MANAGING A DEVELOPMENT PROGRAM

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"Be it a case of commerce, industry, politics, religion, war, or philanthropy, in every concern there is a management function to be performed, and for its performance there must be principles, that is to say acknowledged truths regarded as proven on which to rely" . . .

—Henri Fayol

PREFACE

This manual is designed to serve as a reference text for persons interested in developing an analytical and orderly approach to management. It has been prepared as a guide for personnel of the Federal Aviation Agency, especially those whose duties are related to the conduct and direction of major development programs.

For this reason, there has been presented in considerable detail, the specific methodology followed during application of the technique to the test and evaluation of the Data Processing Central at the National Aviation Facility Experimental Center, Atlantic City, New Jersey.

The principles and procedures illustrated by this case study have been refined and proven through repeatedly successful applications over the course of a number of years. They will be found highly effective for planning, evaluating and controlling other development programs, no matter how large or complex.

If one were to identify the most important lesson to be derived from a study of this manual, it would be the requirement for defining the gross task to be accomplished in terms of its various elements and interdependent combinations. Instead of facing a vast, uncontrollable, complex problem, one thus is able to undertake in planned succession the solution of a series of discrete, recognizable tasks. By means of this process it is possible to direct undiluted energy and attention toward the solution of each problem in a considered and deliberate manner. The clear definition of the work that must be done, the prompt recognition of potential deviations from the plan for accomplishing it and the feedback of information concerning cost and accomplishment are basic to success in the management and control of any project.

The Line of Balance technique provides the necessary means for control. Its effectiveness, however, depends upon the skill and experience of those who collect, correlate, and interpret the facts which are revealed in the analysis. It depends, equally, on the willingness and ability of management to use the facts as a basis for taking timely action to correct deficiencies.

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Chapter I INTRODUCTION TO LINE OF BALANCE

Chapter I

INTRODUCTION TO LINE OF BALANCE

1.1 During the greater part of the last two decades, industry's quest for more effective management techniques has become increasingly urgent. This is especially true in those instances where a ten to twenty year normal growth pattern has been telescoped into only a few short years. Such was the case in 1941 when the Goodyear Tire and Rubber Company faced a skyrocketing growth pattern--an increase from 5,000 to 12,000 employees during a nine month period, and in consequence a severe shortage of supervisors. This lack of qualified talent gave rise to grave concern about its possible effect on the contribution to the war effort that the company might make, and management set up a staff to keep abreast of developments in all important programs.

Origin and Evolution of the Technique

1.2 One of those assigned to this prodigious task and primarily responsible for its initiation was George E. Fouch, who pioneered in the development of the technique as a means of monitoring production effort. Line of Balance, thus born of necessity, demonstrated its effectiveness by keeping members of management apprised of the production status of its various programs.

1.3 Mobilization for World War II soon followed and Mr. Fouch, then a reserve naval lieutenant, was assigned to the Navy's Bureau of Aeronautics in Washington, D.C. Being charged with responsibility for supplying all of the needs of the naval aeronautical establishment, this Bureau was beset by all of the demands of mobilization as well as of those problems which make the planning, scheduling and administration of wartime production so much more difficult than during peace. The Line of Balance technique was introduced and proved demonstrably successful in breaking bottlenecks which restricted the flow of sorely needed aircraft to training centers and to the Fleet.

1.4 With the outbreak of hostilities in Korea, Line of Balance was again given an important part in accelerating production. By 1951 the system had been installed in the plants of a wide band of defense suppliers, not only for the Navy and Marine Corps, but also for certain purveyors to the Army and the Air Force.

1.5 During this period, Line of Balance was used only to monitor production and was used on a variety of products - aircraft, guided missiles, ordnance equipment, electronic devices, ship components, fire control apparatus, tanks and tow tractors, to name but a few. We, who were directly concerned with the installation and analysis of these production studies, recognized that the underlying philosophy of Line of Balance could be applied to problems other than those related to the production of material. Trial studies were attempted in widely divergent areas and clearly demonstrated the utility of the technique as a controlling device in any operation involving the consideration and integration of a number of elements. It was found that it was not necessary for the total to be comprised of homogeneous or identical units, as had previously been thought. Line of Balance worked equally well for monitoring and directing such divergent activities as amphibious operations, base and ship construction, training programs, and for the installation and deployment of an important segment of the DEW-line defenses of the North American continent.

1.6 Upon joining industry in 1956, it became possible for the authors to make the first application of the technique as a fully systemized management mechanism for an entire company operation. By the issuance and control of work orders for a total task breakdown, all performance could be measured down to the operating level. This method was used to monitor the design and prototype construction of the Type 11 Periscope and the Star Tracker, both of them significant portions of the overall Polaris Program, and to other equally complex projects such as a number of highly sophisticated electronic simulator developments and the integration of an entire company operation. Encouraged by the results that had been achieved, Line of Balance next was applied to such highly specialized areas as engineering test, proposal preparation and pre-planning studies for the design and manufacture of complex system developments, including the Data Processing Central for the FAA/BRD at the National Aviation Facilities Experimental Center at Atlantic City, New Jersey.

1.7 Over the twenty years that have passed since Goodyear made the first application of Line of Balance, the technique has been used across the entire spectrum of program types, large and small, ranging between the extremes of production and development, from the delicacy and precision of gyroscope manufacture to the comparatively crude operations of earth-moving and grading in air base construction. Line of Balance can be as simple and informal as a mental attitude, or so complex as to require an electronic computer for solution. The entire gamut of possible installations, whether simple or complex, have one thing in common: the outputs and conclusions are dependent entirely upon the validity of the experience data and analytical processes that go into their derivation. Mechanization will speed up the operation, but it cannot make any other contribution nor will it substitute for human judgment or bolster an inadequate decision.

1.8 Good management has been defined as the continuous, intelligent direction of others in the accomplishment of the organization's objective. To be fully effective, management requires a means of:

1.8.1 fostering proper analysis of required operations;

1.8.2 developing adequate controls over the expenditure of time and materials;

1.8.3 establishing suitable sensors as an accurate means of judging accomplishments;

1.8.4 comparing actual progress with forecast performance;

1.8.5 being alerted to prospective deviations from an established plan;

1.8.6 accurately measuring the expenditure of assets, i.e. manhours, dollars, materials; and,

1.8.7 giving timely notification of required decisions.

In other words, management must be given an integrated, time-phased picture of the entire operation - financial, technical, administrative, productive - free of extraneous detail, and sharply highlighted so as to identify those features requiring decision or corrective action.

1.9 Line of Balance satisfies these requirements, being a system which is not unlike a newspaper headline, discernible at a glance and not subject to unintentional misinterpretation. A dynamic reporting system, it encourages decision-making and provides two-way communications between the operating level and top-management, condensed and synthesized, but not altered, as it progresses up the organizational chain. Because the technique provides a deliberate method for measuring, selecting, interpreting and presenting facts, it is ideally suited to the satisfaction of management's requirements for a control device that clearly defines the common goal or objective, that sets forth a detailed plan for achieving the objective, that provides an accurate measure of program status and, finally, that affords a comparison between measured accomplishment and predicted performance. Unlike some overly detailed programming devices which attempt to present all aspects of a project, Line of Balance examines only the deviations from the established plan. The system makes it possible for senior management officials to examine the sensitive or controlling element and then to make authoritative decisions based on facts furnished by a Line of Balance chart. These facts, derived from data furnished by responsible authorities, verified and affirmed by direct observation, are then reduced for succinct presentation in graphic form.

Applications Within the BRD

1.10 Although Line of Balance found its origin in production analysis, equally remunerative results have followed its introduction into the less well defined processes of engineering design, development and test. In each instance the first step has been to define and place in sequential order all work which must be accomplished before a subsequent task can be started. Major tasks first must be broken down into subtasks which are then segregated into knowns and unknowns. Where alternate approaches are to be studied, decision points and other sensors should be indicated at reasonable intervals, but not less frequently than will afford an accurate measure of progress for every significant task.

Development Projects

1.11 Development project managers also will find Line of Balance useful in organizing and arranging the work that goes into the making of a bid proposal and the effort that follows a successful bid. Proposals so derived and presented are often more credible to the evaluator because they provide the basis for judging the accuracy and completeness of the estimate. Later, of course, these same charts can be updated and used to monitor the subsequent conduct of the program.

Experimentation and Evaluation Projects

1.12 Until recently many otherwise competent persons held that systems projects involving experimentation and evaluation cannot be programmed. The claim has been that failures and difficulties cannot be forecast either as to occurrence or as to extent. If this is so, how can they be estimated? The truth of the matter is, of course, that by proper advance planning unnecessary loss of time can be avoided. Independent work efforts can be identified and isolated so that in case of a stoppage or failure in one area, the effort can be transferred to another unaffected task until such time as the existing fault can be corrected.

1.13 The same principles can be applied at subordinate levels of engineering test -- on any sub-system, component or module including the construction of supporting technical facilities. In operation the Line of Balance system provides a means of determining the progress that is being made toward the objective. Problems contributing to project delay can be considered on an accelerated priority. Overtime and special skills can be applied under controlled conditions, so that expenditures at premium rates will be held to a minimum. More important, perhaps, a long sought means can be provided for stimulating thought and work habits in an organized pattern. The value of this will be seen in a marked improvement in performance. In extreme cases management directly affected by the troubles of engineering testing may feel that the problems have disappeared. In reality the difficulties are still present, but they are being handled at lower levels before their combined magnitude reaches such severe proportions as to require higher management action.

1.14 Fundamental among the principles, and most important to a successful application of the technique, is simplicity. The Line of Balance system should be tailored to satisfy the minimum requirements of the situation, avoiding at all costs an overly complex arrangement. Experience and sound judgment must be carefully exercised when establishing the charts in order to escape the hazards of an unnecessarily burdensome and costly reporting system. One must guard against the development of an elaborate organization which serves no purpose other than the aggrandizement of the individuals concerned or the perpetuation of their assignments.

Application to Program Management

1.15 The FAA/BRD program manager can utilize the Line of Balance technique at each stage of the operation. In the program planning cycle a project is initiated to meet a specific requirement. The entire scope of the program can be reflected in a long range Line of Balance chart to monitor closely the research and study phase, the system design phase, the system development and the test phase. From the FAA project manager's point of view, the primary use of the system is to provide an accurate basis upon which to make timely decisions. It also provides for budgetary and manpower controls and the coordination of supporting efforts.

Application to Development Projects

1.16 After completion of necessary research and systems engineering, the development project manager will select techniques and prepare specifications for the required equipment. To meet the integrated time table of necessity and feasibility, delivery dates are specified as determined by analysis using the overall Line of Balance charts in the current FAA/BRD program plan. For key procurements the specifications should include a requirement for contractor utilization of Line of Balance as a control mechanism.

The Proposal Stage

1.17 Next, after this step in the management process, is the careful and objective evaluation of proposals. Important to the process is the development project manager's review of the contractor's operations with respect to past performance, the effectiveness of his management control system, the technical feasibility of his proposal and his available facilities. For the contractor and the FAA project manager the Line of Balance system should be installed initially at the time of the request for a bid proposal. Here it will be found a valuable aid to the evaluation of contractor performance. Any proposed program can be evaluated by the FAA Source Selection Group and judged in accordance with its existing or proposed method of planning and control. In key contracts there will be included a provision for Line of Balance reporting in order to give convincing assurance of performance capability.

After Award

1.18 Once the contractor has been selected, the project manager must satisfy himself that the contractor's control system will provide adequate information for monitoring the program. Although the project manager should assure himself that the system is properly tailored to give necessary results, the actual preparation, installation and maintenance of Line of Balance charts and reports should be made an unequivocal responsibility of the contractor.

1.19 At the bid stage the contractor should prepare a provisional Level I chart as an expression of the program in terms of cost and performance. But following the contract award, it will be necessary for the project manager to establish with the contractor a schedule for the actual installation of the Line of Balance system for control of the project and for measuring progress and performance.

Method of Operation

1. 20 To satisfy all required levels of presentation for each contract, the Line of Balance system provides a Level I or summary chart, one or more Level II charts of the major subsystems, components or types of effort, and a Level III integrated flow chart showing the details and interplay of the entire effort.

1. 21 This review of the management control system should follow an acceptable pattern. Soon after the contract award, the basic ground rules and assumptions for the Line of Balance installation must be examined by the project manager, a bench mark established for initiating the system, and arrangements made for appropriate displays of the information. Level I and II charts require verification and should be cross-checked by the project manager against each other and compared with the supporting Level III flow diagrams.

