

## FOREWORD

This investigation was conducted for the NASA Langley Research Center by the Convair Aerospace Division of General Dynamics Corporation under Contract NAS 1-11431.

The NASA Technical Monitor was Dr. Robert E. Fulton, Head, IPAD Technology Section, Design Technology Branch, Structures and Dynamics Division, assisted by Dr. Jaroslaw Sobieszczanski and Mrs. Susan J. Voigt. The Convair Project Leader was Mr. C. A. Garrocq, assisted by Messrs. M. J. Hurley, M. Dublin, J. J. Hosek, O. E. Wheeler, R. A. Westerwick, R. H. Trelease, J. S. Barron, G. W. Bradfield, J. D. Sutliff, W. J. Moran, A. Karemaa, R. T. Schemensky, L. A. Evans, D. S. Osterle, R. G. Huntington, J. L. Howse, H. Roland, R. W. McMickle, K. C. Bonine, J. E. Meyer, R. H. Schappelle, D. Kurpiewski, S. K. Pederson, R. Howe, N. E. Tipton, A. H. Cooper, G. M. Oing, J. M. Maughmer, W. E. Jenkins, T. M. Wooster, J. C. Mallory, B. H. Oman, D. W. Peterson, P. K. Shih, D. R. Diaddigo, R. E. Kenyon, B. J. Kuchta, J. D. Neilson, J. T. Gordon, and H. W. Buckner.

The Control Data Corporation participated in the performance of this study as a subcontractor to the General Dynamics Corporation.

The period of performance was from 15 March 1972 to 30 August 1973.

## LIST OF FIGURES

| <u>Figure</u> |                                                                | <u>Page</u> |
|---------------|----------------------------------------------------------------|-------------|
| 1-1           | IPAD Study Flow Chart                                          | 2           |
| 1-2           | Major IPAD Features                                            | 4           |
| 3-1           | Conceptual Design Phase                                        | 8           |
| 3-2           | Preliminary Design Phase                                       | 11          |
| 3-3           | Functional CEP Flow Chart Form                                 | 13          |
| 3-4           | Configuration Design Process                                   | 14          |
| 3-5           | Concept Layout and Basic Design Data Development               | 17          |
| 3-6           | Parametric Configuration Concept Evaluation                    | 18          |
| 3-7           | Initial Configuration Layout                                   | 19          |
| 3-8           | Risk Assessment                                                | 20          |
| 3-9           | Trade Study Layouts                                            | 21          |
| 3-10          | Selected Configuration Layout                                  | 22          |
| 3-11          | Configuration Control Studies                                  | 23          |
| 3-12          | Configuration Description                                      | 24          |
| 3-13          | Final Configuration Control                                    | 25          |
| 3-14          | Configuration Design Studies                                   | 26          |
| 3-15          | Point Design Lift and Drag Analysis                            | 30          |
| 3-16          | Point Design Lift and Drag Analysis (With Wind Tunnel<br>Data) | 31          |
| 3-17          | Wave Drag Analysis and Optimization                            | 32          |
| 3-18          | Wing Detailed Design                                           | 33          |
| 3-19          | Airplane Propulsion Integration                                | 34          |
| 3-20          | Aerodynamic Loads                                              | 35          |
| 3-21          | Mission Performance Analyses                                   | 38          |
| 3-22          | Standard Mission Segments                                      | 39          |
| 3-23          | Acceleration Performance                                       | 40          |
| 3-24          | Climb Performance                                              | 41          |
| 3-25          | Climb and Loiter Performance                                   | 42          |
| 3-26          | Mission Fuel Calculation                                       | 43          |
| 3-27          | Aircraft Sizing Procedure                                      | 44          |
| 3-28          | Sizing and Parametric Trade Studies                            | 45          |
| 3-29          | Flight Mechanics Analyses                                      | 46          |
| 3-30          | Flight Mechanics Simulations and Analyses                      | 47          |
| 3-31          | Configuration Tradeoff Summary                                 | 48          |
| 3-32          | Mission Analysis and Performance System (MAPS)                 | 49          |
| 3-33          | Choice of Propulsion System Size and Type                      | 52          |

## LIST OF FIGURES, Contd

| <u>Figure</u> |                                                                                   | <u>Page</u> |
|---------------|-----------------------------------------------------------------------------------|-------------|
| 3-34          | Propulsion Analysis                                                               | 53          |
| 3-35          | Inlet Control System Concept                                                      | 54          |
| 3-36          | Inlet Performance                                                                 | 55          |
| 3-37          | Inlet Design                                                                      | 56          |
| 3-38          | Prediction of Flow Field at Inlet Location                                        | 57          |
| 3-39          | Selection of Compression Surface Variable Geometry<br>and Design of Subsonic Duct | 58<br>58    |
| 3-40          | Secondary Air System                                                              | 59          |
| 3-41          | Nozzle Loads                                                                      | 60          |
| 3-42          | Nozzle Selection and Performance                                                  | 61          |
| 3-43          | Installed Engine Performance Prediction                                           | 62          |
| 3-44          | Engine Cycle and Control Characteristic Selection                                 | 63          |
| 3-45          | Airbreathing Engine Cycle Analysis                                                | 64          |
| 3-46          | Adverse Weather System Analysis                                                   | 65          |
| 3-47          | Equipment Environmental Control                                                   | 66          |
| 3-48          | Air Conditioning                                                                  | 67          |
| 3-49          | Configuration Geometry Definition                                                 | 69          |
| 3-50          | Preliminary Gross Weight Estimation                                               | 70          |
| 3-51          | Development of Weight Equations                                                   | 71          |
| 3-52          | Parametric Weight Definition                                                      | 72          |
| 3-53          | Weight/Size Relationships                                                         | 73          |
| 3-54          | Point Design Weight Estimation                                                    | 74          |
| 3-55          | Mass Property Data Refinement                                                     | 75          |
| 3-56          | Trade Study Effects on Mass Properties                                            | 76          |
| 3-57          | Weights, Size, and Geometry Update                                                | 77          |
| 3-58          | Weight Minimization                                                               | 78          |
| 3-59          | Detailed Weight Estimation                                                        | 79          |
| 3-60          | Detailed Balance and Loading Data                                                 | 80          |
| 3-61          | Detailed Mass Distributions and Inertias                                          | 81          |
| 3-62          | Weight Penalties Due to Aircraft Features                                         | 82          |
| 3-63          | Cost Elements                                                                     | 83          |
| 3-64          | Weight Substantiation                                                             | 84          |
| 3-65          | Control Surface Sizing                                                            | 85          |
| 3-66          | Program TRIM-STAB                                                                 | 87          |
| 3-67          | Flight Control Simulation                                                         | 88          |

## LIST OF FIGURES, Contd

| <u>Figure</u> |                                                     | <u>Page</u> |
|---------------|-----------------------------------------------------|-------------|
| 3-68          | Catapult Performance Analysis                       | 89          |
| 3-69          | Stores Separation Analysis                          | 90          |
| 3-70          | Program LAUNCH                                      | 91          |
| 3-71          | Mission Effectiveness                               | 96          |
| 3-72          | Transport Mission Effectiveness                     | 97          |
| 3-73          | Tactical Mission Effectiveness Determination        | 98          |
| 3-74          | Strategic Mission Effectiveness Determination       | 99          |
| 3-75          | Preliminary Basing and Operations Analysis          | 100         |
| 3-76          | Availability Analysis                               | 101         |
| 3-77          | Support Assets Determination                        | 102         |
| 3-78          | Survivability Evaluation                            | 103         |
| 3-79          | Vulnerability/Survivability Evaluation              | 104         |
| 3-80          | System Analysis Studies                             | 105         |
| 3-81          | Maneuvering Aircraft Survivability Model            | 106         |
| 3-82          | Aircraft Vulnerable Area Model                      | 107         |
| 3-83          | Reliability/Safety/Supportability/Logistic Analyses | 108         |
| 3-84          | Reliability Analysis                                | 109         |
| 3-85          | Maintainability Analysis                            | 110         |
| 3-86          | Safety Analysis                                     | 111         |
| 3-87          | Logistics Analysis                                  | 112         |
| 3-88          | Total System Cost Analysis                          | 114         |
| 3-89          | First-Unit Cost Model Functions                     | 115         |
| 3-90          | Wing First Unit Cost                                | Vol. II     |
| 3-91          | Environmental Control System First-Unit Cost        | Vol. II     |
| 3-92          | Basic Tool Manufacturing Hours                      | Vol. II     |
| 3-93          | Operating Cost Estimating Methodology               | 116         |
| 3-94          | Cost Sensitivity and Design Tradeoff Analysis       | 117         |
| 3-95          | Preliminary Structural Design Criteria              | 119         |
| 3-96          | Design Critique                                     | 120         |
| 3-97          | Formulate Design Criteria                           | 121         |
| 3-98          | Preliminary Structural Layout Loads                 | 122         |
| 3-99          | Symmetric Maneuver Loads Trend Survey               | 123         |
| 3-100         | Landing/Ground Handling Loads                       | 124         |
| 3-101         | Wing Panel Point Load Distribution                  | 125         |
| 3-102         | Fatigue Loads Spectra                               | 126         |

# LIST OF FIGURES, Contd

| <u>Figure</u> |                                                                 | <u>Page</u> |
|---------------|-----------------------------------------------------------------|-------------|
| 3-103         | Fatigue Evaluation                                              | 127         |
| 3-104         | Gust Loads Analysis                                             | 128         |
| 3-105         | Loads Model Wind Tunnel Test Program Support                    | 129         |
| 3-106         | Airplane Initial Dynamics Maneuver Response<br>Envelopes        | 130         |
| 3-107         | Structural Arrangement and Concept Design Support               | 133         |
| 3-108         | Multispar Box Material and Structural Concept Trade<br>Studies  | 134         |
| 3-109         | Advanced Composite Fuselage Section Optimization                | 135         |
| 3-110         | Finite Element Fuselage Synthesis                               | 136         |
| 3-111         | Material Selection                                              | 137         |
| 3-112         | Finite Element Structural Analysis                              | 138         |
| 3-113         | Finite Element Stress and Modal Analysis                        | 139         |
| 3-114         | Fuselage Multiple Station Synthesis                             | 140         |
| 3-115         | Wing Aeroelastic Synthesis Procedure (WASP)                     | 141         |
| 3-116         | Preliminary Fatigue Analysis                                    | 142         |
| 3-117         | Fatigue Analysis for Unit Damage Data                           | 143         |
| 3-118         | Fatigue Test Evaluation and Qualification                       | 144         |
| 3-119         | Fracture Control                                                | 145         |
| 3-120         | Flaw Growth                                                     | 146         |
| 3-121         | Fracture Arrest                                                 | 147         |
| 3-122         | Nuclear Vulnerability Assessment                                | 148         |
| 3-123         | Structural Test Planning and Testing Support                    | 149         |
| 3-124         | Detailed Stress Analysis                                        | 150         |
| 3-125         | Static Aeroelasticity                                           | 156         |
| 3-126         | Aircraft Flutter Analysis and Panel Flutter                     | 157         |
| 3-127         | Aircraft Gust Response Analysis                                 | 158         |
| 3-128         | Flow of Programs, Symmetric Analysis                            | 159         |
| 3-129         | Flow of Programs, Antisymmetric Analysis                        | 160         |
| 3-130         | Aircraft Taxi and Landing Analysis                              | 161         |
| 3-131         | Acoustic and Vibrations Analysis                                | 162         |
| 3-132         | Thermal Environment and Structural Temperatures                 | 164         |
| 3-133         | Preliminary Structural Design Process                           | 165         |
| 3-134         | Preliminary Propulsion Installation Definition                  | 166         |
| 3-135         | Preliminary Landing Gear Definition                             | 167         |
| 3-136         | AGE Analysis for Preliminary Design                             | 168         |
| 3-137         | Secondary Power System Preliminary Design<br>Definition Process | 169         |
| 3-138         | Conceptual Armaments System Design Process                      | 170         |
| 3-139         | Preliminary Armament System Definition                          | 171         |

## LIST OF TABLES

| <u>Table</u>                                                 | <u>Page</u> |
|--------------------------------------------------------------|-------------|
| 3-1 Configuration Design CEP's and Computer Programs         | 15          |
| 3-2 Aerodynamics CEP's and Computer Programs                 | 27          |
| 3-3 Performance CEP's and Computer Programs                  | 36          |
| 3-4 Propulsion CEP's and Computer Programs                   | 50          |
| 3-5 Inter-Relationship of the CEP Functional Flow Charts     | Vol. II     |
| 3-6 Mass Properties CEP's and Computer Programs              | 68          |
| 3-7 Flight Control and Stability CEP's and Computer Programs | 86          |
| 3-8 Operations Research CEP's and Computer Programs          | 92          |
| 3-9 Economic Analysis CEP's and Computer Programs            | 113         |
| 3-10 Theoretical First-Unit Cost                             | 113         |
| 3-11 Areas for Cost Estimating Improvement                   | Vol. II     |
| 3-12 Structural Loads CEP's and Computer Programs            | 118         |
| 3-13 Structural Analysis CEP's and Computer Programs         | 131         |
| 3-14 Structural Dynamics CEP's and Computer Programs         | 151         |
| 3-15 Thermal Analysis CEP's and Computer Programs            | 163         |

## SUMMARY

The purpose of this study was to determine the feasibility of an IPAD system, define its operating philosophy and organization, and generate an IPAD system design featuring the best approach identified during the study.

The study was divided in two phases encompassing eight tasks. An overall study summary is reported in Volume I. The detailed results of Phase I (Tasks 1 and 2) are reported in Volumes II to V. Volume VI includes the results of Phase II (Tasks 3 to 8).

An evaluation of the design process, as viewed through the activities of various design and engineering disciplines, was performed to segregate the basic creative and evaluation procedures used in the design of an aircraft project. Volumes II and III present the results of the evaluation. This effort yielded a specific set of disciplinary functions required, and identified available automated procedures that can be used in an IPAD system. It also identified a series of procedures presently carried out by hand and further developments that are needed to automate these latter analyses and to conduct the whole design process in a more efficient, cost-effective manner. By reviewing the participation of various disciplines within a project design team, a usage philosophy was evolved whereby the user -- the engineer -- is the focal point of the IPAD concept. This concept involves two major ingredients; an Engineering Capability consisting of a battery of Operational Modules, and a Computer Software/Hardware Complex where that capability will be installed and exercised. The engineering capability is modular and will be tailored to the specific needs of the project team, while the computer complex could be essentially the same for all teams, barring differences among computing systems.

The principal mode of operation is using interactive graphics equipment. The system also includes less sophisticated interactive terminals as well as the common batch mode operation. Details can be found in Volumes III and IV.

A First Release Capability for IPAD is recommended consisting of engineering operating modules, computer systems software and required computer hardware and peripheral equipment. Details of this recommendation can be found in Volume I, Section 2.4.

This volume includes a series of Functional Flow Charts that were developed to properly identify and record the degree of participation of the disciplines considered in this feasibility study and the type of data required in the design process. A discussion of these charts is given in Volume II, Chapter 3.

## 1 INTRODUCTION

The design of a new aerospace vehicle is presently a complex, long-term process. At the onset, a set of objectives is identified in the areas of mission, weight, performance, payload, range, etc.; which are specified with a fairly good knowledge of the available design technology and constraints. The designer's goal is to minimize cost, while meeting basic project objectives. The designer possesses a fund of accumulated experience and knowledge which he applies, with intuition, to the requirements and constraints he has been given. The knowledge and experience of the designer are more and more frequently being delegated to the computer; the intuition and imagination can never be. Some of the purposes of the IPAD feasibility study were to determine what sections of the design process are amenable to automation; how much monitoring must the automation have; how can the design process be effectively organized; and, most important, how can the management/designer/engineer team members retain the visibility and control necessary to exercise their intuition and imagination in the design process.

The introduction of automation is a significant change in the design process; however, the important management aspects of this change are not only related to the technical details of engineering disciplines, programming, data bases, etc., but the key to success also depends upon managing the adaptation required of the people involved in the use of the automated process.

Automation of any process requires not only a thorough knowledge of the process, but of the pivotal factors that drive and control it. When the process involves the myriad details of project team data flow and communications, many programs and subroutines, thousands of variables, and the ramifications of computer operating system characteristics, it is easy to lose sight of the fact that it is still the designer - the engineer - who is the key driver and decision-maker in the process.

Although the various volumes of this report describe some of the considerations necessary for the technical basis needed to successfully automate the design process, the underlying, guiding philosophy has been that of providing a tool adapted to the needs of the members of a management/designer/engineer team--the ultimate users--and that is a truly useful tool. The acknowledged principle has been that the engineer and his management are generally more interested in solving the design problem than in becoming a better communicator with the computer.

The scope of the total IPAD feasibility study is illustrated in Figure 1-1. The study was divided into the following eight tasks within two study phases:

STUDY PHASE I  
7/11/66 10:00 TO

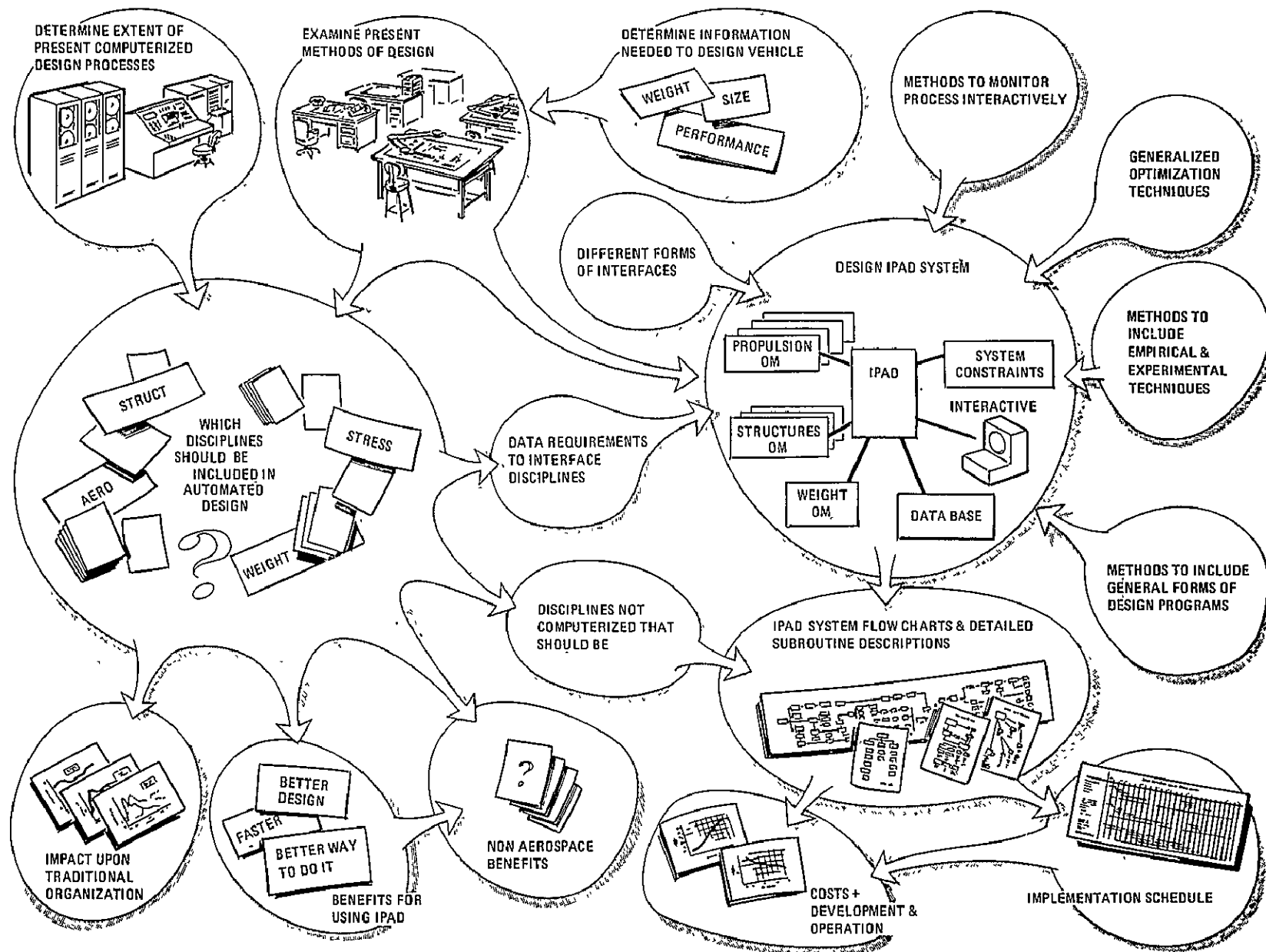


Figure 1-1. IPAD Study Flow Chart

ORIGINAL PAGE IS  
OF POOR QUALITY

## PHASE I

### STUDY PLAN COORDINATION

#### TASK 1 - CHARACTERIZATION OF IPAD SYSTEM

- Define an IPAD Engineering Usage Philosophy
- Identify Feasible Automated Design Procedures
- Evaluate Adequacy of Existing Computer Programs
- Recommend Areas for Further Development
- Determine IPAD Feasibility and Applicability
- Recommend IPAD's First Release Engineering Capability

#### TASK 2 - DESIGN OF IPAD SYSTEM

- Define a Systems Operating Philosophy
- Evaluate System Design Options
- Identify Elements of IPAD's Utility Library
- Investigate Organization and Management of Data Bank
- Determine Number and Type of Input/Output Terminals
- Determine Host Computer Complex Configurations Adequate for IPAD
- Recommend IPAD's First Release Computer System Capability

## PHASE II

#### TASK 3 - IPAD IMPLEMENTATION SCHEDULE

#### TASK 4 - IPAD SYSTEM DEVELOPMENT COST

#### TASK 5 - IPAD SYSTEM OPERATIONAL COST

#### TASK 6 - IPAD SYSTEM BENEFIT ASSESSMENT

#### TASK 7 - IPAD IMPACT ON COMPANY ORGANIZATION

#### TASK 8 - IPAD SPIN-OFF ASSESSMENT

Figure 1-2 summarizes the main features of an IPAD system as presently conceived and described elsewhere in this report.

ORIGINAL PAGE IS  
OF POOR QUALITY

**IPAD IS:**

- AN INTEGRATED SYSTEM OF AUTOMATED MODULES.  
EACH DISCIPLINE IS RESPONSIBLE FOR ITS OWN CAPABILITY DEVELOPMENT, UPDATE & GROWTH
- A USER-ORIENTED & DIRECTED MODULAR SYSTEM WITH FLEXIBILITY FOR CHANGE, ADAPTATION & EXPANSION
- A HARDWARE/SOFTWARE COMPUTER SYSTEM DESIGN APPROACH  
TO PERFORM ENGINEERING DESIGN PROCESSES MORE EFFECTIVELY, ECONOMICALLY & SWIFTLY
- A COMPUTER SYSTEM STRUCTURE  
USABLE IN MANY ENGINEERING & SCIENTIFIC FIELDS
- ITS DATA BANK IS THE REPOSITORY FOR ALL DESCRIPTIVE & INFORMATIVE DATA  
GENERATED BY THE ENGINEERING/SCIENTIFIC TEAM FOR A SPECIFIC PROJECT
- A MANAGEMENT TOOL  
TO PROVIDE IMMEDIATE VISIBILITY INTO PRODUCT STATUS & PROGRESS
- INITIALLY, A REASONABLE ENGINEERING CAPABILITY (SET OF AUTOMATED MODULES) MOUNTED ON A STATE OF THE ART HARDWARE/SOFTWARE STRUCTURE  
THAT CAN BE READILY IMPLEMENTED
- ULTIMATELY, A COMPREHENSIVE, DYNAMIC ENGINEERING TOOL SUPPORTED BY  
EFFICIENT, COST-EFFECTIVE HARDWARE/SOFTWARE CAPABILITY
- AN EDUCATIONAL AID FOR TRAINING NEW ENGINEERS IN THE USE OF VARIOUS  
DESIGN PROCESSES

**IPAD IS NOT:**

- A SINGLE, HARDWIRED COMPUTER PROGRAM
- AN AUTOMATED, SINGLE-PURPOSE PROCEDURE
- A DISLOCATED ARRAY OF RANDOMLY COLLECTED COMPUTER PROGRAMS
- A SYSTEM OF PROGRAMS TO BE RUN BY A SINGLE DISCIPLINE
- A SYSTEM OF PROGRAMS IMPOSED BY AN AGENCY (OR COMPANY) ON THE  
AEROSPACE INDUSTRY COMMUNITY

Figure 1-2. Major IPAD Features

## 2 THE IPAD SYSTEM DESIGN. OBJECTIVES

The overall goal of IPAD is the automation of appropriate sections of the design process to shorten design time, reduce cost, and improve the ultimate product.

The objectives of the present study were to:

- Develop IPAD's Operational Philosophy
- Establish Extent of IPAD Support of the Design Process
- Investigate System Organizational Options
- Determine the Feasibility of an IPAD System
- Generate an IPAD System Design
- Recommend IPAD's First Release Capability

A series of studies were performed in pursuit of these objectives including the following:

### 1. Design Process

- a. Characterize the design process dividing it in various design phases, and segregate the basic functions performed by several representative design/engineering disciplines in each phase.
- b. Identify the interdisciplinary data flow for manual/automated procedures and man-machine interfaces occurring in the design process.
- c. Evaluate the adequacy of existing computer programs and operating modules for use in IPAD.
- d. Define an IPAD usage philosophy from the engineering user point of view.
- e. Identify optimization techniques to be included within an IPAD system.
- f. Recommend IPAD's first release engineering capability.

### 2. Computer System.

- a. Define the system operating philosophy and evaluate system design options.
- b. Investigate the organization and management of the Data Bank.
- c. Identify and describe the software elements of a Utility Library for IPAD.
- d. Determine the number and type of Input/Output Terminals.
- e. Determine host Computer Hardware/Software Complex configurations adequate for IPAD.
- f. Evaluate language and size limitations of existing operational modules.
- g. Recommend IPAD's first release computer system capability.

### 3 DESIGN PROCESS FLOW CHARTS

This section presents flow charts of the design process for aircraft and of pertinent Creative/Evaluation Processes as discussed in Volume II, Chapter 3 of this report.

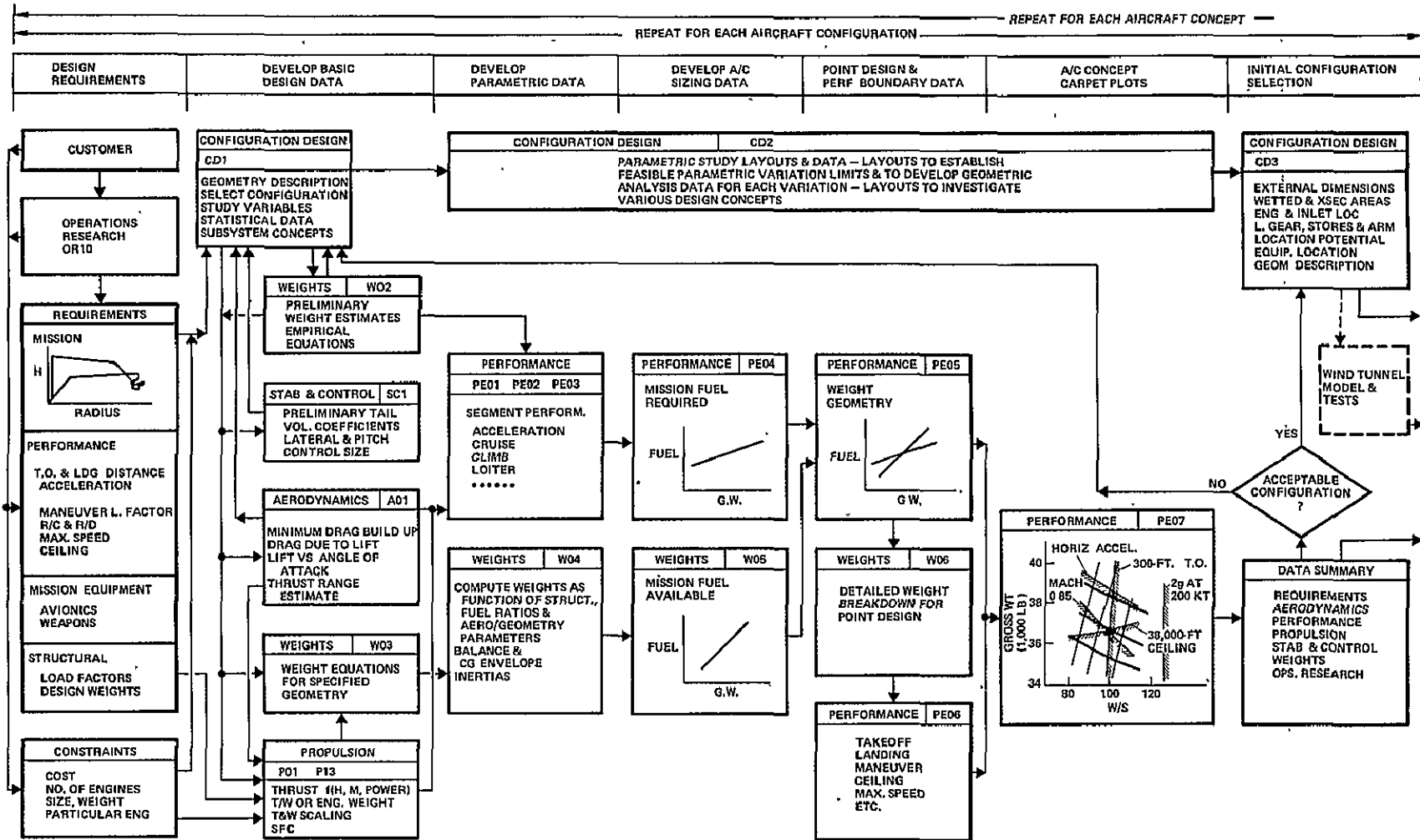


Figure 3-1. Conceptual Design Phase, Continued

 ORIGINAL PAGE IS  
 OF POOR QUALITY

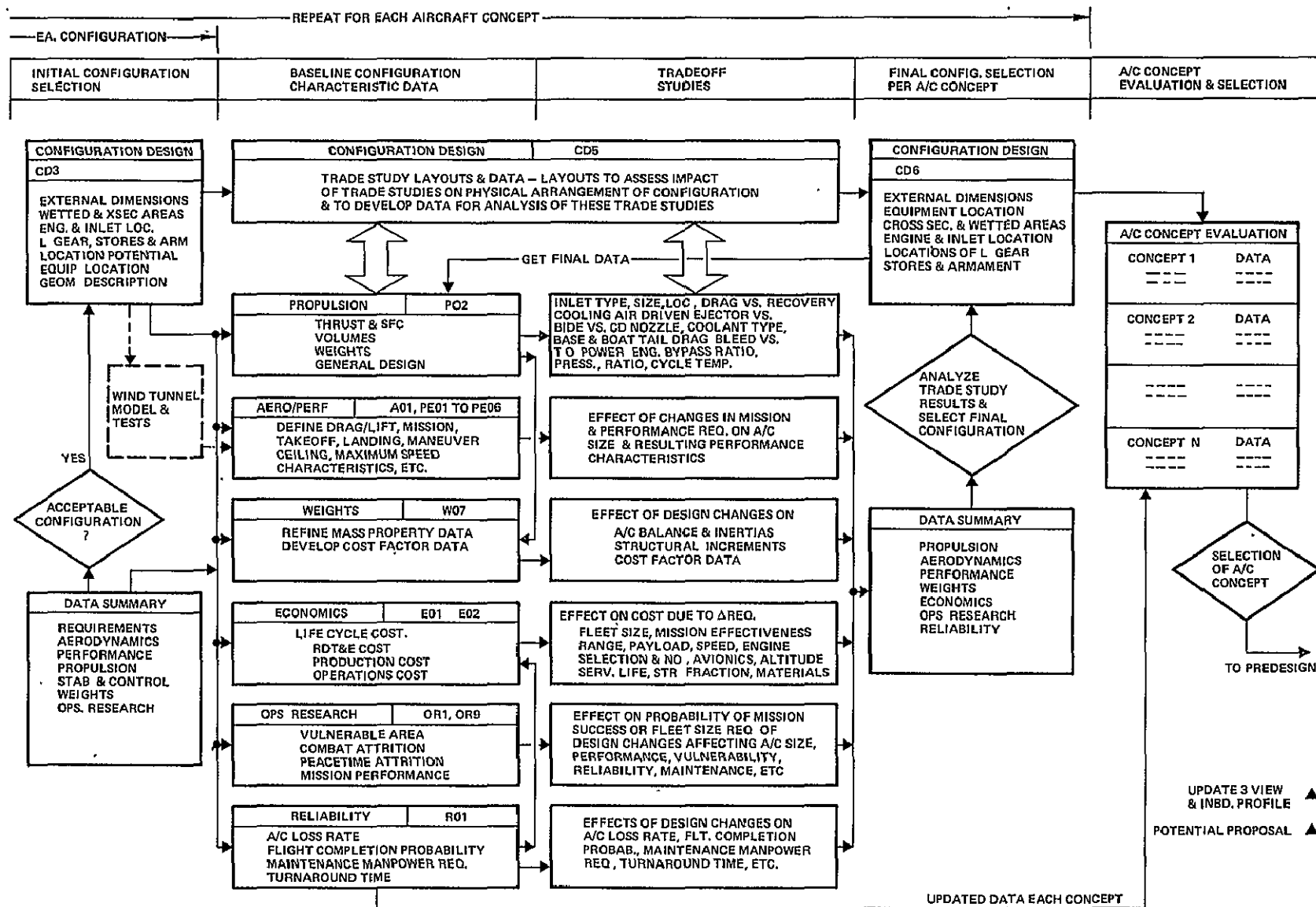


Figure 3-1. Conceptual Design Phase, Concluded.



# Creative/Evaluation Process (CEP)

DISCIPLINE: \_\_\_\_\_ DESIGN PHASE: \_\_\_\_\_

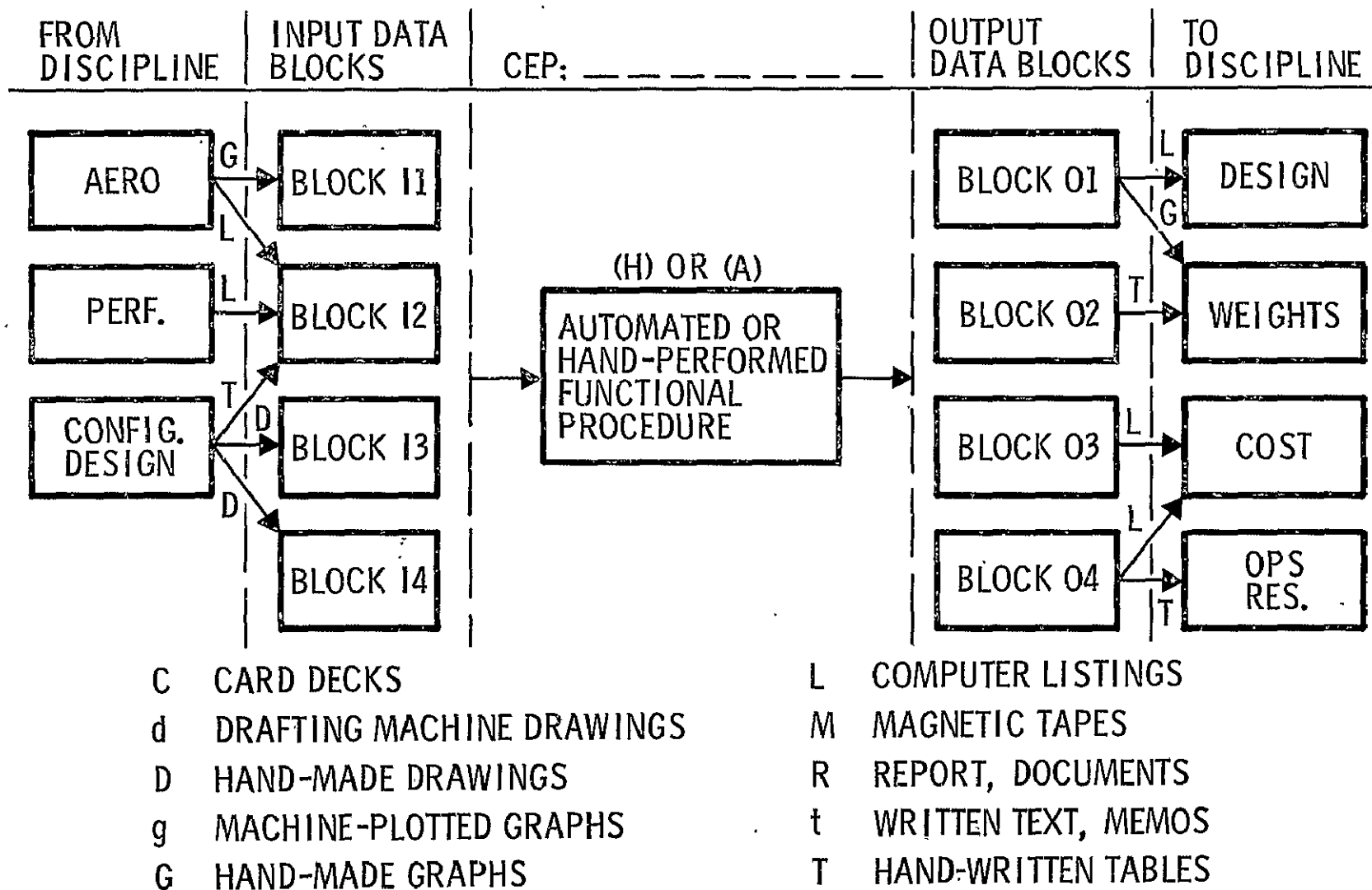


Figure 3-3. Functional CEP Flow Chart Form

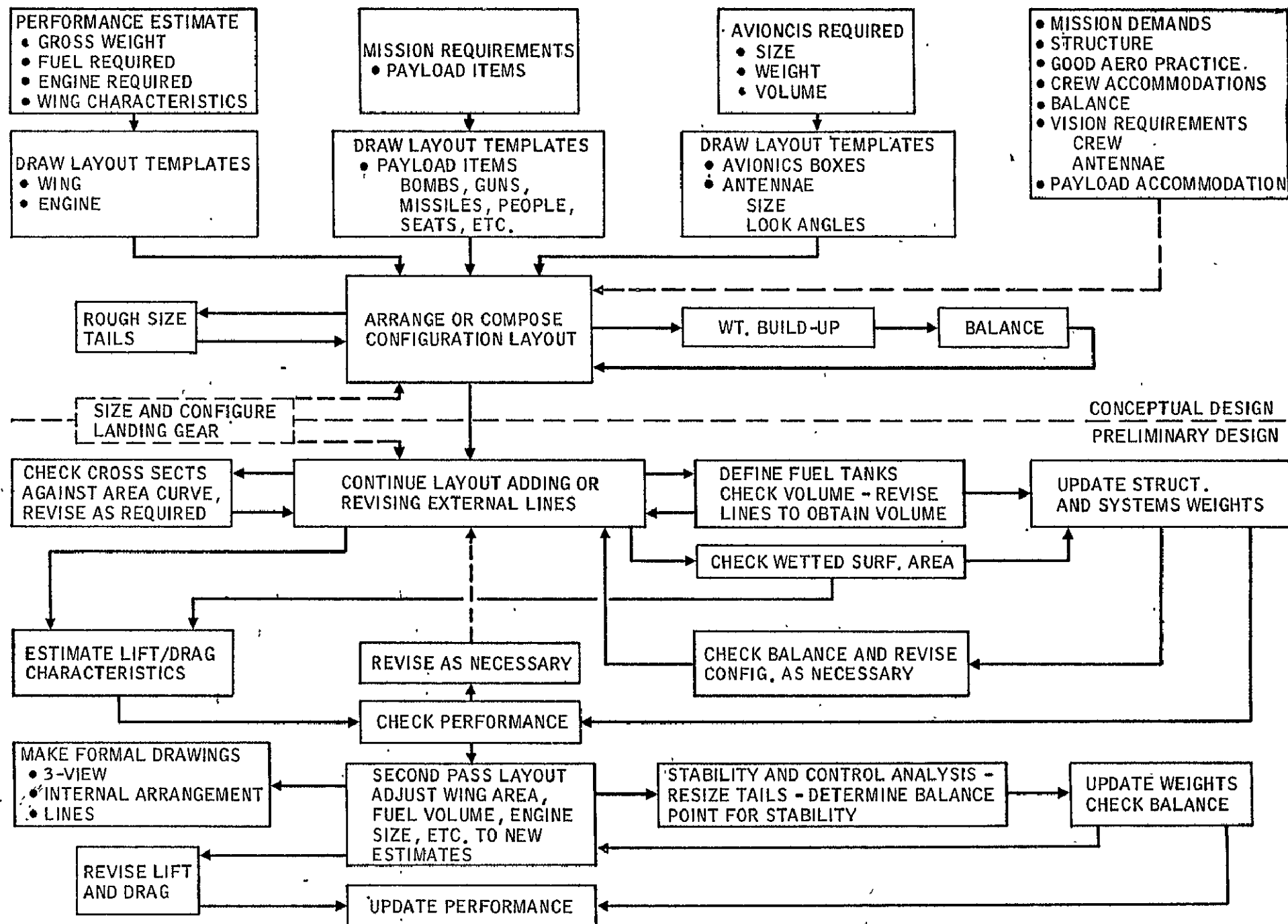


Figure 3-4. Configuration Design Process

TABLE 3-1. CONFIGURATION DESIGN CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                                                                                                                                                            | CEP  | Design Phase |    |    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------|----|----|
|                                                                                                                                                                                                                  |      | C            | PD | DD |
| Develop Layouts of Concepts and Basic Design Data                                                                                                                                                                | CD1  | x            |    |    |
| Parametric Evaluation of Configuration Concept                                                                                                                                                                   | CD2  | x            |    |    |
| Initial Configuration Layouts                                                                                                                                                                                    | CD3  | x            |    |    |
| Perform Risk Assessment                                                                                                                                                                                          | CD4  | x            |    |    |
| Develop Layouts for Trade Studies                                                                                                                                                                                | CD5  | x            |    |    |
| Selected Configuration Layouts                                                                                                                                                                                   | CD6  | x            |    |    |
| Perform Configuration Control Studies                                                                                                                                                                            | CD7  |              | x  |    |
| Provide Concept Configuration Description                                                                                                                                                                        | CD8  |              | x  |    |
| Final Configuration Control Studies                                                                                                                                                                              | CD9  |              | x  |    |
| Configuration Design Studies                                                                                                                                                                                     | CD10 | x            | x  |    |
| <u>COMPUTER PROGRAMS</u>                                                                                                                                                                                         |      |              |    |    |
| Wings, Tails, Airfoil Surfaces:                                                                                                                                                                                  |      | x            | x  |    |
| Various lines programs for fixed and variable sweep wings, fixed and all movable tails, canards, etc.                                                                                                            |      |              |    |    |
| Input: Area, aspect ratio, taper ratio, sweep, airfoil ordinates, camber ordinates, twist, pivot pin location and angle.                                                                                         |      |              |    |    |
| Output: Planview and front of surface element lines, section cuts through surface spanwise, chordwise, or at any skewed angle, print out of cross-sectional area and surface arc length or wetted surface areas. |      |              |    |    |
| Control Surfaces & High Lift Devices                                                                                                                                                                             |      | x            | x  |    |
| Input: Planview and front view location of hinge lines, shape dimensions and ordinates of surfaces such as flap, vanes, slats, ailerons, etc., and angle of rotation or movement.                                |      |              |    |    |
| Output: Planview, front view, and cross section cuts through the surfaces at prescribed rotated or translated conditions.                                                                                        |      |              |    |    |

TABLE 3-1. CONFIGURATION DESIGN CEP'S AND COMPUTER PROGRAMS (CONT'D)

| COMPUTER PROGRAMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | CEP | Design Phase |    |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |     | C            | PD | DD |
| <p>Fuselages, Nacelles, Bodies, etc.</p> <p>Various programs to describe the surface lines with real or pseudo polyconic surface description.</p> <p>Input: Bay start and end stations, points and slopes for the control lines (five for each polyconic surface), points and slopes for the cross section area curve (if the area curve is to control the shape), station to be cut.</p> <p>Output: Planview and side view of all control lines and cross section cuts at prescribed stations, print-out of all surface ordinates, cross section area and arc-lengths or wetted surface area.</p> |     | x            | x  |    |
| <p>Inlets and Ducts</p> <p>Input: Inlet throat shape and size, engine compressor face diameter, center line of duct, and flow cross sectional area distribution from throat to compressor face.</p> <p>Output: Duct lines, planview, side view and cross section cuts at prescribed stations, cross-sectional area distribution, arc lengths or wetted duct surface area, and print-out of all point coordinates.</p>                                                                                                                                                                              |     | x            | x  |    |

ORIGINAL PAGE IS  
OF POOR QUALITY

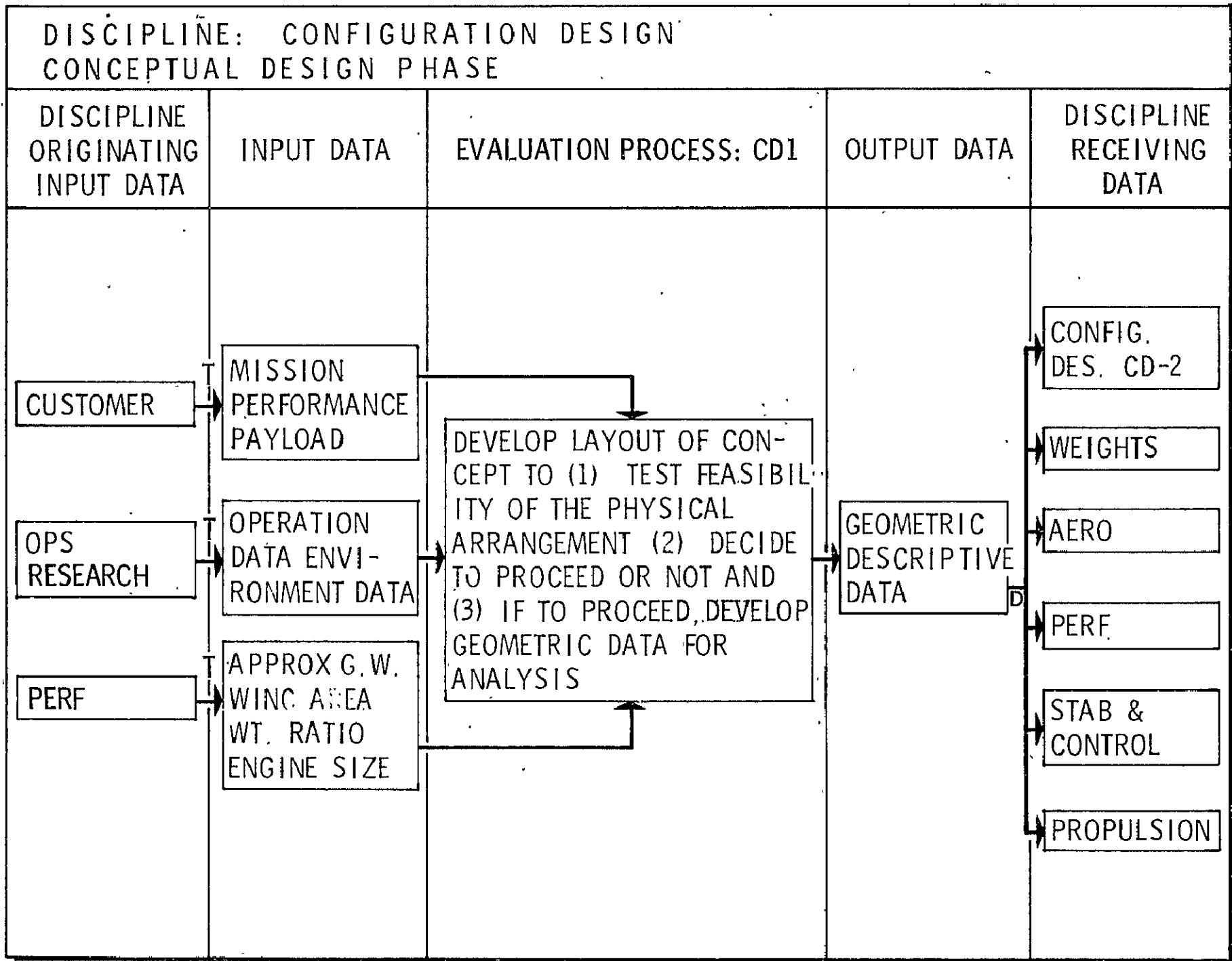


Figure 3-5. Concept Layout and Basic Design Data Development

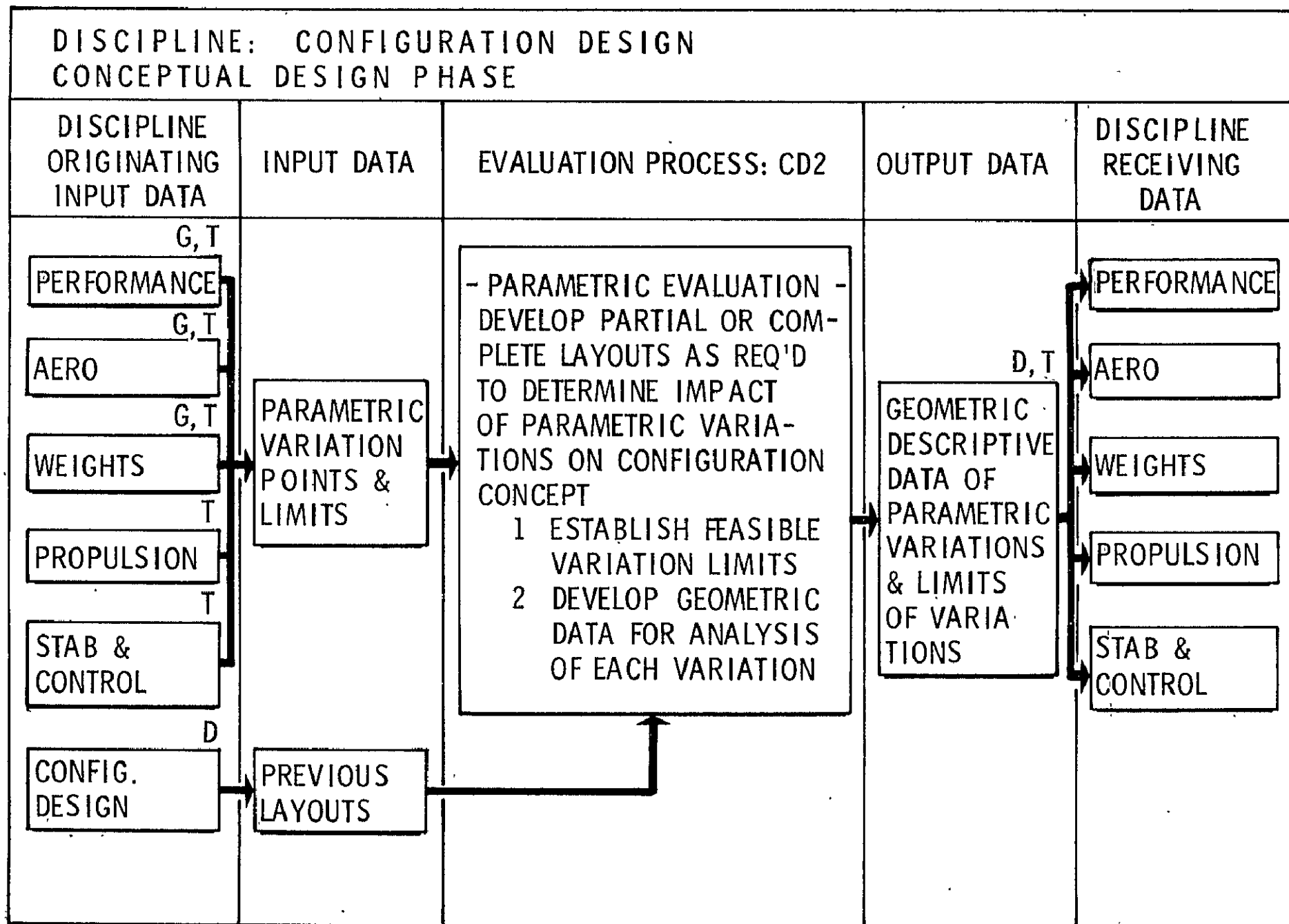


Figure 3-6. Parametric Configuration Concept Evaluation,

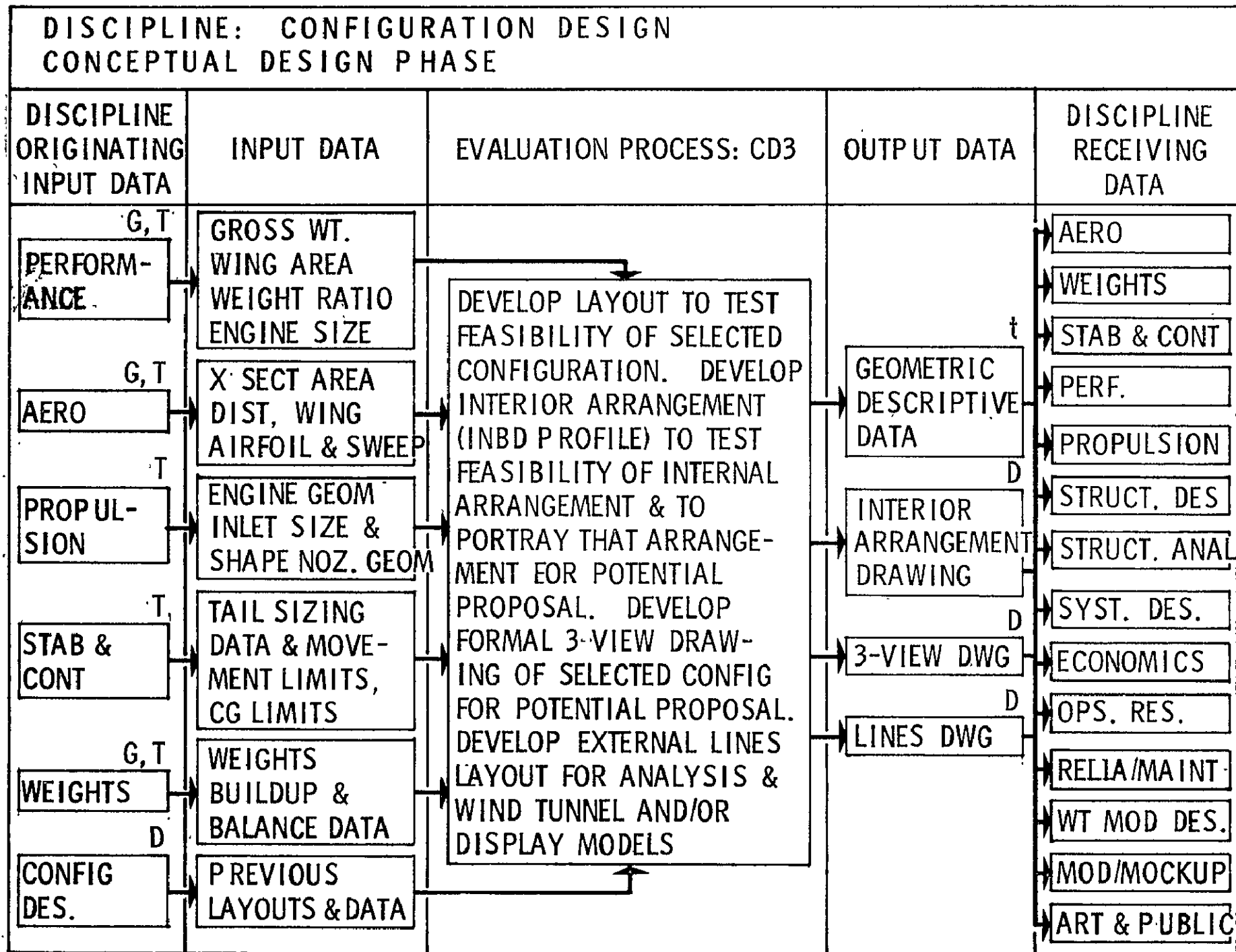


Figure 3-7. Initial Configuration Layout

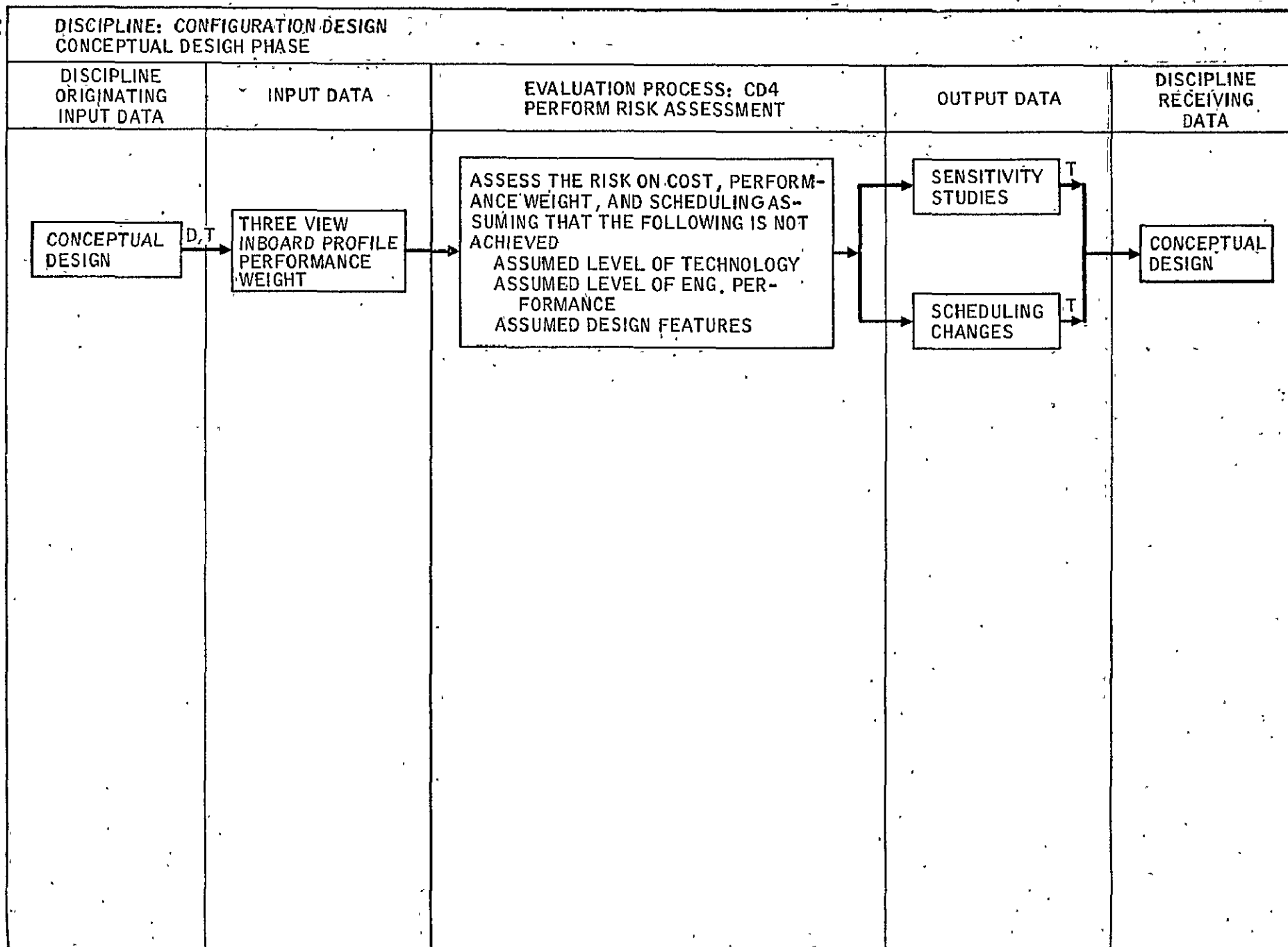


Figure 3-8. Risk Assessment

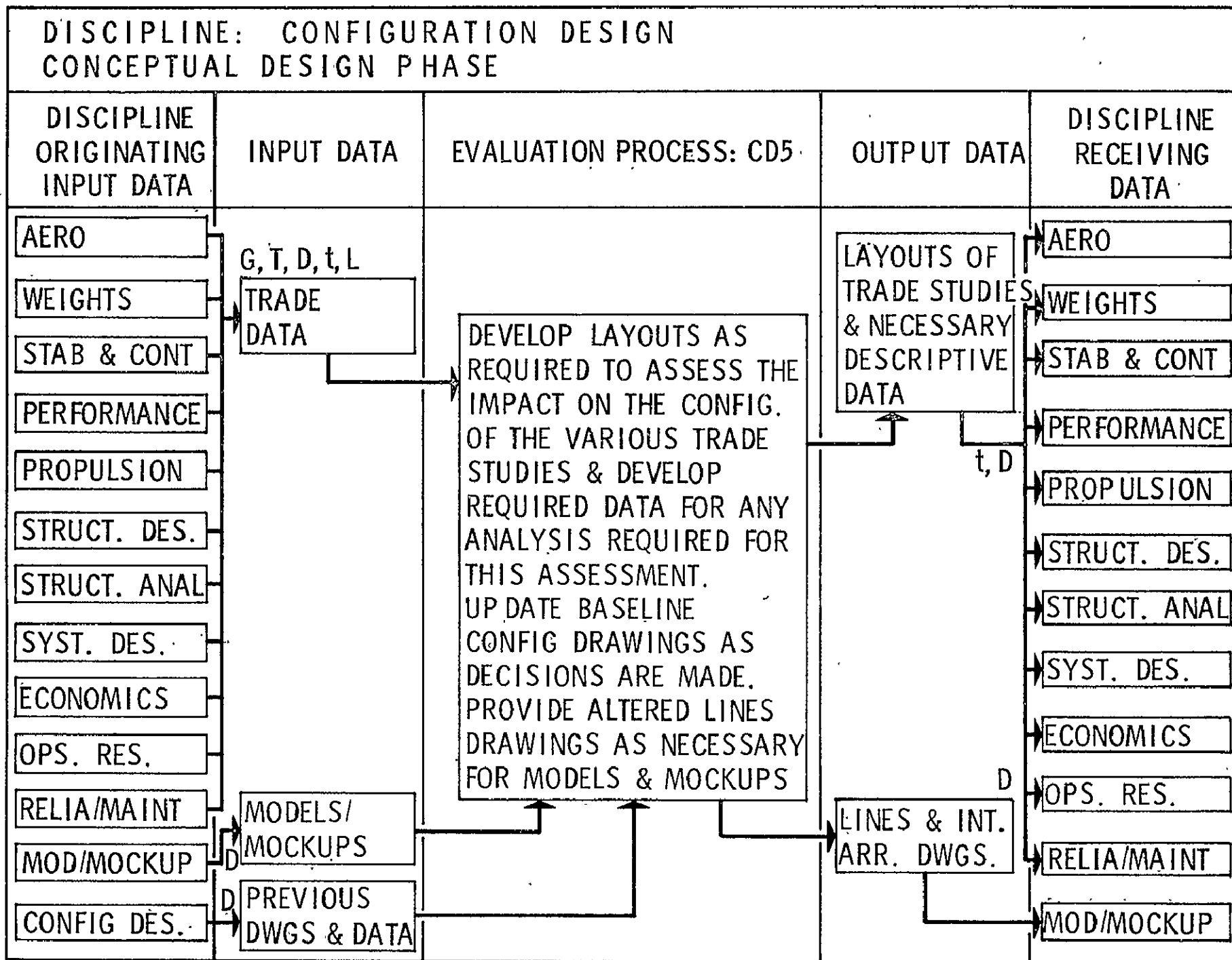
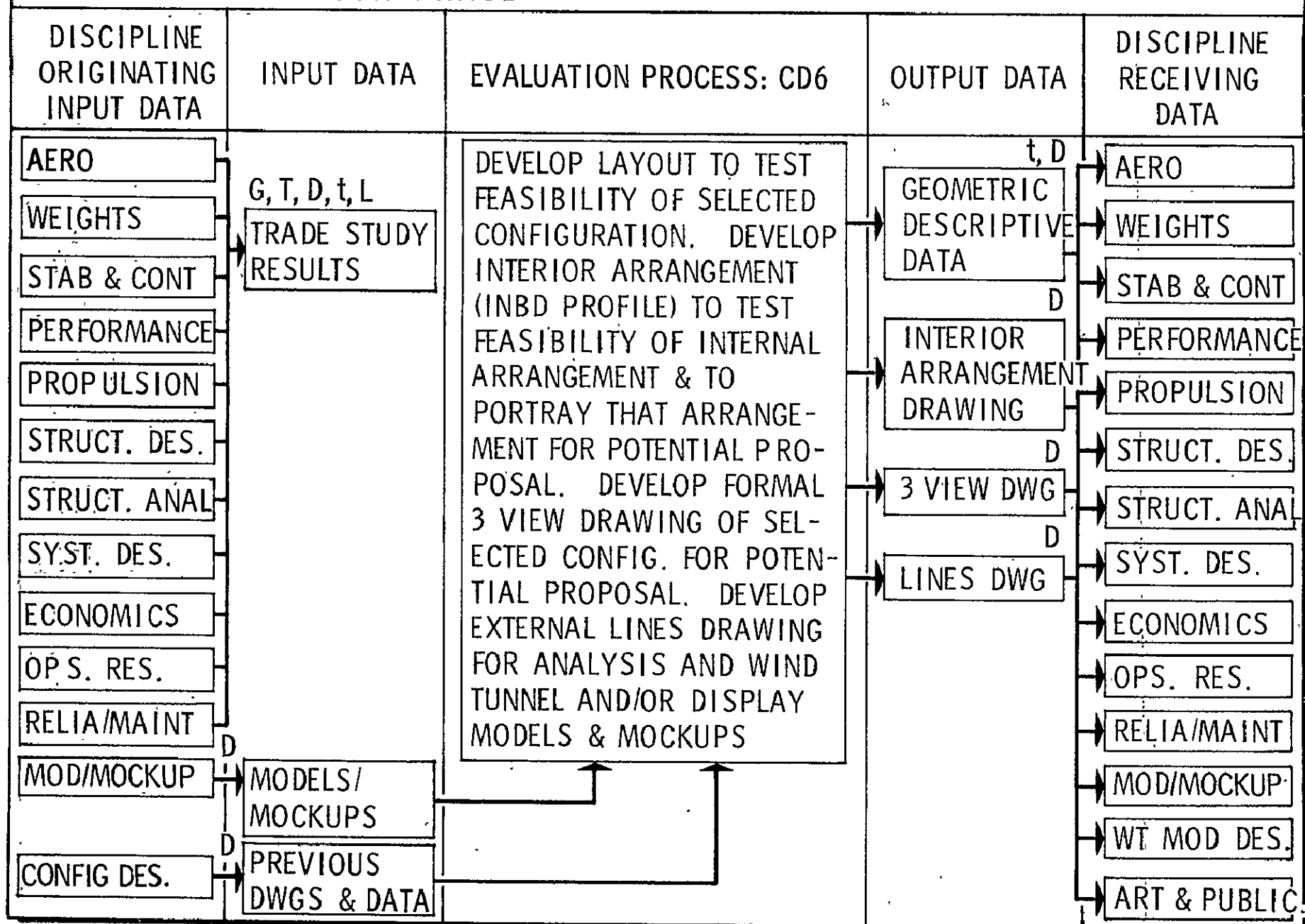


Figure 3-9. Trade Study Layouts

# DISCIPLINE: CONFIGURATION DESIGN CONCEPTUAL DESIGN PHASE



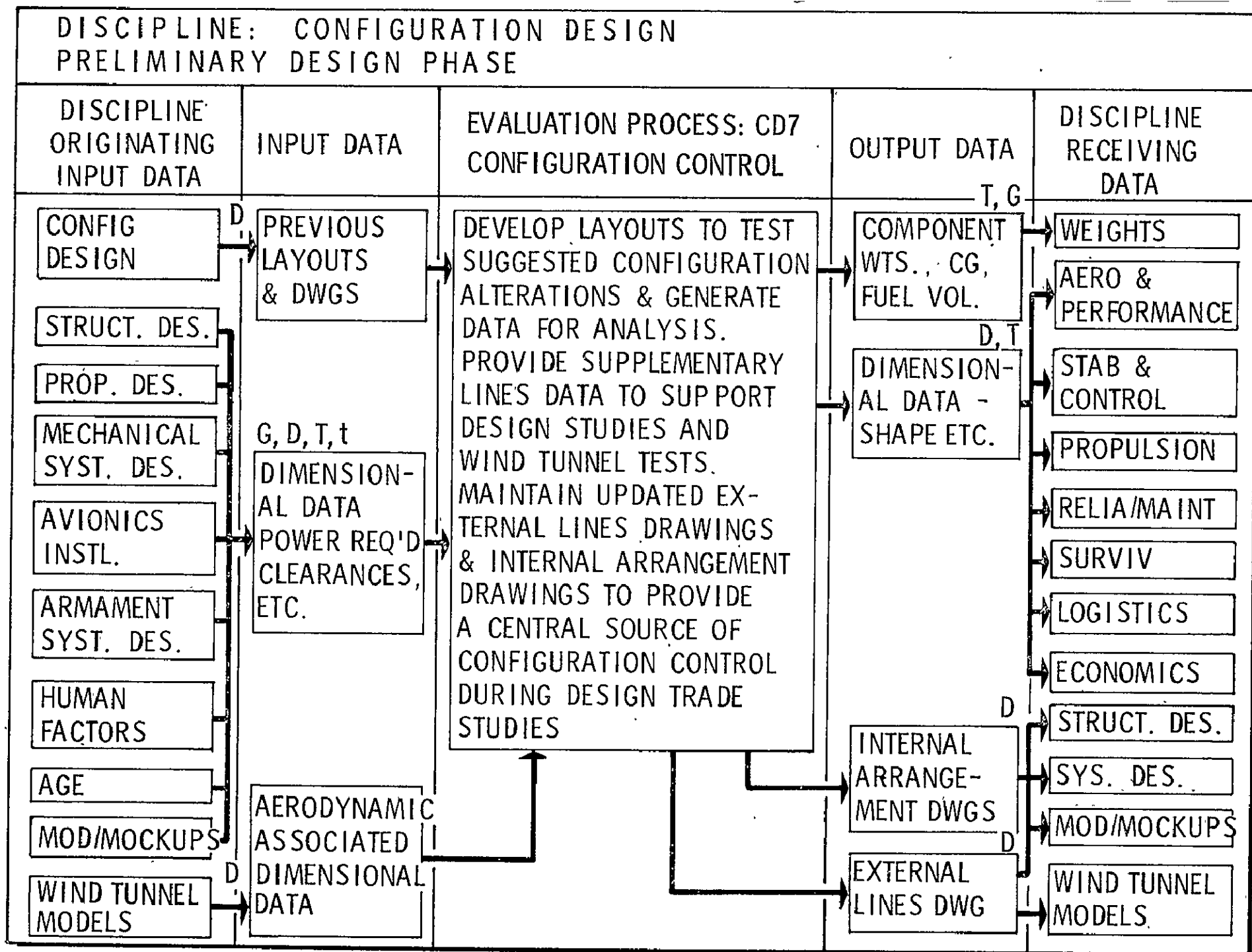
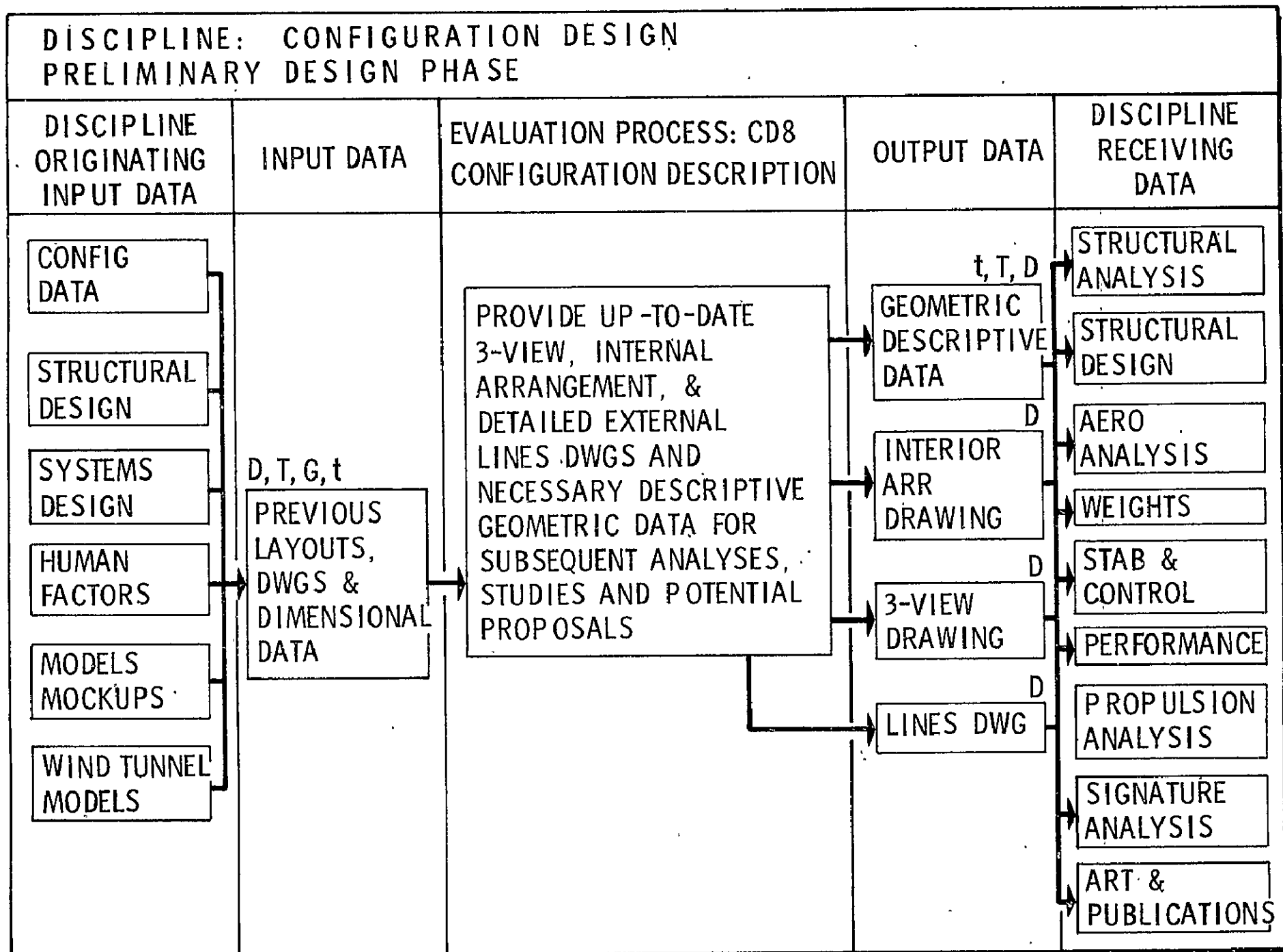


