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A MANAGEMENT PLAN FOR SYSTEMS ASSURANCE DURING PHASES A, B, C, & D

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Resources Management Office

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

TECHNICAL MEMORANDUM X-53516

A MANAGEMENT PLAN FOR SYSTEMS ASSURANCE DURING PHASES A, B, C, & D

By

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ABSTRACT

This plan establishes a sound, practicable management tool for use in coordinating the products, efforts, and functions of the four major support disciplines throughout Phases A, B, C, & D of a system development:

1. Human engineering
2. Maintainability
3. Reliability and quality
4. System safety

It is arranged in two sections which describe the organizational relationships and responsibilities and the functional working relationships.

The objective of this plan is to present management techniques that can be used in guiding the activities of the above disciplines into a team effort. It also insures that maximum application is made of the respective technologies to provide NASA with comprehensive management visibility.

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RESOURCES MANAGEMENT OFFICE
INDUSTRIAL OPERATIONS

TECHNICAL MEMORANDUM X-53516

A MANAGEMENT PLAN FOR SYSTEMS ASSURANCE DURING PHASES A, B, C, &D

SUMMARY

This plan establishes a sound, practicable management tool for use in coordinating the products, efforts, and functions of the four major support disciplines throughout Phases A, B, C, & D of a system development:

1. Human engineering
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INTRODUCTION

The President has directed that all Government Agencies initiate positive action to reduce costs and improve management practices. This document has been prepared to that end.

The forcing management function, as described herein, is accomplished by the preplanning of activities, auditing performance against those plans, and scheduled reporting for maximum management visibility. This plan organizes the activities and end products of the reliability, quality, maintainability, system safety, and human engineering discipline into a team effort wherein each complements and augments the normal functions of the others. This provides both maximum management visibility and total system impact with a minimum of personnel and cost. The plan features a functional block diagram, arranged by phases, that combines the major program elements of all of the disciplines into a single point management tool. The pre-planning of these activities as described in this document, will contribute significantly to cost reduction.

ORGANIZATION AND RESPONSIBILITIES

The NASA Headquarters organization consists of a Systems Assurance (SA) Director who reports to the Program Director, and a staff organization as shown in Figure 1.

The Systems Assurance Director (Block I of Fig. 2) is responsible for:

1. Developing SA program requirements and establishing SA policy.

2. Reviewing the SA plan prepared by thefunctional center to insure that:

   a. It includes the mechanics for making full application of the data, criteria, and analyses generated by the SA organizations to increase management visibility.

   b. Program requirements and policies are fully implemented.

   c. There is no duplication of effort.

   d. All working relationships are fully defined.

3. Auditing the performance of the centers to insure that the program is on schedule and is in consonance with the SA plan as previously prepared.