1. 22 Reports to the FAA project manager ordinarily are based on the Level I chart. Whenever problem areas arise which indicate the need for additional information, however, he may require it in the form of data on the affected Level II or Level III charts. Where there is an FAA resident representative, the contractor will provide Level II charts and deviation reports to him in addition to a copy of the Level I chart furnished to the project manager.

Application to Experimentation and Evaluation

1. 23 Prior to the freeze of equipment design during the development stage, the E & E task manager will have prepared provisional Line of Balance charts which were based on many assumptions regarding equipment design. The tentative plans probably will require revision after equipment design has been firmed and the task manager should not overlook this possibility in putting his plan into action. The detailed plan should include·

1. 23. 1 Test design,

1. 23. 2 Preparation of test environment;

1. 23. 3 Accomplishment of tests; and,

1. 23. 4 Reports of test results.

1. 24 The evaluation of systems and equipment is an "in house" responsibility which cannot be delegated. Preparation and installation of the Line of Balance system is always under the direct supervision of the task manager. When, because of peak workloads or special skills, contractor personnel are utilized in the E & E operation, they are an integral part of the E & E team and do not operate independent of the task manager. Under such conditions the task manager still must see that he provides himself with the management requirements specified in paragraph 1. 8. Additionally, when technical facilities are to be utilized jointly by two or more projects, the ability to satisfy the requirements shall be determined through realistic appraisal by the Project Coordination Activity. An

effective way of working out the time phasing of disputed availability is by use of Line of Balance. Delays in development of equipment and lags in delivery to the test site, or the need for additional test requirements which have been revealed as the result of tests already performed, often can be overcome by an overlay of needs on a matrix of available capacity. By adjusting one to the other, by studied compromise and by time-sharing techniques, or by eliminating overlaps and dead time, it may be quite feasible to solve an apparently impossible situation. These are the means that E & E management must explore and apply to the benefit of the project.

Chapter II ORGANIZING FOR OPTIMUM EFFECT

Chapter II

ORGANIZING FOR OPTIMUM EFFECT

2.1 As indicated previously, for operations within the contractor's plant the contractor has the responsibility to install the Line of Balance system. The cognizant FAA project manager always must be prepared to render assistance in tailoring the system to existing needs and should invariably take it upon himself to verify and check the validity of the contractor's plan.

2.2 Practical experience in applying the Line of Balance management control system to a variety of development projects has shown that it is important:

2.2.1 to conduct the survey at the place where the project is to be accomplished;

2.2.2 to derive the information from the persons who will be responsible for performing the work;

2.2.3 to make a Line of Balance installation only under the sponsorship and support of top management;

2.2.4 to adapt the installation to the project needs, to the engineering and manufacturing processes, and to the record and accounting practices of the contractor; and,

2.2.5 to keep the Line of Balance system as simple as possible consistent with project needs.

2.3 It cannot be overemphasized that top management support is vital to the success of any Line of Balance or other management control system. It is essential that responsibility be assigned to competent persons in each area of participation and that they be provided with necessary technical and administrative personnel, all operating under the direction of a carefully selected, competent individual reporting to top management and having intimate familiarity with company organization and procedures.

2.4 Usually the installation is made by a supervisory team of two to four persons. Invariably the detailed information should be generated by the working level supervisors who must not only provide the necessary data required for the Level III charts but also must be responsible for the detailed execution of the plan.

2.5 The survey team should be well indoctrinated in the principles and techniques of engineering and its administration, and each member should be assigned to one or more specific segments of the survey operation. The persons selected should provide the necessary cross-section of technical and administrative talent which is required for the study, as may be seen in figure 2-1, which illustrates the organization and enumerates duty assignments of a typical four member team.

2.6 All members of a survey team must be prepared to verify the data provided by careful cross-checking and detailed analysis, to derive and execute all Level I and Level II charts, to assist as required in the preparation of Level III charts and integrated flow diagrams, to interpret the information presented, to insure that performance responsibility is assigned, to establish feedback requirements, to report conditions to management, and to conduct periodic checks of system operation.

2.7 The actual survey can be conducted in a period of two weeks to a month depending upon the state of affairs and the complexity of the program under investigation. In many cases it will be found helpful to prepare a skeleton Line of Balance schedule showing the completion dates of the several phases of the installation. Once such a schedule has been developed and approved, it should be issued by management for the guidance and direction of all concerned.

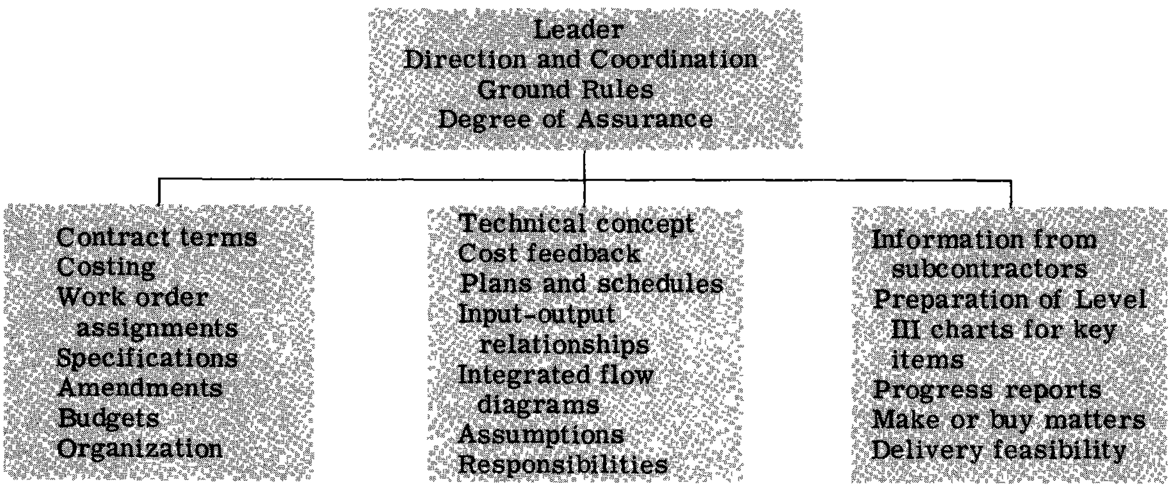


Figure 2-1 Typical Organization for Survey

Establishment of the Ground Rules and Assumptions

2.8 Once the group has been established, the first major task is the preparation of ground rules and assumptions. These criteria should grow out of an orderly review of the contract and its requirements. The ground rules should reflect the specific requirements of the project manager and provide the basis for common understanding with the contractor. Experience data concerning estimating, personnel availability, available facilities, contingency factors, labor efficiency, and use of overtime should be reflected in the ground rules. Criteria should be such as to provide consistency and uniformity throughout all phases of the operation.

2.9 All ground rules should be cleared with departments concerned in order to insure feasibility, acceptability, and compatibility with other governing factors.

2.10 The FAA project manager is responsible for establishing the ground rules and assumptions and for determining whether the contractor's existing practices will provide acceptable management control.

2.11 Because improper or inadequate ground rules may do much to invalidate the effectiveness of the Line of Balance system, the development project manager should give consideration to the following factors in making this appraisal:

2.11.1 the task analysis has been properly prepared,

2.11.2 sufficient information is at hand to support the analysis;

2.11.3 no critical item is overlooked;

2.11.4 resolution is made of any possible conflict;

2.11.5 the assumptions are in conformity with known or established conditions;

2.11.6 realistic values are placed on complexity and cost;

2.11.7 instructions are consistent with contract or specification requirements;

2.11.8 contingency factors are prescribed for cost and performance estimates;

2.11.9 means are provided for the forecasting of potential overruns and possible slippages;

2.11.10 supporting elements are incorporated in the project plan.

Analysis of Contractor System

2.12 At this stage the Line of Balance survey team will indicate the flow of engineering information and identify responsibility for the various technical and administrative operations. An exposition on the proposed system of operation will be found very useful to the FAA project manager in gauging the chances of successful contract performance. He should not overlook the appraisal of technical talent, the judging of experiences and past performance, the demonstrated competence of supervisory management, the financial or other assets of the contractor, the labor conditions and morale in the contractor's establishment, possible competition with other in-plant work, or any other factor which might have either a favorable or an adverse effect upon the project.

Chapter III COLLECTING AND DISPLAYING THE INFORMATION

Chapter III
COLLECTING AND DISPLAYING THE INFORMATION

3.1 During the course of the last ten years there have been developed a number of tools which greatly facilitate the collection and display of Line of Balance information. The manner in which these forms fit into the reporting system and serve to complete the feedback loop can be seen in the diagram appearing herein as figure 3-1. Use of these devices will aid the contractor and the project manager in making their determination of program status and insure against failure to meet the minimum standards for a management control system.

Ground Rules and Assumptions

3.2 Fundamental to the initial installation of Line of Balance is the establishment of a set of ground rules and assumptions for the direction and guidance of those charged with preparation of the charts. These guidelines are developed in consultation, with the contractor's project manager, his senior supporting supervisors and the controller participating in the discussions. More detailed treatment of this subject is to be found in Chapter IV.

Listing the Tasks

3.3 After the Provisional Level I Chart has been prepared and the contractor's task group has established the ground rules and assumptions in consultation with the FAA project manager, the next step in the sequence of operations is the listing of tasks. This work should be done by the supervisors who will be responsible for discharging as well as identifying and estimating the tasks that are inherent to satisfaction of the project requirements. It goes without saying that the FAA project manager should give close attention throughout this effort because the size and the scope of this definition will have an important bearing on the cost and time required to complete the project. The format shown in figure 3-2 can be used to good advantage.

3.4 This form is adaptable to the listing of discrete tasks and serves to provide an inventory of the job content. As an aid to the measure of task complexity a classification system scaled from 1 to 6 can be established. It is conventional to let scale value 6 represent the most difficult category from the standpoint of past experience in similar or projected types of work. When applicable, manhour and material content can be related to the various indices of complexity. The form also will identify the person responsible for performing each listed task assignment.

The Flow Diagram

3.5 Information obtained by analysing the project requirements is now posted on the basic display format, the Flow Diagram, figure 3-3. This constitutes the first attempt to translate the various individual tasks into a workable, time-phased plan. In addition to its use in reflecting progress, the Flow Diagram also identifies the total budget assigned to the task, the total budget expenditure scheduled to date and the total actually expended to the date of the report. Also noted along the lines connecting sensors are figures representing the planned expenditure of manhours by category, and material dollars during the period indicated. Properly used, the Flow Diagram gives the supervisor a graphic picture of his responsibility and a way of monitoring both cost and progress.