Figure 3-11. Configuration Control Studies



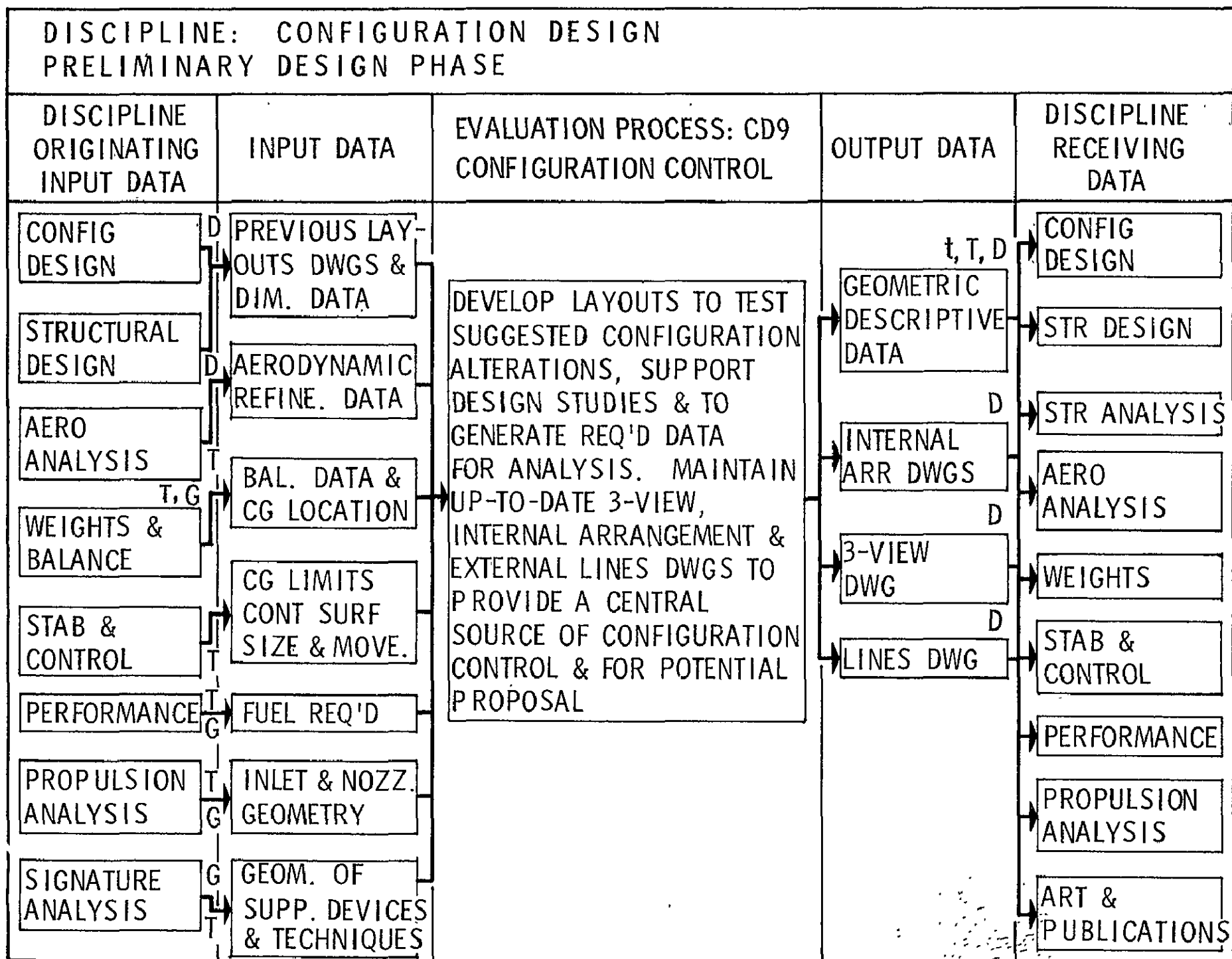


Figure 3-13. Final Configuration Control

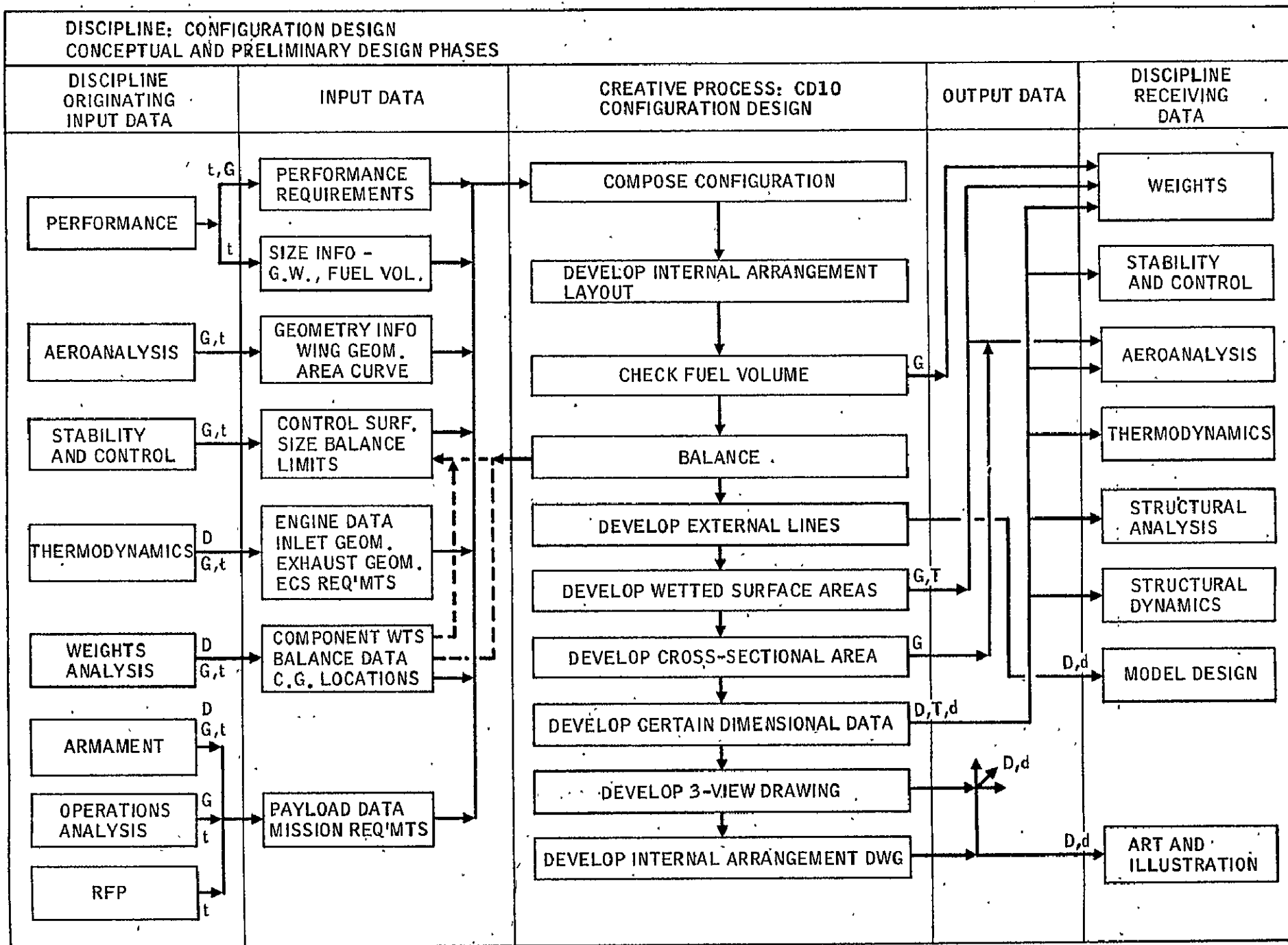


TABLE 3-2. AERODYNAMICS CEP'S AND COMPUTER PROGRAMS

| TASKS                                                          | CEP | Design Phase |    |    |
|----------------------------------------------------------------|-----|--------------|----|----|
|                                                                |     | C            | PD | DD |
| Point design drag and lift analysis                            |     | x            | x  | x  |
| Parametric trade studies                                       |     | x            | x  |    |
| Trim drag analysis                                             |     |              | x  | x  |
| Low speed takeoff and landing aerodynamic analysis             |     | x            | x  | x  |
| Buffet analysis                                                |     |              | x  | x  |
| Sonic boom analysis                                            |     |              | x  | x  |
| Wave drag analysis and minimization                            |     | x            | x  | x  |
| Detailed drag analysis of aircraft roughness and protuberances |     |              |    | x  |
| Airframe-propulsion integration (inlet, diverter, nozzle)      |     |              | x  | x  |
| Wind tunnel planning and test monitoring                       |     |              | x  | x  |
| Wind tunnel data analysis                                      |     |              | x  | x  |
| Wing detailed design                                           |     |              | x  | x  |
| High lift system design                                        |     |              |    | x  |
| Wing load analysis                                             |     |              | x  | x  |
| External store load analysis                                   |     |              |    | x  |
| External surface load analysis                                 |     |              |    | x  |
| Wind tunnel load data reduction                                |     |              | x  | x  |

TABLE 3-2. AERODYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

| COMPUTER PROGRAMS         |                                                                                                                                                                        | CEP | Design Phase |    |    |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                           |                                                                                                                                                                        |     | C            | PD | DD |
| P5401                     | Combat Aircraft Synthesis Program                                                                                                                                      |     | x            | x  |    |
| SPADE                     | Conceptual design aircraft synthesis program. Computes geometry, aerodynamics, weights and performance.                                                                |     | x            |    |    |
| AA20                      | Drag Calculation Procedure                                                                                                                                             |     | x            |    |    |
| AeroModule                | Aerodynamic characteristics (lift, drag, etc.) of aircraft either as perturbations of known characteristics or as the result of internal methods.                      |     |              | x  |    |
| NASA-Carlson              | Determines supersonic pressure distributions and loads on wings or arbitrary planform and warped surface or wing/body/tail combinations.                               |     |              | x  | x  |
| NASA-Friedman             | Sonic boom propagation through a non-homogenous atmosphere with considerations of acceleration and maneuvering.                                                        |     |              | x  | x  |
| NASA-Carlson              | Far field, sonic boom calculations for specific aircraft based on area rule and lift distribution.                                                                     |     |              | x  | x  |
| NASA-Harris               | Calculates zero lift wave drag of arbitrary aircraft and optimizes configuration for minimum wave drag.                                                                |     |              | x  | x  |
| Douglas-Cebeci and Smith  | 2-D axisymmetric laminar/turbulent boundary layer parameters.                                                                                                          |     |              | x  | x  |
| NASA-Charmichael Woodward | Superposition of singularities over finite elements to represent arbitrary 3-D wing-body-tail combinations in subsonic and supersonic flow.                            |     |              | x  | x  |
| Wing Design               | Wing design and analysis including induced drag, isobar mapping, and integrated pressure drag. Uses linear superposition of Charmichael or Woodward procedure results. |     |              | x  | x  |

TABLE 3-2. AERODYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

| <u>COMPUTER PROGRAMS</u>  |                                                                                                                                                                              | CEP | Design Phase |    |    |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                           |                                                                                                                                                                              |     | C            | PD | DD |
| Douglas-Gentry            | Hypersonic Arbitrary Body Program                                                                                                                                            |     |              | x  | x  |
| Vortex Lattice            | Vortex lattice method to represent the potential lifting flow about arbitrary, multi-element, 3-D cambered surfaces.                                                         |     |              |    | x  |
| Distributed Singularities | 2-D inviscid and viscous flow about multi-element airfoils up to maximum lift.                                                                                               |     |              | x  | x  |
| Non-Linear Span Load      | Uses nonlinear section data to predict 3-D characteristics of wings with high lift devices. An iterative procedure is used to obtain the circulation along the lifting line. |     |              | x  | x  |
| Powered Lift              | Empirical prediction method for generalized powered-lift applications.                                                                                                       |     |              | x  | x  |

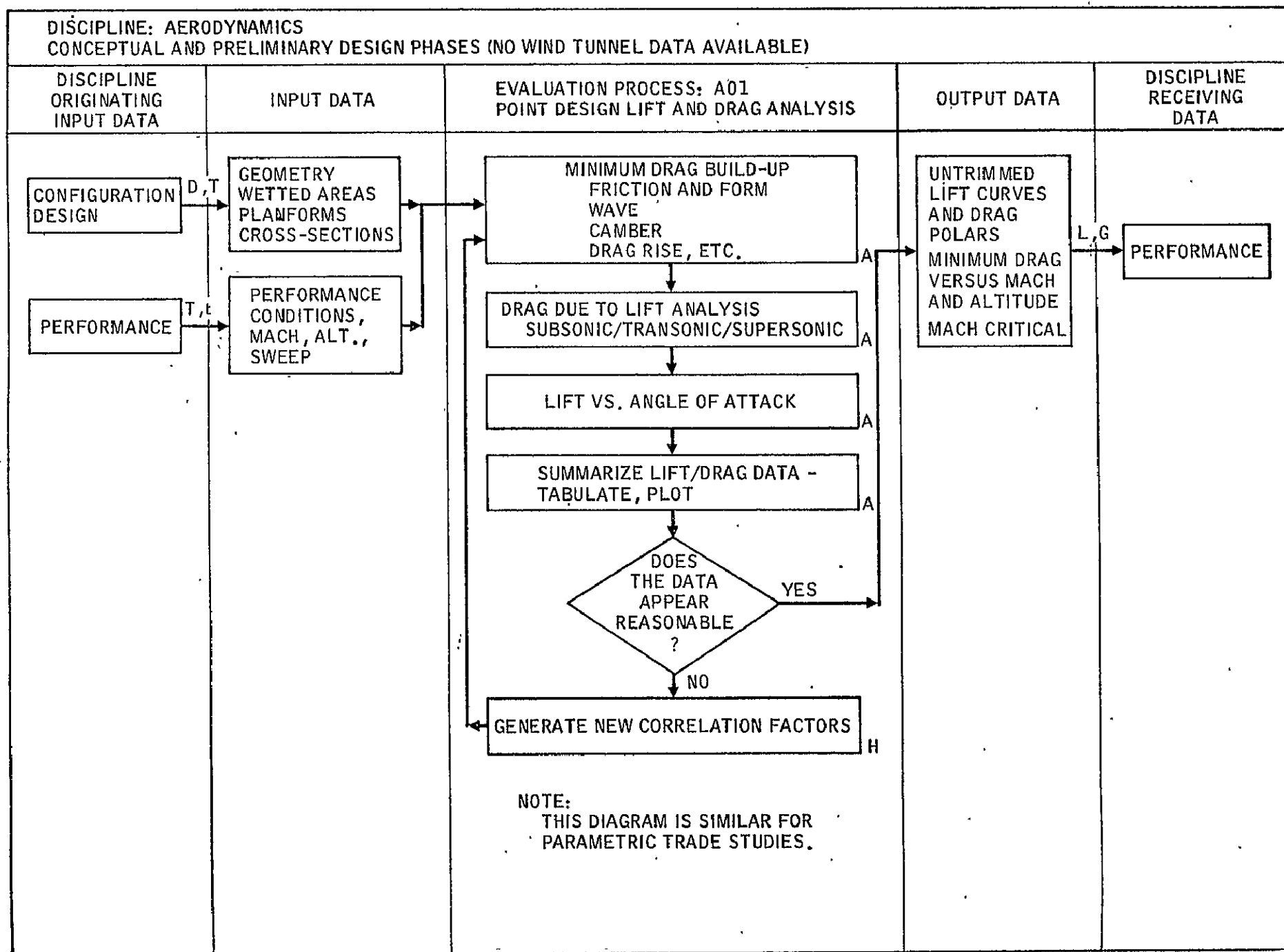


Figure 3.15 Point Design Lift and Drag Analysis (No Wind Tunnel Data)

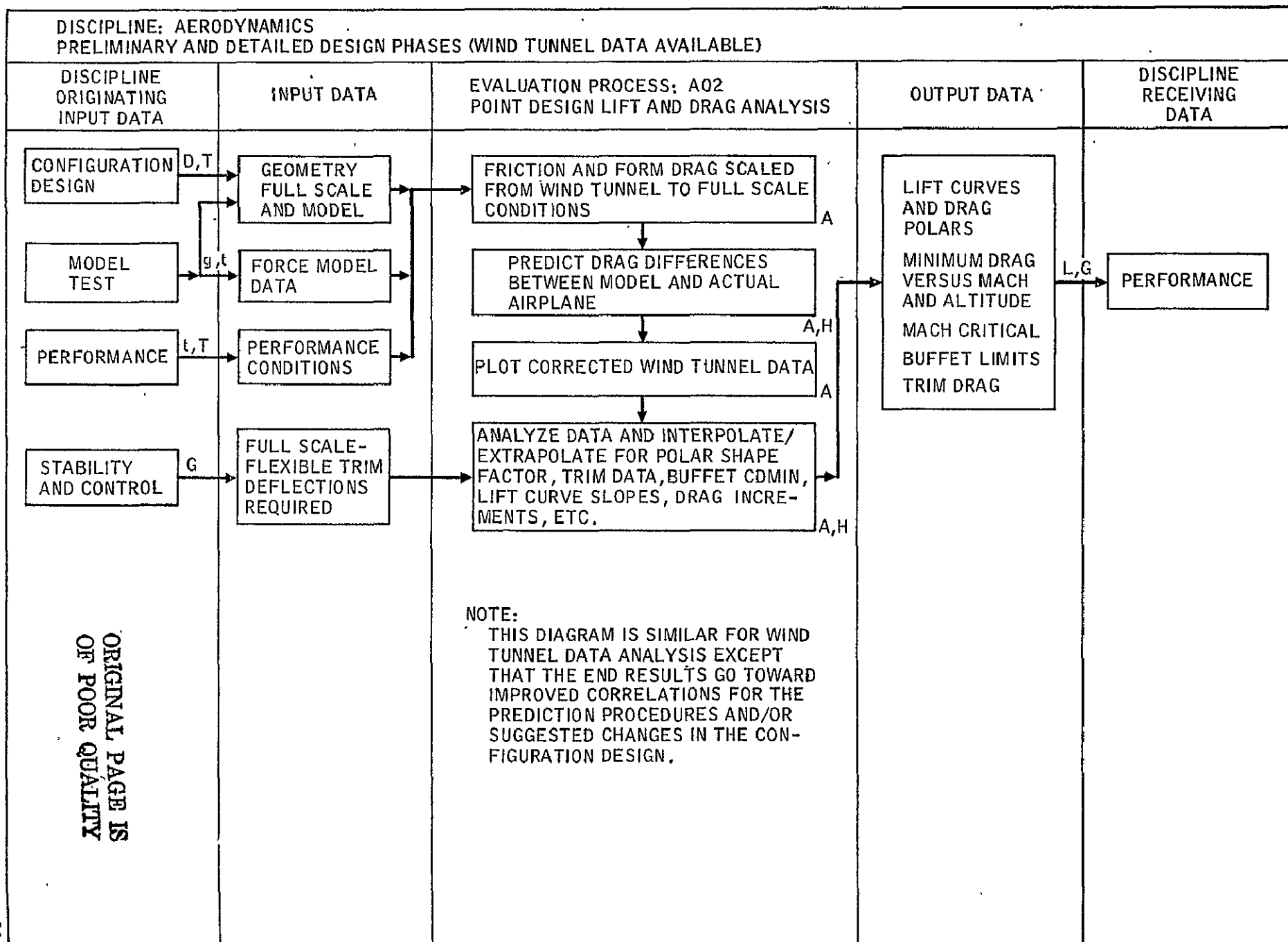


Figure 3-16. Point Design Lift and Drag Analysis (With Wind Tunnel Data)

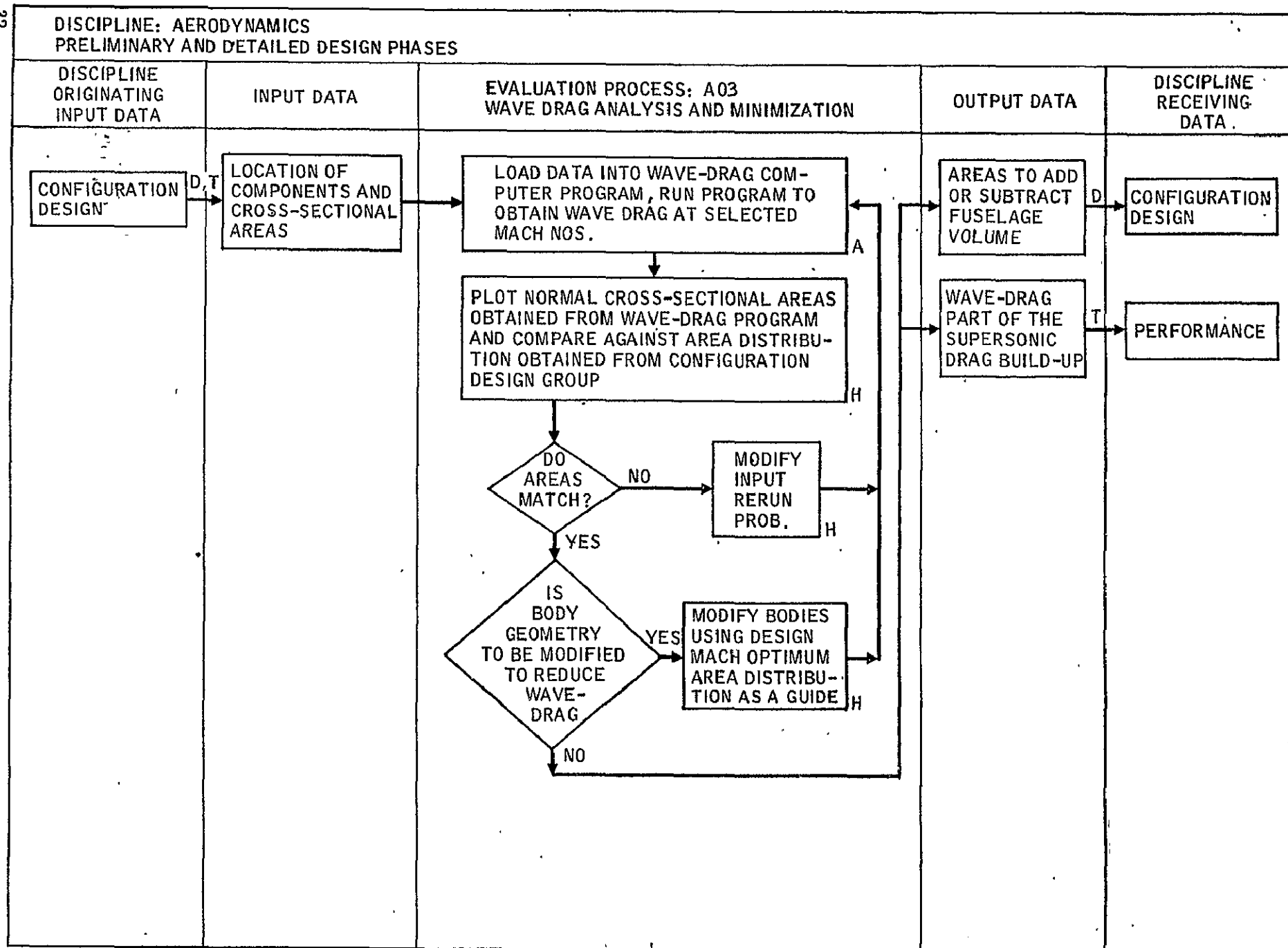


Figure 3-17. Wave Drag Analysis and Optimization

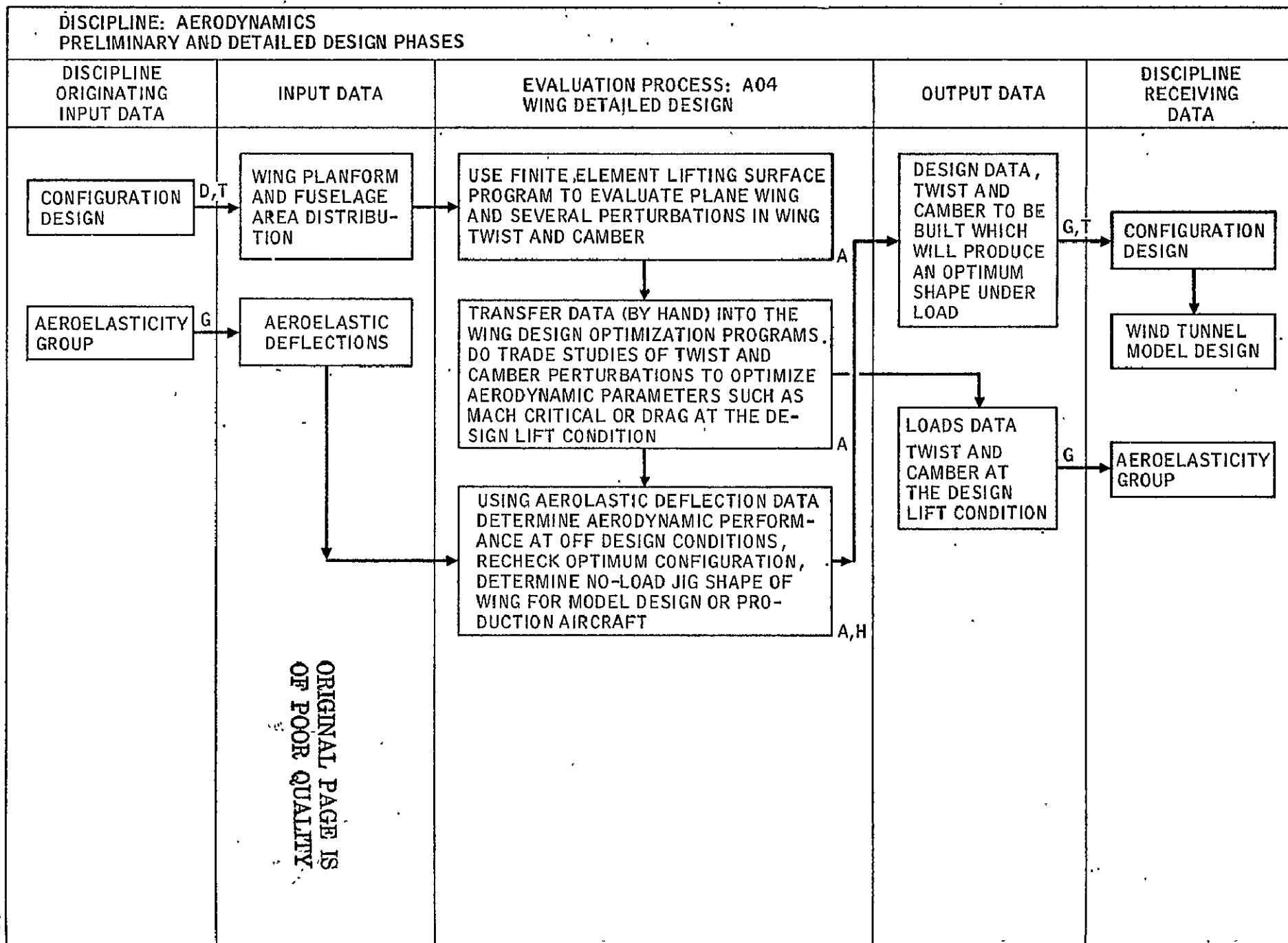
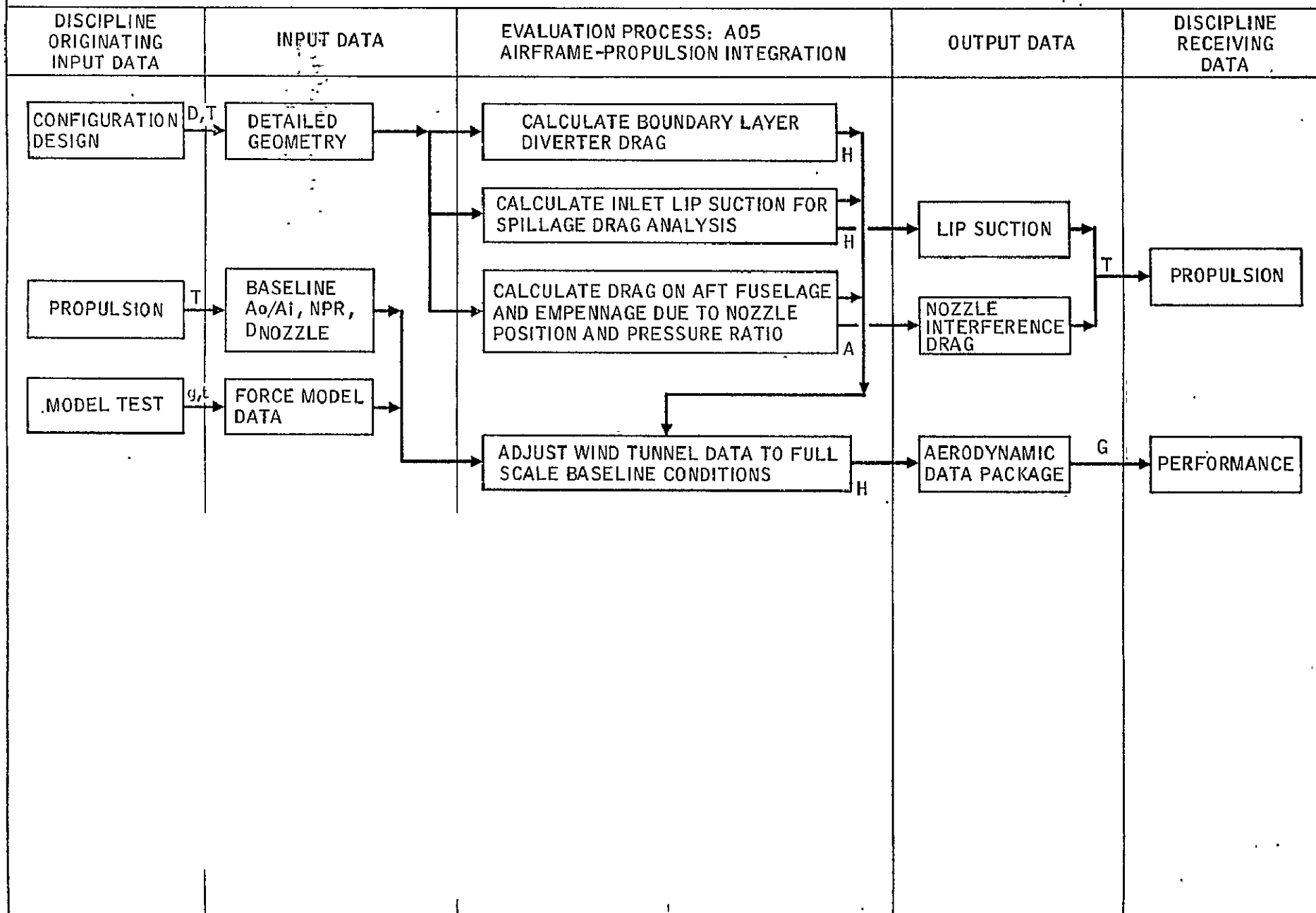


Figure 3-18. Wing Detailed Design

DISCIPLINE: AERODYNAMICS  
PRELIMINARY AND DETAILED DESIGN PHASES



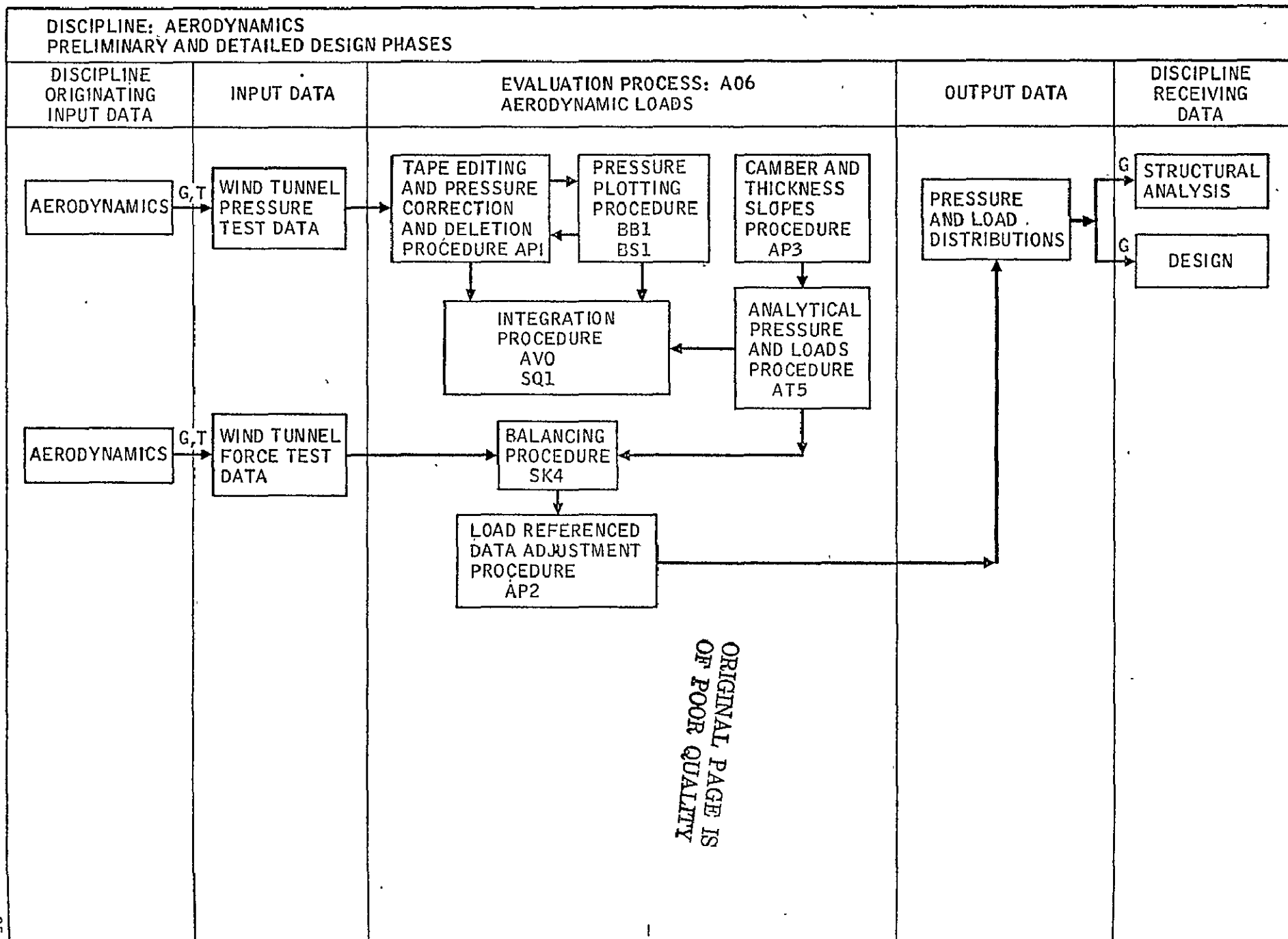


Figure 3-20. Aerodynamic Loads

TABLE 3-3. PERFORMANCE CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                           | CEP                                            | Design Phase |    |    |
|---------------------------------------------------------------------------------|------------------------------------------------|--------------|----|----|
|                                                                                 |                                                | C            | PD | DD |
| Concept Selection                                                               |                                                | x            |    |    |
| Mission Performance Analyses                                                    |                                                |              |    |    |
| Acceleration                                                                    | PE01                                           | x            | x  | x  |
| Climb                                                                           | PE02                                           | x            | x  | x  |
| Cruise and Loiter                                                               | PE03                                           | x            | x  | x  |
| Deceleration                                                                    |                                                | x            | x  | x  |
| Refuel                                                                          |                                                | x            | x  | x  |
| Combat                                                                          |                                                | x            | x  | x  |
| Descent                                                                         |                                                | x            | x  | x  |
| Mission Fuel Calculation                                                        | PE04                                           | x            | x  | x  |
| Sizing and Parametric Trade Studies                                             | PE05                                           |              |    |    |
| Engine cycle, number, size, location                                            |                                                | x            | x  |    |
| Wing size, planform, section                                                    |                                                | x            | x  |    |
| Mission and payload                                                             |                                                | x            | x  | x  |
| Subsystems                                                                      |                                                | x            | x  | x  |
| Materials and structural concepts                                               |                                                | x            | x  |    |
| Flight Mechanics Simulations and Analyses                                       | PE06                                           |              |    |    |
| Landing and takeoff                                                             |                                                | x            | x  | x  |
| Maneuverability                                                                 |                                                | x            | x  | x  |
| Air-to-air combat                                                               |                                                |              | x  | x  |
| Terrain-following                                                               |                                                |              | x  | x  |
| Dynamic flight path optimization                                                |                                                |              | x  | x  |
| Etc.                                                                            |                                                |              |    |    |
| Provide Summary Charts to Project Management,<br>Systems Analysis, and Customer | PE07                                           | x            | x  | x  |
| <u>COMPUTER PROGRAMS</u>                                                        |                                                |              |    |    |
| SYNAC                                                                           | Large scale fighter aircraft synthesis program |              | x  |    |
| SSS-1                                                                           | Space shuttle flyback system synthesis program |              | x  |    |
| MAPS                                                                            | Mission analysis and performance system        |              | x  | x  |
| IMP                                                                             | General aircraft mission integration program   |              | x  | x  |

TABLE 3-3. PERFORMANCE CEP'S AND COMPUTER PROGRAMS (CONT'D)

| CEP                                                            | Design Phase |    |    |
|----------------------------------------------------------------|--------------|----|----|
|                                                                | C            | PD | DD |
| <u>COMPUTER PROGRAMS</u> (Continued)                           |              |    |    |
| LWF Mission Program, Air Vehicle Model TRAP, ATF Mission Prog. |              | x  | x  |
| TAPER, AC6                                                     |              | x  | x  |
| MACE                                                           |              | x  | x  |
| ATAC                                                           |              | x  | x  |
| GROPE                                                          |              | x  | x  |
| P5401                                                          | x            | x  | x  |
| AA21                                                           | x            |    |    |
| AA33                                                           | x            |    |    |
| AA23                                                           | x            |    |    |
| AA32                                                           | x            |    |    |
| AA22                                                           | x            |    |    |
| AA34                                                           |              |    |    |

10/24/74  
7/11/74

U.S. AIR FORCE  
 WRIGHT-PATTERSON AIR FORCE BASE  
 OHIO 45433-6150

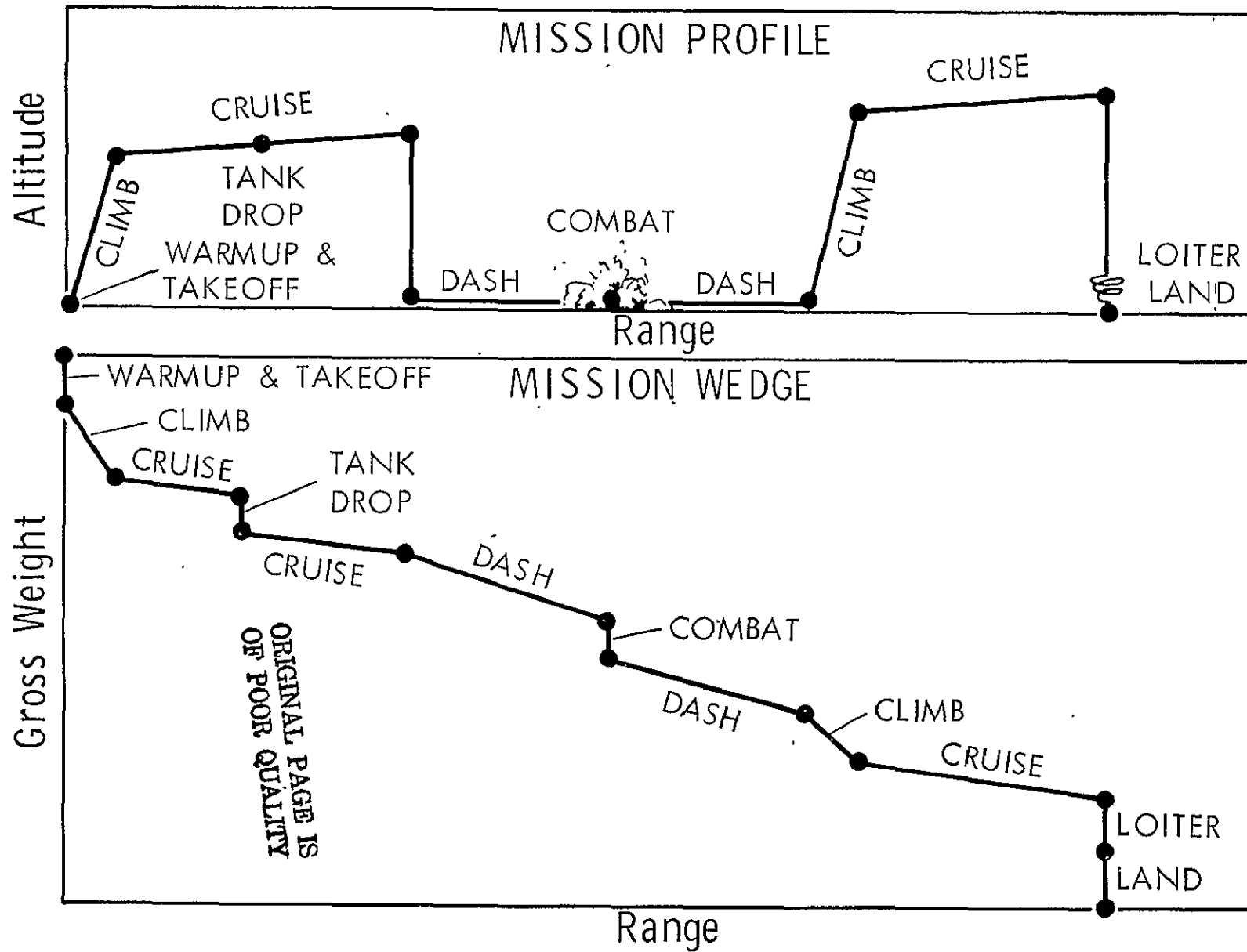
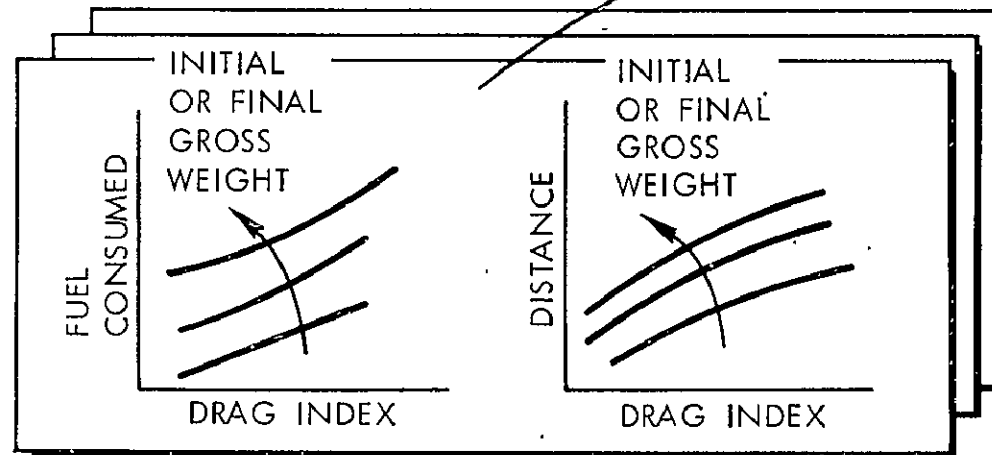


Figure 3-21. Mission Performance Analyses

- TAKEOFF
- LANDING
- DROP
- CRUISE
- DASH
- COMBAT
- LOITER
- CLIMB
- DESCENT
- ACCELERATION
- DECELERATION
- REFUEL

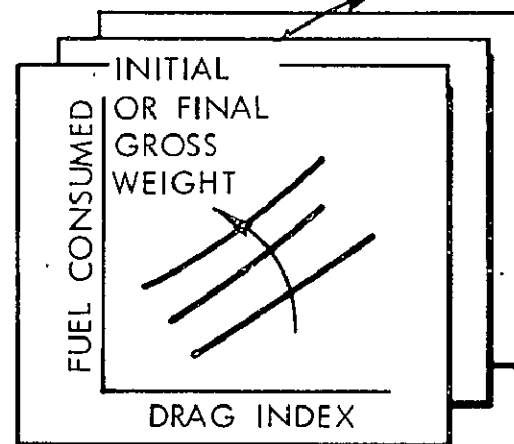
CLIMB, DESCENT, ACCEL, DECEL

Schedule



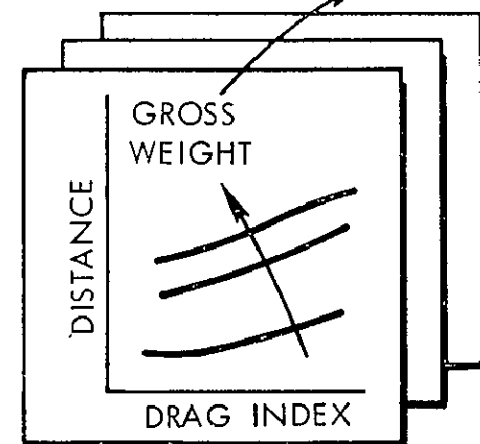
COMBAT, LOITER

Time



CRUISE, DASH

Mach



ORIGINAL PAGE IS  
OF POOR QUALITY

Figure 3-22. Standard Mission Segments

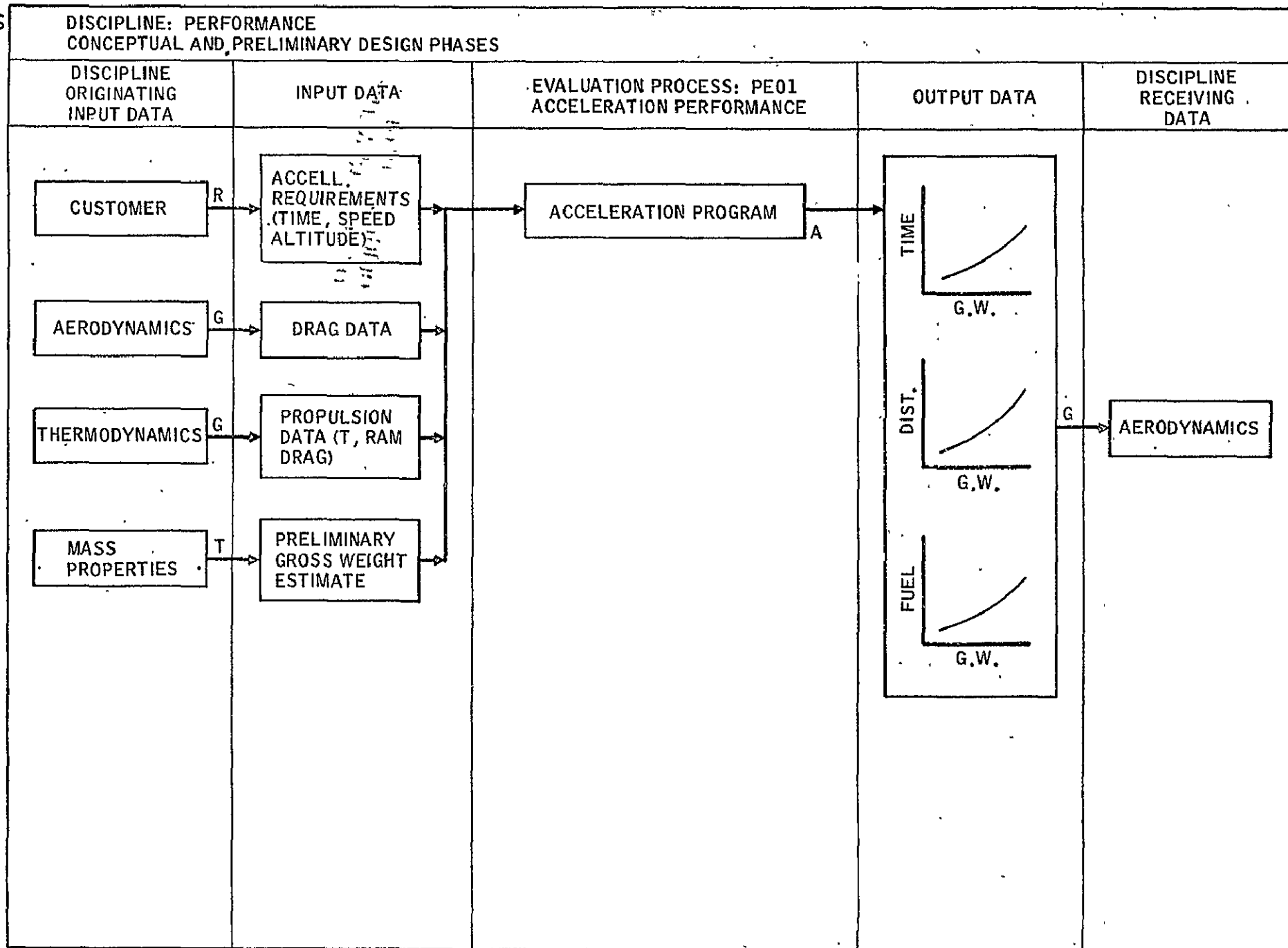


Figure 2.22 Acceleration Performance

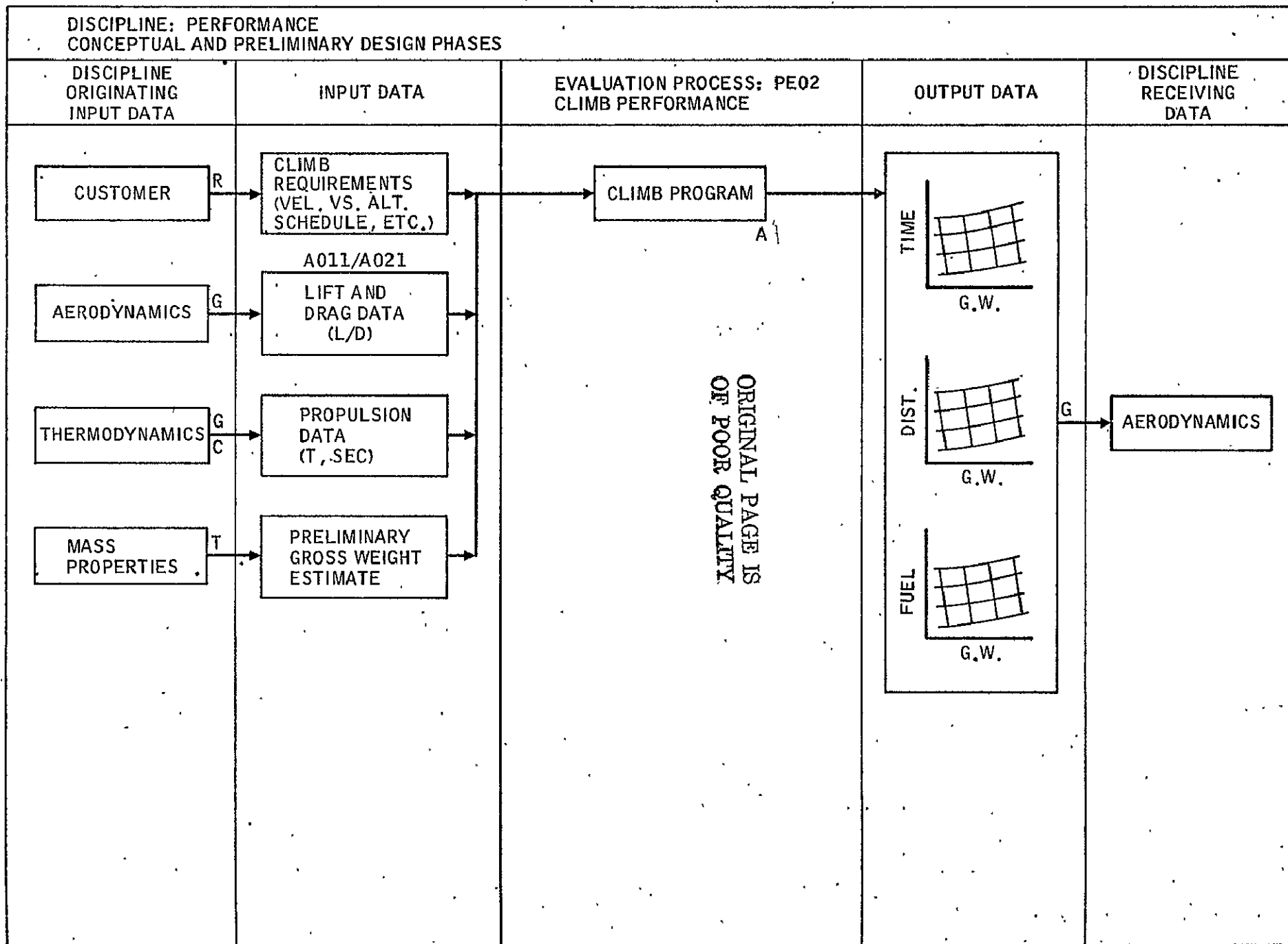
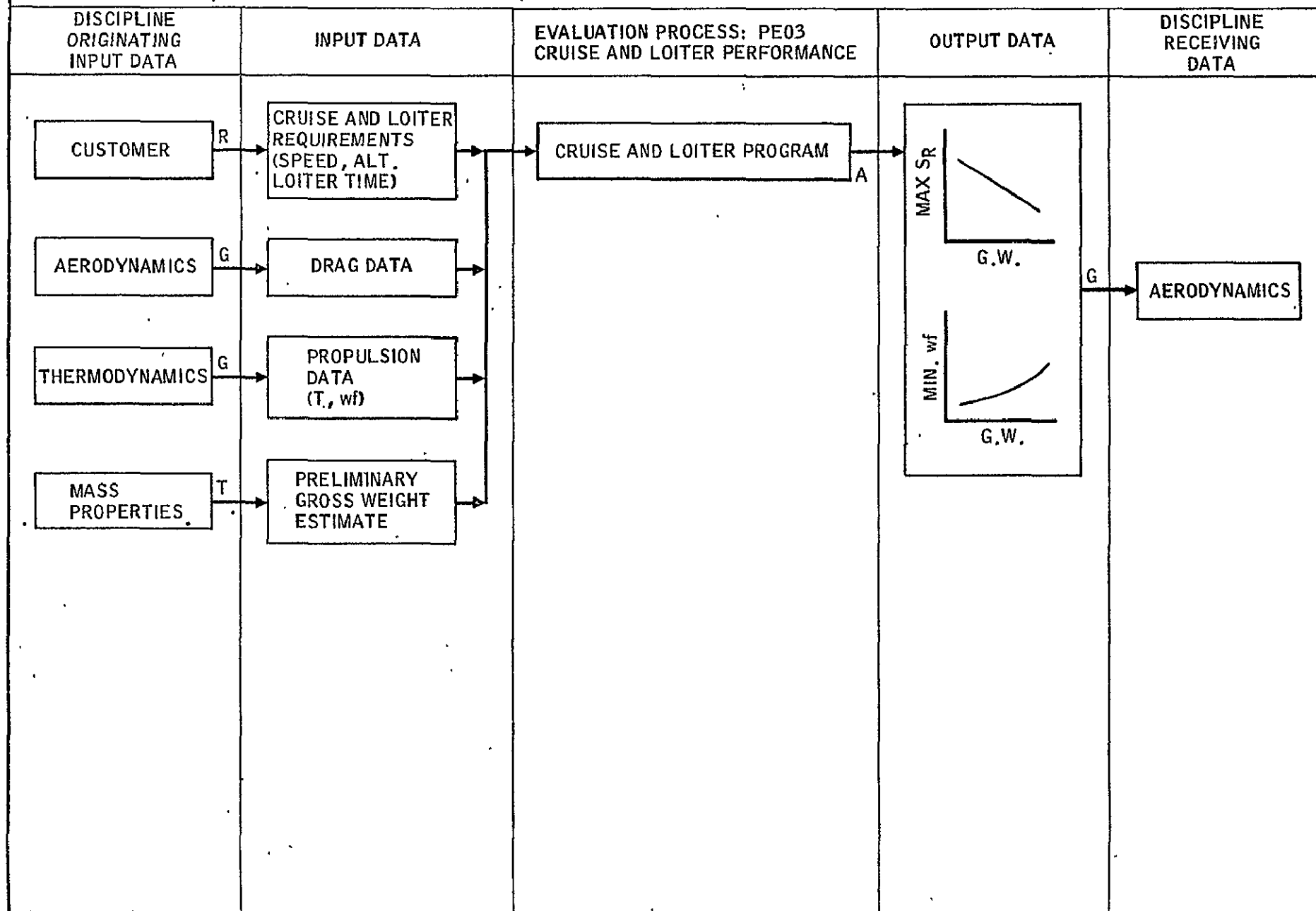


Figure 3-24. Climb Performance

DISCIPLINE: PERFORMANCE  
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



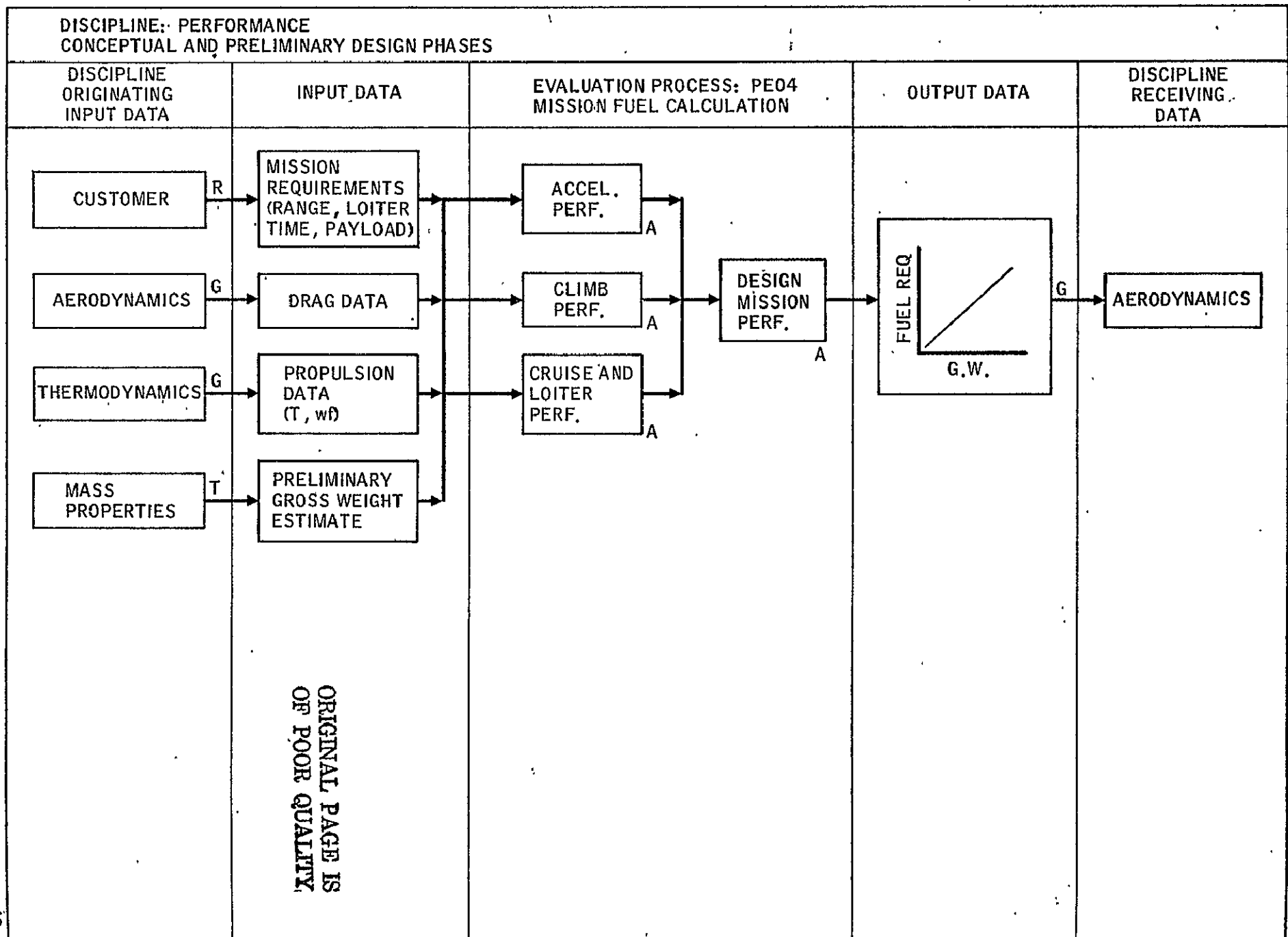
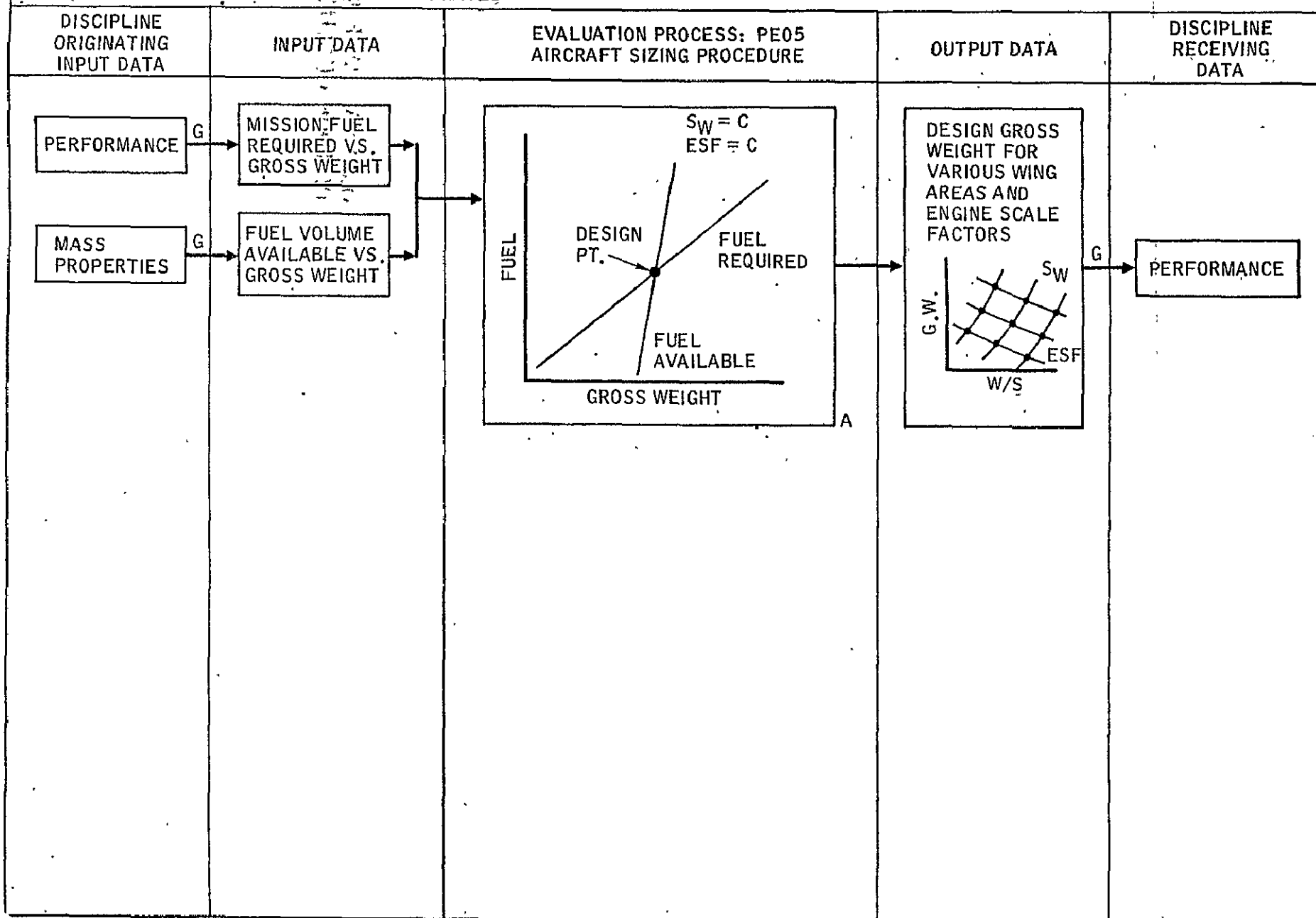


Figure 26. Mission Fuel Calculation

DISCIPLINE: PERFORMANCE  
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



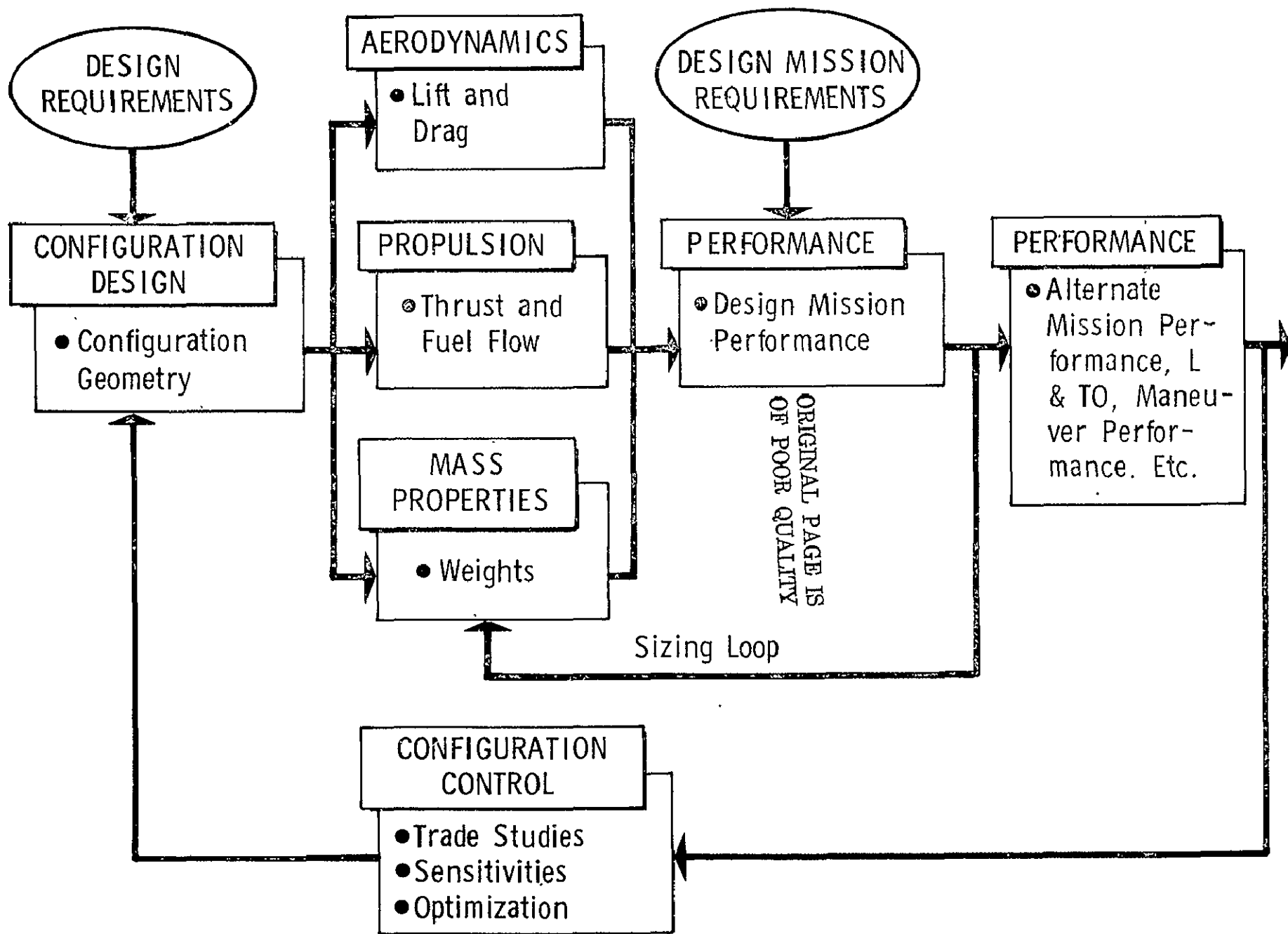
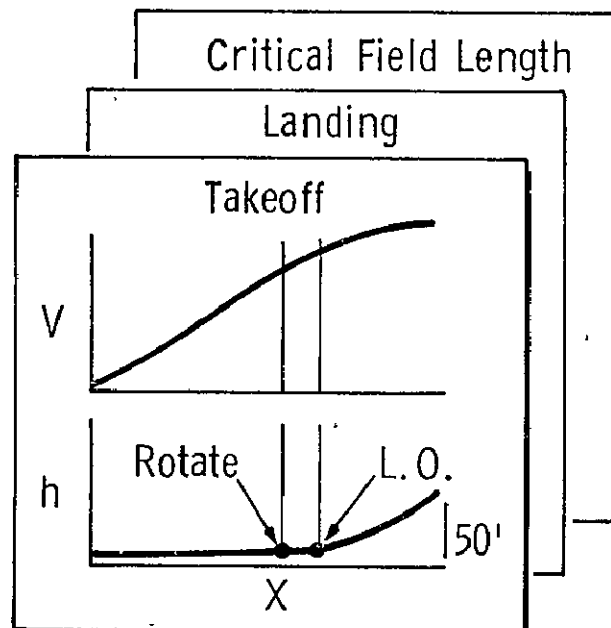
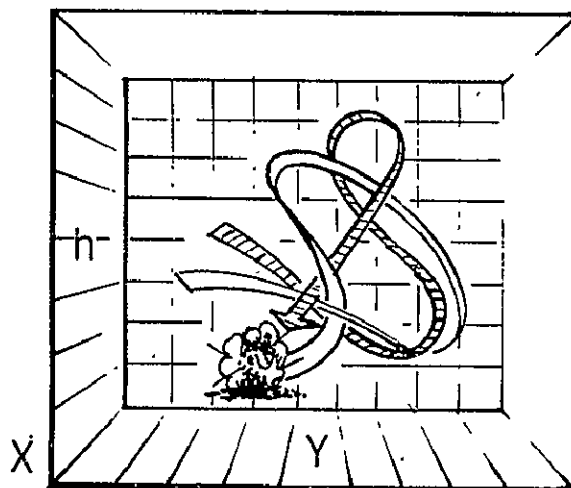