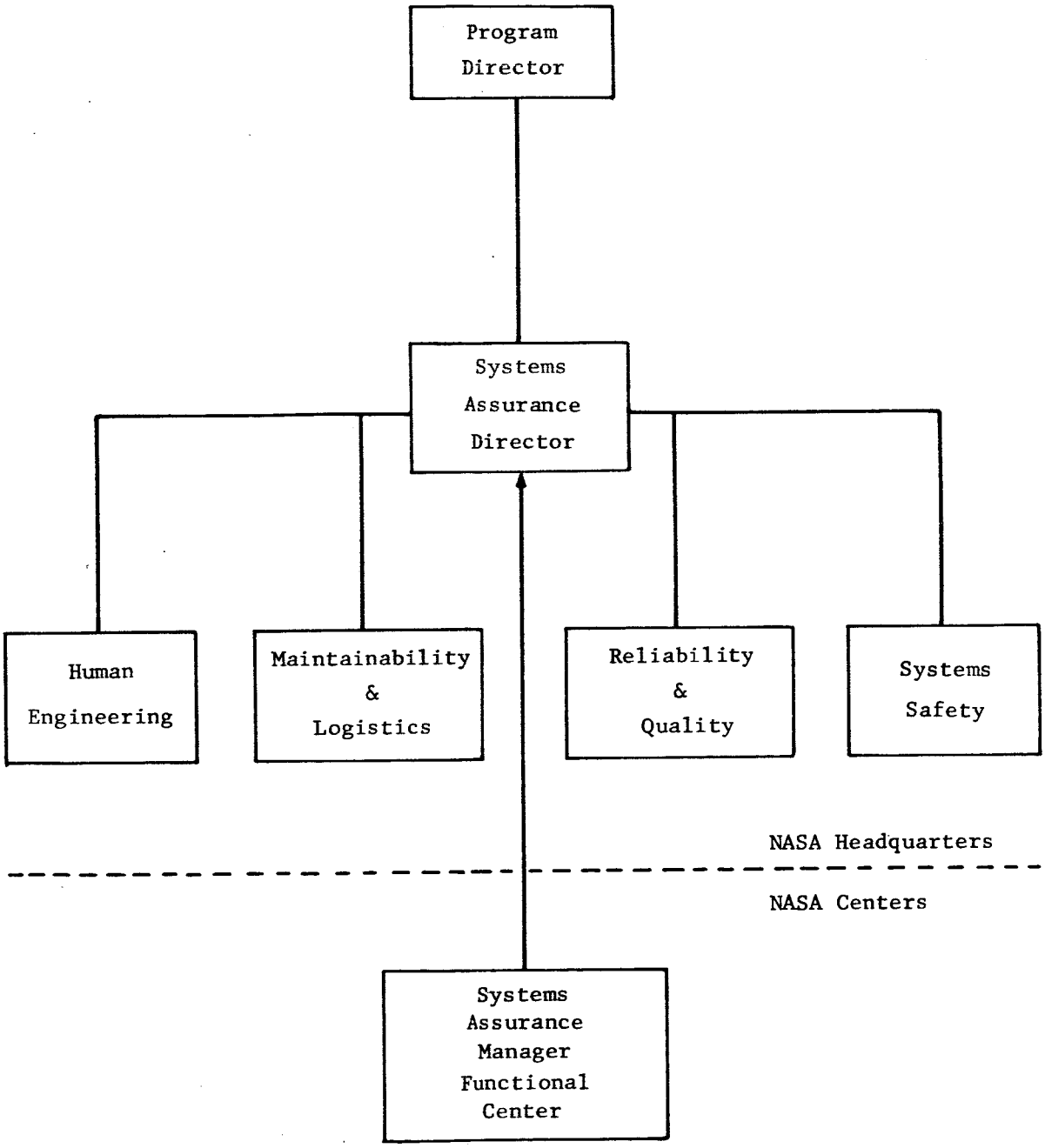

FIGURE 1. NASA HEADQUARTERS/ CENTER ORGANIZATION RELATIONSHIP

4. Provide SA visibility to the Program Director.

5. Develop criteria and planning for phase definition of subsequent phases.

The SA manager at the center, while receiving program requirements and policy direction from the SA Director, reports to the Program Manager at the center. The SA organization is shown in Figure 3 and contains an office of primary responsibility for each of the disciplines. The office depends greatly on the integrating contractor's SA organization for assistance.

The SA manager (Block II, Fig. 2) is responsible for:

1. Advising the four functional organizations of SA program requirements and policies.

2. Reviewing the program plans prepared by each of the discipline organizations to insure that:

   a. Program requirements and policies are correctly interpreted and included.

   b. Each plan clearly describes the tasks to be accomplished and the management and technical methods that will be used to perform these tasks.

   c. All functions and tasks are keyed to major program milestones.

   d. Functional working relationships are clearly defined and there is no duplication of effort.

   e. Maximum possible application is made of parallel effort previously accomplished on other NASA programs.

3. Preparing a cover plan that integrates the individual plans described above into a composite plan that will serve as an effective management tool.

4. Insuring that there is consistancy in the requirements levied on each prime contractor so that there is a uniformity of effort and that each discipline is fully contracted for.

NASA CENTER | CONTRACTOR

I	SYSTEMS ASSURANCE (SA) DIRECTOR
II	SYSTEMS ASSURANCE MANAGER NASA CENTER/CONTRACTOR
III	DISCLIPINE TECHNICAL MANAGER NASA CENTER HE, M/L, R/Q, SS
IV	CONTRACTOR FUNCTIONAL DISCIPLINE ACTIVITIES HUMAN ENGINEERING (HE) MAINTENANCE & LOGISTICS (M/L) RELIABILITY & QUALITY (R/Q) SYSTEM SAFETY (SS)

