MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

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E-2345

SOFTWARE CONFIGURATION MANAGEMENT PLAN

OCTOBER 1968

MIT INSTRUMENTATION LABORATORY
CAMBRIDGE 39, MASSACHUSETTS

E-2345

SOFTWARE CONFIGURATION MANAGEMENT PLAN

ABSTRACT

This document (E-2345) is a description of the MIT/IL Software Configuration Management Plan being employed on the development of Apollo mission flight programs. Its purpose is to describe the necessary procedures with which effective software configuration management and testing can be realized.

October 1968

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SECTION 1

INTRODUCTION

1.1 PURPOSE

This document is a description of the MIT/IL Software Configuration Management Plan. Its purpose is to provide the necessary controls with which effective software configuration management can be realized. Effectively applied, these procedures will contribute significantly to the task of generating quality Apollo mission flight programs.

1.2 SCOPE

The established methods presented herein are designed to effect the release and revision of technical data necessary for the fulfillment of the design responsibilities germane to the Apollo mission flight program effort. As such, configuration control as employed by MIT/IL is devised to be complete to the point of manufacture of the Apollo mission flight programs.

1.3 GENERAL

The flight programs consist of two sections, a "hard wired" memory and an "erasable" load. Developing the programs consists of melding requirements, designing, programming, testing and qualifying a multitude of equations and procedures for mission computer operations. In order to control the input to the assembly, each mission flight program is assigned an identifying name. The "assembly" in this context is the flight program as compiled on the general purpose digital computer.

Assembly names assigned to date are:

SOLARIUM	The flight program for unmanned Command Module earth orbital missions.
SUNBURST	The flight program for unmanned Lunar Module earth orbital missions.
SUNDISK	The flight program for manned Command Module earth orbital missions.

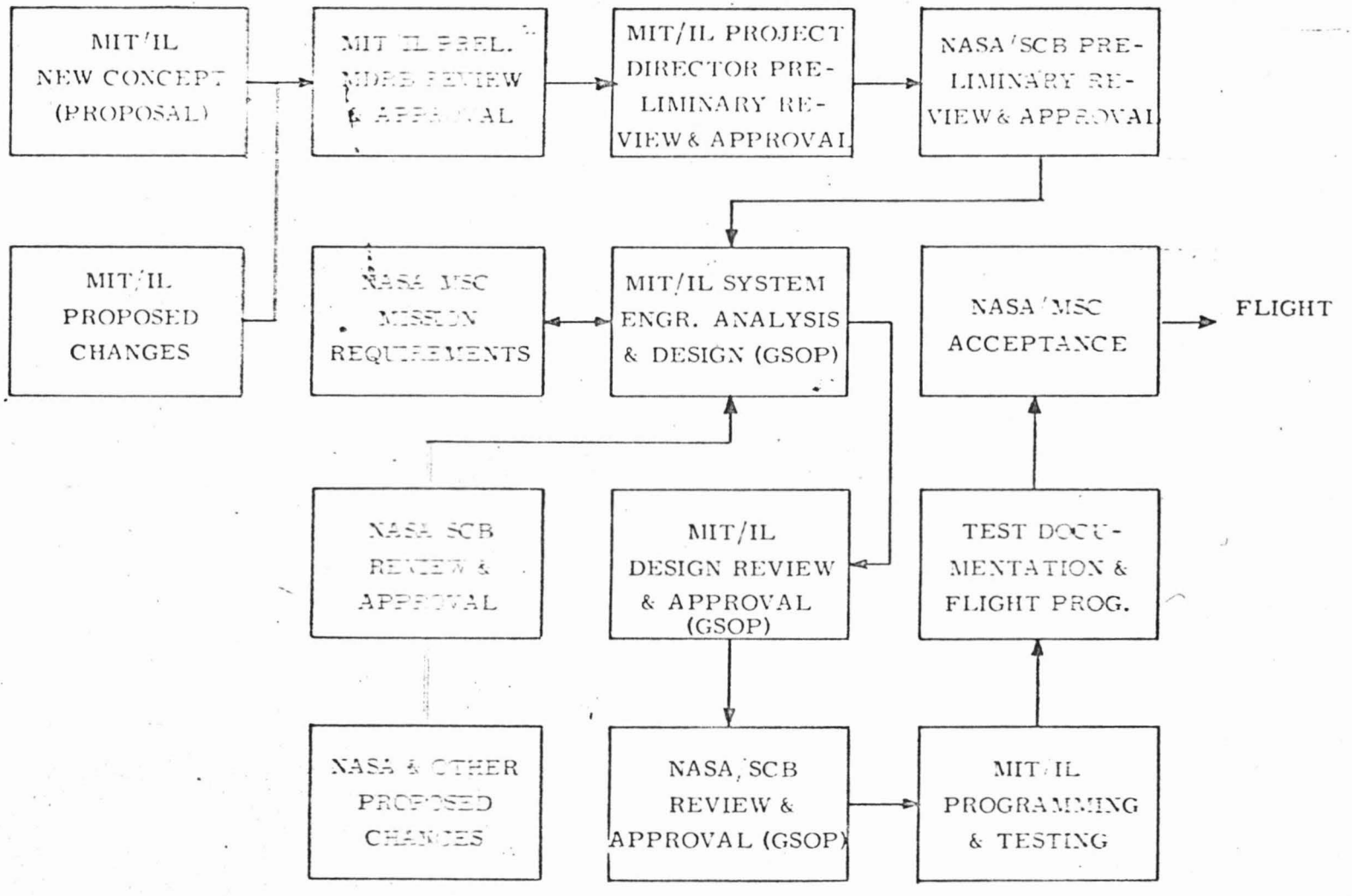


Fig. 1-1 Flight Program Development Flow

SUNDANCE	The flight program for manned Lunar Module earth orbital missions.
COLOSSUS	The flight program for the Command Module containing full manned lunar mission capability.
LUMINARY	The flight program for the Lunar Module containing full manned lunar mission capability.

A management system for control of flight mission programs rests on the effectiveness of organization responsibilities, decision processes and document procedures. A flow chart illustrating the evolution of proposed new concepts and changes pertinent to flight program development from inception to flight status is shown in Figure 1-1.

SECTION 2

ORGANIZATIONAL STRUCTURE

2.1 MISSION PROGRAMMING SUPPORT STRUCTURE

The Project Manager is the heart of the organization for any particular mission flight program. The effectiveness of other procedures are also largely dependent on the Project Manager's energy and ability. To insure overall authority and review competency, a formal weekly meeting with the Program Director and/or the Technical Director Mission Development is scheduled.

The design, development and control organizational structure supporting flight mission programming is shown in Figure 2-1.

The Program Director and the Technical Director Mission Development have the responsibilities for:

(1) the timely delivery of the assembly, SIM Flight, erasable loads, and associated specifications and/or descriptive material,

(2) the quality of the MIT/IL product,

(3) establishing and maintaining reporting procedures,

(4) providing an authoritative customer contact point, and,

(5) gaining visibility into the software effort for the customer as well as for MIT/IL management.

In order to implement the foregoing items, the Project Manager has the authority to:

(1) expedite the timely delivery of the assigned computer program assembly by:

a. making decisions on program improvements,

b. directing that additional personnel or resources be applied to the project,

c. authorizing overtime or extraordinary MIT/IL staff effort as needed, and,

d. adjusting program priorities through emphasizing hybrid or

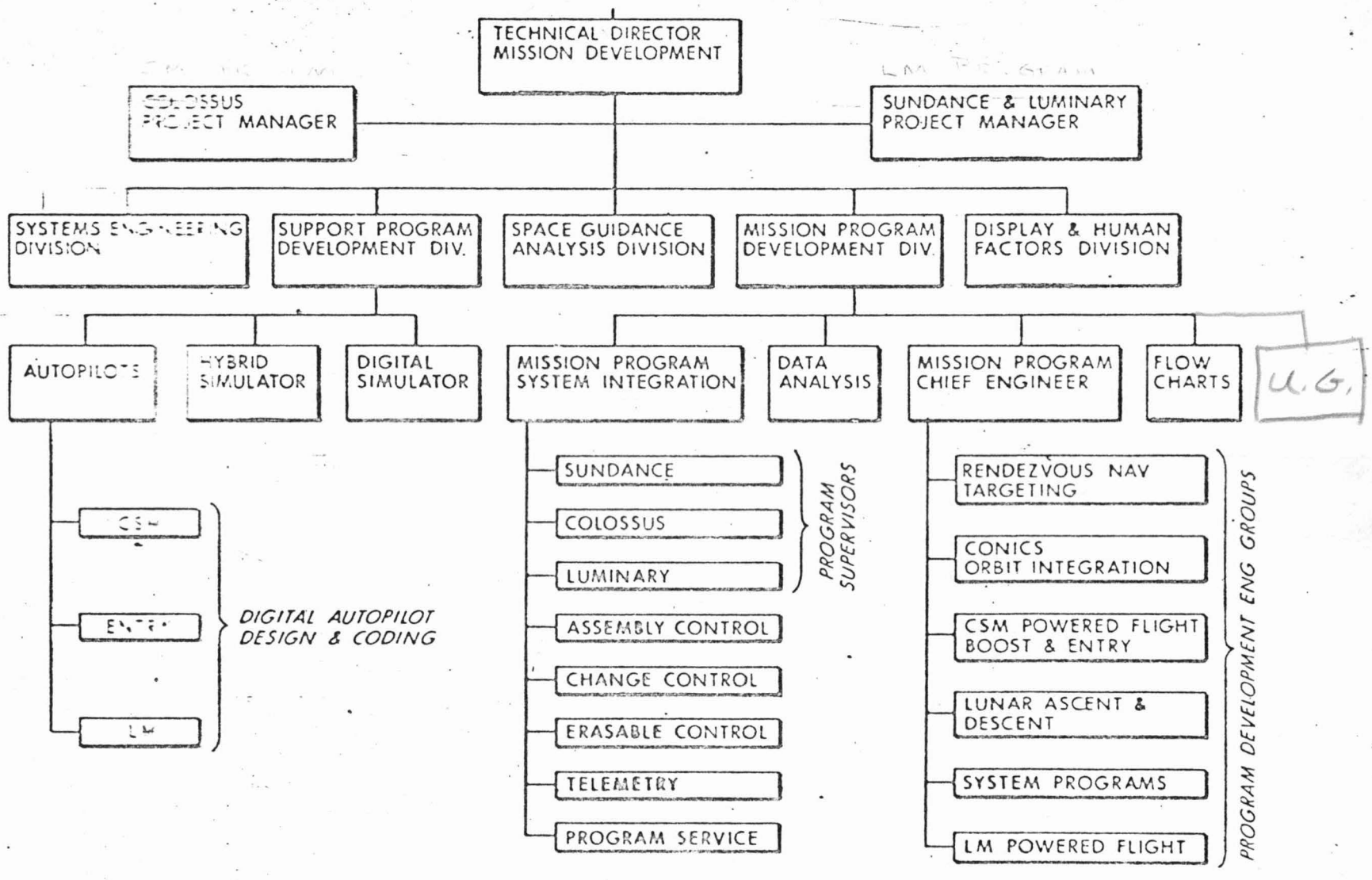


Fig. 2-1 MIT/IL Apollo Software Organizational Structure

digital, testing or coding, etc., as required.