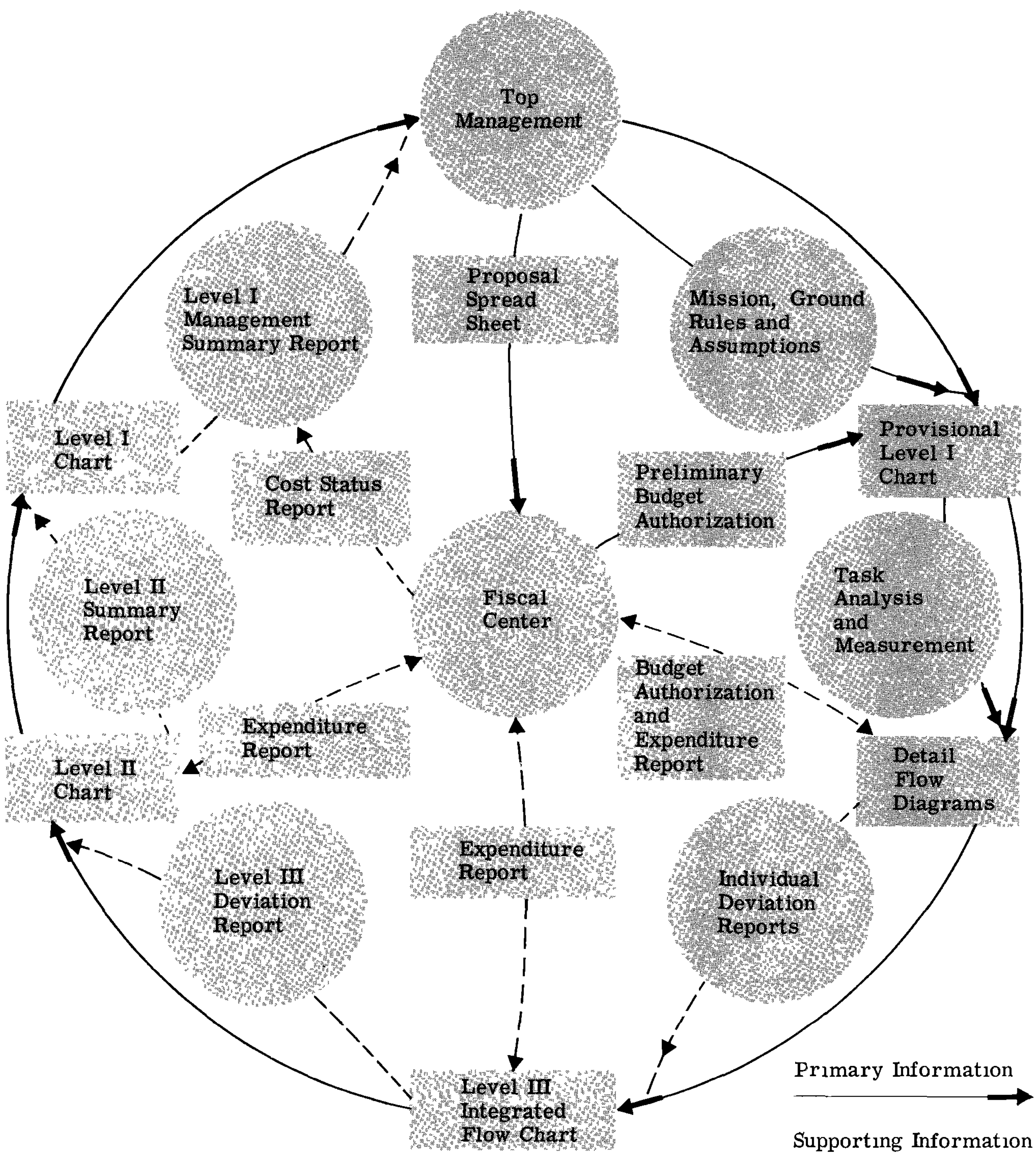


Figure 3-1 Flow of Information

TASK ANALYSIS					
Major Development	Specific Task Assignment	Complexity Scale 1 to 6	Estimated		Person Responsible
			Man hrs.	Mat'l $	

Figure 3-2 Task Analysis Form

Standard Symbology

3.6 As in the case of an engineer who uses certain conventions in the drafting of a schematic, the engineer also requires standard signs to reflect the various actions and work classifications that are diagrammed on a Line of Balance chart. These symbols are readily distinguishable and appear in the margin of figure 3-3. They are designed to cover the entire spectrum of project activity from the initiation of the project to completion, including both internal and external contributions. As a further means of identifying the actions intended, a series of sensor action numbers can be used to augment the information provided by the standard symbols. One of these numerals, placed above and to the right of any symbol appearing on a Level III Flow Diagram, can be used to indicate a start, completion or other action without the need for other identification. For specialized work the list of sensor action numbers can be expanded to include any other pertinent action.

Integrated Flow Charts

3.7 Having prepared individual flow diagrams for each of the subtasks, the supervising manager then consolidates them into one or more Integrated Flow Charts, also called Level III Line of Balance charts, such as may be seen in figure 3-4. His purpose is to insure that the many individual flow diagrams are blended into a single cohesive, unified plan. He tests the interplay of the various parts to see that they are compatible and that it is feasible for them to be accomplished without conflicting demands for facilities or time. When incongruities are detected they should be reconciled with the supervisors concerned so that suitable compromises or alternative actions can be worked out. The resulting Level III Integrated Flow Charts should now be tested by reviewing them in conjunction with the input-output, manpower and facilities requirements that have been derived through the detailed analysis that has thus far taken place.

Inputs and Outputs

3.8 The input/output sheet appearing as figure 3-5 was devised to summarize all needs for coordination within the contractor's establishment. On this form each supervisor will tabulate the specific inputs that he needs to accomplish his assigned tasks, and the dates on which they are required. From these input lists each responsible supervisor will make note of the outputs that he is expected to provide and when.

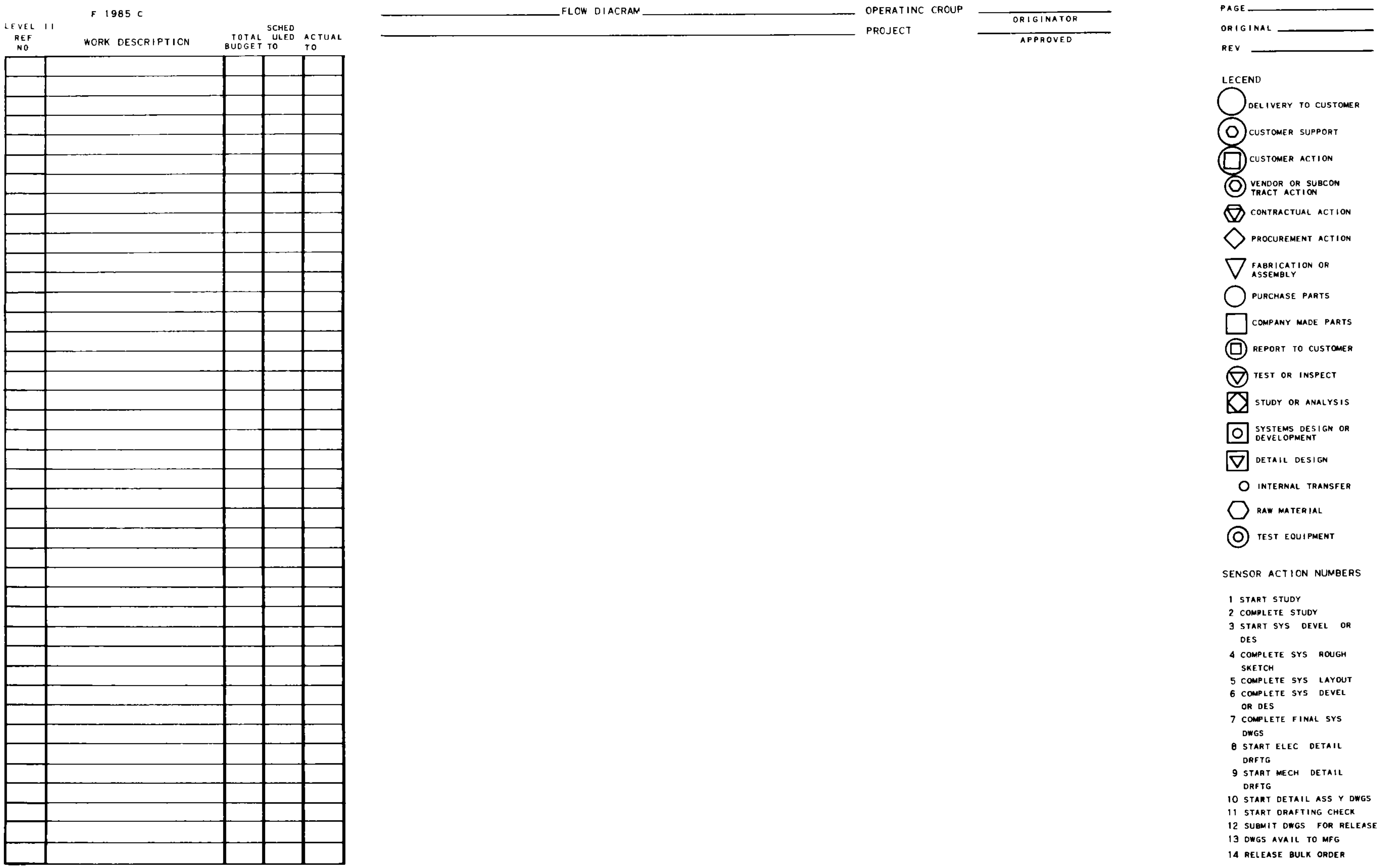


Figure 3-3 Level III Flow Diagram

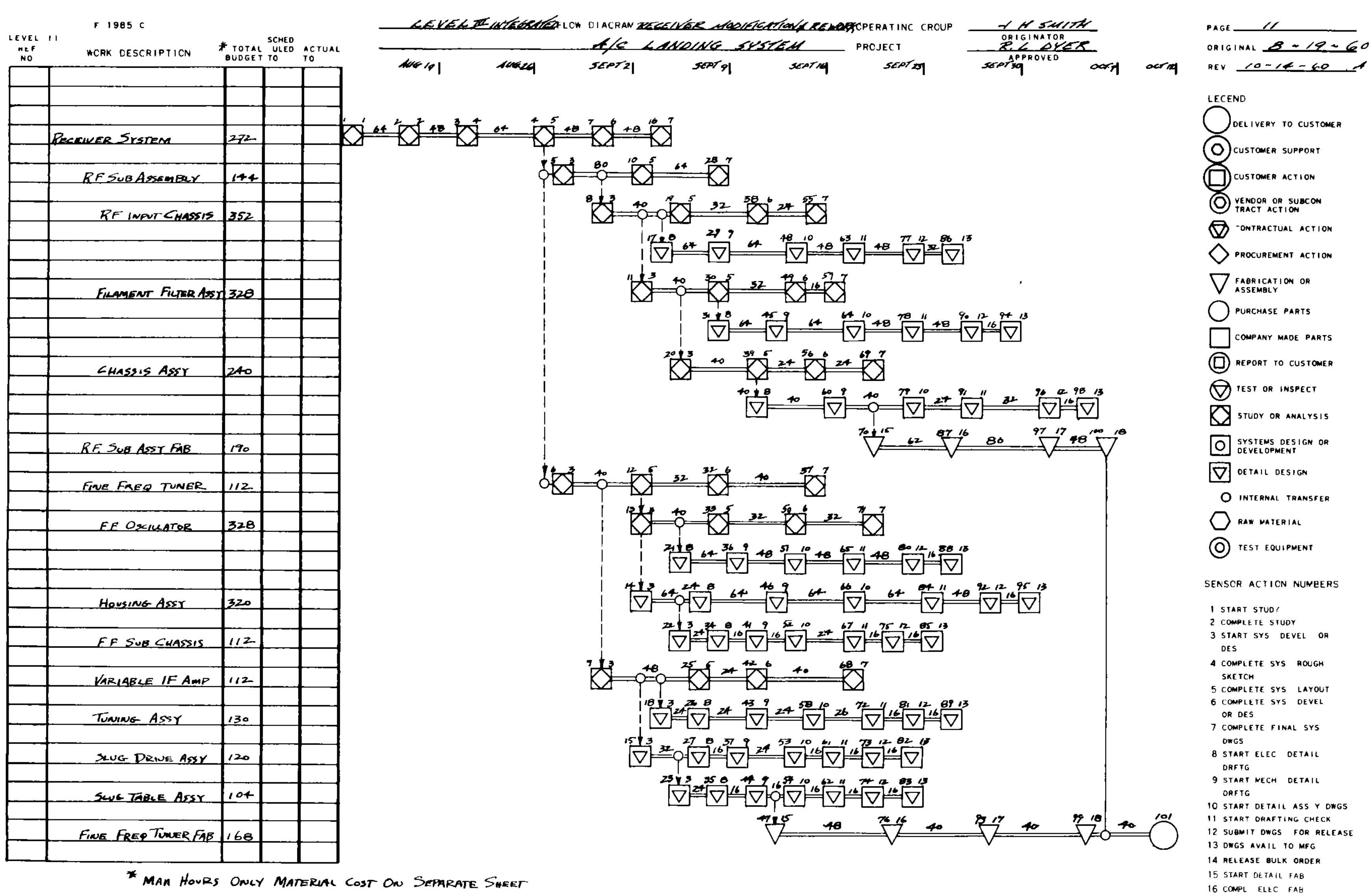


Figure 3-4 Level III Integrated Flow Chart

No. ______________________ Title ______________________

Description	LEVEL III Chart # & Sensor #	Date Req'd	Dept., sec., vendor, or customer		LEVEL III Chart # & Sensor #	Date Avail.	Dept., sec., vendor, or customer

Figure 3-5 Input-Output Chart

These sheets are extremely important because they provide a common understanding of what is required to meet target dates. Study of these sheets will reveal the various factors affecting performance and the areas which require negotiation between supervisors. After his review of controlling items, the project manager may elect to follow certain courses of action which differ from the earlier plan. This information must be fed back to the supervisors for incorporation in their Flow Diagrams and Input/Output sheets.