Figure 3-28. Sizing and Parametric Trade Studies

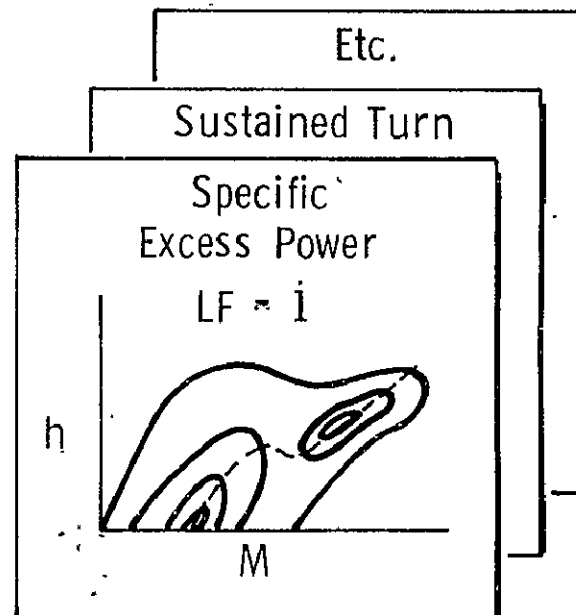
- TAKEOFF & LANDING



### AIR COMBAT SIMULATION



- MANEUVERABILITY



- TERRAIN FOLLOWING
- BOMB RUNS
- OPTIMUM CLIMB, ACCELERATION, INTERCEPT, ETC.
- ... AND OTHERS

Figure 3-29. Flight Mechanics Analyses

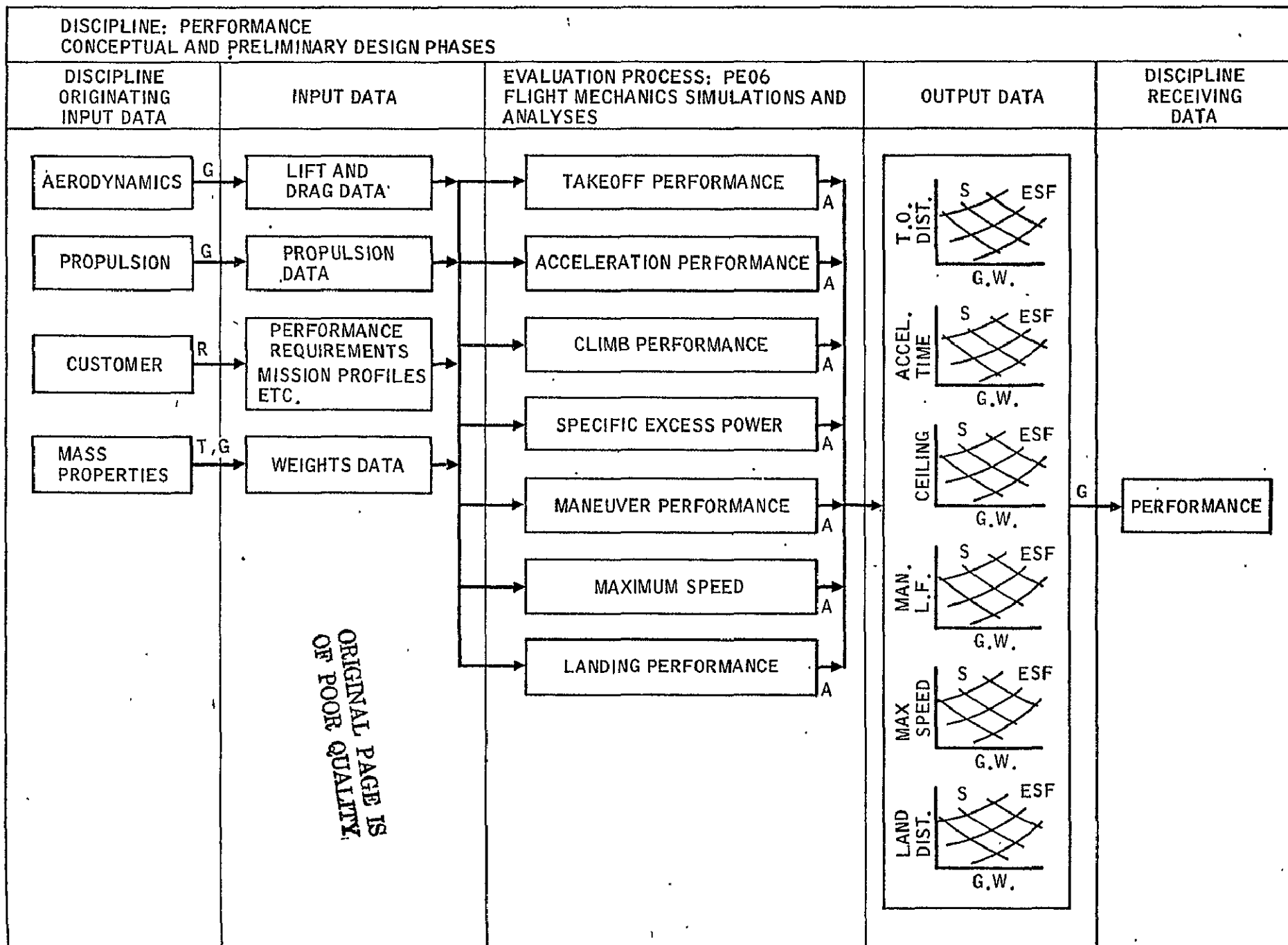
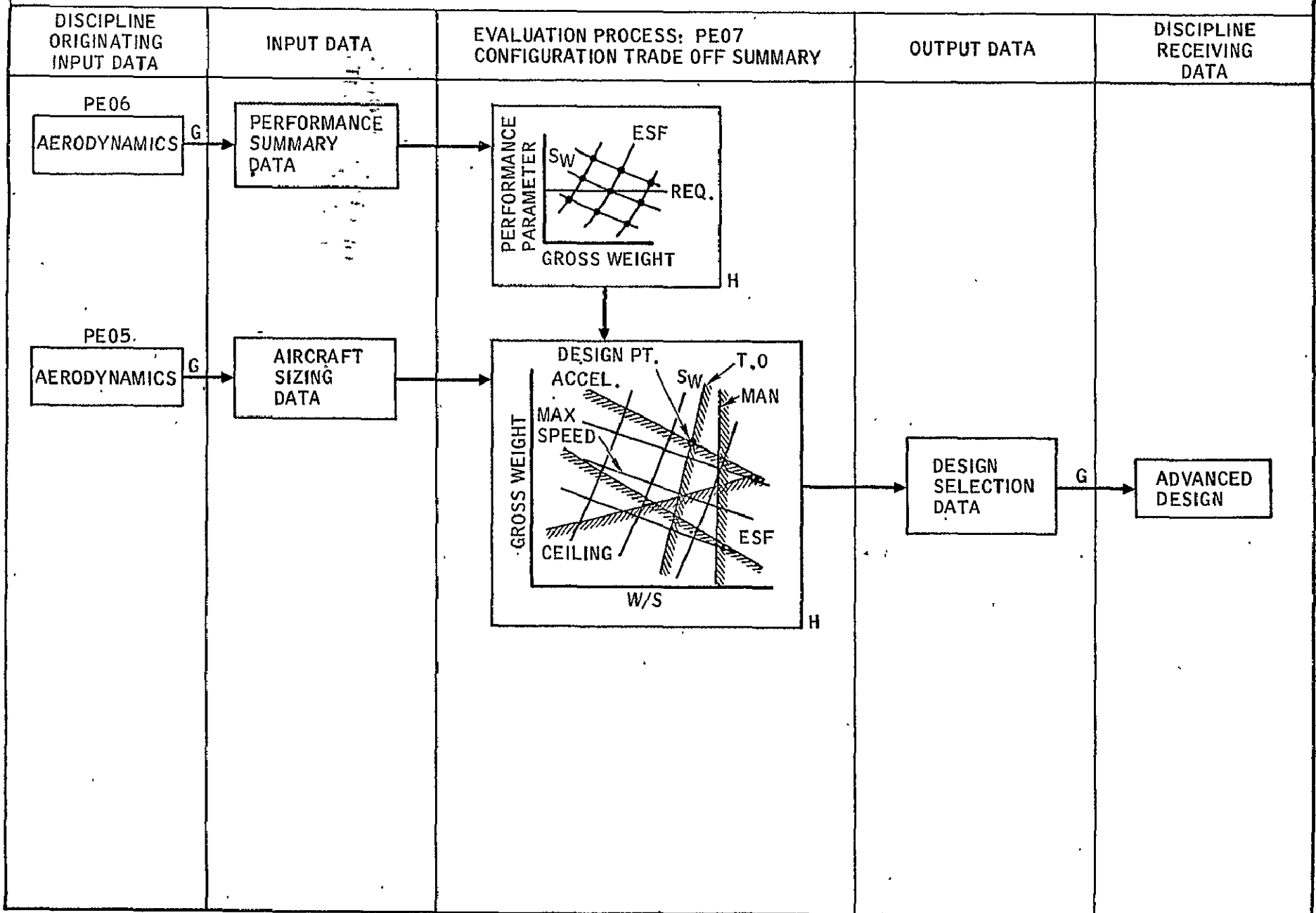


Figure 3-30. Flight Mechanics Simulations and Analyses

DISCIPLINE: PERFORMANCE  
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



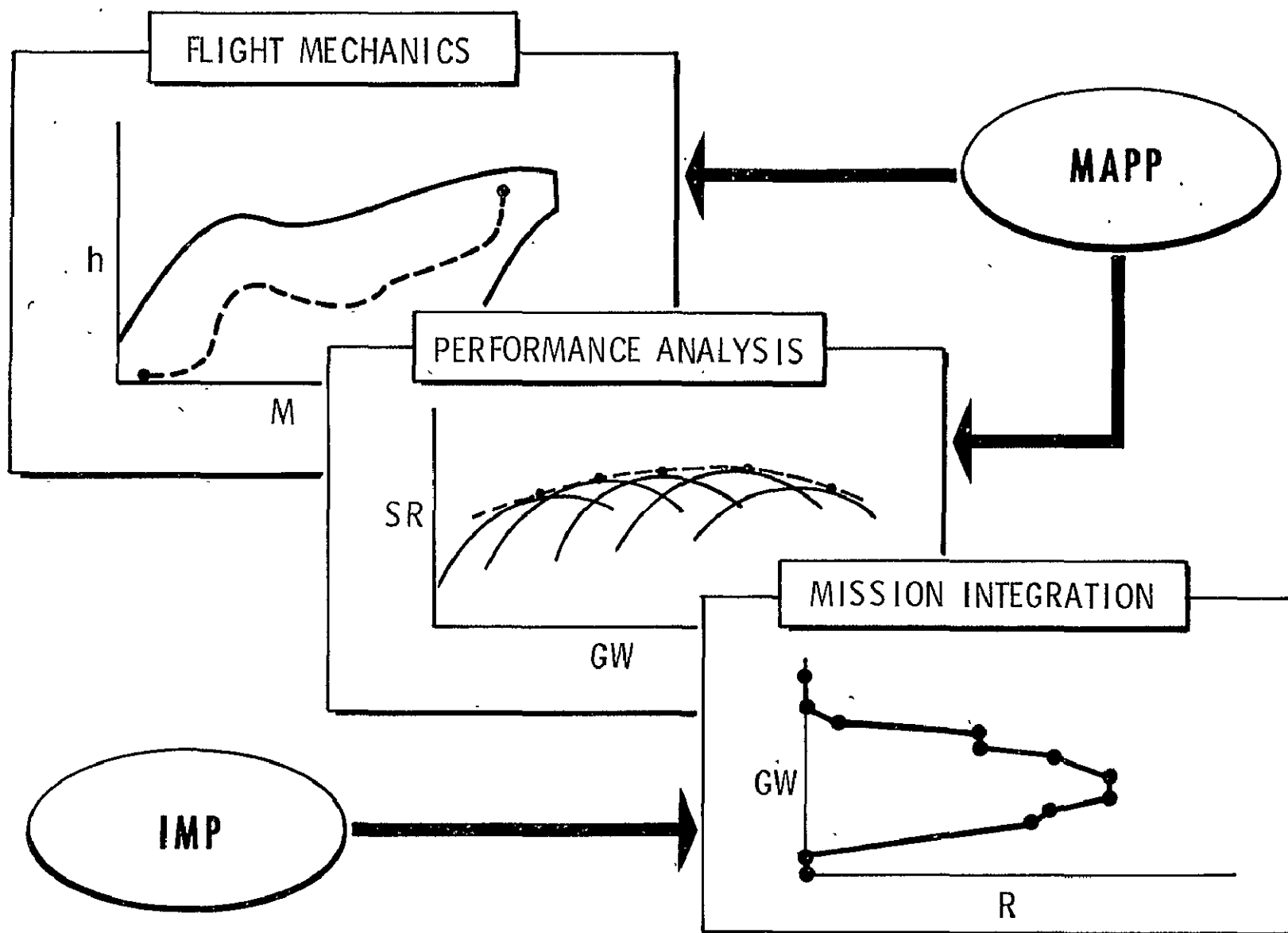


Figure 3-32. Mission Analysis and Performance System (MAPS)

TABLE 3-4. PROPULSION CEP'S AND COMPUTER PROGRAMS

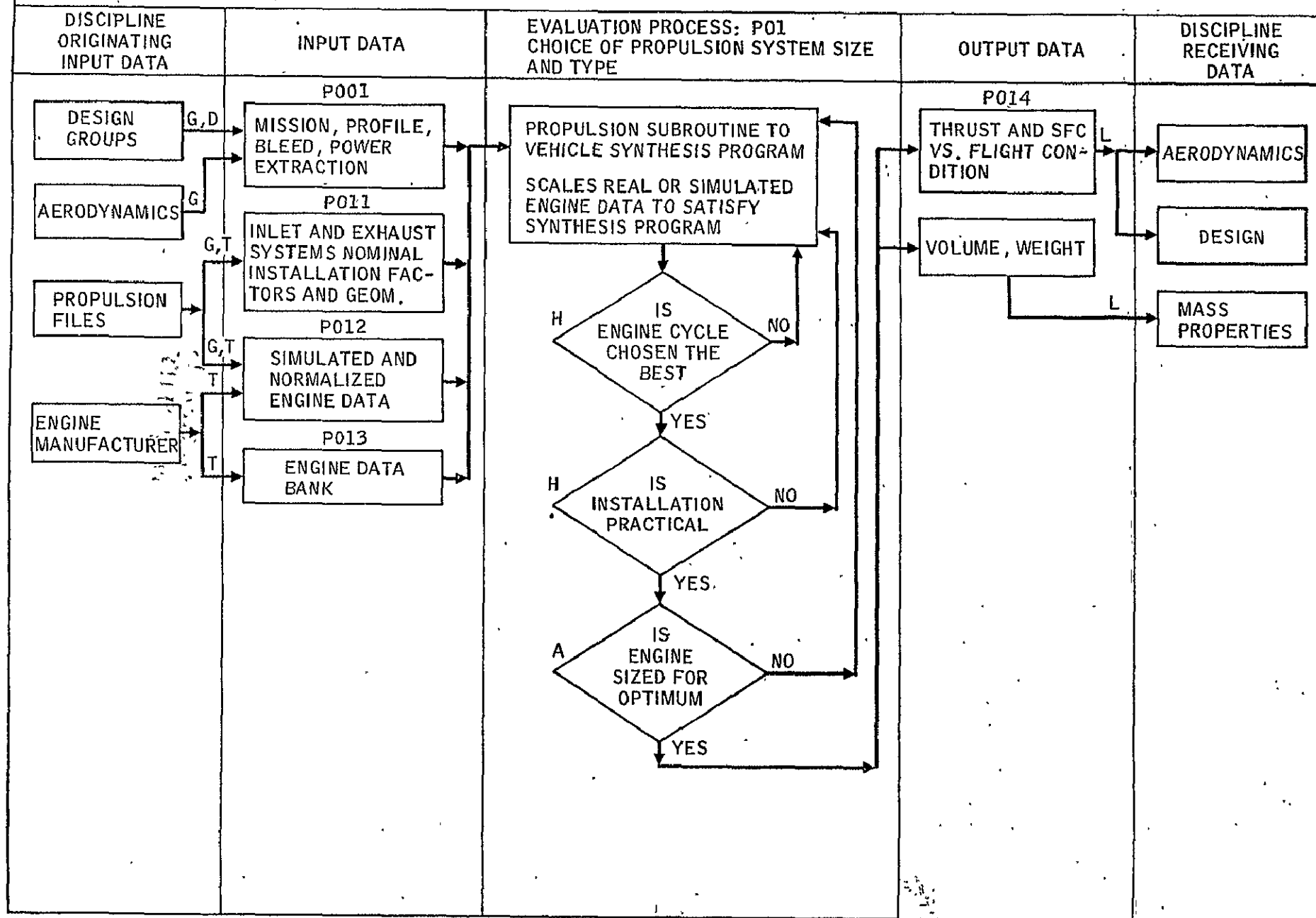
| TASKS                                                                   | CEP | Design Phase |    |    |
|-------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                         |     | C            | PD | DD |
| Choice of Propulsion System Size & Type                                 | P01 | x            |    |    |
| Propulsion System Analysis<br>(Inlet, Exhaust, Bleed, Power, Noise, IR) | P02 | x            | x  | x  |
| Inlet Type and Location Selection                                       | P05 | x            | x  | x  |
| Specification of Forebody Design Constraints                            | P06 |              | x  | x  |
| Prediction of Flow-Field at Inlet Location                              | P06 |              | x  | x  |
| Inlet Size, Orientation, Aspect Ratio Selection                         | P05 | x            | x  | x  |
| Inlet Compression Surface, Variable Geometry & Subsonic<br>Duct Design  | P05 |              | x  | x  |
| Inlet Lip, Sideplate, etc., Design                                      | P05 |              |    | x  |
| Inlet Boundary Layer Bleed and Bypass System Design                     | P05 |              | x  | x  |
| Inlet Blow-in Door (or Auxiliary Inlet) Design                          | P05 |              | x  | x  |
| Predict Inlet Drag and Pressure Recovery                                | P04 | x            | x  | x  |
| Predict Boundary Layer Bleed and Bypass Rates                           | P04 |              | x  | x  |
| Inlet Control System Concept Design                                     | P03 |              | x  | x  |
| Predict Pressures for Inlet Loads                                       | P04 |              | x  | x  |
| Secondary Air System Internal Performance                               | P08 | x            | x  | x  |
| Secondary Air System Design                                             | P08 |              | x  | x  |
| Prediction of Distortion and/or Turbulence                              | P05 |              |    | x  |
| Nozzle Installed Internal Performance                                   | P10 | x            | x  | x  |
| Nozzle Installed External Drag                                          | P10 | x            | x  | x  |
| Nozzle External Air Loads                                               | P09 |              |    | x  |
| Nozzle Selection                                                        | P09 | x            | x  | x  |
| Engine Cycle Selection                                                  | P12 | x            | x  |    |
| Installed Engine Performance Prediction                                 | P11 | x            | x  | x  |
| Engine Control System Characteristics Selection                         | P12 | x            | x  | x  |
| Predict Scaled Engine Physical Characteristics                          | P12 | x            | x  |    |
| Engine Transient Performance                                            | P11 |              | x  | x  |
| Predict Engine IR and Radar Signatures                                  | P11 |              | x  | x  |
| Noise Predictions                                                       | P11 | x            | x  | x  |
| Estimate Bleed System Requirements                                      | P11 |              | x  | x  |
| Estimate Power Extraction Requirements                                  | P11 |              | x  | x  |
| Predict Air Conditioning System Performance                             | T04 | x            | x  | x  |
| Size Air Conditioning System                                            | T04 | x            | x  | x  |
| Establish Distribution System Requirements                              | T04 |              | x  | x  |

TABLE 3-4. PROPULSION CEP'S AND COMPUTER PROGRAMS (CONT'D)

| TASKS                                                        |                                                               | CEP | Design Phase |    |    |
|--------------------------------------------------------------|---------------------------------------------------------------|-----|--------------|----|----|
|                                                              |                                                               |     | C            | PD | DD |
| Predict Performance of Anti-icing Systems                    |                                                               | T02 | x            | x  | x  |
| Size Anti-icing/De-icing Systems                             |                                                               | T02 |              | x  | x  |
| Size Rain Clearing System and Show Performance               |                                                               | T02 |              |    | x  |
| Size and Predict Performance of Engine Cooling System        |                                                               | T03 |              | x  | x  |
| Size and Predict Performance of Engine and Hydraulic Cooling |                                                               | T03 |              | x  | x  |
| Size and Predict Performance of Generator and Drive Cooling  |                                                               | T03 |              | x  | x  |
| Size and Predict Performance of Structural Cooling           |                                                               | T03 | x            | x  | x  |
| Size De-fog System and Show Performance                      |                                                               | T02 |              |    | x  |
| <u>COMPUTER PROGRAMS</u>                                     |                                                               |     |              |    |    |
| Propul                                                       | Subroutine in Aero Synthesis Program                          | P01 | x            |    |    |
| Epic                                                         | Subroutine or Main to Generate Internal Performance Losses    | P02 | x            | x  |    |
| Inst                                                         | Main or Subroutine to Correct for External Inst. Losses       | P02 | x            | x  |    |
| AIV                                                          | Characteristic Solution of Rotationally Symmetric Flow Fields | P07 |              | x  | x  |
| A5M                                                          | Focused Isentropic Spike Design                               | P07 |              | x  | x  |
| A5T                                                          | Conical Flow Field                                            | P07 |              | x  | x  |
| A6C                                                          | Oblique Shocks at High Mach Number                            | P07 |              | x  | x  |
| SF7-A                                                        | Supersonic Flow Field & Boundary Layer Analysis               | P07 |              | x  | x  |
| C76                                                          | Supersonic Internal Flow Analysis                             | P07 |              | x  | x  |
| SL6                                                          | Two-Dimensional Triple-Ramp Inlet Flow Field Properties       | P07 |              | x  | x  |
| SYO                                                          | Airbreathing Engine Cycle Analysis                            | P13 | x            |    |    |
|                                                              | Air Conditioning System Analysis                              | T04 | x            | x  | x  |
|                                                              | Heat Exchanger Analysis                                       | T03 |              | x  | x  |
|                                                              | External Supersonic Inlet Performance                         | P02 | x            | x  |    |

ORIGINAL PAGE IS  
OF POOR QUALITY

# DISCIPLINE: PROPULSION THERMODYNAMICS CONCEPTUAL DESIGN PHASE



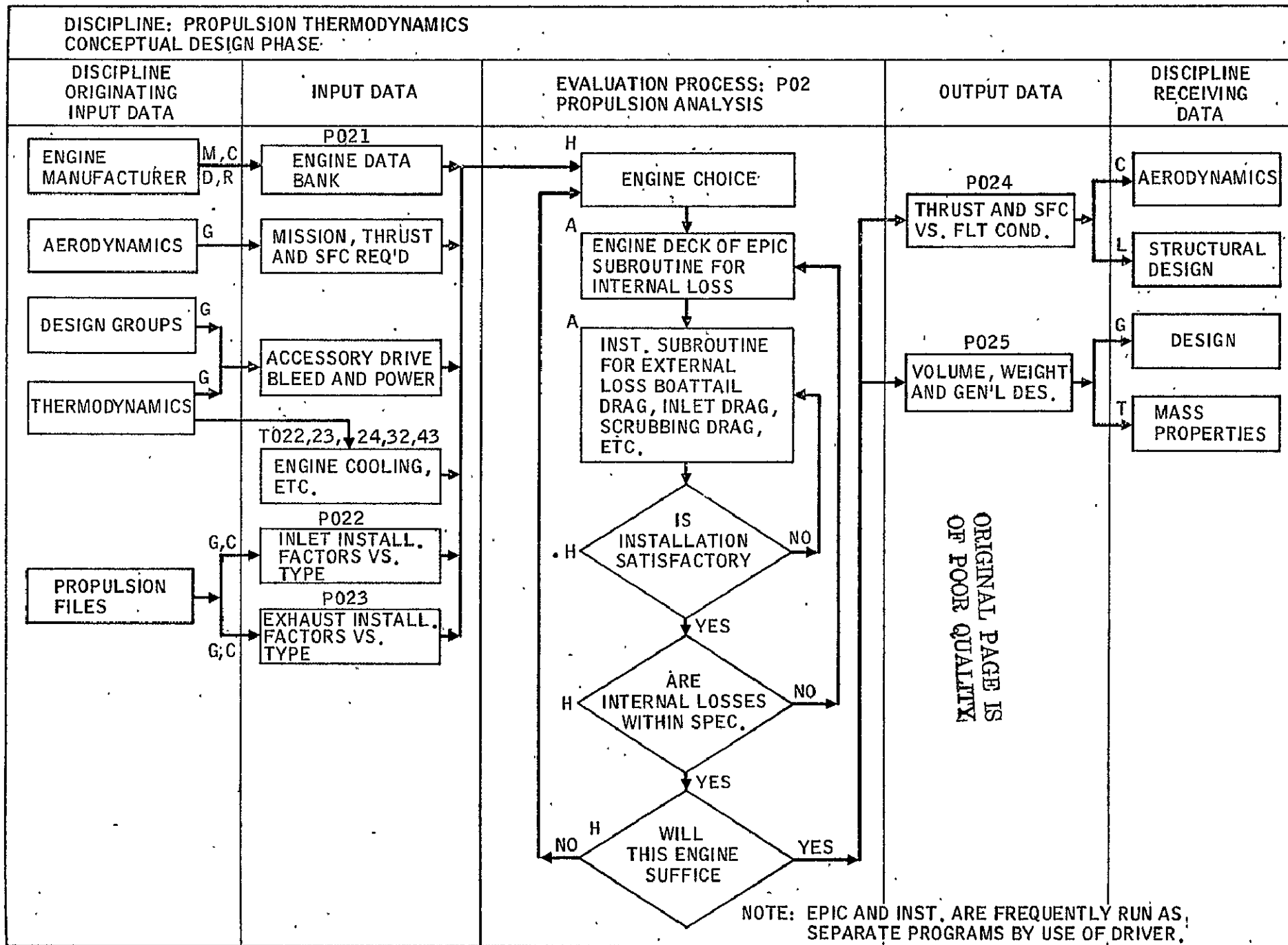


Figure 3-34. Propulsion Analysis

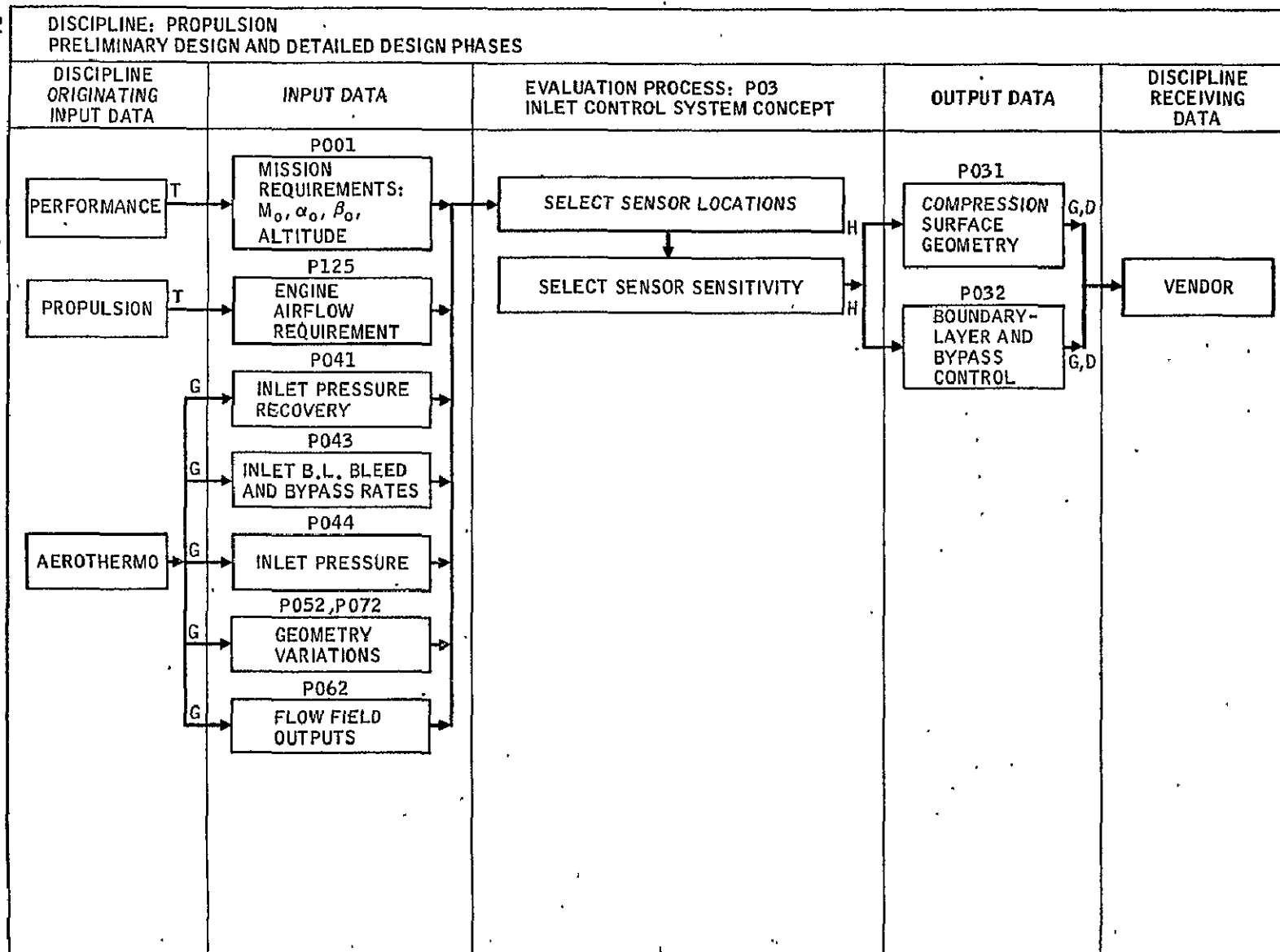


Figure 3-35. Inlet Control System Concept

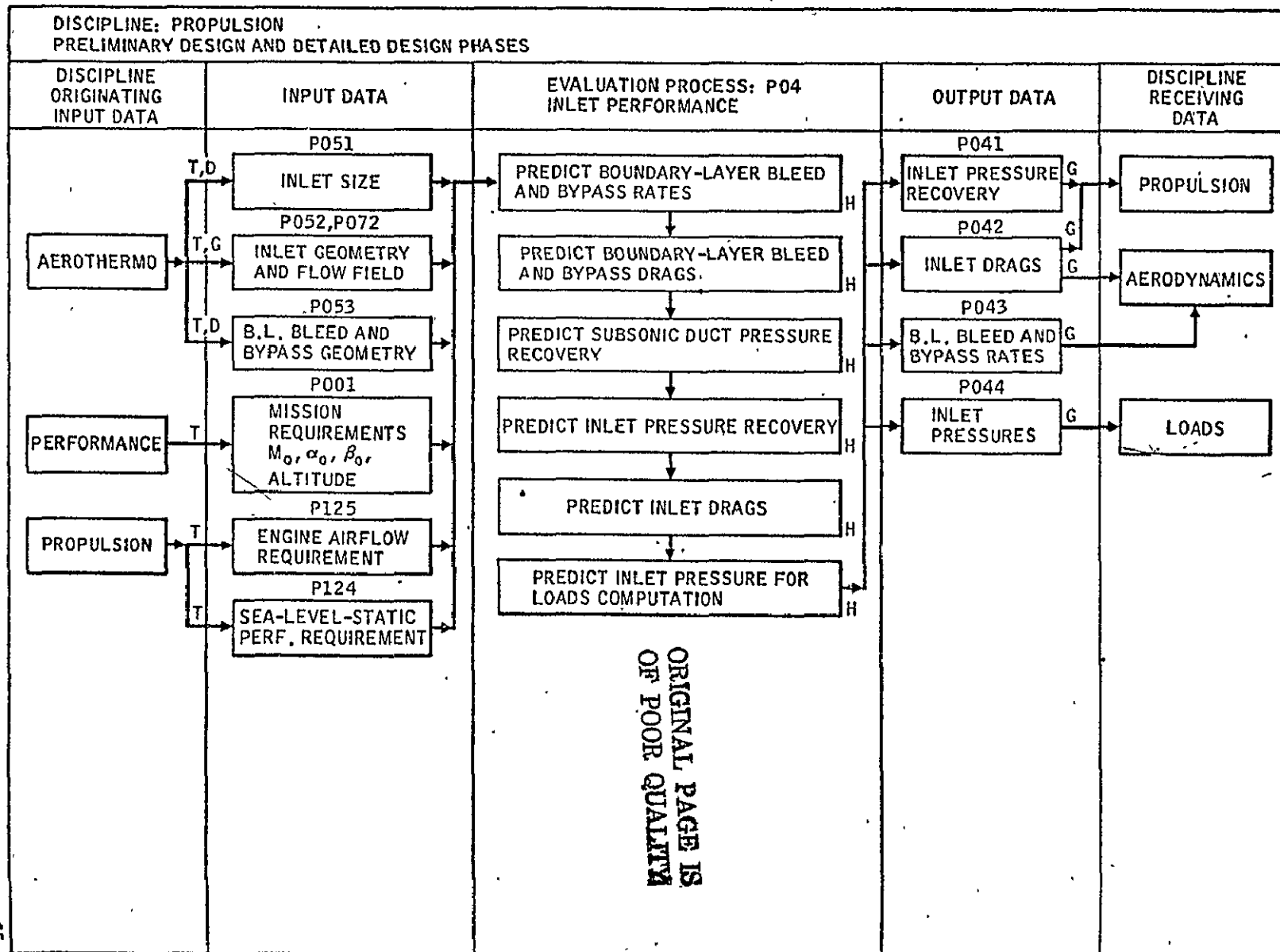
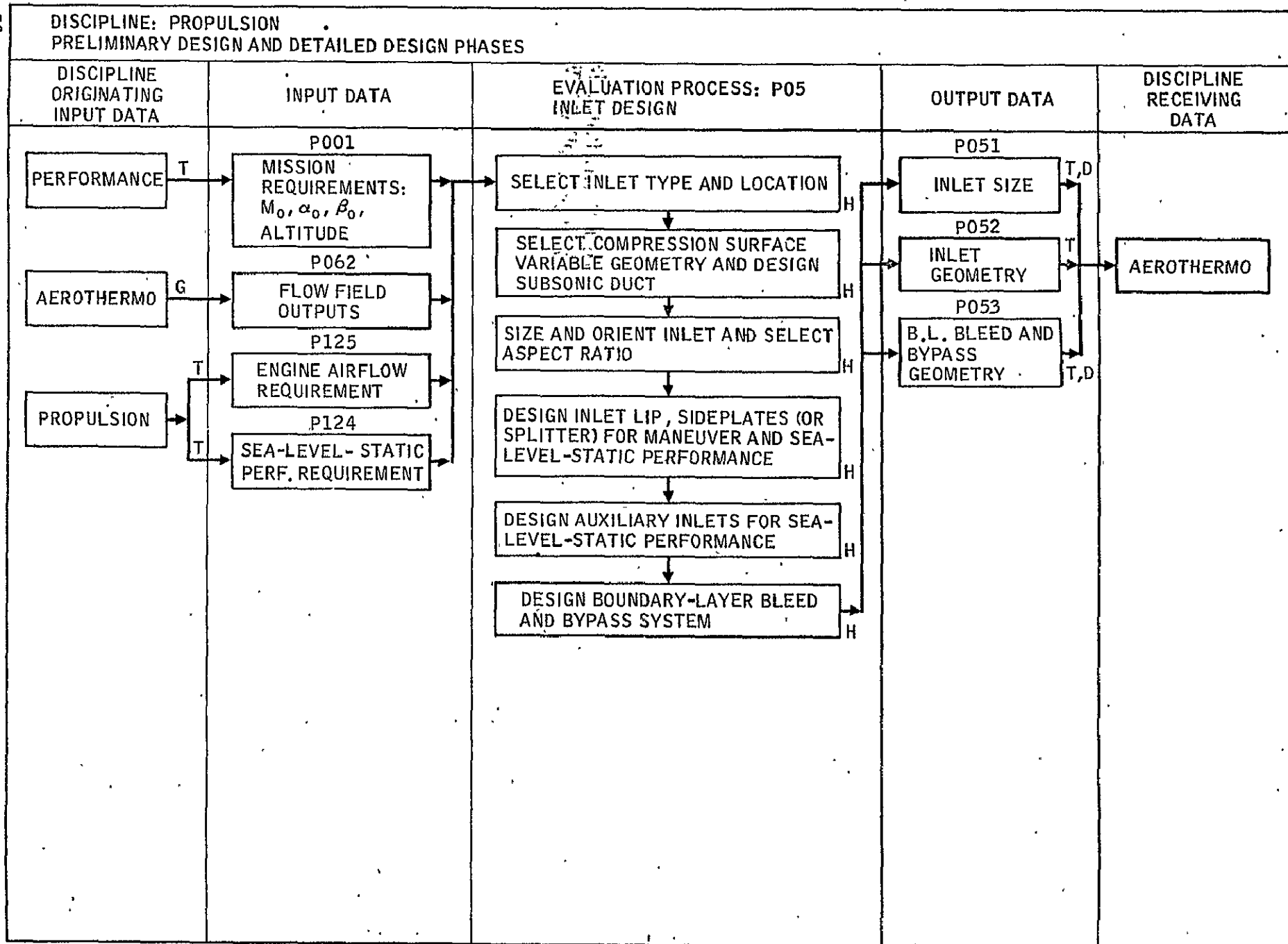


Figure 3-30. Inlet Performance



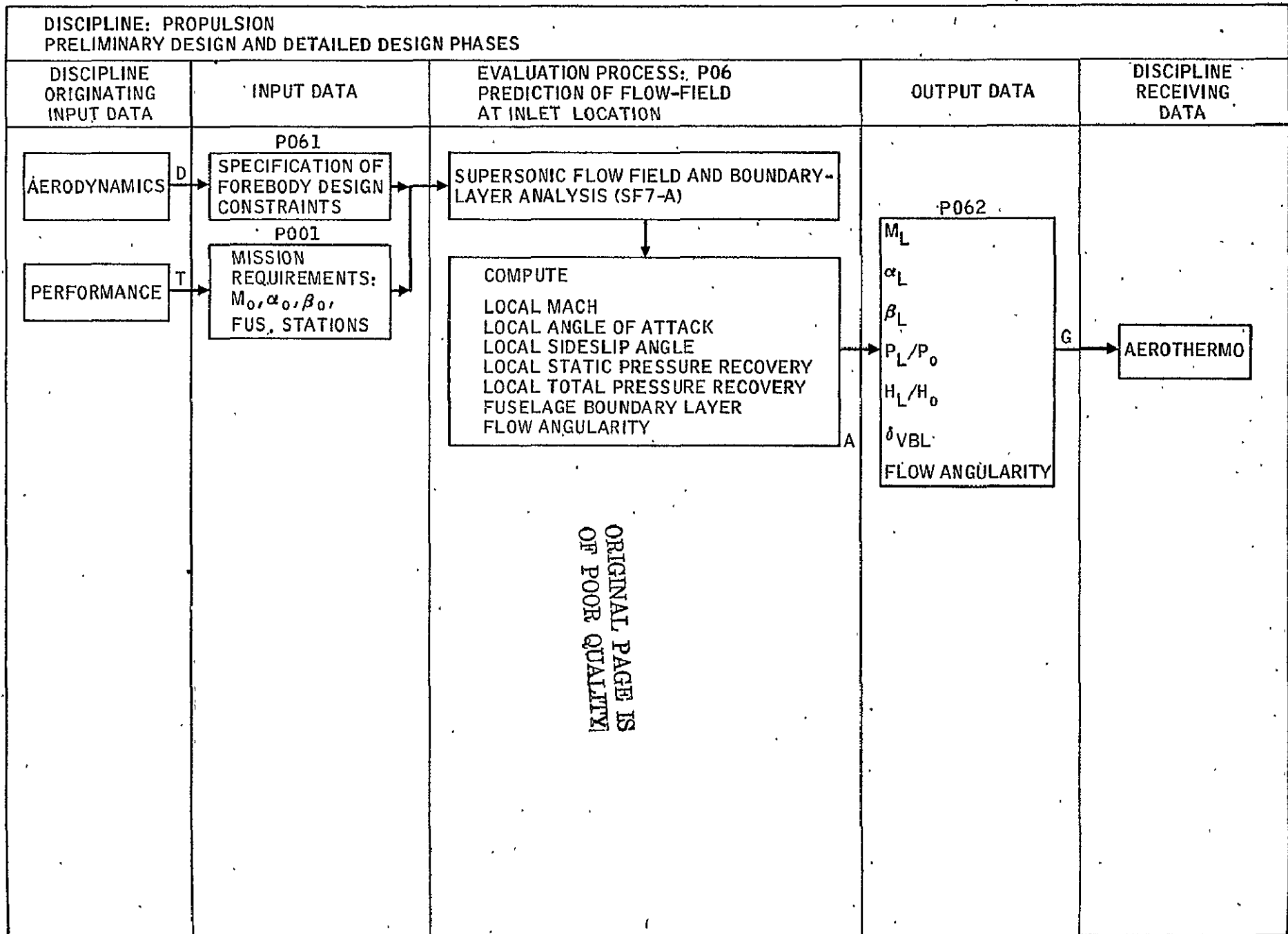
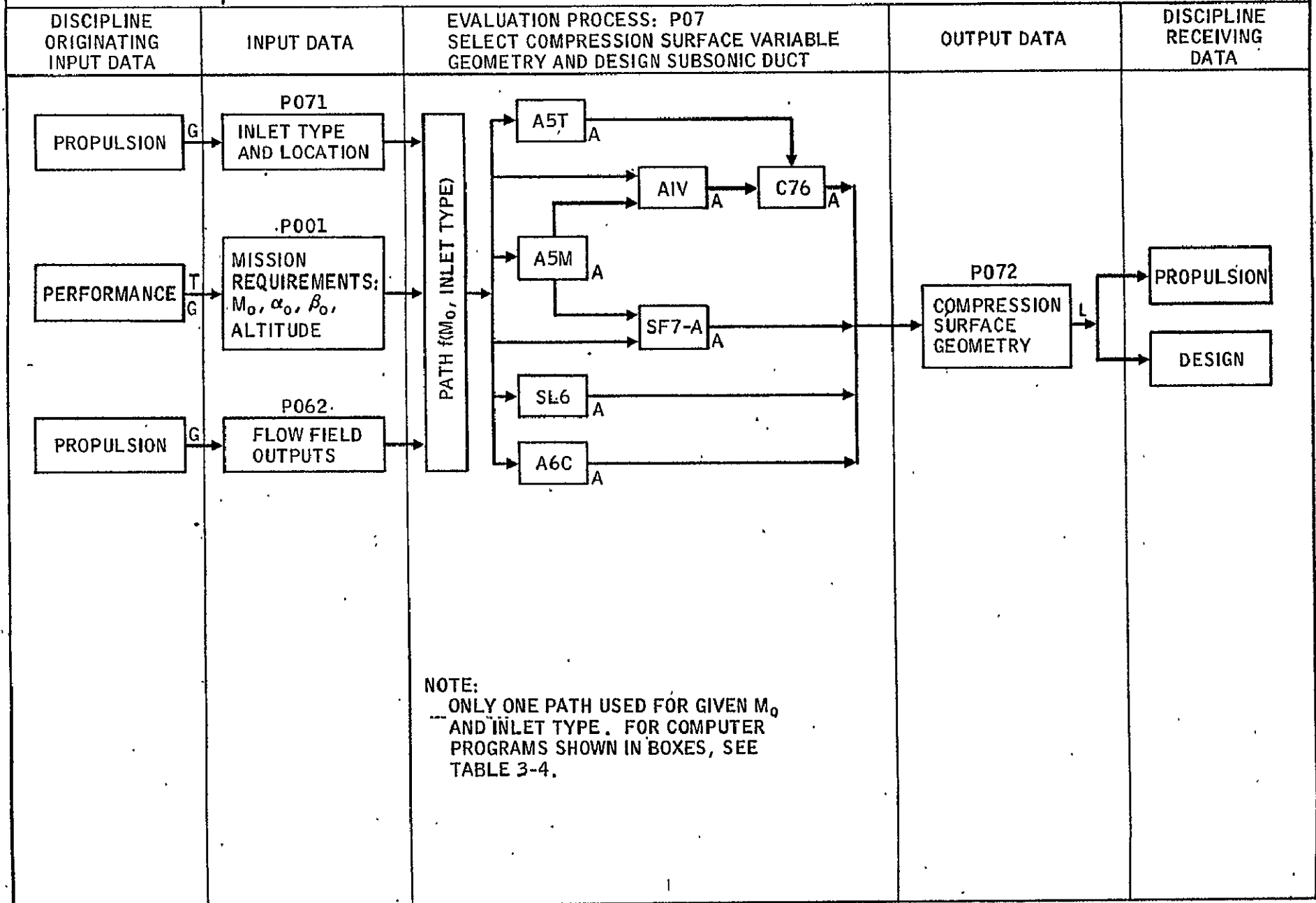


Figure 3-38. Prediction of Flow Field at Inlet Location

DISCIPLINE: PROPULSION  
PRELIMINARY DESIGN AND DETAILED DESIGN PHASES



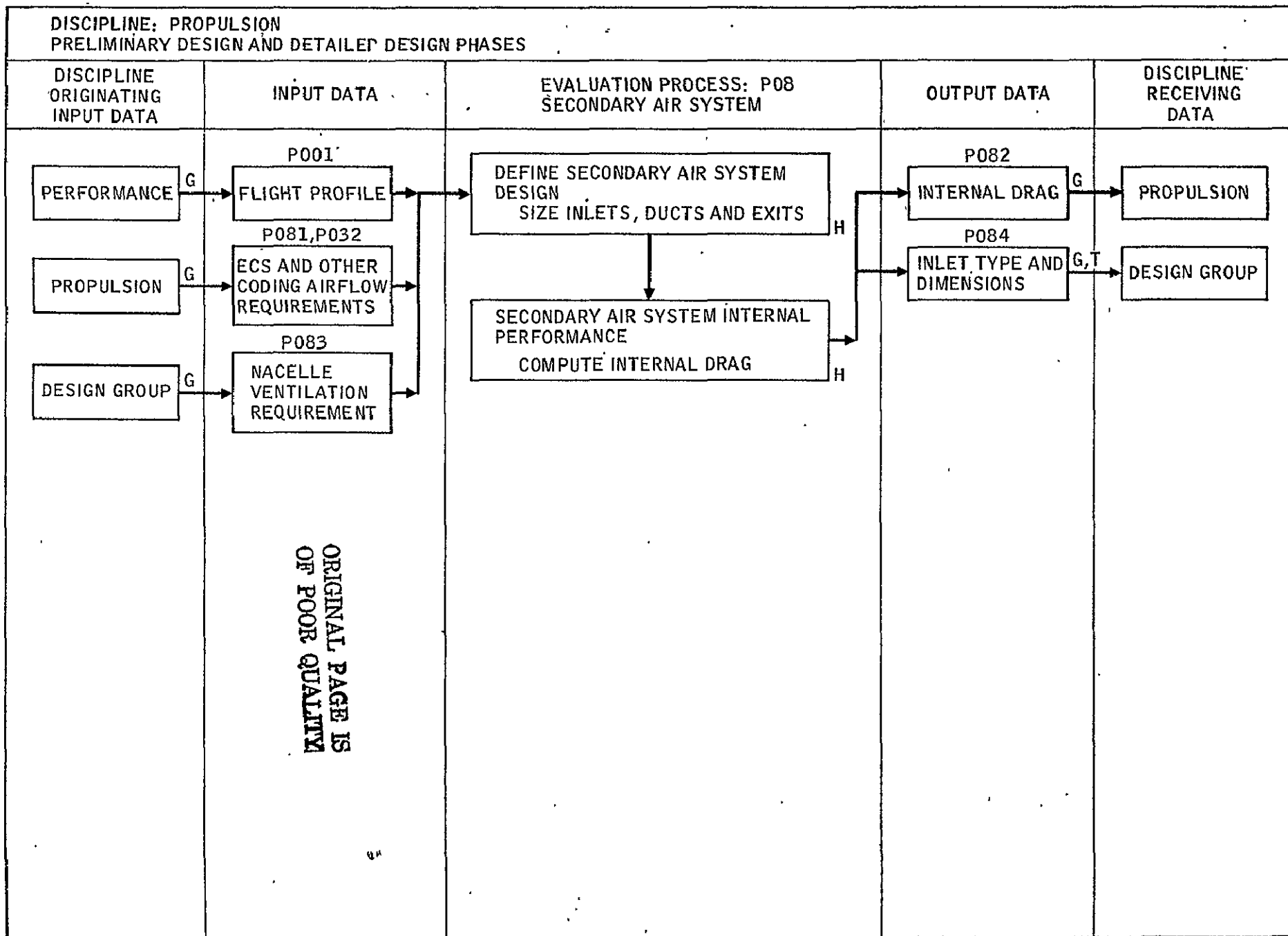
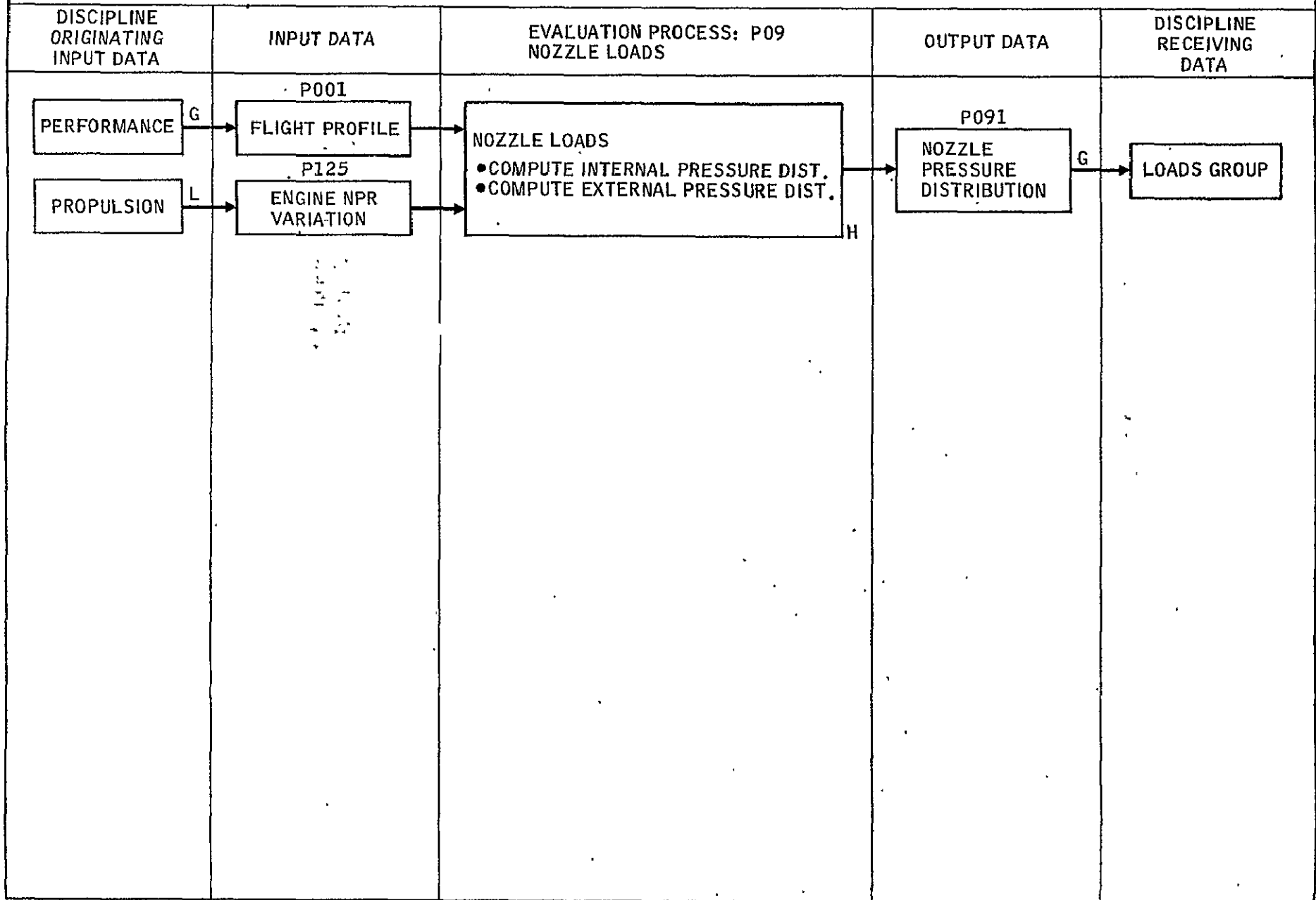


Figure 3-40. Secondary Air System

DISCIPLINE: PROPULSION  
PRELIMINARY DESIGN AND DETAILED DESIGN PHASES



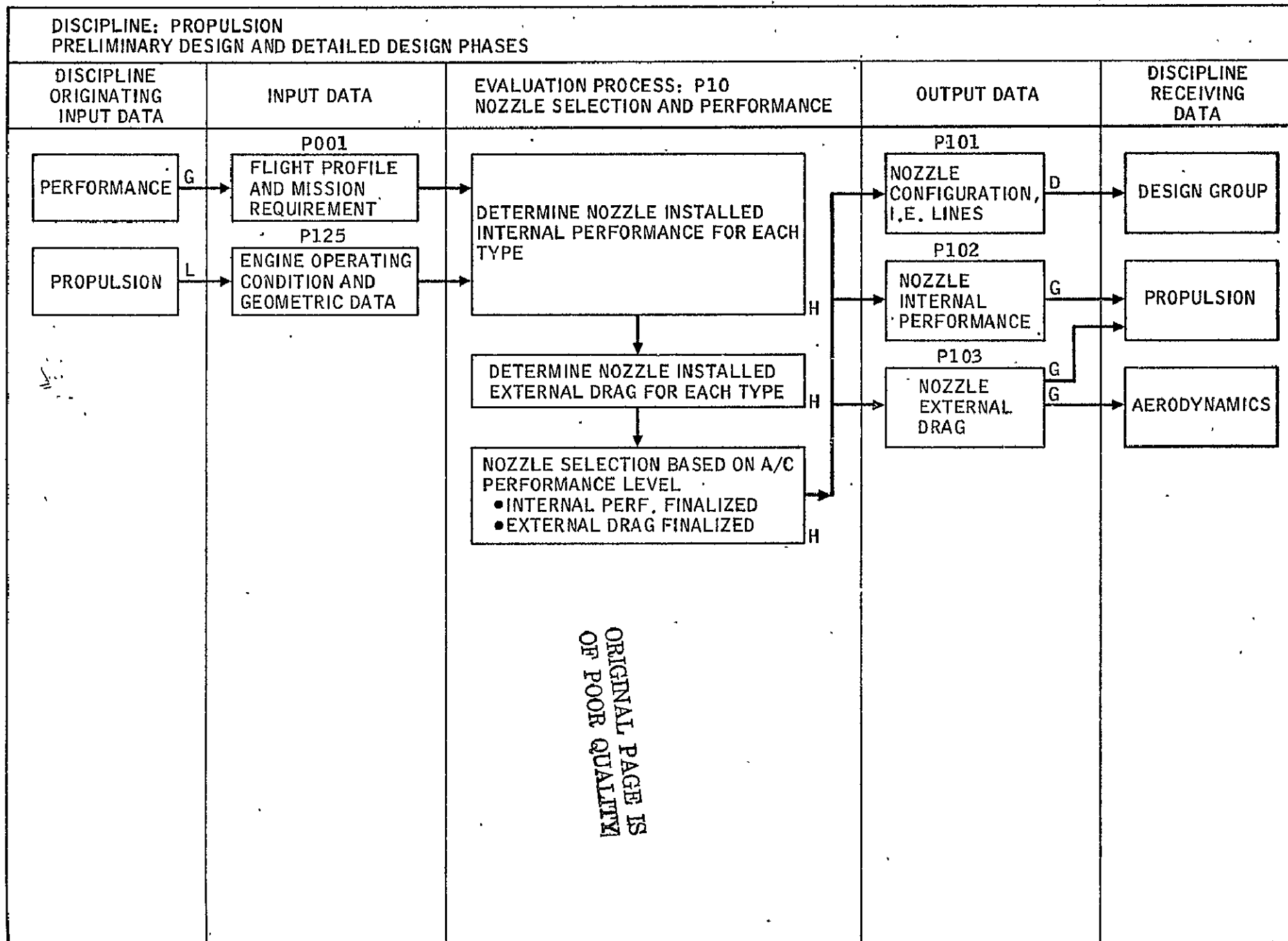


Figure 3-42. Nozzle Selection and Performance

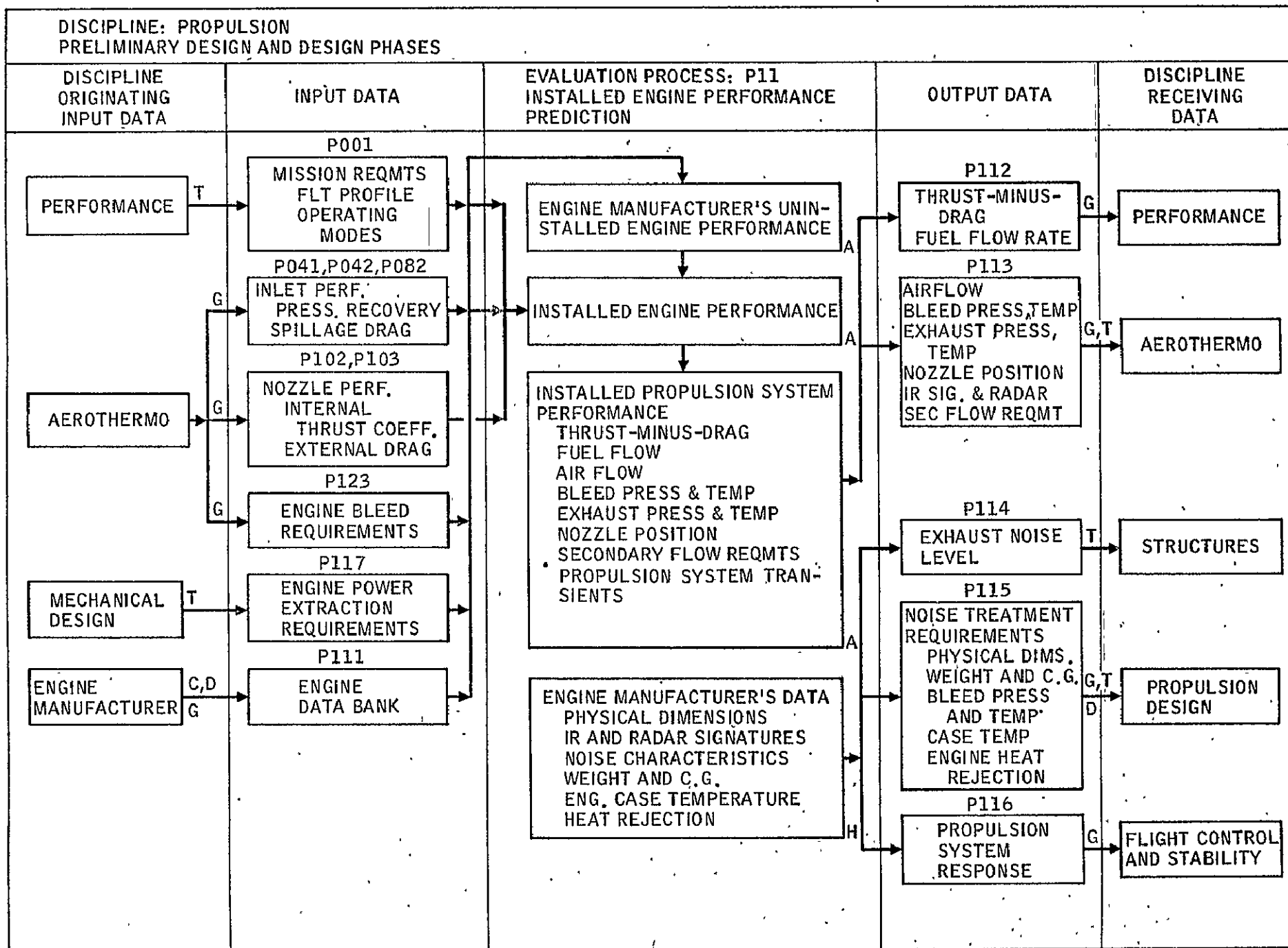


Figure 3-43. Installed Engine Performance Prediction

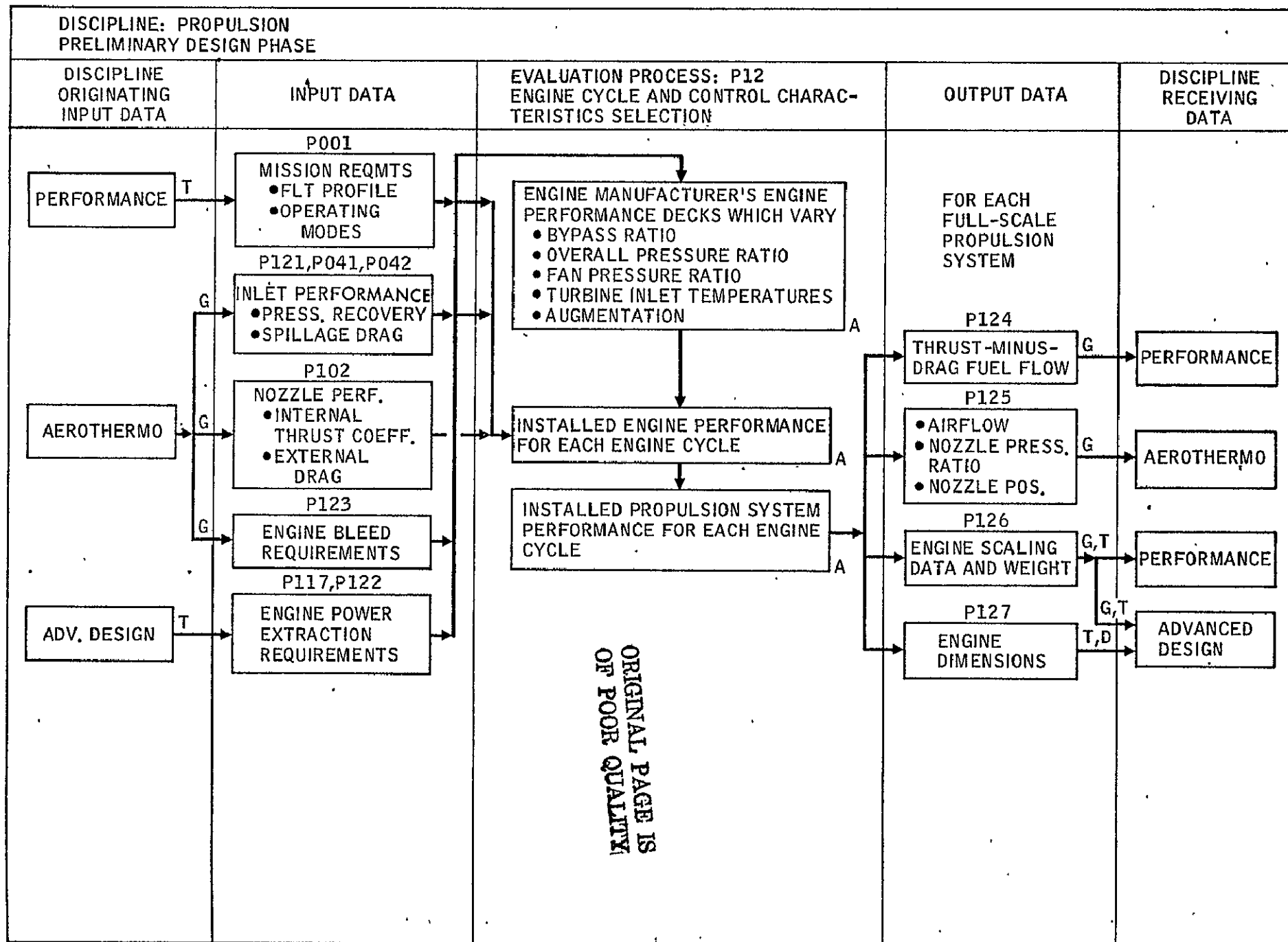
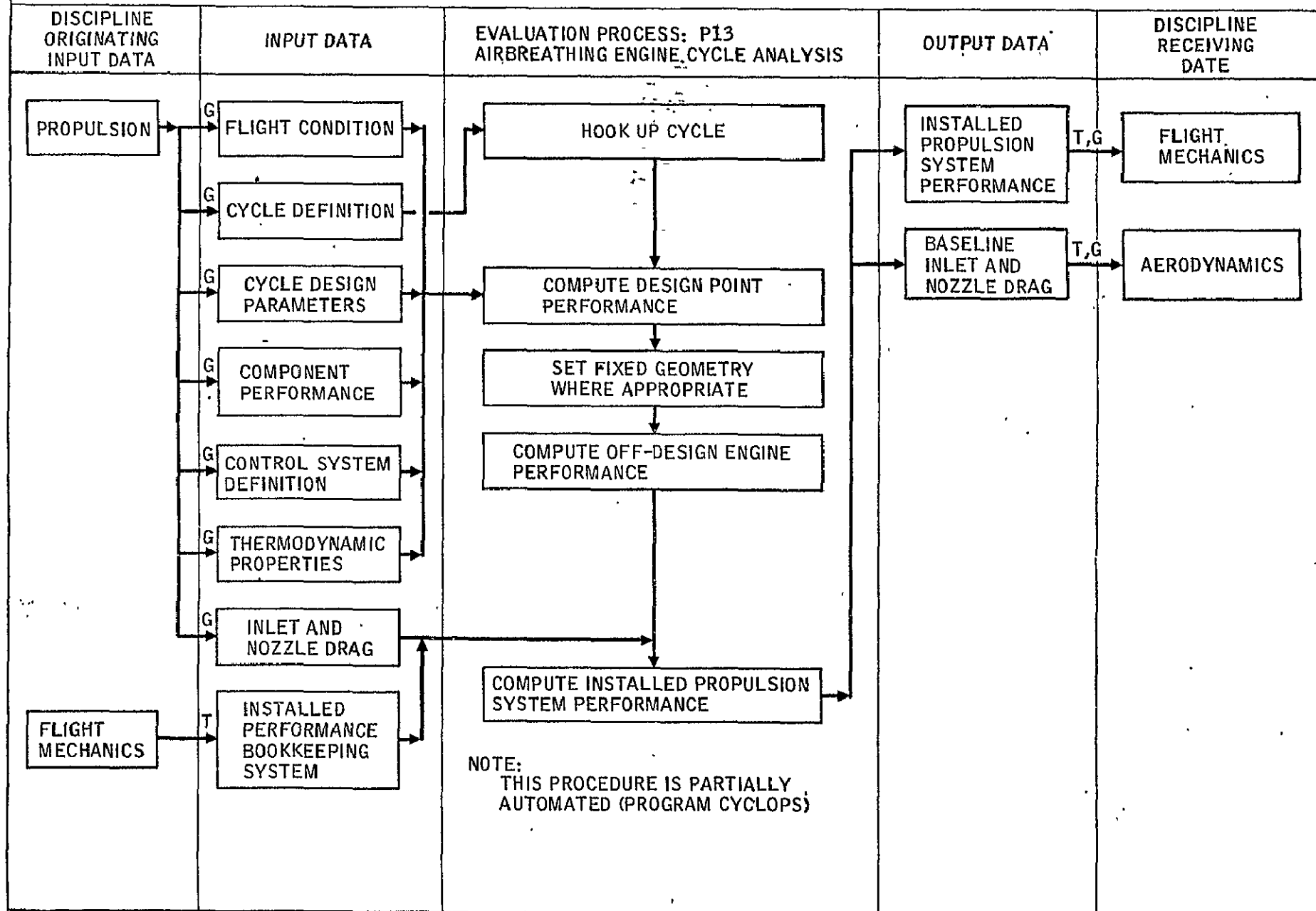


Figure 3-44. Engine Cycle and Control Characteristic Selection

# DISCIPLINE: PROPULSION CONCEPTUAL DESIGN PHASE



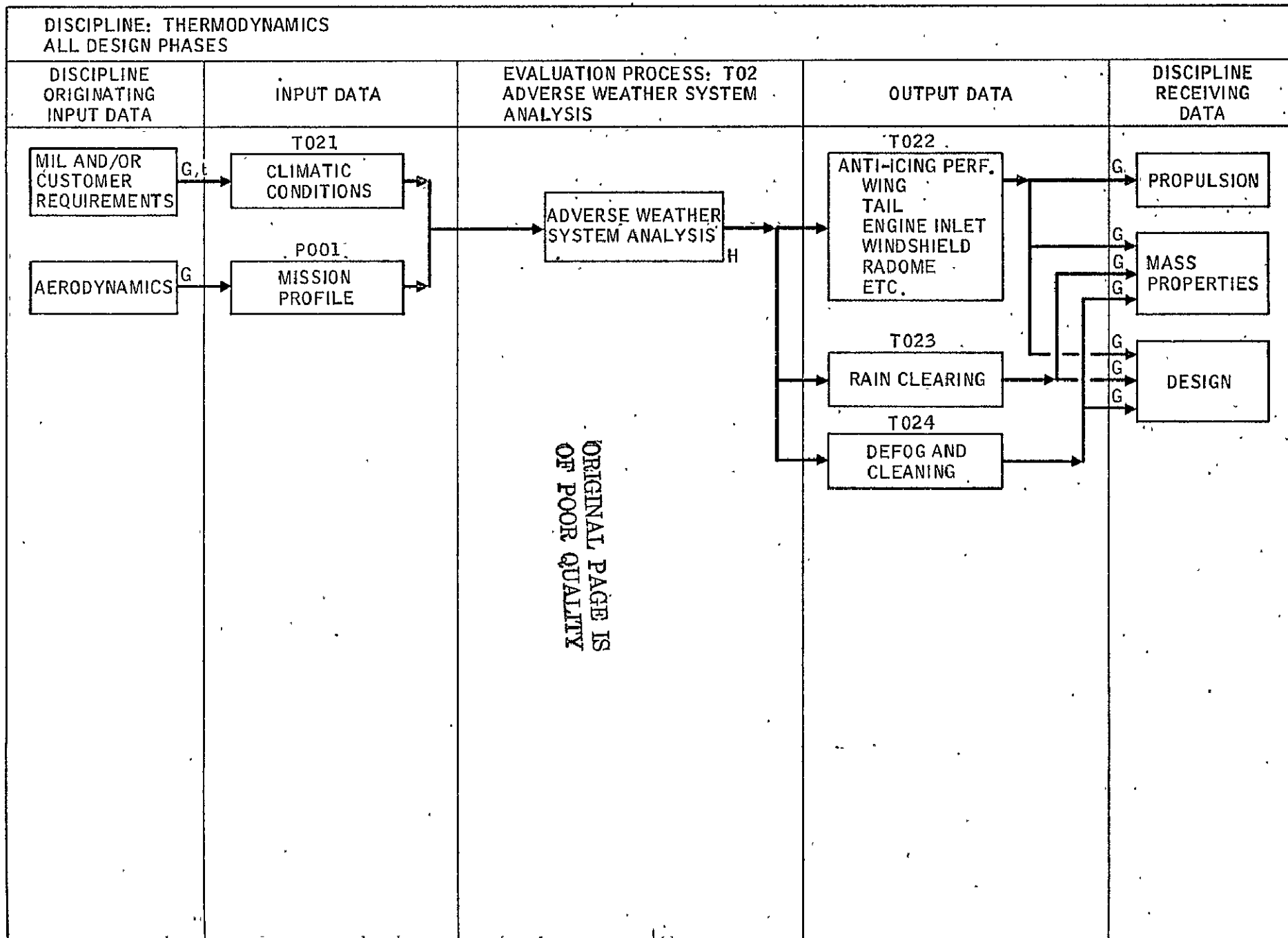
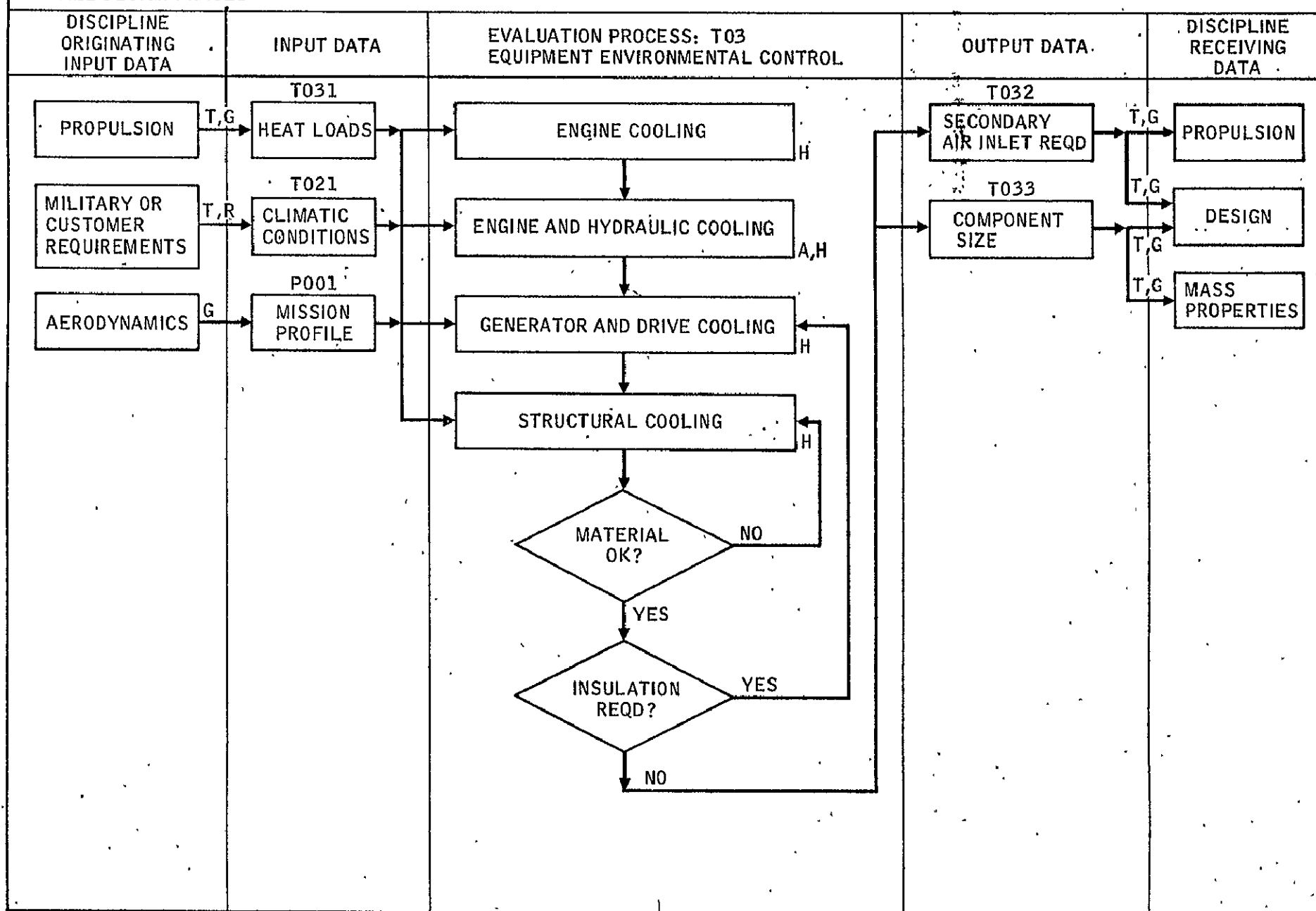