(2) assure the quality of the MIT/IL product by:

a. establishing control documents,
b. establishing boards (or committees) of design and review,
c. establishing control and change procedures,
d. suggesting operating procedures to enhance dissemination of information and project-wide understanding, and,
e. establishing coordinated test procedures.

(3) establish and maintain reporting procedures; that is,

a. negotiate reporting formats with the customer,
b. require certain internal formats for scheduling and charting of the several group activities by the groups,
c. require support of administrative personnel in preparing development plans, and,
d. chair or appoint a chairman of interdivisional meetings as required.

(4) provide an authoritative customer contact through:

a. processing all MIT/IL and NASA initiated program changes (including GSOP),
b. providing single point of schedule quotations and changes in scope of effort,
c. determining proper points of contact for exchange of information and directives between MIT/IL and NASA and between MIT/IL and the associated contractors, and,
d. seeking NASA commitment concerning critical data, negotiating delivery dates of NASA furnished data and equipment, and informing NASA of need dates.

(5) effecting visibility by:

a. requiring organization charts from all the working groups,
b. requiring written progress reports on a scheduled or occasional basis, and,
c. requiring flow chart procedures of a detail sufficient for control and visibility.

The Project Manager reports to the Technical Director Mission Development and, in discharging his responsibilities, he maintains a broad and thorough technical knowledge of the program. He exercises care that directions are given within the criteria of what is to be done while avoiding detailed involvement.

2.2 REQUIREMENTS

Many NASA/MSC documents, meetings, letters of direction, and other forms of communication provide the base for mission flight programs in the early stages of development. Special NASA documents as listed below provide the basis for developing the specification for a particular mission program:

(1) Computer Software Requirements Document

(2) Mission Requirements Document

(3) Reference Trajectory

(4) Mission Data Book

(5) Performance and Interface Specifications (P & I Spec.)

(6) Interface Control Documents (ICD's).

These requirements are distributed to the responsible engineering groups as basic information to be used in developing a specification, with control of applicability and changes being vested in the Systems Engineering Division.

The Systems Engineering Division, the Space Guidance Analysis Division, the Mission Program Development Division, and the Display and Human Factors Division at this point have the responsibility for planning and developing a Guidance System Operations Plan (GSOP) which, when approved by NASA/MSC, is the detailed specification for a flight program. Development and control of this specification (GSOP) is the first critical phase in planning the release of a flight program.

SECTION 3

GUIDANCE SYSTEMS OPERATIONS PLAN

3.1 SPECIFICATION CONTROL

3.1.1 General

The Apollo flight computer program specifications are the Guidance Systems Operations Plans (GSOPs). The GSOP is designed to cover in practical detail all the elements of data necessary for developing the G & C System flight program. The internal control of this specification under the aegis of MSC is covered under the Change Control section as a most important element of the management system. Figure 3-1 shows the relationship of the GSOP and elements of program design phases.

The complete GSOP consists of the following sections:

Section 1	Prelaunch
Section 2	Data Links
Section 3	Digital Autopilots
Section 4	Operational Modes
Section 5	Guidance Equations
Section 6	Control Data

These sections are assigned as follows:

Section 1	System Test Division
Section 2	System Engineering Division
Section 3	Autopilot Development Group
Section 4	System Engineering Division
Section 5	Guidance Analysis Division
Section 6	Support Program Development Division

These assignments are for the generation of the sections with the overall responsibility for coordination and compatibility remaining with the Director of the System Engineering Division.

NASA/FSB is responsible for the content of all GSOPs. The NASA Program Engineer has the authority to approve documentation improvements without NASA/SCB approval.

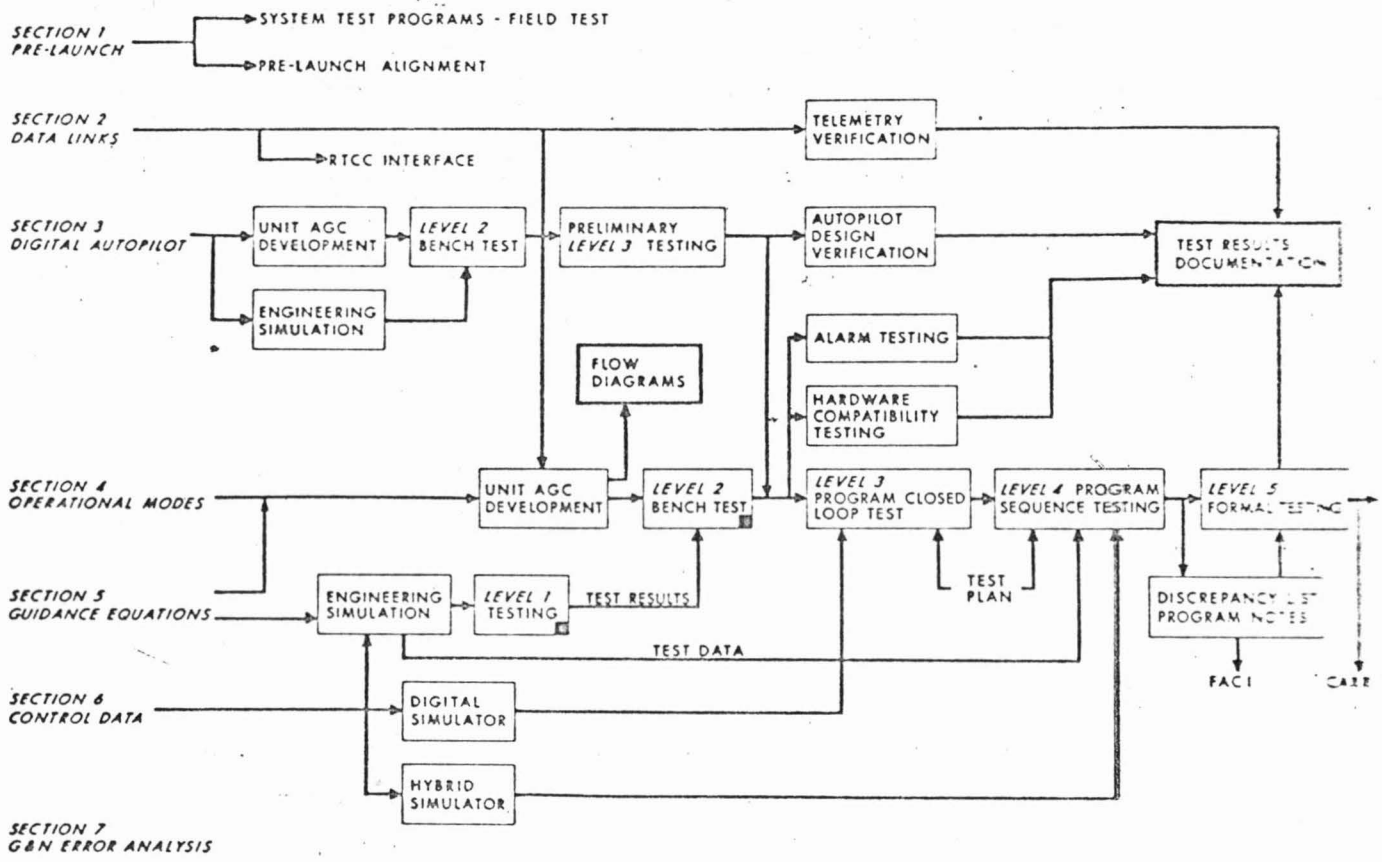


Fig. 3-1 Development Activity Controlled by Guidance System Operations Plan.

3.1.2 Program Change Request Flow

The following procedures describe the control of proposed and authorized changes to the flight program specification, the GSOP. These procedures provide a means for MIT/IL to be responsive to MSC requests with full recognition of the impact under any conditions; it permits MIT/IL to propose changes, and provides for proper implementation when duly authorized. Coordination by the Project Managers and the management group in handling these changes provides, additionally, a means of assessing the impact on other programs and resources. Figure 3-2 shows the flow relationship of the specification changes between MSC and MIT/IL. Figure 3-3 illustrates the PCR and PCN internal flow process.

After approval of the GSOP by the NASA/MSC, changes are requested by means of a Program Change Request (PCR) form which must accurately describe the change required. Editorial comments from NASA, however, can be submitted to MIT/IL in an informal manner and not as part of a PCR. The originator of the PCR containing "NASA Comments" should attempt to restrict the PCR to individual programs or routines in Section 4 or subdivisions of the other sections of the GSOP in order to reduce the size of the individual PCR and allow greater flexibility in negotiation and coordination of changes.

After a MIT/IL proposed change has been defined by the originator on a PCR form, it is submitted to the Project Manager for a brief review that decides whether the change warrants a Program Change Notice (PCN) or a Program Change Request (PCR) status. The PCR is a request by the originator for incorporation of a proposed change. A PCN can be a notification of clerical corrections, or a notification that a change is to be incorporated without which further program development could not proceed. MIT/IL Project Managers shall inform the NASA/FSB Program Engineers of PCNs being implemented, but the detailed explanation of the change and method of implementation shall be done at the MDRB meetings. For additional information about Program Change Notices, see Section 3.1.6.

The only difference in the PCN form from the PCR form is that it is stamped "PCN" at the top to indicate that the start of implementation may occur prior to receiving written direction from the NASA Apollo Spacecraft Software Configuration Control Board (SCB). The PCR or PCN is given a NASA control number and recorded in the PCR/PCN Log. At this point, the Project Manager can reroute the proposed change to the originator for cancellation, correction, or revision.