Manloading and Critical Capacities

3.9 To verify the feasibility of any plan shown on a Flow Diagram, it will be found helpful to use the manloading and critical assets form illustrated in figures 3-6a and 3-6b. This form is constructed to show the number of people by category that will be required on a given contract or project over a twelve month period. With slight modification this same form can be used to summarize manpower requirements for several projects or for an entire organization. Properly interpreted, these data will show when and where personnel should be augmented, decreased, or transferred, and any need for adjustment of critical assets. This summary provides a useful check on the availability of manpower for in-house or anticipated work. If there are discrepancies between the manhour requirements on the flow diagram or manloading charts and the actual availability of manpower, the project manager is afforded a clear indication of the need for further study and adjustment. The end result should be a realistic comparison of manpower requirements and availability. A similar analysis of the availability of critical assets can be obtained by studied examination of this consolidated information.

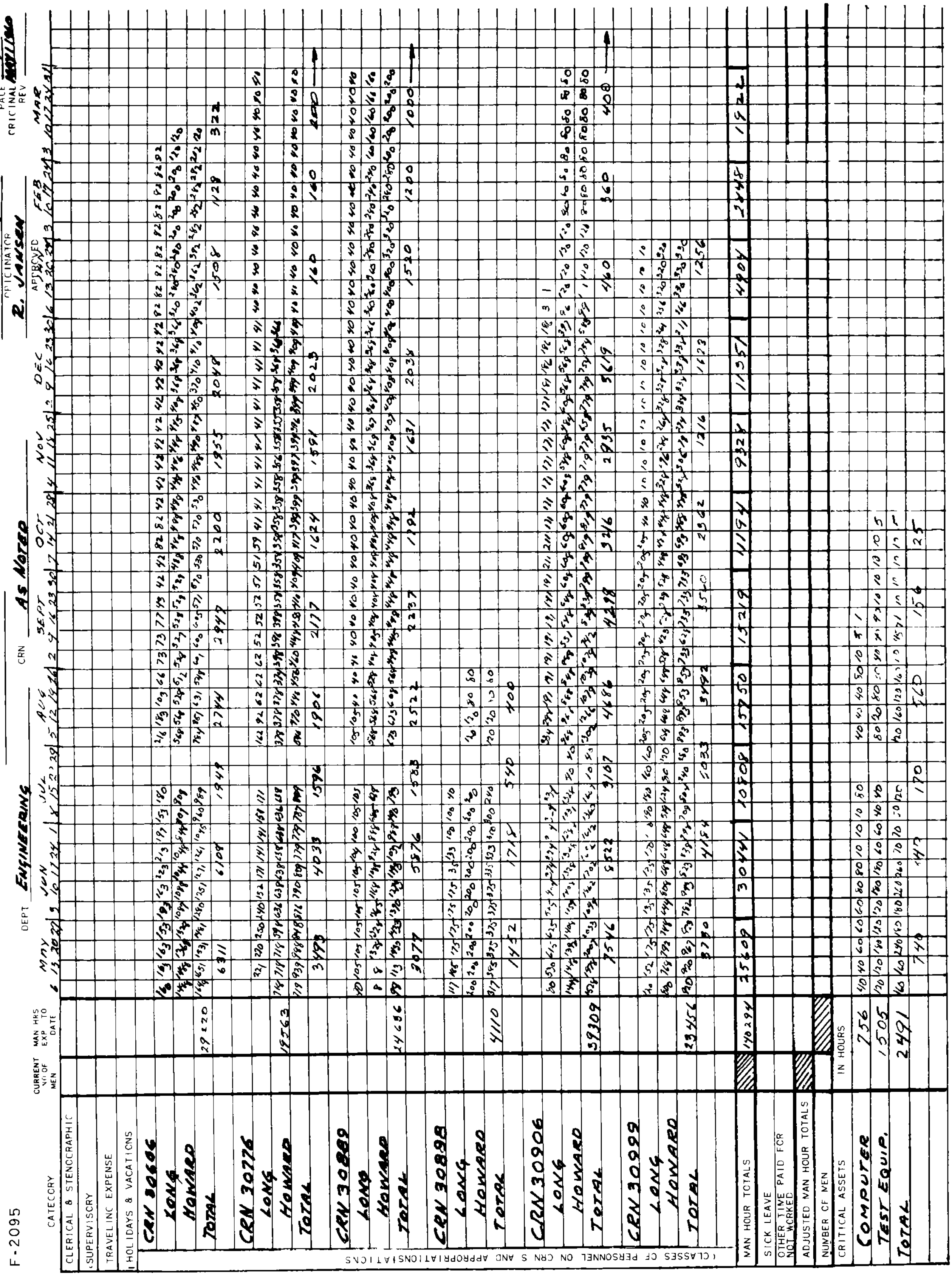


Figure 3-6a Manloading and Critical Capacities

Manloading of a department must be based on the approved work assigned to that department, irrespective of whether the activity is functional, project or service. The term "approved work" includes work on established contracts, work under approved appropriations, trips made on approved trip requests, and estimated work on approved sales forecasts, as reflected in proposals and bids.

For each approved contract and appropriation, supporting individual flow diagrams (form F-1985A) are required to define the necessary work. Each line segment of a flow diagram shall indicate the manhours required for that portion of the task. The methods for doing this have been established by Standard Practice Instruction 0-29, and any necessary additional guidance in its implementation shall be obtained from the Program Planning Department.

Associated with each individual flow diagram and Integrated Flow Chart there shall be a manloading analysis and critical facilities form to show the level and timing of necessary support. The time scales on each of these forms shall be made to correspond to that for each division, or unit period of time. The manhours which are planned to be expended during that period will be summed and entered on the Manhour Totals line. The total for a project will then be broken down into hours for the various categories of personnel making up that total. Using this form, the breakdowns for multiple projects may be similarly combined to determine the gross personnel requirements for an entire operation.

Each Department Manager will collect all flow diagrams for his department. These forms will show only the personnel requirements for that department and will exclude allowances for support to be furnished by others. The Departmental Summary will be so labelled and will include estimates for each of the four accounts listed at the top of the page. On that form also will be entered the number of manhours per period which will be spent in the four accounts near the top of the page. The sum of each column will be entered in the Manhour Totals line, and on this total will be estimated the time for sick leave and other time paid but not worked. That total will be entered under Adjusted Manhours Totals. This line will be converted into the number of men required for that number of manhours expended in that period and entered in the next line, Number of Men. The column on the left will be filled in to show the current number of men in the department by account or class. The total of that column will be entered at the bottom of the page, also.

Copies of the flow diagrams and manloading forms will be approved by the Department Manager and the Division Manager.

The Division Manager will compare estimated costs to complete with the existing budgets. Where this planned expenditure is above the budget, the Project Manager will make arrangements with the affected departments to cut back their expenditures.

Figure 3-6b Instructions for Manloading and Critical Capacities Form

Level I and Level II Charts

3.10 While the integrated flow charts will perform a most useful function for any level of supervision that is directly responsible for doing the work, it is quite obvious that this type of chart is too voluminous and detailed for senior echelons of management. It is necessary, therefore, to distill the information into a more condensed and usable form. The Level I and Level II Line of Balance charts, figure 3-7, are in a format which organizes the presentation of essential data and fosters the rendering of quick and effective decisions.

3.11 The identical form is used for both types of charts. As the Level II charts are a synthesis of the Level III charts, so also is the Level I chart a distillation of the data presented on one or more Level II displays. On both of these charts the lower half of the form is allocated to a graphic presentation of the work plan, scaled against time and symbolized in standard sensors of accomplishment. The upper portion is divided into two sections: the left for plotting the cumulative planned and actual expenditures against a calendar scale; the right section is for the recording of program progress and budget status, both of these items gauged against a standard established by the Line of Balance for some specified date.

3.12 A properly installed Line of Balance will permit ready cross-reference between charts, so that an interested person can find more and more detailed information at any level in going from Level I to Level II charts. It should also be possible to trace with facility in reverse, from the lowest to the highest reporting level, so that any detail can be followed to the degree warranted. (See Figures 5-2, 5-5, 5-6, 9-5b and 9-8b.)

Cost Measurement

3.13 One of the unique features offered by the Line of Balance system is the aptitude with which it makes manifest the progress and cost information for every major segment of a program. A management that wishes to take advantage of this capability will take pains to establish an effective work order numbering system so that cost data can be collected both for appraising current performance and for developing historical records for bidding purposes. It is equally important to insure that the feedback of financial information takes place rapidly so that the relationship between cost and accomplishment is always portrayed as accurately as possible.

Work Order Numbering System

3.14 Judged by Line of Balance requirements a work order numbering system should provide for

3.14.1 a reasonable breakdown of any major task,

3.14.2 the designation of all elements of a major task,

3.14.3 an identification of the class of effort involved in each element;

3.14.4 a means of subdividing any given element into work phases; and

3.14.5 an accounting device for identifying cost.

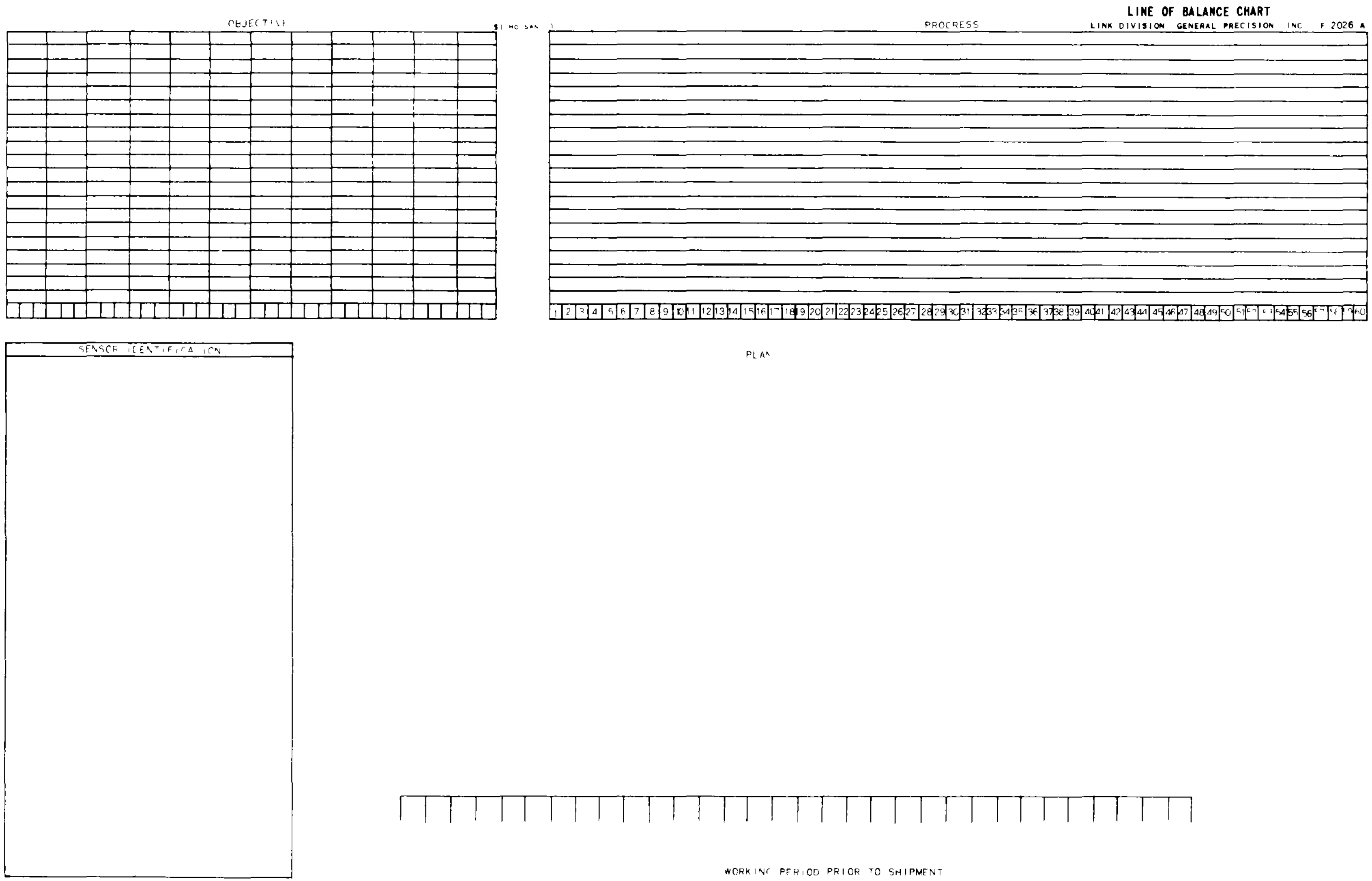


Figure 3-7 Level I and Level II Line of Balance Chart Form

3.15 A work order numbering system that satisfies these stipulations will provide cost information that can be related to the sensors appearing on Level II Line of Balance charts and, by subdivision or phase numbers, to groups of related sensors shown on Level III flow diagrams.

