDD. IBM conducts a Preliminary Design Review for MSFC to assure that the EDD is a sound baseline for the flight program (IBM reviews design philosophy, LVDC memory utilization, scaling requirements, results from math model simulations, possible problem areas, known deviations from original definition).

Operational phase studies containing updated, refined, and previously missing or assumed data, are assembled at this time by Astrionics.

After Astrionics has reviewed the EDD, they issue a "Final Mission Defining Document" (FMDD) incorporating any logic changes and information which finalized the constants required in the final flight program. This is done by an Astrionics cover letter referencing operational phase studies and analyses.

Upon receipt of the FMDD, IBM is to make the necessary changes to the previously initiated level I flight program for incorporation into a level II flight program.

(1), (2), (3), (4), (5)

FLIGHT PROGRAM VERIFICATION AND REVIEW

STATES PRECISELY HOW THE FLIGHT PROGRAM IS TO BE VERIFIED BEFORE IT IS FLOWN

VERIFICATION/SIMULATION MODELS AND TESTS: THERE ARE THREE PRINCIPAL SIMULATION FACILITIES USED TO VERIFY PROPER PERFORMANCE OF THE FLIGHT PROGRAM:

(1) IBM'S ALL DIGITAL 360/6D SIMULATION MODEL USED FOR 6-D BOOST VERIFICATION (DOES NOT TEST HARDWARE/SOFTWARE COMPATIBILITY)

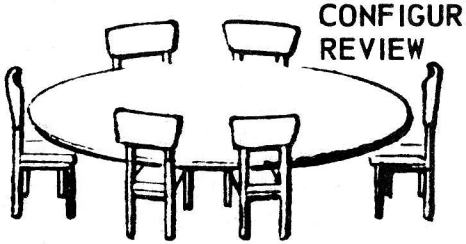
(2) ASTRIONIC'S DIGITAL HYBRID SIMULATION MODEL USED FOR ORBITAL VERIFICATION (DOES TEST HARDWARE/SOFTWARE COMPATIBILITY)

(3) MSFC'S SYSTEM DEVELOPMENT FACILITY (BREADBOARD) USED FOR TIME SEQUENCING OF HARDWARE.

CRITICAL DESIGN REVIEW

ASSURE THAT: (1) THE EDD ADEQUATELY DEFINES THE LEVEL II FLIGHT PROGRAM (2) THE PVP SPECIFIES ADEQUATE VERIFICATION PROCEDURES, (3) THE LEVEL II FLIGHT PROGRAM SATISFIES FINAL MISSION DEFINITION DOCUMENT REQUIREMENTS

FINAL CONFIGURATION REVIEW



VERIFIES THAT: (1) ALL CHANGES HAVE BEEN INCORPORATED, (2) THE FLIGHT PROGRAM HAS BEEN VERIFIED, (3) DOCUMENTATION HAS BEEN UPDATED AND IS IN AGREEMENT WITH THE FINAL FLIGHT PROGRAM.

IBM then prepares a Program Verification Plan (PVP) describing precisely how the flight program is to be verified before it is flown. IBM also conducts a Critical Design Review for MSFC to assure that: (1) The EDD adequately defines the Level II flight program, (2) The PVP specifies adequate verification procedures, and (3) the Level II flight program satisfies FMDD requirements.

There are three principal simulation facilities used to verify proper performance of the flight program: (1) IBM 360/6D all digital, (2) R-ASTR Digital Simulation Lab (HYBRID), and (3) R-ASTR Systems Development Facility (BREADBOARD). The simulation models are updated to the current vehicle configuration for verification of the level II and final flight programs.

IBM is responsible for conducting and documenting the primary flight program verification effort at each of the three principal simulation facilities:

(1) IBM's all digital simulation (IBM System 360) is used for 6-D boost verification (does not test hardware/software compatibility);
(2) Astrionics Digital Simulation Laboratory (HYBRID), is used for orbital verification (does test hardware/software compatibility);
(3) MSFC's Systems Development Facility (BREADBOARD) is used for time sequencing of hardware.

IBM conducts a Final Configuration Review for MSFC which presents: (1) review of all input requirements, (2) review of final flight program implementation, (3) review of final flight program verification, (4) description of all final flight program documentation - for the purpose of verifying that: (1) all changes have been incorporated, (2) programs have been verified, and (3) documentation has been updated and is in agreement with the final program.

Following the Final Configuration Review, official delivery of the flight program is made.

The remainder of this presentation concerns itself with a more detailed explanation of the documentation, simulation, verification, and procedures in the development of a Saturn V flight program.

(1), (2), (3), (4), (5)

LVDC FLIGHT PROGRAM

LEVEL II FLIGHT PROGRAM AND DOCUMENTATION
FINAL FLIGHT PROGRAM AND DOCUMENTATION

AND RELATED DOCUMENTATION,

LVDC MISSION DEFINING DOCUMENT (MDD)
LVDC EQUATION DEFINING DOCUMENT (EDD)
FINAL MISSION DEFINING DOCUMENT (FMDD)
PROGRAM VERIFICATION PLAN (PVP)
FINAL FLIGHT DATA DOCUMENT (FFDD)
POSTFLIGHT EVALUATION PLAN (PEP)
GUIDANCE & CONTROL SUMMARY INFORMATION DOCUMENTS (G&CSID)
FLIGHT PROGRAM VERIFICATION DOCUMENT (FPVD)
POSTFLIGHT EVALUATION DOCUMENT (PED)

REVIEW, APPROVALS,

PRELIMINARY DESIGN REVIEW (PDR)
CRITICAL DESIGN REVIEW (CDR)
FINAL CONFIGURATION REVIEW (FCR)

AND DELIVERIES

UNVERIFIED LEVEL II AND FINAL LVDC PROGRAMS CONCURRENT WITH INITIAL DELIVERY TO CONTRACTOR'S SIMULATION LABORATORY FACILITY

FORMAL DELIVERY OF VERIFIED LEVEL II AND FINAL FLIGHT PROGRAM

070-008-008
LVDC FLIGHT PROGRAM
AND RELATED DOCUMENTATION,
REVIEW, APPROVALS, AND
DELIVERIES

The following flight programs and related documentation are required on each vehicle:

1. Level II Flight Program and Documentation is a complete flight program reflecting the approved LVDC Equation Defining Document and the Final Mission Defining Document. Documentation includes program tapes, detailed flow charts, program listings, telemetry listings, scaling and nomenclature, and repeatable simulated flight mode and flight simulation mode operating procedures.

2. Final Flight Program and Documentation is a complete flight program reflecting the approved LVDC Equation Defining Document, the Final Mission Defining Document, and the Final Flight Data Document. Documentation includes program tapes, detailed flow charts, program listings, telemetry listings, scaling and nomenclature, and repeatable simulated flight mode and flight simulation mode operating procedures.

The following documents are required on each vehicle with the originator and review authority identified:

1. LVDC Mission Defining Document (MDD) - MSFC - NONE

2. LVDC Equation Defining Document (EDD) - IBM - MSFC

3. Final Mission Defining Document (FMDD) - MSFC - IBM

4. Program Verification Plan (PVP) - IBM - MSFC

5. Final Flight Data Document (FFDD) - MSFC - IBM

6. Postflight Evaluation Plan (PEP) - IBM - MSFC

7. Guidance and Control Summary Information Document (G&CSID) - IBM - MSFC

8. Flight Program Verification Document (FPVD) - IBM - MSFC

9. Postflight Evaluation Document (PED) - IBM - NONE

The following reviews are conducted for each vehicle by the contractor (IBM) for MSFC:

1. Preliminary Design Review of EDD.

2. Critical Design Review of EDD, PVP, and the flight program.

3. Final Configuration Review of the final flight program, PEP, and G&CSID.

4. Program delivery reviews and ceritifications prior to each program delivery unless waived by MSFC (apply to all program deliveries to KSC).

The following approvals are required for each vehicle:

1. MSFC formal approval of the EDD and PVP.

2. MSFC formal approval of the Level II Flight Program and documentation, Final Flight Program and documentation, the PEP, G&CSID and FPVD.

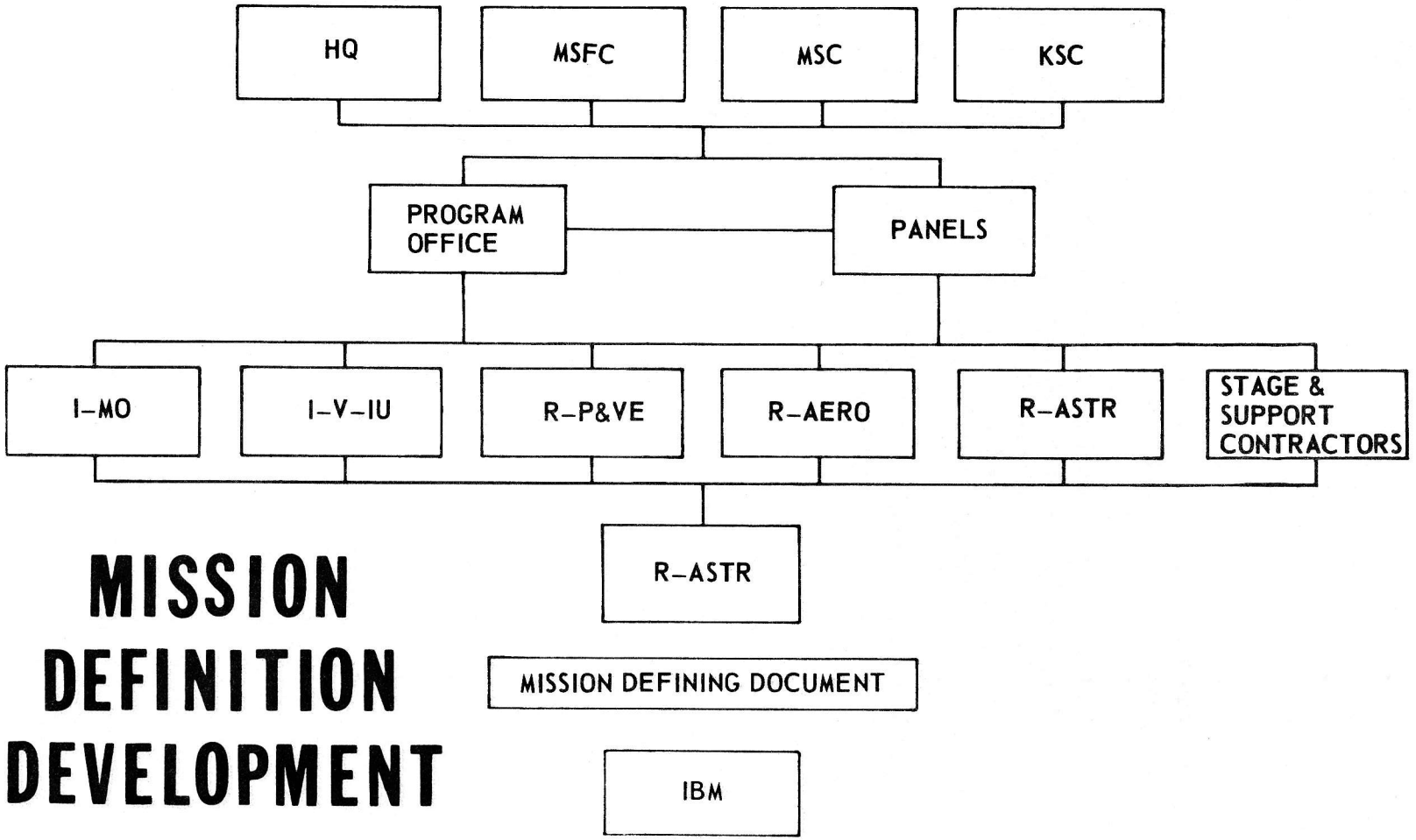
3. Review and approval by the contractor (IBM) of the FMDD to delineate those areas in which adequate definition is lacking. Specific definition required in each area shall be defined.

4. Review and approval by the contractor (IBM) of the FFDD to ensure that requirements listed in the FFDD are consistent with the time available. Logic changes shall be assessed with respect to their magnitude and with respect to the magnitude of the constant changes.

The contractor (IBM) performs the following LVDC software (digital computer programs) and documentation deliveries:

1. A delivery of the unverified Level II and final LVDC programs to MSFC concurrent with the initial delivery to the contractor's Simulation Laboratory Facility. This delivery consists of a program tape and a program listing. Any subsequent deliveries of unverified programs required by MSFC are directed by the contracting officer.

2. Formal deliveries of verified Level II and Final Flight Programs and documentation are made to MSFC and KSC.



MISSION DEFINITION DEVELOPMENT

070-008-009
MISSION DEFINITION
DEVELOPMENT

This slide illustrates the offices involved in the definition, development, and documentation of a Saturn V mission.

NASA headquarters issues a mission assignment document generally stating objectives and guidelines of the mission. The separate centers meet through intercenter panels and prepare a list of joint preliminary mission constraints; defining limitations on targeting, guidance and launch azimuth.

The Saturn V program office administers the overall program for MSFC. Numerous studies and analyses are performed by individual laboratories and project offices on mission profiles and trajectories, navigation and guidance equations and presettings, dynamics and flight control, propulsion data and performance, structural and mass analysis, aerothermodynamics, telemetry and tracking requirements, flight sequencing, and abort and alternate mission plans.

The end results of these studies and reports are routed through R-ASTR for formulation of a Mission Defining Document. IBM, as the flight program software contractor, is the recipient of this document, and based on its contents, develops the LVDC Flight Program.