Specification change proposals, whether MIT/IL or MSC originated, are submitted as PCRs through the appropriate channels to the flight software branch of FSD (MSC Flight Support Division) where it is evaluated for technical content. PCRs not receiving approval are returned to the originator. PCRs receiving FSD approval

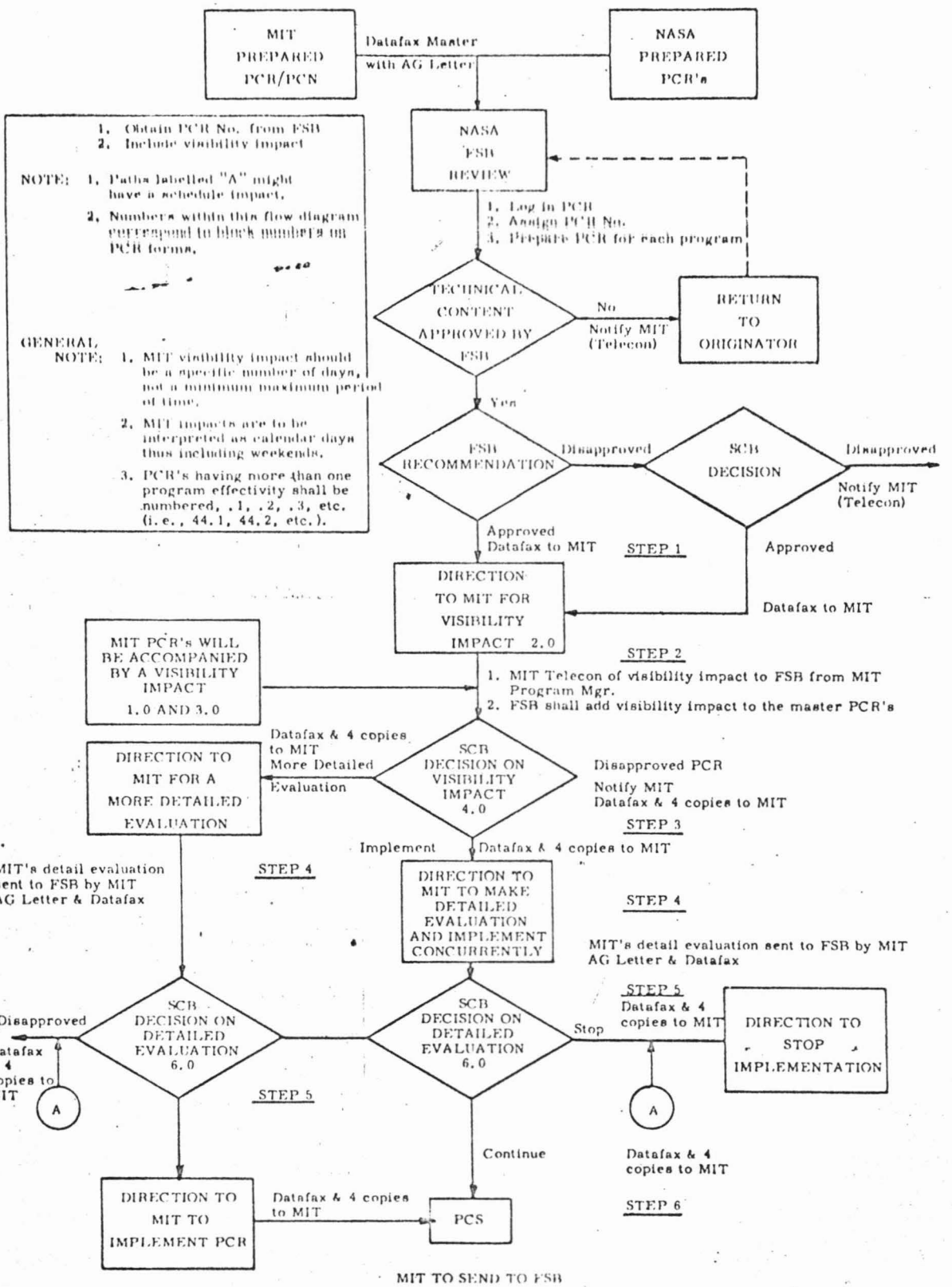


Fig. 3-2 Specification Change Flow

will be given a preliminary recommendation to the secretary of the Apollo Spacecraft Software Control Board and held for the next meeting of the SCB.

In some cases, depending upon the merit of the proposed changes, the secretary may datafax the PCR and forward a copy to the appropriate Project Manager at MIT/IL to obtain a "visibility impact." This visibility impact is a subjective judgement made by the Program Manager taking into account the problems the change may introduce and also how the change might impact the subject program delivery, which can be dependent on the approval route that is taken. This visibility impact is presented by the MIT/IL representative at the next SCB meeting and is used to help the SCB decide on the disposition of the PCR. It is understood that the effort involved in determining the visibility impact is slight and should cause no delivery schedule impact in itself. For this reason some uncertainty associated with the visibility impact is possible.

MIT/IL originated specification change proposals will be submitted as PCRs to the secretary of the SCB along with visibility impacts for the changes.

The PCRs available for the SCB will receive one of the five possible actions by the board:

(1) If a PCR has not received a visibility impact, one may be requested from the secretary before further action is taken.

(2) The board may request a more detailed evaluation from MIT if the visibility impact on a PCR is uncertain and further detail on the schedule effect is desired. This action in itself can be the cause for a program delivery schedule slip. The estimate of such a slip should be given in the earlier visibility impact. This NASA caused slip will automatically change the delivery target date by the associated number of days. The slip in question is caused by the necessary involvement of the working team in determining an accurate change impact for the PCR. The PCR with a detailed evaluation is returned to MSC prior to the next SCB meeting, if possible.

If the detailed evaluation impact is subsequently accepted, the board will then endorse the PCR with an "implement" directive. The PCR schedule impact appears as an extension of the target date on the development plan.

(3) The SCB may direct MIT to make a detailed evaluation and implementation concurrently. In this case, the detailed evaluation will not be available until an extensive effort to implement the change has resulted. Should the PCR then indicate more impact than the board wishes to accept, the PCR will be endorsed with a "stop" action to terminate further activity on the change. However, schedule slippage up to the "stop" action may have accrued.

(4) The board may also turn down a proposal and the PCR gets endorsed "disapproved."

3.1.2.1 PCR Internal Procedure

When the proposed change is given PCR status, it is typed on the standard PCR/PCN form, assigned a NASA control number and logged into the MIT/IL internal PCR/PCN Log. The PCR now is returned to the Project Manager for visibility impact and the appropriate Division Director's concurrences. PCRs originating at SCB are also logged into the MIT/IL Internal PCR/PCN Log and subjected to the same control procedures as those emanating from MIT (see Figure 3-3).

Upon being assigned a visibility impact by the Project Manager, the PCR is disseminated internally and sent to the responsible NASA Program Engineer under an "AG" cover letter. SCB action results in one of three directives that affect PCR disposition:

(1) implement and provide a detailed evaluation,

(2) provide a detailed evaluation, or

(3) disapproved.

With one of these directives affixed to the PCR, it is returned to MIT and logged into a PCR Status Report and distributed internally.

3.1.2.1.1 Implement and Provide Detailed Evaluation

If the directive is to "Implement and Provide Detailed Evaluation," the Program Manager convenes a Technical Design Committee to respond to the PCR.

The Technical Design Committee is an ad hoc committee to the extent that it is comprised of those mission development division directors or representatives deemed necessary by the Project Manager to accomplish the effort. Such design change effort may require that MSC help with the details. This optimizes the MSC change intent with the impact of effort on the word budget or program schedule. The product of the Technical Design Committee in response to a PCR is the draft of change pages to the GSOP. These preliminary GSOP pages are then distributed to members of the Mission Design Review Board (MDRB) one week in advance of the MDRB meeting.

The MDRB can take one of two courses of action; it can approve the PCR and associated change pages, or it can return them to the Technical Design Committee for correction or revision. If approved, the PCR containing the detailed evaluation is distributed internally and sent to NASA/MSC under an "AG" letter. Individual prepublication change pages are collected by the Systems Engineering Group (23S) and forwarded to the Project Manager who authorizes the GSOP update package. It is then ready for publication.

However, upon receiving the detailed evaluation from MIT/IL, the SCB can exercise its prerogative to stop implementation. It is then the responsibility of the Project Manager to take appropriate action.

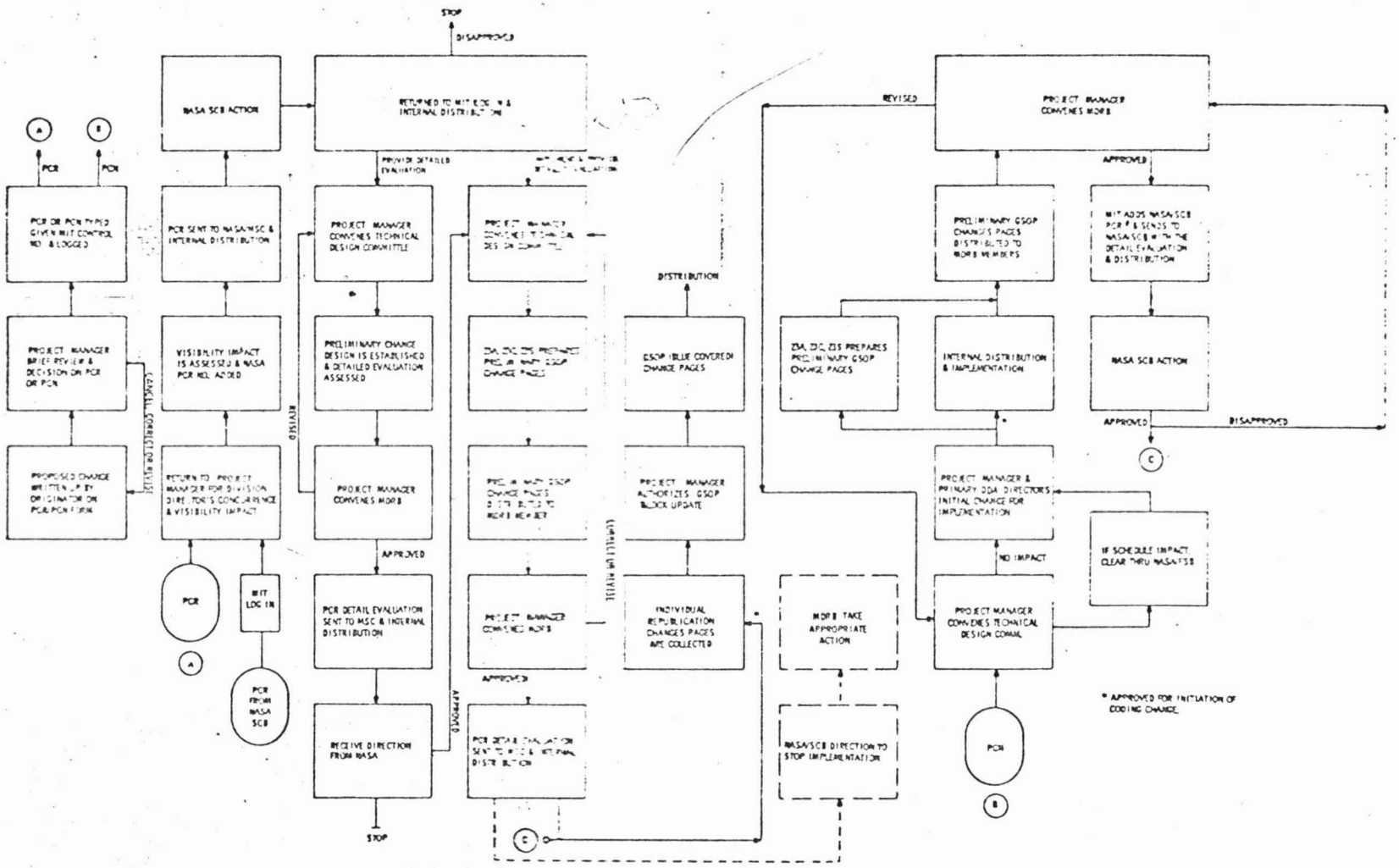


Fig. 3-3 MIT/IL Internal PCR/PCN Procedures

3.1.2.1.2 Provide a Detailed Evaluation

If the directive is simply to "Provide a Detailed Evaluation," a Technical Design Committee is convened as above. The preliminary change design is established and the detailed evaluation assessed. The Project Manager then convenes the MDRB which either approves the PCR or sends it back to the Technical Design Committee for reassessment. If approved, the PCR detailed evaluation is distributed internally and sent to NASA/MSC under an "AG" cover letter. NASA will either issue a "stop" directive or approve the PCR.