Figure 3-46. Adverse Weather System Analysis

DISCIPLINE: THERMODYNAMICS  
ALL DESIGN PHASES



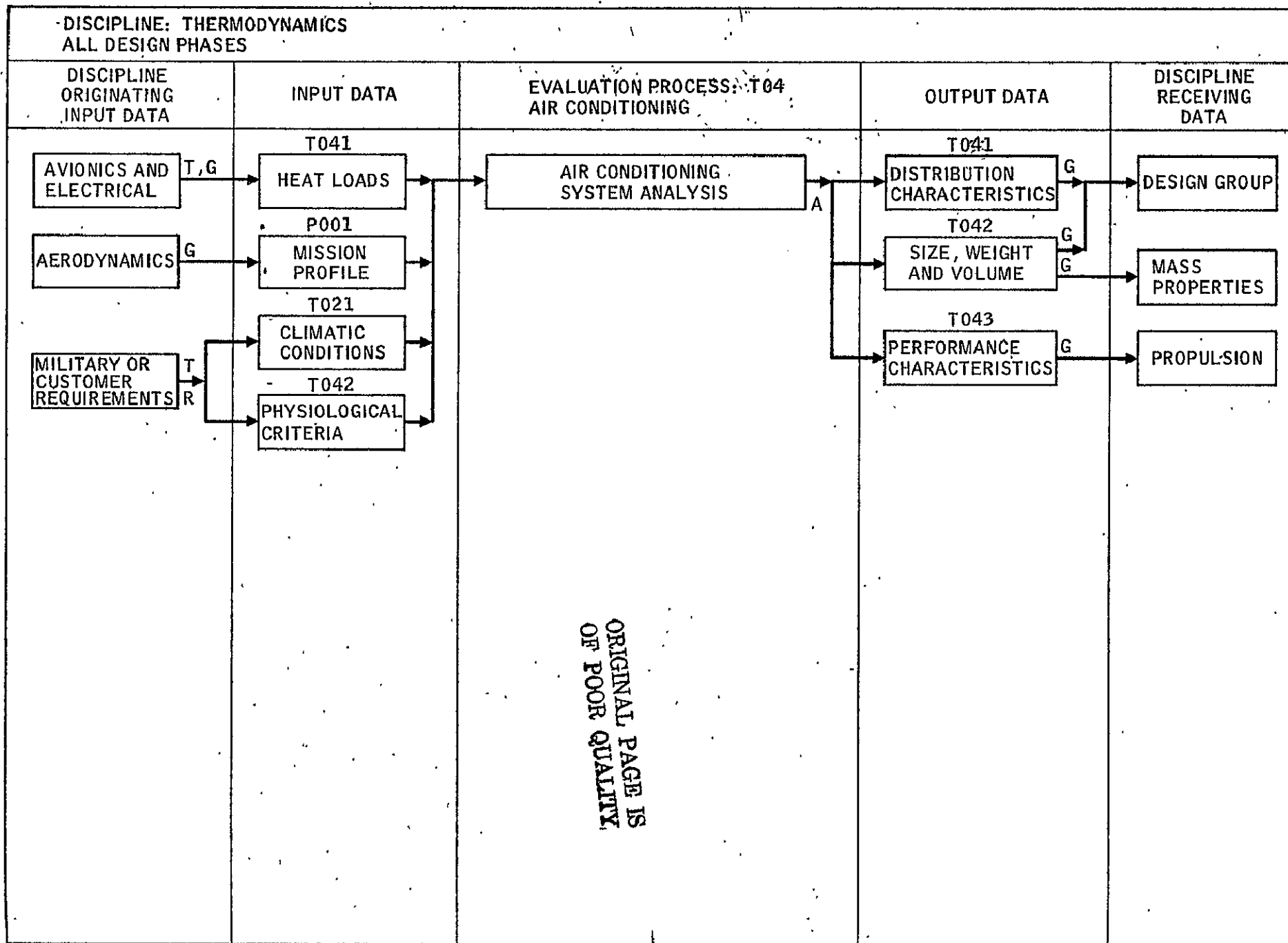


Figure 3-48. Air Conditioning

TABLE 3-6. MASS PROPERTIES CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                    | CEP | Design Phase |    |    |
|--------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                          |     | C            | PD | DD |
| Define configuration geometry                                            | W01 | x            | x  |    |
| Estimate preliminary gross weight                                        | W02 | x            | x  |    |
| Develop weight equations for specific configuration                      | W03 | x            | x  |    |
| Define weights in parametric terms                                       | W04 | x            | x  |    |
| Develop weight/size versus fuel relationships                            | W05 | x            | x  |    |
| Estimate weights for point design                                        | W06 | x            | x  |    |
| Develop mass properties characteristics and refine weights               | W07 | x            | x  |    |
| Determine effect of trade studies on mass properties                     | W08 | x            | x  |    |
| Update weights, size, geometry, etc., to reflect effect of trade studies | W09 |              | x  |    |
| Minimize weight                                                          | W10 |              | x  | x  |
| Estimate detailed weights                                                | W11 |              | x  | x  |
| Develop detailed balance and loading data                                | W12 |              | x  | x  |
| Detailed mass distribution and inertias                                  | W13 |              | x  | x  |
| Weight penalties due to A/C features                                     | W14 |              | x  | x  |
| Cost elements                                                            | W15 |              | x  | x  |
| Weight substantiation                                                    | W16 |              | x  | x  |
| <u>COMPUTER PROGRAMS</u>                                                 |     |              |    |    |
| P5525 Aircraft weight sizing                                             |     | x            | x  |    |
| P5619 Aircraft inertia (MIPI)                                            |     | x            | x  |    |
| P5619 Aircraft mass distribution                                         |     | x            | x  | x  |
| P5152 Aircraft weight, C.G., cost element tabulation                     |     |              | x  | x  |
| Parts count                                                              |     |              |    | x  |

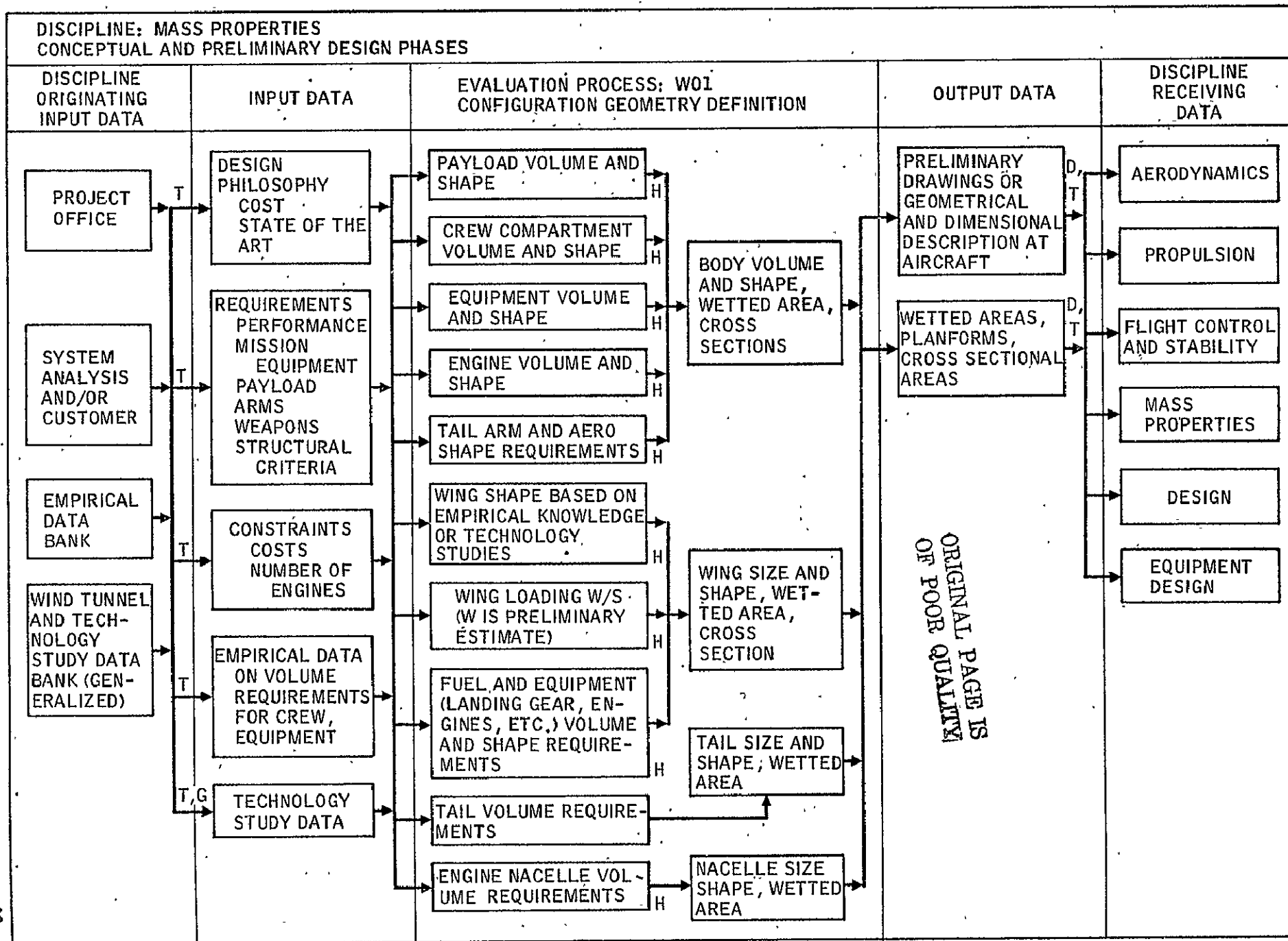
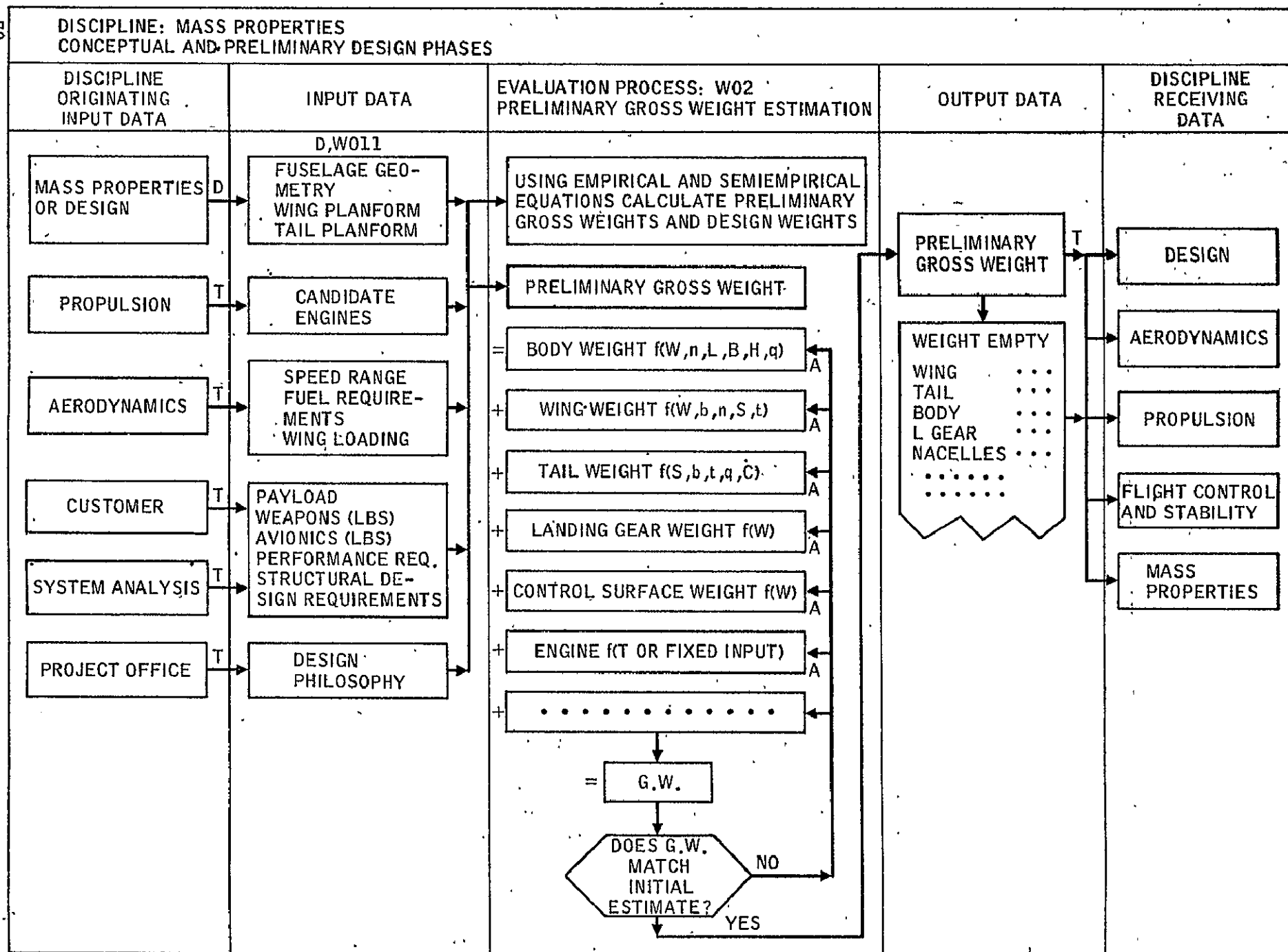
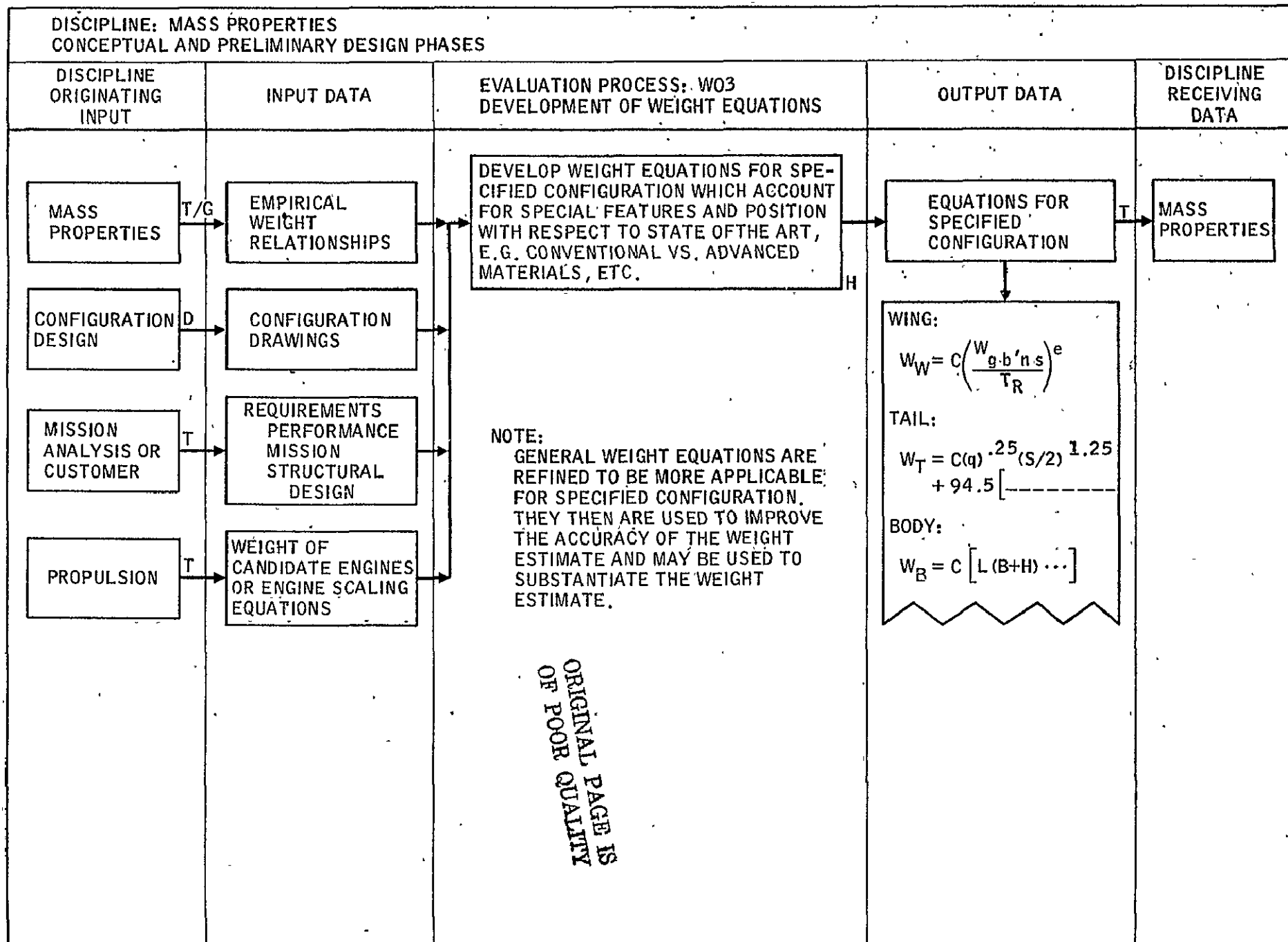


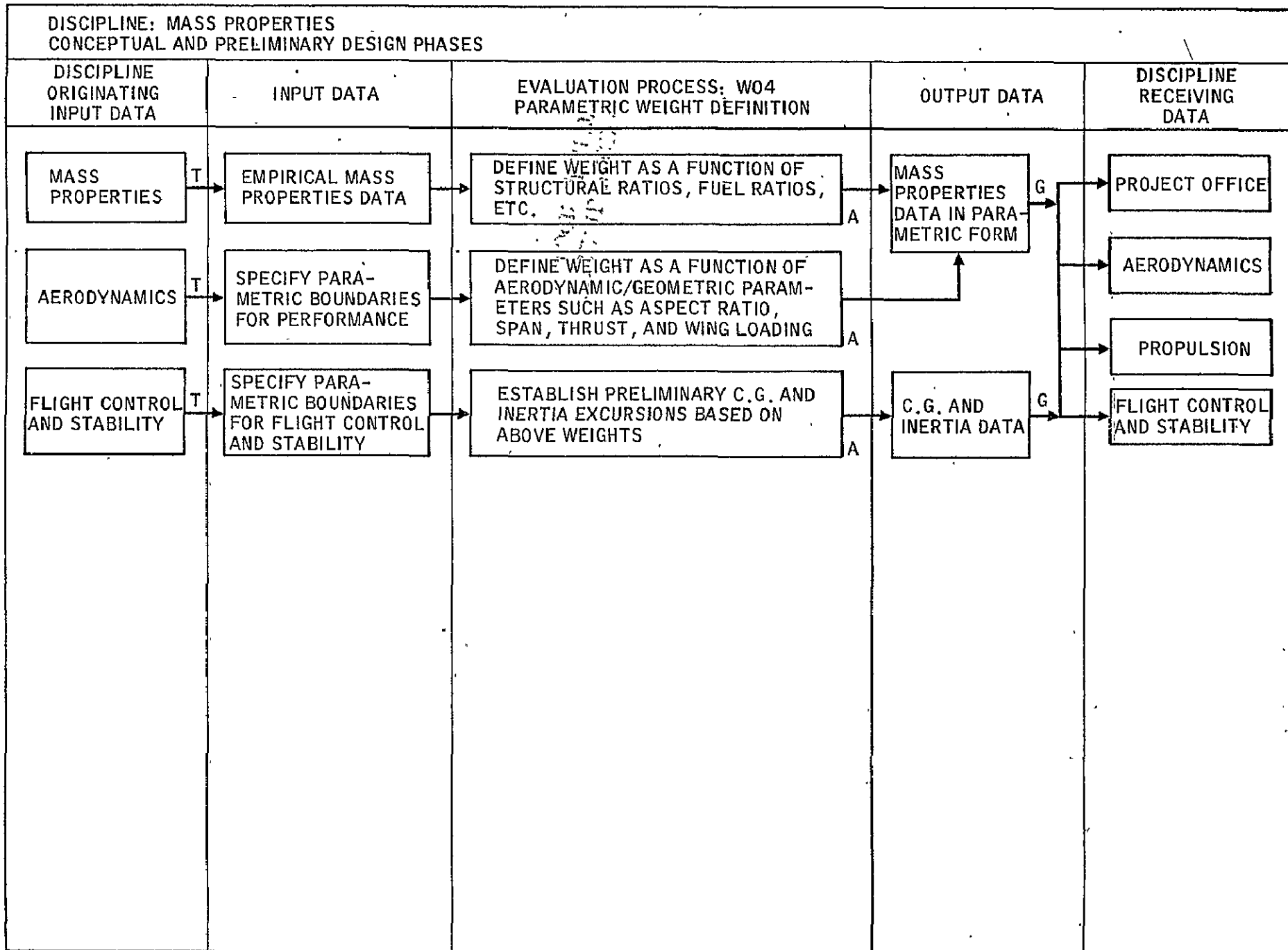
Figure 3-49. Configuration Geometry Definition





ORIGINAL PAGE IS  
OF POOR QUALITY

Figure 3-51. Development of Weight Equations



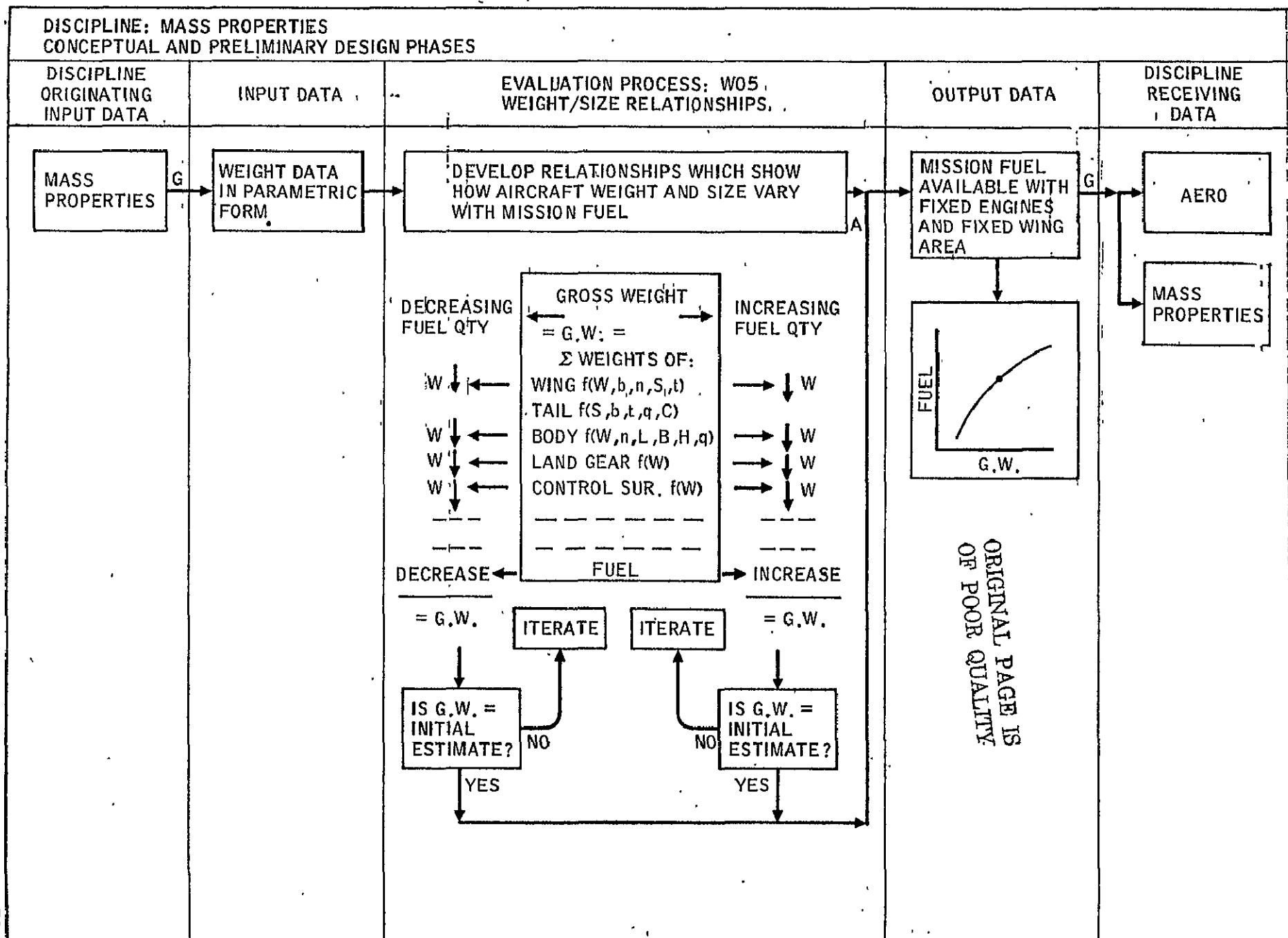
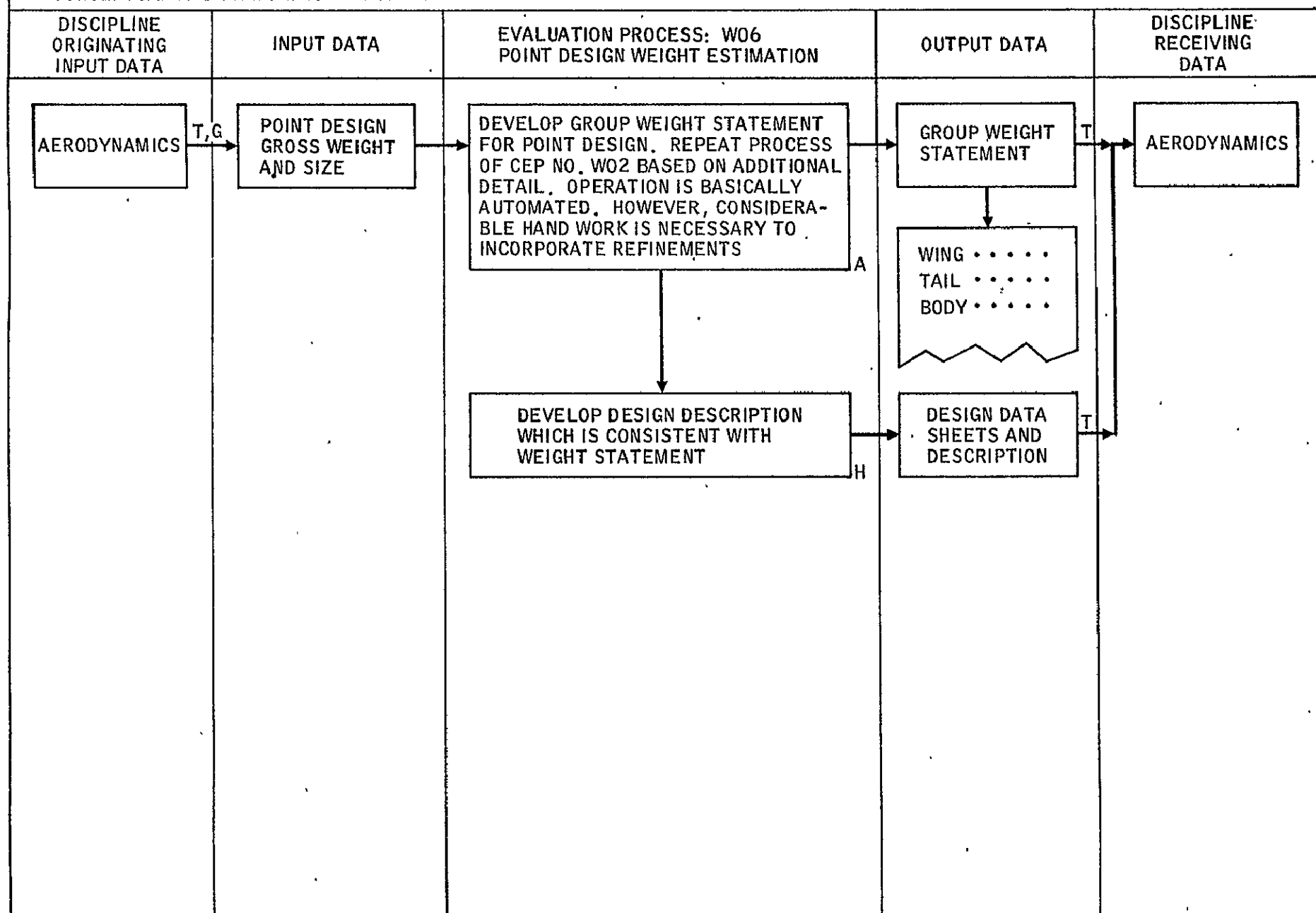


Figure 3-53. Weight/Size Relationships

DISCIPLINE: MASS PROPERTIES  
CONCEPTUAL AND PRELIMINARY DESIGN PHASES



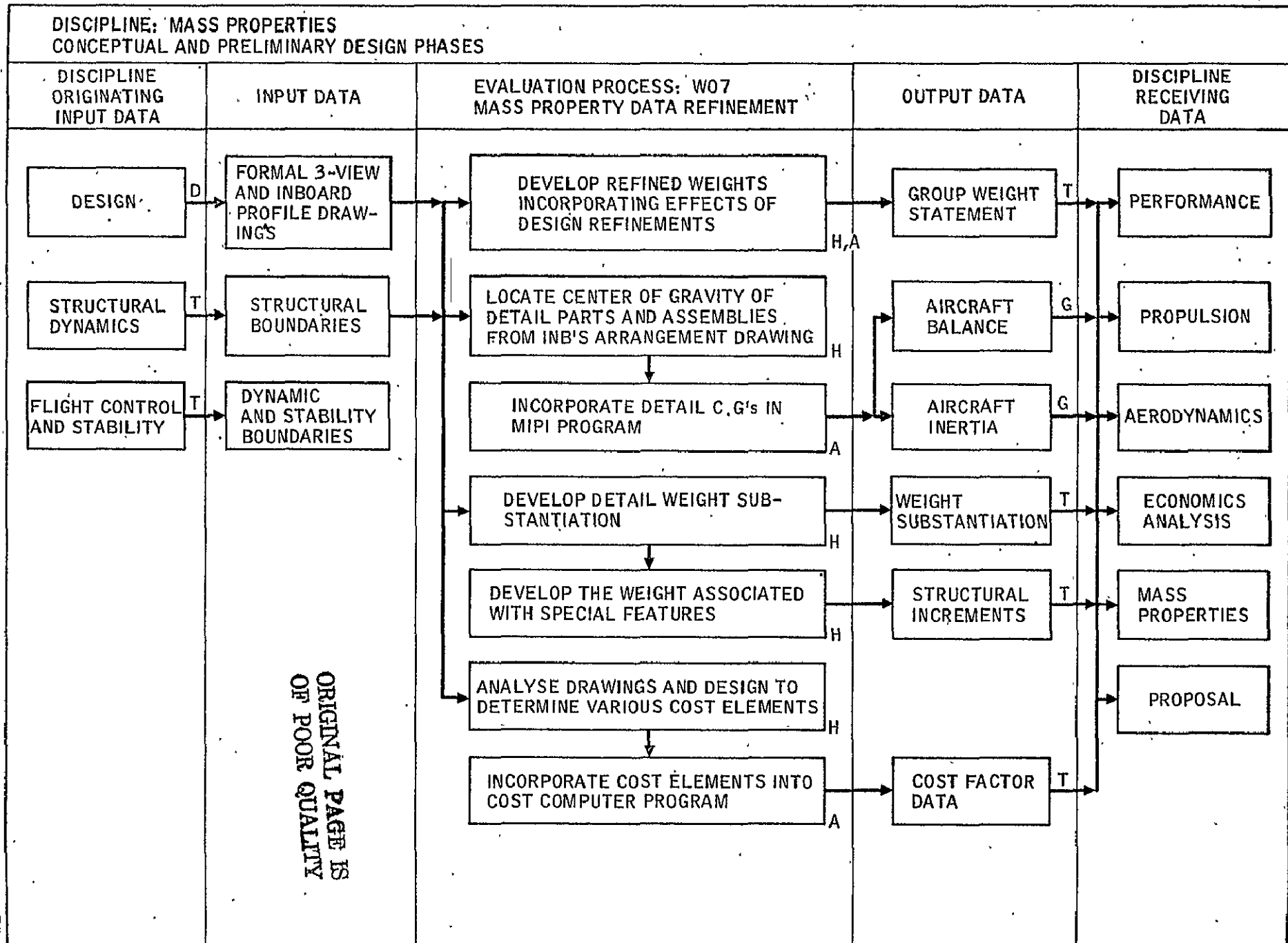
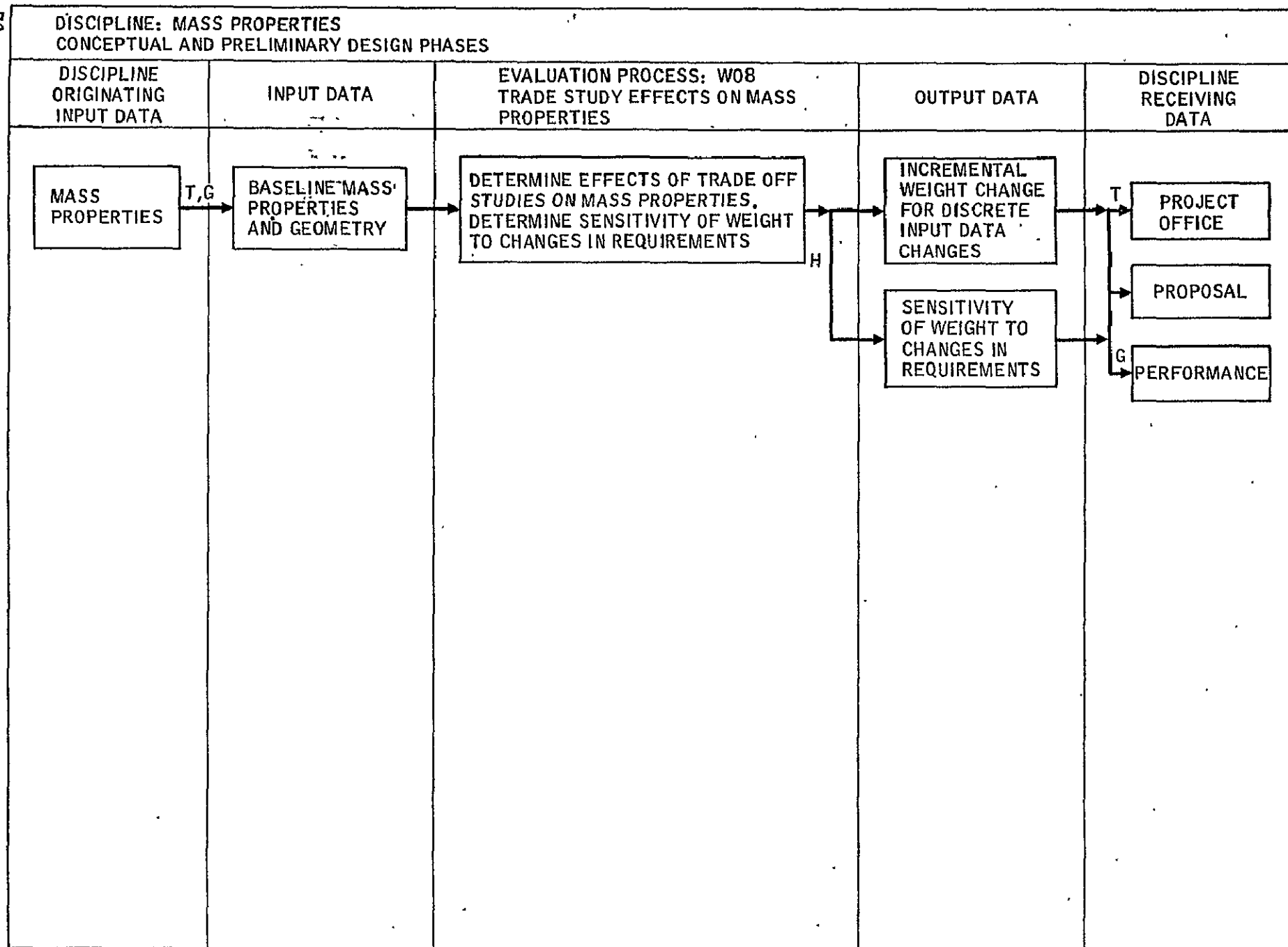


Figure 3-55. Mass Property Data Refinement



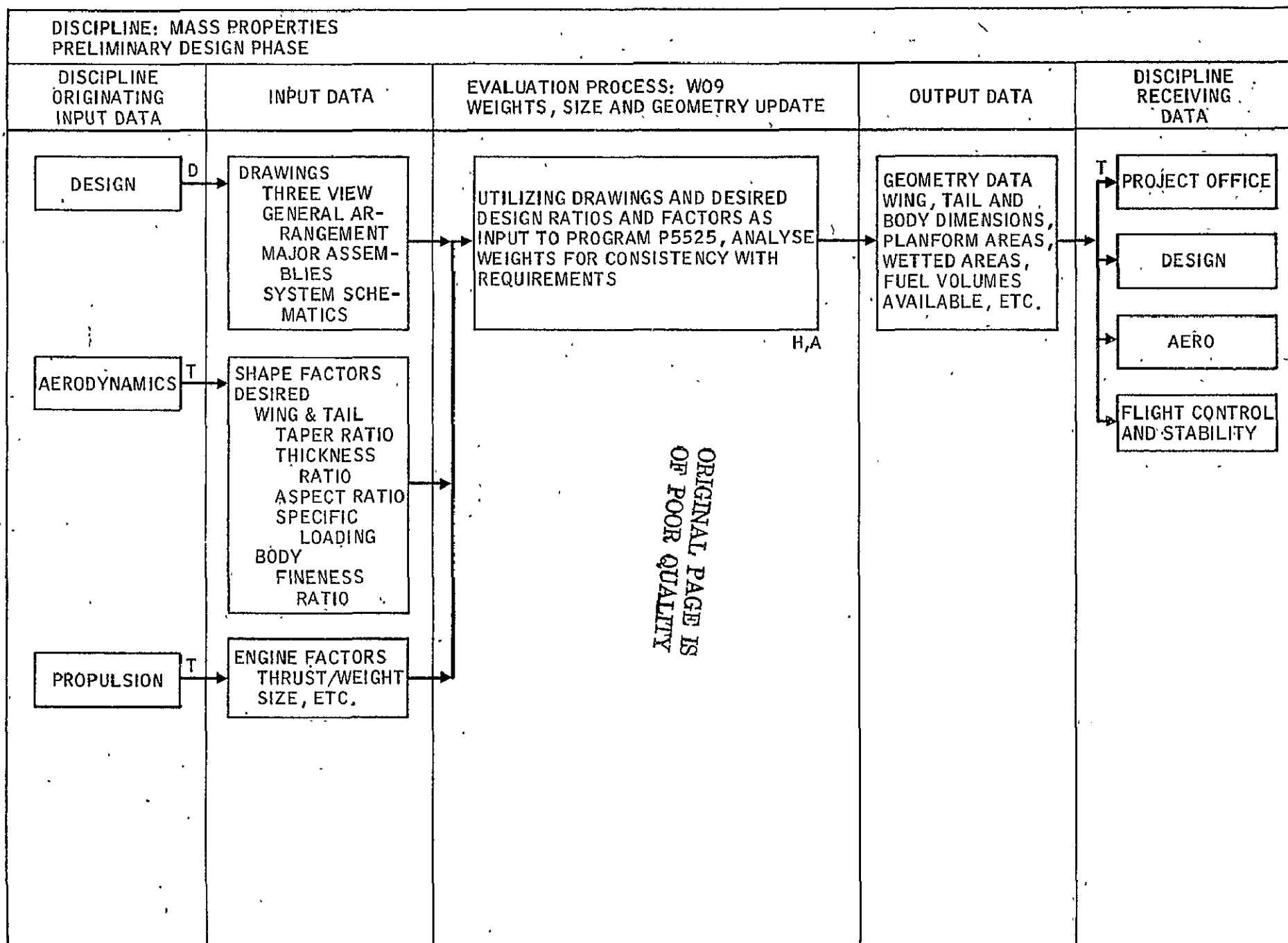
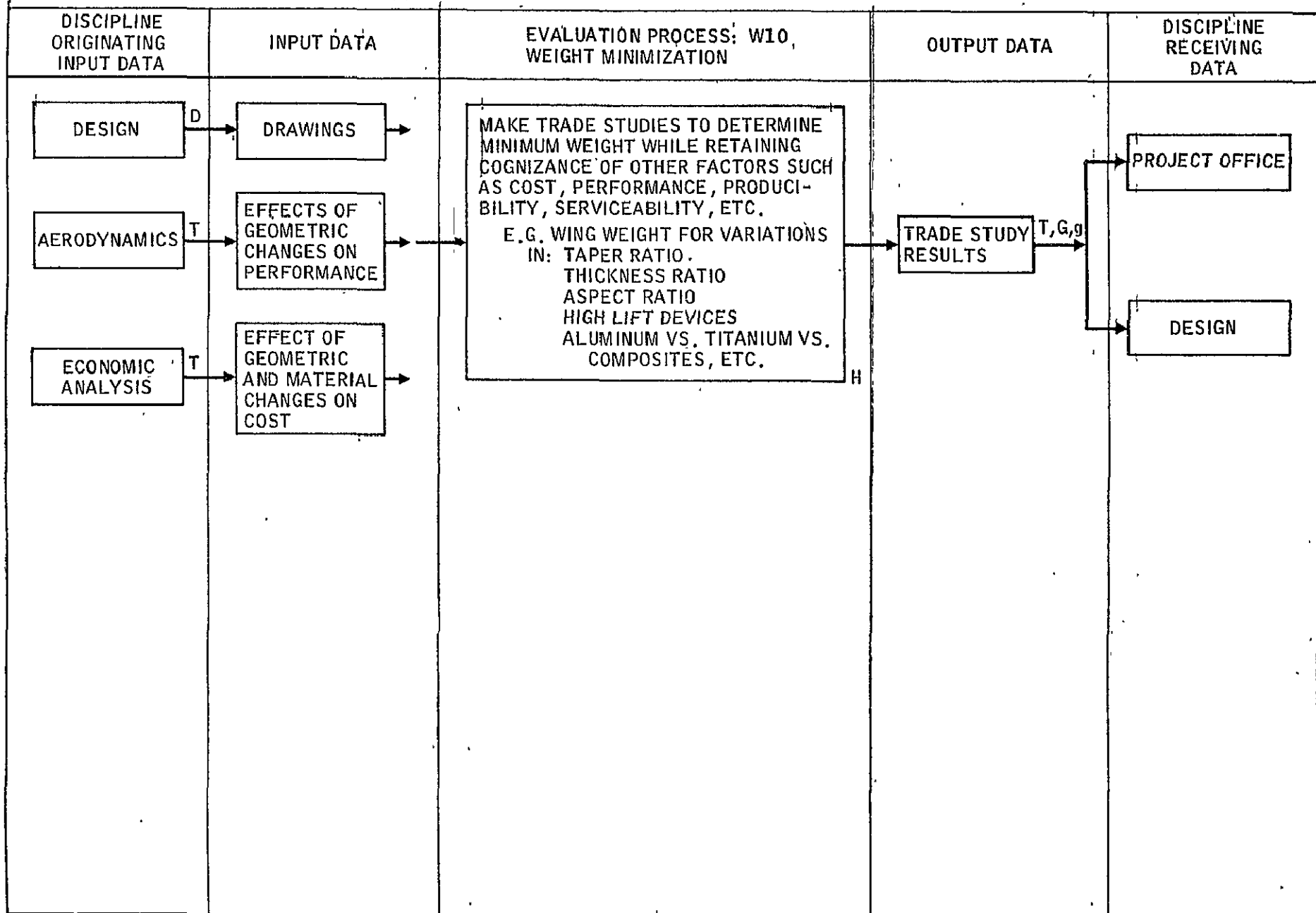


Figure 3-57. Weights, Size, and Geometry Update

DISCIPLINE: MASS PROPERTIES  
PRELIMINARY AND DETAILED DESIGN PHASES



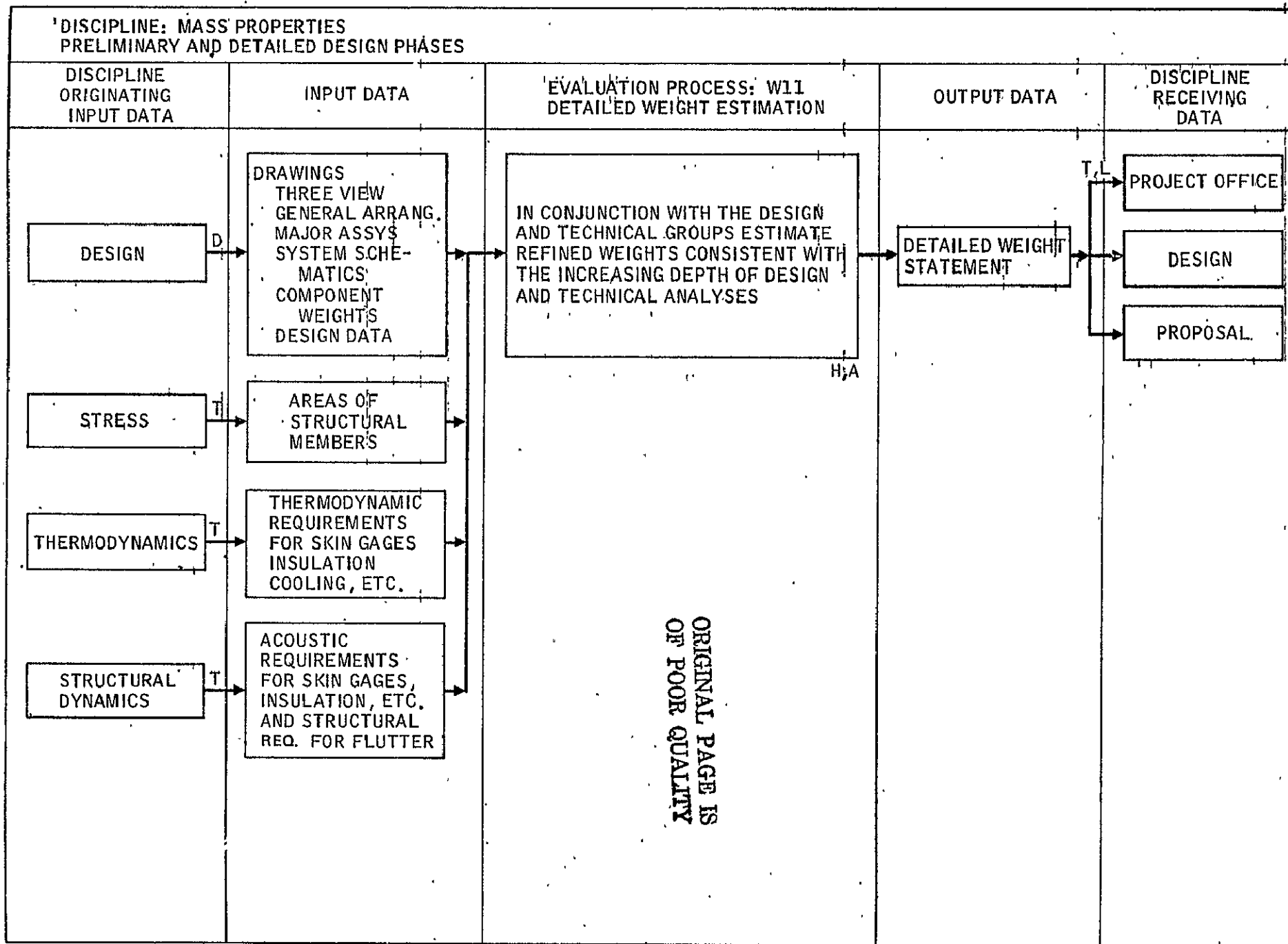
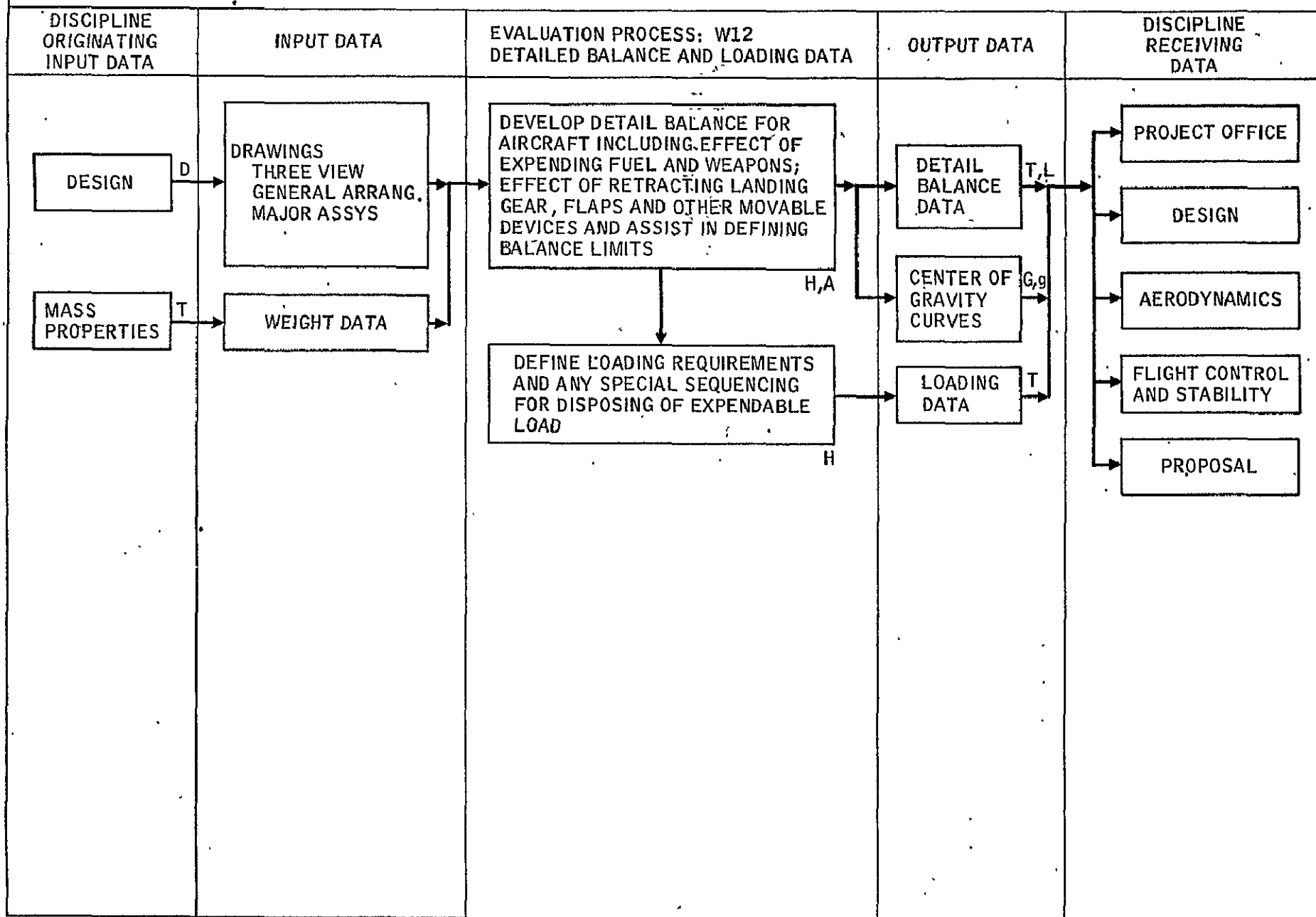


Figure 3-59. Detailed Weight Estimation

DISCIPLINE: MASS PROPERTIES  
PRELIMINARY AND DETAILED DESIGN PHASES



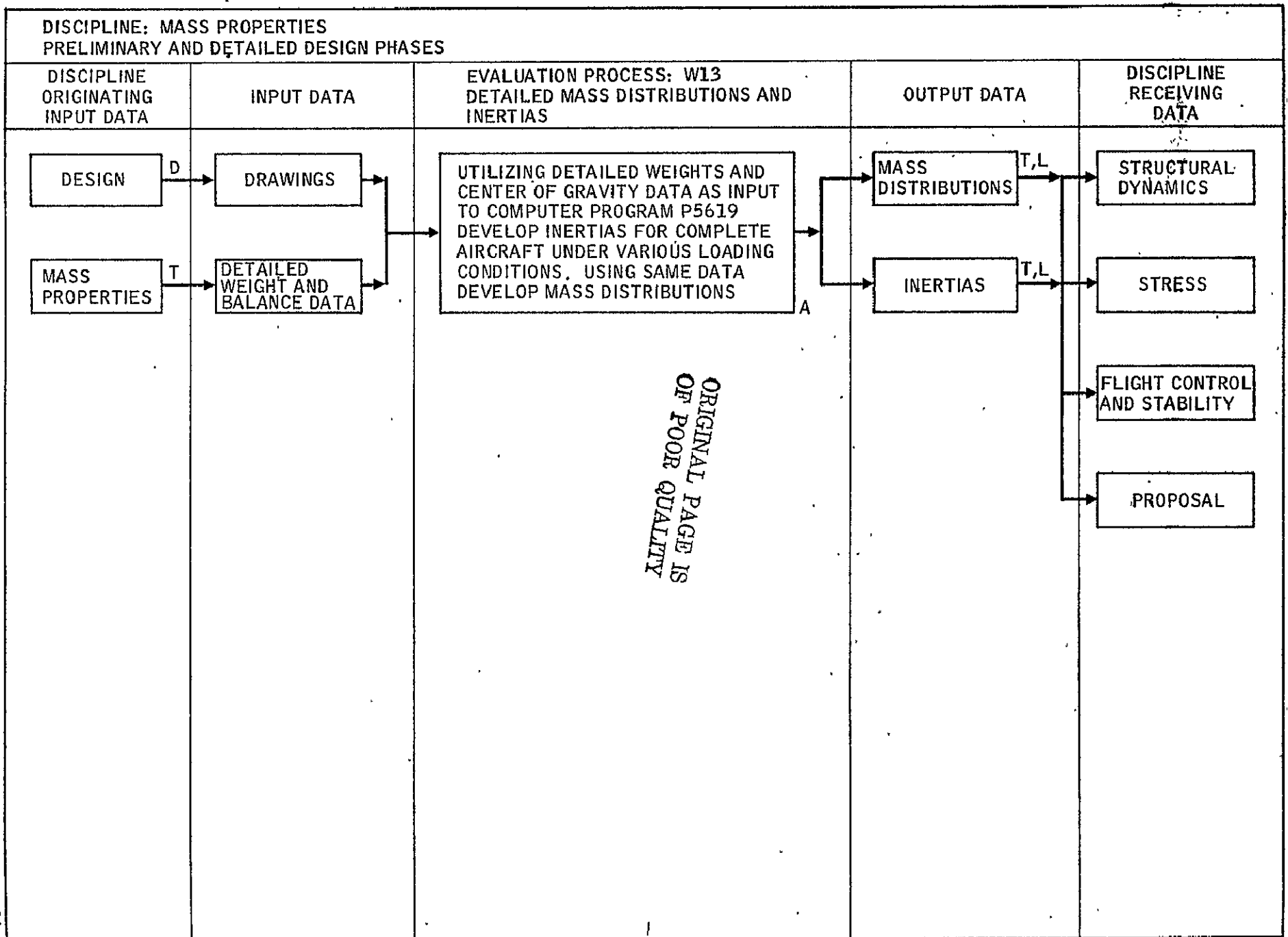
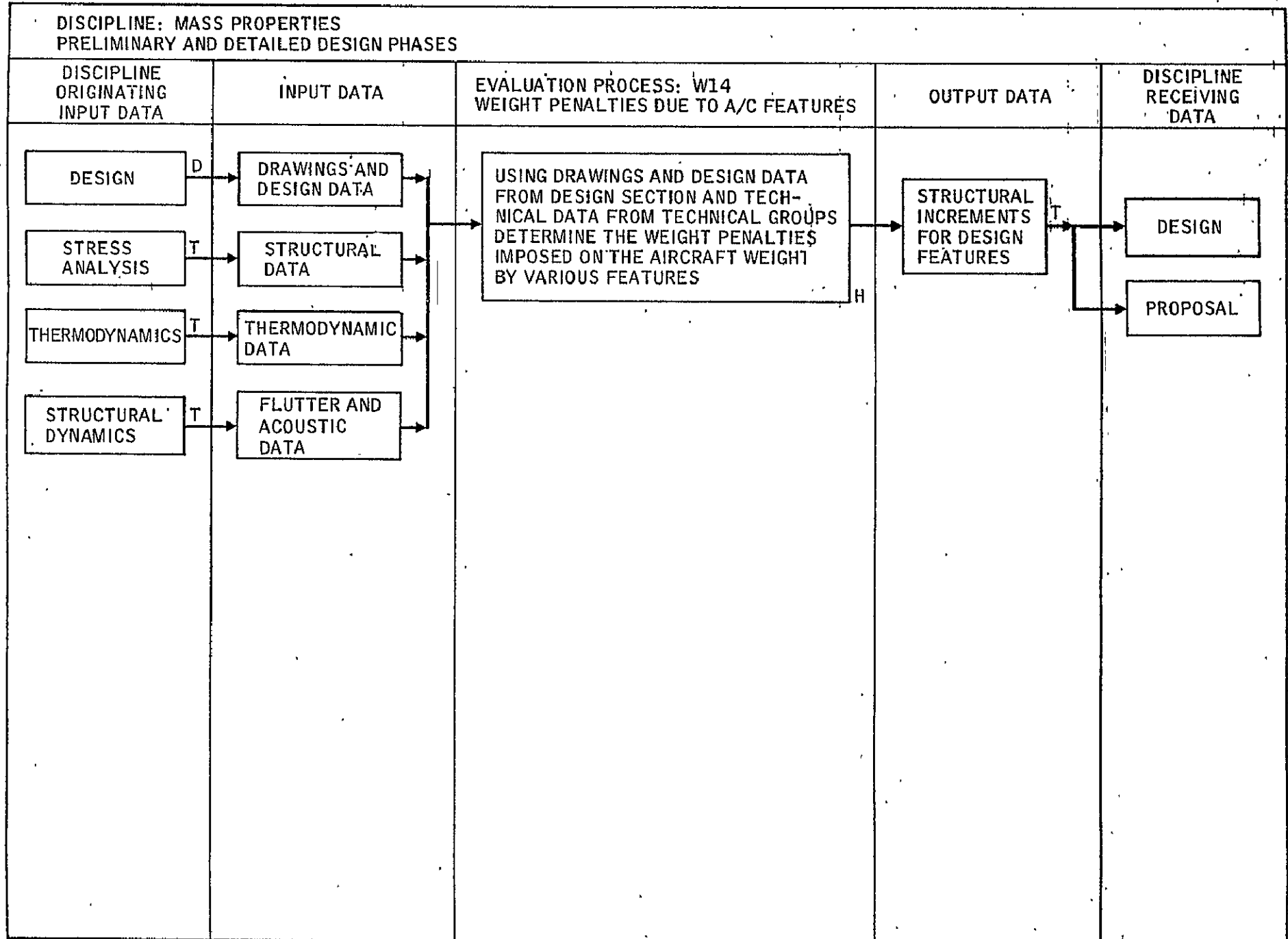


Figure 3-61. Detailed Mass Distributions and Inertias



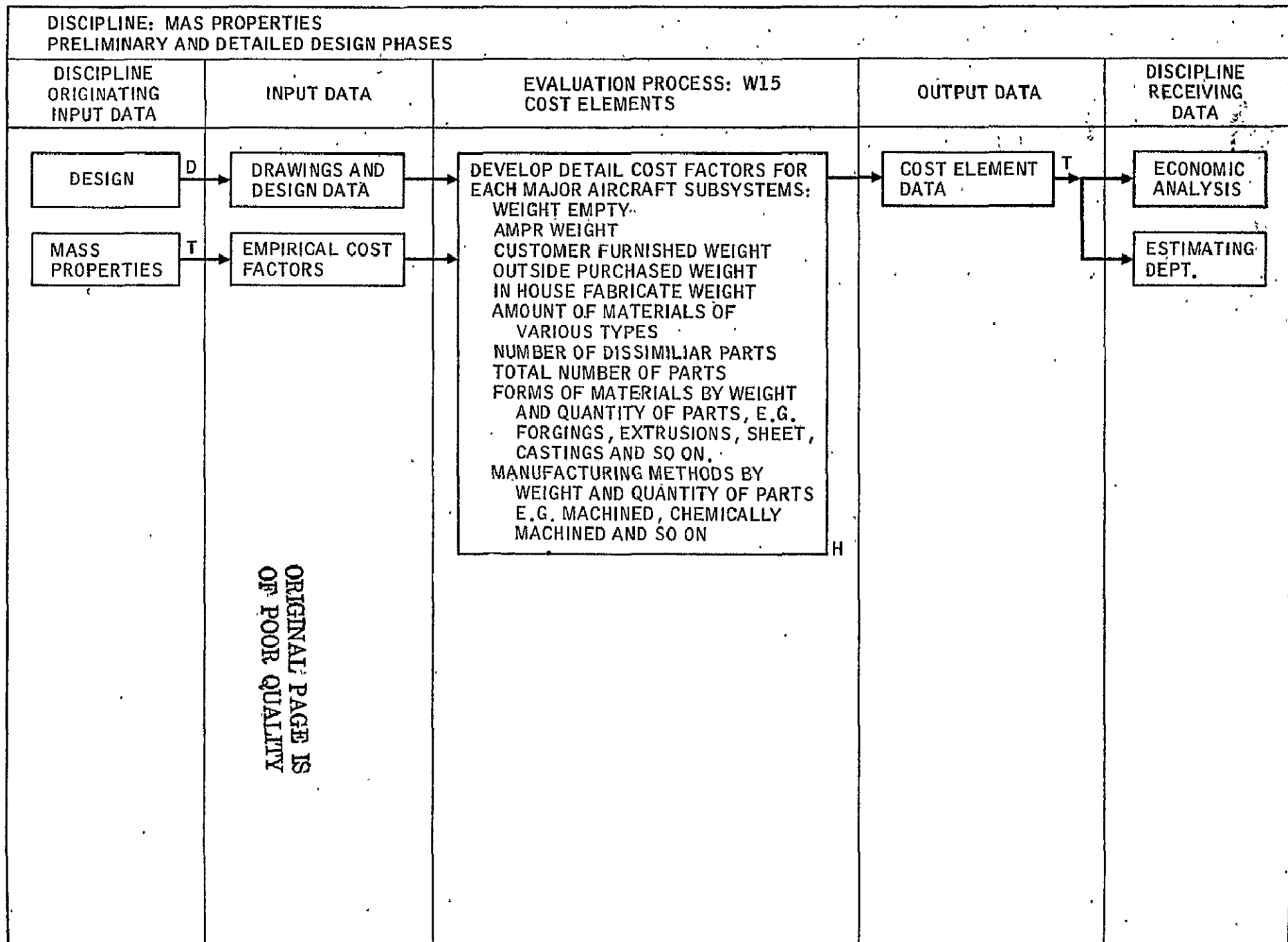
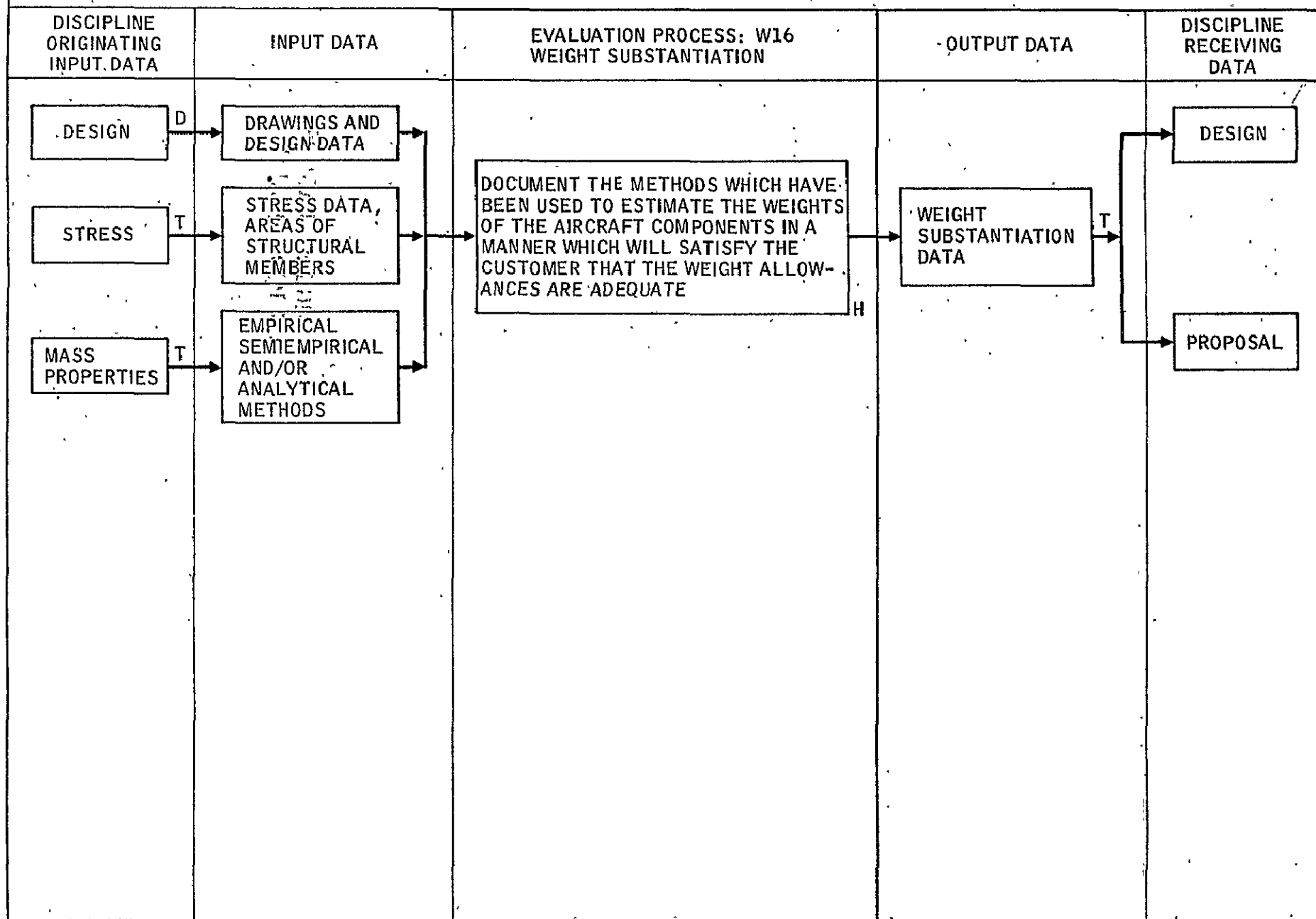


Figure 3-63. Cost Elements

DISCIPLINE: MASS PROPERTIES  
PRELIMINARY AND DETAILED DESIGN PHASES



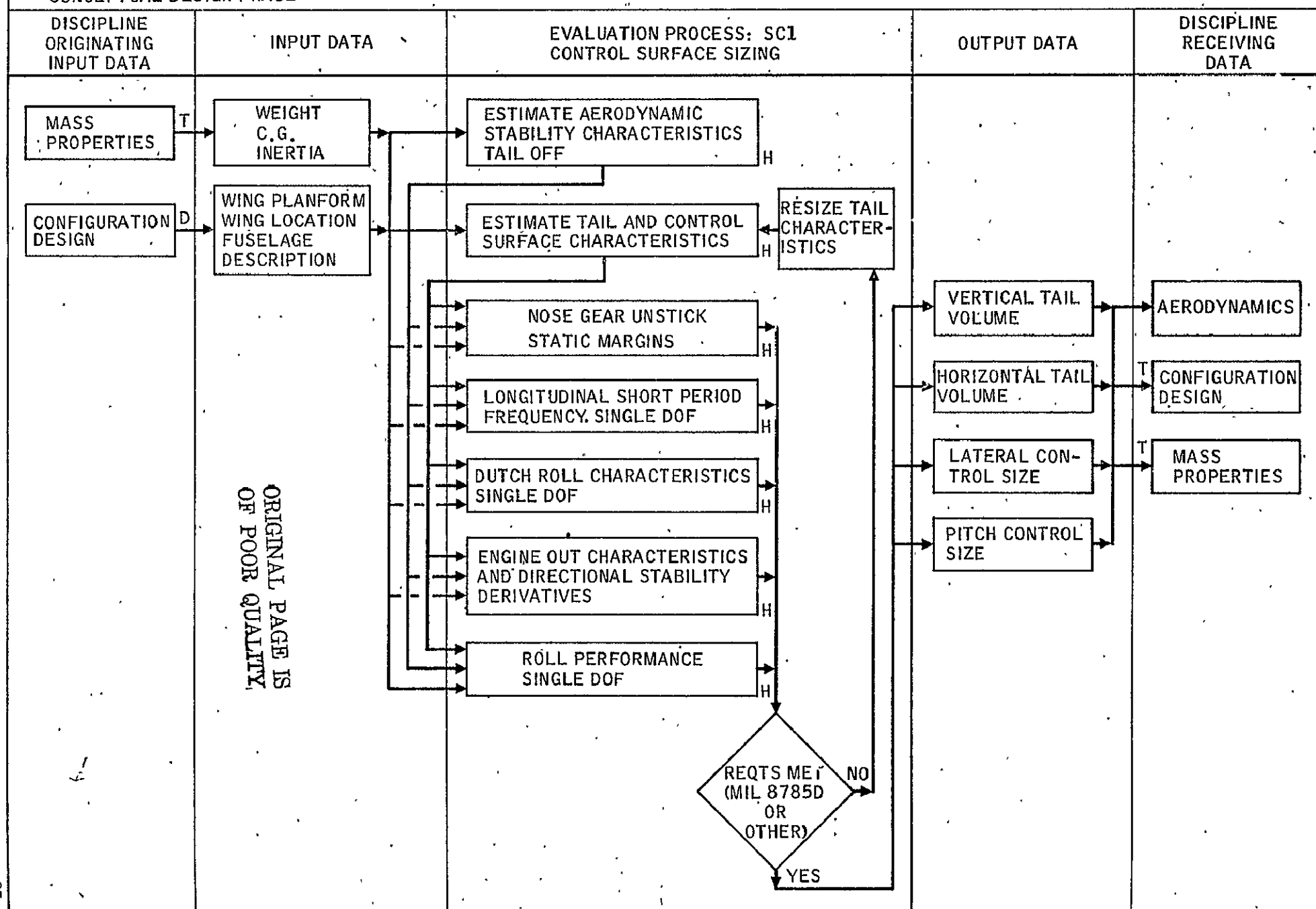


Figure 3-65. Control Surface Sizing

TABLE 3-7. FLIGHT CONTROL AND STABILITY CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                                                                             | CEP | Design Phase |    |    |
|-----------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                                                                                   |     | C            | PD | DD |
| Mechanical Flight Control System Design                                                                                           |     |              | x  | x  |
| Automatic Flight Control System Design                                                                                            |     |              | x  | x  |
| Basic Aircraft Stability Analysis                                                                                                 | SC1 | x            | x  | x  |
| Control Surface Requirements Specification                                                                                        | SC1 | x            | x  | x  |
| Vertical and Horizontal Tail Sizing                                                                                               | SC1 | x            | x  |    |
| Control System Analysis                                                                                                           | SC2 |              | x  | x  |
| Catapult Performance Analysis                                                                                                     | SC4 | x            | x  | x  |
| Stores Separation Analysis                                                                                                        | SC5 |              | x  | x  |
| Six Degree-of-Freedom Trajectory Analysis                                                                                         | SC6 | x            | x  | x  |
| Aerodynamic Stability Derivative Generation                                                                                       | SC1 | x            | x  | x  |
| Propulsive Control Requirements Specification                                                                                     | SC1 | x            | x  | x  |
| Sensor Requirements Specifications                                                                                                | -   |              | x  | x  |
| Flight Control Simulation                                                                                                         | SC3 | x            | x  | x  |
| <u>COMPUTER PROGRAMS</u>                                                                                                          |     |              |    |    |
| TRIM-STAB      General Analysis of Control Systems<br>Evaluates Pertinent System Characteristics                                  | SC2 | x            | x  | x  |
| LAUNCH        Simulates the Launch or Flight of a Missile<br>or Booster During Launch. Determines<br>Control System Requirements. | SC6 |              | x  | x  |
| CATAPULT      Simulates the Catapult Launch of an Aircraft<br>to Evaluate Performance and Control System<br>Requirements.         | SC4 |              | x  | x  |
| 3270            General Differential Equation Solver.<br>Equations in Laplace Notation.                                           |     |              | x  | x  |