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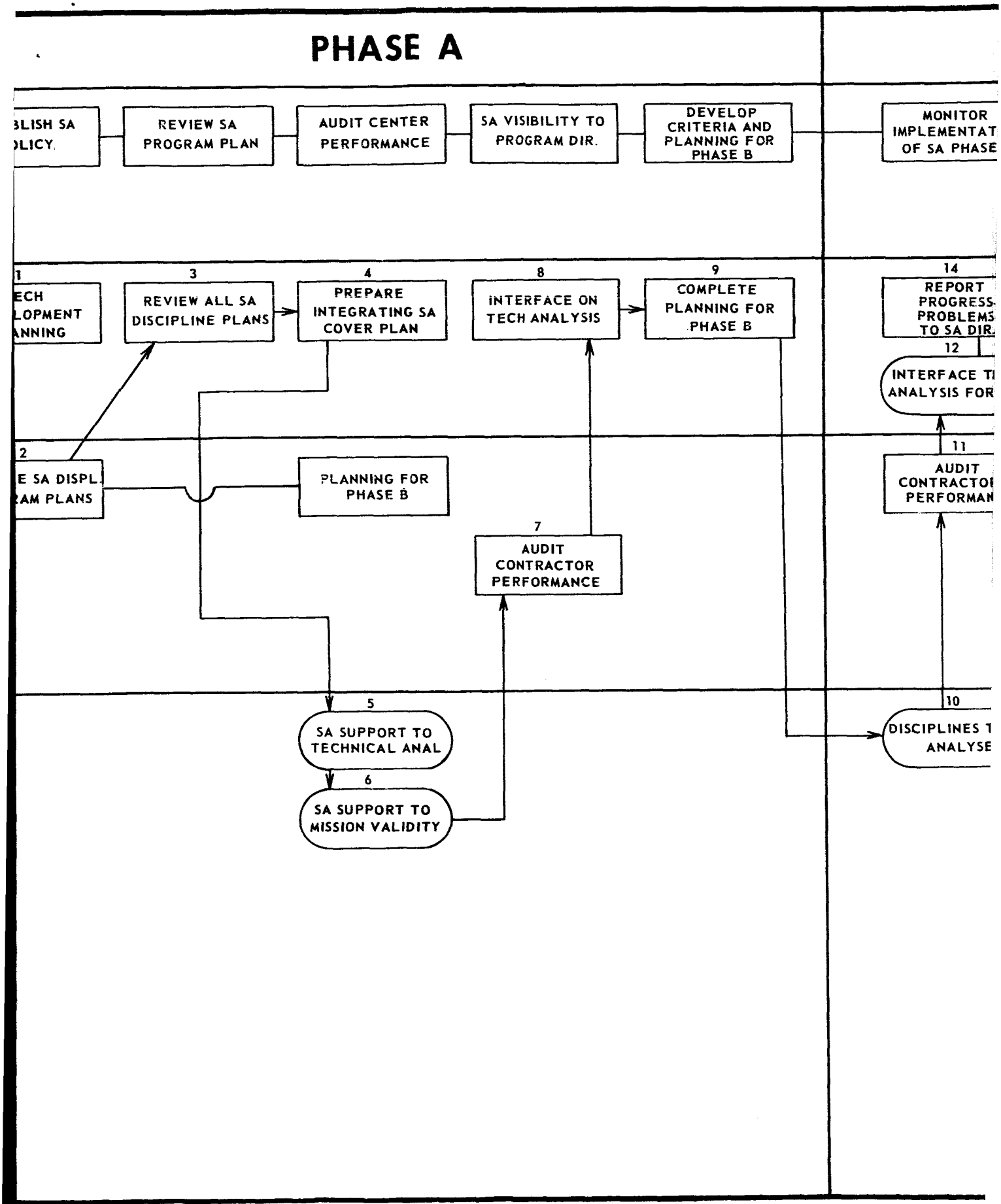
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AUDIT CENTER PERFORMANCE
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ECH LOPMENT ANNING
3
REVIEW ALL SA DISCIPLINE PLANS
4
PREPARE INTEGRATING SA COVER PLAN
8
INTERFACE ON TECH ANALYSIS
9
COMPLETE PLANNING FOR PHASE B