3.1.2.2 PCN Internal Procedure

When a proposed MIT/IL change is given PCN status by the Project Manager, it is typed on the standard PCR/PCN form, assigned a NASA control number and logged into the PCR/PCN Log. The Project Manager may convene a Technical Design Committee to establish the preliminary change design and to assess the schedule impact of the PCN. The proposed change must be cleared through NASA/FSB. Whether or not the proposed change involves a schedule impact, the Project Manager and the necessary division directors initial the PCN form to authorize the start of coding changes. The group concerned (23A, 23B, 23C or 23S) prepares the preliminary GSOP change pages and the Project Manager circulates the proposed changes to the MDRB members for review. Change pages shall be made available for review by the MDRB members one week in advance of the MDRB meeting.

The MDRB can require that the GSOP change pages be revised by the Technical Design Committee or it can approve them. It is then sent to the SCB with a detailed evaluation.

Software Control Board approval of the PCN takes place after the MDRB approval and is not mandatory prior to the release of the change pages for full distribution as a revision to the GSOP. SCB action can result in a disapproval thus returning the PCN to the MDRB for other action to correct the deficiency, or it can be approved. Individual change pages are collected and forwarded to the Project Manager. He authorizes the GSOP update package and it becomes ready for publication. The published package of Program Change Specifications (PCSs) together with the current GSOP becomes the new specification for program development. At the time of publication, the full package of PCSs is summarized in a GSOP change summary and distributed to the holders of the GSOP. See Section 3.1.7 for GSOP change procedures.

3.1.3 NASA/MSC Software Configuration Control Board

The NASA/MSC Software Configuration Control Board (SCB) is responsible for the specification control of the command module computer flight programs and the lunar

module computer flight programs (GNCS and PGNCS). Specifically, the responsibilities of the board are as follows:

(1) The SCB is responsible for all changes to the MSC software requirements, the approved program specifications, and the computer programs assemblies placed under configuration control at the First Article Configuration Inspection (FACI).

(2) The SCB has the authority to approve waivers of software requirements which are not successfully implemented as indicated by the unsuccessful completion of the software contractor's verification testing.

SCB membership is comprised of the organization chief or his duly authorized representatives from each of the following areas:

Flight Operations Directorate, Chairman
ASPO CSM Engineering
ASPO LM Engineering
Guidance and Control Division
Flight Crew Support Division
Mission Planning and Analysis Division
Flight Control Division
Flight Support Division
Flight Crew Operations Division
Bellcomm
ASPO Guidance and Propulsion

The SCB is chaired by the Director of Flight Operations who has the responsibility of making all official board decisions and may at his discretion request NASA contractor representatives to participate in SCB activities. The Flight Software Branch of FSD provides secretarial services and has the responsibility to coordinate and implement the decisions of the SCB.

Each member is charged with the responsibility of representing the interests of his organization and to act as its approving agent.

3.1.4 Mission Design Review Board (MDRB)

MIT/IL controls the incorporation of mission program requirements into the mission programs through the actions of a Mission Design Review Board (MDRB). This is a formally constituted board consisting of the directors of all of the software groups and has the function of approving, internally, all mission related documentation. NASA/FSB Program Engineers will be members and attendees of the MIT/IL MDRB, and shall perform the same function.

As chairman of the MDRB, the Project Manager of a mission program is charged with the responsibility of coordination and participation to insure proper processing of control documentation.

The specific function of the MDRB is to provide a mechanism for internal coordination and change control of mission related activities. The change forms described in Section 3.1.7 are used in making interim revisions to GSOPs and in documenting departures from the published GSOP until such time as MSC approved changes are incorporated in official revisions.

The membership of the MDRB is comprised of the following Division Directors or their designated representatives:

(1) A Project Manager (Chairman)
(2) Systems Engineering Division
(3) Support Program Development Division
(4) Space Guidance Analysis Division
(5) Mission Program Development Division
(6) Display and Human Factors Division

3.1.5 Program Change Requests

3.1.5.1 General

Each proposed change must be written on the approved PCR form and approved by the board member representing the originator's organization prior to submittal to the SCB secretary. The originator must indicate clearly on the PCR the intention, objectives, and justification for the change. Failure to provide this information could result in a delay in obtaining SCB action. MIT/IL gathers the approved PCRs and on a package basis changes the Guidance System Operations Plan (GSOP) in accordance with PCR direction.

3.1.5.2 PCR Origination

A PCR may be originated by the software contractor (MIT/IL), by any organization at MSC, or by the Office of Manned Space Flight (OMSF). The MSC organizations will normally generate PCRs only for changes in areas for which they have prime responsibility.

A PCR is originated by completing a PCR form (Figure 3-4) and submitting it to the SCB secretary. Care must be taken in completing this form to assure that sufficient data is given. Failure to provide sufficient data may be cause for disapproval of the PCR resulting in lost time and effort if the PCR must be resubmitted.

Full justification for the change is particularly important. The statement of reason(s) for the change (PCR form, Block 1.5), in addition to being clear and concise, should explain how the successful completion of mission objectives is enhanced by implementing the proposed change. The description of the change (Block 1.6) also should be complete. The characterization of the software, before the proposed change as well as after, should normally be described as a comparison baseline for the change.

3.1.5.3 Program Change Request Form

The PCR form illustrated in Figure 3-4 serves as a cover sheet for the PCR document and remains with it through final SCB action. The original PCR is held throughout this action and is ultimately filed by the Flight Software Branch. Copies are made as required for distribution to board members and the software contractor. The decisions of the SCB, as indicated on the PCR form and authorized by the signature of the Chairman, become directives to the software contractor.

The Data Amplification Sheet (Figure 3-5) may be used to provide additional information when the space available on the PCR form is inadequate.

3.1.5.4 Visibility Impact Evaluation

When MIT/IL originates a PCR, a visibility impact evaluation of the proposed change by the Project Manager is included on the PCR form (Block 3.0). This is a statement of the probable impact of the change on software schedules and computer permanent memory storage capacity and of other significant effects. It is a cursory evaluation based on experience and is not expected to be complete or entirely accurate. The impact of completing a thorough evaluation should also be stated.

When the PCR is originated by OMSF or MSC, a visibility impact evaluation may be requested of the MIT/IL Project Manager by the FSB or the SCB utilizing Block 2.0 of the PCR form. The visibility impact is presented by the MIT/IL representative attending the SCB, Block 3.0 then being completed by the FSB secretary.

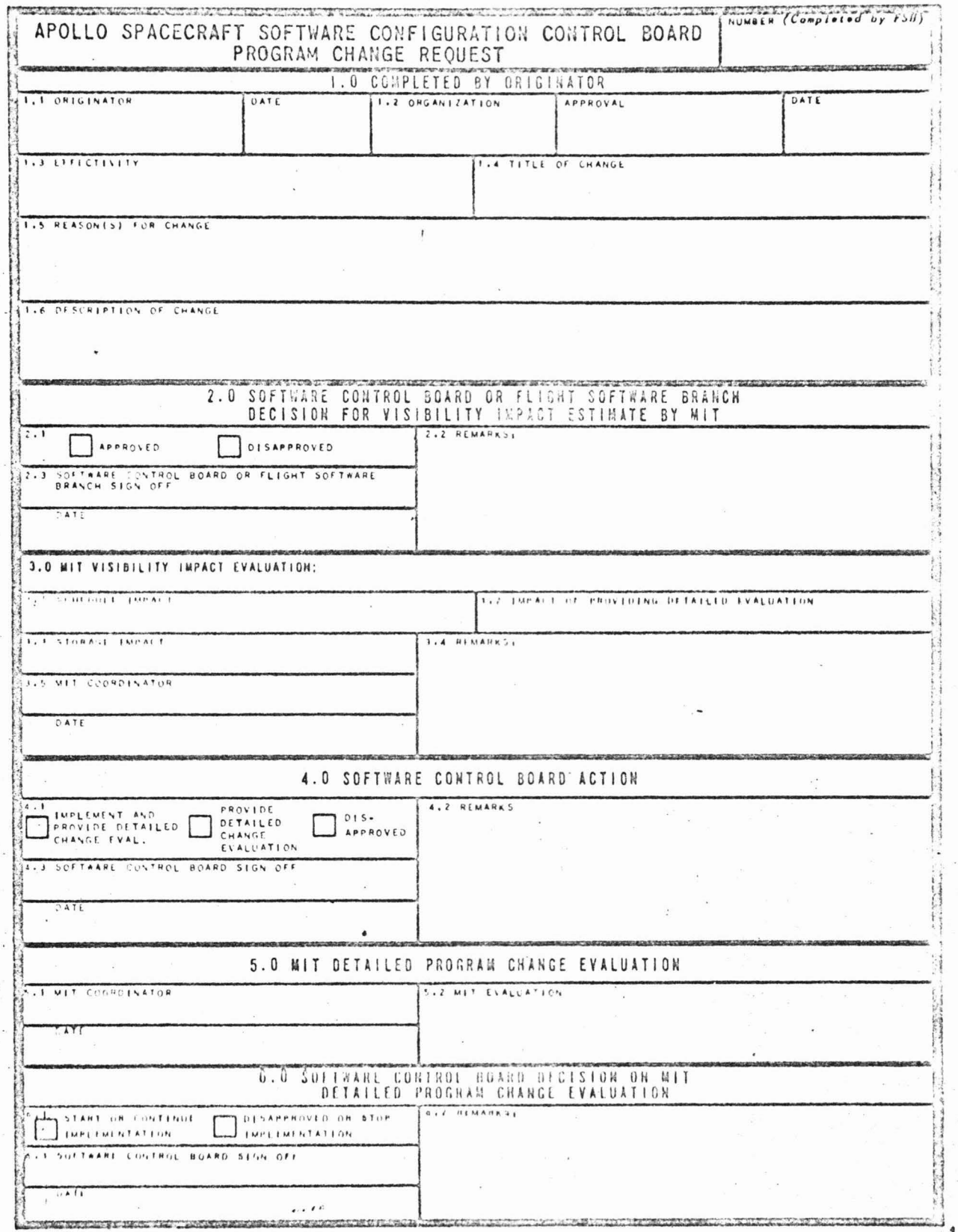
3.1.5.5 Detailed Program Change Evaluation

The detailed program change evaluation (PCR form, Block 5.0), is made by MIT/IL when directed by the SCB (PCR form, Block 4.0). This is a detailed description of the change and a thorough evaluation of its effect and implications on performance, schedules, memory storage, costs, training, program interfaces, test plans, and reviews. It is required for all changes that are to be implemented and may also be requested by the SCB without authorizing implementation of the change (PCR form, Block 4.1). MIT/IL submits the evaluation to the SCB secretary by AG letter, with reference to the PCR by number and title.