3.16 The matrix shown in figure 3-8 is an example of the way in which one contractor met these requirements. Under this method the first digit of any work order number was used to identify a major division of the effort. The second digit referred to a significant segment of the work within a major division. The third digit designated the kind of work, or the shop in which it was to be performed. When required, the fourth and fifth digits were available for subdividing subtasks into subordinate work phases.

Work Order 94203 in this system would signify work done in the broad area of project administration (9), concerning the preparation of handbooks (4), to be performed by the mechanical design group (2), and representing the third phase (03) of this particular task.

Work Order Authorizations

3.17 After the standard work order system has been instituted, the next important tool is the work order authorization. This represents a segment of the flow diagram and provides management with an effective cost control since it is similar to a check which must be endorsed before it can be put into effect. As reflected in figures 3-9a and 3-9b, the work order authorization includes a general work description, a detailed task description, the completion date and the expenditure schedule.

3.18 Cost control is maintained by establishing an approved budget based upon a careful evaluation of the task. Authority to charge an expenditure against this budget is granted by the work order authorization form. No expenditures are permitted without an approved work order authorization. If overruns are anticipated, a revised form must be completed and submitted for approval.

Closing the Loop

3.19 All that has been done thus far is to lay down the fundamental characteristics of the plan. Both the contractor and FAA are interested in knowing the progress that is being made toward achieving their objective, a requirement for feedback of information to close the loop. Two forms will be of assistance to responsible authorities in completing the circle of intelligence: the deviation form and the financial status sheet.

Deviation Reports

3.20 Sensors or checkpoints which are not met according to the prescribed time table automatically become subject to examination and re-evaluation. The deviation report, figure 3-10, was devised to inform management of the nature and extent of all departures from schedule, to describe a problem and the reason for its existence, to state any action taken, to rectify the situation and to enumerate any additional corrective action that may be required. These reports are geared directly to indicated Line of Balance charts and when properly stated will disclose any and all implications of effect upon cost and delivery. The nature and impact of these reports should appear on all affected Line of Balance charts so that management will be apprised of their occurrence and possible impact on the project.

1st Digit	2nd Digit										3rd Digit									
	0	1	2	3	4	5	6	7	8	9	0 Data Analysis	1 System Design	2 Mechanical Des	3 Electrical Des	4 Drafting	5 Testing	6 Tech Writing	7 Eng'g Support	8 Mod Shop Support	9 Redesign
1 Structures	Wing	Empennage	Aux Surfaces	Auto Pilot	Dive Brakes	Landing Gear				General										
2 Propulsion Systems	Propeller	Turbo Prop	Jet	JATO	Nuclear					General										
3 Communications	VHF Radio	UHF Radio	CW & ICW	Interphone	IFF					General										
4 Aircraft Systems	Hydraulic	Pneumatic	Air Condit'ng	Cabin Pressurization	Fire	Anti-icing & De-icing	Fuel	Instruments & Panels	Photo	General										
5 Armament	Bombing System	Special Weapons	Missiles	Guns	Fire Control System	ASW AEW				General										
6 Electronics	ECM Equip	Radar	Mapping	T V	Navigation	Loran	Pot Devel	Ampl Devel		General										
7 Trailer	Configuration	Cockpit	Equipment and Furnishings	Sub-Floor	Cargo	Instructor Zone	Pilot Zone	Equip't Power	Misc Cabinets	General										
8 Services	Data Reproduction	Packaging	Customer Liaison	Field Services	Consulting	Development	Purchased Part Dwgs	Quality Assurance	Standards	General										
9 Administration	Estimating	Special Property	Reports	Data Acquisitions	Proposals	Handbooks	Test Guides	Central Release	Product Tree	General										

Note Additional digits may be added in order to provide more detailed cost information for any of the above work areas

Figure 3-8 Design Order Numbering System

F-2096 WORK ORDER AUTHORIZATION ☐ BID ESTIMATE ☐

1 TITLE
2 AUTHORIZED HOURS
MAT'L. $
3 INITIAL ISSUE ☐ REV. ☐

4. CRN/BID RN
5. PROJECT/PROPOSAL
6. ISSUED TO /FROM
7. ACCEPTED/ APPROVED BY
8. ISSUED BY
9. DATE

10 GENERAL WORK DESCRIPTION

D O.	DEPT.	ACC'T.	TASK	ASSIGNED TO	REQUIRED COMPL. DATE

11 DETAILED TASK DESCRIPTION (SHOW WORK FOR EACH DESIGN ORDER.)

D O.		INITIAL SPECIFICATION AND/OR DATA REFERENCE

12 EXPENDITURE SCHEDULE MAN WEEKS FOR BI-WEEKLY PERIOD ENDING (USE CONTINUATION SHEET IF NECESSARY)

D.O.	DEPT.		TOTAL HOURS	MAT'LS.	
TOTAL (MAN WK.)					SUBTOTAL
MANPOWER REQ D					UN-ALLOCATED

Figure 3-9a Work Order Authorization

Work Order Authorization/Bid Estimate Form (F-685-C) is to be used to transmit information on work assignments or to supply information for proposal purposes. All work order numbers applicable to a major area of work such as flight simulation, radio aids simulation, power supply, etc. may be listed on one (or if necessary, more) sheets of the form F-685-C. There is room for a maximum of six work order numbers on each sheet. Bid estimates should describe the detailed tasks which will later be covered by specific W. O. 's.

When used to transmit bid information, this form will be completely filled in and approved by the Manager of the functional group or supporting department making the estimate. It will then be forwarded to the designated Project Manager or to Administrative Engineering as appropriate. When used to assign work for contracts the Project Manager will be responsible for issuing all work order authorizations required by the scope of his contract. He will provide all information except item 7, the "assigned to" column of item 10 and item 12. These three blanks will be filled in by the Manager of the responsible Functional Group at the time the work is accepted. After signing the acceptance blank and supplying the missing information, the Group or Support department manager will run as many copies as he requires and return the master to the Project office.

Details of Completing Form F-685-C:

Item 1 Enter the major area of activity, i. e. flight system simulation, etc. In general, an area of activity is describable by the first two digits of the standard work order numbering system.

Item 2 Enter total authorized hours and material dollars for all work orders and phases pertaining to the major area of activity. This should compare with total hours and dollars derived in item 12 below. If more than one sheet is used the authorization should appear on the first page and subsequent pages should reference the first.

Item 3 Indicate whether the authorization is an initial issue or a revision of a previously issued number.

Item 4 Enter the CRN or the bid reference number (appropriation numbers) which initially authorized the work. Strike out the term not applicable. Only one CRN or BRN may be used in this block.

Item 5 Enter the project or proposal the authorization pertains to, striking out the term not applicable.

Figure 3-9b Instructions for Completing Form F-685-C (Sheet 1 of 2)

Item 6 Enter the functional group or department the work affects, striking out the term not applicable.

Item 7 This item should be filled in with the signature of the group or department manager receiving the work order or making the estimate. Strike out the term not applicable.

Item 8 Enter the name of the Project Manager in the case of a W. O. authorization or the name of the person making the estimate in the case of a bid estimate.

Item 9 Self explanatory.

Item 10 Enter the work order number using the standardized work order numbering system, the department which will do the work (if known), the account number, the general task description and the date when the work is required to be completed. In the case of a bid estimate, this last item would be the date when the work is estimated to be completed and would be referenced to the receipt of authorization to proceed.

Item 11 Briefly describe the work content required by each work order. Provide sufficient detail to define the nature and scope of the task based upon the Project Manager's interpretation of contract requirements. Identify applicable specifications and other data which are the references for the work effort. For example: Detailed Simulator Specifications, applicable data packages, MIL specs, etc. A continuation sheet should be used if the required detail will not fit on one page.

Item 12 Complete the expenditure schedule by entering the anticipated time to be spent during each two week period. The unit of measure is the man-week (or fraction thereof). Where the total work effort lasts more than one year, a continuation sheet should be used to show the total effort. For each W. O. the expenditure cut-off date should be on or before the required completion date indicated in Item 10. Discrepancies between requirements and capabilities should be resolved prior to acceptance of the work authorization.

The anticipated expenditures for each W. O. should be entered at the end of the line and sub-totalled in the "total hours" column. The "unallocated" amount may be the difference between the anticipated expenditures sub-total and the authorized hours (item 2).

Figure 3-9b Instructions for Completing Form F-685-C (Sheet 2 of 2)

F-2046-A

PAGE ______ OF ______

DEVIATION REPORT

PERIOD COVERED TO ______ REPORTING ENGINEER ______ CHART REF ______ TITLE ______

SENSORS SCHEDULED TO DATE ______ SENSORS SCHEDULED THIS PERIOD ______

SENSORS COMPLETED TO DATE ______ SENSORS COMPLETED THIS PERIOD ______

LEVEL REF	SENSOR NO	MET	NOT MET	DESCRIPTION	PROBLEM	ACTION TAKEN	IMPACT ON L O.B SCHEDULE AS OF ______

Figure 3-10 Deviation Report

Financial Status Reports

3.21 Of no less value to the measurement of actual accomplishment is its comparison with predicted performance. One of the best ways of doing this is in the form of the financial status report, figure 3-11.

Work Order No.	Description	Total Budget	Budget to Date	Actual to Date	Budget for last mo.	Actual for last mo.	Total to Compl.

Figure 3-11 Financial Status Form

This sheet lists all of the information that is necessary to appraise the financial status of the project. The data is extracted from the time cards that have been submitted and from the flow charts which supervisors used to generate their estimates. Financial reports to operating personnel normally are expressed in manhours and material dollars so that they can be compared with their original estimates. Because top management is concerned with the entire picture of profit and loss, with changing burden rates as well as with individual performance, financial reports should contain all of the information that is needed to contrast actual costs with the corresponding bid or negotiated figures.

Chapter IV GATHERING THE FACTS

Chapter IV

GATHERING THE FACTS

4.1 The essence of effective management is foreknowledge. All leadership is heavily dependent upon the quality of information that is furnished to them as the basis for decisions. It is not sufficient that the information be accurate, it is just as necessary for the information to be complete. In order to make correct decisions management must be furnished with a well-rounded, unbiased view of the situation. The satisfaction of this requirement is one of the most important functions that can be served by a Line of Balance installation.

4.2 With respect to all information furnished to him, the project manager must satisfy himself that the facts are logically, intelligently, thoroughly and accurately assembled. He must be certain that his own familiarity with the manner in which the processing is performed is sufficient to enable him to discriminate between a sound and an unsound effort, and good and bad advice.

4.3 Five steps are necessary to satisfy the information requirements of management: collection, evaluation, analysis, synthesis and interpretation. Properly executed, these steps will include consideration of time factors, of interrelationships between tasks, of feasibility and practicability, and of arrangements for the continuous feedback and updating of information.

4.4 At first glance it might seem a prodigious if not impossible task to fulfill these stringent conditions while solving the many technical questions that are invariably a part of any development project. In 1910, Henry Lawrence Gantt wrote, "When we realize, however, that any operation, no matter how complicated, can be resolved into a series of simple operations, we have grasped the key to the solution of many problems". Gantt then was referring to the collection of information necessary to fix proper piece rates in a manufacturing establishment. His theory, nevertheless, is applicable without change to any engineering problem. It can be conclusively demonstrated that the majority of seemingly complicated efforts will factor into a number of simple operations for which we have direct, or can extrapolate, experience. It most often will be found that the number of elementary problems forms by far the larger proportion, while genuine complications represent only a small percentage of the great problem mass.

Examining the Problem

4.5 The most logical method of gathering information about a complicated operation, then, is to examine in detail the simple elements of which it is composed. A thorough knowledge of these will invariably throw a great deal of light on the complex portion and clearly identify and isolate those items which require special attention. The best way to inform ourselves about a complex problem is by studying its component elements: analysing the material at hand; verifying and cross checking the data; separating the problem into its several elements and relating them to each other and to time; segregating the knowns and the unknowns; and, finally preparing a synthesis, or combined presentation of the results of our study.