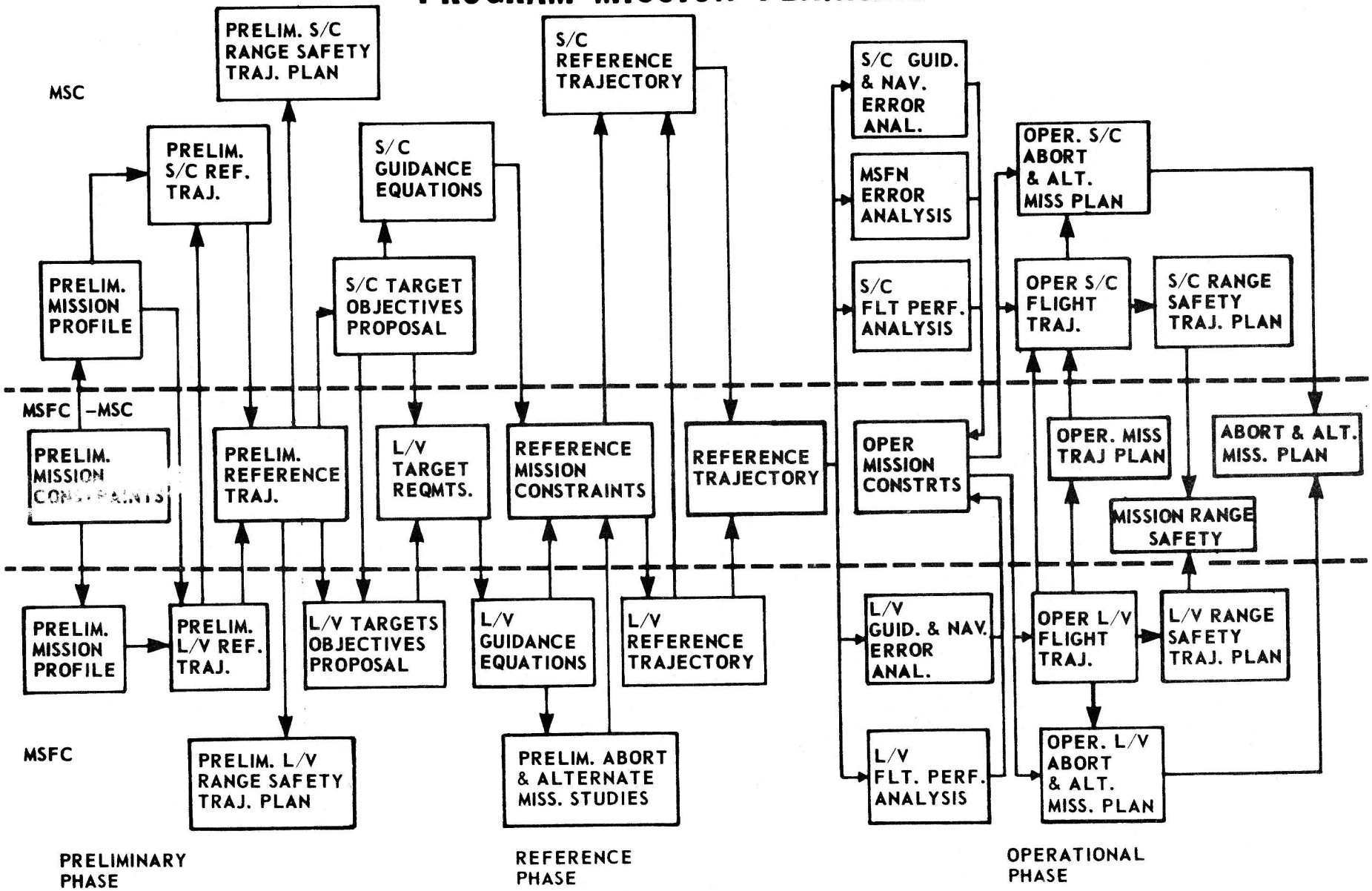
MSFC and contractor elements involved include, but are not limited to, the following:

1. Astrionics Laboratory
2. Aeronautics Laboratory
3. Propulsion and Vehicle Engineering Laboratory
4. I-V-E
5. I-V-IU
6. I-MO
7. Stage Contractors
8. Engine Contractor
9. Instrument Unit Contractor
10. Programming Contractors

In addition to the rigid interface demands imposed on these parties indicated, there is a continuous requirement for Inter-Center exchange of data through the Flight Mechanics Panel and its sub-panels.

(1), (2), (3), (4), (5)

PROGRAM MISSION PLANNING



070-008-010
PROGRAM MISSION
PLANNING

The project phases of mission planning during a flight program development are:

(1) Preliminary mission planning - during which preliminary mission constraints and a preliminary mission profile and trajectory are established, resulting in a preliminary reference trajectory.

(2) Reference mission planning - during which general target requirements and guidance equations and presettings are established; preliminary abort and alternate mission studies are conducted; and concluding with a general reference trajectory;

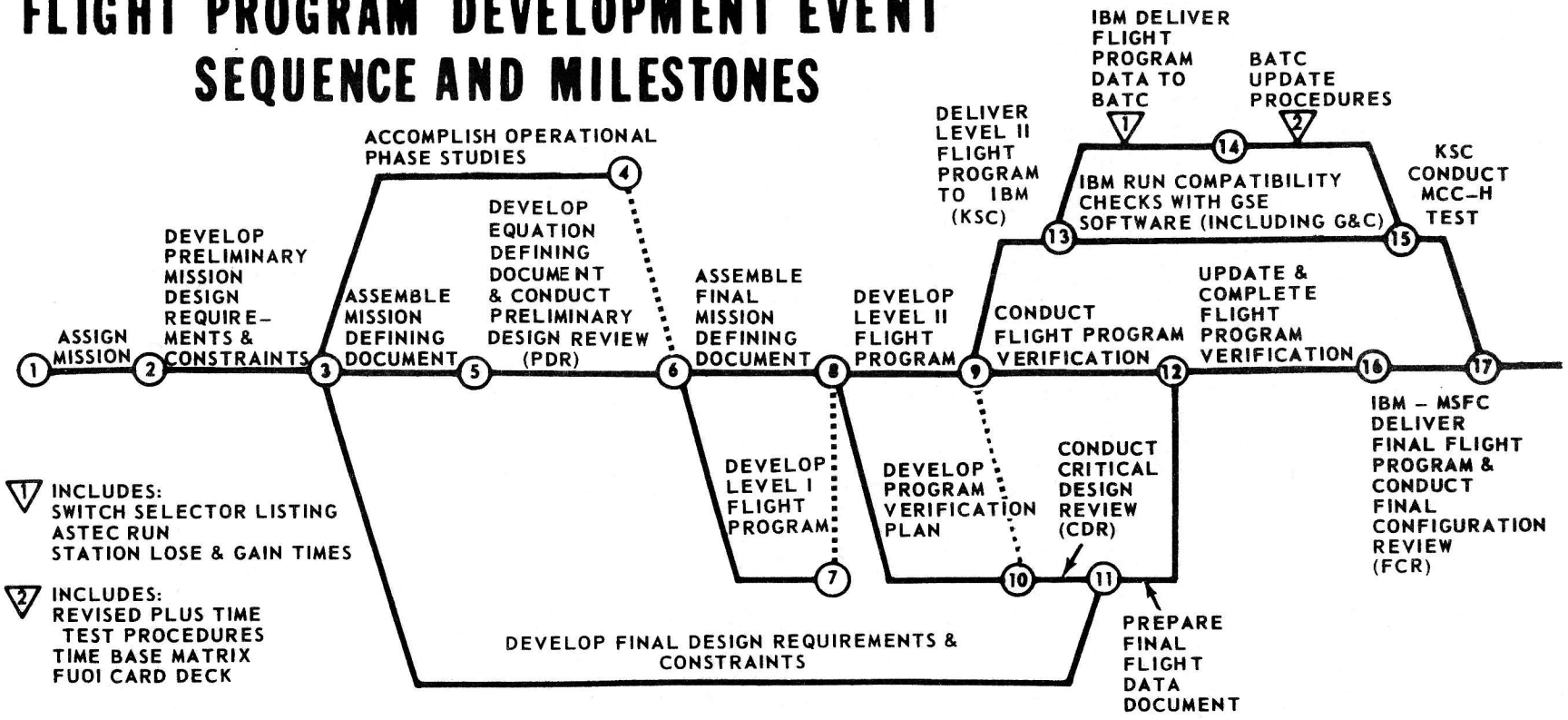
(3) Operational flight planning - during which guidance and error analysis and flight performance predictions are performed and the flight trajectory and abort and alternate mission plans are derived for the specific mission designated.

Preliminary and reference mission planning phases should result in a general definition (a reference trajectory and mission constraints) for a series of launch vehicles.

The operational flight planning is that which is conducted for a specific mission, with a given launch vehicle, for a specific flight, and encompasses the actual LVDC flight program software development; its simulation, verification, and design assurance approvals.

(1), (2), (3), (4), (5)

FLIGHT PROGRAM DEVELOPMENT EVENT SEQUENCE AND MILESTONES



1 INCLUDES:
SWITCH SELECTOR LISTING
ASTEC RUN
STATION LOSE & GAIN TIMES

2 INCLUDES:
REVISED PLUS TIME TEST PROCEDURES
TIME BASE MATRIX
FUOI CARD DECK

NOTE: MILESTONES NOT TO SCALE

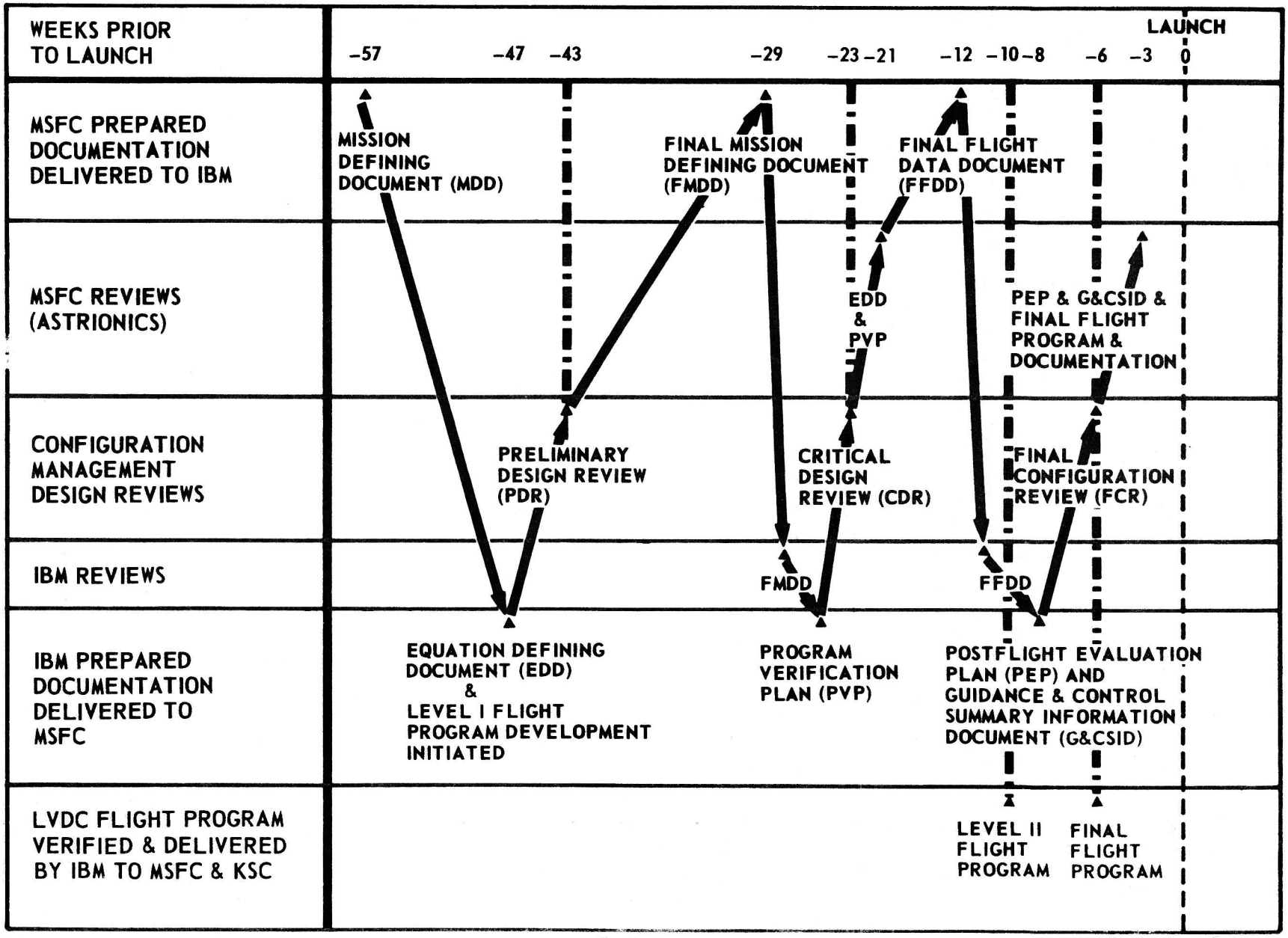
070-008-011
FLIGHT PROGRAM
DEVELOPMENT EVENT
SEQUENCE AND MILESTONES

Preparation for and development of flight program tapes is the most complex and demanding task included in the entire software program. An extensive inter-change of data and documentation between many agencies must start more than two years prior to a given mission and continue until very shortly prior to vehicle launch.

While a previous chart illustrated WHO was involved in flight program development, this slide shows WHAT and WHEN.

(1), (2), (3), (4), (5), (7)

MILESTONES FOR LVDC SOFTWARE DEVELOPMENT



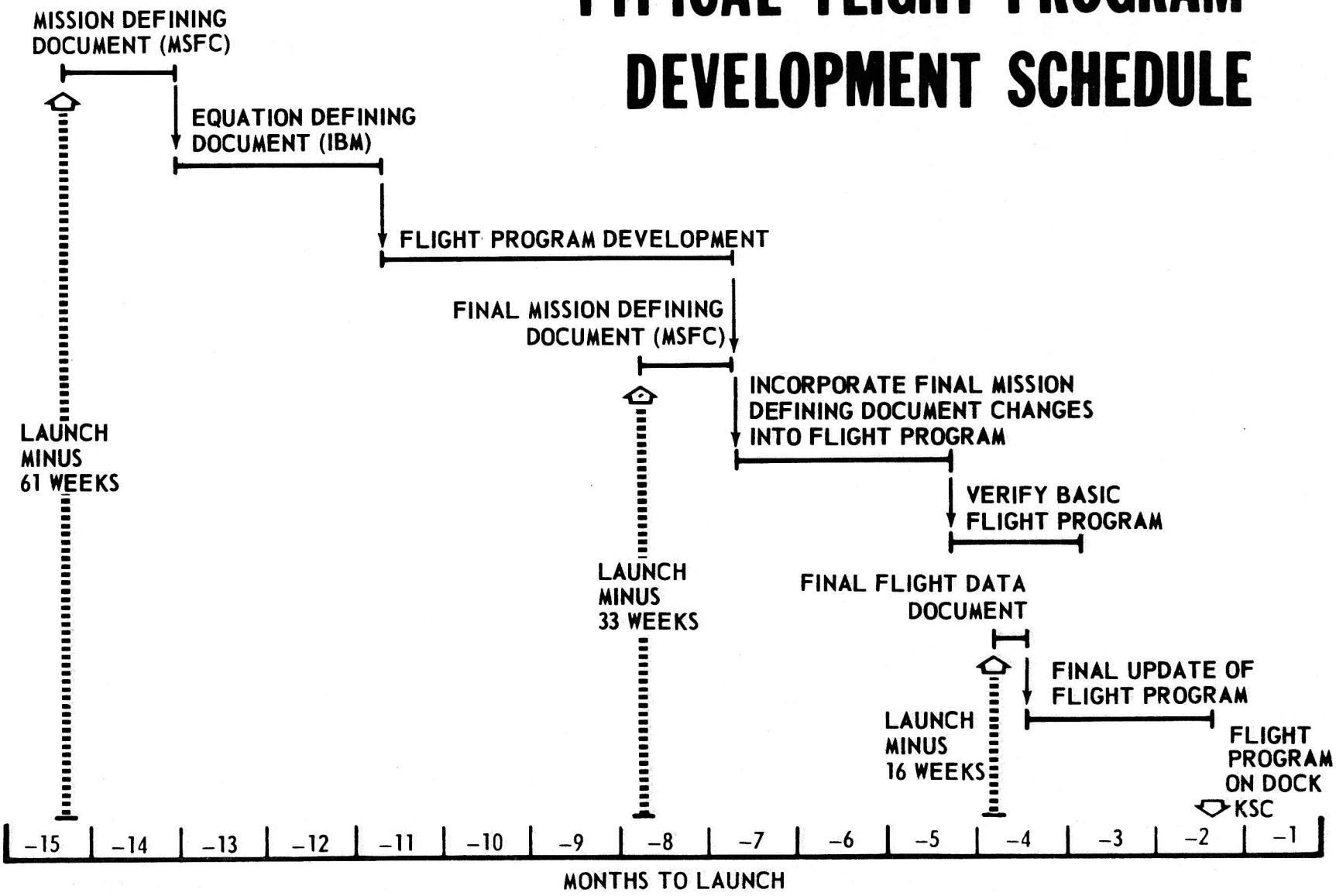
070-008-012
MILESTONES FOR
LVDC SOFTWARE
DEVELOPMENT

The majority of the research studies and reports are done independently by the many separate NASA organizations and their supporting contractors, but it is Astrionics Laboratory's task to integrate all of this material at the time a flight program is actually to be put together. They have contracted with IBM to actually prepare the flight program software and to conduct the simulation and verification program associated with it.