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REPORT PROGRESS PROBLEMS TO SA DIR.
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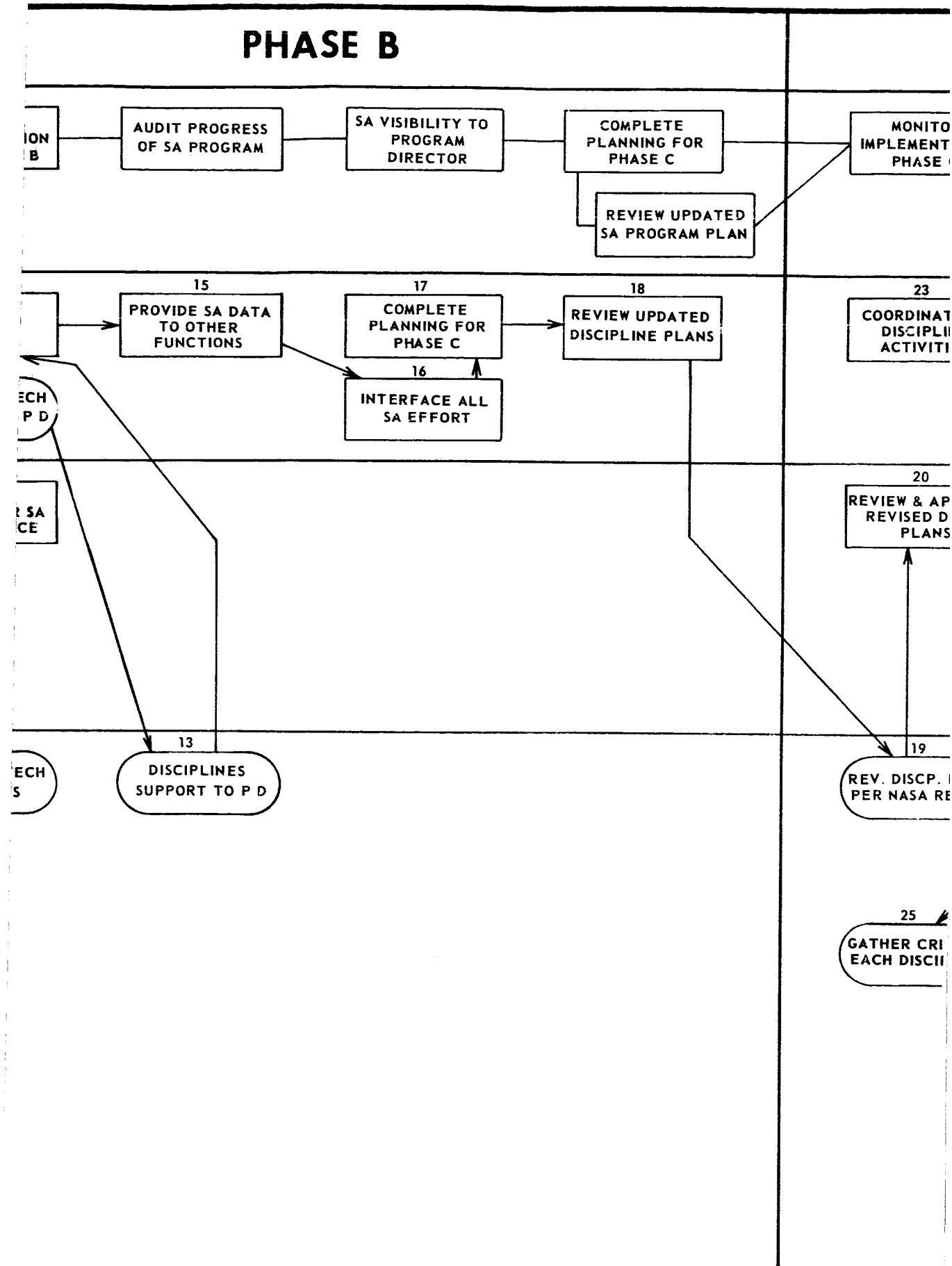
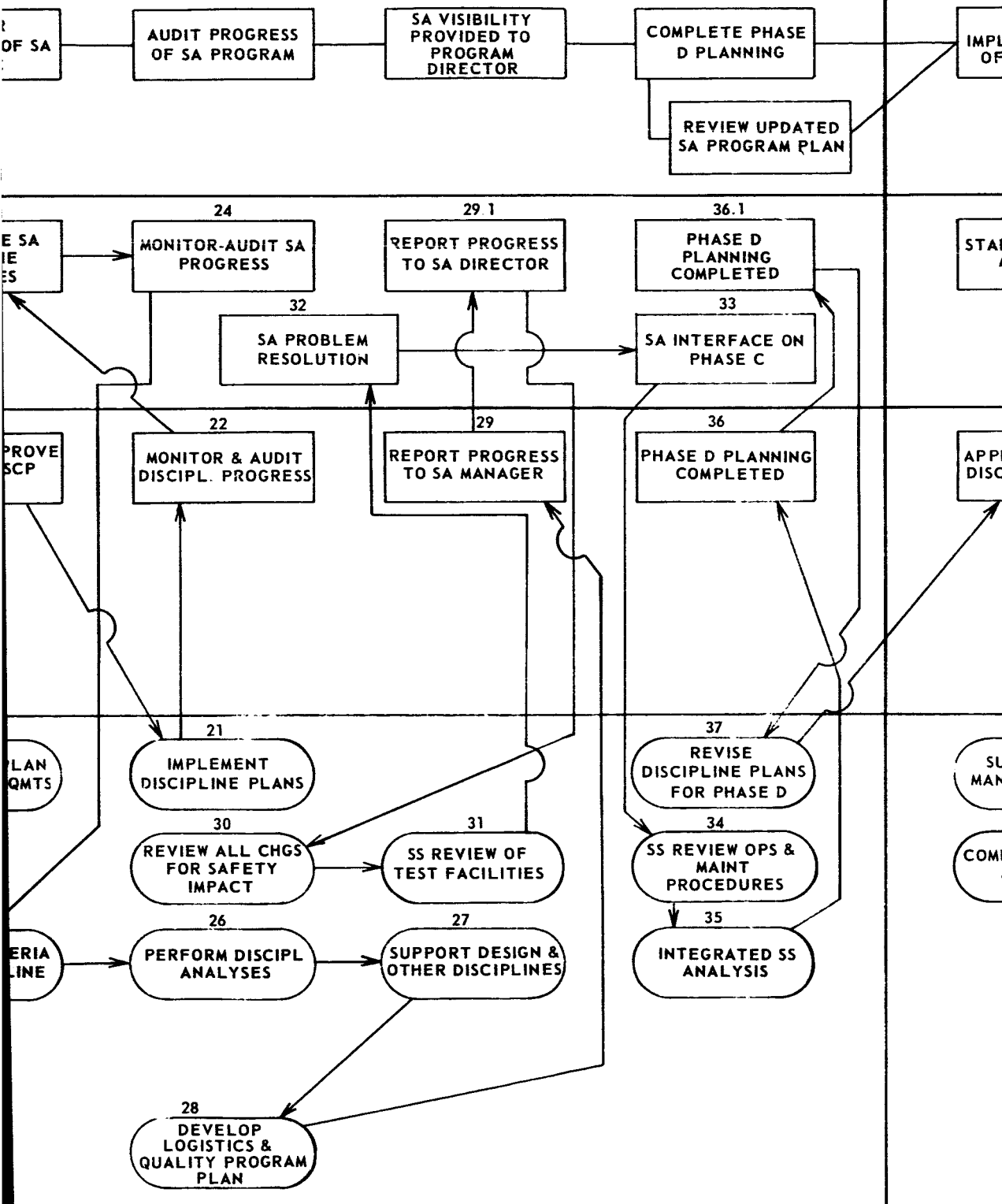
7
AUDIT CONTRACTOR PERFORMANCE
5
SA SUPPORT TO TECHNICAL ANAL
6
SA SUPPORT TO MISSION VALIDITY
10
DISCIPLINES T ANALYSE