4.6 This technique will be recognized as following the ordinary rules for scientific observation. By following these established and proven paths of investigation a correct solution is certain to be found with the minimum of confusion and unproductive effort. Left to the chances of a haphazard approach, however, an investigation seldom will be performed economically, and almost always will be exorbitantly expensive in time and labor.

4.7 Having established the basic method of gathering information and described the manner of going about the matter, it will be helpful to consider a typical electro-mechanical development program, and the way in which it can be reduced to a number of discrete elements. The following outline enumerates the analytical processes involved and how they fit into the general pattern of operation. In many cases it will be found that BRD development projects will commence at the stage indicated by paragraph 4. 7. 5.

Start of Project

4. 7. 1 Provide an initial statement of design and performance objectives

Phase I — Establish Feasibility

4. 7. 2 Create the basic concept and plan by:

stating the problem
searching available literature
analysing the problem
making fundamental inquiries
formulating hypotheses
considering nature of possible solutions
selecting most promising approaches

4. 7. 3 Crystalize thoughts and develop methodology by

determining approach to experimentation
designing experiments
computing and simulating anticipated relationships
sketching experimental layouts

4. 7. 4 Reduce experiments to practice by:

building breadboard models
constructing test equipment
conducting experiments
taking measurements
analysing readings
testing original hypotheses
evaluating results

4. 7. 5 Develop design specifications by:

preparing recommendations
defining system philosophy
enumerating performance objectives
stating pertinent restrictions

Phase II — Establish Practicability

4. 7. 6 Plan design and logic by:

defining overall engineering approach
developing alternative configurations
considering structural combinations
prescribing quality assurance requirements

4.7.7 Define experimental model by.

designing structural features
describing functional features
preparing sketches and schematics
drafting detail and assembly drawings
checking design and drafting
developing a bill of material and parts list

4.7.8 Build and test experimental model by:

fabricating parts
assembling units
testing experimental circuits, components and techniques
constructing special test equipment

4.7.9 Design final model by:

prescribing structural features
preparing necessary drawings, sketches and schematics
checking drafting and design
developing an assembly tree and parts list
reviewing for production design

Phase III — Produce First Article

4.7.10 Build final engineering model by:

fabricating parts
assembling sub units and units
testing for quality of workmanship
constructing related test equipment

4.7.11 Test complete system by·

conducting performance test of assembled model
debugging faults
installing minor changes
evaluating results

4.8 The usual steps in the evolution of an electro-mechanical system are presented in the accompanying tabulation, figures 4-1a and 4-1b. They are set forth in sequence so that relative timing is made apparent, and work phases are divided into generic categories in order to point out the interrelationships and interdependencies.

4.9 Both of the foregoing devices will be of real assistance in pointing out the type of task and related check points which must be segregated and programmed if we are to maintain control over the operation.

4.10 Having identified and recorded all the subordinate tasks, having related them to time and to each other, they must be measured by material cost, by calendar span and

TYPICAL DEVELOPMENT WORK PHASE
Electro Mechanical Devices

Phase Divisions		
Major	Middle	Minor
Preliminary Study	Data	1 Receive initial statement of design parameters (specs & data) 2 Review of initial data
	Concept	3 Formulation of problem 4 Analysis of problem 5 Nature of concept formulated
	Approach	6 Evaluation of concept to approach 7 Approach crystallized
	Proposal	8 Approach proposed in illustration and discourse
	Task analysis	9 Proposal evaluated to cost, time and facilities 10 Task breakdown to facilities and technical areas 11 Establish preliminary plan setting forth planned task against background of time as related to cost objective
Contract Development	Contract review & negotiation	12 Contract award and acceptance
Experimental Design	Approach	13 Proposed approach re-examined 14 Experimental approach established
	Computations	15 Computations and anticipated relationships derived
	Methodology	16 Synthesis of anticipated relationships 17 Selection of problem solving methodology
	Structure	18 Structure and space limitations established
	Block Diagrams	19 Electrical and mechanical block diagrams
	Design Parameters	20 Design parameters prescribed 21 Definitions set forth 22 System philosophy and structure described
	Decision Point	23 Report recommendations, findings and progress 24 Review of point of decision report 25 Engineering model approach established 26 Detailed plan established
Experimental Model	Engineering	27 Engineering approach to whole design crystallized 28 Development of configuration
	System Sketches	29. Mechanical electrical system sketches
	Breadboard models	30. Build breadboard models 31. Construct test equipment 32 Conduct experiment 33 Evaluate results
	Design & Layout	34. Design and layout functional and structural equipment
	Detail drafting	35 Detail drafting, assembly drawings, parts list and bills
	Fabrication	36. Fabricate and assemble experimental model
	Engineering Test	37 Conduct engineering test of whole design
	Rework and Change	38. Rework design and model, change drawings for information record to product engineering

Figure 4-1a Typical Development Work Phase (Sheet 1 of 2)

Review	Program Review	39. Review reports on experimental model and progress to objective Revise plan to reflect task changes for product engineering
Finalization Experimental Program	Acceptance	40. Customer liaison, orientation and instruction 41. Experimental design acceptance
	Specifications	42. Detailed equipment specification established 43. Test procedures and instruction manuals
Engineering Model	Experimental data finalized	44. Experimental data available to product engineering 45. Experimental data finalized for production components
	Product design	46. Production package design and manufacturing analysis 47 Electrical systems design production processes 48. Mechanical systems design production processes 49. Cable design production processes
	Detail drafting	50. Mechanical and electrical detail drafting
	Manufacturing analysis	51. Final and complete review of details by manufacturing/ engineering as applicable to production processes
	Check and release	52. Compatibility check of mechanical and electrical details to systems layouts 53. Release information for manufacturing
	Manufacture	54. Detail fab, sub-assembly fab, top assembly fab
	Test	55. Test of production prototype (first article) 56. Inspection first article
	Rework and change	57. Rework production design and model retest 58. Change drawings for modification article
	Ship	59 Inspection of first production model, quality control and customers 60. Pack 61. Ship first article
Field experience	Installation	62. First article received by customer 63. Study of packaging reliability 64. Installation first article 65. Study installation problems 66. Installation and packing report
	Field experience	67. Study of first article environmental operation 68. Service procedures analyzed under environmental conditions 69. Field report on first article performance and design refinements
Modification	Product engineering	70. Review of environmental operation reports, service reports, packing reports and design refinement recommendations 71. Change design, details, specifications and test information for modification
	Manufacture	72. Manufacture of production quantities

Figure 4-1b Typical Development Work Phase (Sheet 2 of 2)

by manhours. Estimates should be cross-checked for accuracy, as to the degree of assurance that the job can be done in the time allotted and should be based upon past experience or extrapolated for untried tasks. The facts must be appraised in consideration of available manpower and material, taking into account other work in process or projected, and possible competing demands for the various skills that are available. The lines of communications must be clearly defined with an indication of the interrelationships of tasks and the points at which a careful review of the project is required. Uniformity is to be desired so that all responsible authorities have a common understanding of the degree of certainty and reliability of the estimates, and the assumptions on which they are based. It would be well to record these for future reference and recurrent review of the factors that were agreed upon during the formulation of the performance forecast.

Guide Lines

4.11 Although guide lines and operating instructions will vary from project to project, one such list might appear as follows:

Assumptions

4.11.1 Contractual authority to proceed received by (date).
Freedom from work stoppages caused by strikes, acts of God....... etc.
No catastrophic disaster will occur.
Inputs will be received as agreed and scheduled.
There is a common understanding of the work to be performed.
Tasks and specifications are clearly defined.
Facilities will be available as required.
Estimates of performance have been made in accordance with ground rules.
Changes will be instituted only after receipt of contractual authority.
Customer and contractor authorities and responsibilities are defined.
Operation will be conducted on a (one) (two) (three) shift schedule.
Manpower build-up will take place as required.

Ground Rules

4.11.2 Deviations shall be reported to affected element when occurring.
Minor redesign and rework shall be included in test and adjust operation.
Major redesign and rework shall be charged to design and fabrication.
Whenever possible, establish sensor at completion of work phase.
Once approved, no changes or additions to charts without authorization of project manager.
Standard symbology and methodology will be used.
The total task is defined by the various subordinate tasks enumerated on approved charts. Work not appearing thereon shall not be performed without the specific authority of a task order.
Flow charts will be kept updated.
Reports will be rendered (monthly) (bi-weekly) (weekly).
Reports will be due (   ) weeks after close of the accounting period.
A statement of the contingency factor will be included in all estimates.
Estimates will be prepared with a 70/30 degree of assurance.
Estimated manhours and material dollars constitute the budget for the task.
Supervisors will prepare an input - output list for each specified task showing dates required.

Progress reports will contrast sensors scheduled with sensors completed.
Objective curve (will) (will not) include overhead, G & A, and profit.
All items or tasks required under the contract must be indicated on the flow charts.
All customer inputs or actions required shall be indicated on the flow charts.
Task assignments and cost reporting must be compatible.
On Level III charts, sensors should be spaced about one week apart.
On Level II charts, sensors should be spaced no more than one month apart.
Tasks of 200 hours or less need not be subdivided into subtasks.
Level I, Level II and Level III charts must be cross-referenced so that dates, tasks and input/output information may be traced from chart to chart.
Sensor numbers appear above the corresponding symbol.
Budgeted manhours and material dollars are noted respectively above, and below, and approximately at the midpoint of the line connecting the pertinent sensors.
Inputs and source shall be noted above the line on all charts.
Sensors shall be identified with a recognizable action.
Nomenclature must be consistent and in agreement with approved terminology.
Established communication channels will be observed.
Overtime to be held to a minimum and within limits established by law.
The contractor will develop and maintain all Level II and Level III charts.
Sensors completed ahead of schedule shall not be credited until all preceeding sensors have been completed.
At least one sensor shall appear in any given two week period.
Every element depicted by a bar on a Level II or Level I chart will have a charge number in the accounting system.
Expenditure curves shall be drawn to represent the sum of actual expenditures and committed funds.

Inputs and Outputs

4.12 It is important to specify the inputs that will be necessary if a called-for output is to be made on time. Government decisions or support actions, for example, are representative inputs that may be vital to the making of delivery by a certain date. The satisfaction of manpower requirements or the furnishing of special talent or equipment are other examples of assumptions and inputs that should appear in the appropriate places on a Line of Balance chart or flow diagram. The accompanying list will prove helpful in selecting input-output items which should be considered in programming an electromechanical project.

Reports

Bench test
Environmental test
Failure analysis
Status
Expenditure
First article test

Drawings, Sketches, and Diagrams

Functional block diagrams
Functional schematic circuit diagrams
Schematic wiring diagrams

Wiring diagrams
System schematic diagrams
Service schematic diagrams
Outline dimensional sketches
Detail parts drawings
Purchased parts drawings
Sub-assembly drawings
Main assembly drawings
Inseparable assembly drawings
Electrical schematic drawings
Cable assembly drawings
Harness drawings
Mechanical schematic drawings
Installation drawings
Name plate drawings
Gearing diagrams

Models

Bench test breadboard
Engineering prototypes
Service test
Production prototypes
Production

Lists

Wire
Tube complement
Electrical parts
Mechanical parts
Spare parts
Non-standard parts
Purchased parts
Preliminary stock
Special tools and test equipment

Facilities and Services

Special test equipment
Riggers
Power supplies
Work area
Consultants
Inspectors
Tools, dies, fixtures
Government and contractor furnished equipment and material
Computer availability
Test aircraft
Test environment

Approvals, Waivers, and Authorizations

Contracts and contract changes

Design and layout
Design freeze
Overtime
Test procedures
Sub-contractors
Capital expenditures
Extraordinary expenses
Non-standard parts
Shipping instructions
Acceptances
Engineering changes

Publications

Operation manual
Maintenance handbook
Overhaul manual
Installation handbook
Parts lists
Data package

Specifications

Equipment, prime and test
Tests, unit and systems
Installation

Tests

Environmental
Proof
First article
Service
Production
Prototype
Engineering
Packaging
Flight
Calibration

Studies and Developments

Error
Components
Changes
Failure analysis
Reliability

Procedures

Test
Acceptance
Approval

4.13 If all factors for consideration are carefully noted, responsibilities defined and ground rules adequately prescribed, it should be clearly possible to attribute responsibility for deviations from an approved plan and to gauge their specific effect on each dependent portion of the program. By compiling the manhour estimates for the various tasks on a calendar basis, the project manager is afforded an excellent check on manpower requirements and a measure of the practicability of any indicated buildup in personnel. Careful review of the input-output data is generally useful in testing the various elements of the plan for compatibility, acceptability and feasibility.