Consequently, it is appropriate to identify what IBM is more specifically responsible for and when it is due. The chart shows the delivery and review responsibility between Astrionics and IBM in order to successfully accomplish the task of preparing the flight program.

Succeeding slides will present a more detailed explanation of what each of the deliveries and reviews involve.

TYPICAL FLIGHT PROGRAM DEVELOPMENT SCHEDULE



070-008-013
TYPICAL FLIGHT
PROGRAM DEVELOPMENT
SCHEDULE

More than 100 individual major data inputs and documents have been identified that are required either as direct or indirect inputs to Astrionics Laboratory for the purpose of producing the three (3) major documents from which IBM develops the Flight Program. These three (3) major documents are:

(1) Mission Defining Document (MDD)
(2) Final Mission Defining Document (FMDD)
(3) Final Flight Data Document (FFDD)

Phasing of these documents into the flight program development cycle is such that inputs to Astrionics must occur as follows:

(1) Input to MDD - Launch minus 61 weeks.
(2) Input to FMDD - Launch minus 33 weeks.
(3) Input to FFDD - Launch minus 16 weeks.

In the above cases, the preparation of the input data must begin as much as one year prior to the Astrionics Laboratory input requirements. It must be pointed out that the majority of the 100+ major documents comprise a series/parallel network of constraints upon each other. In addition, there is the undocumented region of untold numbers of minor (or less major) data that must be compiled to support those documents that have been identified.

The next several slides discuss the MDD, EDD, FMDD, and FFDD and their identifiable major inputs (in that order) and who prepares them.

The next eight charts represent an effort to depict a typical data requirements schedule oriented to launch date. It represents a "start-from -scratch" condition and all requirements need not be repeated for every flight, particularly when successive missions are the same or similar.

Possible duplications may exist in the data schedule. Similar or identical data may be shown under more than one description or terminology.

MISSION DEFINING DOCUMENT

GENERAL MISSION DESCRIPTION, OBJECTIVES

MISSION REQUIREMENTS, CONSTRAINTS

PRELIMINARY DIGITAL PROGRAM REQUIREMENTS

- NAVIGATION, GUIDANCE, CONTROL
- SWITCH SELECTOR SEQUENCING
- INTERRUPTS, DISCRETES
- ORBITAL OPERATIONS
- TELEMETRY, DIGITAL COMMAND SYSTEM
- BACK-UPS: TIME BASES, HARDWARE
- REAL TIME CONTINGENCIES
- SIMULATED FLIGHT ROUTINES

DATA FOR SIMULATIONS

- VEHICLE PERFORMANCE
- CONTROL SYSTEM PERFORMANCE

070-008-014
MISSION DEFINING
DOCUMENT

LVDC Mission Defining Document (MDD) contains the general mission description, objectives, requirements, and constraints; preliminary vehicle and control system data; preliminary definition of inflight functions to be performed by the LVDC such as guidance, control navigation, sequencing, telemetry, orbital checkout, Digital Command System operation, simulated flight routines, antenna switching, and venting; preliminary time base backup and instrumentation backup requirements; preliminary real time alternate mission requirements; preliminary interrupt and discrete requirements; preliminary propellant utilization requirements; and any other information and/or requirements specified for the mission.

From the Mission Defining Document, IBM begins preparation of math flow diagrams and various study activities. The vehicle parameters are obtained and a 3D and a 6D simulation of the vehicle with a FORTRAN model of the guidance equations is built up. These models are exercised to determine range of all variables, validity of algorithms, behavior of guidance equations under extreme perturbations, adequacy of attitude computations, control gains, steering misalignment correction requirements, smoothing and filtering requirements, payload loss due only to implemented guidance method, and other parameters. The results of these studies are presented in a series of meetings with MSFC and trade-offs are made where required.

Additional studies will be made to establish: discrete input and output program requirements and methods for implementation; prelaunch calculations; telemetry from the LVDC; and other special operations required for the mission under study.

The initial results of these efforts are incorporated into the Equation Defining Document, containing range of variables, sampling rates, filter coefficients, attitude command gains, steering misalignment gains, special protective features for sensitive calculations, and a detailed specification for the flight computer program. A flow diagram will be included to assist in defining the program. Level I Flight Program Development will be initiated upon delivery of this document. The above studies are continued until all recommendations in the Equation Defining Document have been verified.

(1), (2), (3), (4), (5)

OUTLINE FOR MISSION DEFINING DOCUMENT PREPARATION

Assemble Data (Checklist)

Review

- Confirm Mission Requirements vs Data
- Compare with Prior Flight Programs
- Cross Check for Compatibility

Analysis

- Identify Special Routines/Algorithms
- Check Gains, Limits for Adequacy
- Estimate Scaling Requirements

Simulation

- Confirm Navigation/Guidance Equations and Pre-Settings
- Check Back-up Routines
- Assess Orbital Operation

Publication of MDD

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DOCUMENTATION AND DATA INPUTS TO MISSION DEFINING DOCUMENT

DOCUMENT/ACTIVITY	RESPONSIBILITY
MISSION DEFINITION LABS, CENTERS & STAGE CONTRACTOR INPUTS	NASA HDQ
PREL L/V MISSION CONSTRAINTS	R-AERO
VENTING DATA	R-P&VE
WEIGHT & MASS	R-P&VE
PROPULSION DATA	R-P&VE
FLIGHT SEQUENCE	R-P&VE
AERODYNAMICS	R-AERO
PREL MSC MISSION PROFILE	FLIGHT MECH PANEL
PREL MISSION CONSTRAINTS	FLIGHT MECH PANEL
PREL L/V REFERENCE TRAJECTORY	R-AERO
AERODYNAMICS	R-AERO
PROPULSION DATA	R-P&VE
FLIGHT SEQUENCE	R-P&VE
ATMOSPHERIC DATA	R-AERO
PREL REFERENCE TRAJECTORY	THE BOEING CO
TARGETING PROPOSAL	THE BOEING CO
PREL L/V GUIDANCE EQUATIONS	R-AERO
ATMOSPHERIC DATA	R-AERO
VEHICLE CONFIGURATION	R-P&VE
MISSION PROFILE	R-AERO
BOOST AERODYNAMICS	R-AERO
SPACE ENVIRONMENT	R-AERO

DOCUMENT/ACTIVITY	RESPONSIBILITY
ORBITAL CONFIGURATION	R-P&VE
ORBITAL AERODYNAMICS	R-AERO
ABORT & ALTERNATE MISSION CONSTRAINTS	FLIGHT MECH PANEL
MALFUNCTION DEFINITION	?
ABORT & ALTERNATE MISSION STUDIES	THE BOEING CO.
REAL TIME ALTERNATE MISSION PLAN	R-AERO
ANTENNA SWITCHING REQ'MTS	R-ASTR-I
GROUND TEST REQ'MTS	R-ASTR-N
CONTROL GAINS & LIMITS	R-ASTR-F
M/F FILTER DEFINITION	R-ASTR-F
INSTRUMENTATION BACK-UP REQ'MTS	R-ASTR-NG
NAVIGATION EQUATIONS	R-ASTR-NG
T/M REQ'MTS (OTHER THAN MCC)	R-ASTR-NG
AERODYNAMIC DATA	R-AERO-AD/AM
PRELIMINARY MISSION CONSTRAINTS	R-AERO-PA
L/V GUIDANCE EQUATIONS	R-AERO-N R-AERO-DG
PROPULSION PARAMETERS REFERENCE LIST	?
TIME TILT TABLE	R-AERO-DA
STAGE PROPULSION PERFORMANCE & DISPERSION DATA	R-P&VE/PP
UPDATED VENTING DATA	R-P&VE/PP
MISSION CONTROL CENTER T/M	I-MO
MCC DIGITAL CONTROL SYSTEM	I-MO
REAL TIME ALTERNATE MISSION PLAN	FLIGHT MECH PANEL

The documentation and data inputs to Astrionics for preparation of the Mission Defining Document are required at launch data minus 61 weeks for release of the Mission Defining Document at launch date minus 57 weeks.

Following is a list of the identified major inputs to the MDD:

DOCUMENTATION INPUT TO MISSION DEFINING DOCUMENT

Mission Definition	NASA Hdq.
Labs, Centers, & Stage Contractor Inputs	
Prel. L/V Mission Constraints	R-AERO
Venting Data	R-P&VE
Weight and Mass	R-P&VE
Propulsion Data	R-P&VE
Flight Sequence	R-P&VE
Aerodynamics	R-P&VE
Prel. MSC Mission Profile	Flight Mech. Panel
Prel. Mission Constraints	Flight Mech. Panel
Prel. L/V Reference Trajectory	R-AERO
Aerodynamics	R-AERO
Propulsion Data	R-P&VE
Flight Sequence	R-P&VE
Atmospheric Data	R-AERO
Prel. Reference Trajectory	The Boeing Company
Targeting Proposal	The Boeing Company
Prel. L/V Guidance Equations	R-AERO
Atmospheric Data	R-AERO
Vehicle Configuration	R-P&VE
Mission Profile	R-AERO
Boost Aerodynamics	R-AERO
Space Environment	R-AERO
Orbital Configuration	R-P&VE
Mission Profile	R-AERO
Orbital Aerodynamics	R-AERO
Abort & Alternate Mission Constraints	Flight Mech. Panel

(4), (7)

CONTINUED-2
070-008-C15

DOCUMENTATION AND DATA INPUTS TO MISSION DEFINING DOCUMENT	
Malfunction Definition	Flight Mech. Panel
Abort & Alternate Mission Studies	The Boeing Company
Real Time Alternate Mission Plan	R-AERO
Antenna Switching Requirements	R-ASTR-I
Ground Test Requirements	R-ASTR-N
Control Gains and Limits	R-ASTR-F
M/F Filter Definition	R-ASTR-F
Instrumentation Back-up Requirements	R-ASTR-NG
Navigation Equations	R-ASTR-NG
T/M Requirements (Other than MCC)	R-ASTR-NG
Aerodynamic Data	R-AERO-AD/AM
Preliminary Mission Constraints	R-AERO-PA
L/V Guidance Equations	R-AERO-DG/N
Propulsion Parameters Reference List	R-AERO-DG/N
Time Tilt Table	R-AERO-DA
Main Stage Propulsion Performance & Dispersion Data	R-P&VE/PP
Updated Venting Data	R-P&VE/PP
Mission Control Center T/M	I-MO
MCC Digital Control System	I-MO
Real Time Alternate Mission Plan	Flight Mech. Panel

(4), (7)

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EQUATION DEFINING DOCUMENT

EQUATION DEFINING DOCUMENT CONTENTS

- EXACT EQUATIONS (ALGORITHM FORM)
- RANGE OF VARIABLES, SCALING OF PARAMETERS
- INPUT/OUTPUT SPECIFICATIONS
- * INITIAL CONDITIONS, FINAL CONDITIONS
- SAMPLING RATES, DIGITAL FILTER SPECIFICATIONS
- DIGITAL COMMAND SYSTEM REQUIREMENTS
- REASONABLENESS TESTS, WITH LIMITS
- * SEQUENCING REQUIREMENTS
- FLIGHT SIMULATION DEFINITION AND CONSTRAINTS
- * ORBITAL OPERATIONS AND TIMELINES
- ESTIMATED MEMORY REQUIREMENTS
- * VENT AND ATMOSPHERIC DATA
- LIST OF PARAMETERS FOR TELEMETERING
- * BOOST TILT PROFILE
- ORDER OF EQUATION SOLUTION

EQUATION DEFINING DOCUMENT REVIEW

- EDIT FOR COMPLIANCE WITH MDD
- ANALYZE AREAS OF COMPROMISE
- EVALUATE ALGORITHM ACCURACY AND CONVERGENCE
- DETERMINE ADEQUACY OF BACK-UPS
- ANALYZE CONSISTENCY OF SCALING AND ACCURACY
- CRITIQUE PROPOSED IMPLEMENTATION
- JUDGE CREDIBILITY OF FLOW DIAGRAMS
- EVALUATE UTILIZATION OF HARDWARE REDUNDANCY
- EVALUATE DEGREE OF PROGRAM FLEXIBILITY

* DATA MOST SUBJECT TO CHANGE

070-008-016
EQUATION
DEFINING
DOCUMENT

A Guidance Studies and Analyses effort is concerned with performance of system studies which result in the definition of the LVDC Flight Program. The main result is the generation of the Equation Defining Document and a math flow diagram for each flight. The contents of the Equation Defining Document are IBM's recommendations for the equations that are to be performed in the LVDC during preflight and flight of a specified mission. These equations pertain to navigation, guidance, and control calculations.

This document defines the Launch Vehicle Digital Computer (LVDC) flight program for the powered flight and orbital operations phase of a specific Apollo Saturn mission. Included are general and detailed flow charts, equations, and analyses covering guidance, navigation, control, sequencing, test and telemetry functions. In addition, results of digital computer simulations and other detailed studies to verify the flight program are appended.

The definition provides both a general description of the various aspects of the flight program and a basis for the programming effort required to generate the Level I Flight Program Documentation.