FIGURE 2



. SYSTEM ASSURANCE PROGRAM ELEMENTS FLOW CHART

PHASE C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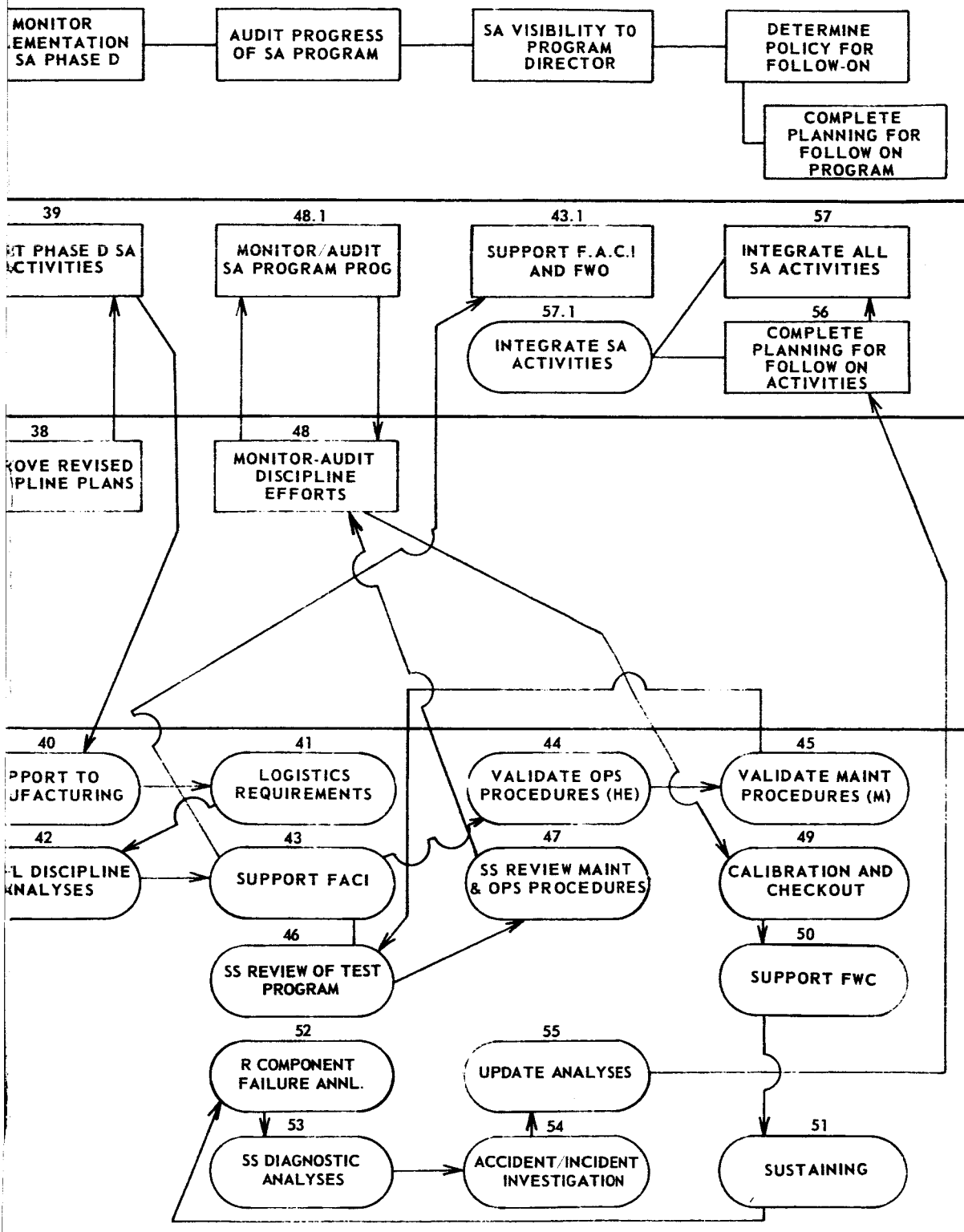
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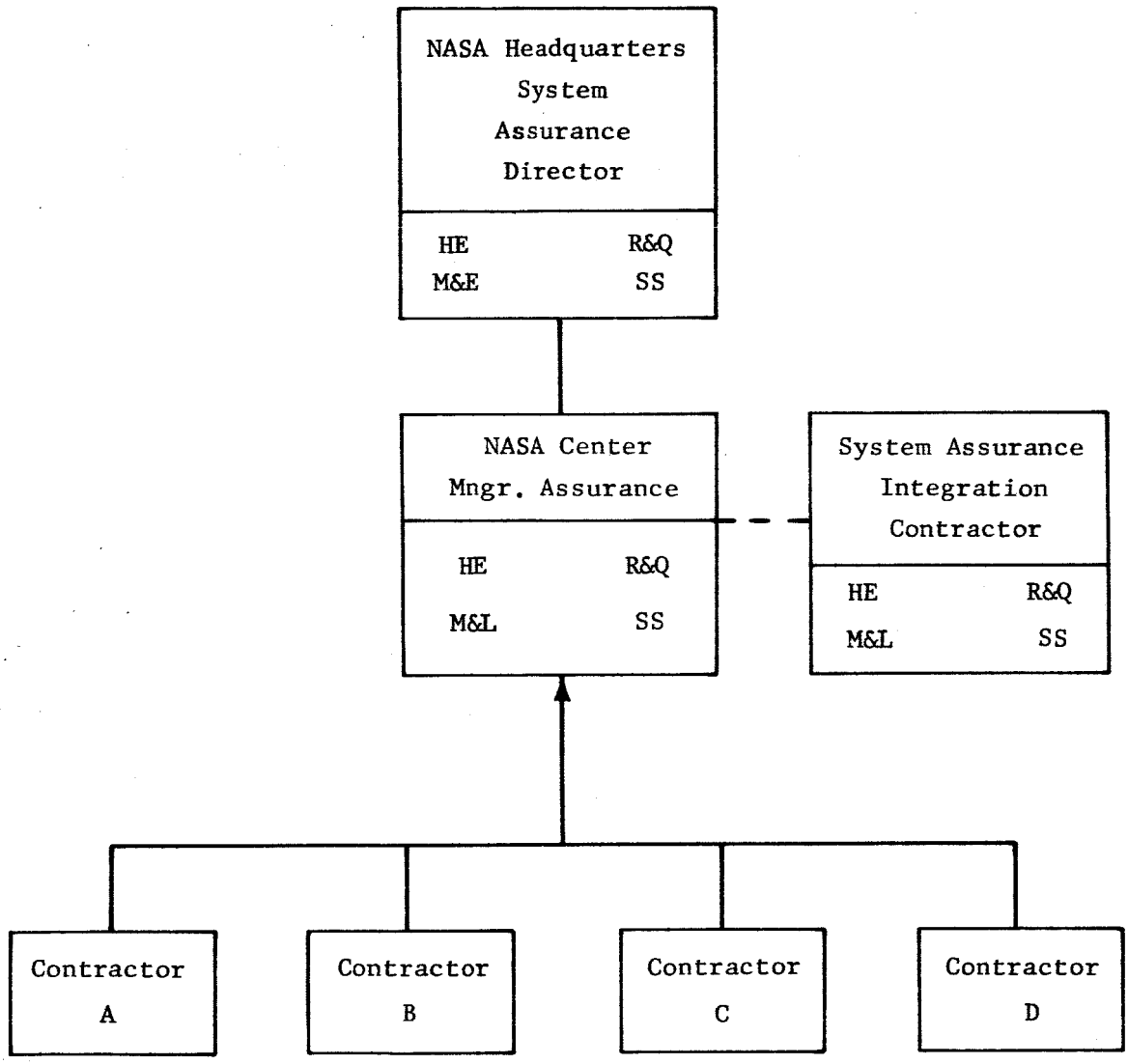

FIGURE 3. NASA/ CONTRACTOR SYSTEM ASSURANCE FUNCTIONAL RELATIONSHIP

5. Establishing a data bank and providing for a free flow of data between the SA organizations on an expedited basis.

6. Performing periodic audits to measure the progress of each SA organization and each prime contractor against its respective program plan to insure that all tasks are being accomplished in accordance with established schedules.

7. Providing technical support to the program manager in all matters pertaining to Systems Assurance.

8. Establishing resources for the SA program and the application of those resources to obtain maximum program efficiency.

9. Assisting the SA Director by keeping him advised of program activities and supporting his program audits.

10. Supporting work statement preparation proposal reviews and contract negotiations prior to beginning of each phase.

FUNCTIONAL ACTIVITIES AND RELATIONSHIPS

Phase A
(Blocks I through 9)

This phase may be accomplished totally by NASA or as a joint NASA-contractor effort as described herein. In either event, it is during this phase that a sound foundation for a system assurance be established and elements composing of reliability, quality control, human engineering, maintainability and logistics, and system safety be identified. Block numbers referenced in text refer to Figure 2.

Technical Development Planning
(Block I)

The SA manager begins Phase A with his technical development planning. Gross functional program requirements and activities are developed. Specific

efforts are scheduled to major milestones, which are in turn broken down into second tier milestones for greater management visibility in the assignment of personnel and the application of resources. He provides for the beginning of the data bank and identifies, reviews, and validates source data; and he establishes the flow of data as a support activity. At this time he also gathers and distributes design requirements prerequisite for the performance of the technical analyses.

Plan Preparation (Block 2)

Each of the four SA organizations begins the preparation of its respective program plan. This plan describes the program elements and tasks to be accomplished during Phases B, C, and D. It also outlines in detail the management and technical methods that are used in meeting the objectives of the discipline. The working relationships with the other SA organization are described as well as the flow of information and data. The plan contains detailed information on how the contractor is to be guided and his performance monitored.