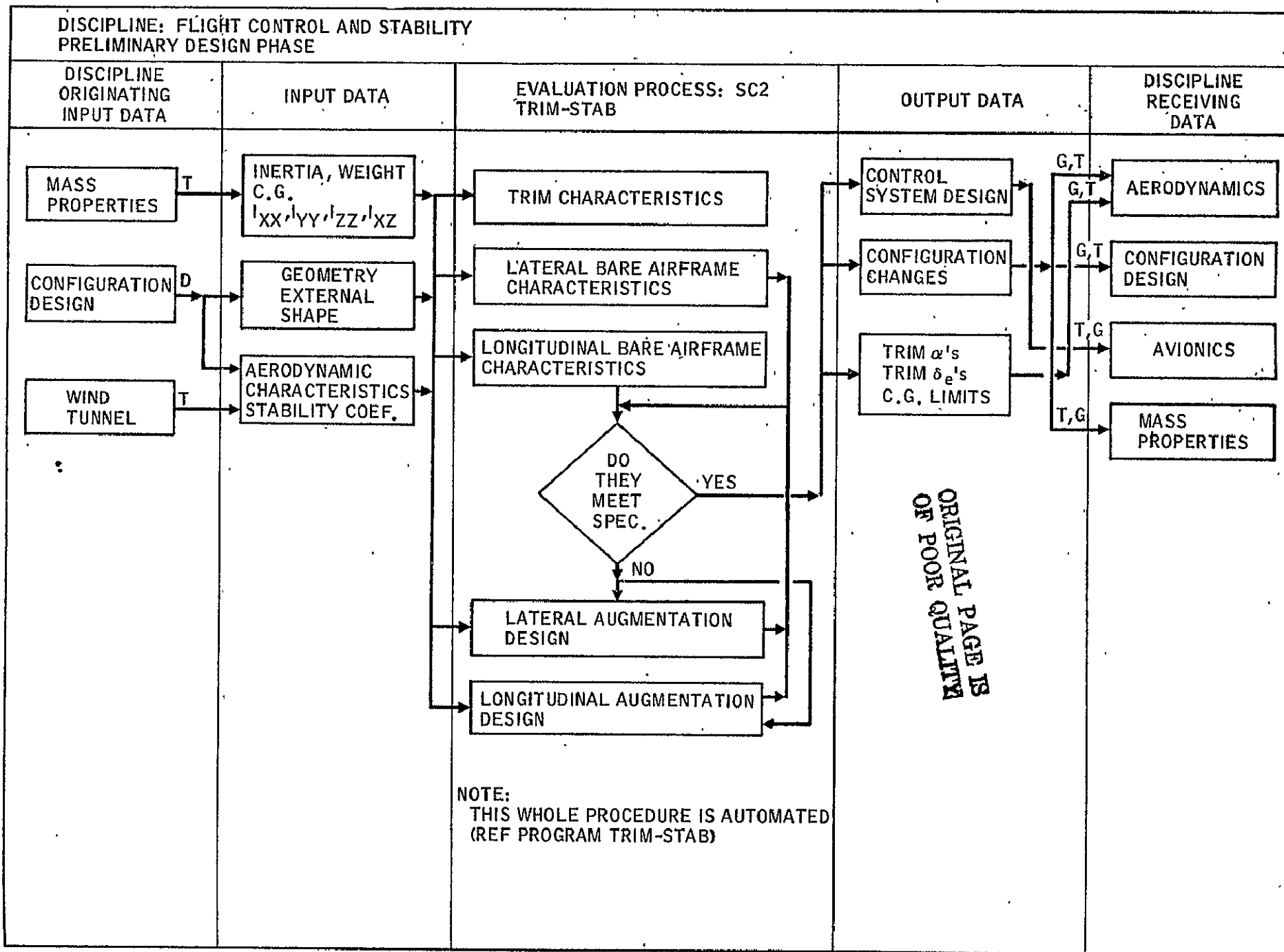
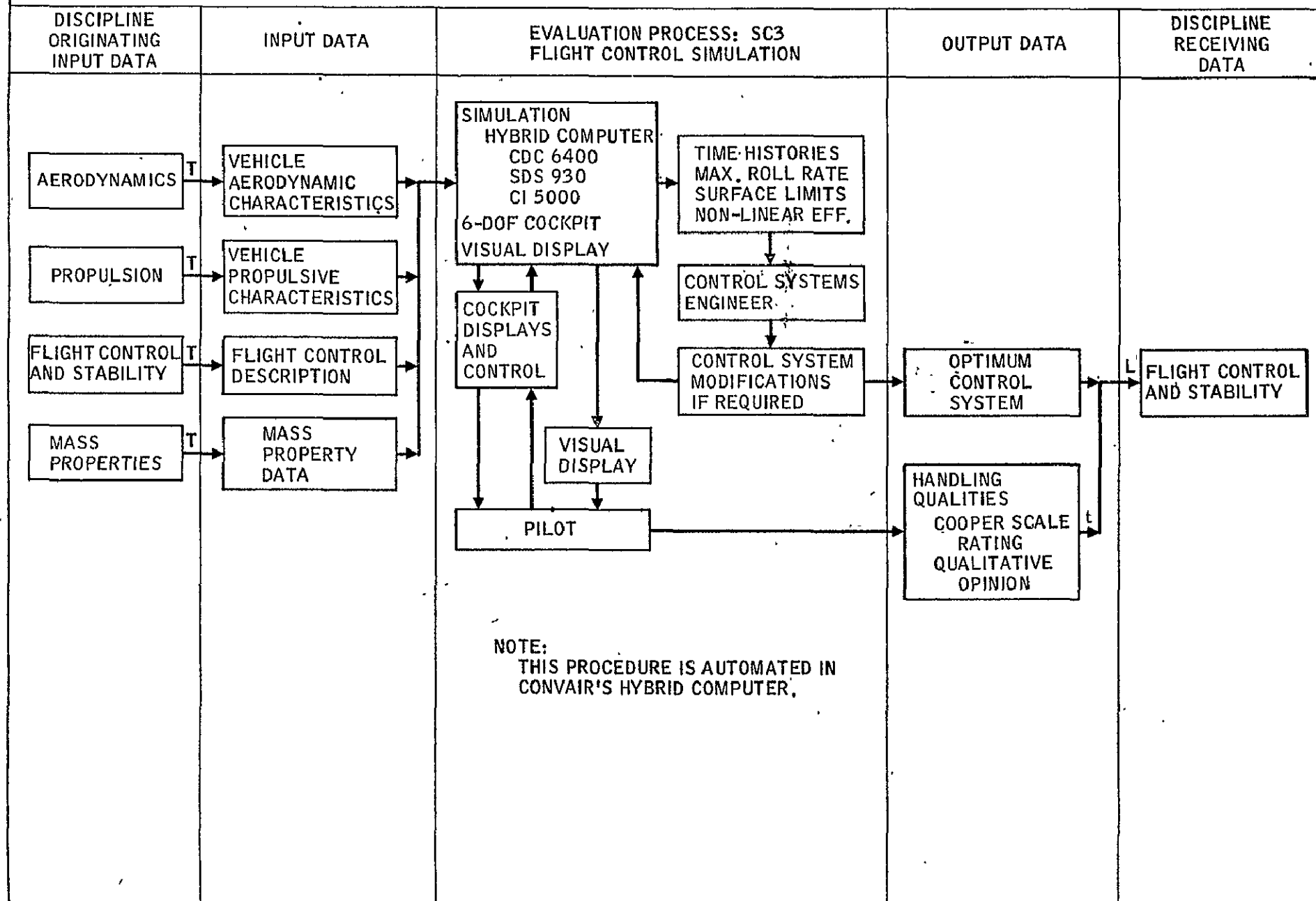


Figure 3-66. Program TRIM-STAB

DISCIPLINE: FLIGHT CONTROL AND STABILITY  
ALL DESIGN PHASES



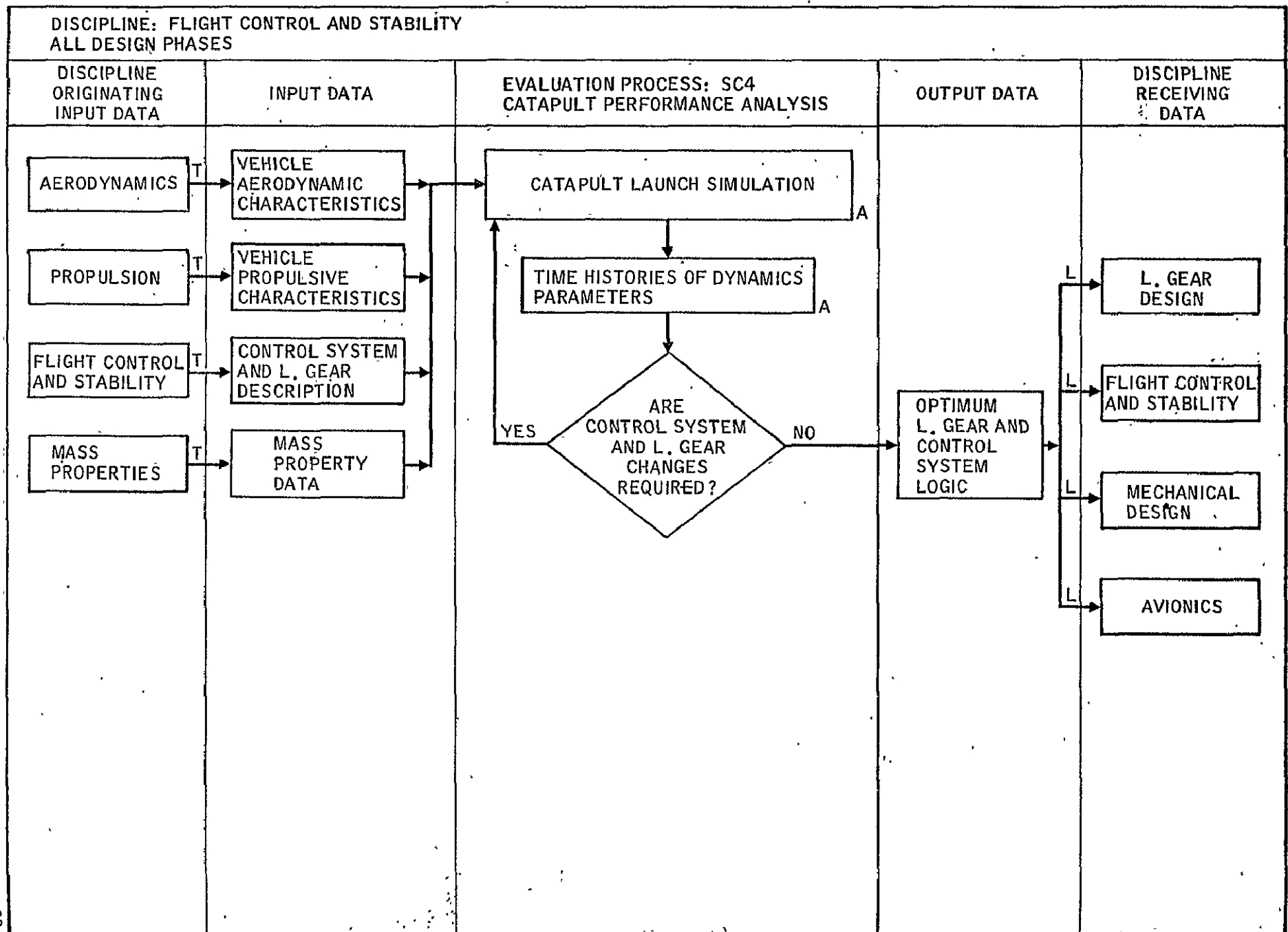
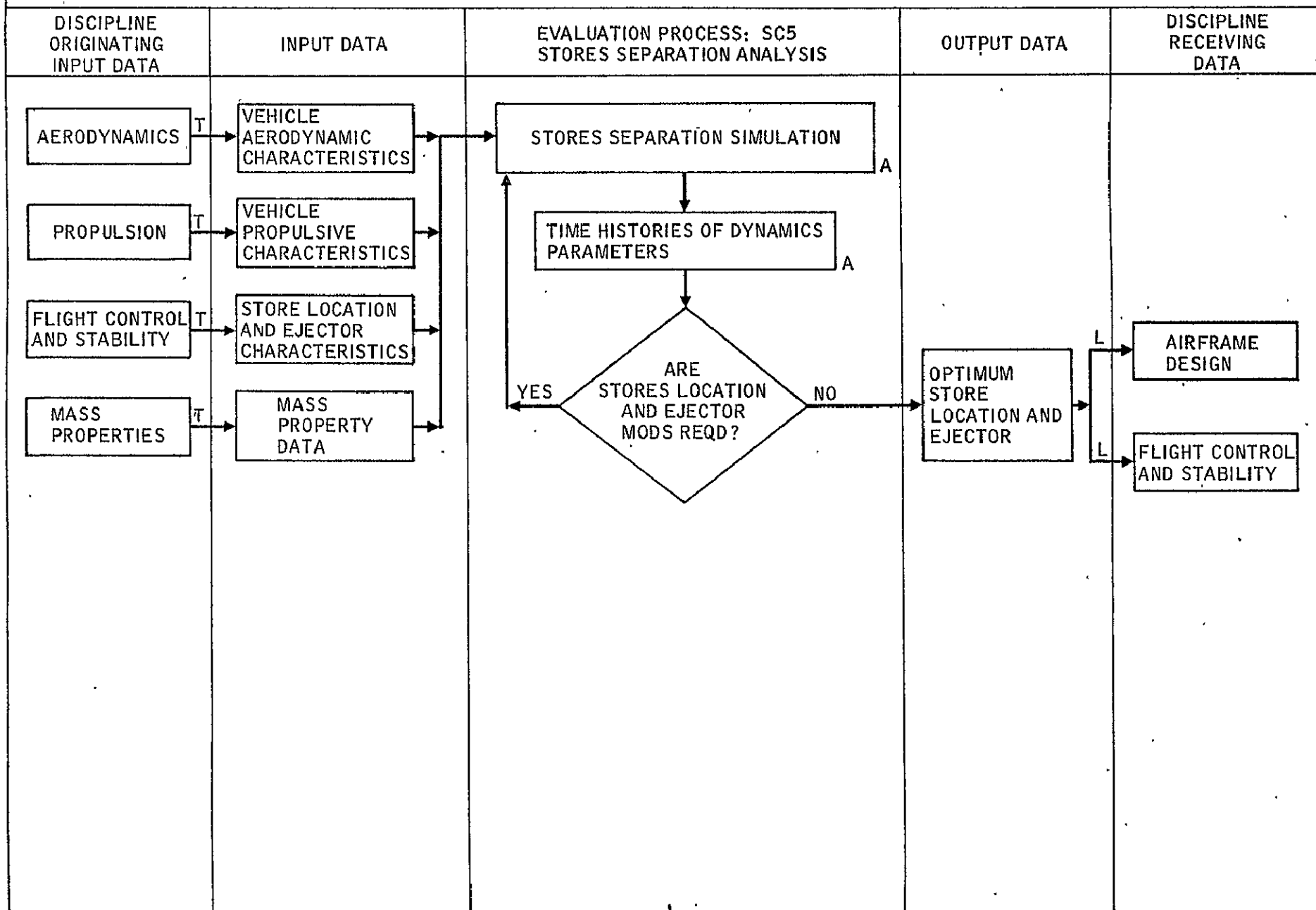


Figure 3-68. Catapult Performance Analysis

DISCIPLINE: FLIGHT CONTROL AND STABILITY  
PRELIMINARY AND DETAILED DESIGN PHASES



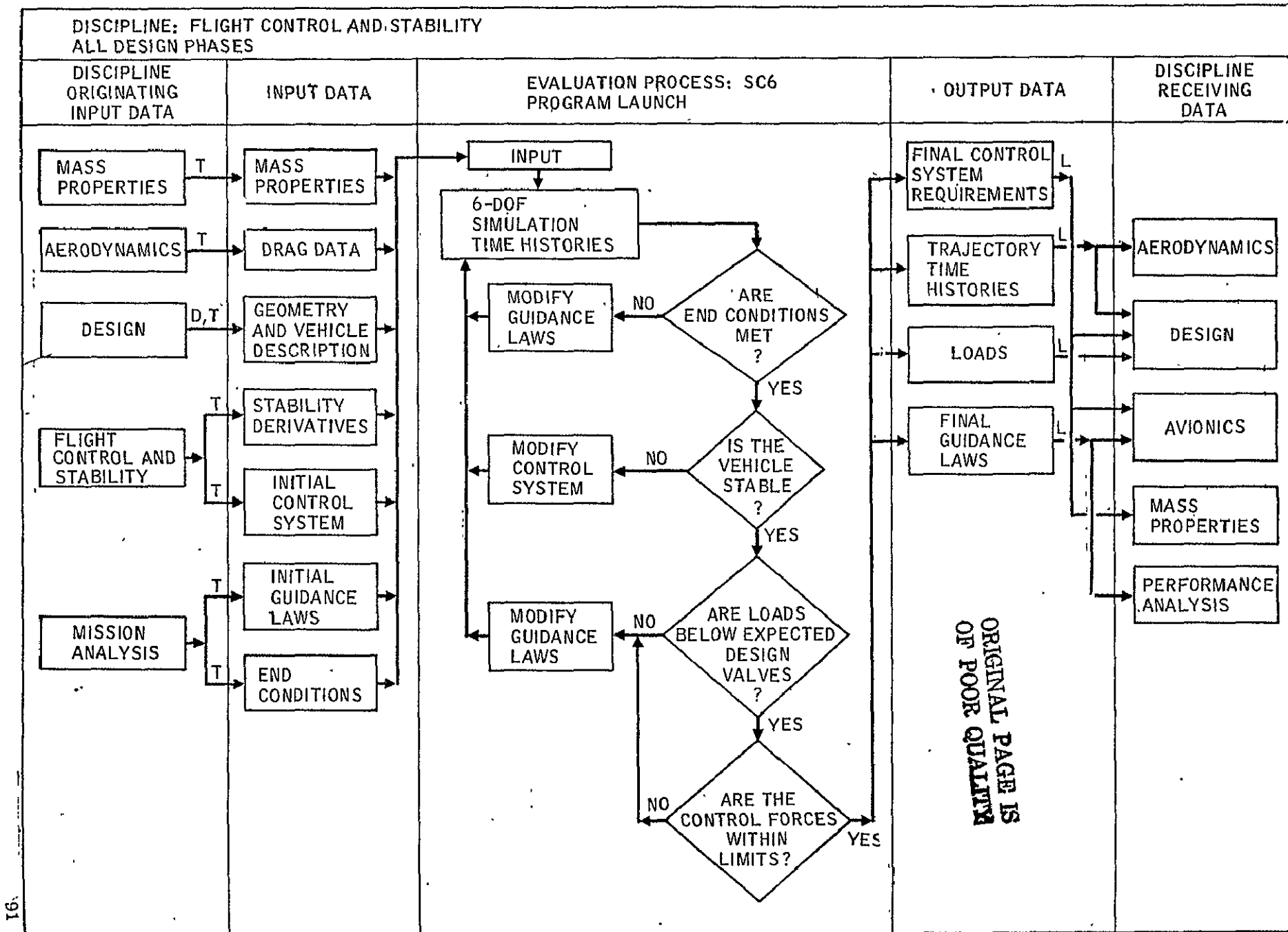


Figure 3-70. Program LAUNCH

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                                                                                                                                                                                                                                                  | CEP | Design Phase |    |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                                                                                                                                                                                                                                                        |     | C            | PD | DD |
| <p>Mission Effectiveness</p> <p>Simplified manual definition of mission, derivation of mathematical model of mission performance, and hand computation of airplane effectiveness in that mission. Typical measure of effectiveness is the number of airplanes required to accomplish a fixed task.</p> | OR1 | x            |    |    |
| <p>Transport Mission Effectiveness</p> <p>Determines transport fleet size required to serve specified route system and tonnages.</p>                                                                                                                                                                   | OR2 |              | x  |    |
| <p>Tactical Mission Effectiveness Determination</p> <p>Simulation of aircraft operation in a tactical environment.</p>                                                                                                                                                                                 | OR3 |              | x  | x  |
| <p>Strategic Mission Effectiveness Determination</p> <p>Simulation of aircraft operation in a strategic environment.</p>                                                                                                                                                                               | OR4 |              | x  | x  |
| <p>Preliminary Basing and Operations Analysis</p> <p>Estimation of support requirements (e.g., tankers, maintenance, spares, personnel) implied by proposed basing scheme.</p>                                                                                                                         | OR5 |              | x  |    |
| <p>Availability Analysis</p> <p>Simulation of maintenance and operations of a wing of aircraft to determine turnaround time-distribution, maximum sortie rates and alert rates.</p>                                                                                                                    | OR6 |              | x  | x  |
| <p>Support Assets Determination</p> <p>Determination of spares, AGE, and personnel required to sustain an operating unit of aircraft under various circumstances.</p>                                                                                                                                  | OR7 |              | x  |    |

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS (CONT'D).

| TASKS                                                                                                                                                                                                                                                                                                                              | ORIGINAL PAGE IS<br>OF POOR QUALITY | CEP  | Design Phase |    |    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------|--------------|----|----|
|                                                                                                                                                                                                                                                                                                                                    |                                     |      | C            | PD | DD |
| Preliminary Survivability Evaluation                                                                                                                                                                                                                                                                                               |                                     | OR8  | x            |    |    |
| Estimation of probabilities of survival for single encounters with various threat types (e.g., SAMs, interceptors) as formation of performance parameters (e.g., speed, penetration altitude).                                                                                                                                     |                                     |      |              |    |    |
| Vulnerability/Survivability Evaluation                                                                                                                                                                                                                                                                                             |                                     | OR9  | x            |    |    |
| Utilizes manual estimates of vulnerable area to rank competing candidates or as input to weapon simulation models to compute relative probabilities of survival.                                                                                                                                                                   |                                     |      |              |    |    |
| System Analysis Studies                                                                                                                                                                                                                                                                                                            |                                     | OR10 | x            |    |    |
| Survivability Evaluation                                                                                                                                                                                                                                                                                                           |                                     | OR11 |              |    | x  |
|                                                                                                                                                                                                                                                                                                                                    |                                     | OR12 |              |    | x  |
| Principal aircraft structural and subsystem components are represented geometrically in computer model which generates tables of vulnerable areas as function of aspect angle and kill level. Tables are then input to various weapon simulation models for computation of survival probabilities in explicit tactical situations. |                                     |      |              |    |    |
| <u>COMPUTER PROGRAMS</u>                                                                                                                                                                                                                                                                                                           |                                     |      |              |    |    |
| Strategic War Model                                                                                                                                                                                                                                                                                                                |                                     |      |              | x  |    |
| Determines targets killed and aircraft attrition for a mixed force of aircraft attacking a defended target complex.                                                                                                                                                                                                                |                                     |      |              |    |    |
| Penetration Simulation Model                                                                                                                                                                                                                                                                                                       |                                     |      |              | x  | x  |
| Provides a detailed simulation of an attack on a strategic target complex by a fleet or aircraft.                                                                                                                                                                                                                                  |                                     |      |              |    |    |

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS (CONT'D)

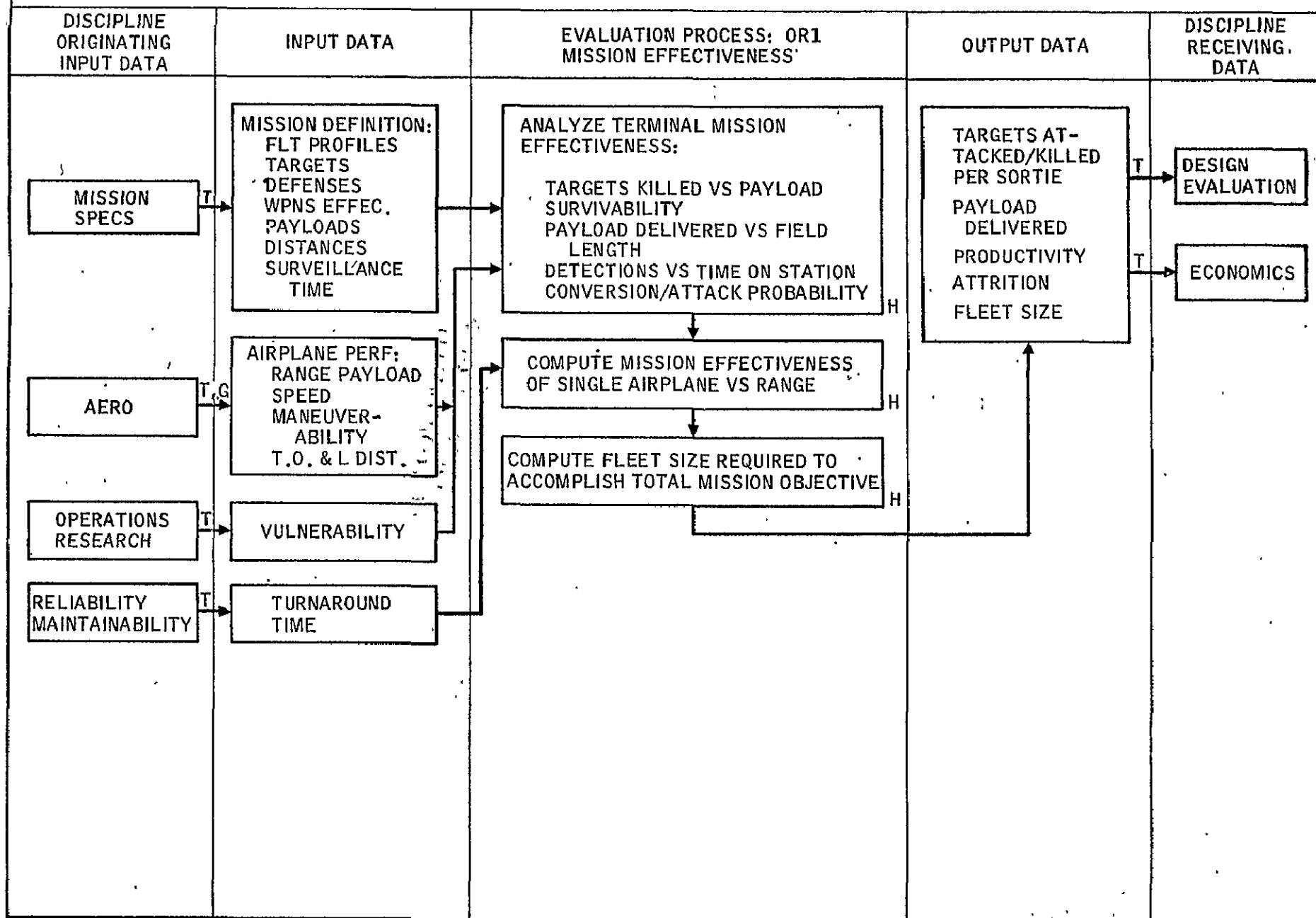
| COMPUTER PROGRAMS                                                                                                                                                             | CEP | Design Phase |    |    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                                                                                                                               |     | C            | PD | DD |
| Cruise-Out Model<br><br>Determines feasible routings for strategic aircraft and tankers from bases to penetration point.                                                      |     |              | x  | x  |
| Limited War Effectiveness Model<br><br>Computes effectiveness measures (e.g., targets killed per sortie, attrition rate) for an aircraft operating in a tactical environment. |     | x            | x  |    |
| SAM Encounter Model<br><br>Simulates an encounter between an aircraft and a SAM site.                                                                                         |     | x            | x  | x  |
| Air Interceptor Model<br><br>Determines feasible intercept points along the flight path of an aircraft flying through a complex of interceptor bases and radar installations. |     | x            | x  |    |
| Maneuvering Aircraft Survivability Model<br><br>Dynamic simulation of maneuvering aircraft engages by antiaircraft artillery and automatic weapons.                           |     |              |    |    |
| Subsystem Simulation Model<br><br>Determines turnaround time distribution and asset requirements of each subsystem.                                                           |     |              | x  | x  |
| Network Analysis Model<br><br>Determines maintenance turnaround time distribution for an aircraft.                                                                            |     |              | x  | x  |

TABLE 3-8. OPERATIONS RESEARCH CEP'S AND COMPUTER PROGRAMS (CONT'D)

| COMPUTER PROGRAMS                                                                                                                                                                                                                                                                                                                                  | CEP | Design Phase |    |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                                                                                                                                                                                                                                                                                                    |     | C            | PD | DD |
| <p>Aircraft Vulnerability Analysis Model</p> <p>Aircraft structure and subsystem components are represented by large number of spatially oriented geometric shapes. Model projects shapes at desired aspect angle and computes vulnerable areas, accounting for masking effects and projectile slow down during penetration of each component.</p> |     |              | X  | X  |

ORIGINAL PAGE IS  
OF POOR QUALITY

# DISCIPLINE: OPERATIONS RESEARCH CONCEPTUAL DESIGN PHASE



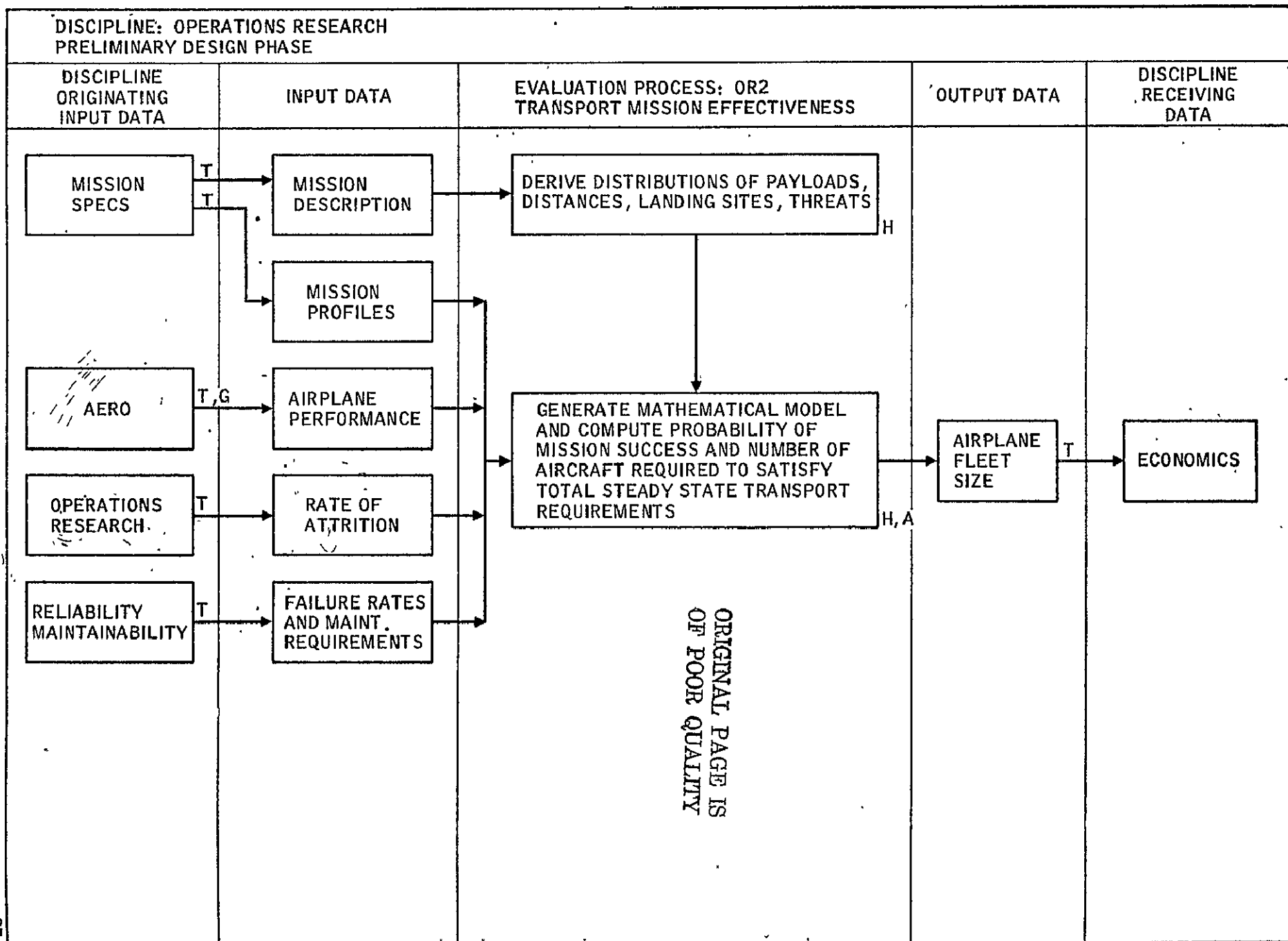


Figure 3-72. Transport Mission Effectiveness

DISCIPLINE: OPERATIONS RESEARCH  
PRELIMINARY DESIGN PHASE

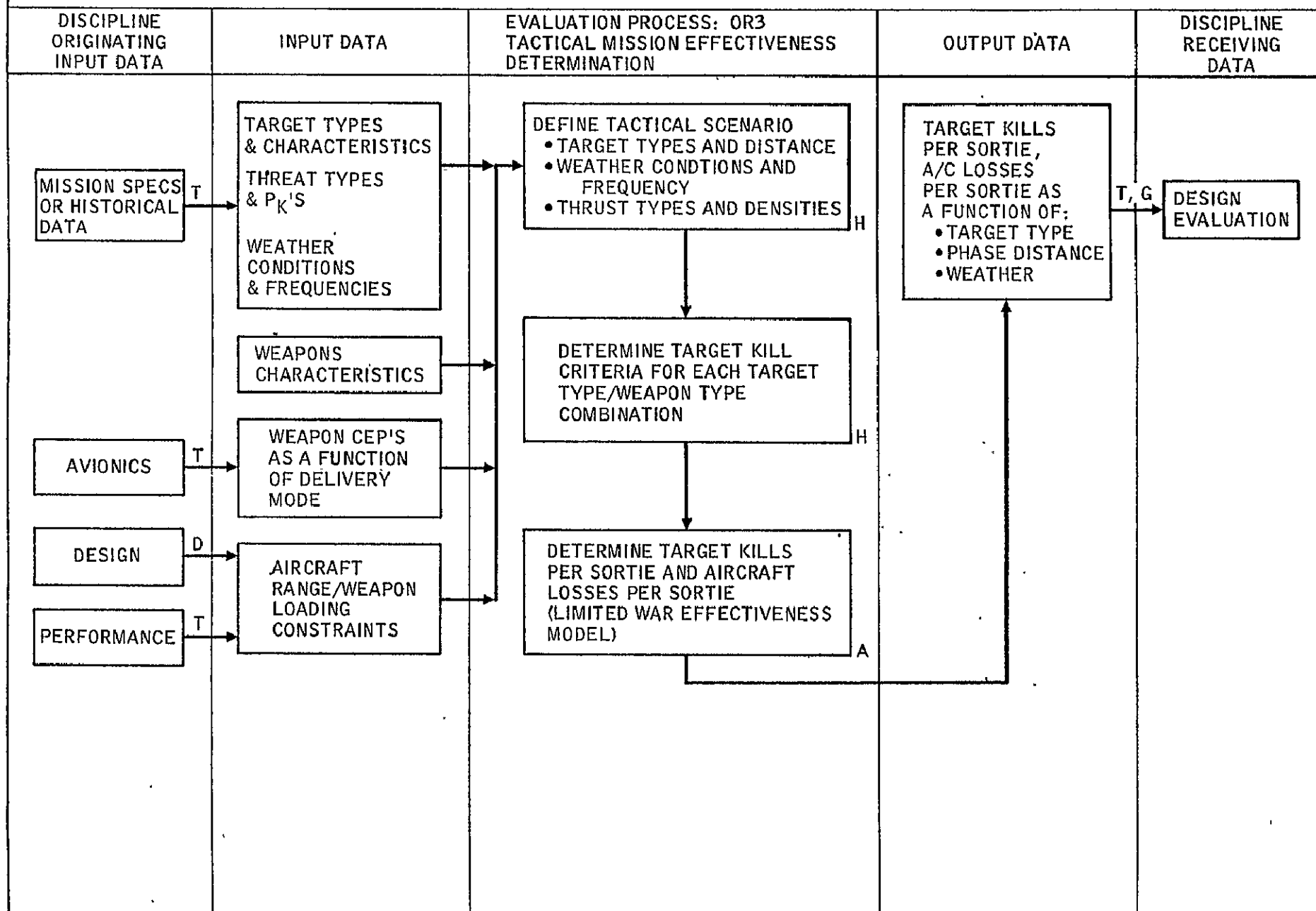


Figure 3-73. Tactical Mission Effectiveness Determination

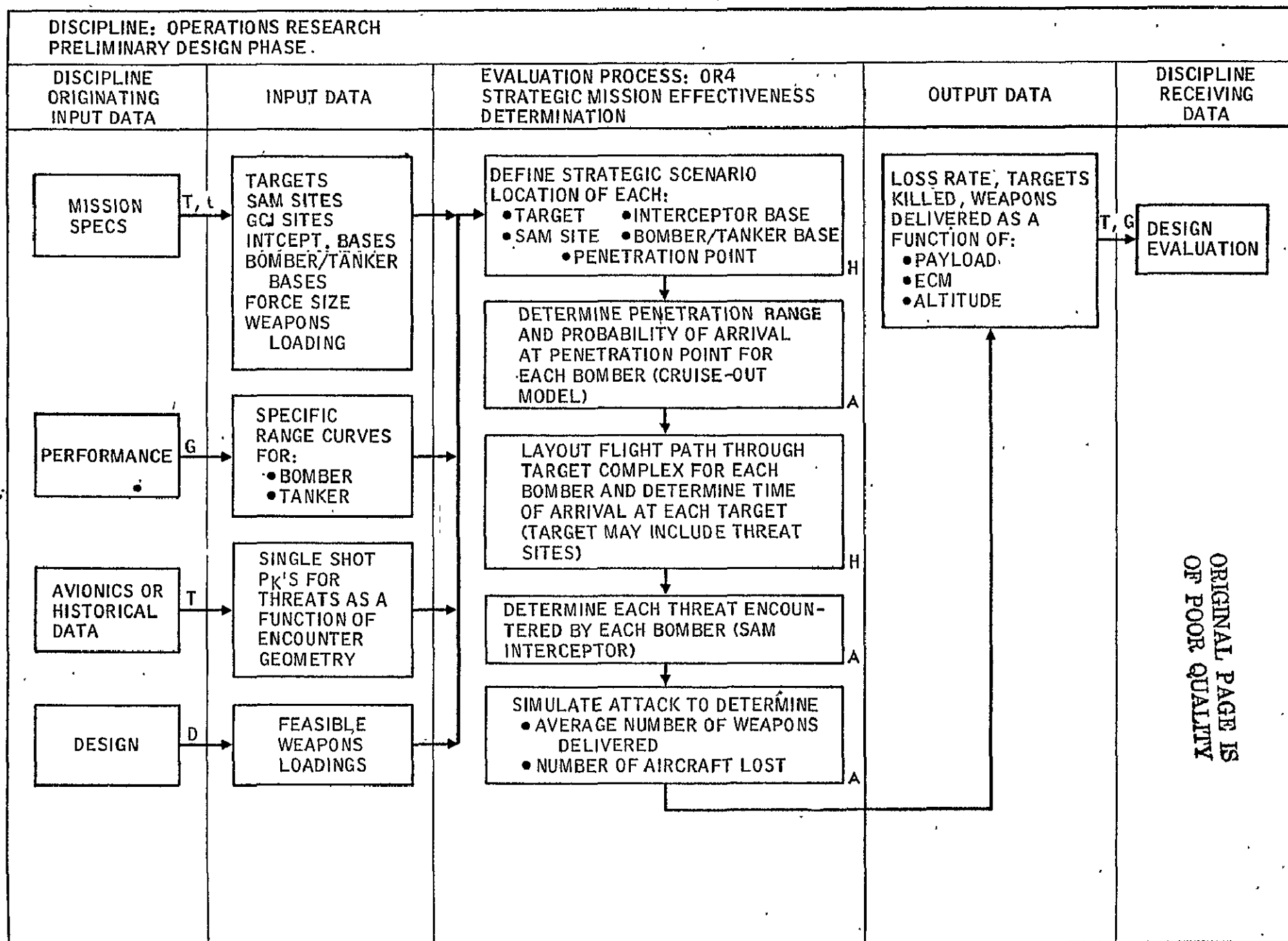
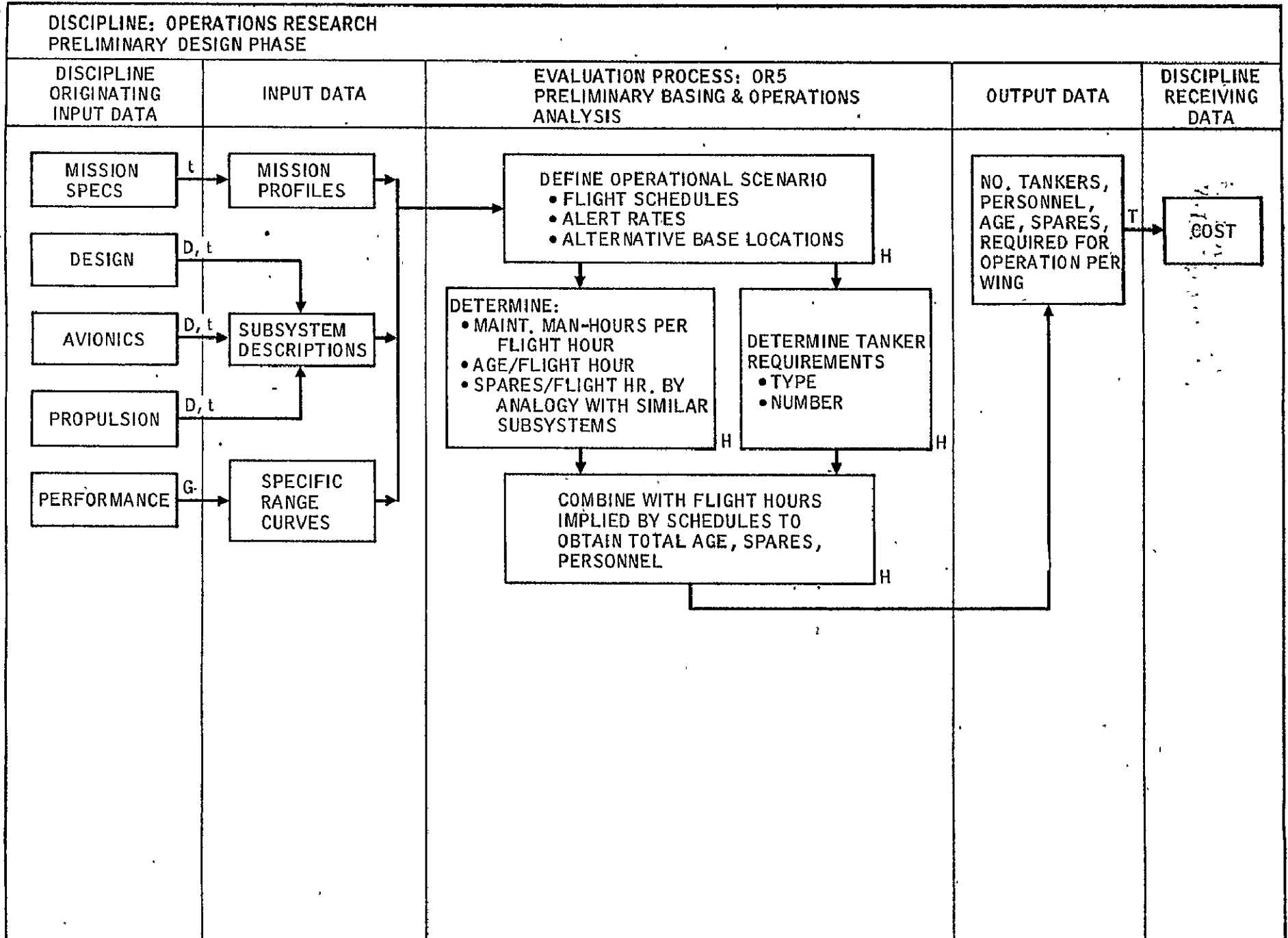


Figure 3-74. Strategic Mission Effectiveness Determination



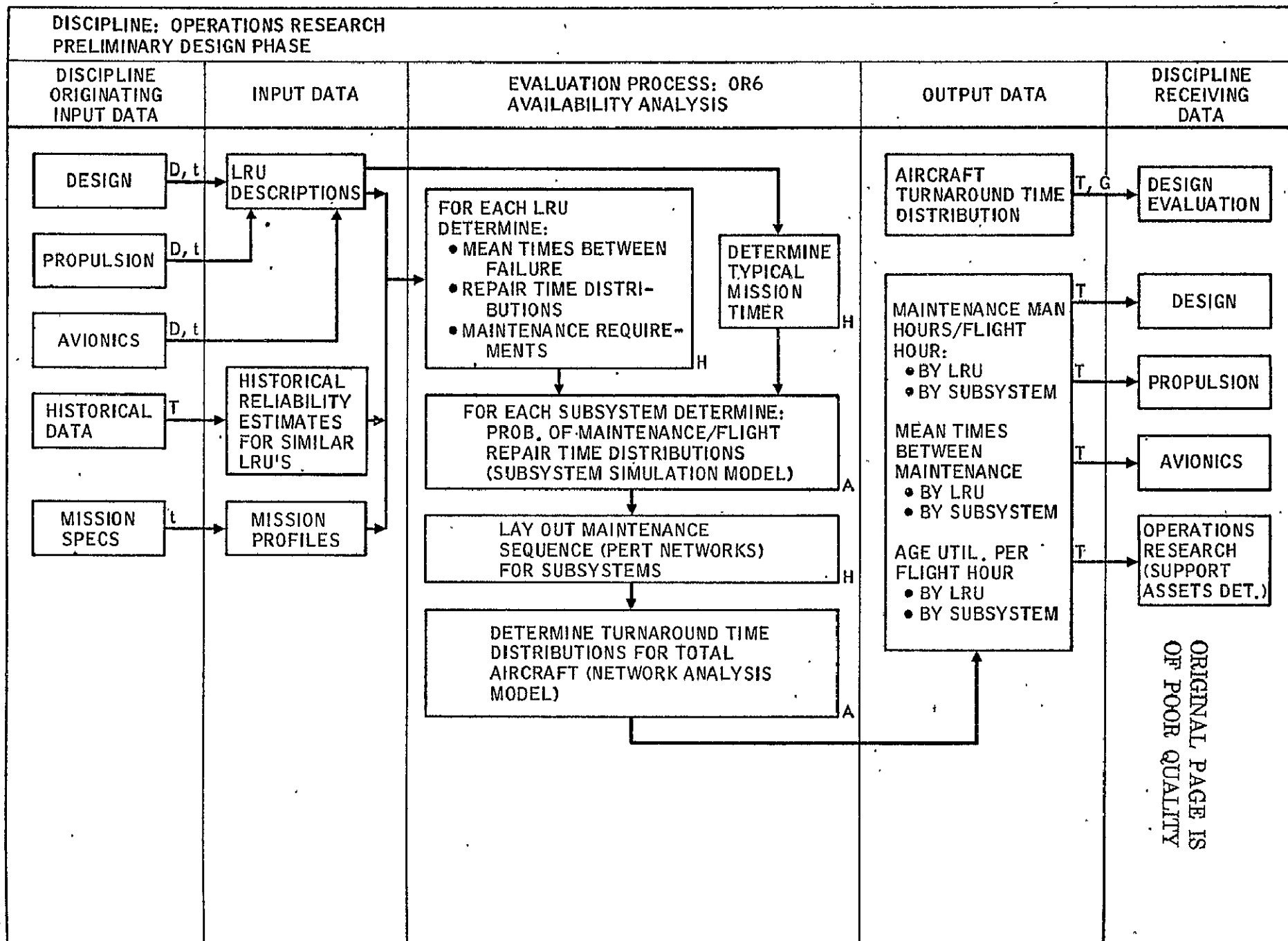
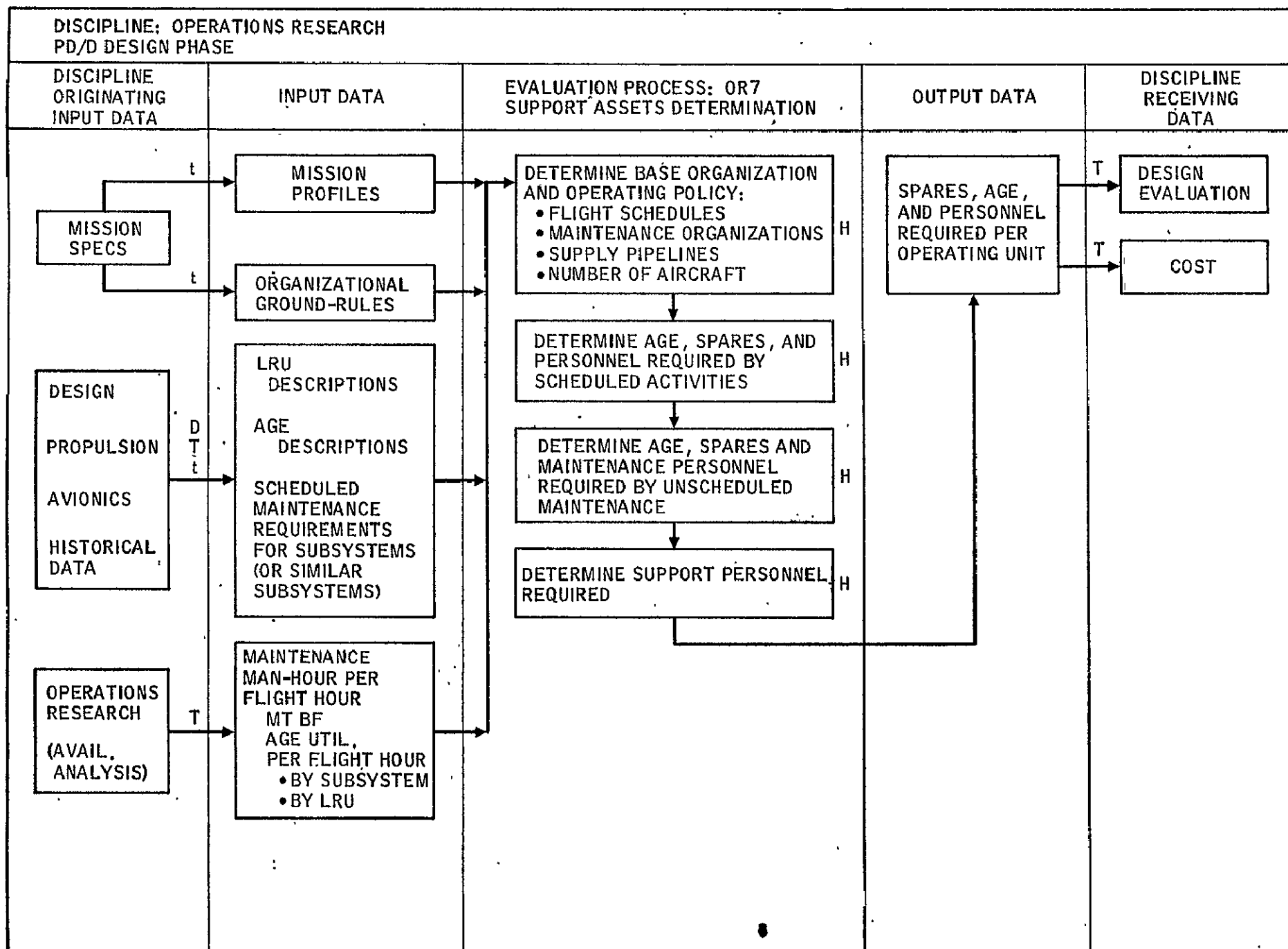


Figure 3-76. Availability Analysis



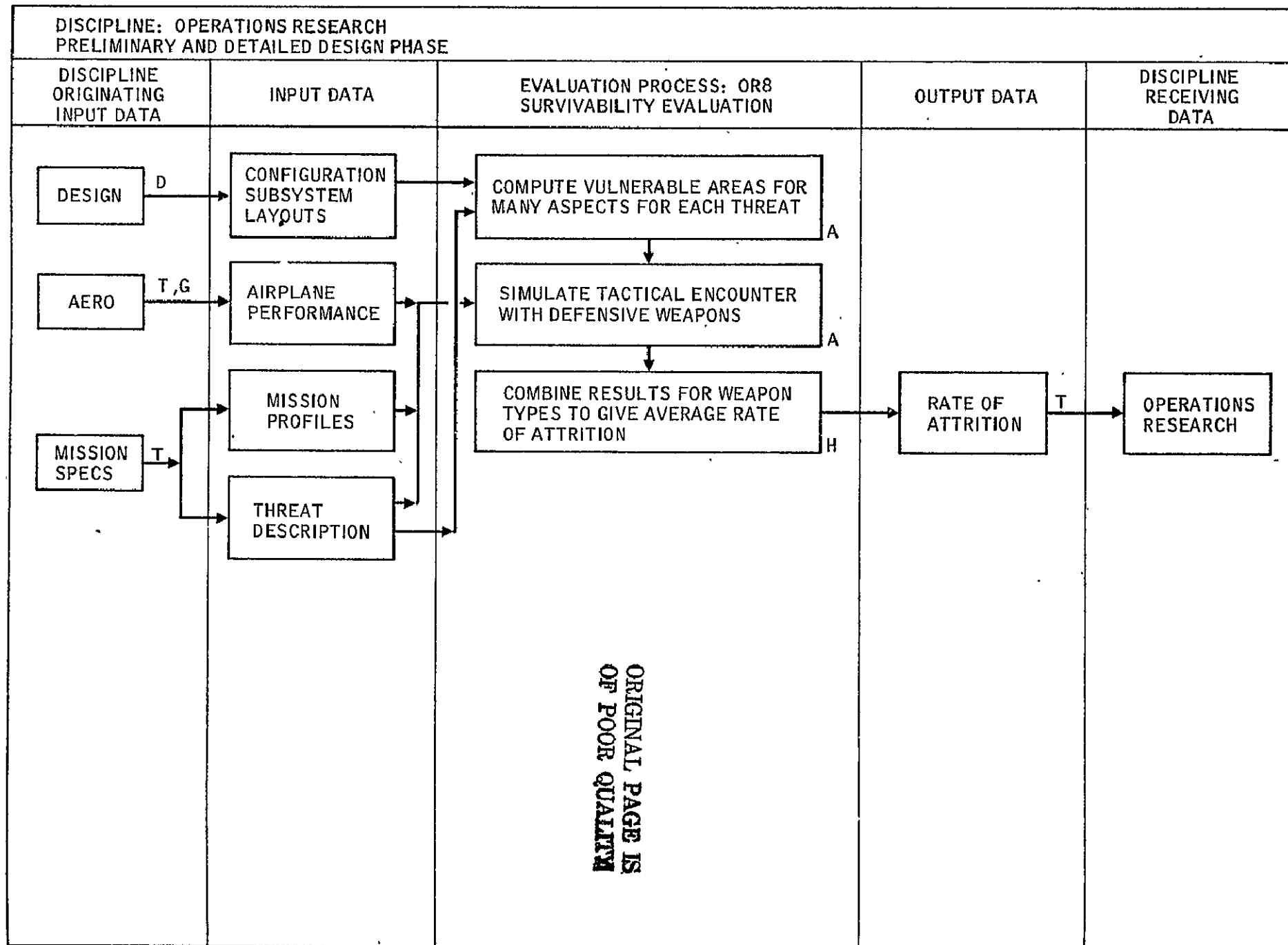
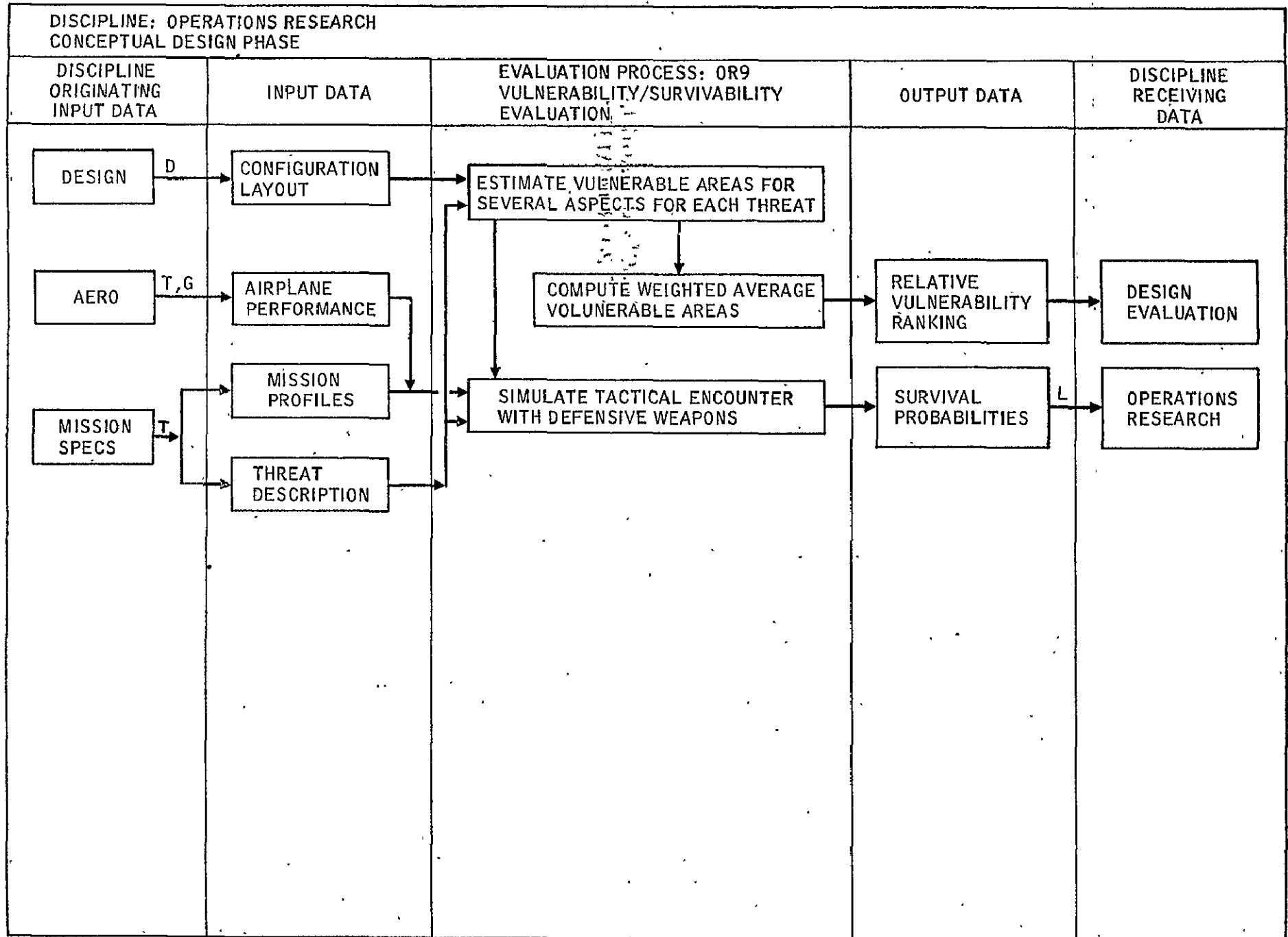


Figure 3-78. Survivability Evaluation



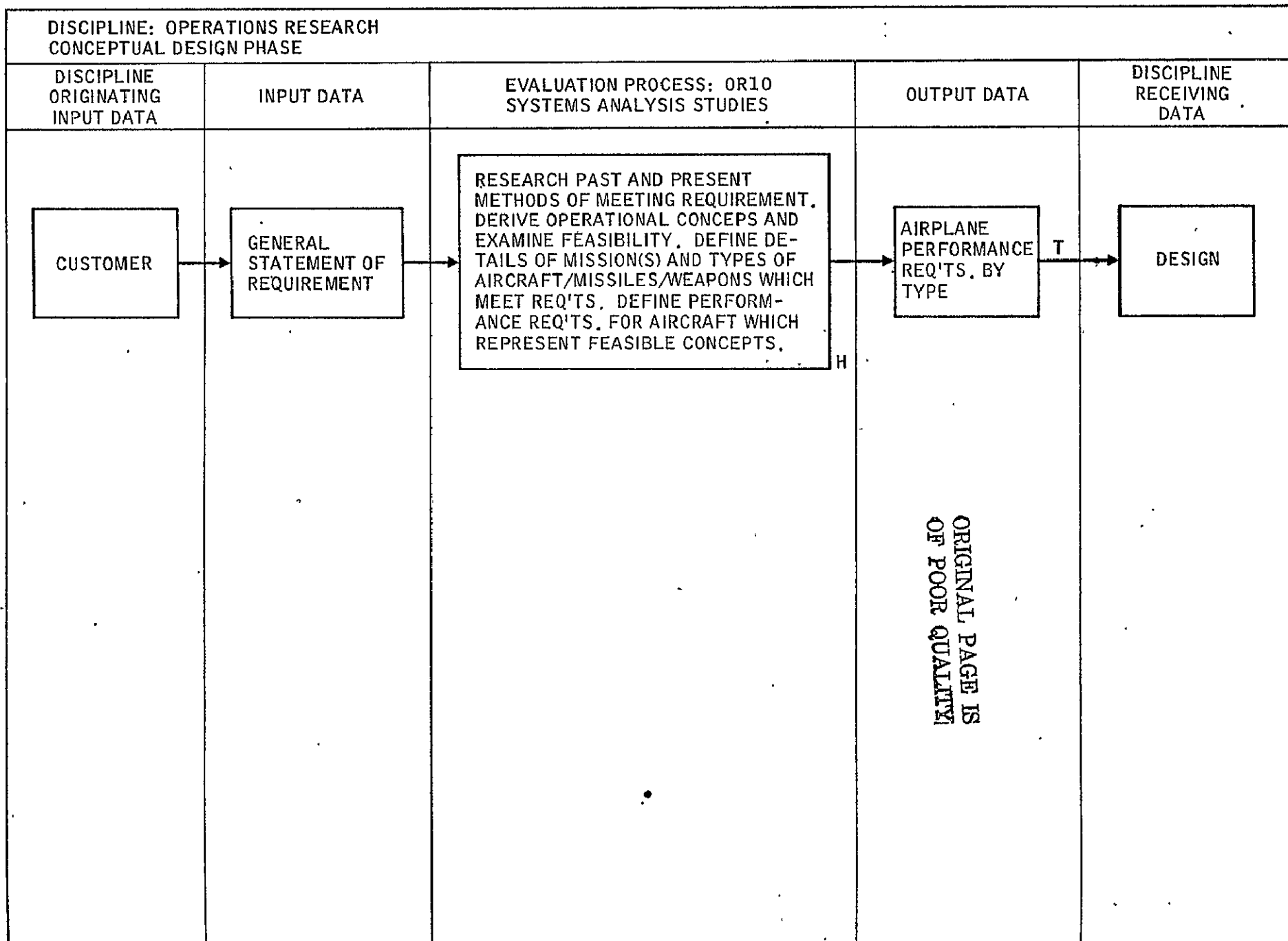
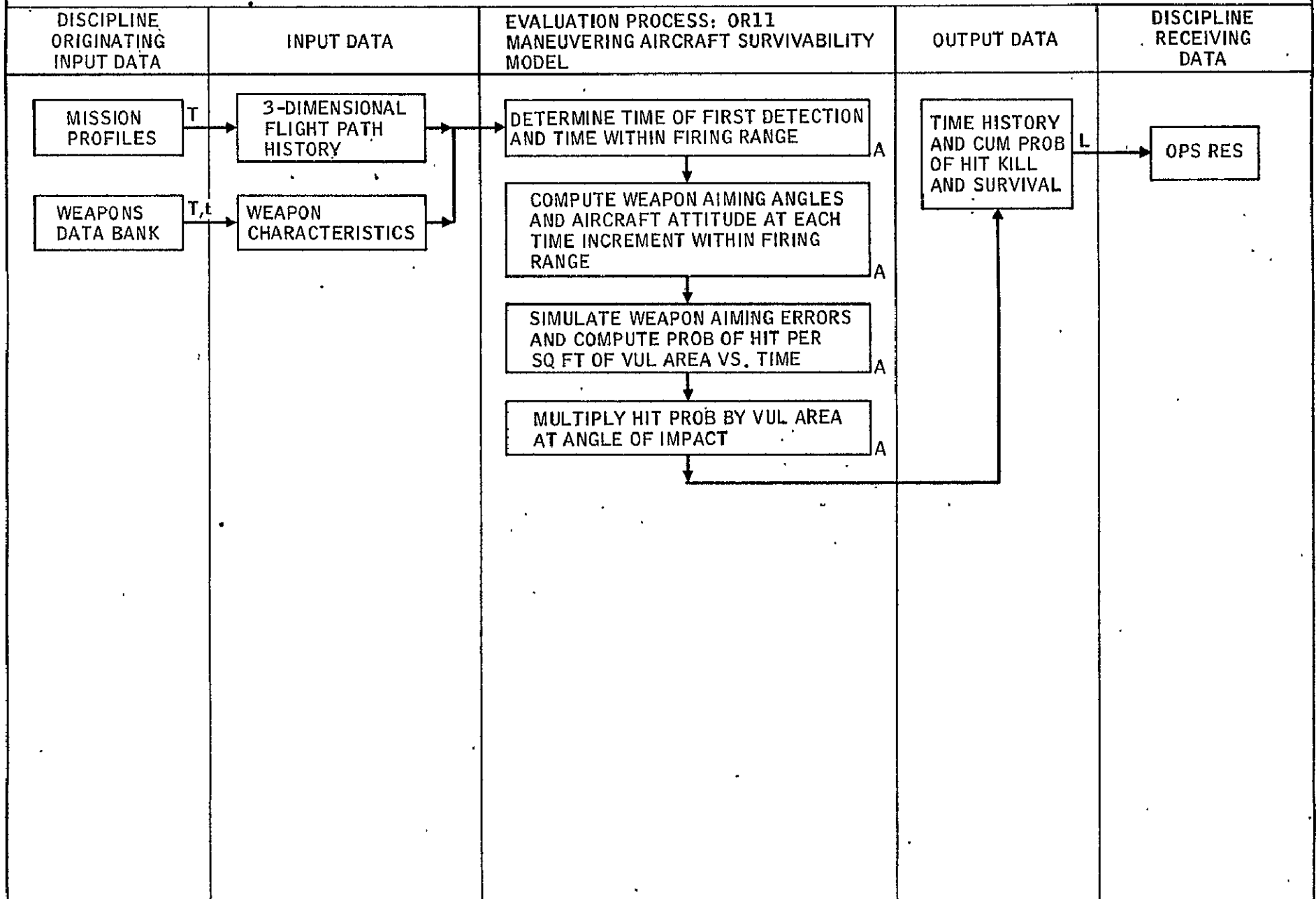


Figure 3-80. System Analysis Studies

DISCIPLINE: OPERATIONS RESEARCH  
DETAILED DESIGN PHASE



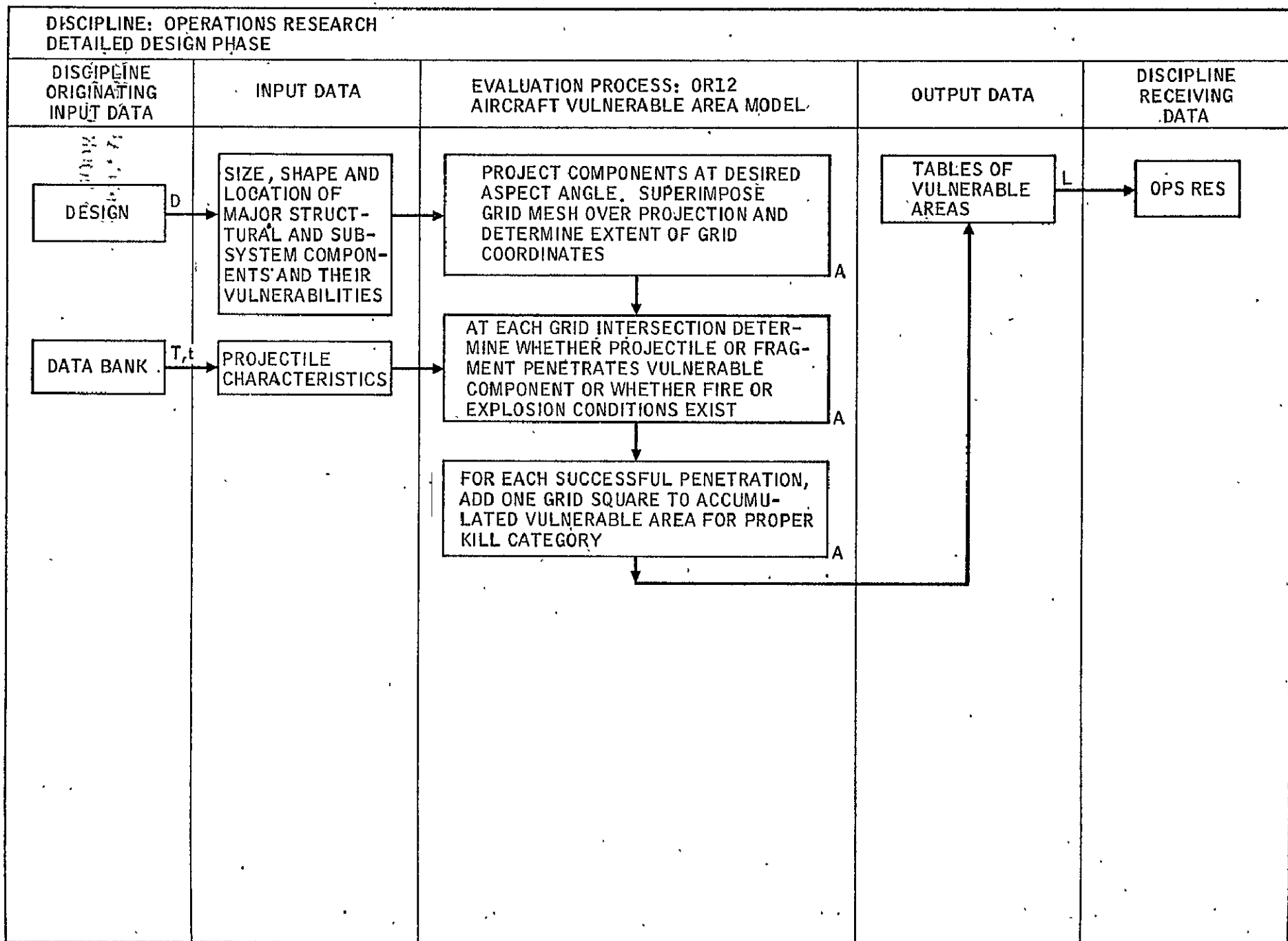
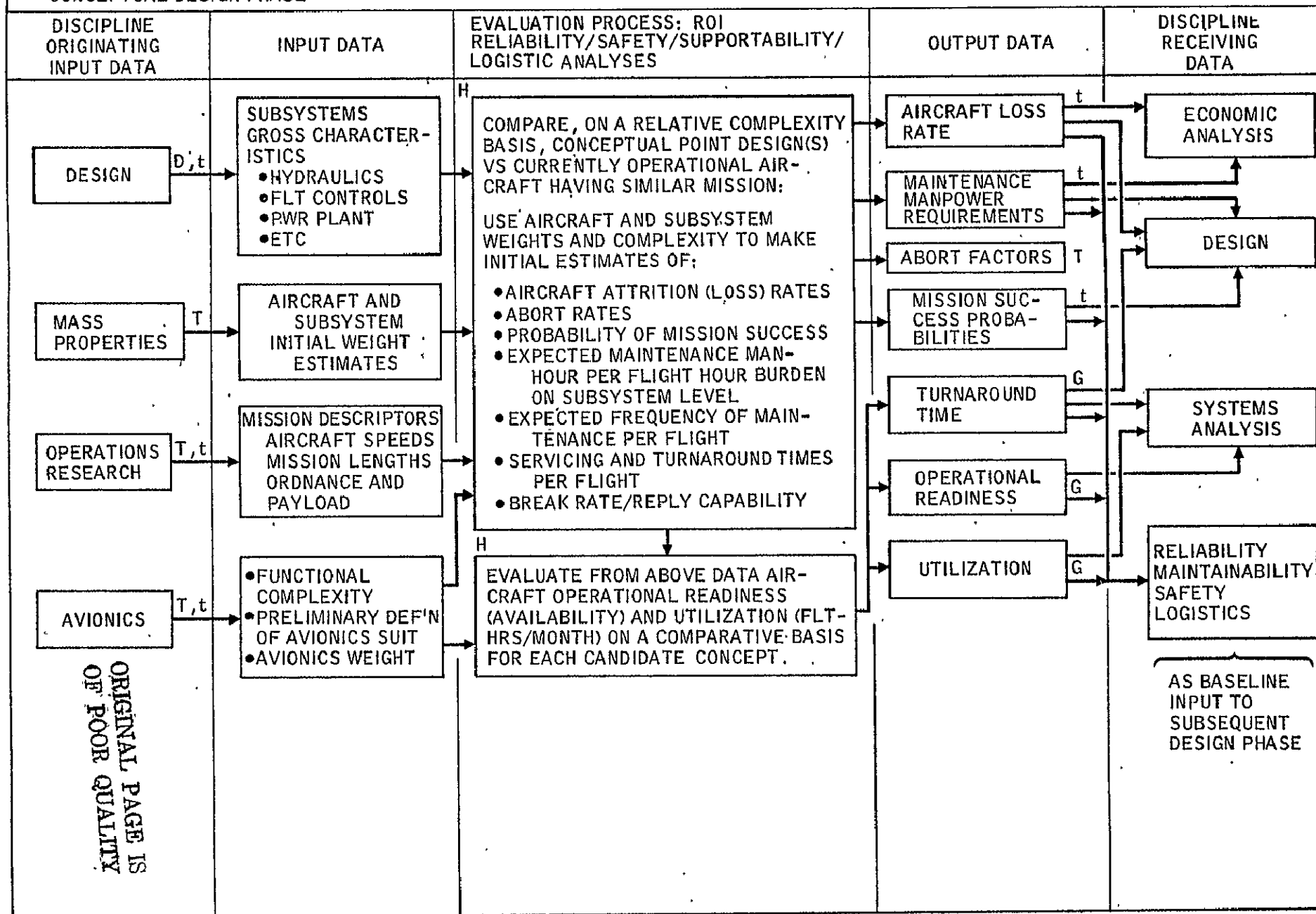