LVDC Equation Defining Document (EDD) is based on the MDD and contains all the information necessary to program the LVDC. The EDD includes the following: exact equations to be solved in the LVDC (algorithm form); order in which equations must be solved; range of variables; scaling of quantities; discrete input and output specifications; orbital operations, equations and definitions; mode sequencing definition; initial conditions and final conditions (IGM); sampling rates; estimated memory requirements; specifications of all digital filters to be used in the flight program, including those required to reduce the effects of any undesirable characteristics of the platform accelerometer outputs arising from thrust oscillation; noise, and other causes which affect the guidance accuracy and stability; and other equations and information specified by the MDD.

(1), (2), (3), (4), (5), (8)

FINAL MISSION DEFINING DOCUMENT

- UPDATES/COMPLEMENTS MDD
- FINAL LOGIC REQUIREMENTS
- FINAL DATA FROM REFERENCE TRAJECTORY
- FINAL SEQUENCING DATA
- ORBITAL TIMELINE UPDATE
- BOOST TILT FROM REFERENCE TRAJECTORY

070-008-017
FINAL MISSION
DEFINING DOCUMENT

A follow-up effort is required after delivery of the Equation Defining Document and math flow diagram. This effort is required to incorporate minor changes brought about by mission changes occuring after original mission definition and prior to issuance by MSFC of the Final Mission Defining Document.

The expected range of the important flight computer variables will be available from the results of the various perturbed flight simulation runs. From these ranges, an envelope can be established within which the guidance system performance can be expected to fall, barring unexpected perturbations or failures.

Final Mission Defining Document (FMDD) is based upon the same general mission as specified by the MDD and shall update and/or complement the information and requirements of the MDD. The FMDD finalizes the logic requirements for the Level II Flight Program. (Ref. earlier slide on MDD).

(1), (2), (3), (4), (5), (7), (9)

DOCUMENTATION AND DATA INPUTS TO FINAL MISSION DEFINING DOCUMENT

DOCUMENT/ ACTIVITY	RESPONSIBILITY
MISSION CONSTRAINTS	FLIGHT MECH PANEL
MISSION PROFILE	R–AERO
ATMOSPHERIC DATA	R–AERO
FLIGHT SEQUENCE	R–P&VE
AERODYNAMICS	R–AERO
PREL REFERENCE TRAJECTORY	THE BOEING CO
PREL GUIDANCE EQUATIONS	THE BOEING CO.
PROPULSION DATA	R–P&VE
L/V REFERENCE TRAJECTORY	R–AERO
PREL GUIDANCE EQUATIONS	THE BOEING CO
MISSION CONSTRAINTS	FLIGHT MECH PANEL
AERODYNAMICS	R–AERO
FLIGHT SEQUENCE	R–P&VE
ATMOSPHERIC DATA	R–AERO
PROPULSION DATA	R–P&VE
CONTROL SYSTEM DATA	R–ASTR
VENTING DATA	R–P&VE

DOCUMENT/ ACTIVITY	RESPONSIBILITY
REF TRAJECTORY	THE BOEING CO
FINAL L/V GUIDANCE EQUATIONS	R–AERO
MISSION CONSTRAINTS	FLIGHT MECH PANEL
MANEUVERS	FLIGHT MECH PANEL
VENTING DATA	R–P&VE
FLIGHT SEQUENCE	R–P&VE – R–ASTR
REFERENCE VEHICLE ATTITUDE TIME LINES	R–AERO
FLIGHT SEQUENCE PROGRAMS	R–ASTR–EA
FINAL ANTENNA SWITCHING REQ'MTS	R–ASTR–I
UPDATED GUIDANCE EQUATION DOCUMENTS	R–AERO–DA
REFERENCE TRAJECTORY	R–AERO–DA
UPDATED PROPULSION PERFORMANCE DATA	R–P&VE/PP
UPDATED VENTING DATA	R–P&VE/PP
MASS CHARACTERISTICS (DEPLETION CUT OFF)	R–P&VE–VOO
FLIGHT SEQUENCE DATA	R–P&VE–VOO
UPDATED MISSION VEHICLE TIME LINES	FLIGHT MECH PANEL

070-008-018
DOCUMENTATION AND
DATA INPUTS TO FINAL
MISSION DEFINING DOCUMENT

The documentation and data inputs to Astrionics for preparation of the Final Mission Defining Document are required at launch date minus 33 weeks for release of the Final Mission Defining Document at launch date minus 29 weeks.

Following is a list of the identified major inputs to the FMDD:

DOCUMENTATION INPUT TO FINAL MISSION DEFINING DOCUMENT

Mission Constraints	Flight Mech. Panel
Mission Profile	R-AERO-
Atmospheric Data	R-AERO-
Flight Sequence	R-P&VE-
Aerodynamics	R-AERO-
Prel. Reference Trajectory	The Boeing Company
Prel. Guidance Equations	The Boeing Company
Propulsion Data	R-P&VE-
L/V Reference Trajectory	R-AERO-
Prel. Guidance Equations	The Boeing Company
Mission Constraints	Flight Mech. Panel
Aerodynamics	R-AERO-
Flight Sequence	R-P&VE-
Atmospheric Data	R-AERO-
Propulsion Data	R-P&VE-
Control System Data	R-ASTR-
Venting Data	R-P&VE-
Ref. Trajectory	The Boeing Company
Final L/V Guidance Equations	R-AERO-
Mission Constraints	Flight Mech. Panel
Maneuvers	Flight Mech. Panel
Venting Data	R-P&VE-
Flight Sequence	R-P&VE-/R-ASTR-
Reference Vehicle Attitude Time Lines	R-AERO-
Flight Sequence Programs	R-ASTR-EA
Final Antenna Switching Requirements	R-ASTR-I
Updated Guidance Equation Documents	R-AERO-DA
Reference Trajectory	R-AERO-DA
Updated Propulsion Performance Data	R-P&VE/PP
Updated Venting Data	R-P&VE/PP
Mass Characteristics (Depletion Cut-off)	R-P&VE/VOO
Flight Sequence Data	R-P&VE/VOO
Updated Mission Vehicle Time Lines	Flight Mech. Panel

(4), (7)

FLIGHT PROGRAM DOCUMENTATION

FINAL FLIGHT DATA DOCUMENT:

CONTAINS MINOR LOGIC CHANGES AND INFORMATION WHICH FINALIZES THE CONSTANTS REQUIRED IN THE FINAL FLIGHT PROGRAM. CONSTANTS RESULTING FROM FFDD SHALL BE WITHIN THE PARAMETER SCALING LIMITS ESTABLISHED IN THE EQUATION DEFINING DOCUMENT (EDD).

BASED ON OPERATIONAL TRAJECTORY:

- FINAL BOOST TILT PROFILE
- FINAL PRESETTINGS
- FINAL SEQUENCING
- FINAL ORBITAL TIMELINES
- TARGETING AND LAUNCH AZIMUTH

GUIDANCE & CONTROL SUMMARY INFORMATION DOCUMENT:

CONSOLIDATES PERTINENT INFORMATION ABOUT THE GUIDANCE AND CONTROL SYSTEM AND THE LVDC FLIGHT PROGRAM FOR EACH VEHICLE. IT INCLUDES BLOCK DIAGRAMS OF THE GUIDANCE AND CONTROL SYSTEM, GENERAL FLOW CHARTS OF THE LVDC FLIGHT PROGRAM, CONTROL SYSTEM EQUATIONS, GAINS, POLARITIES, SCALE FACTORS, SEQUENCE OF EVENTS, AND ALL FLIGHT PROGRAM BACKUP MODES.

Final Flight Data Document (FFDD) contains minor logic changes and information which finalizes the constants required in the Final Flight Program. The contractor shall assess all changes to determine if the magnitude of the change will necessitate an adjustment in the final program delivery schedule. Constants resulting from the FFDD shall be within the parameter scaling limits established in the EDD.

Final Flight Data document contents (based on the operational trajectory) are:

Final Boost Tilt Profile
Final Presettings
Final Sequencing
Final Orbital Timelines
Targeting and Launch Azimuth

Guidance and Control Summary Information Document (G and CSID) consolidates pertinent information about the guidance and control system and LVDC flight program for each vehicle. The document constitutes a single source of general information on the mission and operation of the guidance and control system and LVDC flight program. It includes block diagrams of the guidance and control system, general flow charts of the LVDC flight program, control system equations, gains, polarities, scale factors, sequence of events, and all flight program backup modes. This document does not include test specifications.

(1), (2), (3), (4), (5)

DOCUMENTATION AND DATA INPUTS TO FINAL FLIGHT DATA DOCUMENT

DOCUMENT/ ACTIVITY	RESPONSIBILITY
MISSION CONSTRAINTS	FLIGHT MECH PANEL
AERODYNAMICS	R-AERO
ATMOSPHERIC DATA	R-AERO
CONTROL SYSTEM DATA	R-ASTR
LVDC EDD	R-ASTR
FLIGHT SEQUENCE	R-P&VE – R-ASTR
VENTING DATA	R-P&VE
APS DATA	R-P&VE – R-ASTR
WEIGHT & MASS	R-P&VE
PROPULSION DATA	R-P&VE
GUIDANCE PRESET	R-AERO
L/V OPERATIONAL TRAJECTORY	R-AERO
MANEUVERS	FLIGHT MECH PANEL
VENTING DATA	R-P&VE
FLIGHT SEQUENCE	R-P&VE – R-ASTR

DOCUMENT/ ACTIVITY	RESPONSIBILITY
FINAL VEHICLE ALTITUDE TIME LINES	R-AERO
TRACKING NETWORK	R-AERO
OPERATIONAL TRAJECTORY TAPE	THE BOEING CO
ACQUISITION & LOSS	R-AERO
FINAL FLIGHT SEQUENCE	R-ASTR-EA
OPERATIONAL TRAJECTORY	R-AERO/FM
GUIDANCE PRESETTINGS	R-AERO/FM
FINAL MISSION VEHICLE ALTITUDE TIME LINES	FLIGHT MECH PANEL
MISSION DEFINING DOCUMENT (MSFC)	R-ASTR-NG
EQUATION DEFINING DOCUMENT	IBM
FLIGHT PROGRAM DEVELOPMENT	IBM
FINAL MISSION DEFINING DOCUMENT (MSFC)	R-ASTR-NG
BASIC FLIGHT PROGRAM AVAILABLE	IBM
BASIC FLIGHT PROGRAM VERIFIED	IBM
FINAL FLIGHT DATA DOCUMENT	R-ASTR-NG
FINAL FLIGHT PROGRAM ON DOCK KSC	IBM(I-V-IU)

070-008-020
DOCUMENTATION AND DATA
INPUTS TO FINAL FLIGHT
DATA DOCUMENT

The documentation and data inputs to Astrionics for preparation of the Final Flight Data Document are required at launch date minus 16 weeks for release of the Final Flight Data Document at launch minus 12 weeks.

Following is a list of the identified major inputs to the FFDD:

DOCUMENTATION INPUT TO FINAL FLIGHT DATA DOCUMENT

Mission Constraints	Flight Mech. Panel
Aerodynamics	R-AERO-
Atmospheric Data	R-AERO-
Control System Data	R-ASTR-
LVDC EDD	R-ASTR-
Flight Sequence	R-P&VE-/R-ASTR-
Venting Data	R-P&VE-
APS Data	R-P&VE-/R-ASTR-
Weight and Mass	R-P&VE-
Propulsion Data	R-P&VE-
Guidance Presettings	R-AERO-
L/V Operational Trajectory	R-AERO-
Mission Constraints	Flight Mech. Panel
Maneuvers	Flight Mech. Panel
Venting Data	R-P&VE-
Flight Sequence	R-P&VE-/R-ASTR
Final Vehicle Attitude Time Lines	R-AERO-
Tracking Network	R-AERO-
Operational Trajectory Tape	The Boeing Company
Acquisition and Loss	R-AERO-
Final Flight Sequence	R-ASTR-EA
Operational Trajectory	R-AERO/FM
Guidance Presettings	R-AERO/FM
Final Mission Vehicle Attitude Time Lines	Flight Mech. Panel

The remaining items shown are the resulting steps in development and delivery of the flight program from the 105 pieces of documentation just discussed.

Mission Defining Document	R-ASTR-NG
Equation Defining Document	IBM

(4), (7)

Flight Program Development	IBM
Final Mission Defining Document	R-ASTR-NG
Basic Flight Program Available	IBM
Basic Flight Program Verified	IBM
Final Flight Data Document	R-ASTR-NG
Final Flight Program on Dock KSC	IBM (I-V-IU)

(4), (7)

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FLIGHT PROGRAM VERIFICATION PLAN

PROGRAM VERIFICATION PLAN (PVP) CONTENTS

A DESCRIPTION OF ALL PLANNED SIMULATIONS

- A DISCUSSION OF HOW EACH PORTION OF THE FLIGHT PROGRAM IS TO BE EXERCISED AND WHICH TEST CASES ARE TO ACCOMPLISH THAT PARTICULAR TASK.

SECTIONS:

NAVIGATION
GUIDANCE
CONTROL
SEQUENCING
COMMAND SYSTEM
TELEMETRY
MISCELLANEOUS

FLIGHT PROGRAM VERIFICATION DOCUMENT (FPVD) CONTENTS

PROGRAM VERIFICATION RESULTS

- NAVIGATION ERRORS
- TERMINAL CONDITIONS FOR PERTURBATION CASES
- GUIDANCE ERRORS

UNCORRECTED PROBLEMS

- A DESCRIPTION OF EACH PROBLEM
- AN EXPLANATION OF WHY IT WAS NOT CORRECTED

DEVIATIONS FROM THE PVP

- THE DEVIATION IS IDENTIFIED AND EXPLAINED IN EACH CASE

070-008-021
FLIGHT PROGRAM
VERIFICATION PLAN

Program Verification Plan (PVP) is a plan stating how the flight program is to be verified before it is flown. It includes the following items:

(1) A description of the simulation facilities to be used.

(2) The results of an analysis to determine specifically what simulated flights should be made to verify that the primary equations are adequate for the mission and to insure that all system backups are exercised. This number of simulated flights must take into account the simulation facilities and time available.

(3) All flight program functions will be assessed.

PVP Development

Test runs are selected to check program capability under a worse case trajectory envelope based on performance variations and failure conditions.

Additional runs are required to generate hardware failures that exercise all program backups.

Each successive PVP uses previous experience as a baseline.

Modifications are made to the PVP based on mission or flight program changes.

Flight Program Verification Document (FPVD) contains the results of the verification effort specified in the Program Verification Plan, expected positions and velocity envelopes under perturbed flight conditions, accuracy estimates, and other predicted flight performance data. This will include a discussion of uncorrected problems and any deviations from the PVP.

(1), (2), (3), (4), (5), (10)

IBM performs the following tasks:

Assists in debugging the flight program and investigates potential problem areas.