3.1.5.6 Mandatory Change

The implementation of any change to an approved software specification or controlled program requires SCB approval. However, MIT/IL may begin work on a software change prior to receipt of SCB direction when, in the opinion of MIT/IL and the FSB, the change fulfills the following conditions:

(1) The change is obviously appropriate and minor in nature (no schedule impact), or



APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
PROGRAM CHANGE REQUEST

NUMBER (Completed by FSB)

1.0 COMPLETED BY ORIGINATOR

1.1 ORIGINATOR | DATE | 1.2 ORGANIZATION | APPROVAL | DATE

1.3 EFFECTIVITY | 1.4 TITLE OF CHANGE

1.5 REASON(S) FOR CHANGE

1.6 DESCRIPTION OF CHANGE

2.0 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH
DECISION FOR VISIBILITY IMPACT ESTIMATE BY MIT

2.1 ☐ APPROVED ☐ DISAPPROVED | 2.2 REMARKS:

2.3 SOFTWARE CONTROL BOARD OR FLIGHT SOFTWARE BRANCH SIGN OFF

DATE

3.0 MIT VISIBILITY IMPACT EVALUATION:

3.1 SCHEDULE IMPACT | 3.2 IMPACT OF PROVIDING DETAILED EVALUATION

3.3 STORAGE IMPACT | 3.4 REMARKS:

3.5 MIT COORDINATOR

DATE

4.0 SOFTWARE CONTROL BOARD ACTION

4.1 ☐ IMPLEMENT AND PROVIDE DETAILED CHANGE EVAL. ☐ PROVIDE DETAILED CHANGE EVALUATION ☐ DIS-APPROVED | 4.2 REMARKS

4.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

5.0 MIT DETAILED PROGRAM CHANGE EVALUATION

5.1 MIT COORDINATOR | 5.2 MIT EVALUATION

DATE

6.0 SOFTWARE CONTROL BOARD DECISION ON MIT
DETAILED PROGRAM CHANGE EVALUATION

6.1 ☐ START OR CONTINUE IMPLEMENTATION ☐ DISAPPROVED OR STOP IMPLEMENTATION | 6.2 REMARKS:

6.3 SOFTWARE CONTROL BOARD SIGN OFF

DATE

MSC Form 288 (Jul 68)

Fig. 3-4 Program Change Request Form.

APOLLO SPACECRAFT SOFTWARE CONFIGURATION CONTROL BOARD
DATA AMPLIFICATION SHEET

PAGE _____ OF _____

PROGRAM CHANGE REQUEST NO.	PREPARED BY	DATE	ORGANIZATION

CONTINUATION SECTION: (Refer to Block Number and Title on Program Change Request Form.)

MSC Form 288A (Jul 68)

Fig. 3-5 Data Amplification Form.

(2) The change is significant (has schedule impact) but is deemed essential.

This is an exceptional procedure to be used only when clearly appropriate and only by agreement with the Flight Software Branch. The detailed change evaluation is also undertaken prior to SCB direction and simultaneously with work on the change.

3.1.5.7 Program Change Request Procedure

Instructions for preparing program change request forms are presented in this section. Block numbers pertain to the PCR form, Figure 3-4. The procedures flow is illustrated by Figure 3-3.

Block 1.0 - Completed by Originator

Block 1.1 Entry — The name of the individual originating the request. The date on which the PCR is completed and submitted for organization approval.

Block 1.2 Entry — The name and office symbol of the cognizant approving organization (MSC Division, MIT/IL Division, or OMSF) must be one of the following:

Flight Operations Directorate
ASPO CSM Engineering
ASPO LM Engineering
Guidance and Control Division
Mission Planning and Analysis Division
Flight Crew Support Division
Flight Control Division
Flight Support Division
Flight Crew Operations
OMSF (Bellcomm)
MIT/IL

Name of the SCB member or alternate from above organization approving the request.

Date of request approval by the originating organization.

Block 1.3 Entry — Identify the CMC or LGC computer program specification affected by this change. Separate PCRs shall be prepared for each program change request. A program change having multiple effectivity shall have

the same basic PCR number. Each program affected by said change shall be assigned a decimal of the basic number.

Block 1.4 Entry — A descriptive title for the change.

Block 1.5 Entry — Provide sufficient definition to justify the proposed change. Include, if applicable, how successful accomplishment of mission objectives was enhanced by the change and/or consequences of not making the change.

Block 1.6 Entry — The description of the change shall clearly indicate the intent of the change; i.e., how it is to affect program functions, performance, or interfaces. Logic diagrams and similar information may be included, if desired, to illustrate a suggested method of implementation. The software contractor will not be constrained, however, to this particular method.

NOTE 1 — If the PCR is originated by MIT/IL, Blocks 1.0 and 3.0 are completed at the same time and Block 2.0 is crossed out.

NOTE 2 — If work toward implementation of the change has been started by MIT/IL with FSB concurrence but without SCB direction, a statement to this effect is entered in Block 3.4 together with the expected PCS completion date and the detailed program change evaluation completion date (Block 5.0). Block 4.0 is crossed out by MIT/IL.

NOTE 3 — The originating organization forwards the PCR to the Flight Support Division, MSC, Attention: Secretary, SCB.

Block 2.0 - To be completed by the FSB or SCB

(1) FSB Approval

Block 2.1 Entry — APPROVED square is checked.

Block 2.2 Entry — As appropriate.

Block 2.3 Entry — Signature of Chief, FSB and date (direction to MIT/IL on visibility impact estimate).

(2) FSB Disapproval

Block 2.1 Entry — Left empty by the FSB and filled in later by the SCB.

Block 2.2 Entry — FSB recommends disapproval of the PCR and states reason(s).

Block 2.3 Entry — SCB Chairman's signature authorizes the decision indicated in Block 2.1 (approval by the Chairman directs MIT/IL for the visibility impact estimate).

NOTE 4 — If Block 2.1 indicates disapproval by the SCB, the originator is so advised by the SCB secretary,, and the PCR is filed by the Flight Software Branch.

Block 3.0 - To be completed by MIT/IL when MIT/IL originates the PCR or by the FSB in other cases. In all cases, the entries are based upon information provided by MIT/IL.

Block 3.1 Entry — Schedule impacts are quoted in calendar days.

Block 3.2 Entry — Indicate the effect on schedule of diverting effort to the detailed change evaluation before decision to implement requested changes.

Block 3.3 Entry — Indicate the impact on the fixed memory and erasable memory capacity of the computer.

Block 3.4 Entry — Other pertinent information (see Note 2).

Block 3.5 Entry — Signature of the appropriate MIT/IL Project Manager of FSB representative and date.

NOTE 5 — After completion of Block 3.0, the PCR is put on the agenda for board action and copies are distributed to board members for review.

Block 4.0 - To be completed by the SCB or its secretary.

Block 4.1 Entry — Self evident.

Block 4.2 Entry — As appropriate.

Block 4.3 Entry — To be signed by the Chairman of the SCB. Directs the indicated activities by MIT/IL.

NOTE 6 — In the event of disapproval, the PCR is filed by the FSB and the originator is notified by the SCB secretary.

NOTE 7 — If "Implement and/or provide detailed change evaluation" is approved, MIT/IL is directed through the FSB to take the indicated action.

Block 5.0 - To be completed by the SCB secretary upon receipt of the MIT/IL evaluation.

NOTE 8 — When a detailed change evaluation is requested (PCR form, Block 4.1) MIT/IL is to complete the evaluation within three working days after receipt of instructions from the FSB and is to return their evaluation to the secretary of SCB via AG letter with reference to the PCR number and title. The secretary of the SCB will complete Block 5.0. If it is evident to MIT/IL that more time will be required, the secretary of the SCB should be notified and a completion date will be agreed upon.

Block 5.1 Entry — The MIT/IL Project Manager (Chairman of the MDRB) signs Block 5.1 indicating approval of the change pages by the MDRB. The NASA/FSB Program Engineer initials Block 5.1 to indicate concurrence. In the absence of a NASA/FSB Program Engineer, consent may be given to the MIT/IL Project Manager via telecon, TWX, or as appropriate.

Block 5.2 Entry — As appropriate.

NOTE 9 — The results of the MIT/IL evaluation are forwarded via AG letter referencing the PCR number and title to the Flight Software Branch, MSC, Attention: Secretary, SCB.

Block 6.0 - To be completed by the SCB.

Block 6.1 Entry — Final disposition of the PCR by the SCB is indicated by a check in the appropriate square.

Block 6.2 Entry — As appropriate.

Block 6.3 Entry Signature by the Chairman of the SCB directs MIT/IL to take the action indicated in Block 6.1.

NOTE 10 SCB direction will be forwarded to MIT/IL by the FSB, and the secretary will file the completed PCR. SCB minutes, published and distributed by the secretary, will note all SCB decisions.

3.1.6 Program Change Notices

In the course of program development there arise situations where the intent or literal interpretation of the GSOP cannot be executed in program code for technical or for logical reasons. Consequently, further program development is curtailed initiating a quick specification redesign and change cycle. The MIT/IL design divisions and the MSC Flight Software Branch study the problem and agree to a solution. Implementation of the changes is then started immediately. The appropriate MDRB is convened to approve the draft GSOP change pages. Then the PCN is submitted to SCB for approval.