Figure 3-82. Aircraft Vulnerable Area Model

DISCIPLINE: RELIABILITY/SAFETY/SUPPORTABILITY/LOGISTICS  
CONCEPTUAL DESIGN PHASE



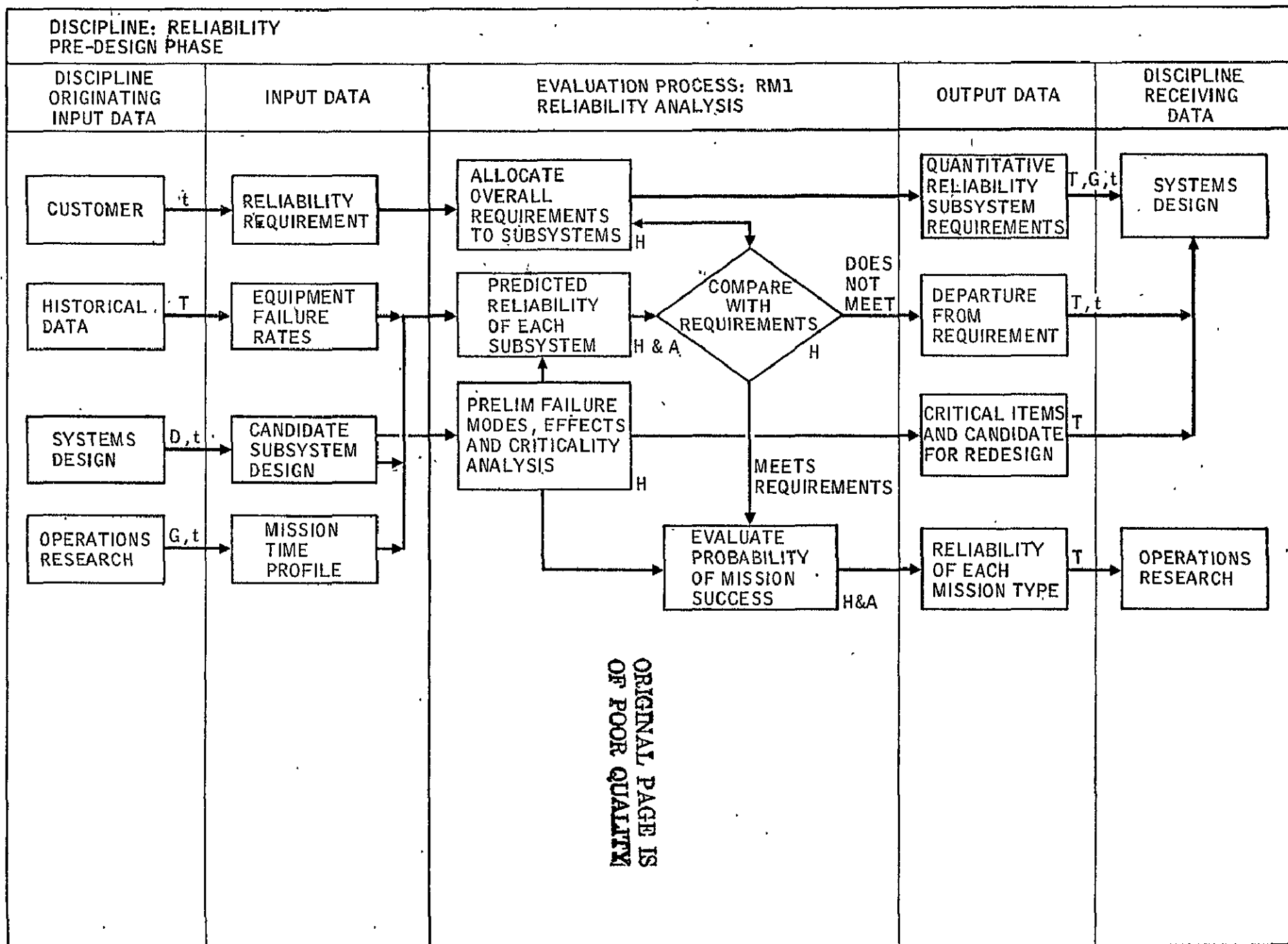
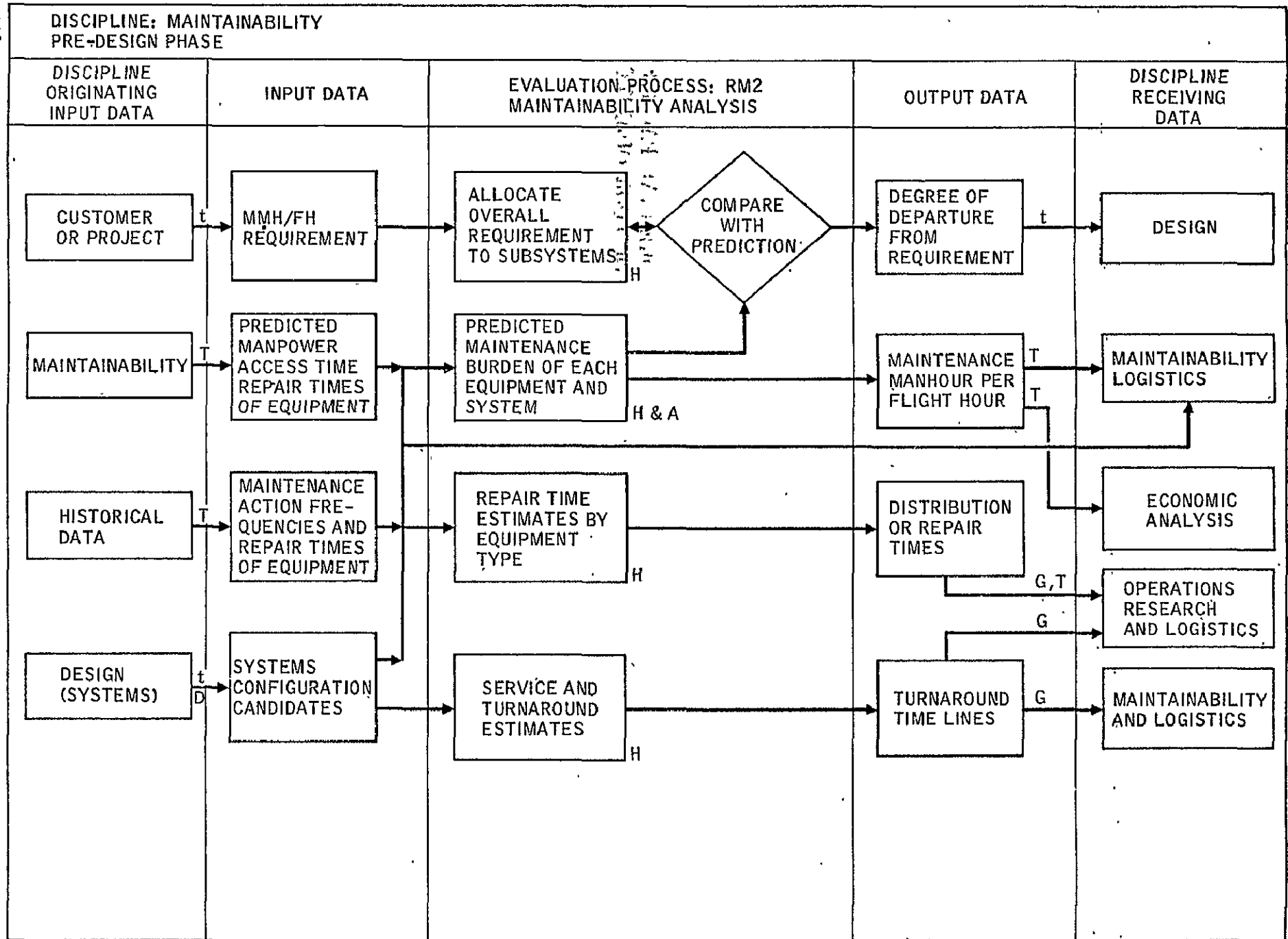


Figure 3-84. Reliability Analysis



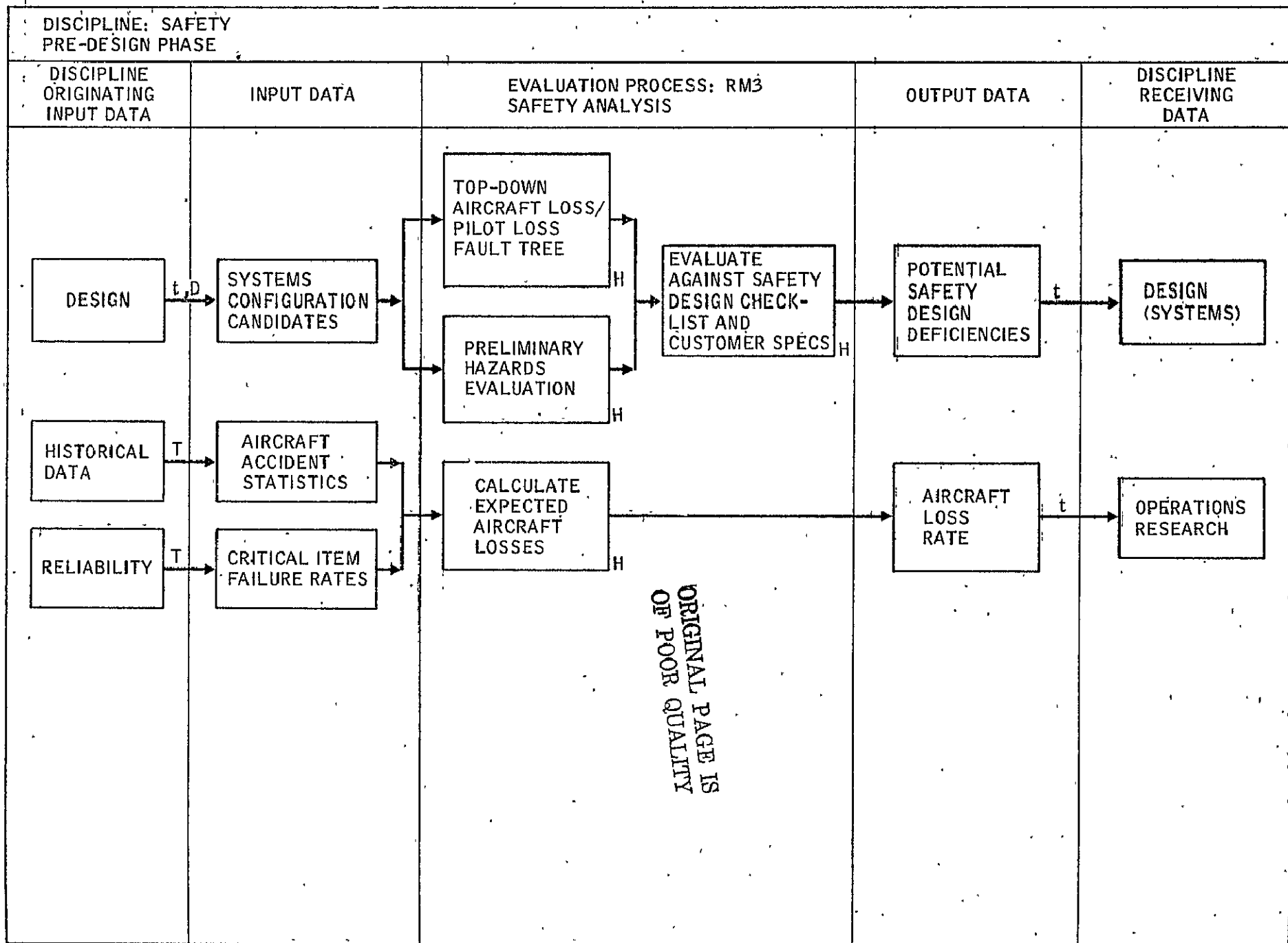


Figure 3-86. Safety Analysis

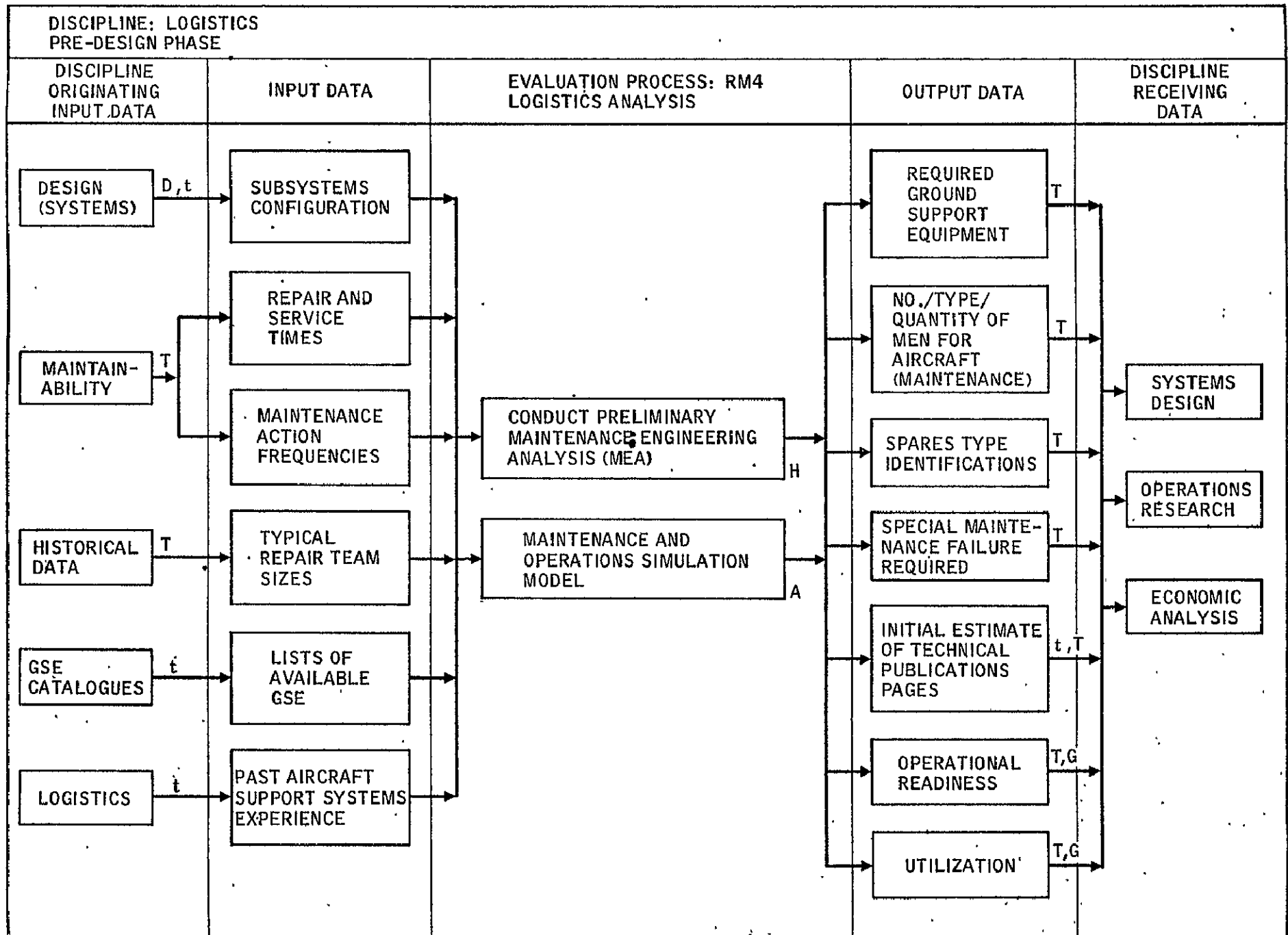


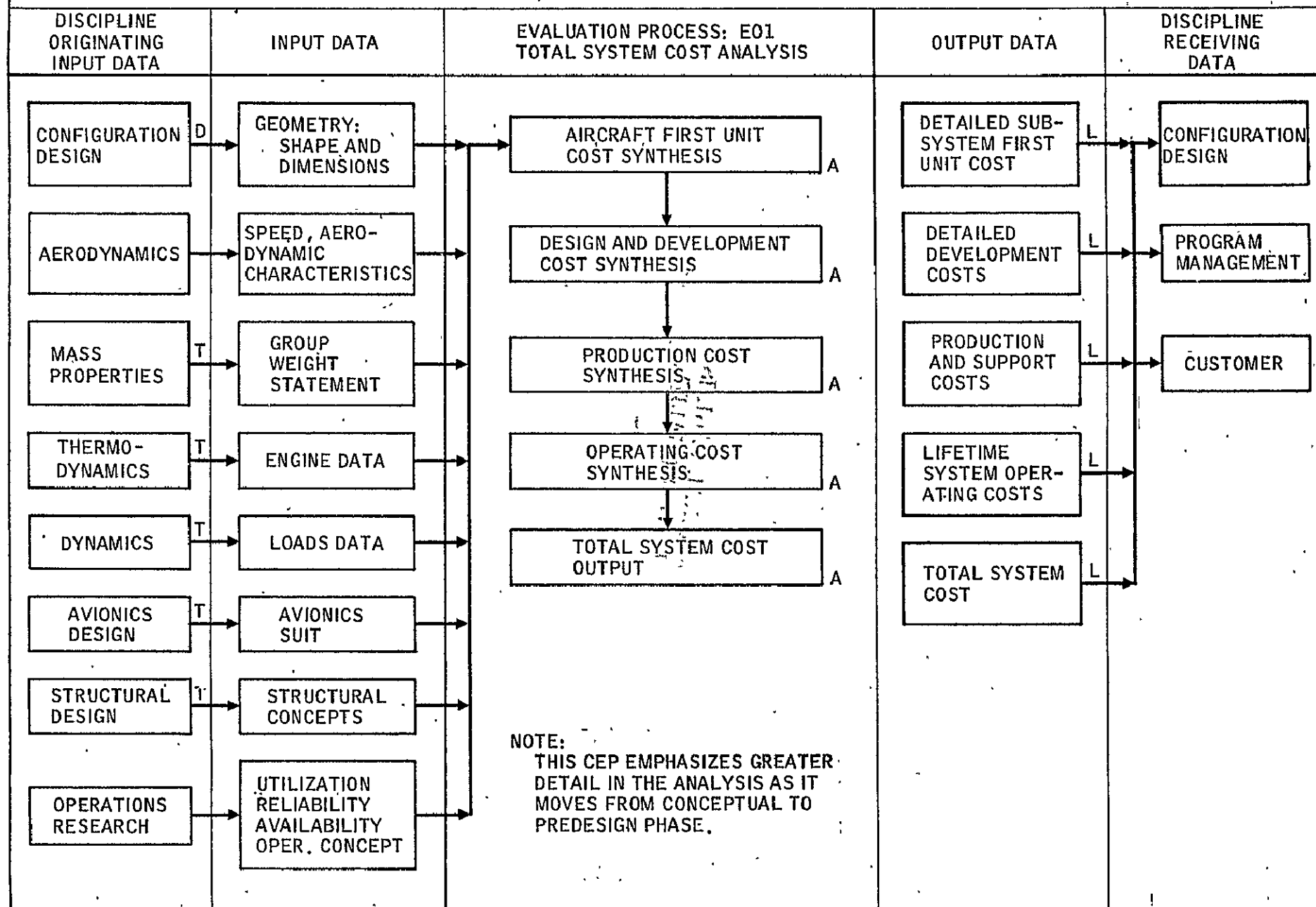
TABLE 3-9. ECONOMIC ANALYSIS CEP'S AND COMPUTER PROGRAMS

| TASKS                                          | CEP | Design Phase |    |    |
|------------------------------------------------|-----|--------------|----|----|
|                                                |     | C            | PD | DD |
| Total System Cost Analysis                     | E01 | x            | x  |    |
| Cost Sensitivity and Design Trade Off Analysis | E02 | x            | x  | x  |
| COMPUTER PROGRAMS                              |     |              |    |    |
| COSTC      Total system parametric cost model  |     | x            | x  | x  |
| STRCOST    Airframe structure cost analysis    |     |              | x  | x  |

TABLE 3-10. THEORETICAL FIRST-UNIT COST

|                               |                                |
|-------------------------------|--------------------------------|
| AIRFRAME                      |                                |
| Basic Structure               | Cooling System                 |
| Wing                          | Lubricating System             |
| Body                          | Fuel System (Less Tanks)       |
| Empennage                     | Fuel Tanks                     |
| Nacelle                       | Engine Controls                |
|                               | Starting System                |
| Subsystems                    | Primary & Final Assembly       |
| Lighting Gear                 | Mission Equipment Installation |
| Surface Controls              | Acceptance Operations          |
| Auxiliary Power               |                                |
| Instruments & Navigation      | PROPULSION                     |
| Hydraulic & Pneumatic         | Primary                        |
| Electrical                    | Secondary                      |
| Electronics                   |                                |
| Armor                         | AVIONICS                       |
| Furnishings & Equipment       | New Design                     |
| Air Conditioning & Anti-Icing | Prior Prediction               |
| Photographic                  |                                |
| Auxiliary Gear                |                                |
| Engine Associated             |                                |
| Air Induction                 |                                |
| Exhaust System                |                                |
|                               | TOTAL FIRST UNIT COST          |

DISCIPLINE: ECONOMIC ANALYSIS  
CONCEPTUAL AND PREDESIGN DESIGN PHASE



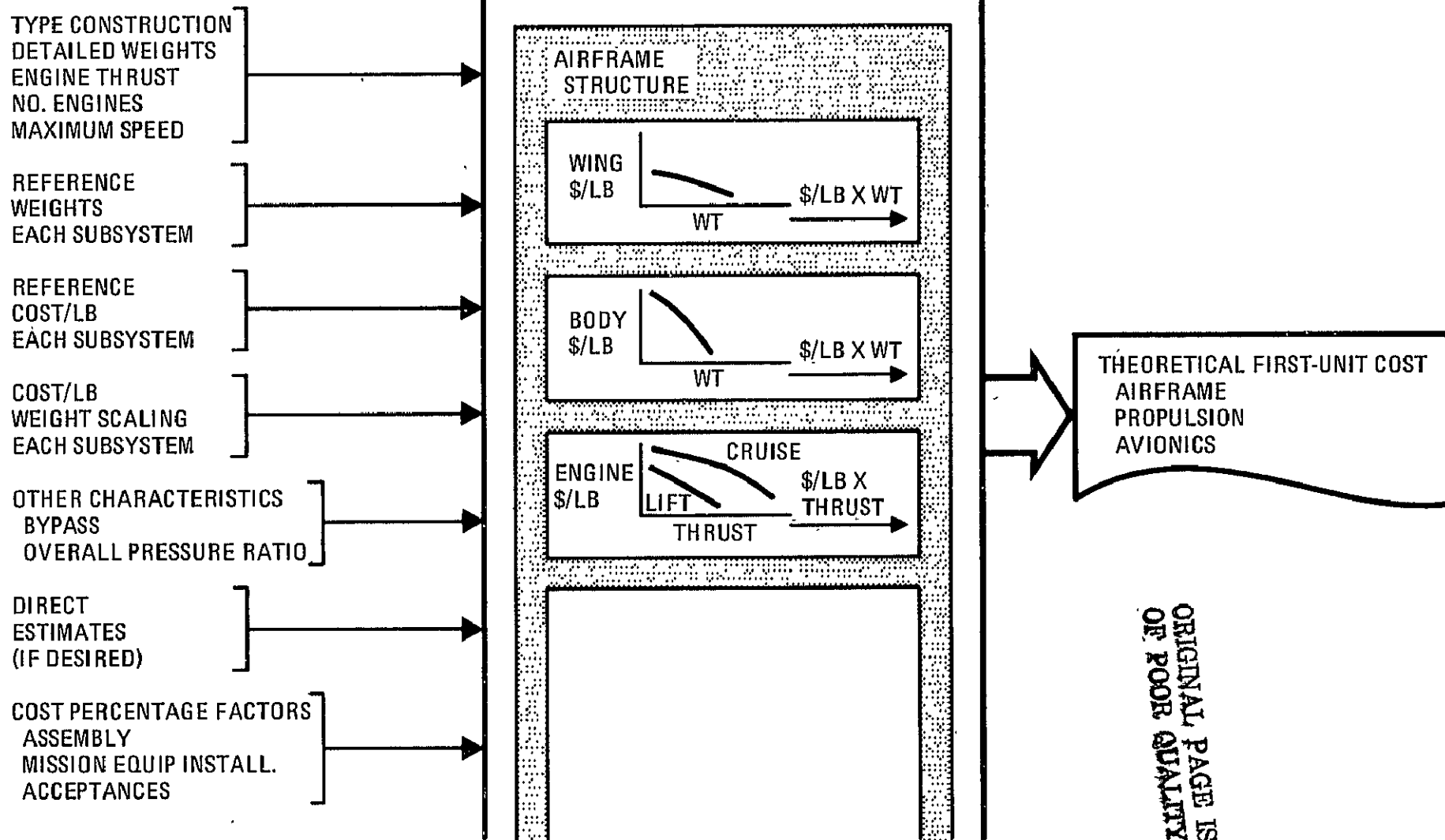


Figure 3-89. First-Unit Cost Model Functions

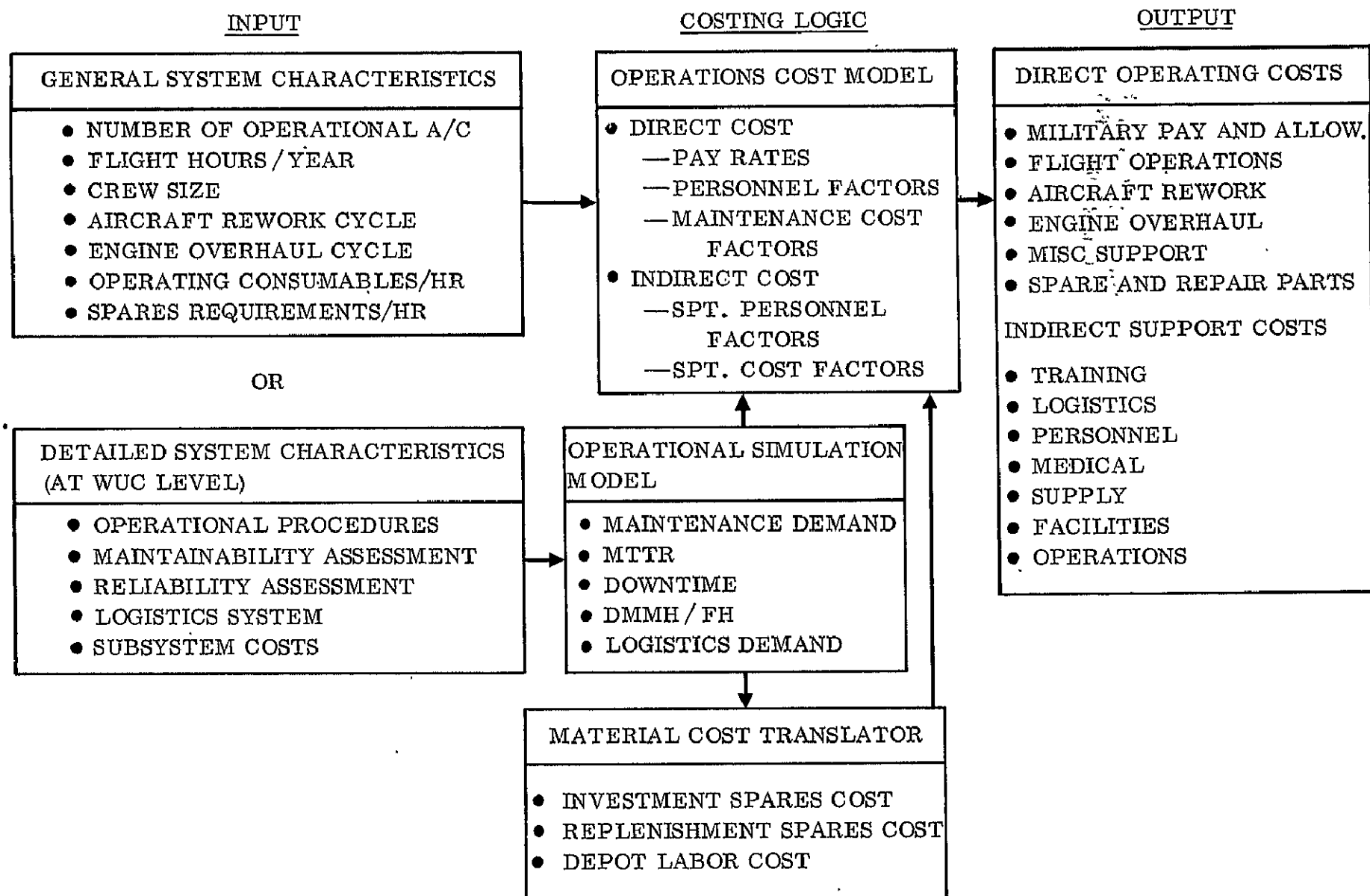


Figure 3-93. Operating Cost Estimating Methodology

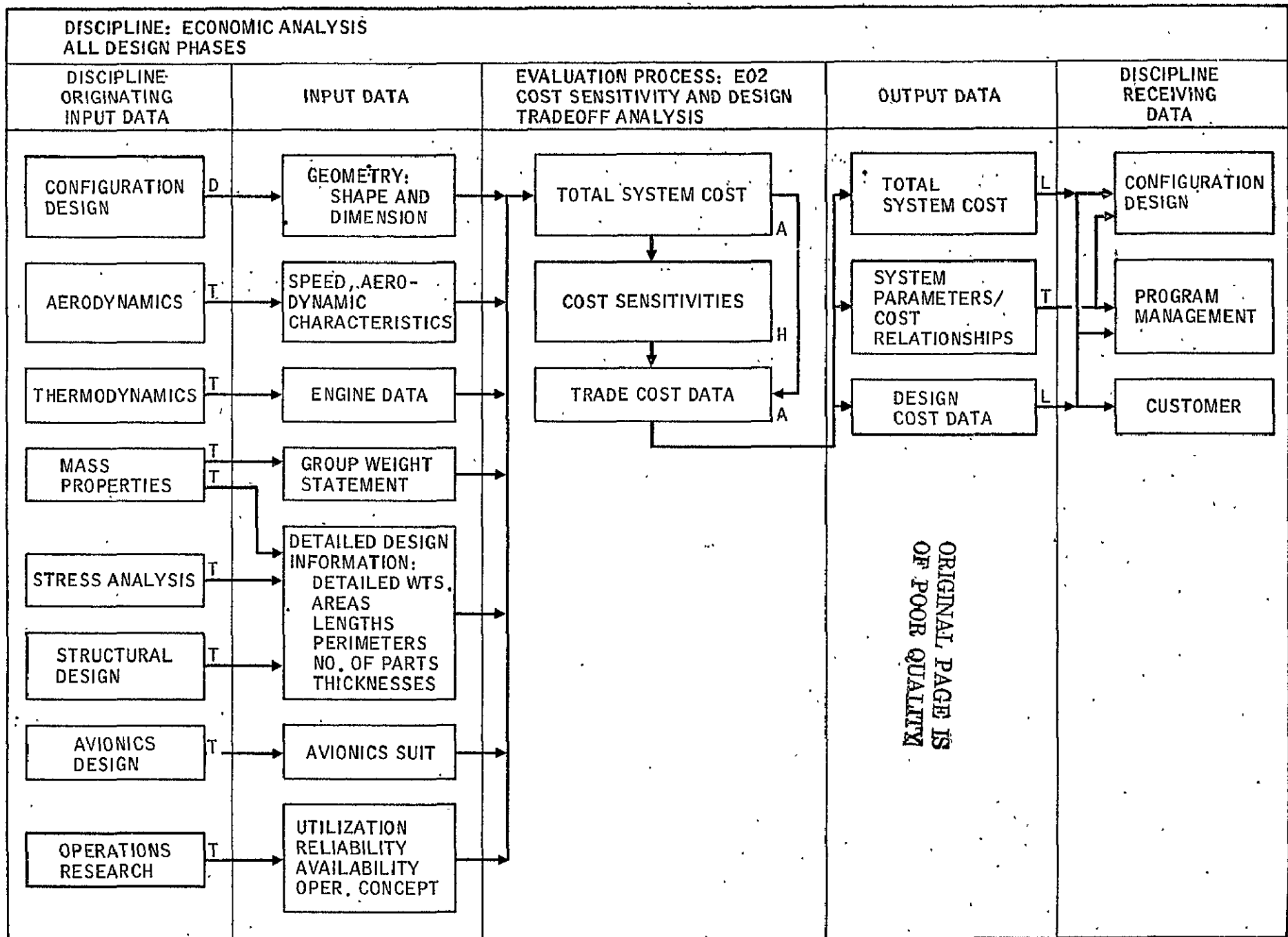


Figure 3-94. Cost Sensitivity and Design Tradeoff Analysis

TABLE 3-12. STRUCTURAL LOADS CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                      | CEP  | Design Phase |    |    |
|----------------------------------------------------------------------------|------|--------------|----|----|
|                                                                            |      | C            | PD | DD |
| Establish Preliminary Structural Design Criteria                           | SL1  | x            |    |    |
| Design Critique                                                            | SL2  | x            |    |    |
| Formulate Design Criteria                                                  | SL3  |              | x  | x  |
| Determine Preliminary Structural Layout Loads                              | SL4  |              | x  |    |
| Perform Symmetric Maneuver Load Trend Survey                               | SL5  |              | x  |    |
| Determine Landing and Ground Handling Design Loads                         | SL6  |              | x  |    |
| Calculate Wing Panel Point Loads Distributions                             | SL7  |              | x  | x  |
| Determine Fatigue Loads Spectra                                            | SL8  |              | x  |    |
| Perform Fatigue Evaluation                                                 | SL9  |              | x  |    |
| Perform Gust Loads Analysis                                                | SL10 |              | x  |    |
| Support Loads Model Wind Tunnel Test Program                               | SL11 |              | x  | x  |
| Airplane Rigid Body Initial Dynamic Maneuvers Response Parameters Envelope | SL12 |              | x  |    |
| <u>COMPUTER PROGRAMS</u>                                                   |      |              |    |    |
| RL1    Balanced Symmetric Maneuver Load Trends                             |      |              | x  | x  |
| RL9    MIL-A-8861 Discrete Gust Analysis                                   |      |              | x  | x  |
| BO5    Fatigue Damage Due to Maneuver and Continuous Turbulence            |      |              | x  |    |
| UB1    Landing Gear Design Loads (MIL-A-8862)                              |      |              | x  | x  |
| TC4    Wing and Tail Distributed Loads and Panel Point Loads               |      |              | x  | x  |

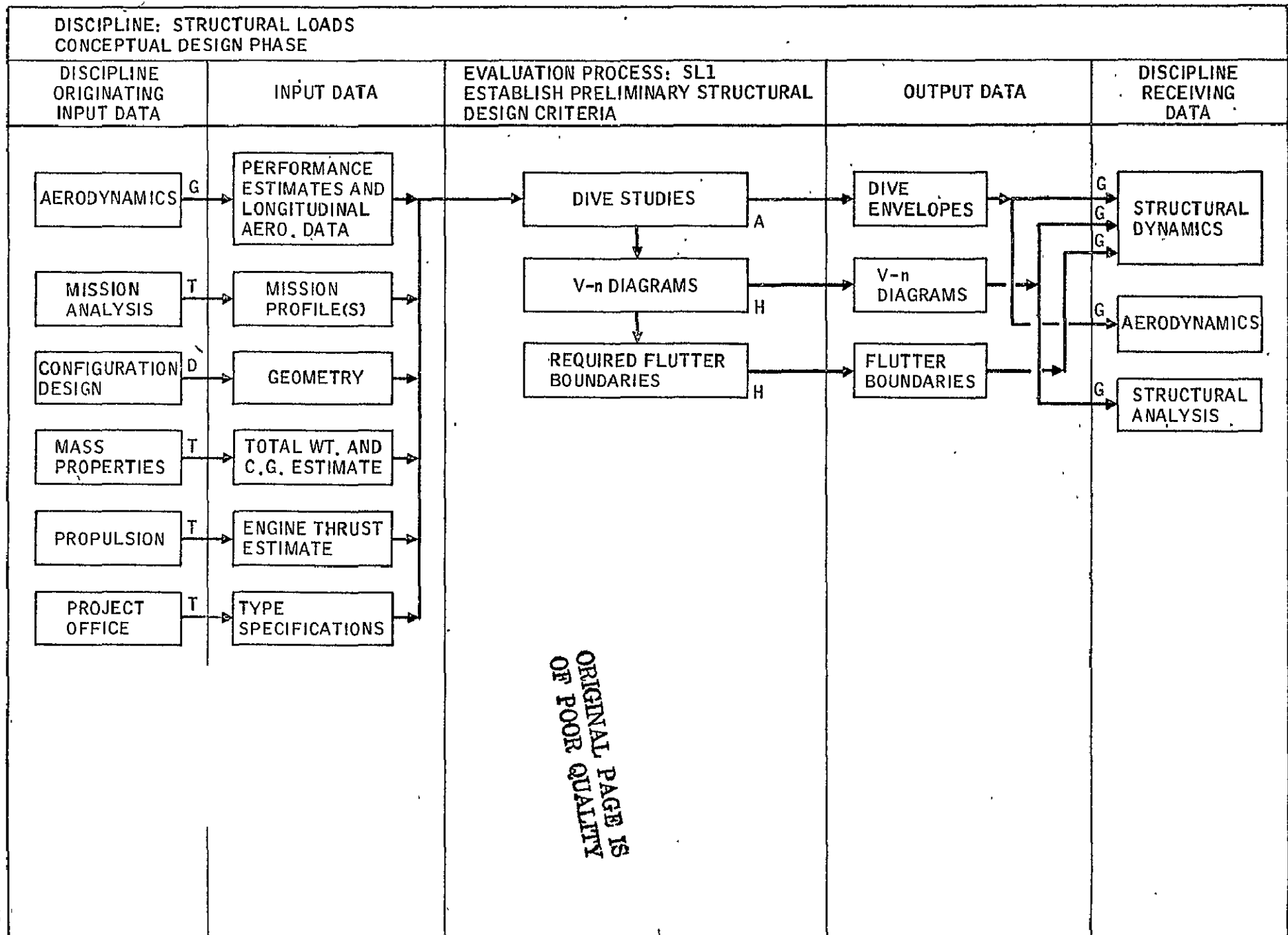
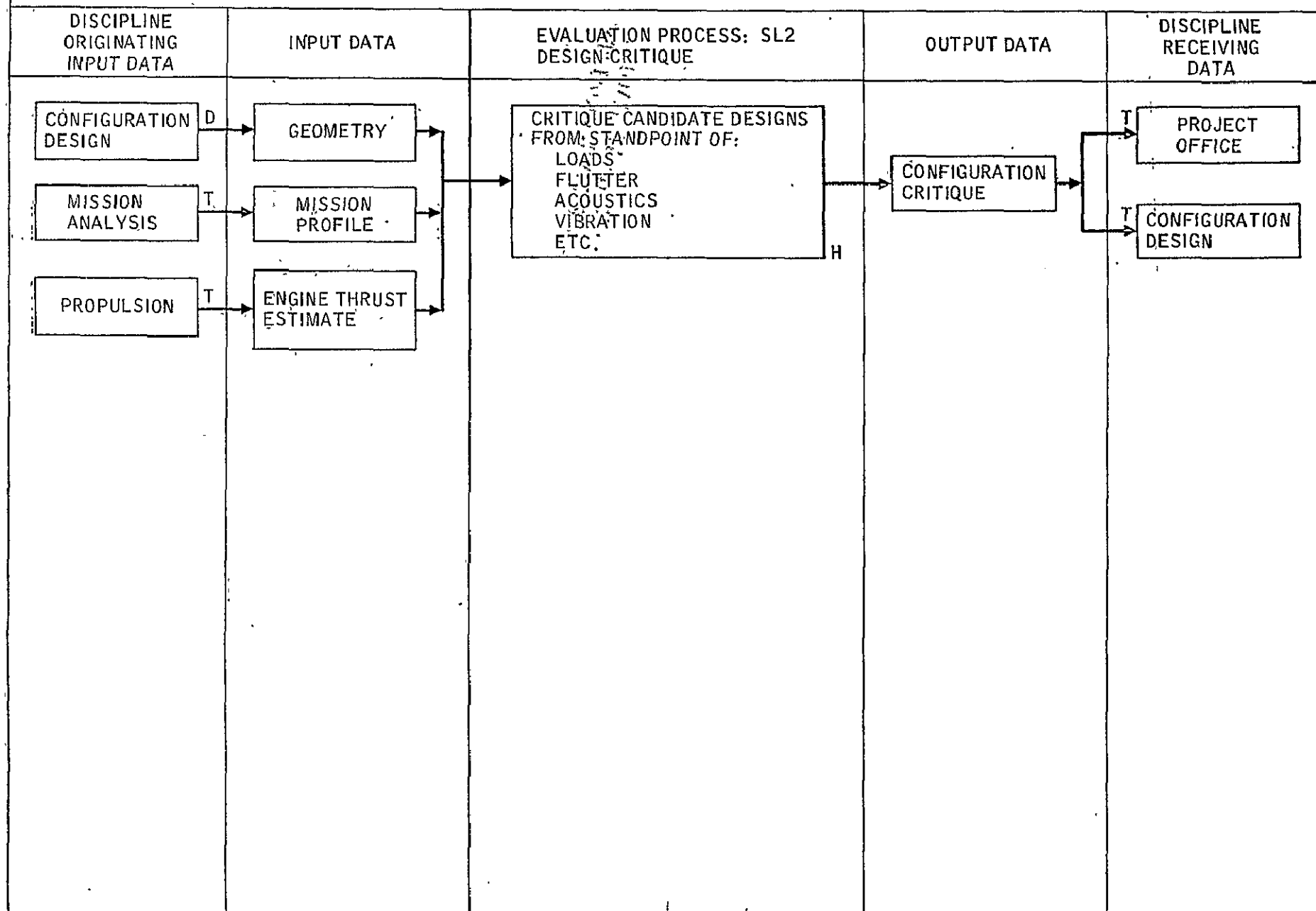


Figure 3-95. Preliminary Structural Design Criteria

DISCIPLINE: STRUCTURAL LOADS  
CONCEPTUAL DESIGN PHASE



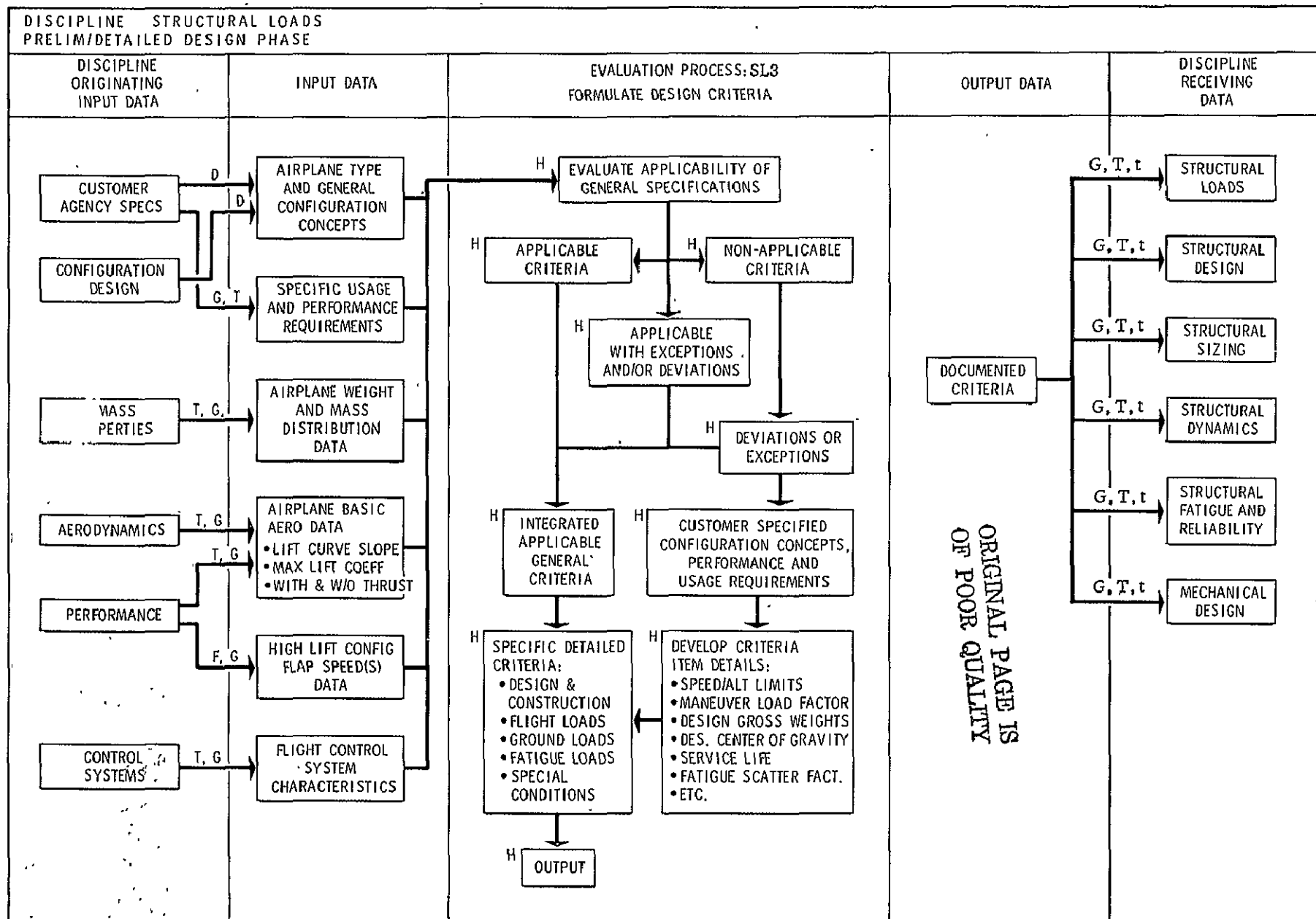


Figure 3-97. Formulate Design Criteria

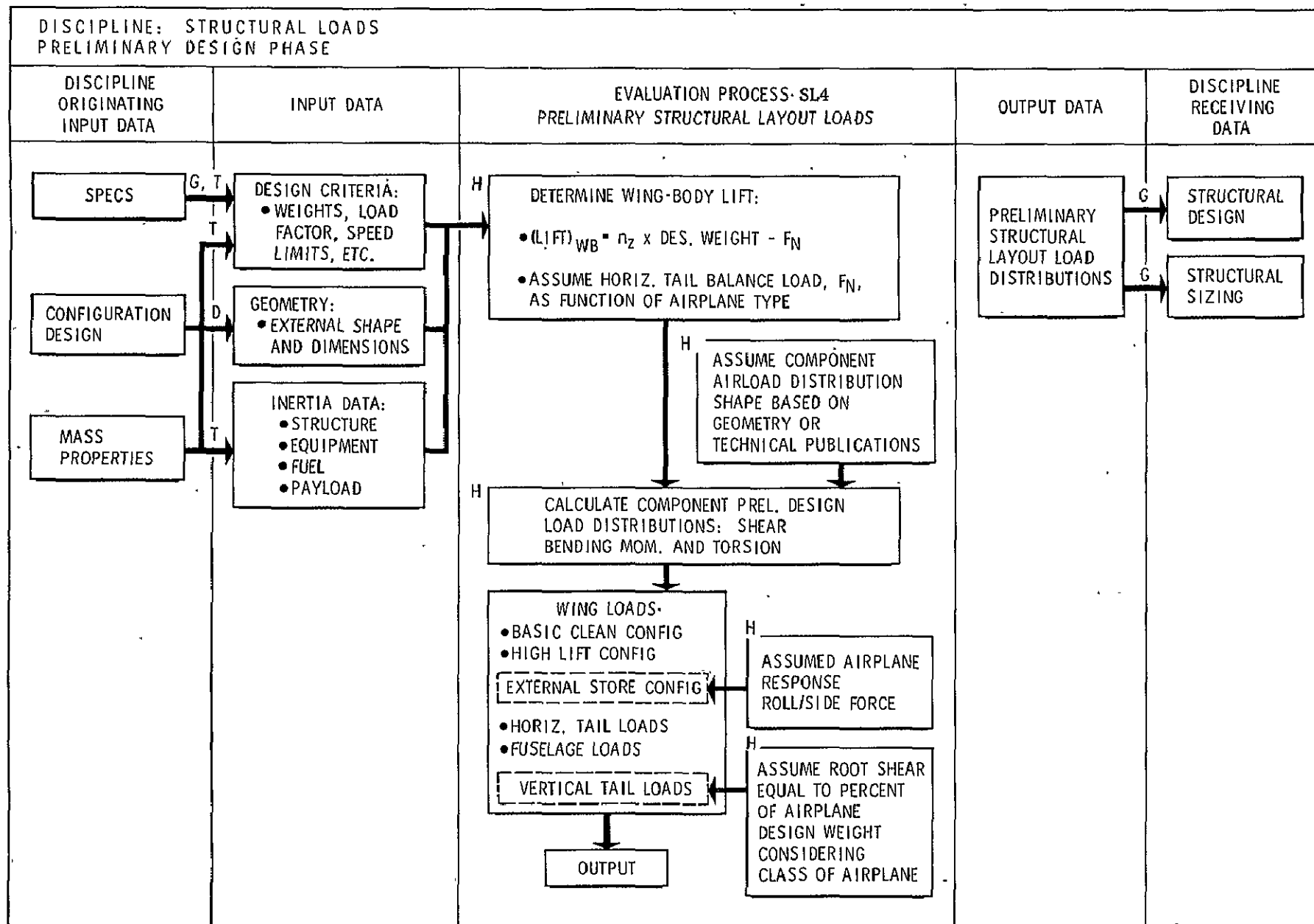


Figure 3-98. Preliminary Structural Layout Loads

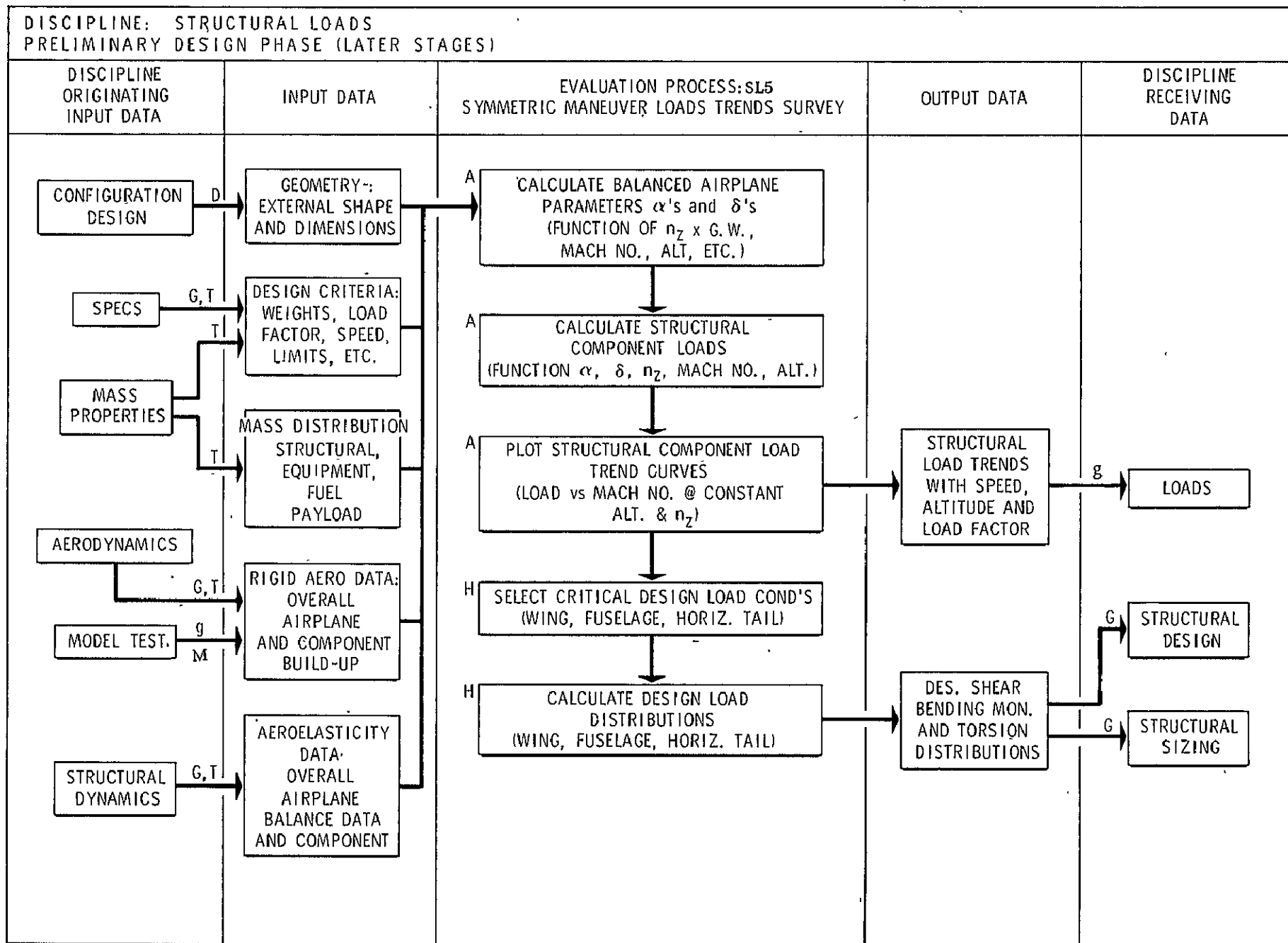


Figure 3-99. Symmetric Maneuver Loads Trend Survey

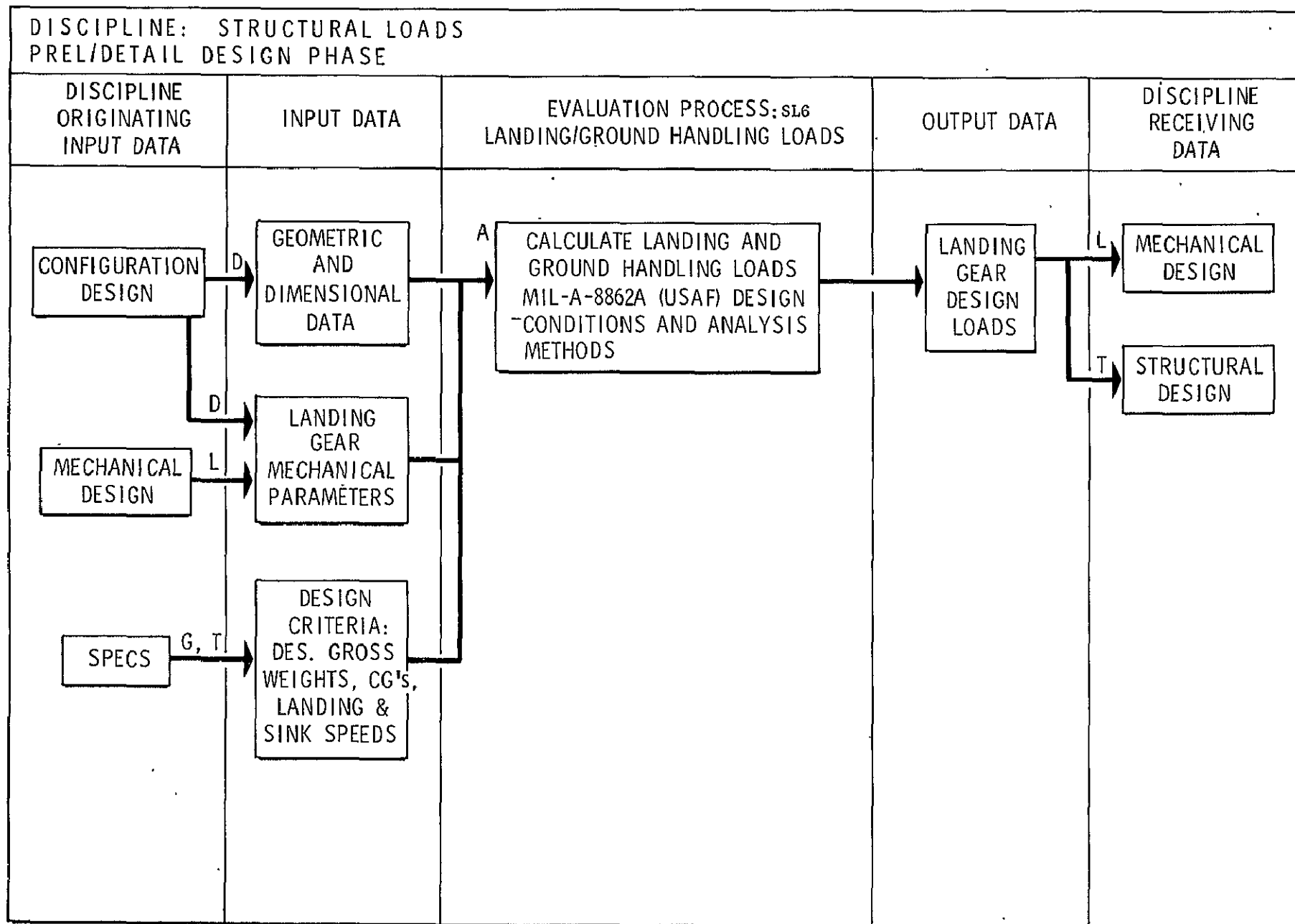


Figure 3-100. Landing/Ground Handling Loads

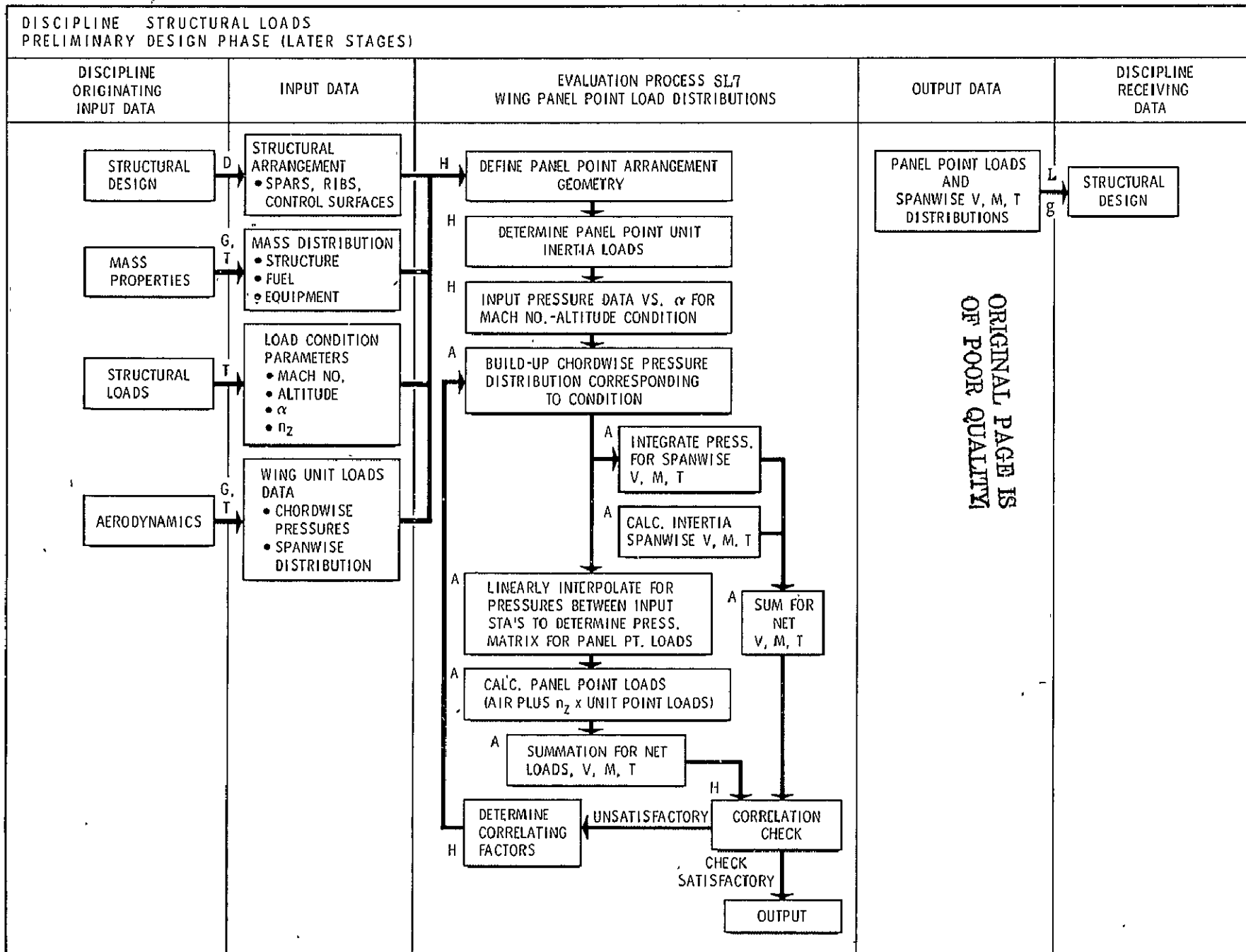


Figure 3-101. Wing Panel Point Load Distribution

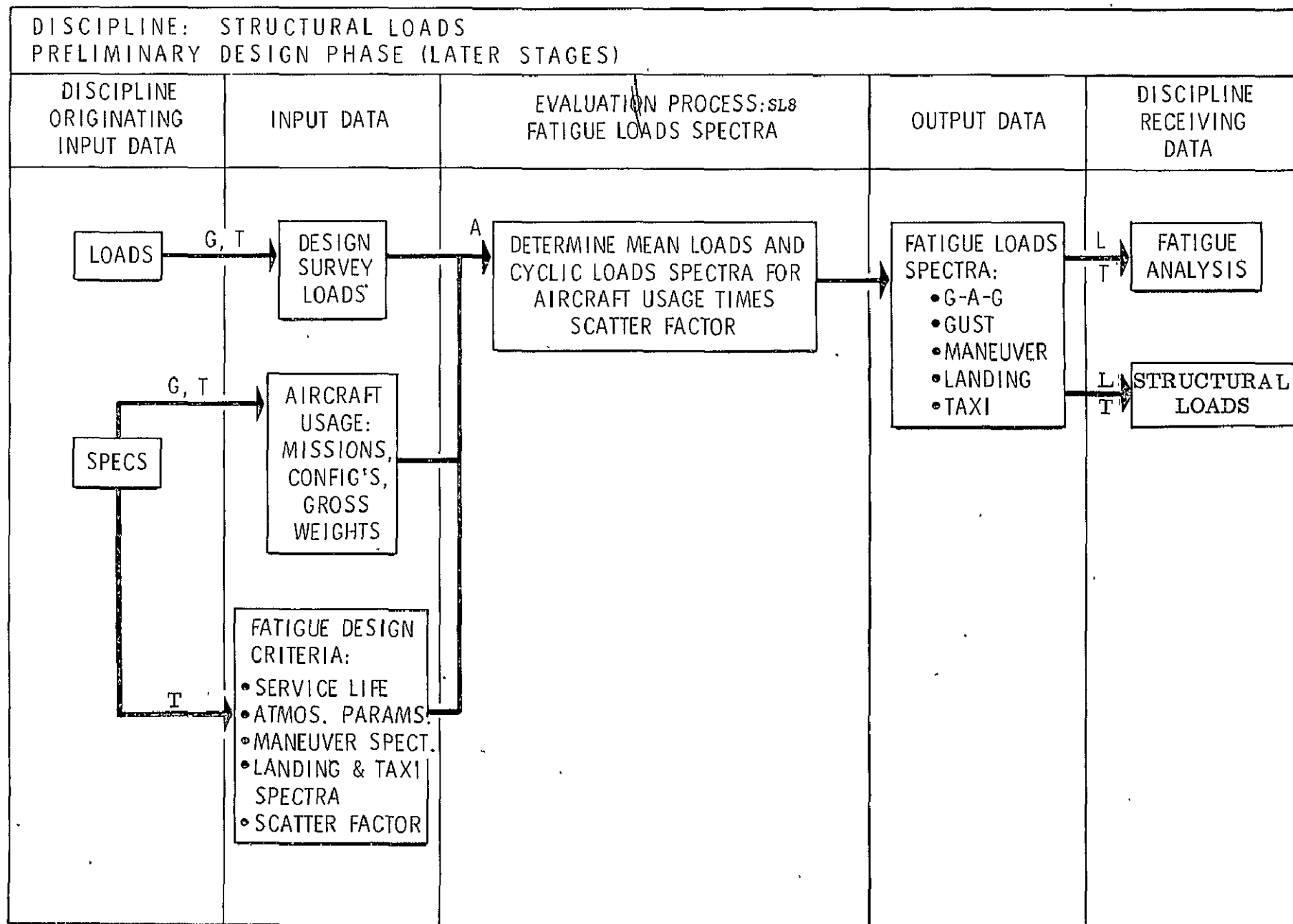
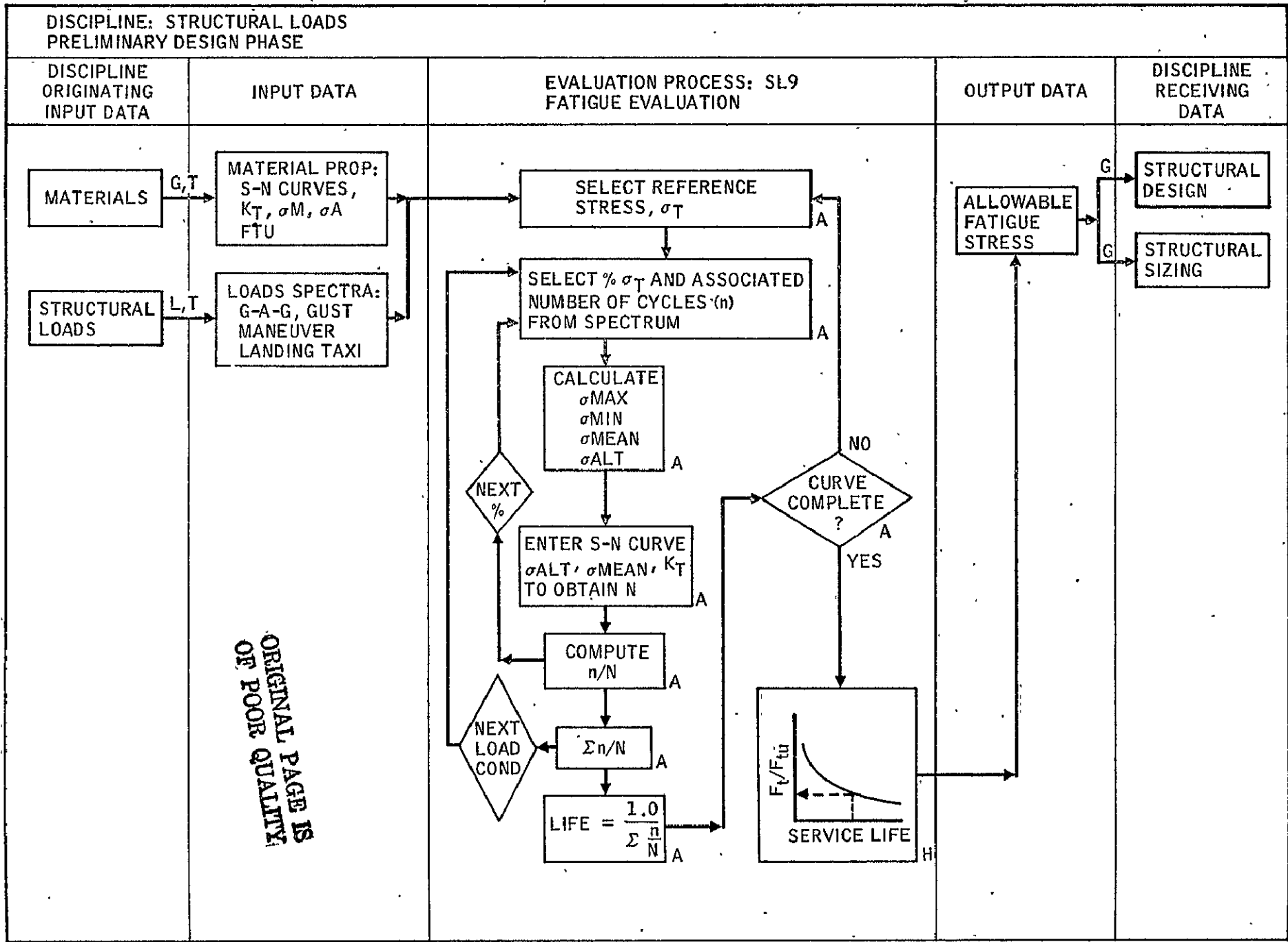