Verifies the final flight program. The program checkout procedure will include the following tests:

a. Run the flight program under nominal and/or perturbed conditions continuously through all stages

b. Check the preflight sequencing

c. Check the switch selector functions

d. Run the simulated flight (SIMFLT) and pseudo flight (PSEUDO FLT) program

e. Monitor all PCM outputs by means of the PCM ground station for special tests

Performs guidance system performance prediction and error analysis.

Digital error models of all pertinent subsystems will be constructed and used to prepare a guidance system error prediction for each flight. Specific tasks include:

Establish error models and procedures. This task includes preliminary studies of subsystems, definition of error equations, and construction of appropriate digital models.

Predict the total guidance errors due to guidance intelligence errors, navigation errors, steering errors, and cutoff and sequencing errors.

The results of these predictions and error analyses will be incorporated into the flight program verification and performance prediction documents.

(1), (2), (3), (4), (5), (10)

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LVDC FLIGHT PROGRAM TAPE DEVELOPMENT

INITIATE LEVEL I LVDC FLIGHT PROGRAM

(BEGUN WITH INITIAL DELIVERY OF EDD 47 WEEKS PRIOR TO LAUNCH)

1. RECEIVE MISSION REQUIREMENTS (MISSION DEFINING DOCUMENT AND PRELAUNCH & ORBITAL CHECKOUT PROGRAM).

DEVELOP LEVEL II LVDC FLIGHT PROGRAM

(DELIVER TEN WEEKS PRIOR TO LAUNCH)

2A. UPDATE PREVIOUS EQUATION DEFINING DOCUMENT AND VEHICLE SIMULATION MODELS.

2B. COMPLETE ANALYSIS OF SPECIAL PROBLEMS AND CHANGES TO EDD. ALSO RUN SIMULATION MODEL TESTS.

PREPARE FINAL FLIGHT PROGRAM

(DELIVER SIX WEEKS PRIOR TO LAUNCH)

3. UPDATE SIMULATION MODELS BASED ON FINAL PROGRAM DATA AND PERFORM MODEL SIMULATION AND FLIGHT HARDWARE LABORATORY SIMULATION VERIFICATIONS.

070-008-022
LVDC FLIGHT
PROGRAM TAPE
DEVELOPMENT

The Saturn V Flight Program tape development is normally considered to progress through three steps; Level I, Level II, and Final. However, if the mission requirements and objectives are similar, a duplicate of the previous flight's program is used as the next flight's Level I flight program. Consequently, each flight's tape development actually consists of updating a previously proven tape (Level I), checking out a developed tape(Level II) and then preparing the Final Flight Program.

In order to record the contents of the flight program, the EDD is updated. In order to verify the flight program, the various simulation models must be updated. These actions accompany the flight program tape development.

The following flight programs and related documentation are required on each vehicle:

a. Level II Flight Program and Documentation is a complete flight program reflecting the approved LVDC Equation Defining Document and the Final Mission Defining Document. Documentation includes program tapes, detailed flow charts, program listings, telemetry listings, scaling and nomenclature, and repeatable simulated flight mode operating procedures.

b. Final Flight Program and Documentation is a complete flight program reflecting the approved LVDC Equation Defining Document, the Final Mission Defining Document, and the Final Flight Data Document. Documentation includes program tapes, detailed flow charts, program listings, telemetry listings, scaling and nomenclature, and repeatable simulated flight mode and flight simulation mode operating procedures.

The contractor shall perform LVDC software (digital computer programs)

(1), (2), (3), (4), (5)

and documentation deliveries as follows:

a. A delivery of the unverified Level II and final LVDC programs shall be made to MSFC concurrent with the initial delivery to the contractor's simulation laboratory facility. This delivery shall consist of a program tape and a program listing. Any subsequent deliveries of unverified programs required by MSFC shall be directed by the Contracting Officer.

b. Formal deliveries of verified Level II and Final Flight programs and documentation shall be made to MSFC and KSC. Pending establishment of the revised detailed requirements and procedures through separate contractual action, the present procedures and requirements shall remain in effect concerning delivery of the Level II and Final Flight Programs.

(1), (2), (3), (4), (5)

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FLIGHT PROGRAM BASELINE REVIEWS

PRELIMINARY DESIGN REVIEW (PDR)

PRESENTS:

1. FLIGHT PROGRAM DESIGN PHILOSOPHY
2. LVDC MEMORY UTILIZATION
3. CRITERIA FOR SCALING REQUIREMENTS
4. RESULTS FROM MATH MODEL SIMULATIONS
5. POSSIBLE PROBLEM AREAS
6. KNOWN DEVIATION FROM ORIGINAL DEFINITION

PURPOSE:

ASSURE EDD IS SOUND BASELINE FOR FLIGHT PROGRAM

CRITICAL DESIGN REVIEW (CDR)

PRESENTS:

1. CHANGES TO EDD AND PROGRAM IMPACT THEREOF
2. IMPACT OF FINAL MISSION DEFINITION DOCUMENT
3. BASIS AND LIMITATIONS OF PVP
4. FINAL CONFIGURATION OF LEVEL II FLIGHT PROGRAM
5. OUTSTANDING CHANGES TO LEVEL II FLIGHT PROGRAM

PURPOSE:

1. ASSURE EDD ADEQUATELY DEFINES LEVEL II FLIGHT PROGRAM
2. ASSURE PVP SPECIFIES ADEQUATE VERIFICATION PROCEDURES
3. ASSURE LEVEL II FLIGHT PROGRAM SATISFIES FMDD REQUIREMENT

FINAL CONFIGURATION REVIEW (FCR)

PRESENTS:

1. REVIEW OF ALL INPUT REQUIREMENTS
2. REVIEW OF FINAL FLIGHT PROGRAM IMPLEMENTATION
3. REVIEW OF FINAL FLIGHT PROGRAM VERIFICATION
4. DESCRIPTION OF ALL FINAL FLIGHT PROGRAM DOCUMENTATION

PURPOSE:

1. VERIFY THAT ALL CHANGES HAVE BEEN INCORPORATED
2. VERIFY THAT FINAL FLIGHT PROGRAM REFLECTS ALL PROGRAM SPECIFICATIONS
3. VERIFY THAT PROGRAMS HAVE BEEN VERIFIED AND ARE FLIGHTWORTHY
4. VERIFY THAT PROGRAMS AND UPDATED DOCUMENTATION ARE IN AGREEMENT

Baseline reviews are established at those times in a program when it is necessary to "fix" the design, development, or production of a system, equipment, or facility in order to have a point of reference for control and maintenance of design. A basic premise of the baseline concept is that there must be a recognized and documented statement of requirements. Once stated, any changes to these requirements will be documented so that the current status and configuration of a program may be judged in terms of conformance to established requirements.

PRELIMINARY DESIGN REVIEW (PDR)

The flight program preliminary design review is a formal technical review of the basic design approach used in the Equation Defining Document (EDD). This review presents the following:

1. Flight program design philosophy
2. Launch Vehicle Digital Computer (LVDC) memory utilization
3. Criteria for scaling requirements
4. Results from math model simulations
5. Possible problem areas
6. Known deviations from original definition

Its purpose is to assure that the EDD is a sound baseline for the flight program. (The previous vehicle flight program forms the basis for each succeeding one).

CRITICAL DESIGN REVIEW (CDR)

The flight program critical design review is a formal technical review of the design for the Level II Flight Program as defined by the EDD and the Program Verification Plan. This review presents the following:

1. Changes to the EDD and their program impact
2. Impact of the Final Mission Defining Document (FMDD)
3. Basis and limitations of the Program Verification Plan
4. The final configuration of the Level II Flight Program
5. Outstanding changes to the Level II Flight Program (FPCR's)

(1), (2), (3), (4), (5), (15)

Its purpose is to assure that the EDD and its changes adequately define the design for the Level II Flight Program, that the Program Verification Plan specifies an adequate verification procedure for the Level II Flight Program, and that the Level II Flight Program design will satisfy all known requirements existing through final MDD delivery.

FINAL CONFIGURATION REVIEW (FCR)

The final configuration review is a formal technical review of the final flight program and documentation. This review presents the following:

1. Review of all flight program input requirements, including changes to baseline documents.
2. Review of final flight program implementation.
3. Review of final flight program verification history and verification results.
4. Description of all final flight program documentation.

Its purpose is to verify that all changes not incorporated in the Level II Flight Program have been incorporated in the Final Flight Program, that the Final Flight Program reflects all previous program specifications and changes, that the documentation has been updated, that the programs have been verified in accordance with the Program Verification Plan and proven flightworthy, and that the programs and the related documentation are in complete agreement.

The preceeding discussion was concerned with configuration baseline reviews only as they apply to the flight program. As a matter of general information and comparison, the following paragraphs describe principal configuration management reviews as they are defined in the MSFC Configuration Management Manual:

1. Preliminary Design Review (PDR) - is a formal technical review of the basic design approach for a contract end item. The PDR is accomplished prior to, or early in, the detail design stage to ensure compatibility between the selected basic design approach, as identified by Part I of the Contract End Item (CEI) Detail Specification, and the program requirements and criteria.

The primary products of a PDR are identification of engineering documentation which establishes physical and functional relationships of the CEI to other system equipment/facilities and approval of Part I of the CEI specification.

2. The Critical Design Review (CDR) - is a formal technical review of the detail design and performance characteristics of a contract end item.

The CDR is accomplished when the detail design is essentially complete in order to establish the design and provide the basis for formal release of engineering drawings describing the CEI, for purposes of manufacturing, preparation of technical manuals, certain test activities, and other supporting activities.

The primary product of the CDR is identification and NASA approval of specific engineering documentation which defines the design of the CEI and which will be released for manufacturing of the unit.

3. The First Article Configuration Inspection (FACI) - is a comparison of a selected article's configuration with the CEI specification (Part I and Part II) to establish the product configuration baseline for the contract end item.

FACI results in the approval and contractual implementation of Part II of the CEI specification.

The primary product of the FACI is acceptance by the procuring agency of Part II of the end item detail specification as an audited and approved document and contractual implementation of Part II as the product configuration baseline.

4. The Final Configuration Review (FCR) - is a formal technical review of the deliverable CEI.

The FCR is performed prior to initiation of simulated countdown. The purpose is to verify that all changes approved since FACI have been incorporated, the documentation has been updated and that the configuration and related documentation are in complete agreement.

(1), (2), (3), (4), (5), (15)

Various degress of change control are applied to the contractors with each successive baseline review. Normal quality assurance surveillance is conducted throughout the manufacturing, testing, installation, and check-out phases of a program to assure compliance with engineering requirements.

(1), (2), (3), (4), (5), (15)

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CHANGE CONTROL

FLIGHT PROGRAM CHANGE DECISIONS FOR KNOWN PROBLEMS

- A DECISION TO CORRECT THE FLIGHT PROGRAM WHEN A PROBLEM IS DISCOVERED IN THE VERIFICATION PROCESS IS BASED ON THE FOLLOWING, IN ORDER OF PRIORITY:
  - THE EFFECT (MISSION FAILURE, LOSS OF REDUNDANCY, ETC.)
  - THE PROBABILITY (A COMBINATION OF UNLIKELY EVENTS OR TIME RESTRICTED)
  - THE IMPACT (HOW COMPLEX, EXPENSIVE, SCHEDULE IMPACT, TRADEOFF IN RELIABILITY)
- FINAL DECISIONS ON FLIGHT PROGRAM CHANGES ARE MADE BY THE PROGRAM MANAGER.

REVERIFICATION

- A COMPLETE RERUN OF ALL PERTURBATION CASES IS NOT USUALLY REQUIRED AFTER A SINGLE FLIGHT PROGRAM CHANGE.
- THE NOMINAL RUN IS REPEATED AS A STANDARD FOR COMPARISON.
- PERTURBATION CASES ARE SELECTED FROM THE PVP BASED ON THEIR APPLICABILITY TO THE CHANGE.
- SPECIAL RUNS ARE SOMETIMES DEVISED TO CREATE SPECIFIC TEST CONDITIONS.

A decision to correct the flight program when a problem is discovered in the verification process is based on the following, in order of priority:

(1) The effect (mission failure, loss of redundancy, etc.)

(2) The probability (a combination of unlikely events or time restricted)

(3) The impact (how complex, expensive, schedule impact, tradeoff in reliability)

Final decisions on flight program changes are made by the program manager.

Reverification of the flight program is necessary if a change has been made in it. However, the following statements generally apply:

1. A complete rerun of all perturbation cases is not usually required after a single flight program change.

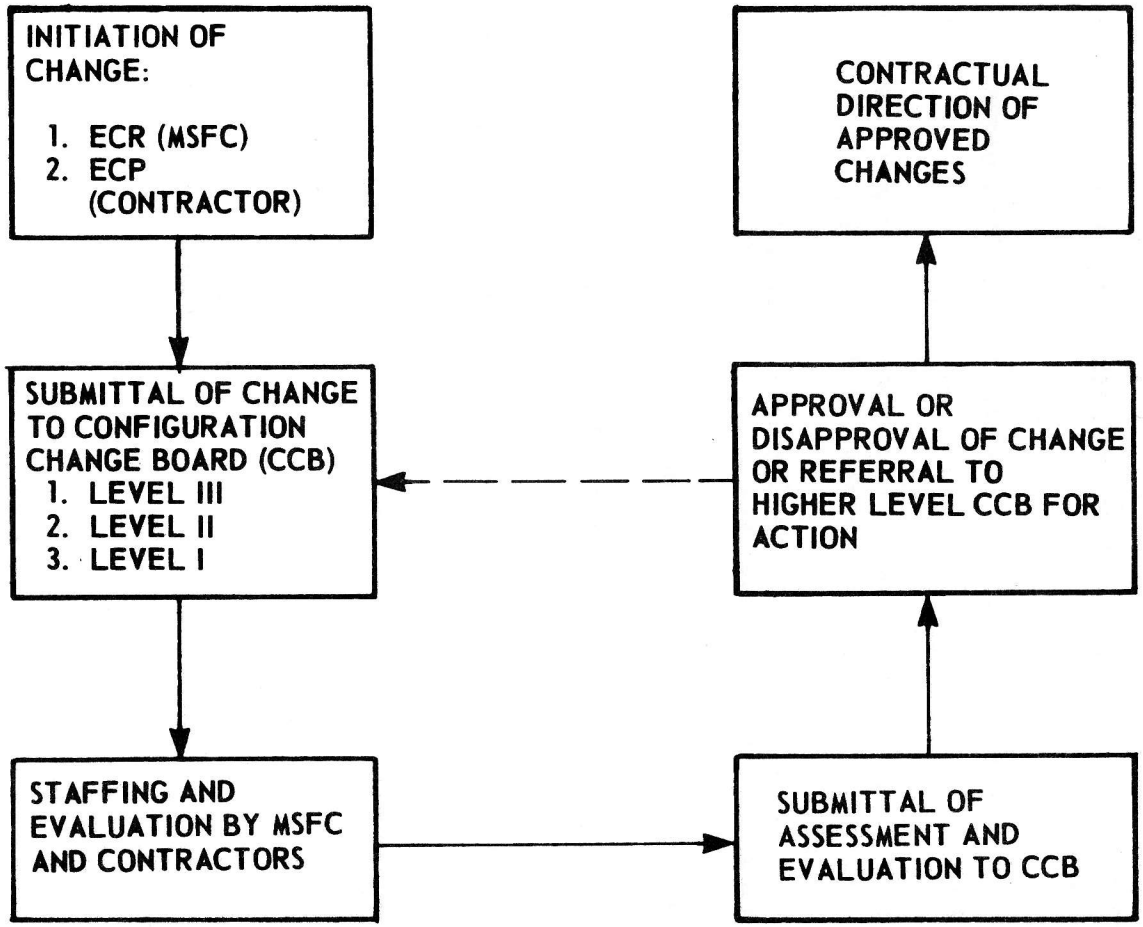
2. The nominal run is repeated as a standard for comparison.