3.1.7 GSOP Change Procedures

After the MIT/IL MDRB has approved the individual change pages and SCB PCR approval is received, they are collected and forwarded to the Project Manager who authorizes the GSOP update package and it becomes ready for publication. Documentation improvements as such shall be done at the time page changes are being made as a result of a PCR or PCN. Changes of this nature (document improvements) are to be clearly marked in some method other than those used for changes as a result of a PCR/PCN. These document improvement changes shall be approved by the MDRB and FSB at the same time approval is given for the changes resulting from a PCR/PCN. The Division Director of the originator of the document improvement is responsible for the changes being just document improvements and will indicate the same at the MDRB meeting. The pertinent features of the GSOP update package are:

(1) The block update package for any particular GSOP section consists of:

a. A copy of each changed page in the format described by Figure 3-6.

b. An updated index cover sheet for each changed GSOP section in the format described by Figure 3-7.

c. Or new issues of GSOP sections rather than change pages, whichever are more convenient.

where NBSM and REFSMMAT are defined in Section 5.6.3 and $\underline{u}_Z$ is a unit vector along the Z-body axis expressed in basic reference coordinates. The angle θ is then found as follows:

$$\underline{u} = \text{UNIT}\,(\underline{r}_L \times \underline{v}_L)$$

$$\underline{u}_P = \text{UNIT}\left[\underline{u}_Z - \left(\frac{\underline{u}_Z \cdot \underline{r}_L}{r_L^2}\right)\underline{r}_L\right]$$

$$\theta = \cos^{-1}\left[\underline{u}_Z \cdot \underline{u}_P\, \text{SGN}\,(\underline{u}_P \cdot \underline{u} \times \underline{r}_L)\right] \qquad (6.7.3)$$

$$\text{If } \underline{u}_Z \cdot \underline{r}_L < 0 \;;\; \theta = 2\pi - \theta$$

The three displays of R-31 are automatically updated until R-31 is terminated by the astronaut. The logic flow required to accomplish this update is shown in Fig. 6.7-2.

5.6.7.2 Final Attitude Display

Routine R-63 may be used to compute and display the FDAI angles required to point either the LM Z-axis or LM X-axis at the CSM. The choice of axis is made by the astronaut at the beginning of the routine as described in Section 4.

After initiation of this routine the state vectors of both vehicles are extrapolated to the present time plus one minute using the Coasting Integration Routine (Section 5.2.2). Based on these new state vectors the required gimbal angles are computed. These angles are converted to FDAI angles using the transformation described in Section 5.6.12 and the result is displayed.

There is no automatic display update; however, R-63 may easily be recycled manually.

5.6.7.3 Out-of-Plane Rendezvous Display

Routine R-36 may be used during any phase of the rendezvous sequence to provide information about the out-of-plane geometry. Three quantities (Y, $\dot{Y}$, and ψ) are computed for a given time which is determined by the astronaut. The first two, Y and $\dot{Y}$, represent the out-of-plane position and velocity in some sense. The third display, ψ, is the angle between the

☑ Revised SUNDANCE
☐ Added GSOP # R-557 PCR # 414 Rev. 1 Date 3-5-68

Fig. 3-6

Date: July 1, 1968

REVISION INDEX COVER SHEET

GUIDANCE SYSTEM OPERATION PLAN

GSOP # R-557 Title: For Manned Earth Orbital Mission Using Program SUNDANCE

Section # 4 Title: PGNCS Operational Modes (Rev. 2)

Date	Rev.	Remove Pages	Add Pages	PCR Ref.
2/20/68	1	All of R-53 (ppgs. 399-416 inclusive) Title Page	New R-53 (16 pages numbered R53-1 to R53-16), last page of R-52, and first page of R-54 included in order to permit neat insertion. Title Page, Index Sheet	PCR #7

7/1/68 2 Revision 2 incorporates the following NASA/MSC approved changes and is published as a complete new document.

MIT No.	NASA PCR		
15.1	146.1	*	Emergency termination of integration function
27.2	80.1	*	State Vector synchronization
30	145	*R	GSOP Change R63
39.1	85.1	*R	Attitude hold during X axis over ride
40.1	86.1	*	Deadband selection changes
44.1	124.1	*	Attitude maneuver during search routine
47.1	405.1	*	GSOP update (sect. 4) R30
49	177	*	GSOP update (section 4) P 40
50.2	148.2	*	IMU ON check in P51
52.1	406.1	*	Correction to R04 in GSOP section 4
56	178	*	P30 displays and section 4 of update flag changes
57.1	449	*	Noun 78 scaling in V/Noun list of sect. 4
58.1	450	*	Noun 78 scaling in R04
60.1	251	*	GSOP update section 4
65	126	*	GSOP update section 4
71	179	*	New alarm code (1711) for P40, P41, P42
74	180	*	R77 restriction
85.1	184.1	*	Standardize termination of extended verbs 47 and 48

* Indicates an MIT Program Change Notice (PCN)

Fig. 3-7

MIT/IL PROGRAM CHANGE ROUTING SLIP

PCR/PCN # _____

ANOMALY # _____

☐ SUNDISK ☐ SUNDANCE

☐ COLOSSUS ☐ LUMINARY

☐ COLOSSUS II ☐ LUMINARY II

☐ MIT Approved PCN ☐ NASA Approved PCR ☐ NASA Approved Software Anomaly

A. Coding

○ Begin coding immediately _____

ACTION: _____

Program Supervisor: _____

○ Do not code until new GSOP material has been approved by the MIT Mission Design Review Board (MDRB) and distributed.

B. GSOP Preparation

○ Prepare GSOP revisions for MDRB consideration _____

ACTION: _____

☐ Technical Committee Meeting not required.

☐ Technical Committee Meeting(s) held on _____

Attendees:

C. KSC Testing and Checkout

○ Review for possible impact on KSC testing and checkout

ACTION: _____

D. Other Programs Affected

○ Review for corresponding changes in _____

Special Instructions

ACTION: _____

Project Manager _____

Date _____

Fig. 3-8

(2) PCS Block packages will be published at such a frequency as to cover the volume of changed pages in a timely manner.

(3) The distribution list for each PCS package will be identical to the distribution list for the parent GSOP section. In addition, a spare set of thirty packages will be printed and filed at MIT/IL for use in compiling a final valid set of the current changes for delivery to NASA immediately before the flight.

(4) Changed pages of the "document improvement" kind may be included in the PCS package and given full distribution.

(5) The "Index Cover Sheet" accompanying the PCS package includes instructions to remove certain pages from the GSOP and to add the pages included in the package. Each time a new PCS package is published for a particular GSOP section, the instructions are added to a new Index Cover Sheet without deleting previously tabulated instructions so that each index page is complete and is a replacement of its predecessor index page. (See Figure 3-7.)

(6) Features to be incorporated on the changed GSOP page include:

a. A page number will be chosen to indicate the location of the new page. If pages are added, suffix capital letters in sequence will be appended to the page number. For Section 4, "Operational Modes," because page numbers are not included in the initial IBM print-out format, no page number will be indicated. Rather, each program or routine will be replaced in its entirety when revision is needed.

b. A standard marking (vertical solid bar for typed portion, "+" sign for computer copy) will be placed along the border of the page to indicate the areas that have been changed.

c. The lower border of the page will contain complete identification so that proper filing of the new pages may be simply accomplished. The identification will include the word "Revised" or "Added", the document identification number as "R-547", the page number, the revision number, and the date of publication.

3.1.8 MIT/IL Program Change Routing Slip

The MIT/IL Program Change Routing Slip (Figure 3-8) is utilized by the Project Managers for the internal routing of PCRs, PCNs or Anomalies. By the use of these slips the required action or disemination of information is relayed to the proper MIT/IL personnel for action.

SECTION 4

PROGRAM CHANGE CONTROL

4.1 MISSION PROGRAM CHANGE BOARD

The Mission Program Change Board (MPCB) is a regularly scheduled meeting for the purpose of reviewing each change candidate. The board is staffed as follows:

Mission Program Integration Director, Chairman
Mission Project Managers
Program Supervisors
Program Development Chief Engineer
Assembly Control Group Leader
Supporting Staff as assigned by above
Other Division representation as requested

Available to the MPCB are two listings of the trial assemblies for each of the mission programs containing the change candidates (see "Assembly Control", section 4.2). Also available are two copies of each of the modification sheets supporting each change candidate appearing in the trial assemblies.

The modification change sheet for each change candidate is submitted by the program supervisors. A common format is utilized to list the identity and reason for the change, the effect on the word budget, the effect on the erasable memory, and a flow diagram of changes to the logic in question. Also available to the board are the word count listings for the trial assemblies.

The trial assemblies permit the board to examine the effect of the changes in the program. The board, moreover, examines the suitability and correctness of the change by the systematic use of a checklist. Typical items on the checklist are intended to force examination of the effects of the change on fixed and erasable memory, telemetry lists, extended verbs, alarms, other mission program elements.

The results of Change Board thinking are (1) decisions on each of the change candidates, (2) further direction to and action required of the program supervisors (such as to incorporate the same change into another mission program at next opportunity), and (3) authorization to make the new official assemblies for each mission program.

MPCB action allows the program supervisor to prepare the Change Notice for the new assembly. This Change Notice lists the known characteristics of the assembly, the changes incorporated, known cautions, faulty areas, workarounds, known discrepancies not fixed, known restraints, patches left in from unaccepted changes and the retesting required.

4.1.1 Change Board Checklist

The following items are contained on the checklist as an aid to the Change Board in making judgments on a proposed revision to the approved assembly. The first four items concern the assembly itself and should be thoroughly checked by the Program Supervisors prior to the meeting.

(1) Quality:

a. Is the Modification Report adequately made out?

b. Does the proposed change violate any established coding ground rules?

c. Has the memory map been reviewed for bank conflict?

d. Have card numbers, DELETE's, constants, and similar variables been adequately checked?

(2) Fixed Memory budget impact

(3) Erasable allocation impact

(4) Sealed subsection impact

(5) Proper authorization for change (PCR/PCN)

The following items concern the impact that the changes may make on users of the assembly:

(6) Testing

a. Has the change been advertised to all the activities concerned?

b. Does the change require changes to test decks, e.g., erasable load changes, astronaut card changes, hybrid scripts?

c. Does the change require the rerunning of any Level I, II, III, IV or V Tests?

d. Does the change require the definition of a new Level I, II, III, IV or V Test?

e. Does the change require a change to the Verification Test Plan?

(7) Schedule impact, if any; then

a. Has the Project Manager been made aware of it?

b. If the change is in response to a PCR, has the impact been reassessed?

c. Has the Development Plan been updated?

(8) Documentation:

a. Has the Program Description been updated?

b. Is a new Program Description required?

c. Is the Class A Flow Chart activity impacted?

d. Are the Discrepancy and Program Notes affected?

e. Does the change affect any issued Test Level I, II, III, IV or V document?

f. Is the GSOP affected, e.g., flag settings or sign errors requiring PCR/PCN action?

(9) Work arounds:

a. Can the change be replaced by an operational procedure?

b. Can the change be made more expediently with less coding elegance?

(10) Have remaining patches for both Hybrid and Digital been reviewed and justified?