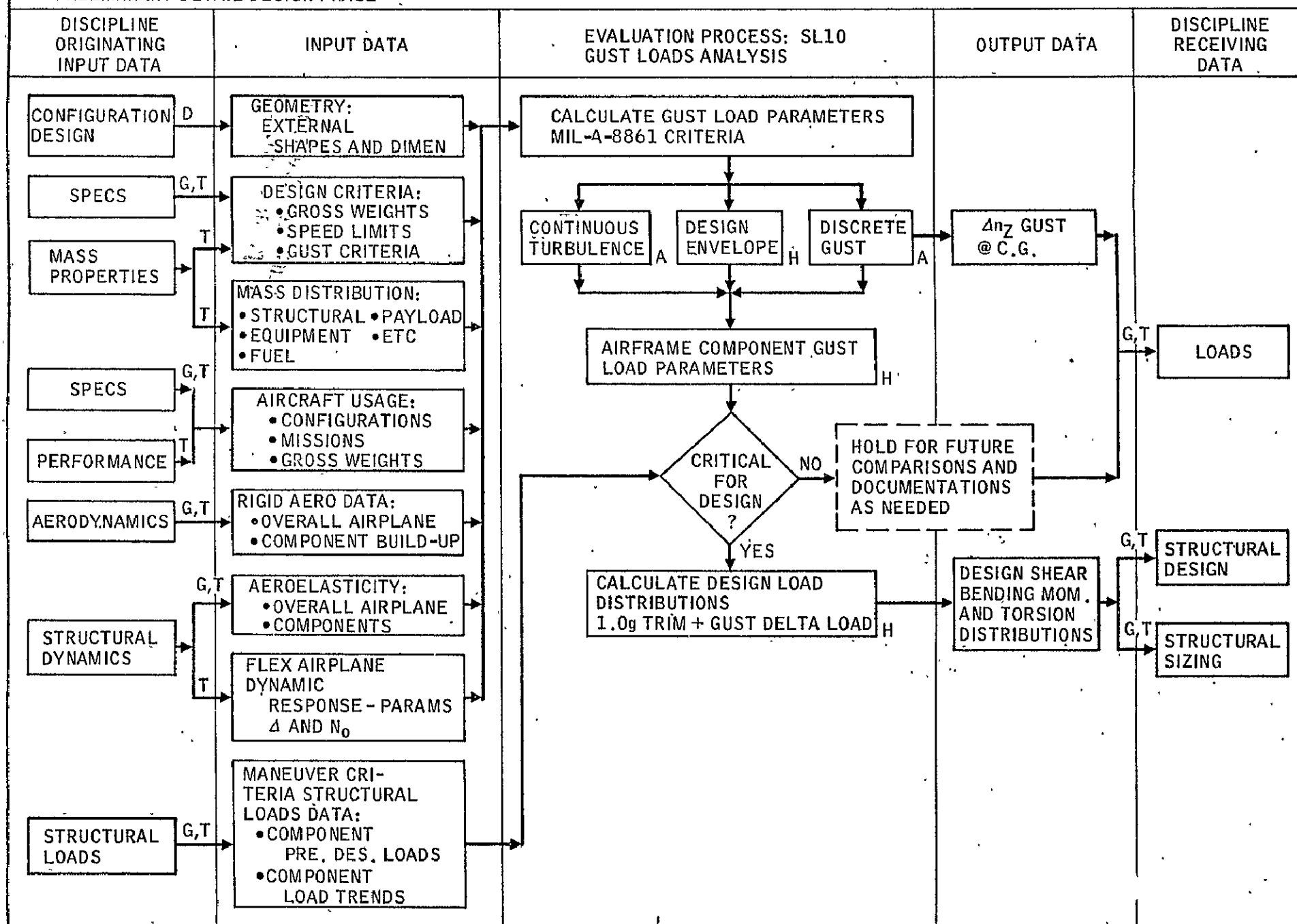
Figure 3-102. Fatigue Loads Spectra



ORIGINAL PAGE IS  
OF POOR QUALITY

Figure 3-103. Fatigue Evaluation

DISCIPLINE: STRUCTURAL LOADS  
PRELIMINARY DETAIL DESIGN PHASE



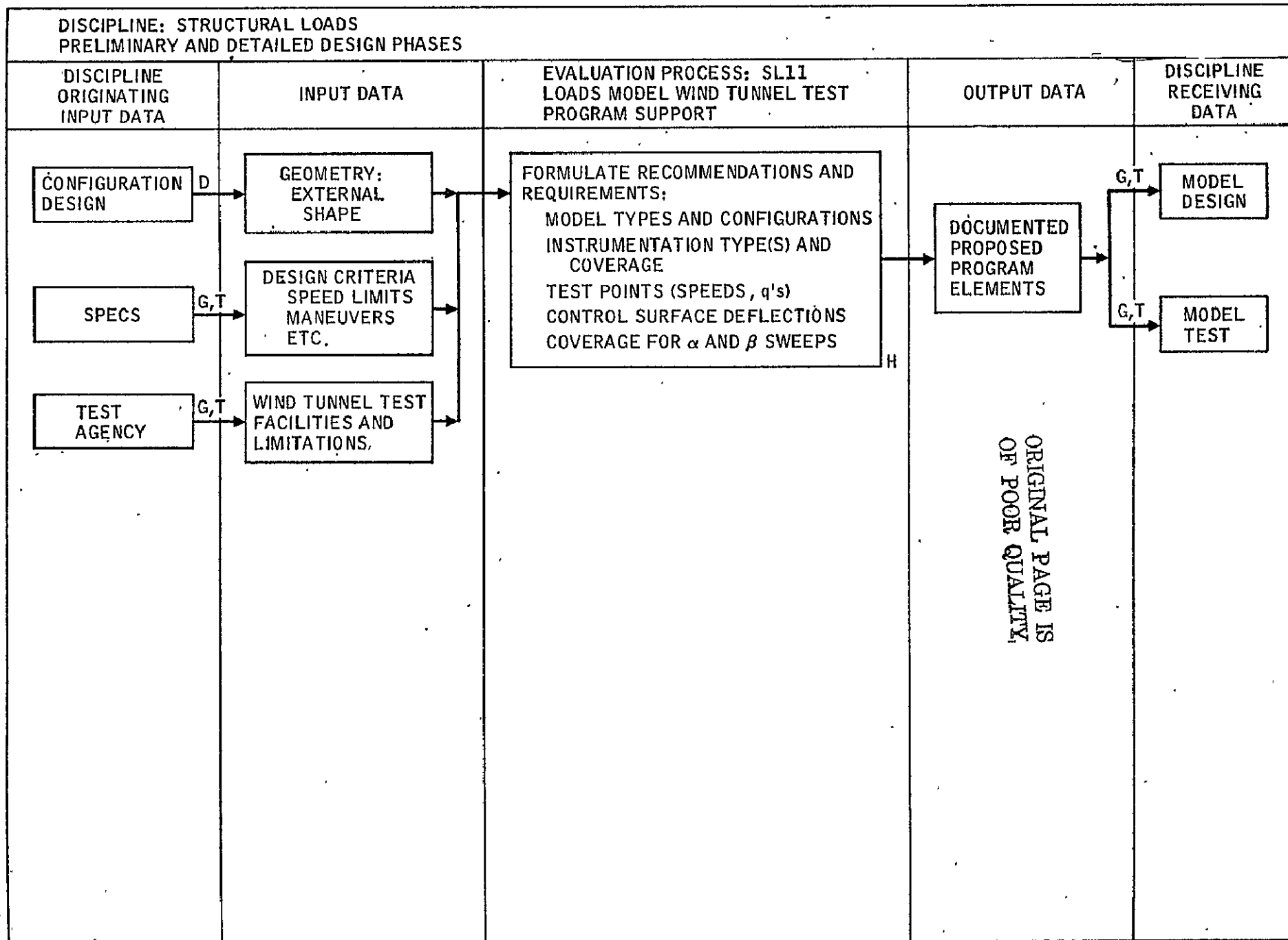


Figure 3-105. Loads Model Wind Tunnel Test Program Support

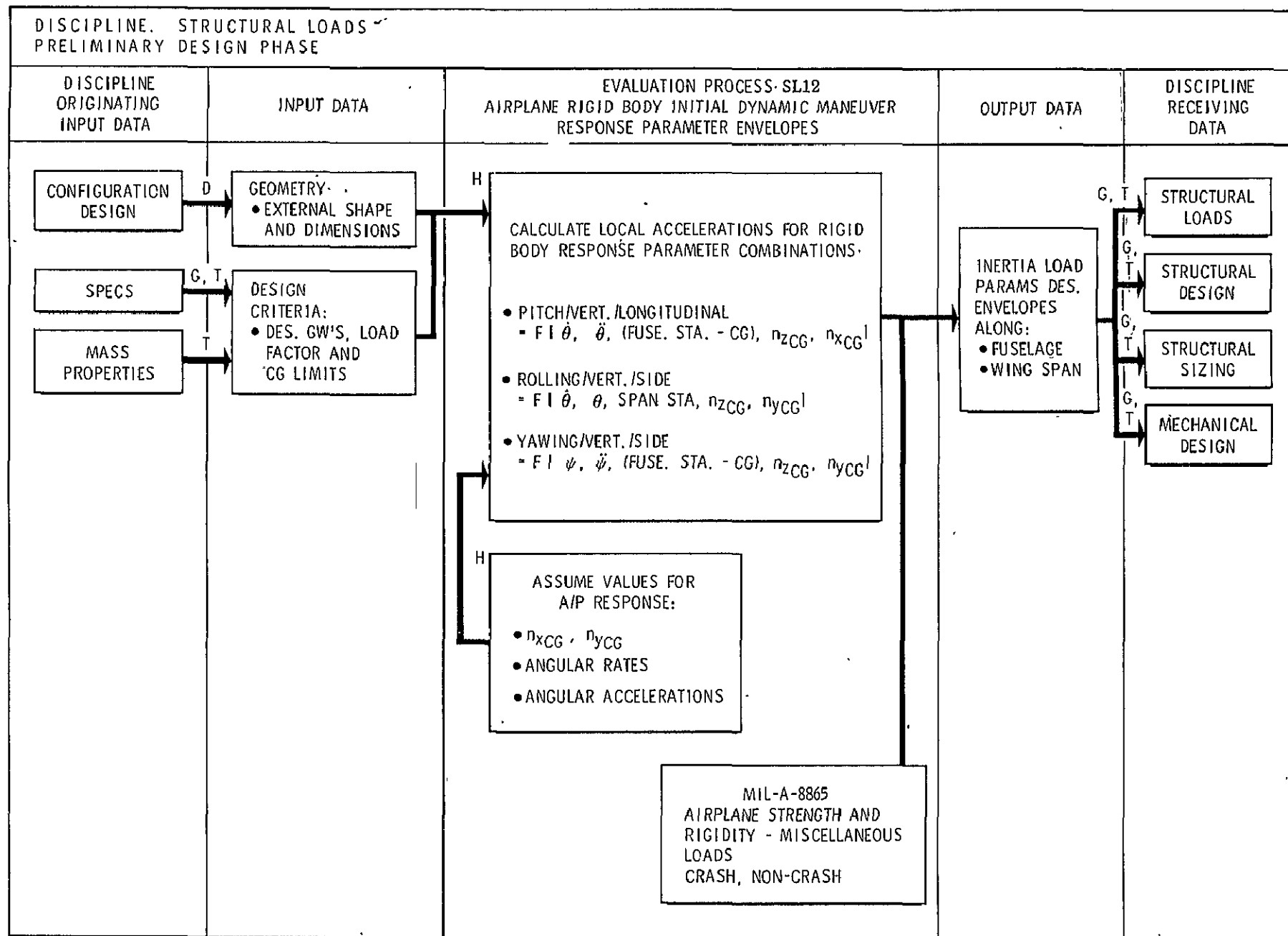


Figure 3-106. Airplane Initial Dynamics Maneuver Response Envelopes

TABLE 3-13. STRUCTURAL ANALYSIS CEP'S AND COMPUTER PROGRAMS

| TASKS                                                        | CEP  | Design Phase |    |    |
|--------------------------------------------------------------|------|--------------|----|----|
|                                                              |      | C            | PD | DD |
| Structural Arrangement and Concept Design Support.           | SA1  | x            | x  |    |
| Multispar Box Material and Structural Concept Trade Studies. | SA2  | x            | x  |    |
| Advanced Composite Fuselage Section Optimization.            | SA3  |              | x  | x  |
| Finite Element Fuselage Synthesis.                           | SA4  |              | x  |    |
| Material Selection.                                          | SA5  | x            | x  | x  |
| Finite Element Structural Analysis.                          | SA6  |              | x  | x  |
| a. Internal Loads Analysis                                   |      |              |    |    |
| b. Deflection Analysis                                       |      |              |    |    |
| c. Stress Analysis                                           |      |              |    |    |
| d. Stiffness and Flexibility Data Generation.                |      |              |    |    |
| Finite Element Stress Modal and Analysis.                    | SA7  |              | x  | x  |
| Fuselage Multiple Station Synthesis.                         | SA8  |              | x  |    |
| Wing Aeroelastic Synthesis Procedure (WASP).                 | SA9  |              | x  |    |
| Preliminary Fatigue Analysis.                                | SA10 |              | x  |    |
| Fatigue Analysis for Unit Damage Data.                       | SA11 |              |    | x  |
| Fatigue Test Evaluation and Qualification.                   | SA12 |              |    | x  |
| Fracture Control.                                            | SA13 |              | x  | x  |
| Flaw Growth.                                                 | SA14 |              | x  | x  |
| Fracture Arrest.                                             | SA15 |              | x  | x  |
| Nuclear Vulnerability/Survivability Assessment.              | SA16 |              | x  | x  |
| Structural Test Planning and Test Support.                   | SA17 |              | x  | x  |
| Detailed Stress Analysis.                                    | SA18 |              |    | x  |

ORIGINAL PAGE IS  
OF POOR QUALITY

TABLE 3-13. STRUCTURAL ANALYSIS CEP'S AND COMPUTER PROGRAMS (CONT'D)

| COMPUTER PROGRAMS |                                                                                                                      | CEP | Design Phase |    |    |
|-------------------|----------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                   |                                                                                                                      |     | C            | PD | DD |
| SEO/<br>Family    | Family of Multi-Spar Box Analysis<br>Procedures Used to Facilitate Material<br>and Structural Concept Trade Studies. |     |              | x  |    |
| RJ4               | Optbox II is a box beam minimum weight<br>design algorithm.                                                          |     |              | x  |    |
| TC6               | Fuselage Section Analysis.                                                                                           |     |              | x  |    |
| ATO               | Composite Structural Box Synthesis.                                                                                  |     |              | x  |    |
| TL7               | Finite Element Stress and Modal Analysis.                                                                            |     |              | x  | x  |
| XQ4               | NASTRAN Finite Element Stress Analysis.                                                                              |     |              | x  | x  |
| CLAAS             | Finite Element Structural Analysis.                                                                                  |     |              | x  | x  |
| FADES             | Finite Element Fuselage Synthesis.                                                                                   |     |              | x  |    |
| NOVA              | Skin/Stringer Sizing.                                                                                                |     |              | x  |    |
| WASP              | Wing Aeroelastic Synthesis.                                                                                          |     |              | x  |    |

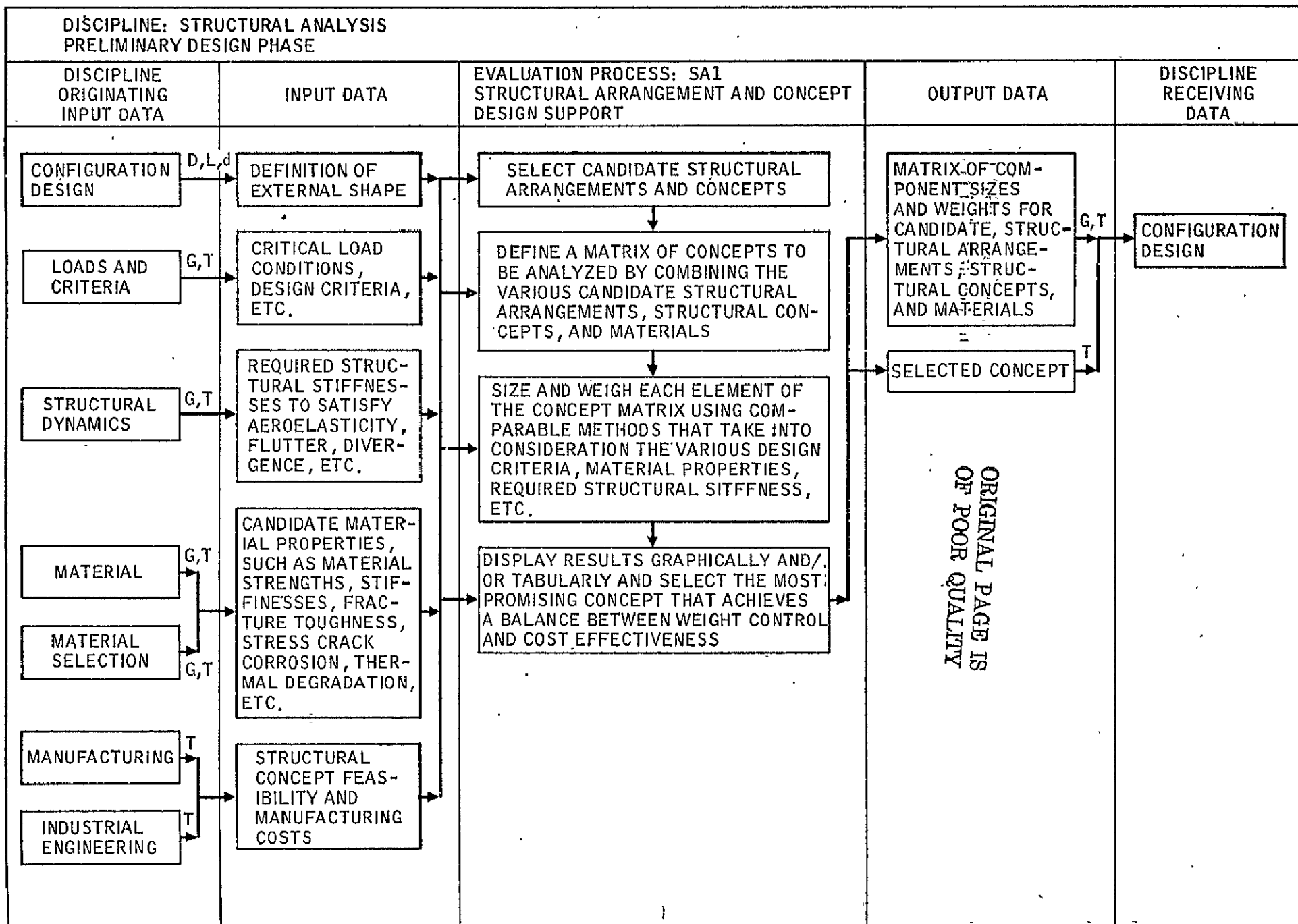


Figure 3-107. Structural Arrangement and Concept Design Support

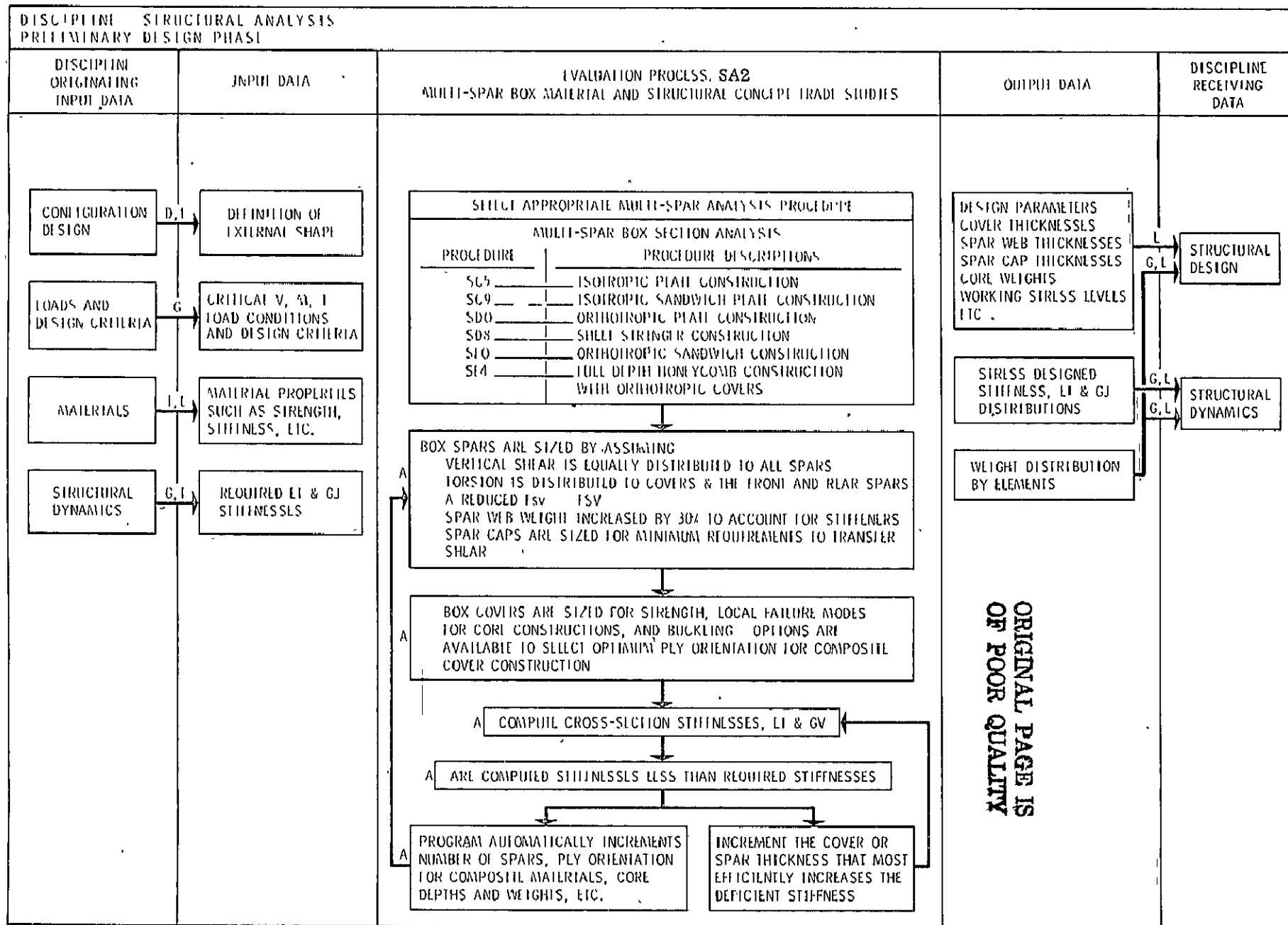


Figure 3-108. Multispar Box Material and Structural Concept Trade Studies

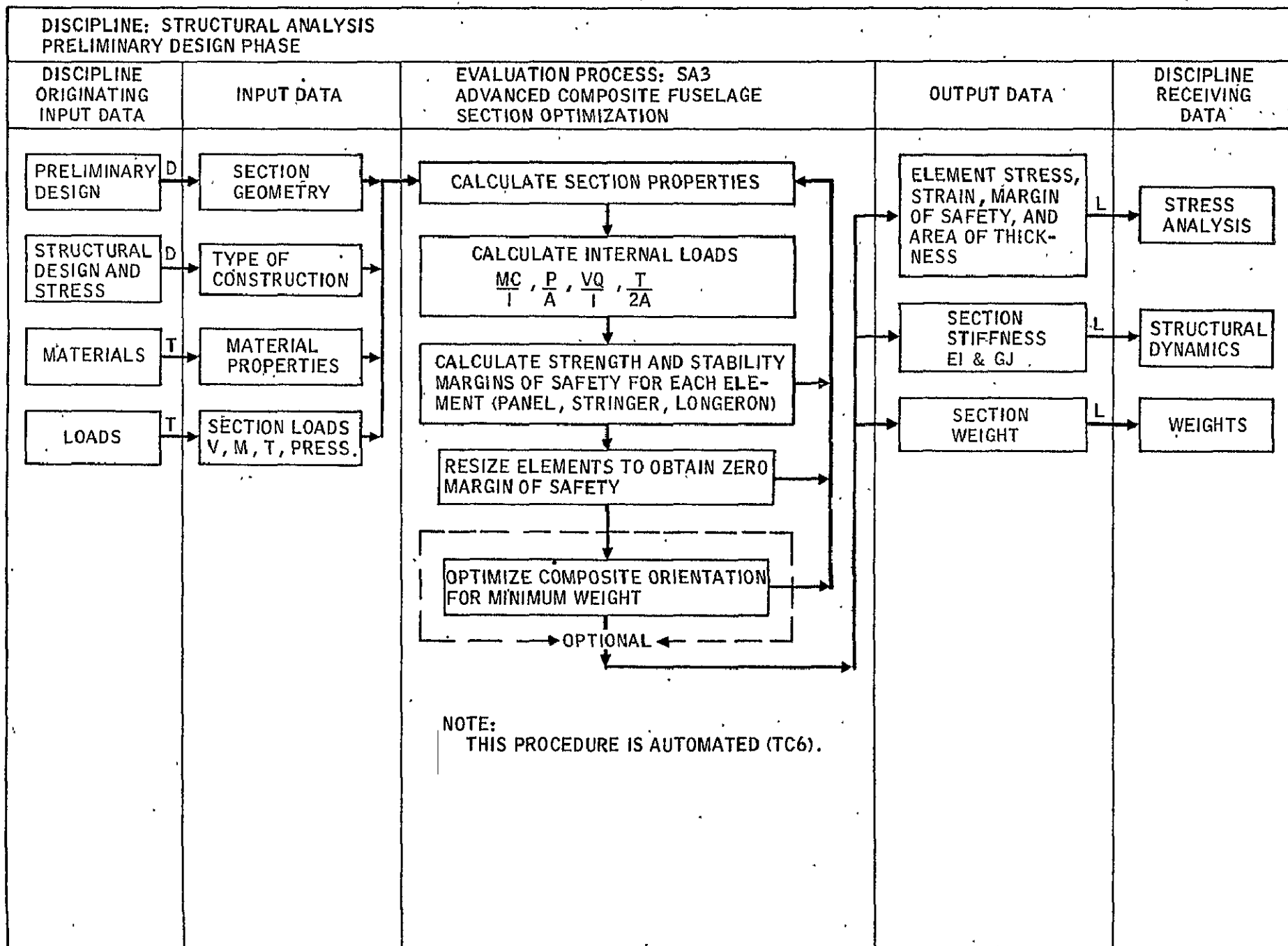
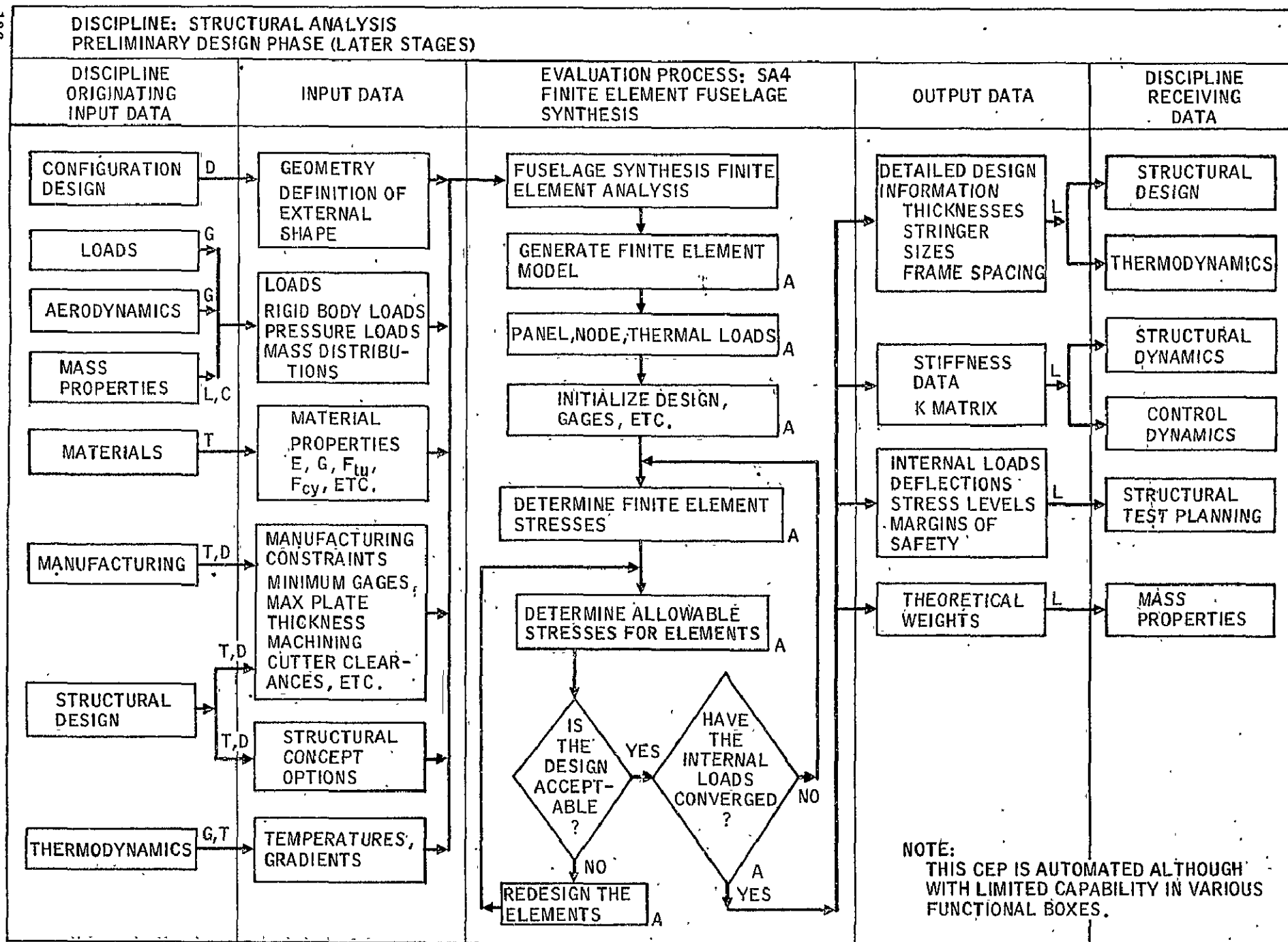


Figure 3-109. Advanced Composite Fuselage Section Optimization



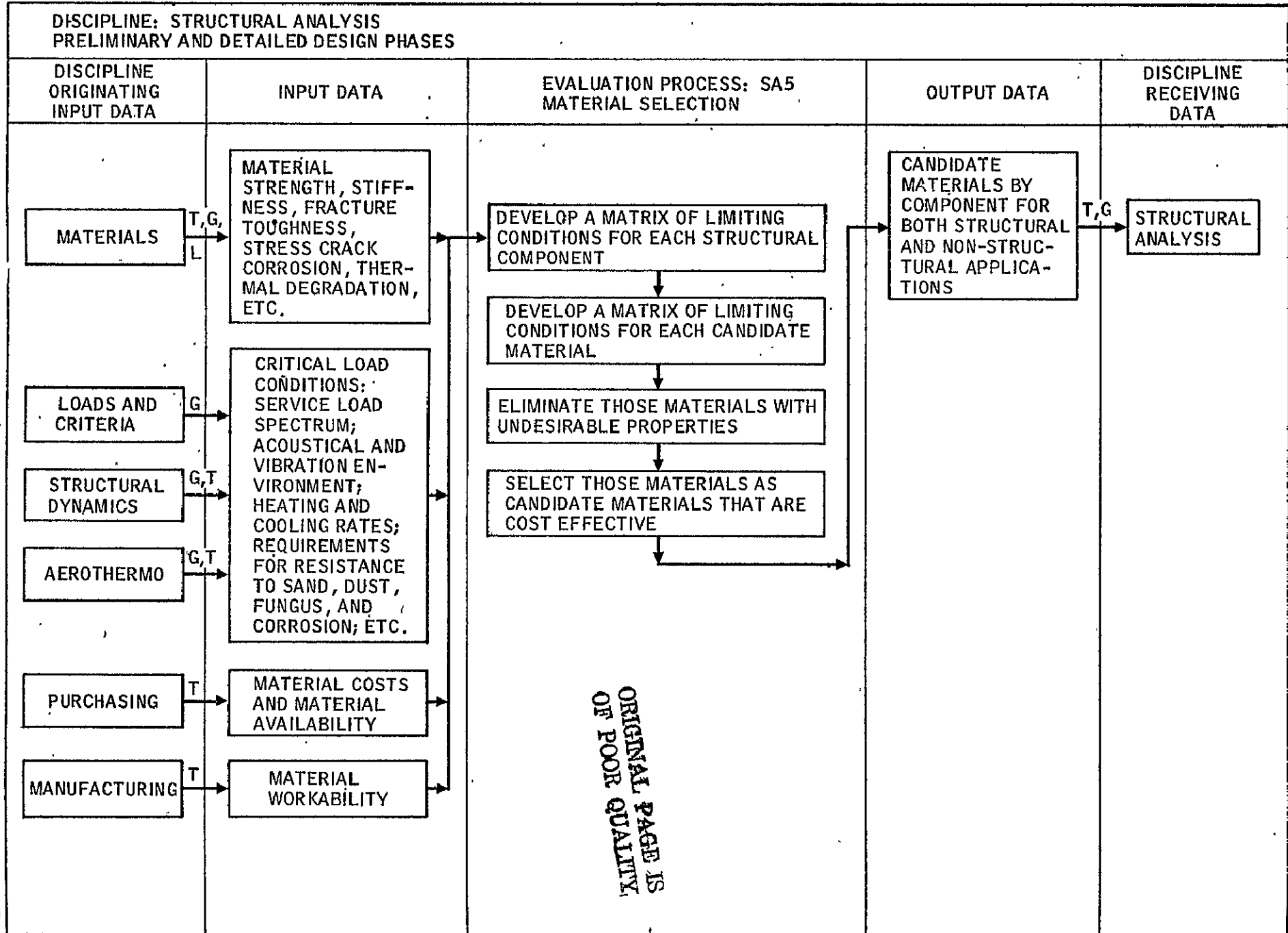
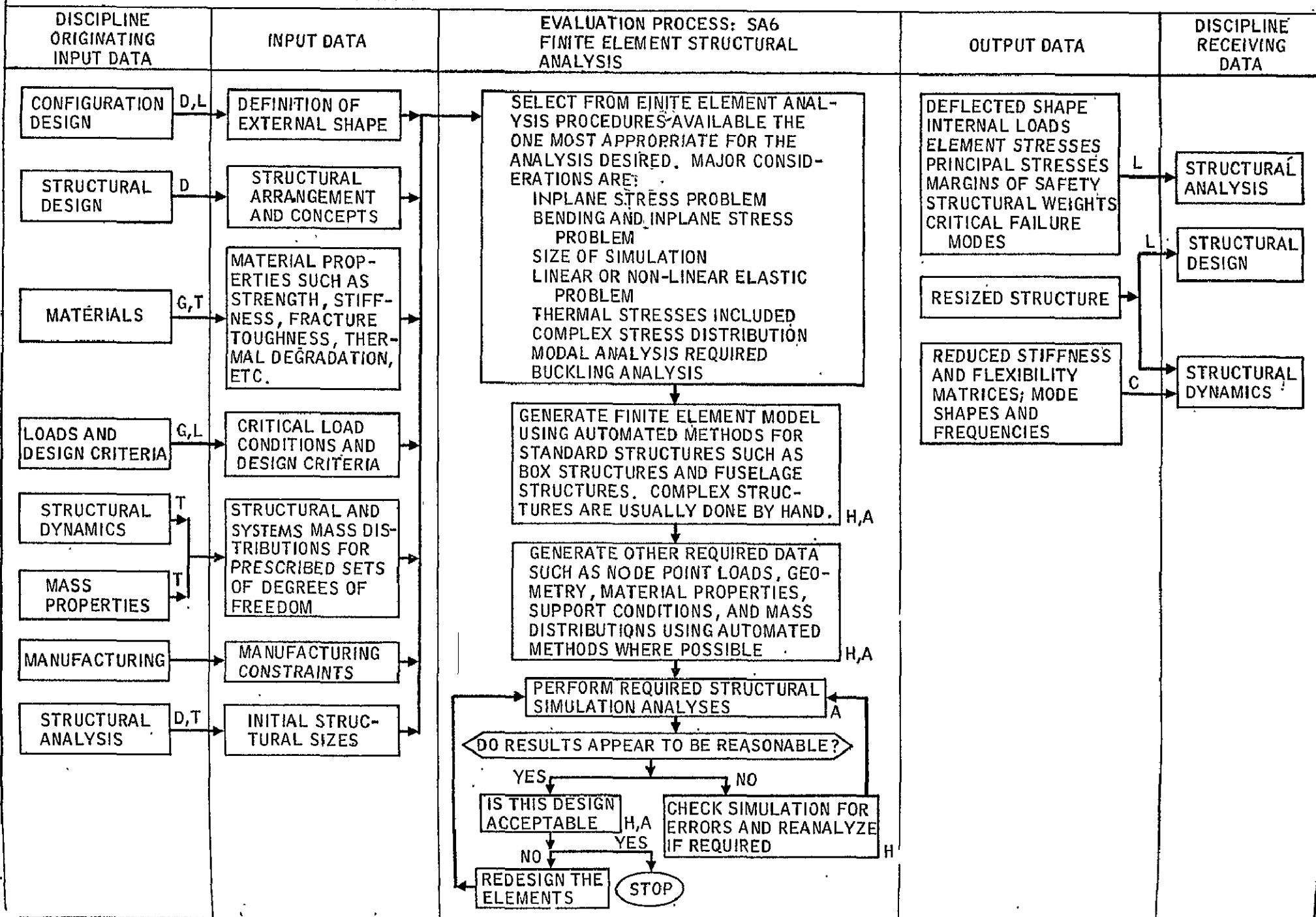


Figure 3-111. Material Selection

**DISCIPLINE: STRUCTURAL ANALYSIS**  
**PRELIMINARY AND DETAILED DESIGN PHASES**



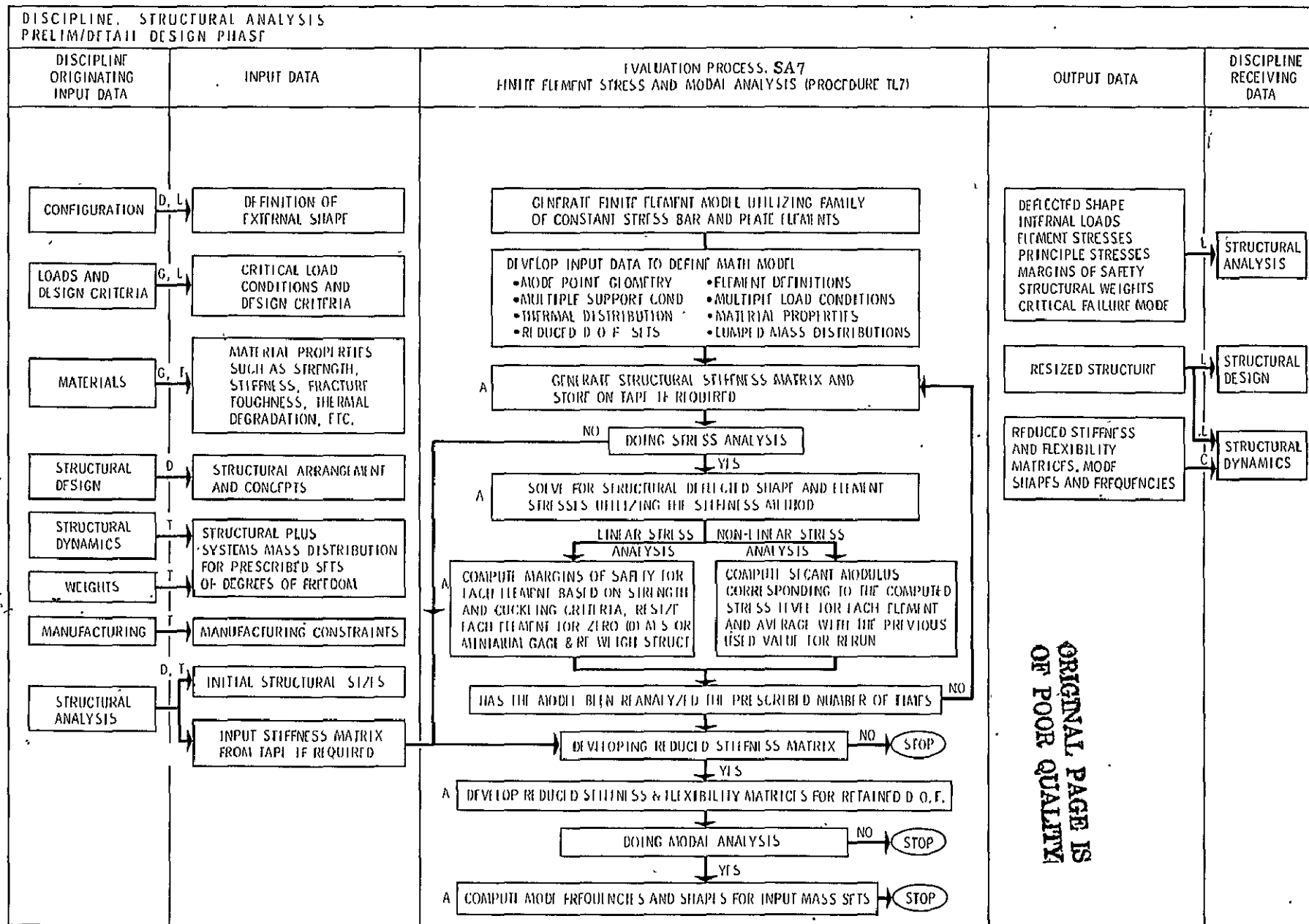
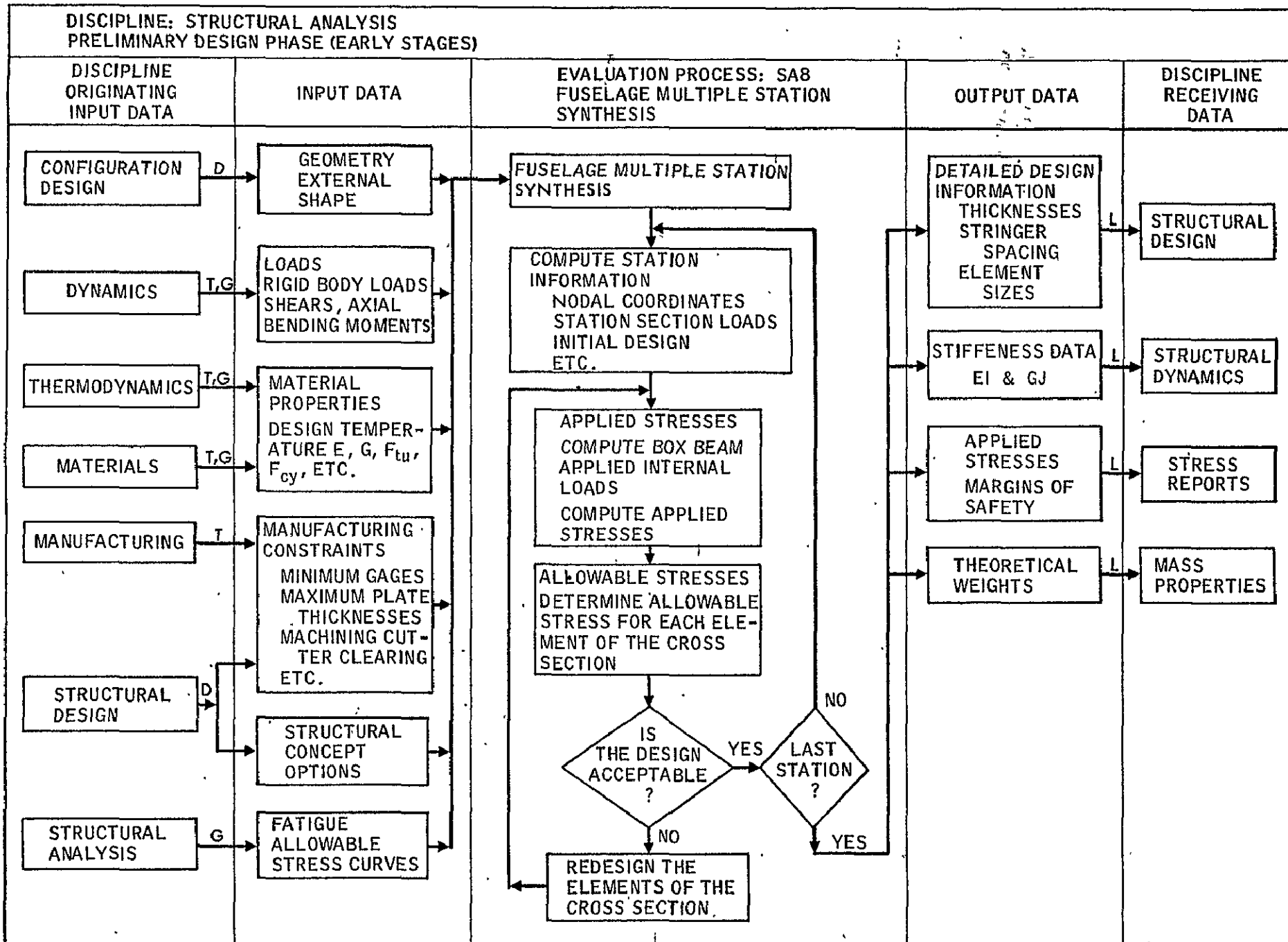


Figure 3-113. Finite Element Stress and Modal Analysis



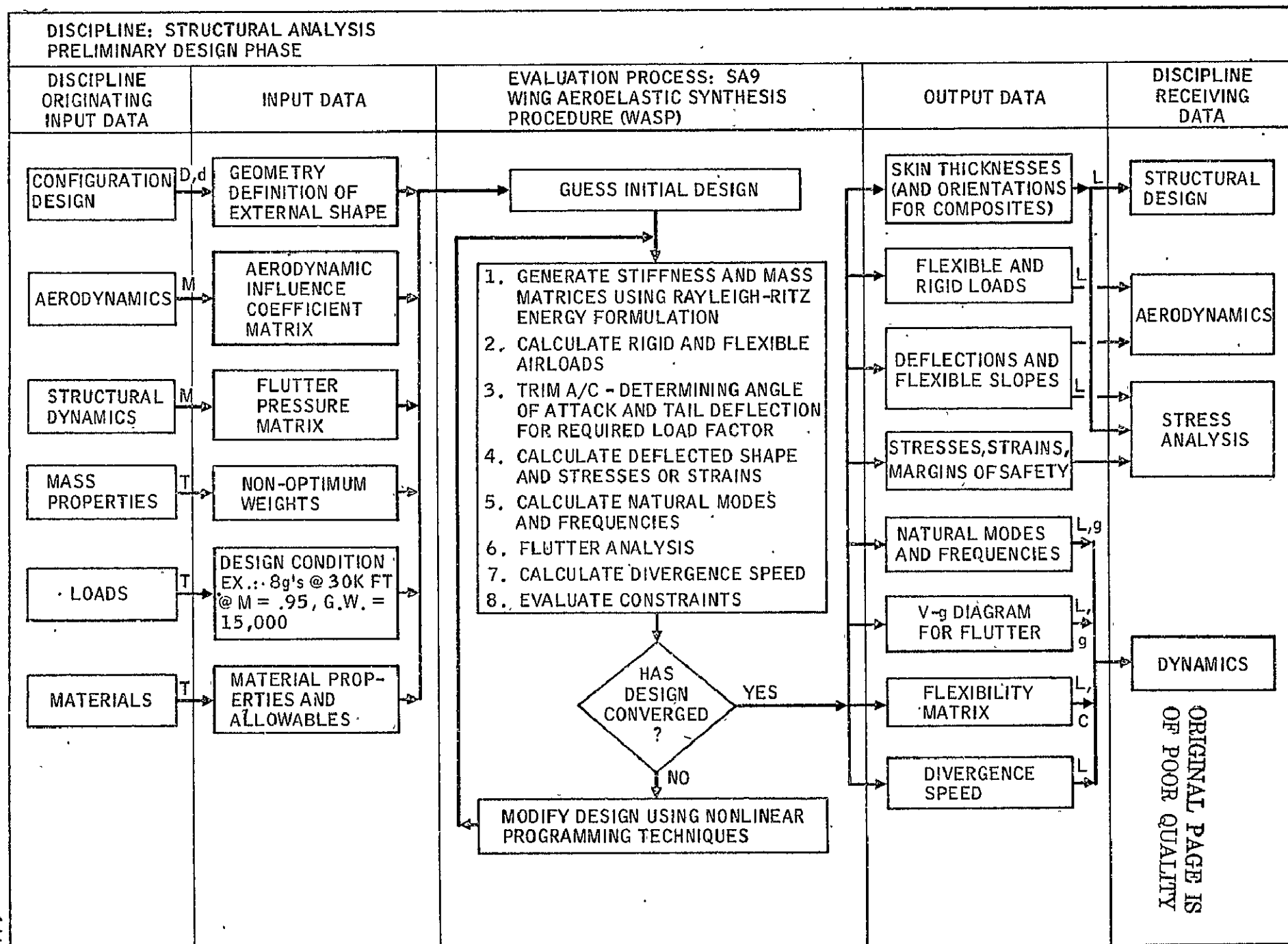


Figure 3-115. Wing Aeroelastic Synthesis Procedure (WASP)

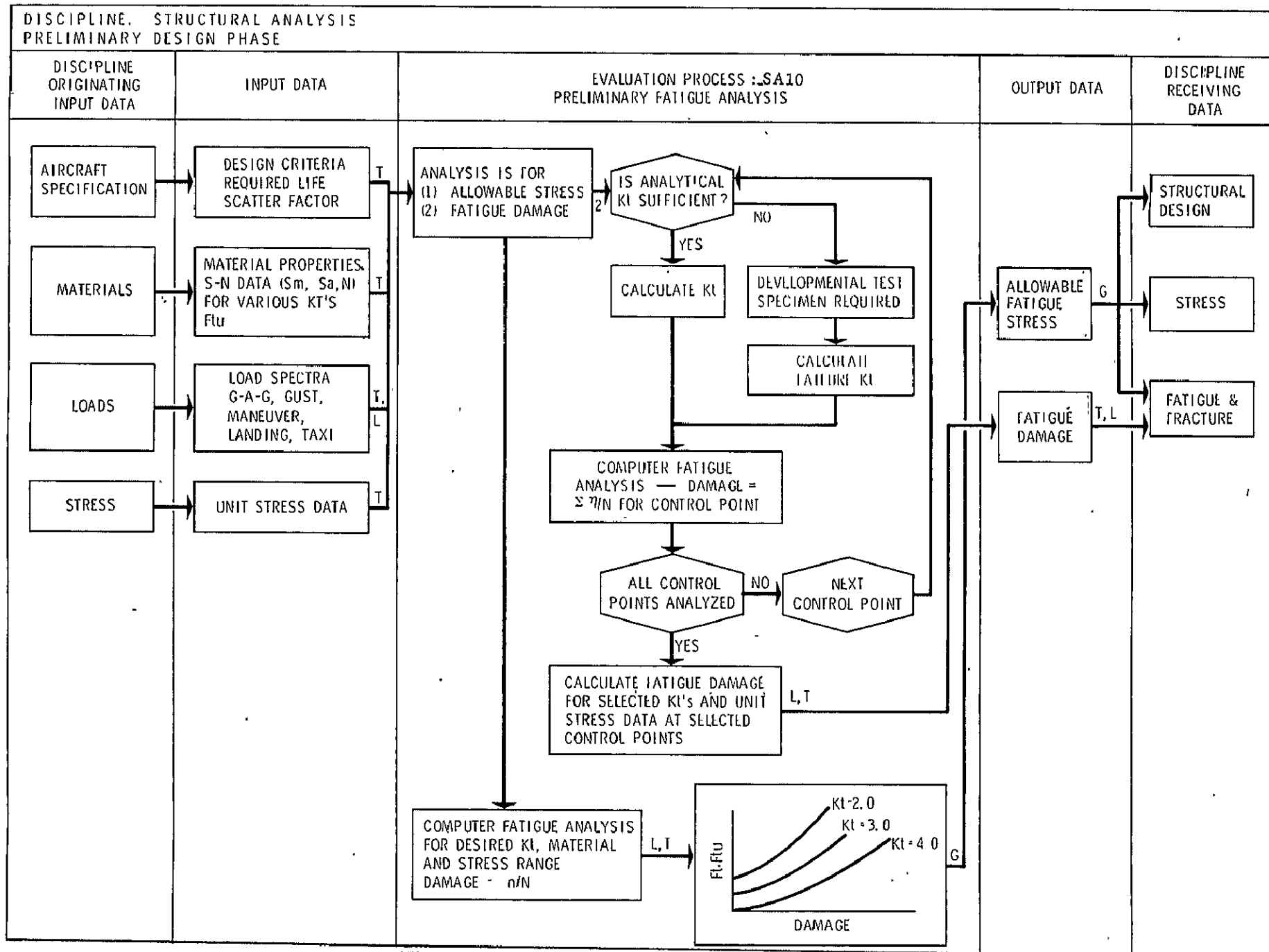


Figure 3-116. Preliminary Fatigue Analysis

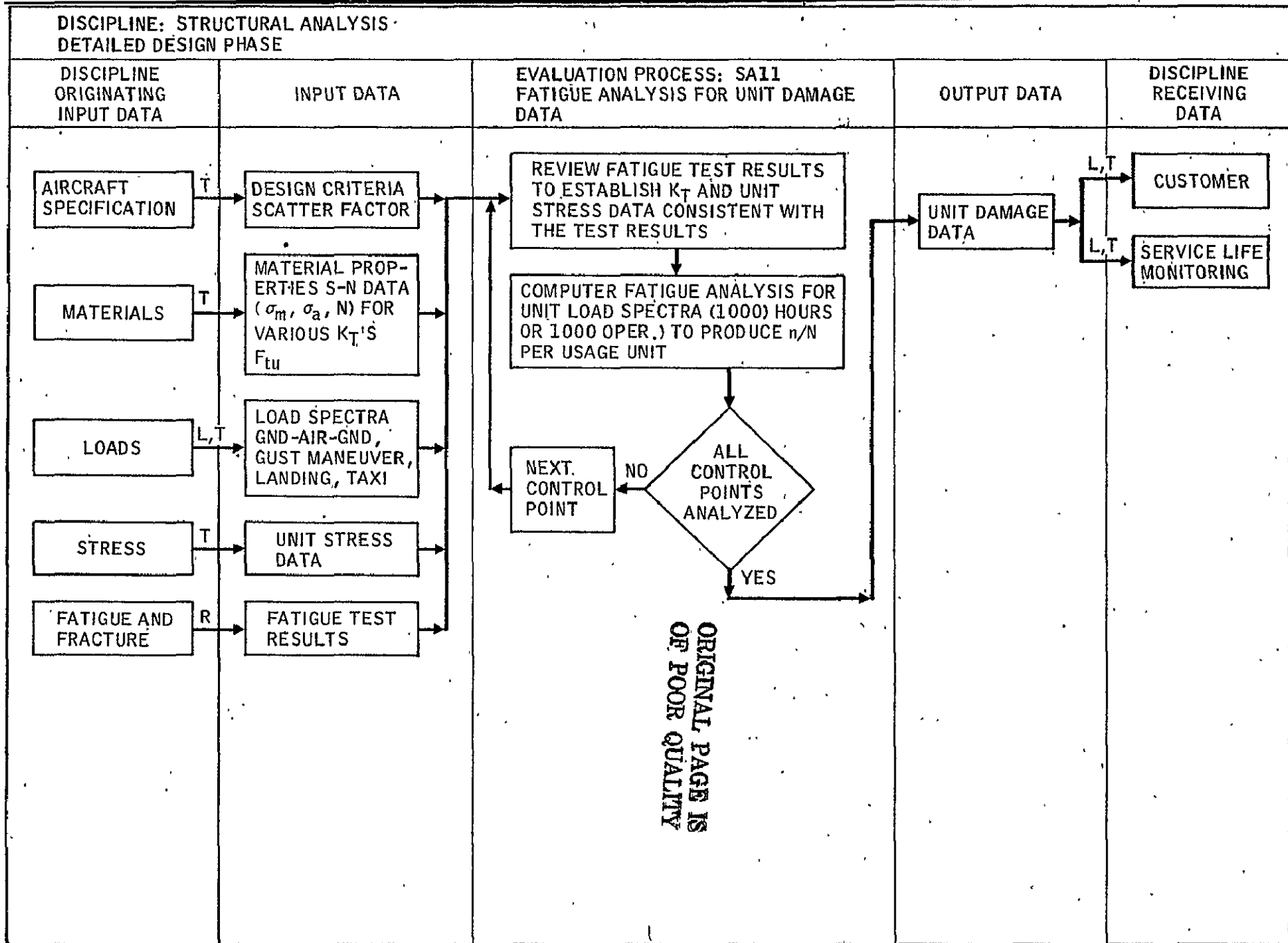
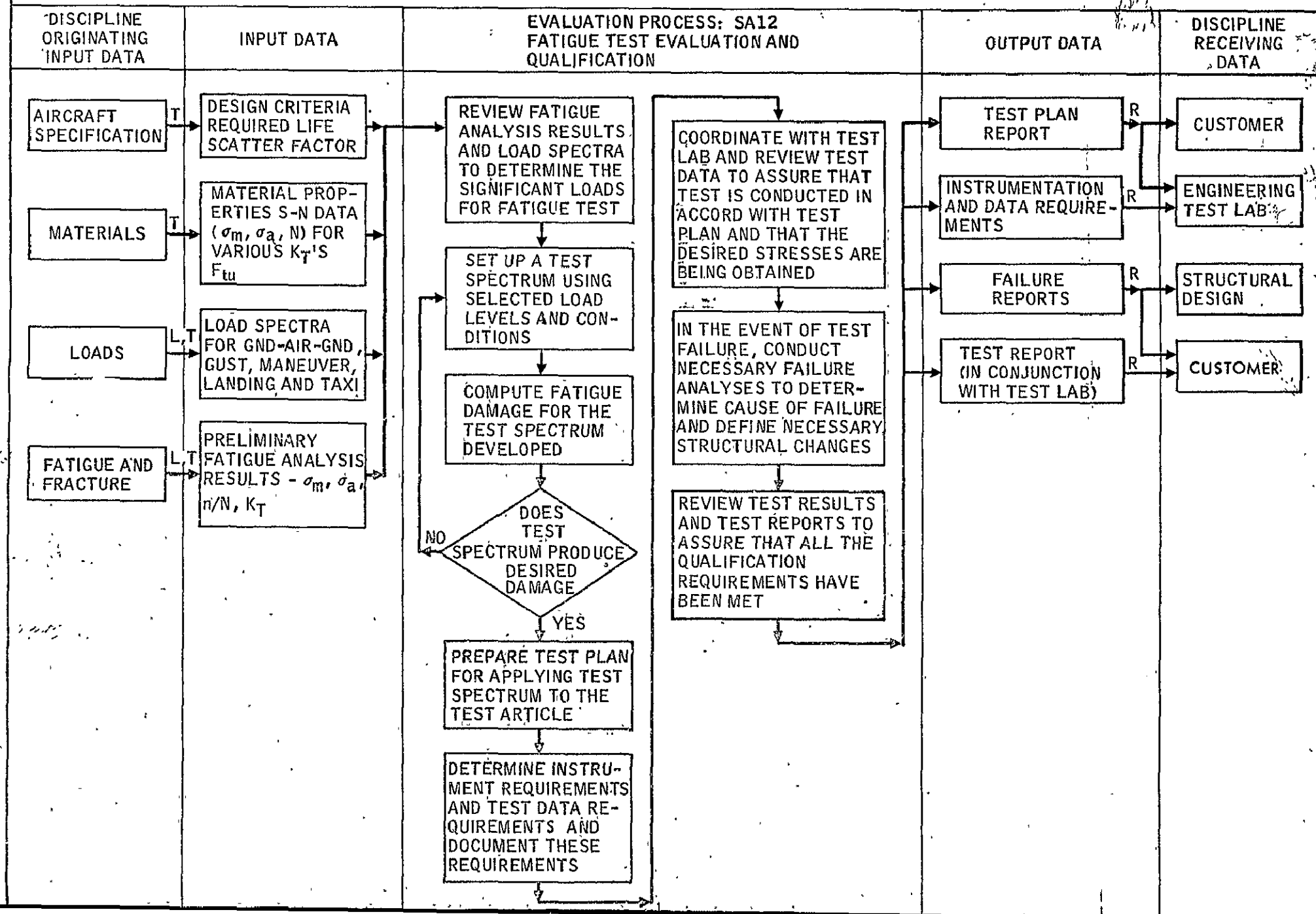


Figure 3-117.. Fatigue Analysis for Unit Damage Data

**DISCIPLINE: STRUCTURAL ANALYSIS**  
**DETAILED DESIGN PHASE**



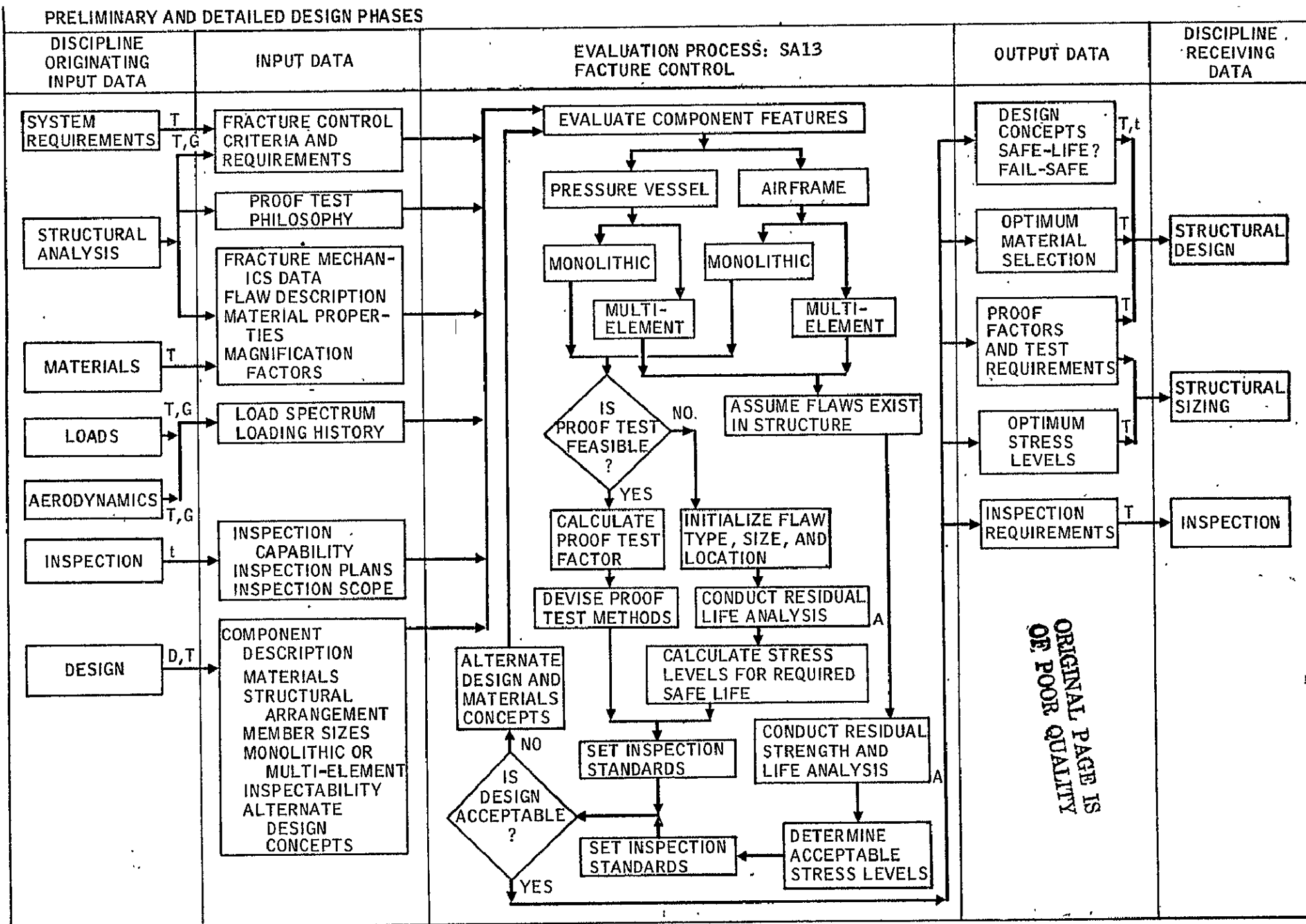
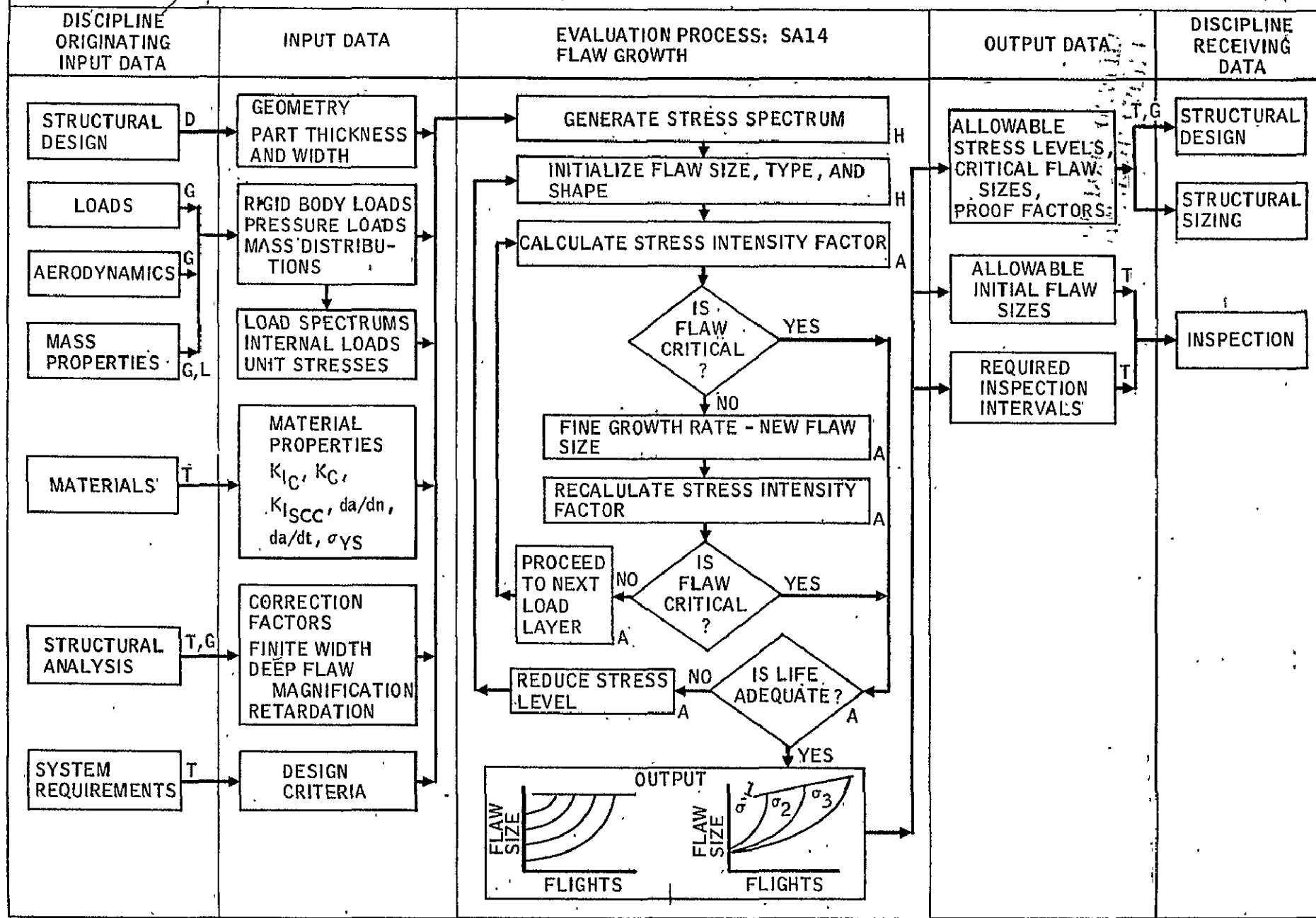


Figure 3-119. Fracture Control

# DISCIPLINE: STRUCTURAL ANALYSIS PRELIMINARY AND DETAILED DESIGN PHASES



DISCIPLINE: STRUCTURAL ANALYSIS  
PRELIMINARY AND DETAILED DESIGN PHASES

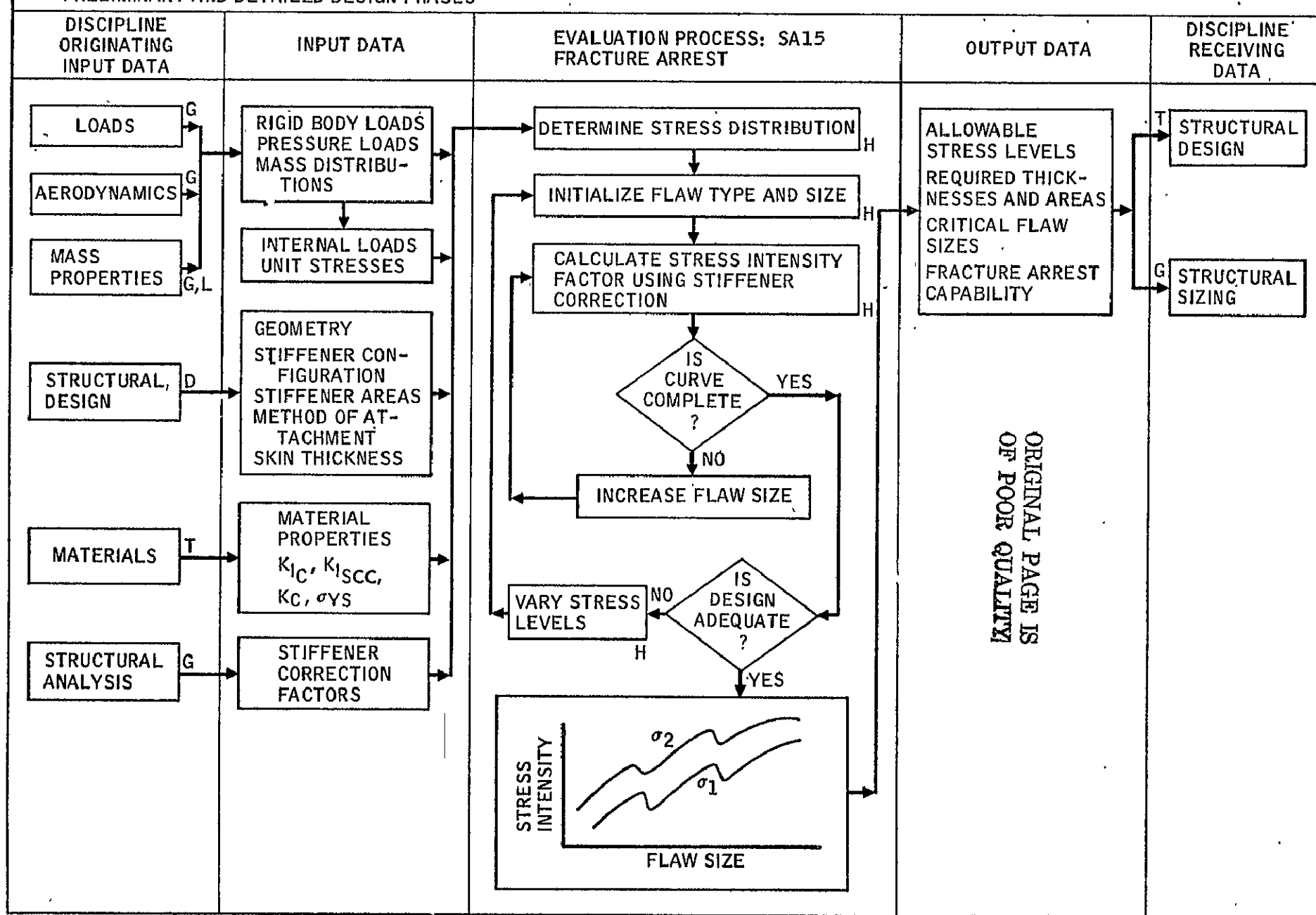
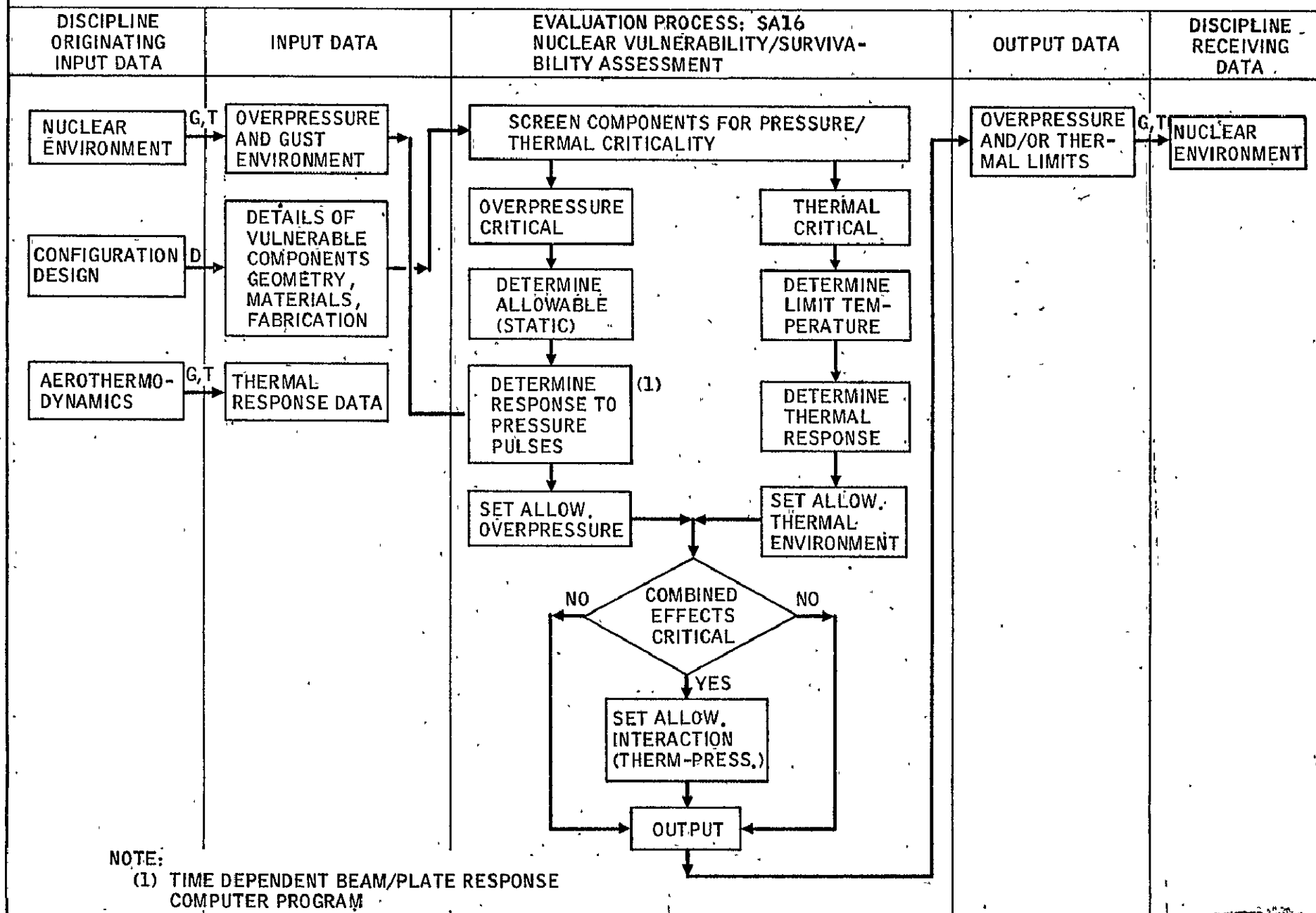