3. Perturbation cases are selected from the PVP based on their applicability to the change.

4. Special runs are sometimes devised to create specific test conditions.

(1), (2), (3), (4), (5)

SOFTWARE CHANGE PROCEDURE (CLASS I CHANGES)



NOTE: CLASS I CHANGES

1. AFFECT BOTH SOFTWARE AND HARDWARE
2. REQUIRE STAGE OR GSE CHANGES
3. AFFECT ICD'S AND IRN'S
4. AFFECT COST OR SCHEDULED SOFTWARE DELIVERIES
5. DEGRADE RELIABILITY OR SAFETY

070-008-025
SOFTWARE CHANGE
PROCEDURE (CLASS I
CHANGES)

To impose effective change control of the flight program and to permit corrections when a problem is discovered in the verification process, procedures must be established and terms defined. Following is a definition of Class I changes.

Class I changes are so designated whenever one or more of the following items are affected:

1. Contract specification, contract price or fee, contract weight, contract guarantees, contract delivery, or contract test schedules.

2. Contract reliability or contract maintainability.

3. Performance as stated either in definite terms or goals or as experienced in items in service use.

4. Interchangeability or a change in category regarding substitution or replaceability.

5. Safety

6. Electrical interference to communications, electrical equipment, or electromagnetic radiation hazards.

7. Aerospace ground equipment/support equipment (AGE/SE) trainers, training devices, or government furnished equipment (GFE).

8. Present adjustments of preset schedules to the extent that (a) new identification must be assigned or (b) operating limits are affected.

9. Systems, equipment, or facilities produced by other contractors to the extent that the affected contractor must accomplish an engineering change to maintain compatibility of the interface.

10. Operational computer programs.

(1), (15)

Class I changes to the flight program are processed according to configuration management procedures as explained in MSFC CMM-002-001-2H and R&DO directive 4-11.

An MSFC laboratory can initiate a change by means of an ECR (MSFC form 2327). A contractor initiated change is by means of an ECP.

The requested or proposed change is processed through the responsible project office (I-V-IU) and identified as an agenda item for the appropriate configuration control board (CCB). The CCB, in accordance with their procedures, advise affected contractors of the ECR (requesting impact change packages) and coordinate administrative and technical evaluation of the contractors' ECP's between IO and R&DO.

R&DO analyzes each ECP to determine all end-items affected and technically assesses the change. An evaluation report is prepared to record their findings and state their recommendations for approval or disapproval. After technical evaluation, reconciliation of technical areas, and agreement between the responsible R&DO laboratory organization and IO project offices and affected contractors, the change package is acted upon by the appropriate CCB.

The appropriate CCB will formally act upon each change package by issuing a CCBD (CCB Directive), either approving or disapproving the change. (CCBD's constitute the sole authority for change implementation).

The decision is processed back through the project offices for instruction sheets and to the contracting office for implementation by affected contractors as required.

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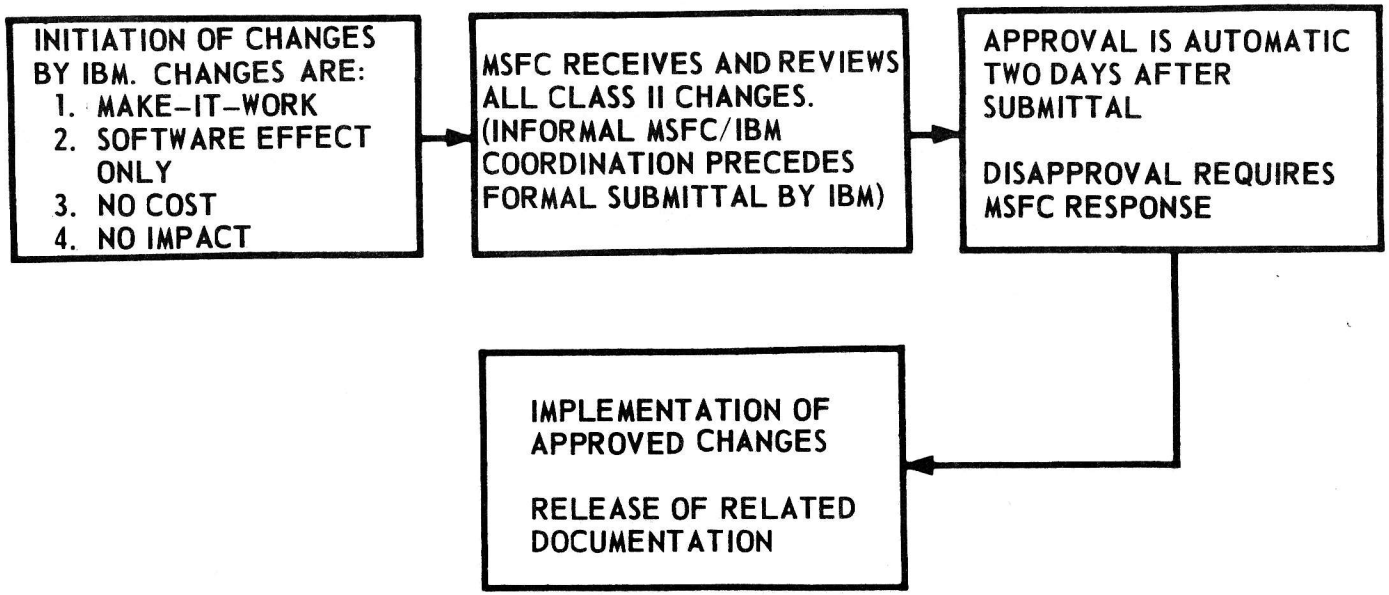
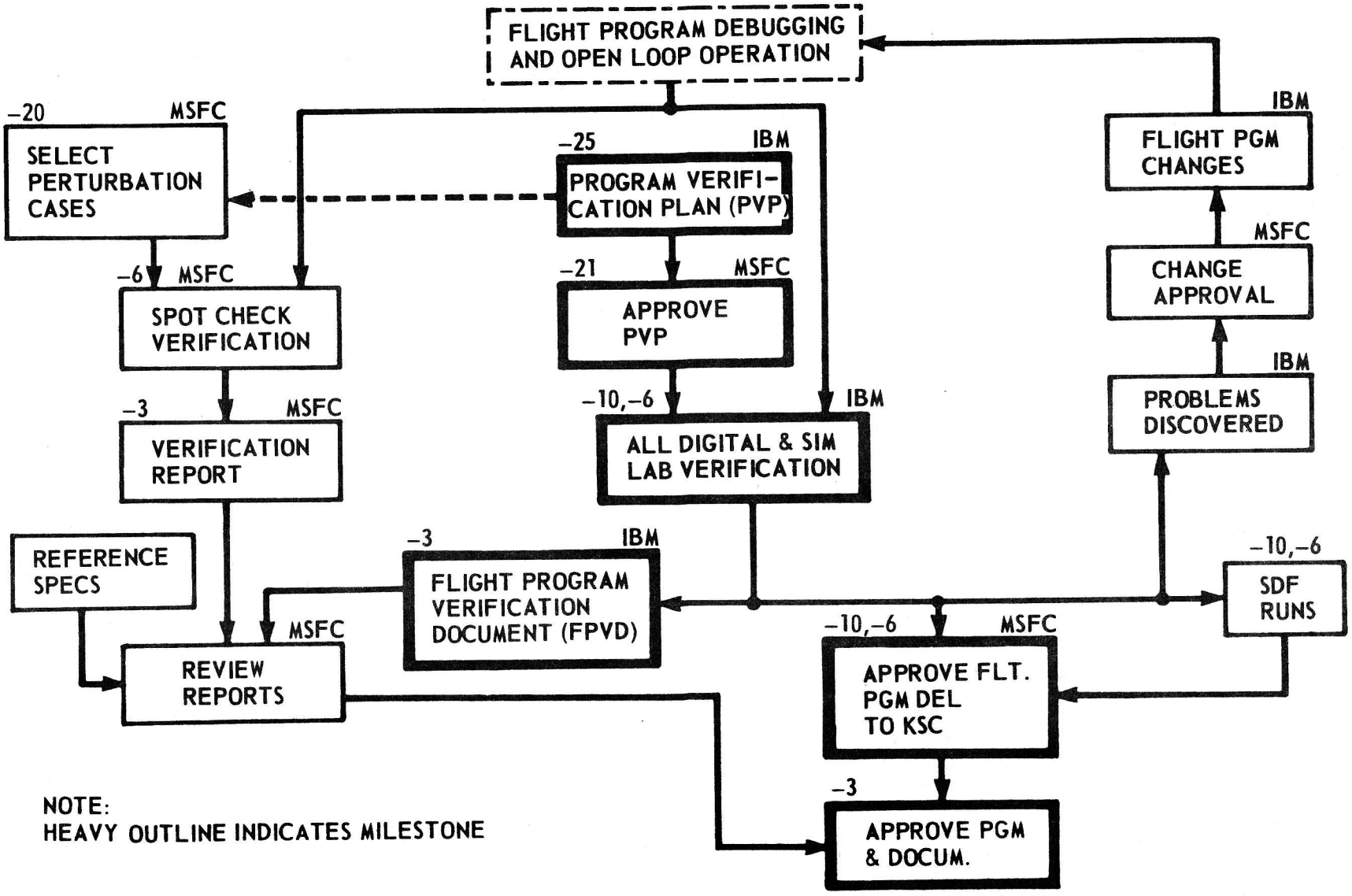
SOFTWARE CHANGE PROCEDURE (CLASS II CHANGES)



Class II changes are any changes which do not fall within the previously noted categories.

Class II changes are coordinated between IBM and Astrionics and are not processed through a configuration control board.

FLIGHT PROGRAM VERIFICATION ACTIVITIES AND DOCUMENTATION



NOTE:
HEAVY OUTLINE INDICATES MILESTONE

070-008-027
FLIGHT PROGRAM
VERIFICATION
ACTIVITIES AND
DOCUMENTATION

This slide illustrates LVDC Flight Program verification activities and major associated documentation. Time phasing used for planning purposes is also shown (in weeks).

Program Verification Plan (PVP)

The Program Verification Plan (PVP) is a plan stating how the flight program is to be verified before it is flown. It includes the following items:

(1) A brief description of the existing simulation facilities used.

(2) The results of an analysis to determine specifically what simulated flights should be made to verify that the primary equations are adequate for the mission and to insure that all system backups are exercised. This number of simulated flights must take into account the simulation facilities and time available.

(3) A description of all planned perturbations.

(4) The expected flight environment, such as signal noise and combinations of perturbations.

PVP Development

Test runs are selected to check program capability under a worse case trajectory envelope based on performance variations and failure conditions.

Additional runs are required to generate hardware failures that exercise all program backups.

Each successive PVP uses previous experience as a baseline.

Modifications are made to the PVP based on mission or flight program changes.

All Digital, Sim. Lab and SDF Verification

A discussion of "all digital," sim lab and Systems Development Facility (SDF) verification activities is presented later in this section.

(8), (10)

Reverification

A complete rerun of all perturbation cases is not usually required after a single flight program change. The nominal run is repeated as a standard for comparison. Perturbation cases are selected from the PVP based on their applicability to the change. Special runs are sometimes devised to create specific test conditions.

Flight Program Changes and Change Approval

A decision to correct the flight program when a problem is discovered in the verification process is based on the following, in order to priority.

(1) The effect (mission failure, loss of redundancy, etc).

(2) The probability (a combination of unlikely events or time restricted).

(3) The impact (how complex, schedule impact, tradeoff in reliability).

Flight Program Verification Document (FPVD)

The Flight Program Verification Document (FPVD) contains the results of the verification effort specified in the Program Verification Plan, expected positions and velocity envelopes under perturbed flight conditions, accuracy estimates, and other predicted flight performance data.

A description of each uncorrected problem and an explanation of why it was not corrected is included in the document. Deviations from the Program Verification Plan (PVP) are identified and explained in each case.

(8), (10)

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HUNTSVILLE SIMULATION FACILITIES- CAPABILITIES & CHARACTERISTICS

OVERALL HUNTSVILLE SIMULATION CAPABILITIES

- ACCURATELY SIMULATE ANY VEHICLE INPUTS TO LVDC/LVDA
- SIMULATE ANY SEQUENCE OR COMBINATION OF INPUTS TO LVDC/LVDA
- FORCE ANY HARDWARE FAILURES – BOTH VEHICLE AND LVDC/LVDA
- SIMULATE EXTREME VEHICLE AND ENVIRONMENTAL CONDITIONS

DIGITAL SIMULATION LABORATORY (R–ASTR)

PRIMARY USE – ORBITAL VERIFICATION
CHARACTERISTICS:

- FLIGHT TYPE LVDC/LVDA
- SIMULATION OF PLATFORM INTERFACE
- FLIGHT TYPE SWITCH SELECTOR
- REAL TIME OPERATION
- LIMITED PERTURBATION CAPABILITIES

ALL DIGITAL SIMULATION (IBM 360)

PRIMARY USE – BOOST VERIFICATION
CHARACTERISTICS:

- SIMULATION OF LVDC/LVDA
- SIMULATION OF PLATFORM INTERFACE
- FLIGHT TYPE SWITCH SELECTOR
- PERTURBATION CAPABILITY
- TRACE AND RESTART CAPABILITY
- RELATIVELY SLOW
  - 8:1 REAL TIME – MOD 50
  - 2:1 REAL TIME – MOD 75

070-008-028
HUNTSVILLE SIMULATION
FACILITIES - CHARACTERISTICS
AND CAPABILITIES

Two principal simulation facilities are used in Huntsville to verify proper performance of the flight program prior to its use at the Systems Development Facility (SDF) and at KSC. These are the "all digital" simulation facility (IBM 360) and the R-ASTR Digital Simulation Laboratory.