These plans may be prepared by the Phase A contractor as part of the contracted effort; however, the requirements in the RFQ statement of work must be well defined, and the contractor must demonstrate a clear understanding of the requirements.

Plan Review (Block 3)

The SA manager reviews the individual plans to assess their suitability as management tools. He insures that:

1. They fully and completely implement the program requirements and policies set forth by the SA Director.

2. They demonstrate that each respective output is to be in a form that can be evaluated in consonance with those of the other SA organizations to provide complete management visibility.

Integrated SA Plan
(Block 4)

The SA manager prepares a cover plan which, with the four individual SA plans, comprises the management tool that is to be used in implementing and directing the SA program. The SA cover plan describes the applications of the system analyses performed by each of the functional activities. It shows how each discipline is considered during the decision making process, by describing the methods used to insure that the safety, reliability, or maintainability of the system are not inadvertently traded off or compromised. The plan also describes the SA audit techniques and frequencies. It outlines the contract management methods and techniques for efficient contractor relationships.

Technical Analysis for System Feasibility
(Block 5)

The Phase A contractor's SA organization begins its activities by providing support in the performance of the technical analysis. Inputs are provided to the engineering effort in all matters relating to each respective discipline, Special analyses are performed on critical systems of subsystems as required.

Mission Validity Determination
(Block 6)

Parallel with the technical analysis, Block 5, the Phase A contractor's SA organizations support the analyses performed to determine mission validity.

Audit of Contractor Performance
(Block 7)

Each of the SA organizations audits the performance of his counterpart in the contractor's SA organization to be sure that the program requirements

are understood and that emphasis is placed properly in the critical areas. Progress and problems are reported to the SA manager in accordance with established requirements.

Interface on Analyses (Block 8)

The SA manager becomes the focal point for all Phase A SA activities at this time. He is fully informed on progress and problems and is prepared to provide the chief engineer with management visibility in SA. The contractor's SA organization serves as a focal point for all SA technical data developed during the phase and provides strong support to the SA manager.

Phase B Planning (Block 9)

The SA manager, working with the NASA technical manager for each discipline, participates in the preparation of the RFQ for Phase B when there is to be a contractor participation. He makes sure that it is in consonance with the Phase A planning. SA program resource requirements are determined and included into the total program budget. Proposals are reviewed and SA is considered as one of the parameters in contractor selection.

Phase B Project Definition (Blocks 10 through 18)

Phase B, as in Phase A, may be accomplished by NASA or as a NASA-contractor team effort, depending on the program requirements established by the program director. In the event that it is a NASA effort, Block 11 drops out and all other elements are accomplished.

Technical Analyses
(Block 10)

Each of the disciplines performs detailed studies and analyses of the data developed under Phase A with the effort oriented toward the selection of a single project approach. Strong support is provided to the engineering effort, and close working relationships are maintained with the other disciplines to insure that the complete spectrum of SA is covered.

Performance Audit
(Block 11)

The performance of the contractor's effort is audited by the technical manager of each respective discipline. The technical manager insures that activities are performed within the scope of the plan developed for each discipline under Phase A. He provides for data distribution and participates in all problem solving activities.

Interface Activities
(Block 12)

The contractor's SA manager serves as a pivot for all of the disciplines' functions. He makes sure that resources are being properly applied and that each discipline is fulfilling its functional responsibility. Further, he insures that valid data are available to the disciplines when they are needed.

Preliminary Design
(Block 13)

The detail studies and analyses being performed in Block 10 flow right into support of the preliminary design effort of the engineering organization.

Progress Reporting (Block 14)

The progress and program activity information gathered under the audit activities (Block 11) is reported to the SA manager by the technical manager of each discipline. The integration of other contractor activities is performed by contractor's SA manager and reported to the NASA SA manager. These reports provide the SA manager with complete SA visibility, which enables him to provide strong support to the center's engineering manager. The reports also serve as the basis for supporting the SA technical director's program audit functions as shown in Figure 4.

Functional Support (Block 15)

The SA manager sees that the analyses and data developed by his functional organizations are made available to all other technical organizations in a usable form and on time. He also establishes the need for all special SA data required for the program development.

SA Program Interface (Block 16)

The NASA SA manager, supported by the contractor's SA manager, becomes the focal point for the culmination of all SA activities. It is at this point that a decision must be made conceiving the proposed system. The three choices are:

1. Further study of the concept.
2. Abandonment or deference of the development.
3. Decision for full design and development of the system (Phases C & D).