4.1.2 Mission Program Development Calendar

The coordination of the many elements involved in a flight program requires the establishment of procedures and routine meetings for control and dissemination of information at the group leader and man-on-the-job level. Figure 4-1 shows the weekly review plan of these various elements, each covered by a specific procedure or charter to pinpoint responsibility.

4.2 ASSEMBLY CONTROL

The Assembly Control Group reporting to the Mission Program System Integration Director has full time responsibility for the making and the control of YUL assemblies. Each Mission Program has a weekly updated assembly revision. This is the only official revision for all users for the week.

Each Mission Program Supervisor is responsible for submitting to Assembly Control each week the change cards for all change candidates for the next assembly. The Program Supervisors are responsible for determining that these change candidates

	MON	TUES	WEDS	THU	FRI	WEEKEND
SPECIFICATION CONTROL (MONTHLY)		CANDIDATE CHANGES ACTION AT MSC/MIT DEVELOPMENT PLAN MEETING	BLOC SPEC CHANGE RELEASED GSOP			
MEMORY CONTROL (WEEKLY)	FIXED MEMORY BUDGET REVIEWED AT MPCB MEETING			ERASABLE MEMORY CONTROL COMMITTEE MEETS		
ASSEMBLY CONTROL (WEEKLY)	TRIAL ASSEMBLY REVIEWED AT MPCB MEETING	NEW OFFICIAL ASSEMBLY READY & PROGRAM CHANGE NOTICE			SUPERVISORS SUBMIT CHANGE CARDS FOR TRIAL ASSEMBLIES	ACCOMPLISH SUCCESSFUL TRIAL ASSEMBLIES
CHANGE CONTROL (WEEKLY)	MISSION PROGRAM CHANGE BOARD MEETS					
TECHNICAL DESIGN REVIEWS (ODD WEEKS)		RENDEZVOUS NAVIGATION & TARGETING	LM DIGITAL AUTOPILOT LM POWERED FLITE	LM ASCENT AND DESCENT		
ENGINEERING DESIGN REVIEWS (EVEN WEEKS)		CONICS AND ORBIT INTEGRATION	CMS & ENTRY DIGITAL AUTOPLOTS CSM POWERED FLITE, BOOST & ENTRY	SYSTEM PROGRAMS		
MIT MANAGEMENT DEVELOPMENT PLAN REVIEW (WEEKLY)	DEVELOPMENT PLANS UPDATED	MIT DEVELOPMENT REVIEW BOARD MEETING	UPDATED DEVELOPMENT PLANS DISTRIBUTED			
MSC MANAGEMENT DEVELOPMENT PLAN REVIEW (MONTHLY)		MSC/MIT DEVELOPMENT PLAN MEETING				

Fig. 4-1 Mission Program Development Calendar

constitute a proper package. It is expected that all patches found necessary to run with the current assembly will appear in the packages change candidates submitted by the Program Supervisors.

The Assembly Control Group takes the change candidate packages received weekly and generates successful "trial" YUL assemblies for each of the mission programs, e.g., TRIALDANCE 162, TRIALCOLOS 57, and TRIALLUM 27. These are for the use of the Mission Program Change Board at their regular weekly meeting.

The Program Supervisors are responsible for delivering to the Mission Program Change Board the Modification Sheets for each of the change candidates in trial assembly.

The Mission Program Change Board using the trial assemblies, the Modification Sheets, and other material (see "Change Control") will select those change candidates for next official revision for each mission program assembly. Experience shows that programmers are helped more if they can use the updated assembly as soon as possible after the initial trial assembly is assembled.

Following the Mission Program Change Board meeting, the Assembly Control Group will make the new YUL assemblies with the changes accepted by the board. Successful assemblies should then be available to become the new official revisions.

4.3 FIXED MEMORY CONTROL

Each log section of each of the assemblies is assigned a fixed memory budget. This budget is a design limit to the generation of code by the programmers. A special listing (COUNTDANCE, COUNTCOLOSSUS, etc.) is made automatically by Assembly Control at the time of program assembly that reveals by each log section the comparison of actual and budgeted word count. These listings are examined by the Mission Program Change Board (see "Change Control"), and problems in meeting budgets are resolved by the Board.

The Assembly Control Group includes in its responsibilities the control of all program constants. The intent of control is to guarantee that each parameter representing a constant will have only one value throughout the program and that this value is that listed in official controlling documentation.

4.4 ERASABLE MEMORY CONTROL

The Erasable Control Group reporting to the Mission Program System Integration Director has full time responsibility in the control of the erasable memory. Responsibilities include the assignment of erasable memory locations, the resolution of erasable conflicts, and the identification of existing and potential problems in erasable memory.

The Erasable Control Committee is staffed as follows:

Mission Program System Integration Director, Chairman
Program Supervisors
Mission Program Chief Engineer
Mission Program Engineering Leaders

The Erasable Control Committee meets weekly to provide the guidelines and budgets in the layout or distribution of erasable memory parameters, to identify and resolve problems in the use of erasable memory, and to correct unusual difficulties in erasable conflicts.

SECTION 5

SIMULATOR CHANGE CONTROL

5.1 FACILITIES

The following Apollo simulation facilities will be subject to change control: (1) Digital, (2) Hybrid, (3) Cockpits, (4) Dalto and (5) MACSIM. These facilities have corresponding code letters and are listed as follows:

Facility	Code
Digital	D
Hybrid	H
Cockpits	C
Dalto	T
MACSIM	M

The attached form (Fig. 5-1) was designed to help mechanize change control and is prepared in two parts.

5.1.1 Change Request

A change request need only be completed as far as "description" and "reason" and should be signed by the requestor. Approval to implement the change may be sought if any appreciable scheduling impact is involved. In this case a Project Manager may be required to approved the request.

5.1.2 Change Record

To record a change requires that the entire form be completed. If the implementation is in response to a prior request, the "description" and "reason" must reference the request.

The person implementing the change is required to sign the form. The change is then officially approved by the appropriate responsible person. SCRs are numbered sequentially after the facility code letter as listed above.

This change control procedure shall be applied to every change to simulation facilities under configuration control, no matter how small. It is also to apply to changes that are made to simulation "elements" as part of the development if any change affects the way the element operates for the user.

SIMULATION CHANGE REQUEST/RECORD SCR #

Facility:	Program/Equipment:
Description:	
Reason:	
Originator:	Date:
Accepted by:	Estimated delivery date:
Implementation Detail:	
How Tested:	
Documentation affected: New Log/Rev/Date:	
Implemented by:	Completion date:
Approved:	Date:
Remarks:	

TP# 21737

Internal changes to elements under development that do not affect simulation users need not be recorded.

Each responsible person whose signature must appear on changes to simulation elements under his responsibility will in effect constitute a Change Control Board of one.

SECTION 6

ANOMALY REPORTING

6.1 GENERAL

"Anomalies" are deviations in expected performance, program irregularities or amplifications arising out of post-FACI testing and inspection. Such anomalies are controlled by submitting to NASA/FSB a detailed description of the anomaly, its cause and effect, and recommendations for effective action.

6.2 ANOMALY ORIGINATION

An anomaly may be originated by MIT/IL, NASA, or other NASA contractors. An anomaly is originated by completing an anomaly form (Fig. 6-1) and submitting it to NASA/FSB. Care must be taken in completing this form to assure that sufficient data is provided or appropriate direction cannot be given. An amplification sheet (Fig. 6-2) is provided if additional space is needed. Sufficient data is provided by completing the section devoted to analysis which takes into account the cause, how the anomaly was recognized, its effect on the mission, avoidance procedure, recovery procedure, program correction, and recommended disposition and re-testing.

6.3 ANOMALY REPORTING PROCEDURE

Each MIT/IL originated anomaly must be written on the approved MIT/IL Software Anomaly Report form and approved by the Project Manager prior to submittal to NASA/FSB. The originator completes blocks 1.1 through 1.6. The MIT Program Supervisor completes blocks 2.1 through 2.10 and NASA/FSB completes blocks 3.1 through 3.4. NASA/FSB also assigns an MSC report number to the anomaly.

Relevant to the closing action that is taken, either MIT/IL or NASA may complete blocks 4.1 through 4.4. For example, if only program notes are involved, NASA/FSB will fill in this section. On the other hand, if a change in the program must be made, MIT/IL will complete blocks 4.1 through 4.4.

Should NASA or another agency originate the anomaly, the originating agency completes blocks 1.1 through 1.6. Then NASA/FSB reviews this section and assigns an MSC control number. The MIT/IL Project Manager completes blocks 2.1

MIT/IL SOFTWARE ANOMALY REPORT

MSC REPORT NO.
PROGRAM
PROGRAM REVISION

1.1 ORIGINATOR:	1.2 ORGANIZATION:	1.3 DATE:	1.4 ORIGINATOR CONTROL NO.

1.5 DESCRIPTION OF ANOMALY:

CONTINUED ON PAGE

1.6 DESCRIPTION OF RUN:

CONTINUED ON PAGE

- MIT ANALYSIS -

2.1 CAUSE:

CONTINUED ON PAGE

2.2 RECOGNITION:

CONTINUED ON PAGE

2.3 MISSION EFFECT:

CONTINUED ON PAGE

2.4 AVOIDANCE PROCEDURE:

CONTINUED ON PAGE

2.5 RECOVERY PROCEDURE:

CONTINUED ON PAGE

2.6 PROGRAM CORRECTION:

CONTINUED ON PAGE

2.7 RECOMMENDED DISPOSITION (Fix, Work-around, etc):

CONTINUED ON PAGE

2.8 RECOMMENDED RE-TESTING:

CONTINUED ON PAGE

2.9 MIT/IL SIGNATURE:	2.10 DATE:

3.1 NASA DIRECTION:	4.1 CLOSING ACTION TAKEN:
CONTINUED ON PAGE	CONTINUED ON PAGE

3.2 NASA/MSC SIGNATURE:	3.3 ORGANIZATION	3.4 DATE:	4.2 SIGNATURE:	4.3 ORGANIZATION:	4.4 DATE:

MSC Form 1409 (Rev May 68)

PAGE 1 OF ____

Fig. 6-1

MIT/IL SOFTWARE ANOMALY REPORT

1.1 ORIGINATOR:	1.2 ORGANIZATION:	1.3 DATE:	1.4 ORIGINATOR CONTROL NO.	(C) REPORT NO.
				PROGRAM
				PROGRAM REVISION

MSC Form 1409A (May 68)

PAGE ___ OF ___

35H

Fig. 6-2

through 2.10. The NASA/FSB completes blocks 3.1 through 3.4 and, as above, depending upon the action that is taken, either the NASA/FSB or the MIT Project Manager completes blocks 4.1 through 4.4.

Instructions in completing the anomaly forms are presented below: Block numbers pertain to the MIT/IL Software Anomaly Report form, Fig. 6-1.