Figure 3-121. Fracture Arrest

DISCIPLINE: STRUCTURAL ANALYSIS  
PRELIMINARY AND DETAILED DESIGN PHASES



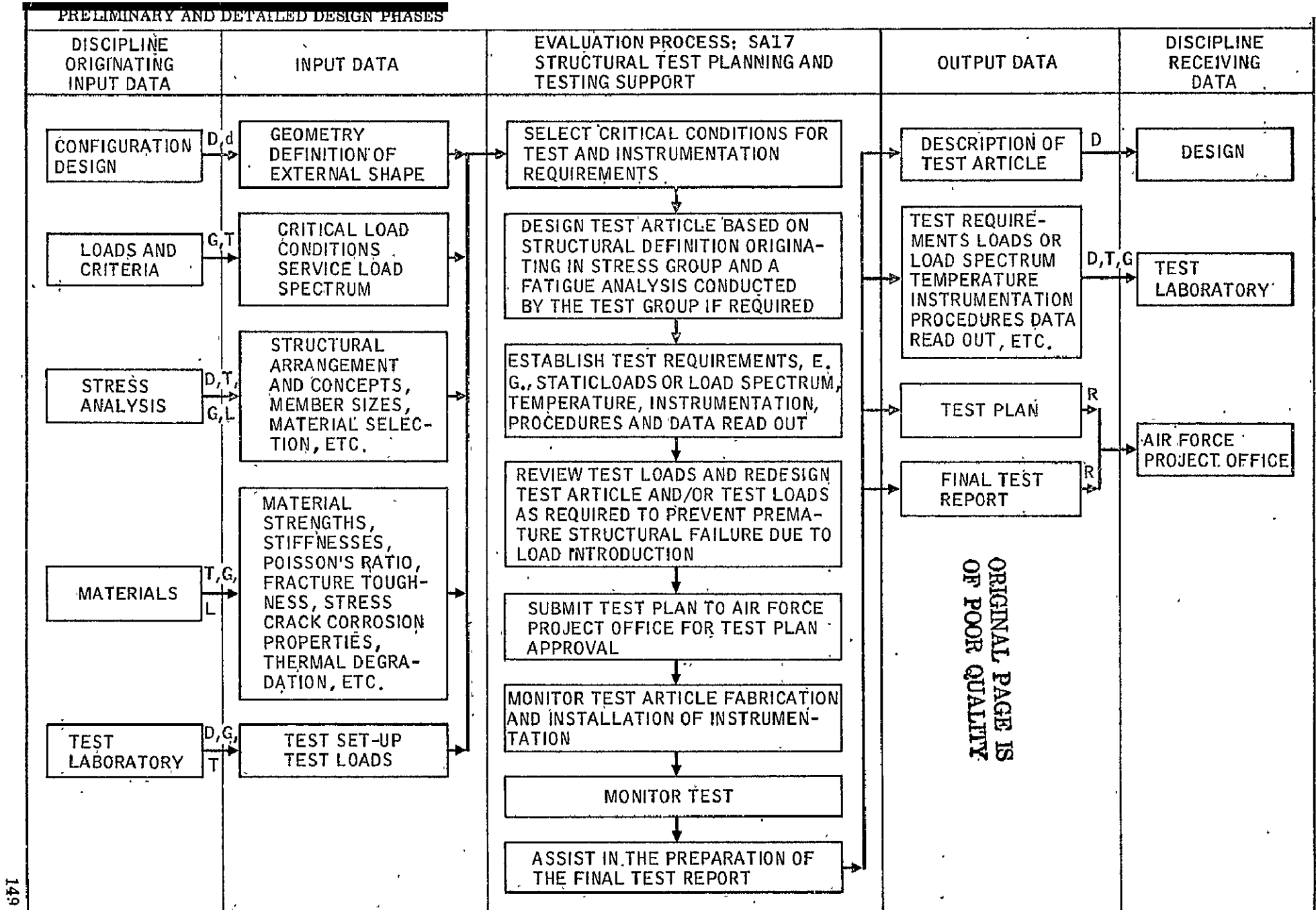


Figure 3-123. Structural Test Planning and Testing Support

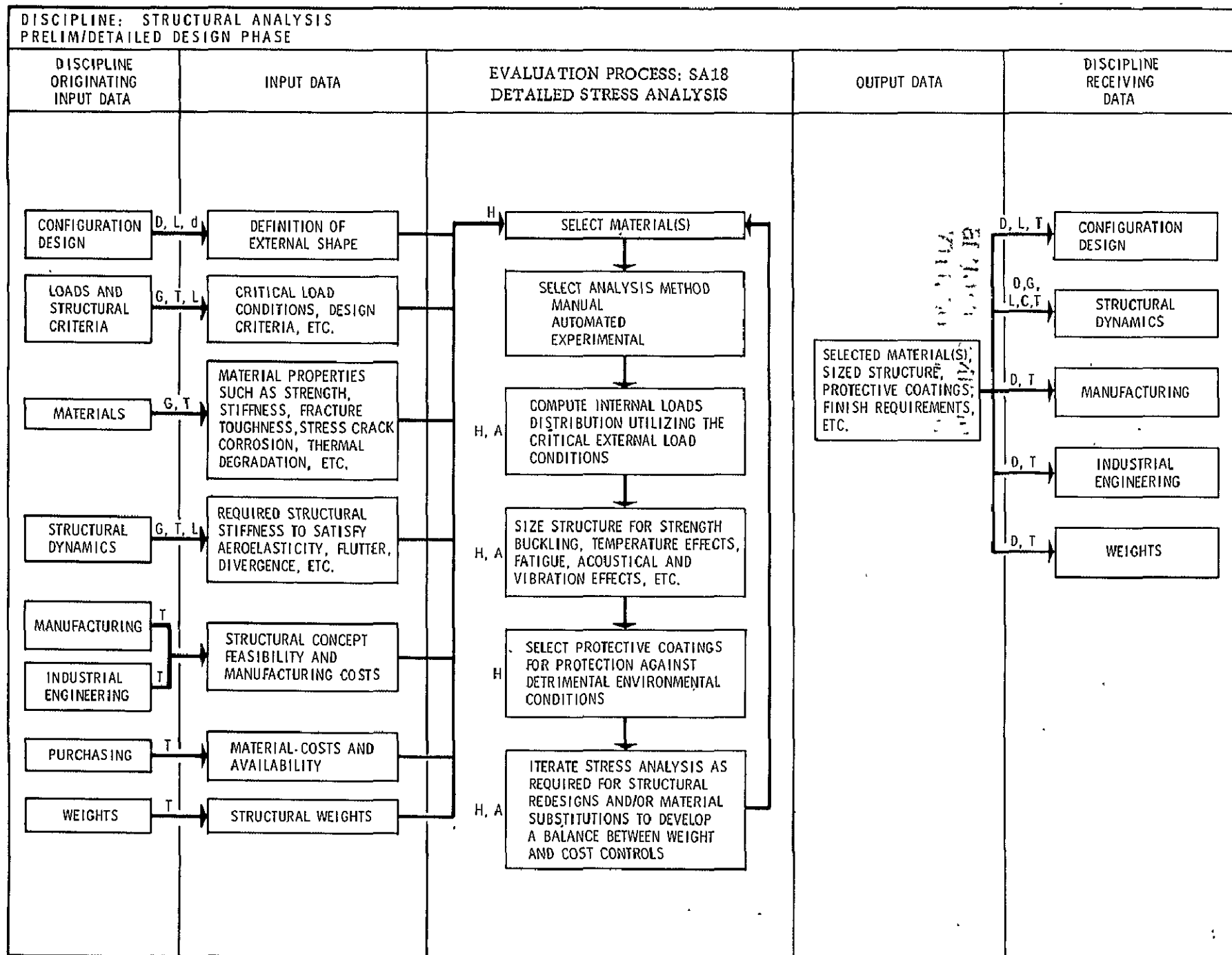


Figure 3-124 Detailed Stress Analysis

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS

| TASKS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CEP | Design Phase |    |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |     | C            | PD | DD |
| <p><u>Static Aeroelasticity</u></p> <p>Compute over speed envelope surface divergence speed<br/>control surface reversal speed</p> <p>Predict flexible airplane aerodynamic stability derivatives</p> <p>Compute jig shape for cruise condition</p> <p>Predict flexible airplane shape for off design conditions</p> <p>Predict flexible airplane loads for selected flight conditions</p> <p>Provide support for configuration design</p> <p>Provide support for wind tunnel model design</p>                                          | SD1 |              | x  |    |
| <p><u>Flutter</u></p> <p>Predict airplane flutter speeds over the altitude range</p> <p>Provide structural analysis with stiffness requirements</p> <p>Provide incremental weight changes due stiffness or mass<br/>balance additions</p> <p>Provide sensor locations and feedback characteristic gains<br/>for flutter suppression</p> <p>Predict panel sizes and skin gages for panel flutter</p> <p>Provide support for configuration and flutter model design</p> <p>Plan and support ground vibration and flight flutter tests</p> | SD2 |              | x  | x  |
| <p><u>Gust Response</u></p> <p>Predict fatigue and probability strength transfer function<br/>data</p> <p>Predict PSD response data</p> <p>Predict ride quality characteristics</p> <p>Provide quasi-steady dynamical matrices and sensor/control<br/>surface transfer functions</p>                                                                                                                                                                                                                                                    | SD3 |              | x  | x  |

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

| TASKS                                                                        | CEP | Design Phase |    |    |
|------------------------------------------------------------------------------|-----|--------------|----|----|
|                                                                              |     | C            | PD | DD |
| <u>Gust Response (Continued)</u>                                             |     |              |    |    |
| Establish gust alleviation system requirements                               |     |              |    |    |
| Provide support for configuration design                                     |     |              |    |    |
| Crew vibration environment                                                   |     |              |    |    |
| <u>Taxi and Landing Response</u>                                             | SD4 |              | x  |    |
| Predict landing gear and airplane response due to discrete and random inputs |     |              |    |    |
| Provide fatigue and probability strength data                                |     |              |    |    |
| Support configuration design with landing gear characteristics               |     |              |    |    |
| <u>Acoustics and Vibrations</u>                                              | SD5 |              | x  |    |
| Predict external noise environments                                          |     |              |    |    |
| Predict noise transmission losses                                            |     |              |    |    |
| Predict internal noise environments                                          |     |              |    |    |
| Establish acoustic qualification test criteria                               |     |              |    |    |
| Predict acoustic fatigue life of structure                                   |     |              |    |    |
| Plan acoustic fatigue life developmental tests                               |     |              |    |    |
| Plan acoustic fatigue life verification tests                                |     |              |    |    |
| Predict vibration environments                                               |     |              |    |    |
| Establish vibration qualification test criteria                              |     |              |    |    |
| <u>COMPUTER PROGRAMS</u>                                                     |     |              |    |    |
| BY7 Finite element structure techniques                                      |     |              | x  | x  |
| XQ4 NASTRAN                                                                  |     |              |    | x  |
| RZO Family of finite element structural techniques                           |     |              |    | x  |

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

|                                      |                                                                                                                                                                                                                                      | CEP | Design Phase |    |    |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                      |                                                                                                                                                                                                                                      |     | C            | PD | DD |
| <u>COMPUTER PROGRAMS (Continued)</u> |                                                                                                                                                                                                                                      |     |              |    |    |
| AT5                                  | Steady state finite element aerodynamic technique for wing-body-tail configurations subsonic and supersonic speeds                                                                                                                   |     |              | x  | x  |
| TS5                                  | Steady and/or unsteady finite element aerodynamic technique for wing-tail configurations at subsonic speeds. The program also performs flutter analysis and computes the generalized aerodynamic forces for use in gust analysis.    |     |              | x  | x  |
| BQ8                                  | Steady and/or unsteady supersonic aerodynamic Mach box technique wing alone                                                                                                                                                          |     |              | x  | x  |
| AA8                                  | Steady and/or unsteady kernel function technique                                                                                                                                                                                     |     |              | x  | x  |
| XOQ                                  | Steady and/or unsteady supersonic aerodynamic Mach box technique for wing-tail configurations                                                                                                                                        |     |              | x  | x  |
| SK5                                  | Unsteady slender body aerodynamic technique                                                                                                                                                                                          |     |              | x  | x  |
| TF2                                  | Steady and/or unsteady subsonic aerodynamic kernel function technique for wings with and without control surfaces. Also, the program performs flutter analysis and computes generalized aerodynamic forces for use in gust analysis. |     |              | x  | x  |
| ROS                                  | Steady and/or unsteady, subsonic and supersonic aerodynamic kernel function technique for multiple lifting surface configurations.                                                                                                   |     |              | x  | x  |
| UB3                                  | Procedure for modifying the theoretical aerodynamic matrix (AT5) using experimental pressure data.                                                                                                                                   |     |              | x  | x  |
| ROU                                  | Procedure used to assemble experimental pressure data from tape into UB3.                                                                                                                                                            |     |              | x  | x  |
| SZ4                                  | Steady state aeroelastic procedure. This program assembles the aerodynamic and structural technique to solve for the flexible aerodynamic characteristics.                                                                           |     |              | x  | x  |

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

|                                      |                                                                                                                                                                                       | CEP | Design Phase |    |    |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                      |                                                                                                                                                                                       |     | C            | PD | DD |
| <u>COMPUTER PROGRAMS (Continued)</u> |                                                                                                                                                                                       |     |              |    |    |
| TH3                                  | Program is used to combine procedures AA8 and SK5 to formulate the flutter solution for a complete air-plane system.                                                                  |     |              | x  | x  |
| BS5                                  | Curve fitting and interpolation procedure. This program is used to interpolate the modes for slopes and deflections at the aerodynamic control points for the AA8 and BQ programs.    |     |              | x  | x  |
| BS6                                  | Program generates the data required to include the effects of a stability augmentation system (SAS) in the analysis of the dynamic response of an elastic vehicle.                    |     |              | x  | x  |
| TM9                                  | Curve fitting and interpolation procedure is a modification of BS5 for the TF2 program.                                                                                               |     |              | x  | x  |
| SB2                                  | Program is used to compute the response of an aircraft to random atmospheric turbulence and/or discrete gusts. The program also has provision for including gust alleviation systems. |     |              | x  | x  |
| SY1                                  | A flutter optimization program used to resize finite elements of a structural simulation to obtain the required flutter speed with reduced weight.                                    |     |              | x  | x  |
| CSMP                                 | A taxi and landing procedure used to compute the gear and airframe response.                                                                                                          |     |              | x  | x  |
| BM9                                  | Computes constant sound pressure level contours for overall and octave band frequencies in a jet near noise field.                                                                    |     |              | x  |    |
| A1X                                  | Computes sound pressure levels from engine and aerodynamic data. Computes panel response to the noise and compares with allowable acoustic fatigue life.                              |     |              | x  | x  |
| UA4                                  | Computes far-field noise levels from basic engine parameters.                                                                                                                         |     |              | x  | x  |

TABLE 3-14. STRUCTURAL DYNAMICS CEP'S AND COMPUTER PROGRAMS (CONT'D)

| COMPUTER PROGRAMS (Continued)       |                                                                                                                                                                 | CEP | Design Phase |    |    |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|----|----|
|                                     |                                                                                                                                                                 |     | C            | PD | DD |
| A4N                                 | Computes the effective perceived noise level EPNL, footprint of an aircraft flyover using engine noise characteristics from measurements or predictions by UA4. |     |              | x  | x  |
| A4O                                 | Computes EPNL at any given point on the centerline of the aircraft takeoff or landing flight paths.                                                             |     |              | x  | x  |
| A4P                                 | Computes point along the sideline where the EPNL is greatest.                                                                                                   |     |              | x  | x  |
| ORIGINAL PAGE IS<br>OF POOR QUALITY |                                                                                                                                                                 |     |              |    |    |
|                                     |                                                                                                                                                                 |     |              |    |    |
|                                     |                                                                                                                                                                 |     |              |    |    |
|                                     |                                                                                                                                                                 |     |              |    |    |

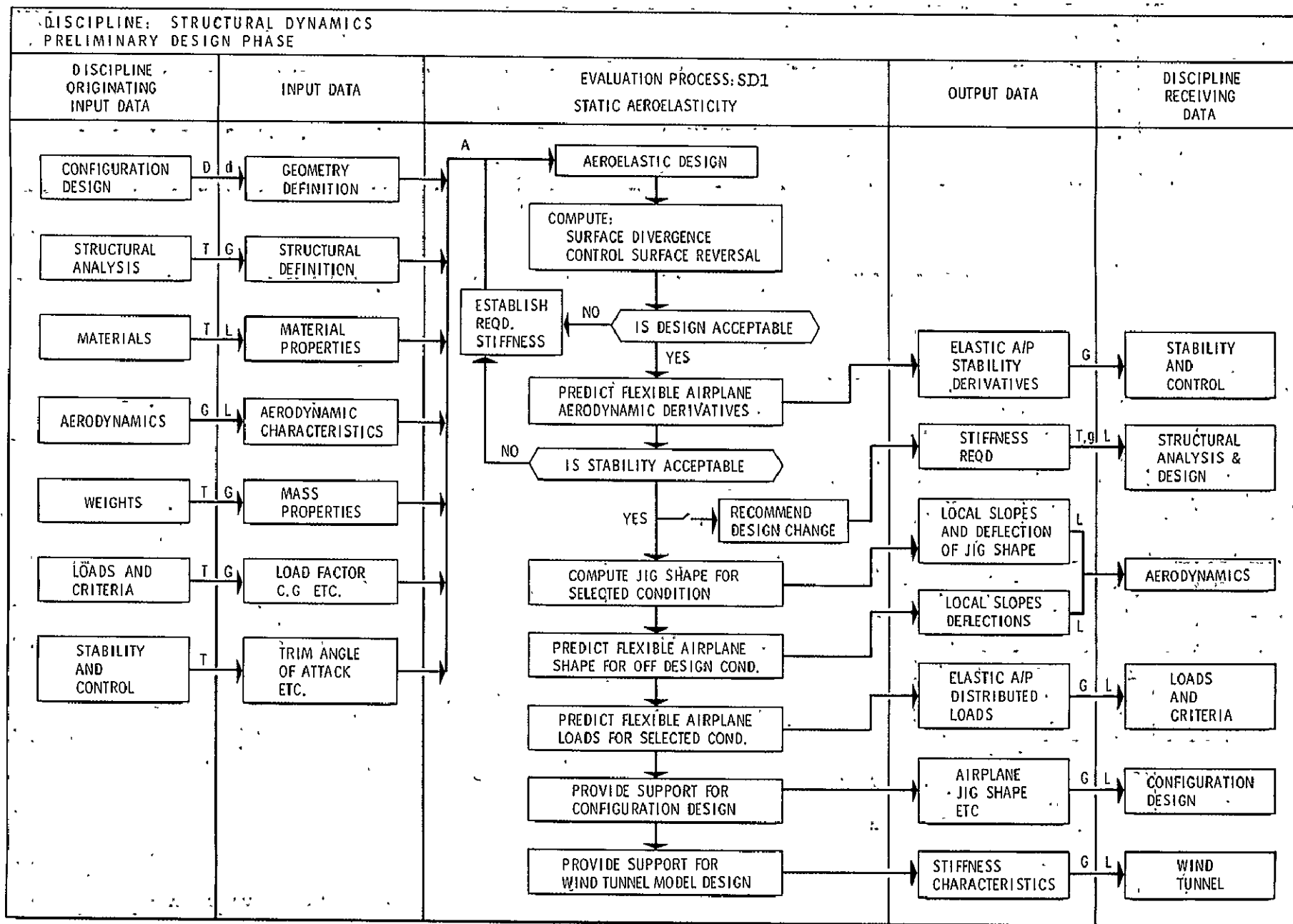


Figure 3-125. Static Aeroelasticity

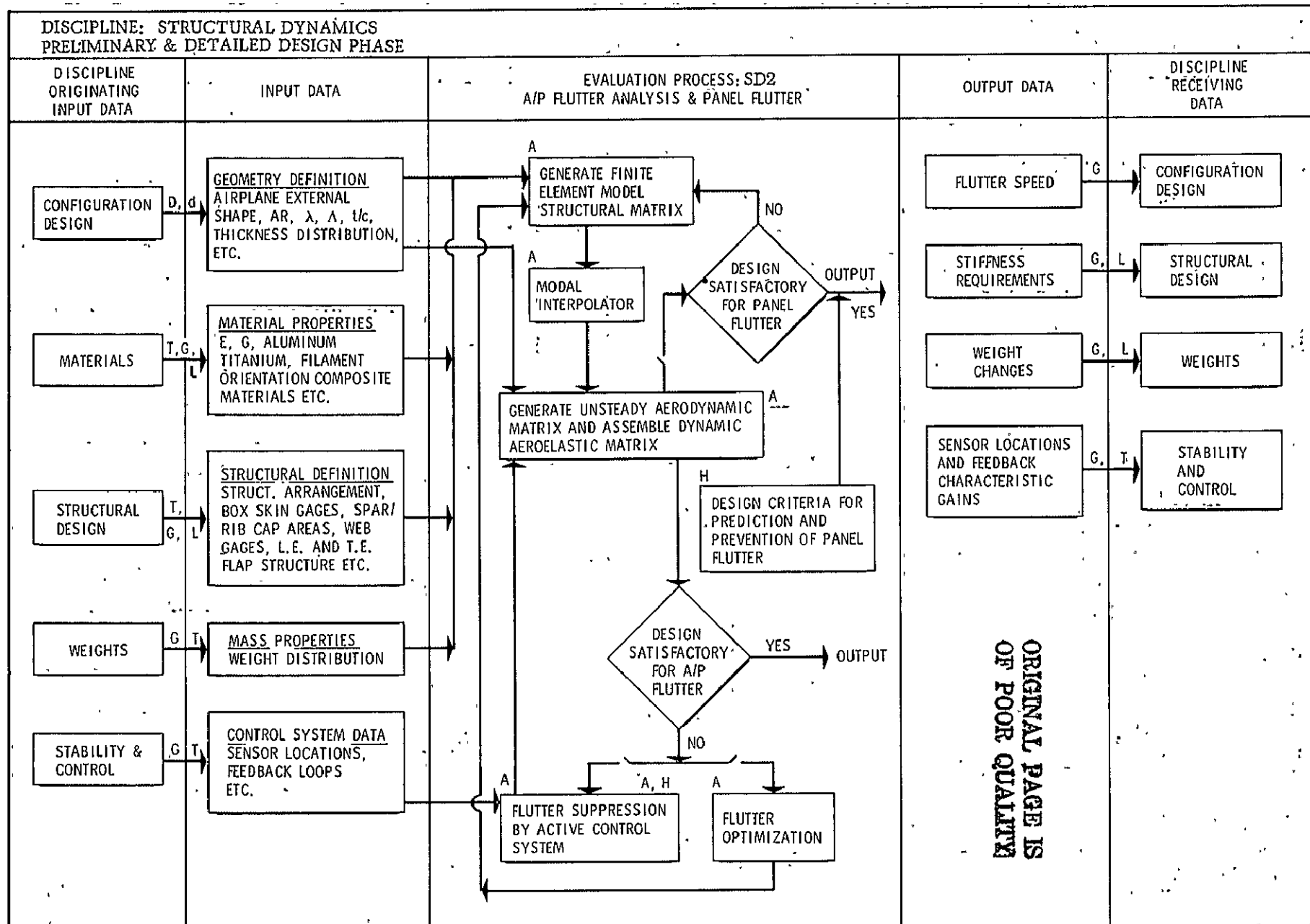


Figure 3-126. Aircraft Flutter Analysis and Panel Flutter

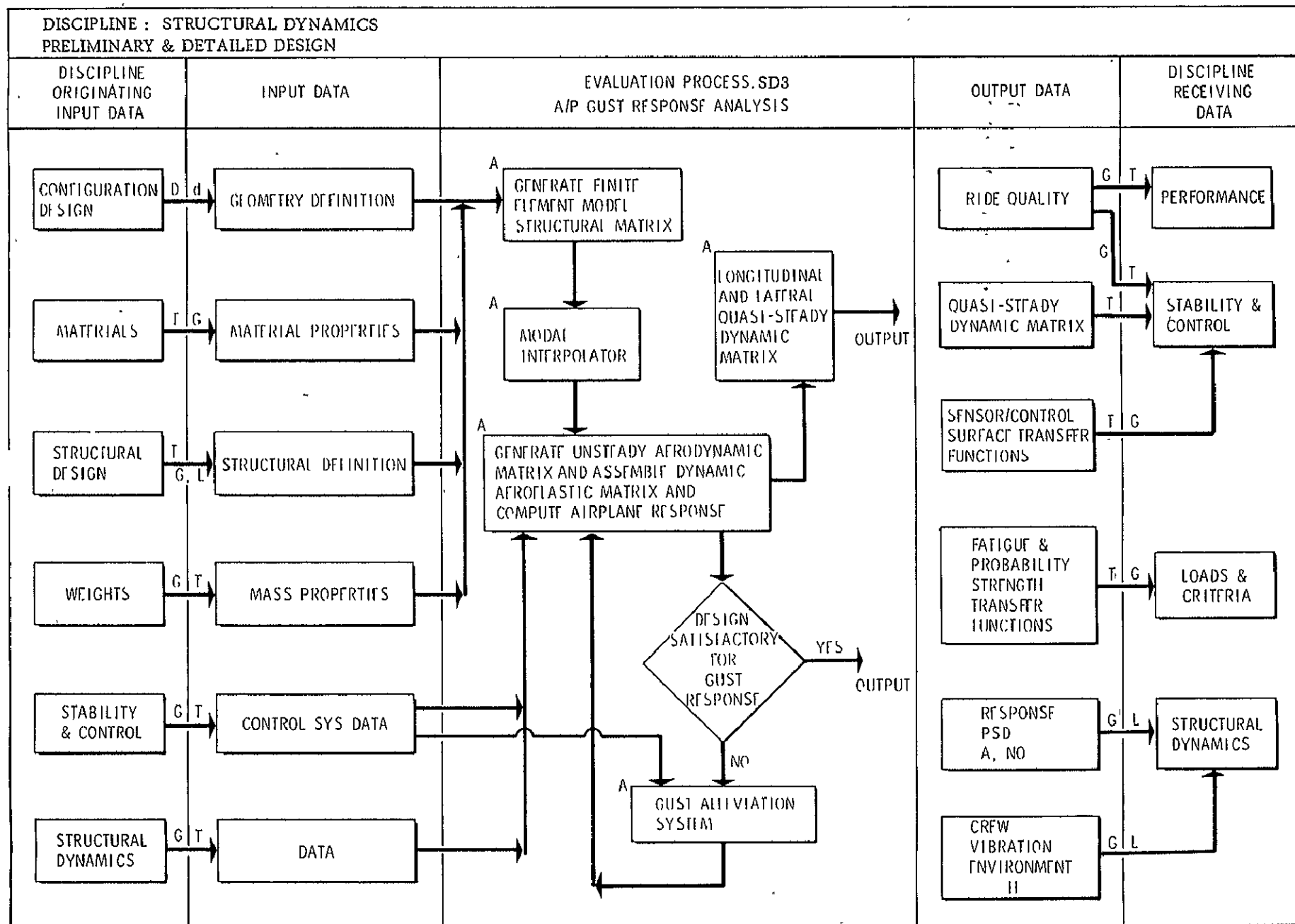


Figure 3-127. Aircraft Gust Response Analysis

ORIGINAL PAGE IS  
OF POOR QUALITY

- FLUTTER
- GUST RESPONSE

} SYMMETRIC ANALYSIS

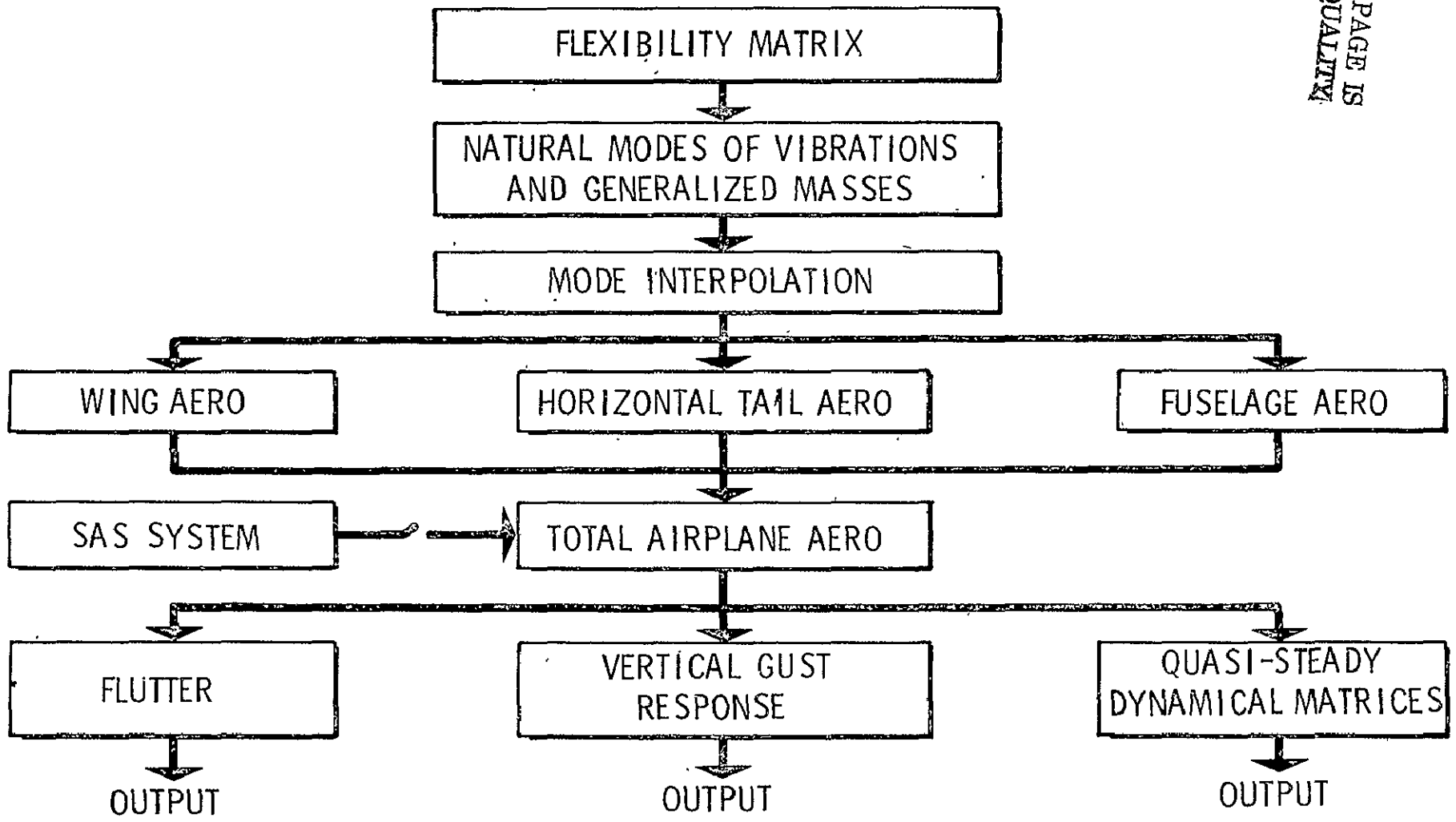


Figure 3-128. Flow of Programs, Symmetric Analysis

- FLUTTER
  - GUST RESPONSE
- } ANTISYMMETRIC ANALYSIS

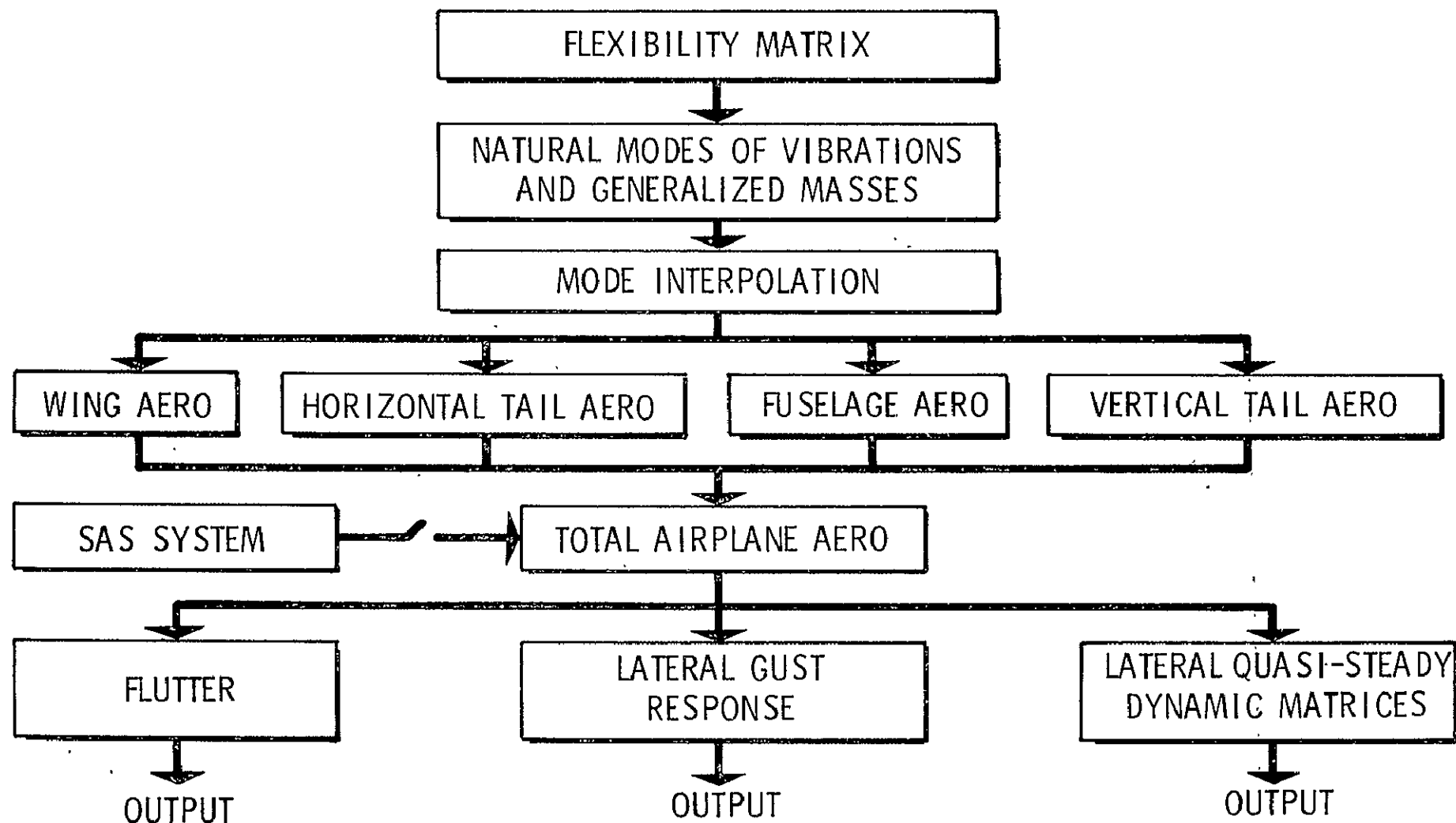


Figure 3-129. Flow of Programs, Antisymmetric Analysis

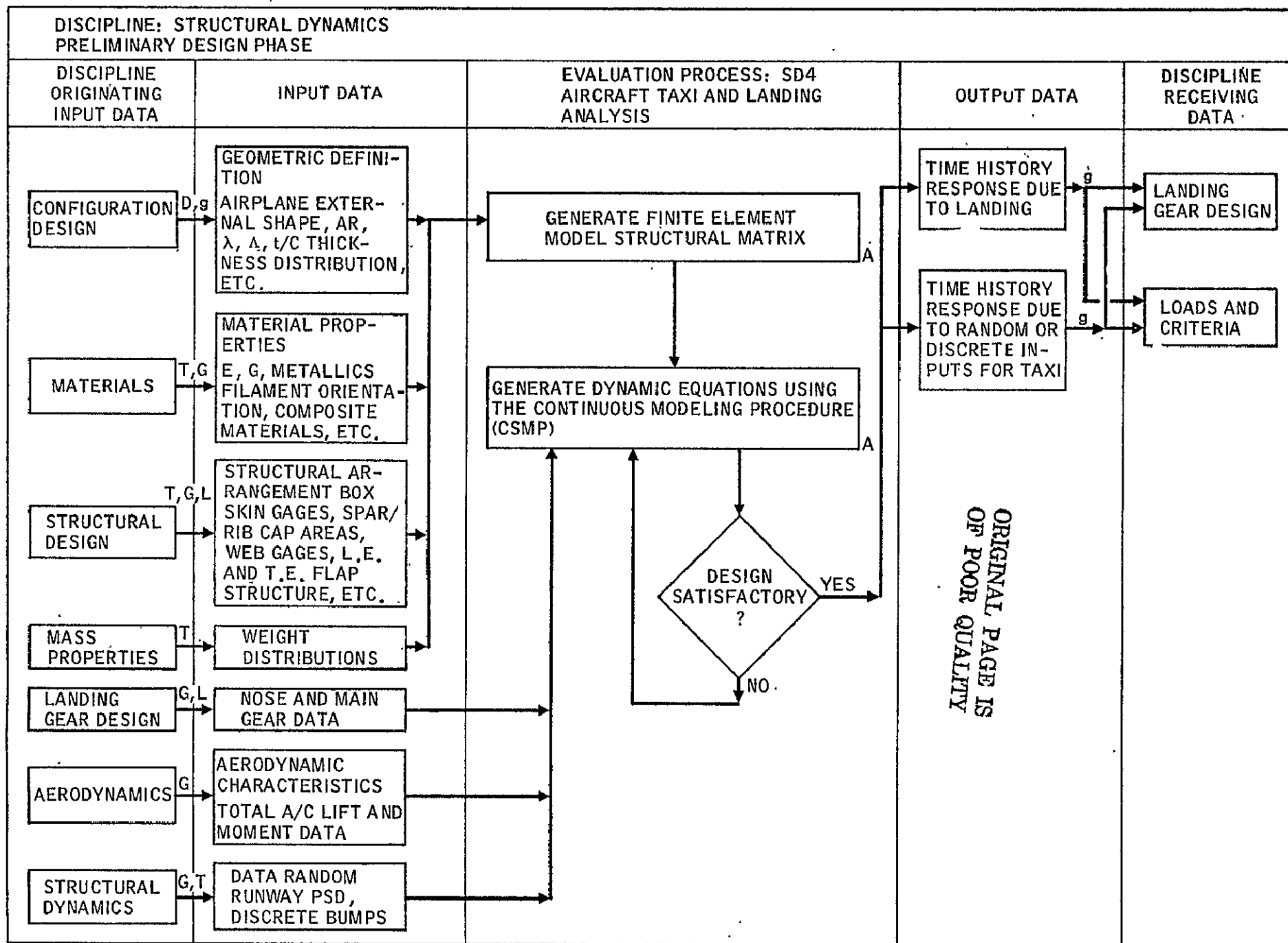


Figure 3-130. Aircraft Taxi and Landing Analysis.

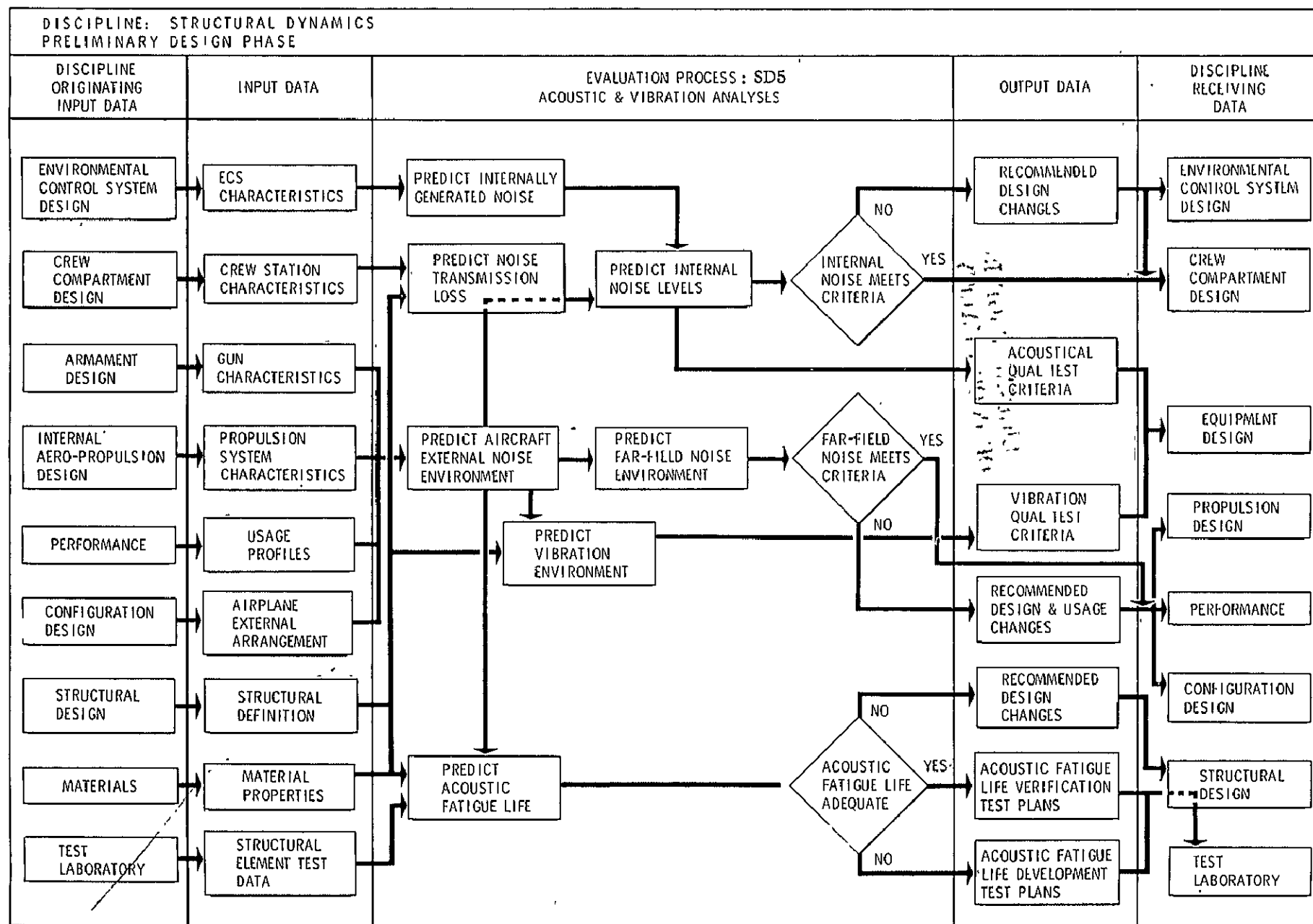


Figure 3-131. Acoustic and Vibrations Analysis

TABLE 3-15. THERMAL ANALYSIS CEP'S AND COMPUTER PROGRAMS

| TASKS                                               | CEP | Design Phase |    |    |
|-----------------------------------------------------|-----|--------------|----|----|
|                                                     |     | C            | PD | DD |
| Aerothermal Environment Analysis                    | T01 | x            | x  | x  |
| 1. Flow Field                                       |     |              |    |    |
| 2. Cold Wall Heat Flux                              |     |              |    |    |
| 3. Radiation Equilibrium Temperature                |     |              |    |    |
| Finite Difference Structural Temperature Analysis   | T01 | x            | x  | x  |
| <u>COMPUTER PROGRAMS</u>                            |     |              |    |    |
| P5613     Aerodynamic/Structural Heating            |     | x            | x  |    |
| P2162     Variable Boundary Heat Conduction Program |     | x            | x  | x  |
| P4560     Thermal Analyzer                          |     |              | x  | x  |
| ORIGINAL PAGE IS<br>OF POOR QUALITY                 |     |              |    |    |

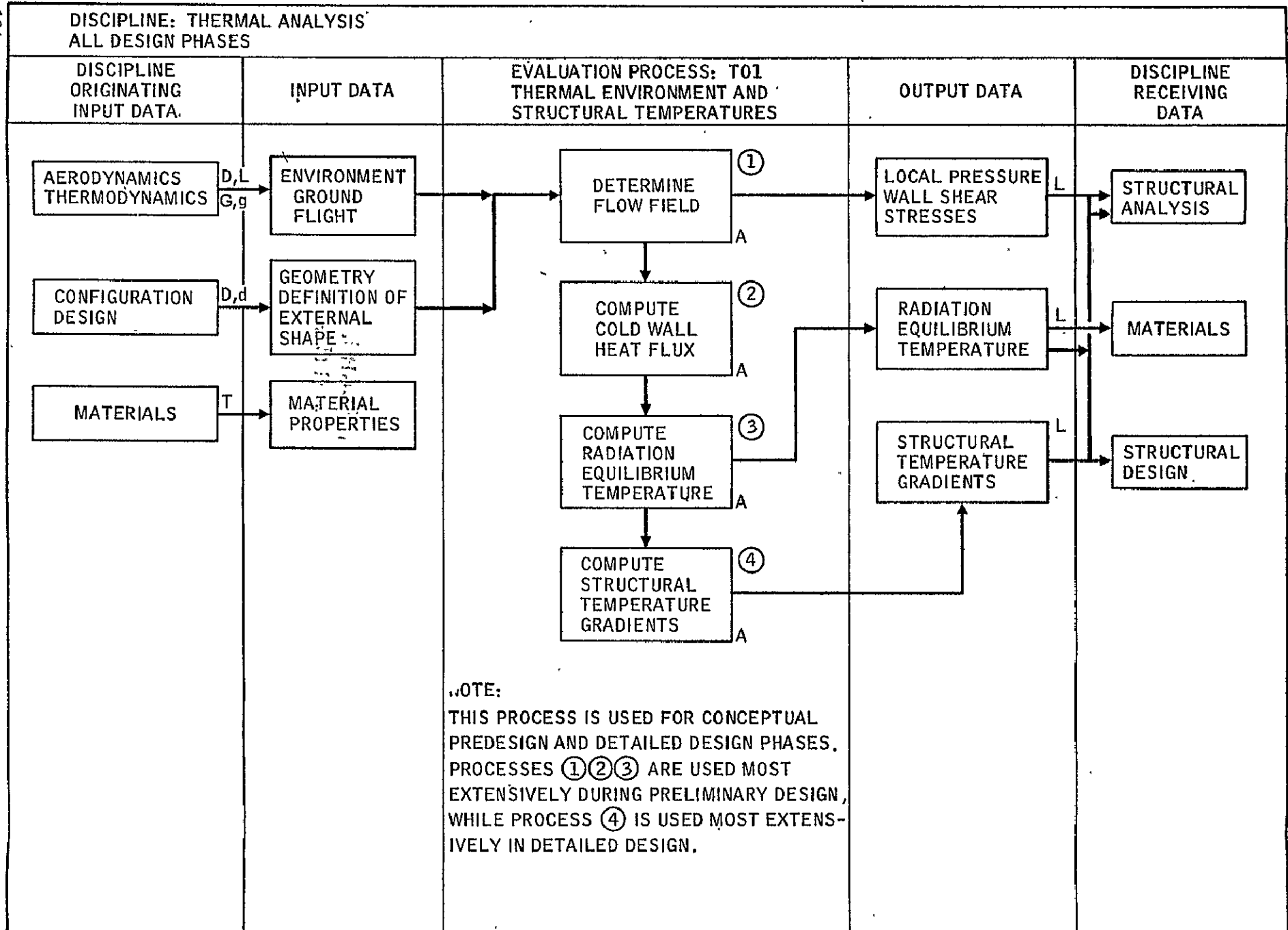
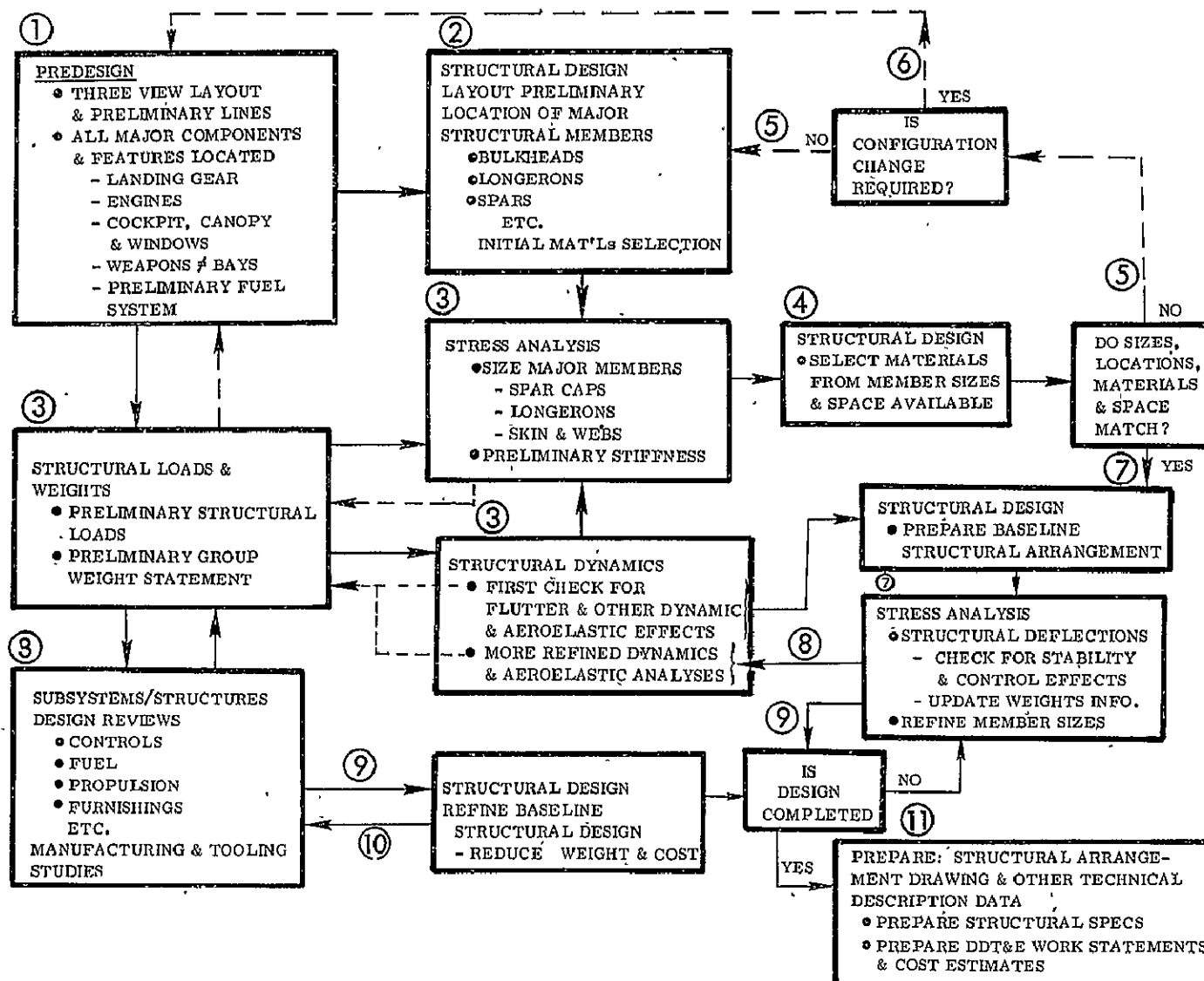


Figure 3-132. Thermal Environment and Structural Temperatures



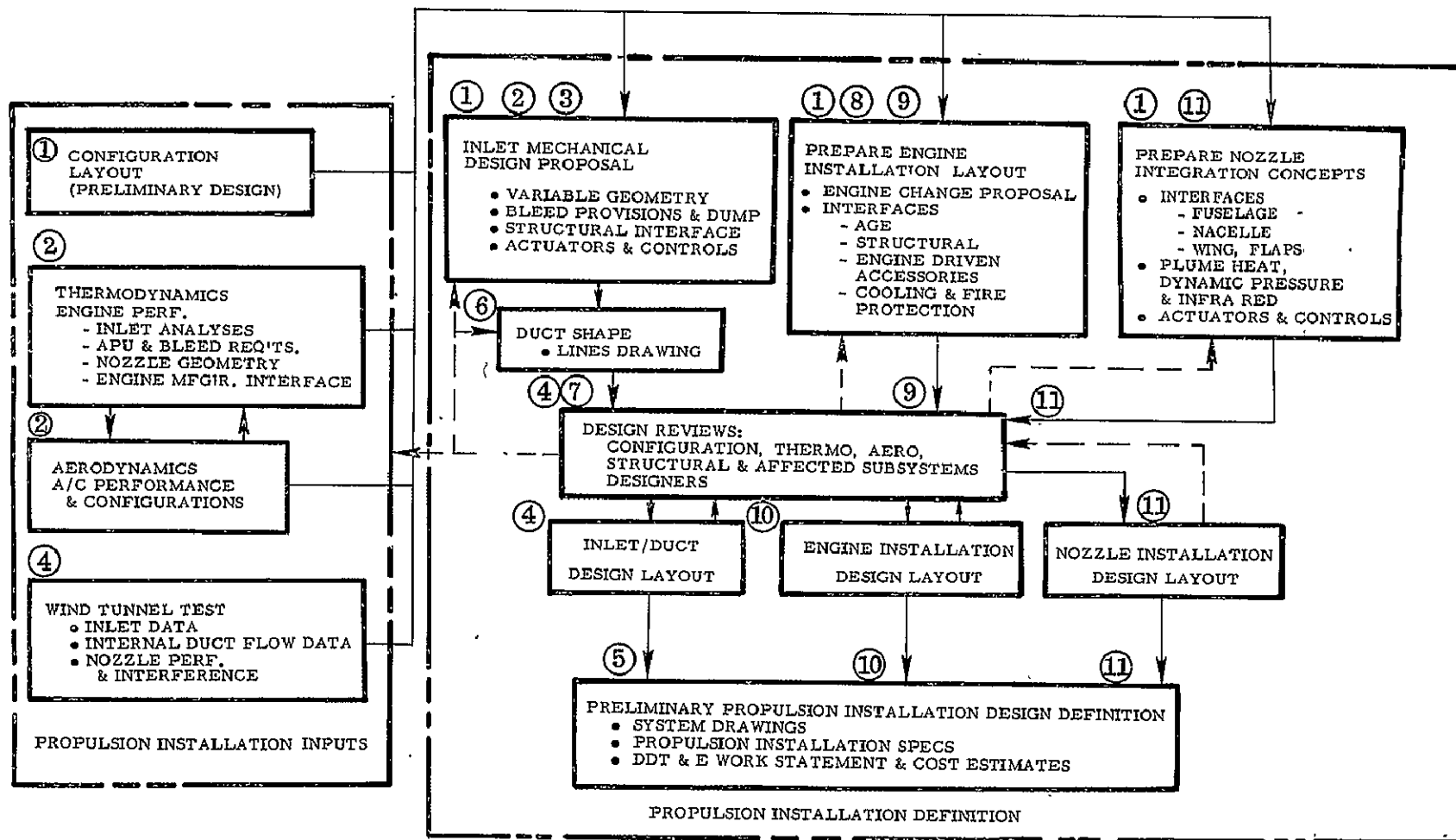


Figure 3-134. Preliminary Propulsion Installation Definition

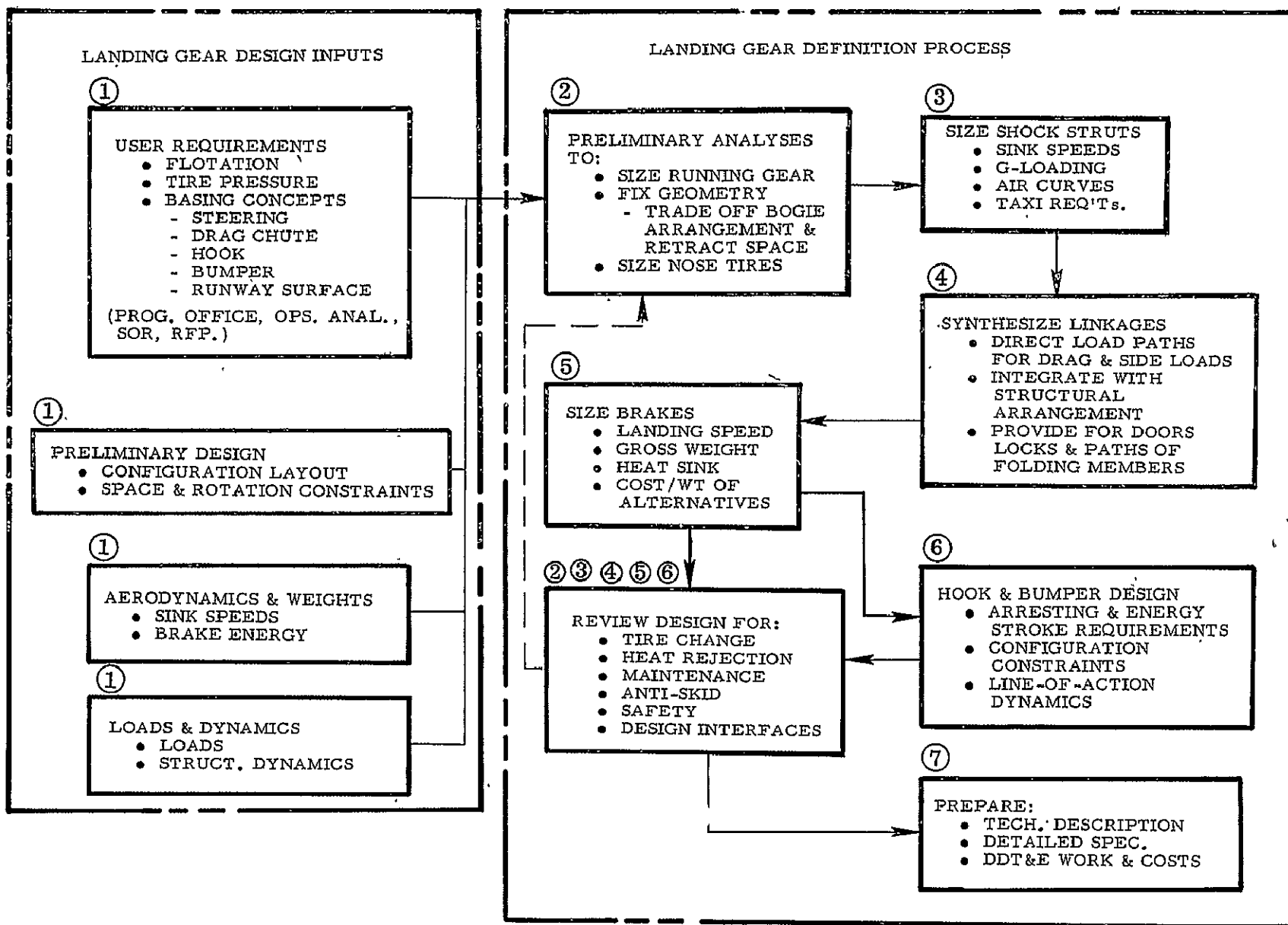


Figure 3-135. Preliminary Landing Gear Definition

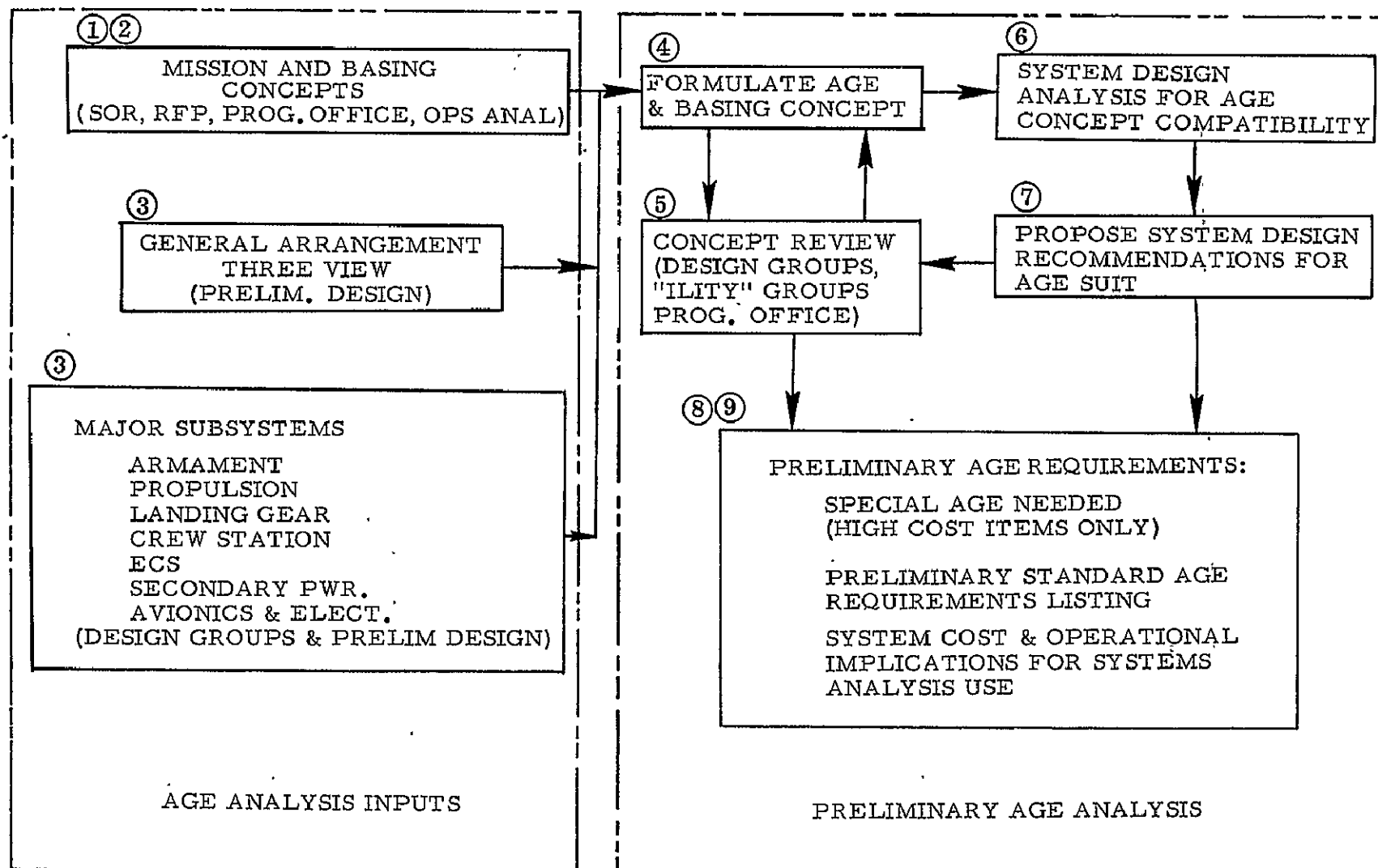


Figure 3-136. AGE Analysis for Preliminary Design

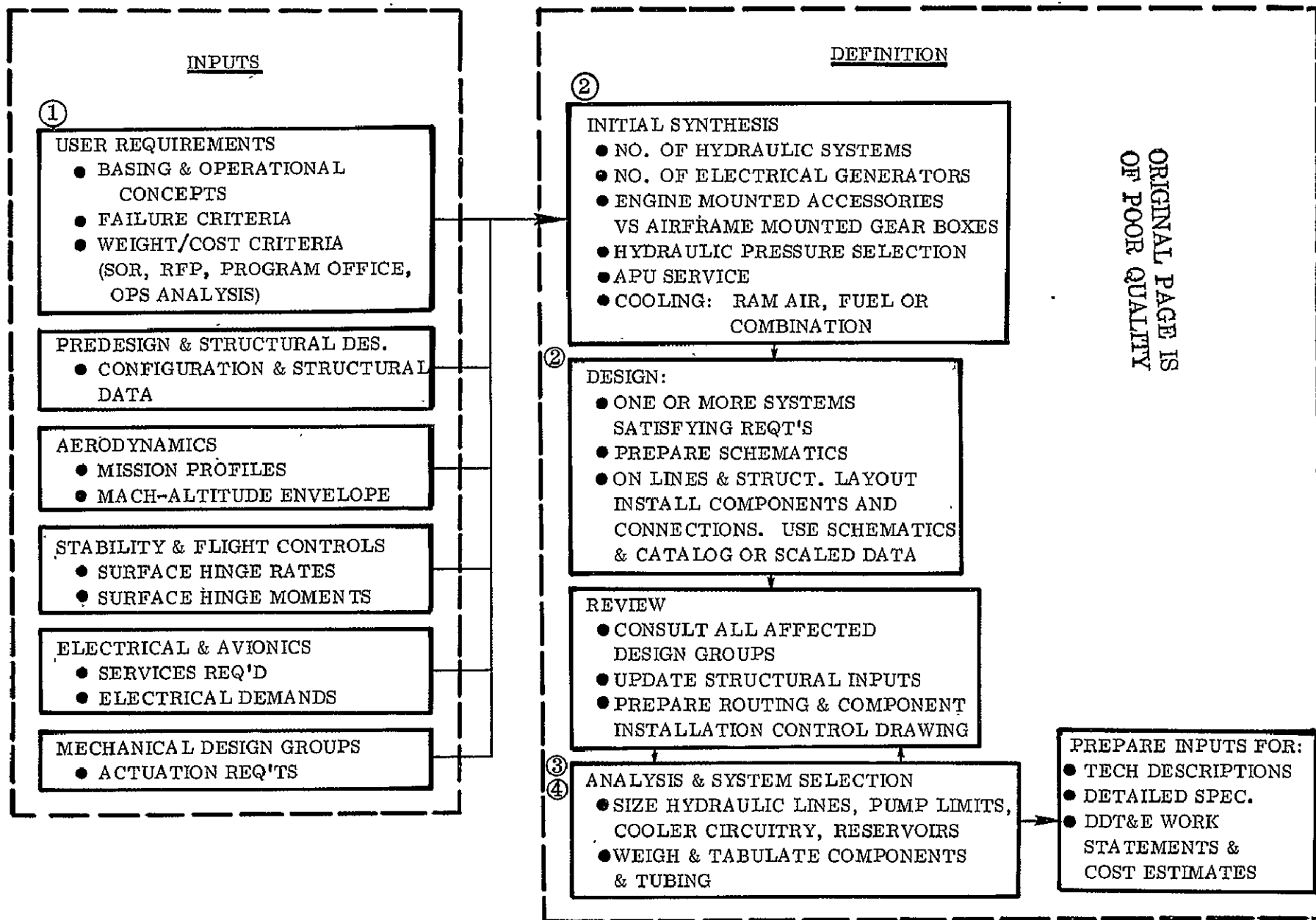


Figure 3-137. Secondary Power System Preliminary Design Definition Process

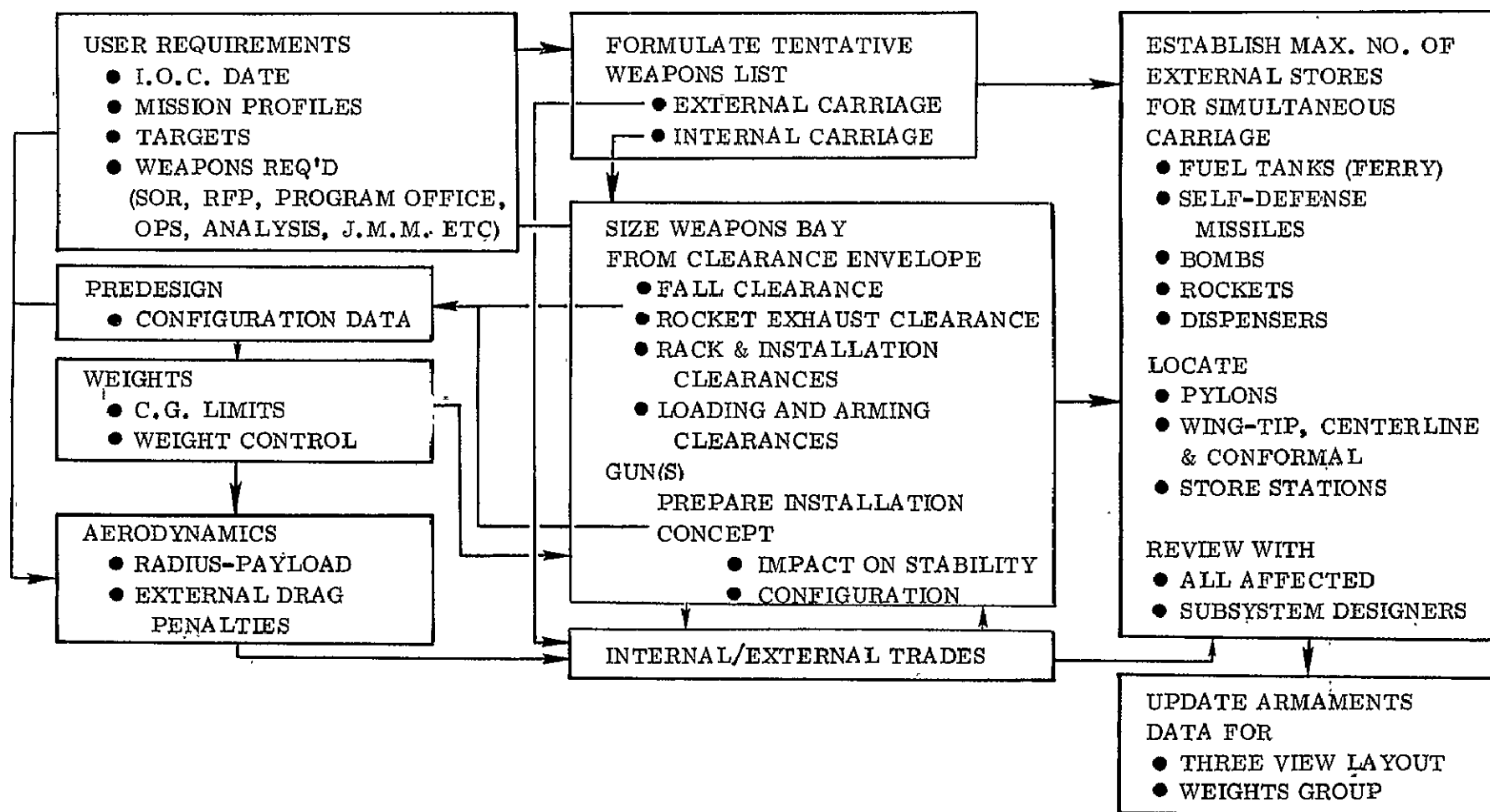
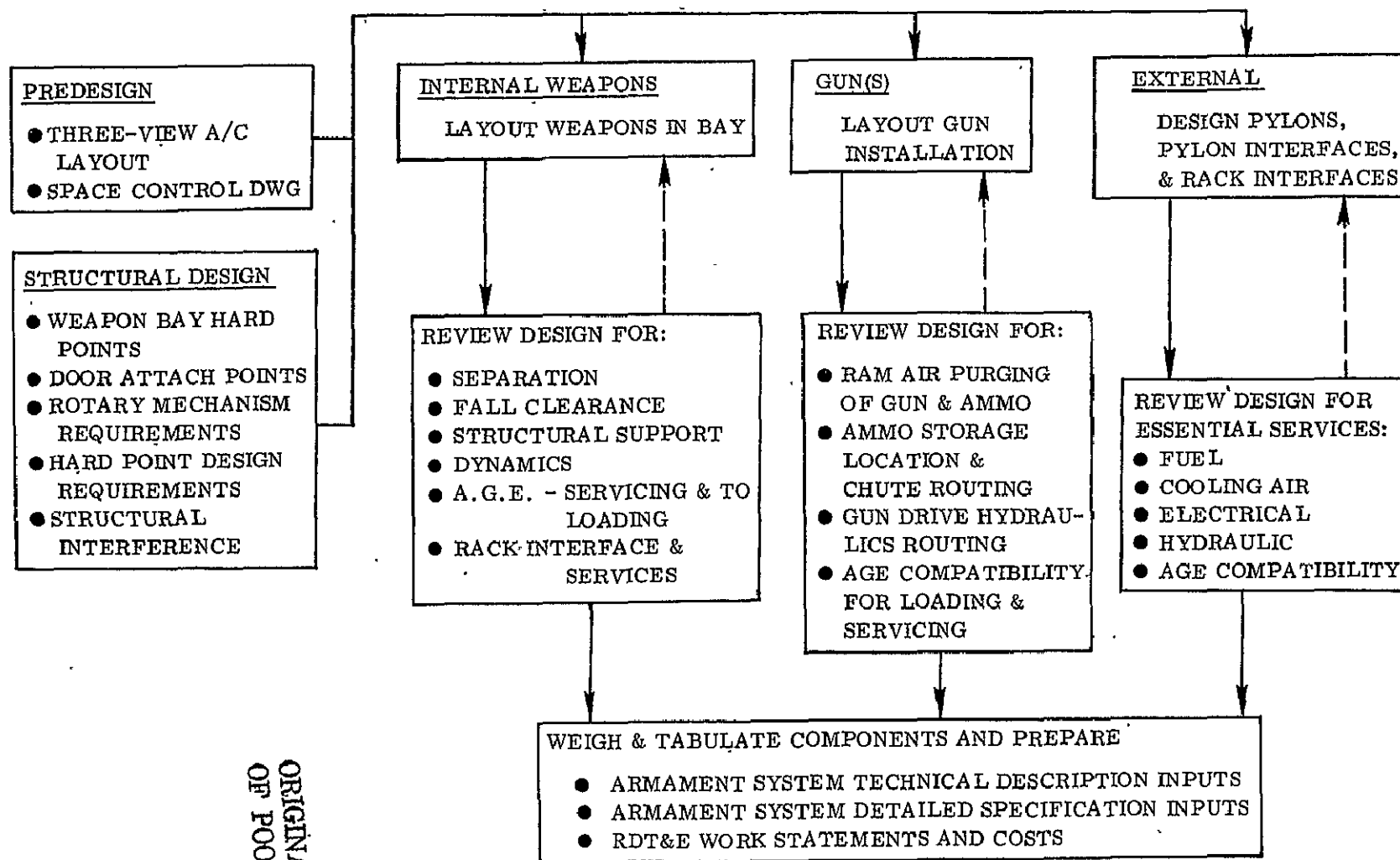


Figure 3-138. Conceptual Armaments System Design Process



ORIGINAL PAGE IS  
OF POOR QUALITY

Figure 3-139. Preliminary Armament System Definition