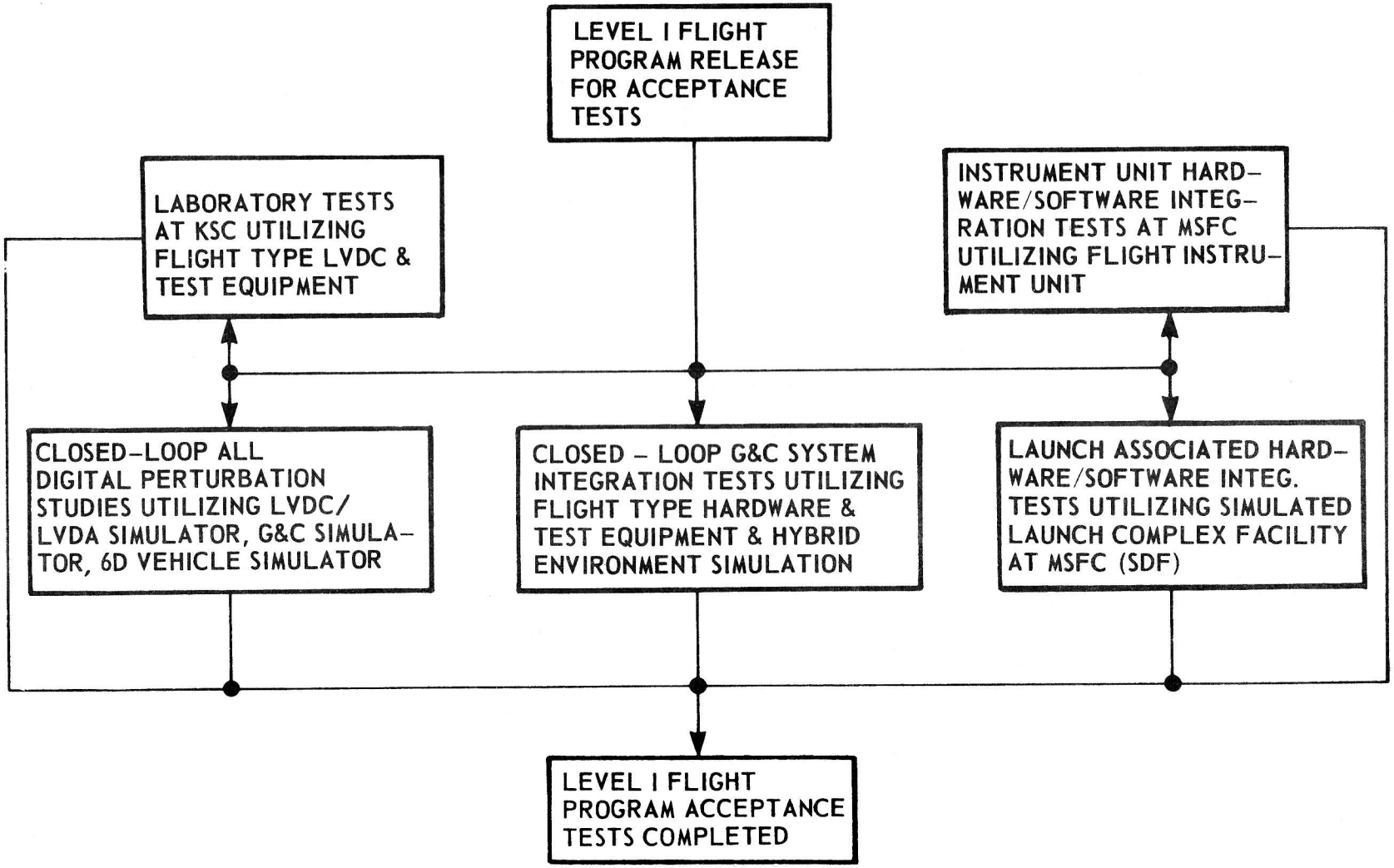
All Digital Simulation (IBM System 360). The "all digital " simulation is composed of two principal simulators: (a) A 6 degree of freedom vehicle simulator (3 degrees of translational freedom and 3 degrees of rotational freedom) which simulates vehicle perturbations (b) An LVDC simulator which is a bit-by-bit simulator with trap and trace facilities. One limitation of this system is that it is relatively slow, as shown on the slide. Another is that it does not test hardware/software compatibility.

Digital Simulation Laboratory (R-ASTR). The Digital Simulation Laboratory is a hybrid test facility (Analog vs LVDC). It uses 5 computers (including the LVDC) and provides real time simulation. A flight type LVDC, LVDA and switch selector are used and hardware/software compatibility is tested. One limitation of this system is that there is limited access to internal LVDC quantities.

In addition to the above simulation facilities there is also an ASTEC/ACAPE test facility which utilizes a programmable test controller (PTC) and an LVDC. This facility is not 6-D and cannot run in flight mode. Tests can be run with or without an LVDA. The facility is used for real time checkout and debug.

(1), (10)

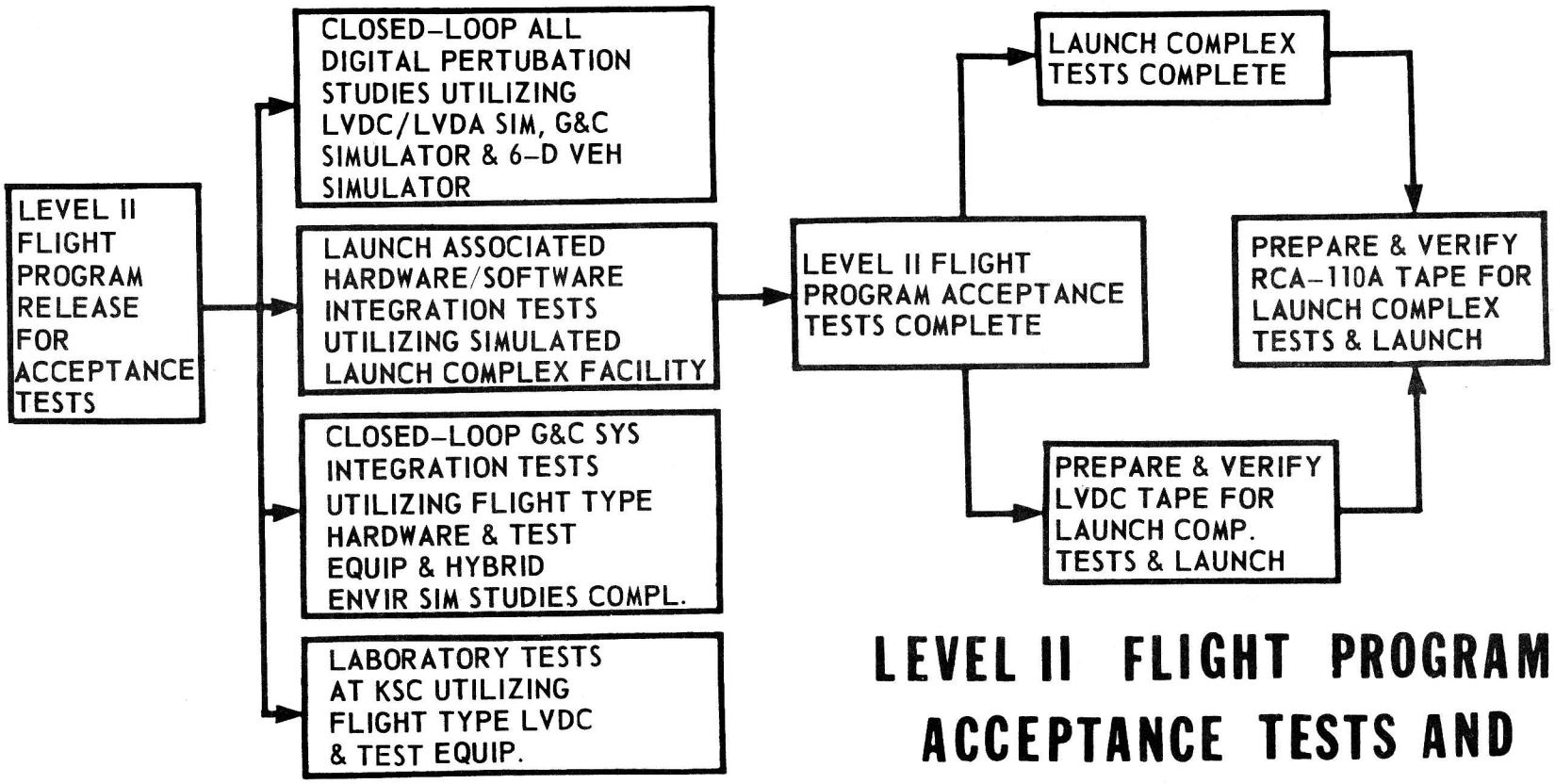
LEVEL I FLIGHT PROGRAM ACCEPTANCE TESTS



070-008-029
LEVEL I FLIGHT
PROGRAM ACCEPTANCE
TESTS

The Level I Flight Program is a preliminary flight program based on information contained in the LVDC/LVDA Equation Defining Document for a particular mission. The acceptance tests which are performed on this program are outlined in this slide.

(8), (13)



LEVEL II FLIGHT PROGRAM ACCEPTANCE TESTS AND PREPARATION OF KSC TAPES

070-008-030
LEVEL II FLIGHT PROGRAM
ACCEPTANCE TESTS AND
PREPARATION OF KSC TAPES

The Level II Flight Program is a complete flight program reflecting the approved LVDC Equation Defining Document and the Final Mission Defining Document. Acceptance tests performed and tapes prepared are shown on this slide. Current planning calls for delivery of the Level II Flight Program and documentation approximately ten (10) weeks prior to launch. Documentation includes program tapes, detailed flow charts, program listings, telemetry listings, scaling and nomenclature, and repeatable simulated flight mode and flight simulation mode operating procedures.

(8), (13)

ALL DIGITAL PERTURBATION RUNS (TYPICAL)

FIRST BOOST AND PARKING ORBIT PERTURBATIONS

- ± 5% THRUST DEVIATIONS COMBINED WITH θ AND β BIASES
- S-IC ENGINE OUT AT VARIOUS TIMES
- S-II ENGINE OUT AT VARIOUS TIMES AND 5% LOW THRUST
- RANGE SAFETY LIMITS
- MINOR LOOP BACKUPS
- HARD FAILURE OF FINE GIMBALS
- COMBINATIONS OF ACCELEROMETER FAILURES
- TIME BASE BACKUPS
- ABORT TO ORBIT AT VARIOUS TIMES WITH 5% LOW THRUST
- SWITCH SELECTOR FAILURES AND TIMING
- UNUSUAL DISCRETES AND INTERRUPTS

SECOND BOOST AND WAITING ORBIT PERTURBATIONS

- ± 5% THRUST DEVIATIONS COMBINED WITH θ AND β BIASES
- LADDER FAILURE MODES
- COMBINATIONS OF ACCELEROMETER FAILURES
- RE-IGNITION EQUATION TESTS
- SWITCH SELECTOR TIMING
- MINOR LOOP

070-008-031
ALL DIGITAL
PERTURBATION
RUNS (TYPICAL)

This slide lists typical perturbation runs for the System 360 6D/LVDC Simulation. Exact perturbations are given in the Program Verification Plan for each mission.

(8), (12)

SIMULATION LAB PERTURBATIONS (TYPICAL)

- CIU PERTURBATIONS
- DCS PERTURBATIONS
- DCS NOMINAL OPERATION
- FINE GIMBAL ANGLE FAILURES
- ABORT TO ORBIT AT VARIOUS TIMES
- SWITCH SELECTOR FAILURES AND TIMING
- UNEXPECTED INTERRUPTS AND DISCRETES
- TELEMETRY TESTS

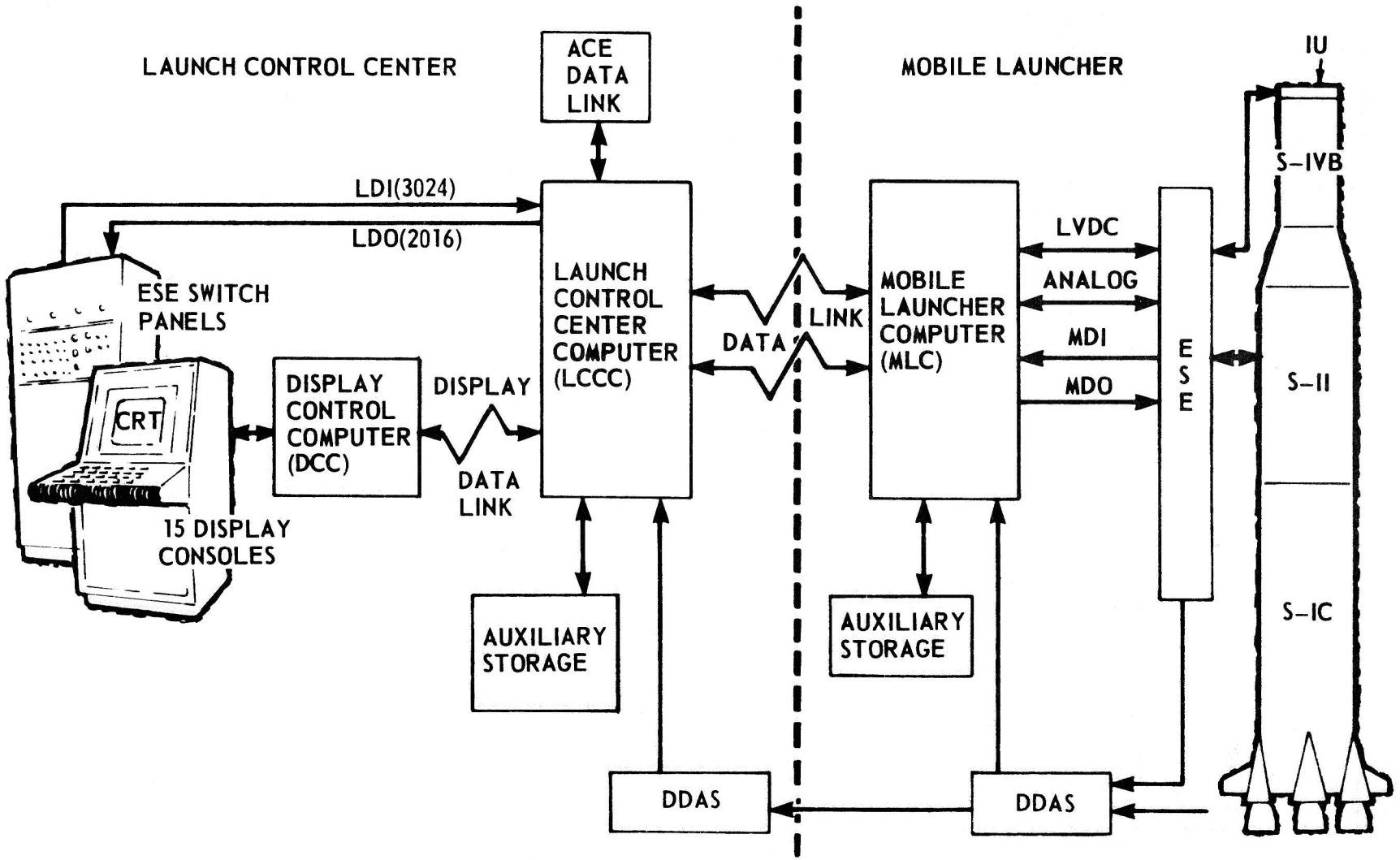
070-008-032
SIMULATION LAB
PERTURBATIONS
(TYPICAL)

This slide lists typical simulation lab perturbations. A detailed listing is available in the Program Verification Plan for each mission.