Block 1.0 - Completed by the originator*

Block 1.1 Entry - The name of the individual originating the request.

Block 1.2 Entry - The name of the organization to which the originator is associated.

Block 1.3 Entry - Date on which the anomaly report is prepared.

Block 1.4 Entry - Control number affixed by originator for traceability purposes.

Block 1.5 Entry - The description of the anomaly shall show clearly the affect on program performance and associated functions.

Block 1.6 Entry - Provide an accurate description of the run affected.

Block 2.0 - Completed by Project Manager

Block 2.1 Entry - Provide a clear indication of the cause of the anomaly.

Block 2.2 Entry - Provide an indication of how the anomaly can be recognized, i.e., by visual inspection, atypical performance etc.

Block 2.3 Entry - Provide a description of the effect the anomaly has on the mission.

Block 2.4 Entry - Provide, if applicable, a description of the procedure to follow if the anomaly is to be avoided.

Block 2.5 Entry - Describe, if applicable, the procedure necessary to restore program to normal operating status.

Block 2.6 Entry - Indicate clearly, if possible, how a program correction could be made.

Block 2.7 Entry - Describe the recommended method most appropriate to effecting the necessary correction.

Block 2.8 Entry - Describe the recommended tests to be repeated to reverify the program.

---

*Note: The program and program revision affected by the anomaly are indicated by the originator in the blocks provided for that purpose.

Block 2.9 Entry - Signature of Project Manager responsible for analysis.

Block 2.10 Entry - Date the Project Manager approves the anomaly analysis.

Block 3.0 Completed by NASA/FSB*

Block 3.1 Entry - Description of NASA direction as a result of the anomaly

Block 3.2 Entry - Signature of FSB representative responsible for direction pertinent to the anomaly.

Block 3.3 Entry - Organization of NASA representative.

Block 3.4 Entry - Date on which NASA direction is given.

Block 4.0 Completed by individual responsible for the closing action

Block 4.1 Description of action taken to remedy the anomaly as directed in block 3.1.

Block 4.2 Signature of individual responsible for closing action.

Block 4.3 Organization to which the closing action applies.

Block 4.4 Date at which the closing action is taken.

*Upon receipt of the Anomaly Report, MSC affixes a report number in the block provided for that purpose.

SECTION 7

MISSION PROGRAM REVIEWS

7.1 DEVELOPMENT PLANS

Development Plans are maintained for all active mission flight programs. The format and period of updating depends upon the development status of the program involved. For mission flight programs prior to FACI, updating must occur every two weeks. The format of these development plans must include all detailed milestones and a clear indication of what previous milestones must be completed in order to accomplish subsequent milestones.

The mission Flight Program Development Plans are the basic tools used to control schedules, personnel assignments, and internal requirements. The Development Plans are made for each mission program under the responsibility of the Project Manager to a level of detail practical at any particular phase of the program. Upon receipt of the guidance computer software requirements, a first plan is detailed to develop the GSOP for MSC approval and to identify long lead time tasks. The Development Plans evolve on a bi-weekly basis so as to provide management insight from the level of contract requirements to a minor subroutine personnel assignment. Survey sheets provide a weekly review to this lowest assignment providing latest requirements data and obtaining status of assignment, support requirements, and data needs.

The management system provides for the compilation and review of the plans on a weekly basis. From this compilation the following information is obtained:

(1) Status of each individual assignment, i.e., coding, tests, etc.

(2) Support requirements -- the need for simulator capabilities, facilities, etc.

(3) Personnel assignments -- permit assessment of utilization in view of other program needs.

(4) Schedules -- assessment of impact on other schedules.

(5) Impact of approved changes on a flight program schedule.

The review, decision, and assignment of responsibilities of the results of this information provide the key to effective management of the available resources.

It is the responsibility of the Project Managers supported by the development planning section of Group 23P and the development design divisions to achieve a useful and current development plan for each mission flight program.

The weekly MIT/IL Management Development Plan Meeting is staffed as follows:

Deputy Director MIT/IL (or designee), Chairman
Apollo G&N Program Director
Apollo Mission Development Director
Mission Program Project Managers
Program Development Director
Program Support Director
Systems Engineering Director
Display and Human Factors Director
Space Guidance Analysis Director

Each month one of these meetings will be substituted by a NASA/MSC chaired joint Program Development Review held at MIT/IL. The function of this monthly meeting is to review mission program development progress.

7.2 ENGINEERING TECHNICAL DESIGN REVIEWS

The Program Development Chief Engineer directs the Program Development Engineering groups that provide the engineering design and coding of functions in generating elements specified for the mission flight programs. The engineering design and coding of the various Digital Autopilot programs are the responsibility of the Autopilot Group reporting to the Program Support Director.

It is the responsibility of the above-mentioned groups to design the programs to meet the specifications listed in the Guidance System Operation Plans and other contractual specifications. These groups act to support the requirements of the Mission Project Managers.

The engineering design of the subject programs requires support by the Space Guidance Analysis Division, the Displays and Human Factors Division, and the Systems Engineering Division to resolve questions not evident in the GSOPs and other specification documents. Design reviews of involved groups needed to meet problem areas may be called and chaired by the Project Managers as necessary. To assure across-the-board visibility and uncover difficulties, regular Design Reviews are scheduled for each of the program engineering groups on a bi-weekly basis. The Program Design Review Committee for these regular reviews are

staffed as follows:

Mission Program Chief Engineer (or designee), Chairman
Mission Program Project Managers
Mission Program Engineering Leader
Space Guidance Analysis Division designee
Systems Engineering Division designee
Displays and Human Factors Division designee
Program Support Division designee
Autopilot Group designee

The intent of these design reviews in all program areas is to assure that all aspects of the program are considered and to identify problems as early as possible. The routine serves the needs of the Project Managers and allows program development and design personnel to exchange information and identify difficulties on a regular basis.

SECTION 8

PROGRAMMING TEST PACKAGES

8.1 GENERAL

The purpose of the Programming Test Package is to identify and define a set of tests to ensure that guidance computer programs correspond satisfactorily to the analytical procedures defined in the GSOP and other documents for each mission. There are five basic levels of testing required during the development of a mission program.

8.1.1 Level I

Using the guidance equation material of Section 5 in the GSOP, computational difficulties such as loss of accuracy are identified. Numerical examples are developed to check the adequacy of the coded Apollo Guidance Computer (AGC) programs to handle sufficient ranges of variables. These check solutions are generated using a general purpose algebraic compiler (MAC) and are based on AGC program block diagrams.

8.1.2 Level II

Using the data obtained from the Level I package, actual tests on the coded programs are performed. The flight computer solutions are checked against the sample MAC solutions.

The first two test levels include the analytical processes associated with trajectory computations, displays, steering equations, navigation and targeting programs as described in Section 5 of the GSOP.

8.1.3 Level III

At the third level of testing, complete programs and routines using sufficient simulated environment to verify the performance of the system under flight simulated conditions, are checked out on the all digital simulator.

8.1.4 Level IV

The testing of program sequences, and mission phases which require use of several of the programs tested at the third level, constitute the fourth stage in the evolution of a fully verified mission program. As an example, a sequence might include attitude and alignment determination, realignment, targeting, burn, trim and return to the idle mode.

8.1.5 Level V

A final qualification testing using a controlled assembly to verify and document formally the Level III and IV tests.

SECTION 9

DOCUMENTATION

9.1 GENERAL DOCUMENTATION REQUIREMENTS

Throughout the development of mission programs an extensive level of documentation exists to disseminate at the engineering level as much information about requirements and test results as possible. This documentation provides the basis for acceptance of the end item and a continual insight into the implementation of requirements [First Article Configuration Inspection (FACI) and Customer Acceptance Readiness Review (CARR)]. The following paragraphs describe the kinds of documentation and their use: basically this is all Type -2 NASA documentation.

(1) Memorandums and reports -- A formal series identifiable to a specific mission program designed to provide detailed analysis of equations, test plans, and to report test level I and II results.

(2) E and R Notes -- Formal reports on design or analysis studies of major significance -- usually developmental work and applicable to more than one mission program. (These reports are part of an overall laboratory system with the Apollo reports forming only a part of what becomes a broad technical library.)

(3) Flow Charts -- A formal indexed series per mission program of the coding of computer logic designed to provide a detailed description of the implementation of the GSOP requirements. These charts are controlled by drawing numbers and revisions and are updated to reflect a present status applicable to a GSOP Section 4 revision.

(4) Verification Test Results -- A formal document compiling the Level III, IV and V test results. The data in rough form through Level IV testing is utilized for a FACI. The FACI decisions and the Level V testing results are added to complete the document as the test history of a specific mission program with an appropriate assessment of any constraint on requirements.

In developing the flight programs the total Apollo System must be considered with all its interfaces to the G&C system. These are requirements in the form of the P&I Specification, Interface Control Documents (ICD), and hardware constraints.

To the flight program designers, the P&I specifications and the ICD's represent an agreed-to contractual interface which must be rigorously recognized. The Design Control Staff or the MIT/IL Apollo Program Director is responsible for ICD negotiation and control. By dissemination of the information, by participation in design reviews, and by review of all changes the Design Control Staff insures compatibility with the ICD requirements.

During the development of the G&C hardware and software on parallel schedules, a major exchange of information between the two groups is necessary to insure full compatibility. Changes to both hardware and software within the G&C system are the responsibility of the Program Director's Design Control Staff. This responsibility is carried out by this staff through review of all changes and participation in the design review boards.

Additional requirements related to the flight programs are as follows:

(1) Tape versions of the programs for simulator use and testing.
(2) Engineering studies.
(3) Simulated Flight programs.
(4) MIT/IL Simulation design.

These and similar requirements are usually received in letters of direction or accepted as action items at meetings with MSC. They are usually scheduled and assigned on an individual basis with a management system follow-up to insure compliance or resolution.

9.2 PROGRAM CHARACTERISTICS REPORTING

Each of the Program Supervisors maintains a master log book for entering program characteristics of the mission program under his responsibility. All persons operating with these programs in informal or formal testing are directed to enter significant "characteristics" discovered and identified by assembly number and log section.

"Characteristics" can be bad operations, discrepancies from specification, unadvertised restraints, and other user-oriented useful notes about the program. Those characteristics that have not been fixed or will not be fixed by candidate changes for next assembly revision must be examined by the Program Supervisor for his judgment of importance. Those he feels that should be advertised so as to help program assembly users will be listed in the Change Notice issued with the next program assembly revision. At the time of Configuration Control of the program occurring at FACI and release for manufacture with the Customer Acceptance Readiness Review (CARR), the log of program characteristics will be used to generate a complete list of discrepancies from the specification and a complete list of program notes providing operational characteristics not otherwise advertised.