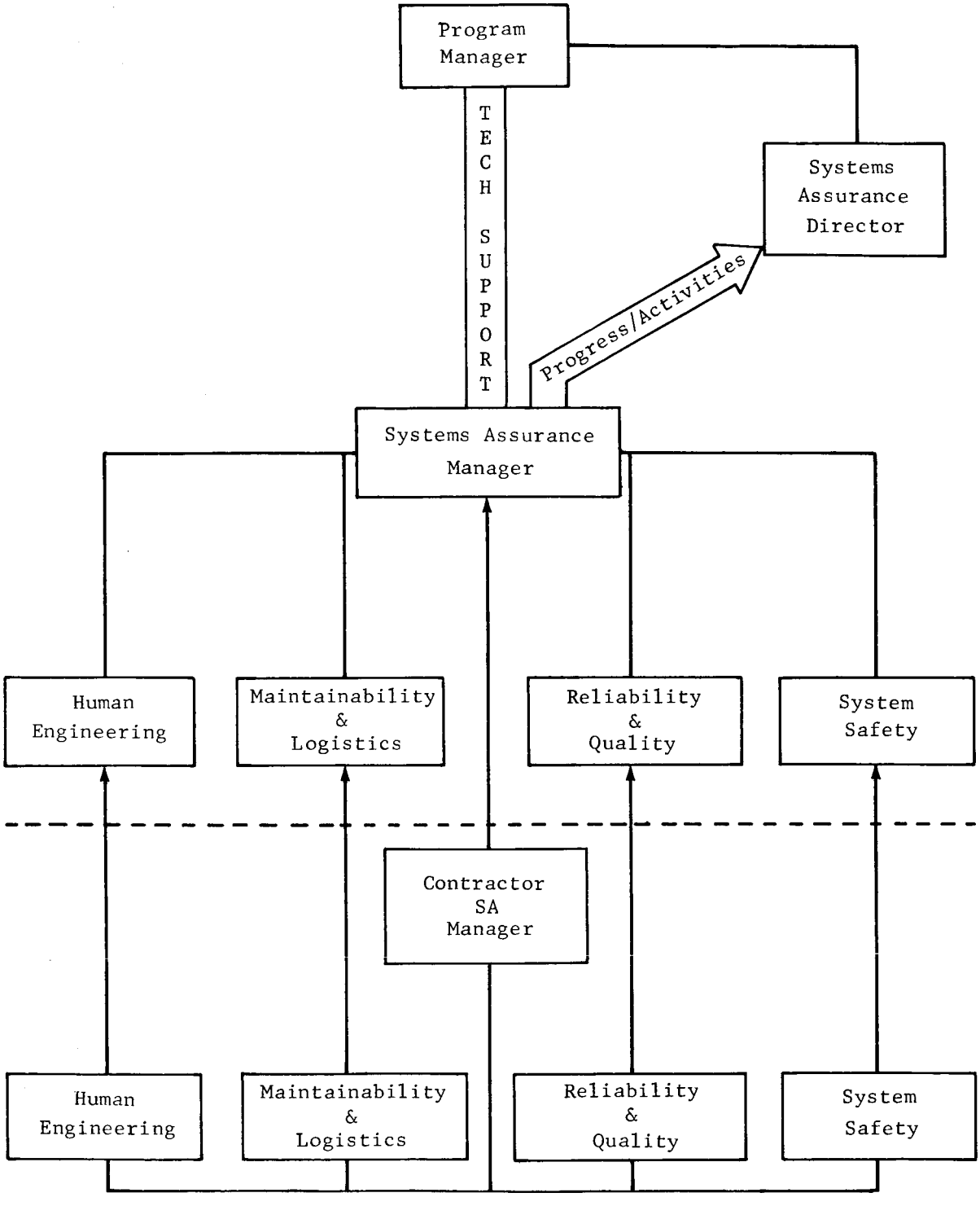

FIGURE 4. SYSTEM ASSURANCE DATA FLOW

The SA planning and technical efforts accomplished under Phases A and B should support the decision made, 1, 2, or 3 above, on an equal basis with the engineering product of Phases A and B.

Phase C Planning (Block 17)

The SA manager, and the NASA technical manager for each discipline, participates in the pre-phase C planning activities. Program requirements are furnished by each functional discipline for inclusion in the RFQ. Also included in the RFQ is the requirement for each contractor to submit preliminary SA, human engineering, maintainability, reliability, and system safety plans as part of his proposal. These plans describe how each discipline accomplishes the program requirements through Phases C and D. They also outline in detail the management and technical methods to be used, organizational structure, reporting lines, and functional working relationships. A description of the corporate policies as related to each of the disciplines is included as well as schedules for the accomplishment of all program elements, keyed to major program milestones.

The SA manager participates in the proposal reviews to see that SA is considered as one of the parameters in contractor selection.

Plan Updating (Block 18)

The respective program plans prepared by each discipline manager under Phase A are reviewed and updated to incorporate any changes to the program that have developed during Phase B.

Phase C Design (Blocks 19 through 37)

Phase C may be accomplished by a NASA-contractor team, or by NASA-prime contractors or integrating contractor teams depending on the size and

type of the program under development. The mechanics of managing either of these team efforts is developed as a function of the contractors program plans (see Block 17, Phase B) through a proper framing of the RFQ plan requirements.

Plan Revision
(Block 19)

The contractor's human engineering, maintainability, reliability, and system safety plans submitted with the proposal are reviewed by the NASA technical manager for each respective discipline. Changes are coordinated, and the plan is revised to incorporate these changes.

Plan Approval
(Block 20)

The NASA manager for each respective discipline, having assured himself that the revised plan is a good management tool, approves it.

Plan Implementation
(Block 21)

The contractor implements his approval plan and begins the normal function of the human engineering, maintainability, reliability, and system safety organizations as described in each respective plan.

Performance Audit
(Block 22)

The NASA technical manager for each discipline monitors and audits the contractor's performance against the technical and schedule requirements

contained in the approved plan throughout the entire phase. Problem areas are identified and resolved before they become costly in money and schedule time.

SA Coordination (Block 23)

The NASA SA manager coordinates and guides the overall activities during revision, approval, and implementation of the plans. He uses his office to make sure that these steps are completed in a timely manner.

The contractor's SA manager coordinates the plan approval and implementation activities of each discipline. He sees that maximum application is made of all analyses and data generated and that the full spectrum of SA is covered without duplication.

SA Program Audit (Block 24)

The NASA SA manager reviews and audits the performance of all disciplines to insure that each is well managed and that schedules are maintained throughout the entire phase. He resolves interfunctional problems and disagreements.

The contractor's SA manager monitors and audits the performance of each functional discipline to bring about high technical quality and schedule performance. He also monitors the functional relationships to see that each discipline is participating and cooperating with the others for maximum efficiency and economy. He makes certain that full SA support is provided to the engineering and systems engineering effort.

Criteria (Block 25)

The initial Phase C technical activities begin with a review of criteria gathered under Phase B, together with other current discipline requirements,

to determine applicability. Suitable criteria are documented and applied to the design. Close design support is maintained so that correct interpretation and implementation of these requirements result. It is also during this period that reliability begins to develop subsystem reliability budget numbers for use later in the phase.

Component/Subsystem Analyses (Block 26)

Each discipline begins its respective analytical tasks in accordance with the methods described in its plan. Critical components and subsystems receive more detailed attention, and the analyses results are provided to engineering. This insures maximum use of each technology and precludes designing many deficiences into the system.

Design Reviews (Block 27)

The results of the analyses completed under Block 26 are used to support preliminary design reviews and critical design reviews. They are made accessable to all functional organizations so that raw data or analyses will not be generated twice.