A great deal of redundancy exists between the IBM 360 all digital and the simulation lab perturbation runs. This is done intentionally to provide greater confidence in the total verification effort.

(8), (12)

SATURN V SYSTEMS DEVELOPMENT FACILITY (BREADBOARD)



070-008-033
SATURN V SYSTEMS
DEVELOPMENT FACILITY
(BREADBOARD)

The Saturn V Systems Development Facility (SDF) provides an electrical simulation of the Saturn V vehicle and electrical support equipment with some items of flight-type hardware being used. Items of flight type equipment include the LVDC/LVDA, ST-124M platform, switch selectors and the flight control computer. The breadboard is the final proving ground for flight program tapes prior to their delivery to MSFC and KSC. Nominal, accelerated and abort-to-orbit runs are made at the SDF.

(10), (12)

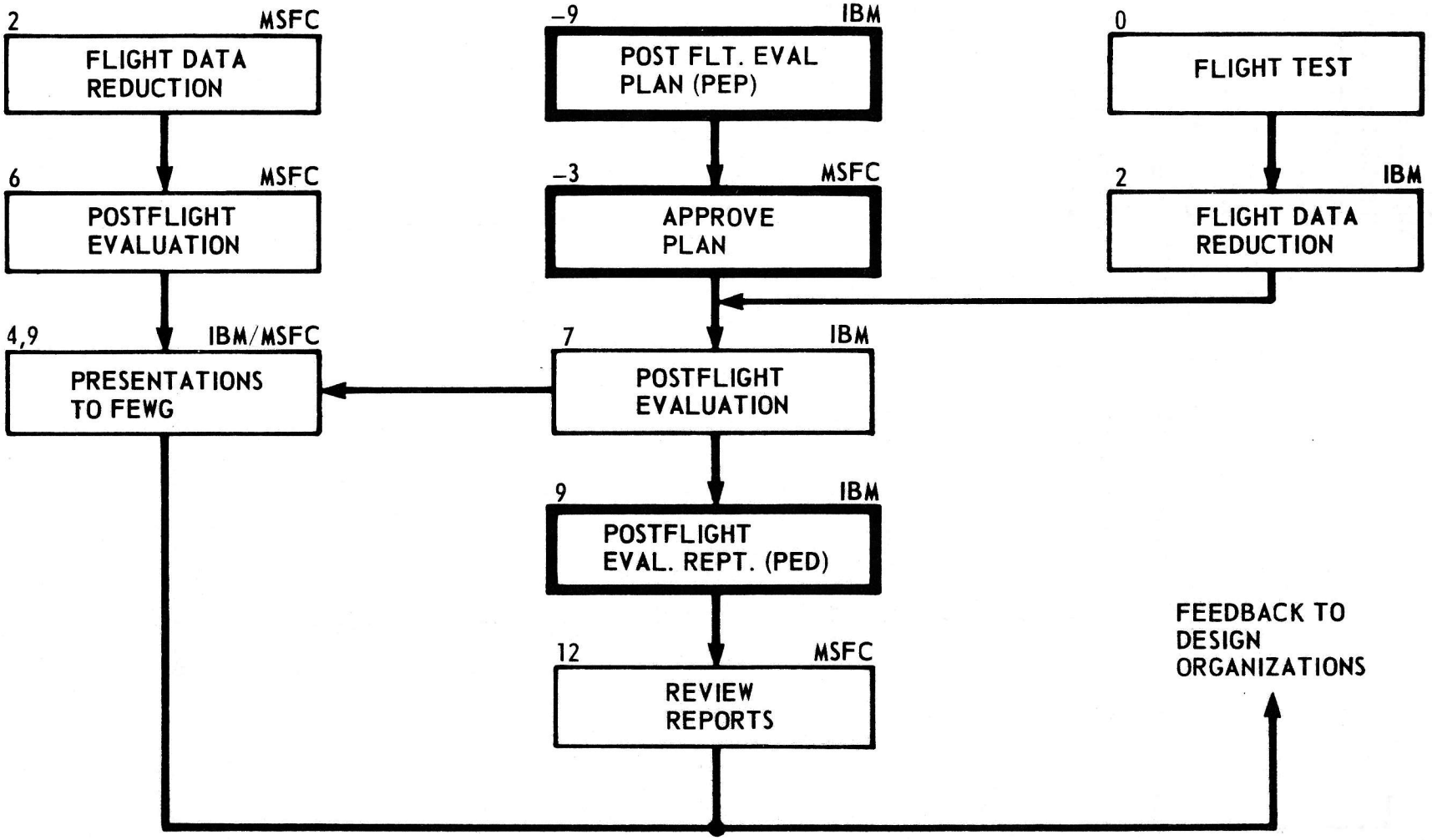
DIFFERENCES BETWEEN FLIGHT AND SIMULATED FLIGHT

- SIMULATED FLIGHT INDICATOR
- VELOCITY TEST FOR STARTING TB2 CANNOT BE FAILED IN SIMULATED FLIGHT
- ENGINE OUT GUIDANCE CAPABILITY NOT IN SIMULATED FLIGHT
- STORED THRUST PROFILE BIASED FROM OPERATIONAL THRUST PROFILE
- VEHICLE MASS RE-INITIALIZED IN TB6 TO GUARANTEE PREDICTABLE SECOND BURN OF S-IVB
- ROLL GIMBAL ANGLE INITIALIZATION
- PLATFORM NOT USED AFTER FIRST S-IVB CUTOFF
- DATA COMPRESSION OPTION

070-008-034
DIFFERENCES BETWEEN
FLIGHT AND SIMULATED
FLIGHT

This chart illustrates the differences that exist between a simulated flight and the actual flight of a vehicle.

IBM POSTFLIGHT EVALUATION TASKS



NOTE:
HEAVY LINE INDICATES MILESTONE

Data necessary from MSFC for the postflight evaluation effort are:

Telemetry tapes and charts from the overall systems test, for each vehicle at KSC, covering the IU operation.

All telemetry tapes and charts from each flight covering the IU operation, as specified in the Contractor Data Requirements Document.

The necessary calibration curves and/or other data necessary for interpreting these telemetry tapes and charts.

Range tracking data in the form of trajectories for the comparison with guidance computer data.

The primary reports issued by the IBM postflight evaluation group are listed below with the delivery times based on the flight:

Quick look report	72 hours after flight
Intermediate evaluation report	21 days after flight
Final evaluation report	60 days after completion of IU mission

POSTFLIGHT EVALUATION PLAN (PEP) DEVELOPMENT

The PEP will define:

The postflight data format.
The quick look evaluation procedures.
The techniques for evaluation of program performance.
The techniques for evaluation of total navigation errors.

The PEP will contain the results of an error analysis based on measured or known errors and anomalies.

POSTFLIGHT EVALUATION DOCUMENT (PED) CONTENTS

Review of launch problems

Event and switch selector time compared to nominal

(1), (2), (3), (4), (5)

A description of navigation, guidance and control performance

Terminal conditions compared to nominal (Error Analysis)

A description of flight program operation compared with preflight simulation

A summary of malfunctions and deviations

(1), (2), (3), (4), (5)

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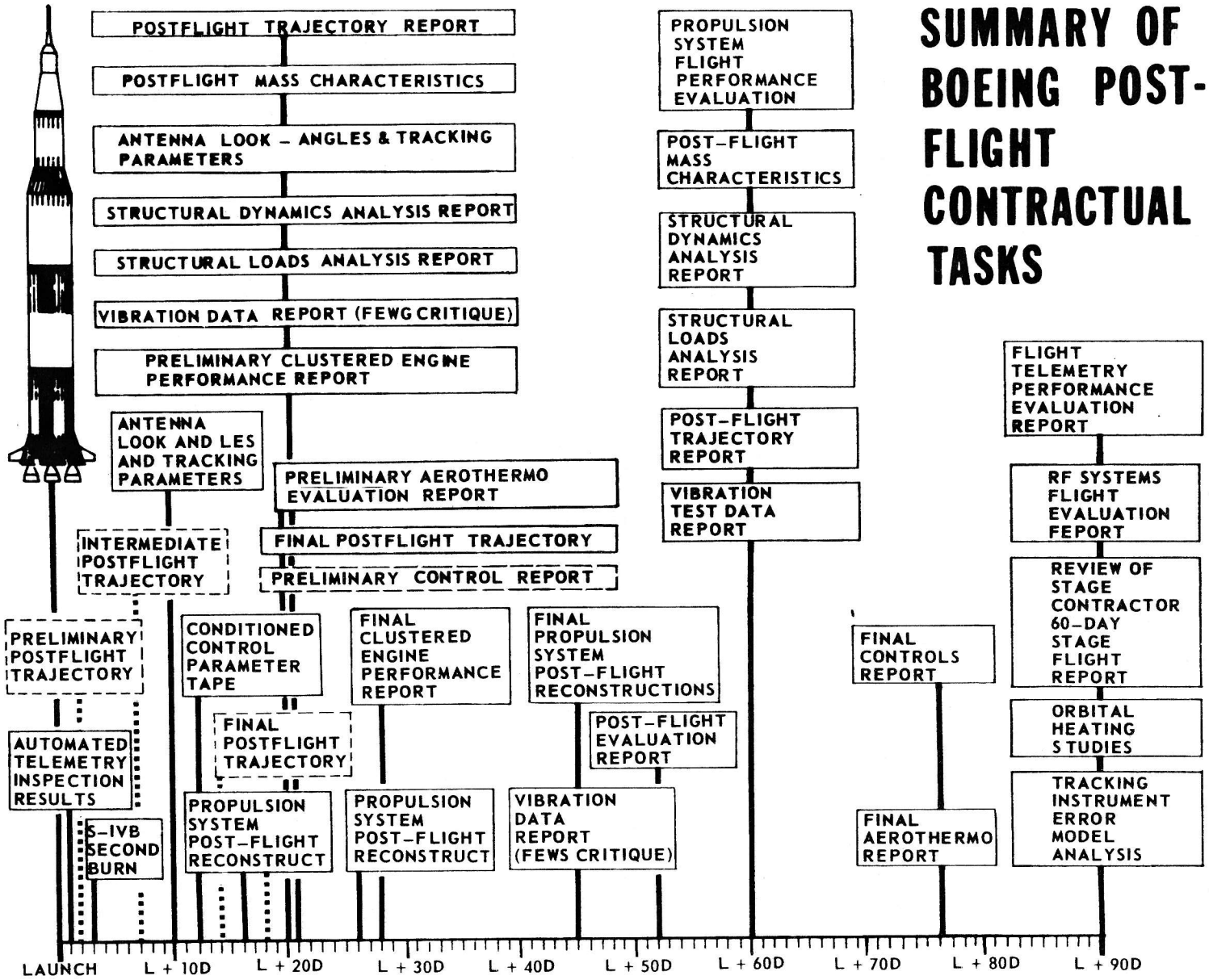
SUMMARY OF BOEING POST-FLIGHT CONTRACTUAL TASKS



070-008-036
SUMMARY OF BOEING
POSTFLIGHT CONTRACTUAL
TASKS

The Boeing Saturn Flight Evaluation Activity is composed of 36 individual tasks with deliveries beginning on the day of launch + 120 days.

Technical analyses are performed in the following areas:

a. Post launch trajectory reconstruction.

b. Inspection and analysis of telemetry data.

c. Structural and loads analyses.

d. Dynamic and control analyses.

e. Propulsion system performance reconstruction.

f. Aerodynamic and aerothermodynamic analyses.

Each of these Flight Evaluation Activities have required the development of extensive analytical and computer program software able to perform many of the required Flight Evaluation tasks.

Additional support is provided in program management and in publishing Flight Evaluation reports.

Boeing also provides technical assistance to the Flight Evaluation Working Group (FEWG) in preparing the necessary FEWG reports.

FLIGHT EVALUATION TASKS

(1) Provide a post-flight reconstruction of propulsion system flight performance

The Post-flight Reconstruction provides data for evaluation of trajectories, flight control systems, S-IC stage clustered engine performance and structural loads.

(1), (2), (3), (4), (5)

2. Summarize propulsion system flight evaluation and review and verify stage contractor propulsion system inputs to FEWG.

   The summary of all propulsion system flight evaluation efforts in documented form, and review of stage contractor propulsion system inputs to the Flight Evaluation Working Group (FEWG), are included in this task.

3. Review stage contractor flight reports to P&VE

   The post-flight review of the 60-day stage contractor's reports provides a documented review and verification of the propulsion sections of the reports.

4. Produce the propulsion data requirements for input to the processed data requirements document.

   The Propulsion Data Requirements Task identifies telemetry data required for post-flight propulsion performance analyses.

This information from postflight analyses is then used in preparation of the next mission flight program.

(1), (2), (3), (4), (5)

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APPENDIX "A"

SATURN V FLIGHT PROGRAM DEVELOPMENT SOURCE DATA

070-008

1.	MSFC	MSFC Flight Software Presentation for Guidance Software Task Force February 23, 1968
2.	The Boeing Company	Saturn V Program Documentation and Software Task 8.0 Flight Vehicle Systems Analysis Program
3.	IBM No. 67-F11-0012	Saturn V Vehicle Flight Program
4.	The Boeing Company	Synopsis of Saturn V Software Program Requirements and Development Study May 26, 1967
5.	The Boeing Company	Saturn V Mission Planning, February 1967
6.	MSFC	Software Development Presentation (Unidentified)
7.	I-V-IU-1577-66	MOD 760 to Contract NAS8-14000
8.	IBM No. 7915041	LVDC EDD for AS-503
9.	R-ASTR-NG-49-68	FMDD for AS-503
10.	IBM No. 68-K10-007	PVP for AS-503 (D-Mission)
11.	No Number	Astrionics Systems Handbook
12.	MSFC-MAN-503	Saturn V Flight Manual
13.	66-966-0003	Navigation, Guidance, and Control System Description
14.	FC-004	Saturn Launch Vehicle Systems Handbook
15.	CMM-MSFC-002-001-2H	Saturn V Configuration Management Manual

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