4.14 Thus far we have directed our attention at the process of breaking down the project into a number of discrete tasks and developing the best possible estimate of dollar and manhour content for each. We still lack an extremely important part of the whole -- feedback -- for without it we can only guess at the results of our efforts.

4.15 The cost control system can be used to close the loop and provide the necessary information. For this reason a specific work authorization number must be assigned to each established task so that time spent in accomplishing it can be properly charged. Accounting information should be as current as the system allows, being in most cases about two weeks in arrears.

4.16 It often happens that accounting months and calendar months do not coincide. This is of no consequence as long as all reporting is done on a consistent basis. This means that reports of financial commitments, obligations and expenditures may be expected to lag behind reports of program progress by a certain given period of time. If this is understood, and an appropriate allowance is made for it, the delay in receipt of fiscal data need not be considered a very serious handicap. In any event, one should be careful to see that all factors are included, and that the costs of authorized changes are covered by adjustments to the established budgets. By combining actual expenditures to date with established costs to complete, and comparing the resulting total with the original budget estimate, it is relatively easy to forecast eventual total costs. This method has been proven far more accurate than the usual procedure of relating expenditures to percentage of work accomplished, and should invariably be used when estimating the project total.

Chapter V THE MECHANICS OF PREPARATION

Chapter V

THE MECHANICS OF PREPARATION

Standard Symbology

5.1 For a common understanding of the types of actions indicated on a Line of Balance chart there has been devised a set of standard symbols which have proven satisfactory across a wide range of projects, from the most simple to the most complex. Adherence to these standards will further the aims of rapid communication and avoid any danger of confusion through lack of a common understanding of their significance. Figure 5-1 illustrates the symbols that are uniformly understood by a large number of contractors for the FAA to indicate the scheduled occurrence of measurable events. The same types of sensors are used on every class of Line of Balance chart, and they are to be interpreted in the same manner regardless of whether they appear on a Level I, Level II or Level III diagram.

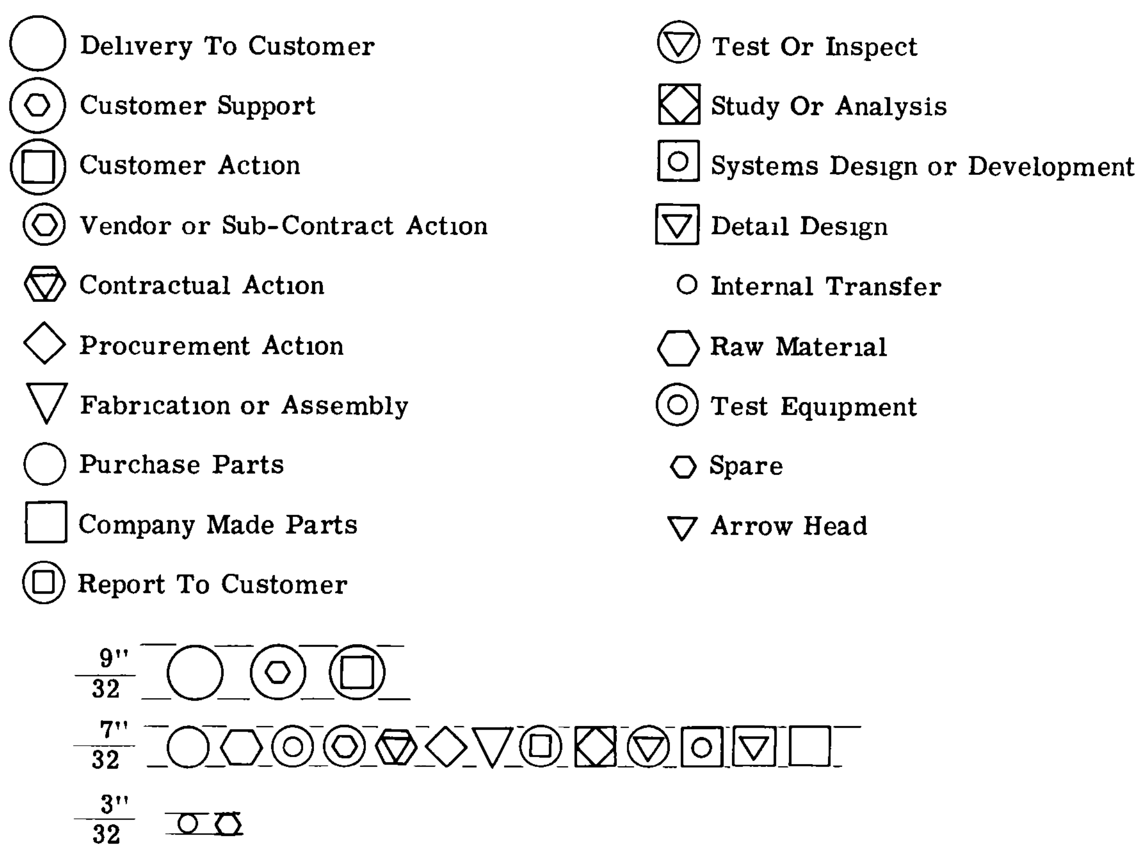


Figure 5-1 Standard Sensor Symbols and Stamp Set Complement Table

Sensor Action Numbers

5.2 An ingenious device has been created in order to avoid the unduly long legend that would be required to identify the large number of sensors appearing on any integrated flow diagram. This convention consists of a number, placed immediately above and to the right of the sensor to which its applies, to be interpreted according to the following table of sensor action numbers:

1 - Start study

2 - Complete study

3 - Start system development or design

4 - Complete system rough sketch

5 - Complete system layout

6 - Complete system development of design

7 - Complete final system drawings

8 - Start electrical detail drawings

9 - Start mechanical detail drawings

10 - Start detail assembly drawings

11 - Start drafting check

12 - Submit drawings for release

13 - Drawings available to manufacturing

14 - Release bulk order

Under this system the sensor ⊽ combined with the numeral 8, thus ⊽^{8}, symbolizes the start of detail electrical design; and ◇^{2} would be used to mark the completion of a study or analysis.

5.3 The list of sensor action numbers can be temporarily expanded to meet the requirements of some unusual situation, but experience has shown the above list will prove adequate for the design phase of development programs. The use of the following blocks of numbers for the purpose indicated will provide a measure of standardization in expanding the above list:

15 to 49 Development projects

50 to 75 Test, experimentation, and evaluation projects

76 to 99 Capital improvement projects

Other Methodology

5.4 Adherence to the following rules will insure standardization and improve communication at all levels:

5.4.1 A sensor which indicates an input should appear directly above the sensor to which it relates;

5.4.2 A sensor which indicates an output should be drawn below the sensor generating the output;

5.4.3 An arrow head indicates the direction of flow or movement;

5.4.4 A dotted vertical line indicates the flow of information;

5.4.5 A solid vertical line indicates the movement of material or equipment;

5.4.6 Sensors are numbered in sequence from top to bottom and from left to right;

5.4.7 Only approved equipment nomenclature should be used;

5.4.8 Sensors should be used to establish a measurable or recognizable action;

5.4.9 Sensors shall be identified by a number appearing immediately above and to the left of the related symbol;

5.4.10 As a general rule, it is preferable to indicate the completion and not the start of an action;

5.4.11 Level I and Level II charts should have fewer than 100 sensors and, ideally, not more than 60;

5.4.12 Estimated manhours are recorded at the midpoint and immediately above the line connecting pertinent sensors;

5.4.13 Estimated material dollars are recorded at the midpoint and immediately below the line connecting pertinent sensors;

5.4.14 The symbol "o" is used whenever an internal transfer takes place at a point where there is no other sensor;

5.4.15 The normal pattern of flow should be from top to bottom and from left to right;

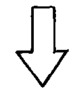
5.4.16 Only when unavoidable may flow lines be permitted to cross unrelated, intervening tasks;

5.4.17 Flow lines that cross unrelated tasks should be suitably broken;

5.4.18 Total budgeted hours for any task is the sum of the estimated manhours for all subtasks;

5.4.19 Program progress appears as a solid bar which is keyed by number to a corresponding sensor;

5. 4. 20 Expenditures appear as a hollow bar which is keyed by number to a corresponding sensor;

5. 4. 21 The date of the survey is indicated against the calendar scale thus: 

Provisional Level I Chart

5. 5 The first chart that is usually prepared is the preliminary or Provisional Level I Line of Balance chart shown as figure 5-2. This represents the initial estimate and plan at the time of bid or contract award.

On the plan segment of the chart a time scale is inscribed on the bottom of the charts. The major segments of the job are shown in the form of a series of tasks, each indicated by appropriate sensors. Among the major events usually shown on the chart are:

5. 5. 1 Significant Government action

5. 5. 2 Start and completion of system and subsystem design

5. 5. 3 Start and completion of electrical and mechanical detailed drafting

5. 5. 4 Start and completion of fabrication

5. 5. 5 Start and completion of assembly

5. 5. 6 Start and completion of test

5. 5. 7 Acceptance

In the upper left hand side of the chart is shown the cumulative expenditure curve over the time span. This curve generally is based upon the summation of expenditures and material commitments and therefore is scaled along the ordinate axis in dollars, and along the abscissa in time.

Flow Diagrams

5. 6 With the general layout of the plan having been shown in the preliminary Level I chart, the next step is to prepare individual flow diagrams. These charts, which should be prepared by the supervisors, set forth the detailed job analysis for each major task and subtask. As a measure of the work content, the budgeted number of hours and material cost are prescribed in the manner illustrated in figure 5-3.

The tasks and subtasks are set forth by a series of sensors plotted against time. To identify further the activity undertaken with each task, a sensor action number is usually located above and to the right of the symbol.

Between any two symbols there is shown the number of manhours or material dollars required to execute that stage of the plan. These figures represent the budgeted estimates for that portion of the work. The sum of all these, of course, will be the budgeted amount for the gross task.

5. 7 On the flow diagrams the interrelationship of the various subtasks is indicated by vertical lines connecting points having a common interest. The direction of flow is indicated by arrows, and the nature of flow by appropriate coding. The transfer of infor-

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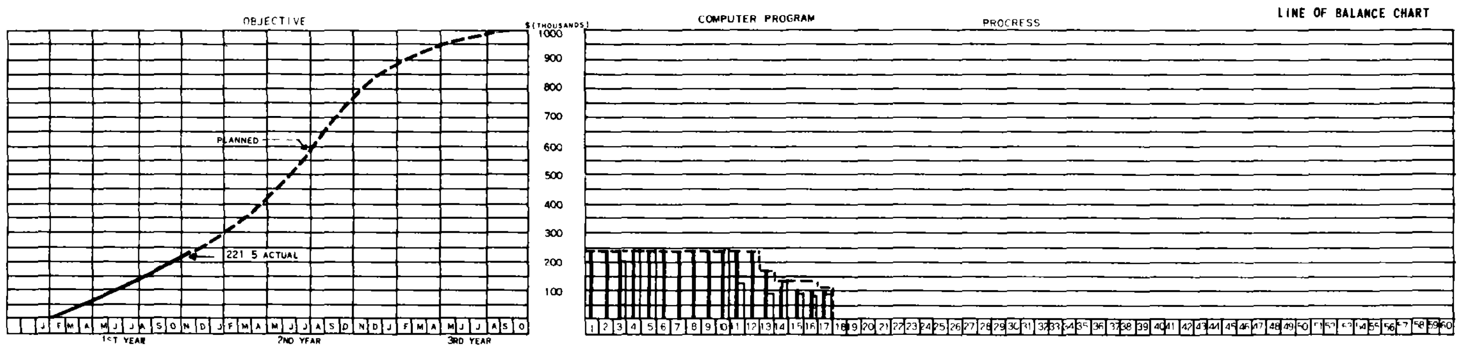