Associate Plans (Block 28)

The Logistics and quality assurance plans are prepared, coordinated, and approved by the NASA technical manager for maintainability and reliability and are implemented.

Progress Reporting
(Block 29 &29. 1)

Each contractor's SA discipline reports progress and activities to his NASA technical manager in addition to supporting the program audits. These reports and the contractor's SA managers integrated SA progress report are furnished to the SA manager. He, in turn, provides this information to the center's program manager and to the SA director in Washington.

System Changes
(Block 30)

The system safety organization reviews all changes to the system to make certain that hazards to the system are not created.

Test Facilities
(Block 31)

The SA organization reviews the test facilities, test equipment and test procedures to see that hazards are not created in the system through the use of improper test equipment or procedures.

SA Problem Resolution
(Block 32)

The NASA systems assurance manager, supported as required by the contractor SA managers, resolves all interdiscipline management and technical problems and makes sure that the program flows smoothly through Phase C.

SA Interface
(Block 33)

The NASA SA manager, supported by the contractor's SA manager, serves as a focal point for all SA efforts and activities. The technical activities of each discipline are combined with all other disciplines to provide complete management visibility in SA during Phase C.

Operating Procedures
(Block 34)

The system safety organization reviews operating procedures generated by the systems engineering organization to see that no system hazards are created through their use.

Integrated Analysis
(Block 35)

The system safety organization prepares an integrated system safety analysis using the component-subsystem analyses performed under Block 26. 3. This analysis performed in accordance with the methods described in the System Safety Plan (Block 25. 3), provides a quantification of the safety of the system.

Phase D Planning
(Block 36 &36. 1)

Planning activities are performed for the Phase D segment of the development. Data are prepared and incorporated into the RFQ based on the requirements for Phase D as dictated by the completion of Phase C. Resource requirements are identified and established, and proposals are reviewed for SA and weighed.

Plan Revision
(Block 37)

The contractor's SA plans developed at the beginning of Phase C are reviewed for correctness, revised to reflect changes in program direction that result from the completion of Phase C and should be implemented into Phase D.

Plan Approved
(Block 38)

The human engineering, maintainability,reliability, and system safety plans are approved by the respective NASA technical managers for implementation by the contractors.

SA Activities Started
(Block 39)

The SA manager makes sure that the momentum developed during Phase C carries right on through Phase D. He determines that plan approvals are accomplished promptly and that contractor activities are begun. He then makes sure that resources are properly applied and schedules are maintained. He also see that functional working relationships are maintained.

Manufacturing Support
(Block 40)

Liaison is established with manufacturing through the planning activities to assure product quality.

Logistics Requirement
(Block 41)

The maintainability organization develops logistics requirements in accordance with the plan prepared under Block 28. Required spaces are established. The maintenance tooling, checkout calibration, and test equipment requirements are released.

Analyses
(Block 42)

Each of the disciplines concludes its analyses and releases them in final documented form to demonstrate that SA goals are met.

FACI Support
(Block 43 &43. 1)

The principal use of all the analytical work accomplished by the respective disciplines is the support of FACI activities. These analyses, together with other criteria developed during the program, are used to demonstrate that:

1. The crew/machine interface is workable.
2. The system is maintainable at minimum cost.
3. The system is reliable.
4. The system is safe.

The NASA systems assurance manager together with contractor's SA manager provides strong participation in the FACI activities. He establishes a team from both the contractor's SA organization and his own for the purpose of demonstrating SA.

Operating Procedures
(Block 44)

The human engineering organization completes validation of the operating procedures. Time studies of the various crew operations are documented and published.

Maintenance Procedures
(Block 45)

Maintenance procedures are given final validation and are documented and published.

Test Program
(Block 46)

System safety reviews test procedures for possible safety impact on the system. Testing is witnessed to insure that hazards are not introduced into the system during the process.

Procedure Review
(Block 47)

The operating and maintenance procedures are given a safety review to see that warnings are properly marked and included in the correct place. Check lists for safe maintenance configurations are established as required.

Program Audit
(Block 48 &48. 1)

The NASA SA manager, supported by the contractor's SA manager and the technical manager for each discipline performs, periodically audits throughout

the entire Phase D. Problem areas are identified and resolved. Resources are adjusted as required to maintain schedules and keep the quality high.

Calibration Checkout (Block 49)

Maintenance witnesses the calibration and checkout of the system and supporting subsystems to be sure that all requirements are met.

Flight Worthiness Certificates (Block 50)

Another principal use of the analyses completed by the respective disciplines is supporting justification of vehicle flight worthiness certification. This work demonstrates that the system is both reliable and safe.

Sustaining (Block 51)

Both the human engineering and maintainability organizations initiate a sustaining effort that supports all subsequent operational activities and launch vehicles.

Component Failure Analyses (Block 52)

The reliability organization analyzes all system failures down to the component level to determine the effect of the failure on the safety of the system.

Diagnostic Analyses
(Block 53)

System safety performs diagnostic analyses of the system following an accident or incident to determine the cause, the manner of failures, the probability of reoccurence, and the method of reducing the probability of future accidents to acceptable risk levels.

Accident/Incident Investigation
(Block 54)

The accident/incident investigation activities complement the diagnostic analyses performed under Block 53. System safety personnel supported by other affected organizations accomplish the accident/incident investigation when requested to do so by the NASA SA manager.

Update Analyses
(Block 55)

The reliability and system safety analyses are updated to reflect the configuration of the next vehicle in the series to be used. The analyses become a working tool to measure the maintainability, reliability, and safety of each succeeding configuration.

Planning
(Block 56)

The technical manager for each of the four disciplines completes the planning required for the effective use of all analyses and data on insuring vehicles of a like configuration. This provides maximum system assurance efficiency at a minimum cost.

SA Integration
(Block 57)

The NASA SA manager is as the focal point for all of the four disciplines. He correlates their technical capabilities and products into a team effort and with this team, and he is equipped to provide the highest quality of management visibility in SA.

The contractor's SA manager is the center of the human engineering, maintainability, quality, reliability, and system safety functions. As such he provides strong support to the NASA SA manager in the accomplishment of his responsibilities. He also provides technical support and systems assurance visibility to his own engineering management.

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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