LEVEL II	SENSOR IDENTIFICATION
1 1	1 RECEIVE CONTRACT
1 2	2 START DFG STUDY PROGRAM
1 3 4	3 START STUDY PROGRAM & TIMING UNITS
1 6 7	4 START STUDY DRUM UNIT
1 5 & 12	5 COMPL STUDY PROGRAM & TIME SYS
1 13	6 START STUDY POWER SUPPLIES
1 16	7 START MECH & ELEC DES POWER SUPPLIES
1 18	8 START DEVEL COMPARATOR & INTERPOLATOR UNITS
1 19	9 START DET DRFTG POWER SUPPLIES
1 11 21	10 COMPL STUDY PROGRAM UNITS
1 27	11 COMPL POWER SUPPLY STUDIES
1 28	12 START DET FAB DEVEL UNIT
1 34 36	13 COMPL MECH & ELEC DES POWER SUPPLIES
1 20 & 38	14 AVAIL TO MFG DET DRWGS PROGRAM&TIMING UNITS
1 41	15 START SUB ASSY FAB DEVEL UNIT
1 9 & 42	16 AVAIL TO MFG DET DRWGS DRUM UNIT
1 43	17 AVAIL TO MFG DET ELEC DRWGS POWER SUPPLIES
1 46	18 AVAIL TO MFG DET MECH DRWGS POWER SUPPLIES
1 17 & 48	19 AVAIL TO MFG DET DRWGS MATRIX & CONVERTER UNITS
1 49	20 COMPL DET FAB DEVEL UNIT
1 24 & 50	21 AVAIL TO MFG DET DRWGS COMPARATOR&INTERPOLATOR UNITS
1 51	22 COMPL SUB ASSY FAB DEVEL UNIT
1 52	23 COMPL FINAL ASSY DEVEL UNIT
1 53	24 START TEST & ADJUST DEVEL UNIT
2 2	25 START PROCURE [illegible] PROD UNIT
2 3 4	26 START STUDY REVIEW OF EXPERIMENTAL DATA
2 5 7	27 START REDES OF DEVEL UNIT SYS &PRINTED CIRCUIT BOARDS
1 54	28 COMPL TEST POWER SUPPLY DEVEL UNIT
2 8	29 REC PURCHASE HARDWARE RACK & CAB PROD UNIT
2 11 12	30 START MECH & ELEC DET DWGS PRINTED CIRCUIT BOARDS
2 14	31 REC POWER SUPPLY HARDWARE
1 55	32 COMPL TEST RACKS DEVEL UNIT
2 9 & 16	33 AVAIL TO MFG UPDATEI DRWGS PROD UNIT PWR SUPPLY&CAB
2 17	34 START DET FAB PROD UNIT CAB & PWR SUPPLY
2 18	35 RECEIVE DRUM UNIT FOR PROD MODEL
2 20	36 COMPL CAB ASSY PROD UNIT
2 21	37 START LOADING SYNC TRACK PROD UNIT
1 56	38 COMPL ENG TEST DEVEL UNIT
2 15 & 22	39 AVAIL TO MFG DET DRWGS RACK A1 PROD UNIT
2 23	40 START DET FAB PRINTED CIRCUIT BOARDS
2 24	41 COMPL ASSY PROD PWR SUPPLY
1 57 58	42 COMPL CUSTOMER ACCEPTANCE DEVEL UNIT
1 59	43 SUBMIT DEVEL REPORT
2 27 28	44 AVAIL TO MFG DET DWGS ALL RACKS
2 29	45 START DETAIL FAB ALL RACKS
2 30	46 COMPL CUSTOMER REQ DET DES CHANGES
2 31	47 COMPL DET FAB PRINTED CIRCUIT BOARDS
2 26 &33	48 COMPL POWER SUPPLY TEST
2 34	49 COMPL ASSY PRINTED CIRCUIT BOARDS RACK A1
2 35	50 COMPL ASSY RACK A1
2 36	51 START TEST RACK A1
2 37	52 COMPL ASSY PRINTED CIRCUIT BOARDS RACK A2
2 38	53 COMPL ASSY RACK A2
2 39	54 START TEST RACK A2
2 40	55 COMPL ASSY PRINTED CIRCUIT BOARDS RACKS A3 & A4
2 41	56 COMPL ASSY RACKS A3 &A4
2 42	57 START TEST RACKS A3 & A4
2 43	58 COMPL ENG TEST
2 44 45	59 COMPL CUSTOMER ACCEPTANCE
2 46	60 SHIP FIRST PRODUCTION UNIT

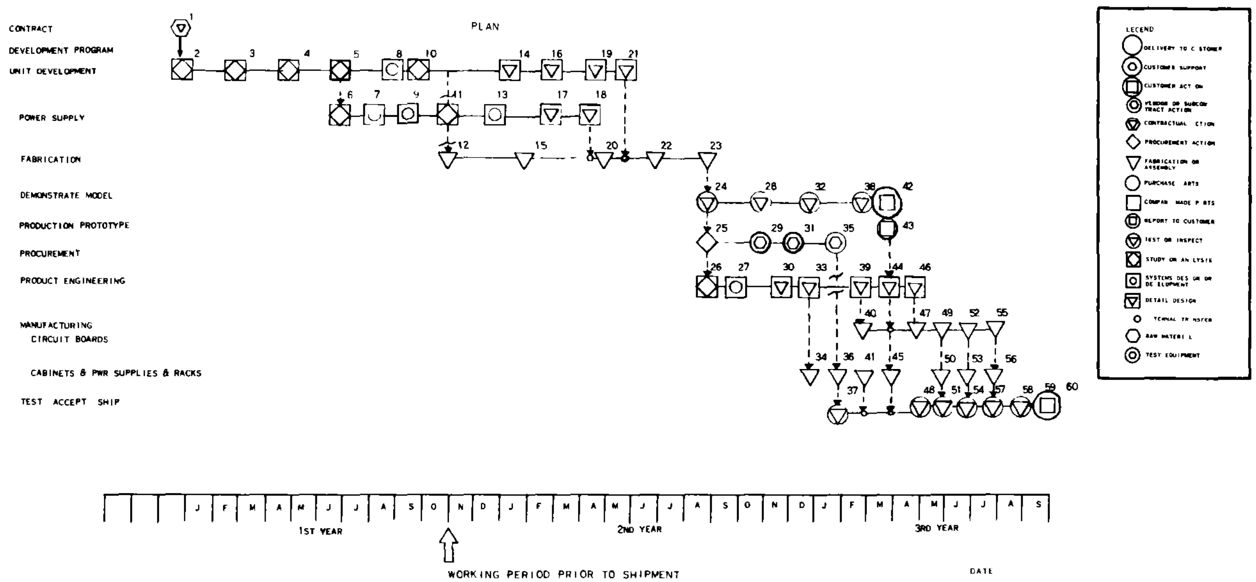

Figure 5-2 Provisional Level I Line of Balance Chart

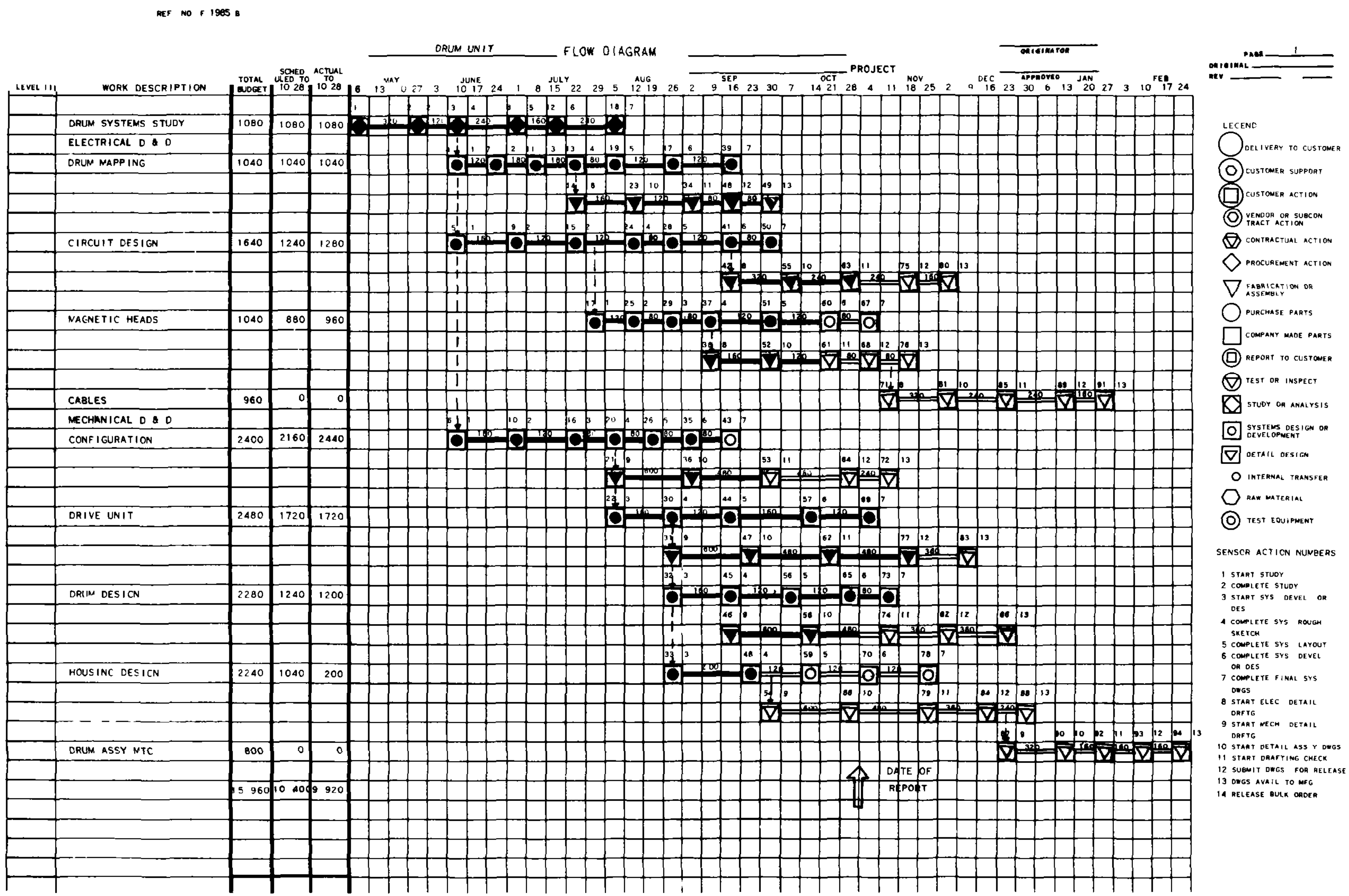

Figure 5-3 Level III Individual Flow Diagram

mation is always suggested by a dotted line, whereas the physical transfer of equipment is shown by a solid connecting line.

Integrated Flow Diagram

5.8 The Level III Line of Balance Chart, or Integrated Flow Diagram, is a composite of the individual flow diagrams. The data appearing on the face of the chart are repeated from the work sheets in order to permit the summation of manhour and dollar requirements by work weeks, and to show other critical needs by calendar date. Figure 5-4, a typical example of this form of chart, is used to illustrate the features mentioned above.

Level II Line of Balance Chart

5.9 A Level II Line of Balance Chart synthesizes but does not alter the data provided by an integrated flow diagram. The information is presented in the standard four-part Line of Balance form shown in figure 5-5, consisting of the objective, the plan, the program progress and the line of balance. The objective and the plan are constructed as described in paragraph 5.5 and illustrated in figure 5-2. Every sensor appearing in the plan of a Level II chart is cross-referenced to a homogeneous group of related sensors on the Level III diagram and serves to represent the progress and budget status of the entire group.

A Level II chart usually is prepared for every area of major responsibility, such as:

5.9.1 Design and fabrication of major system components;

5.9.2 Study programs;

5.9.3 Special test equipment;

5.9.4 System testing;

5.9.5 Critical facility requirements;

5.9.6 Customer action (when appropriate); and

5.9.7 Vendor action (when appropriate).

Selection of Sensor Groups

5.10 On a Level II Line of Balance chart the various sensors describing major segments of the project plan are each representative of a group of sensors on a Level III flow diagram. These sensors are related by the work order numbering system and are grouped for the purpose of collecting costs on that portion of the project. The selection of sensor groups is closely related to the manner in which work authorizations have been issued and, in some extreme cases, to organizational matters. There are, however, some natural divisions of effort which lend themselves to ready combination.

Suggested Groupings

5.11 The table shown in figure 5-6, will assist the project manager to combine a number of Level III sensors into groups for display on a Level II chart.

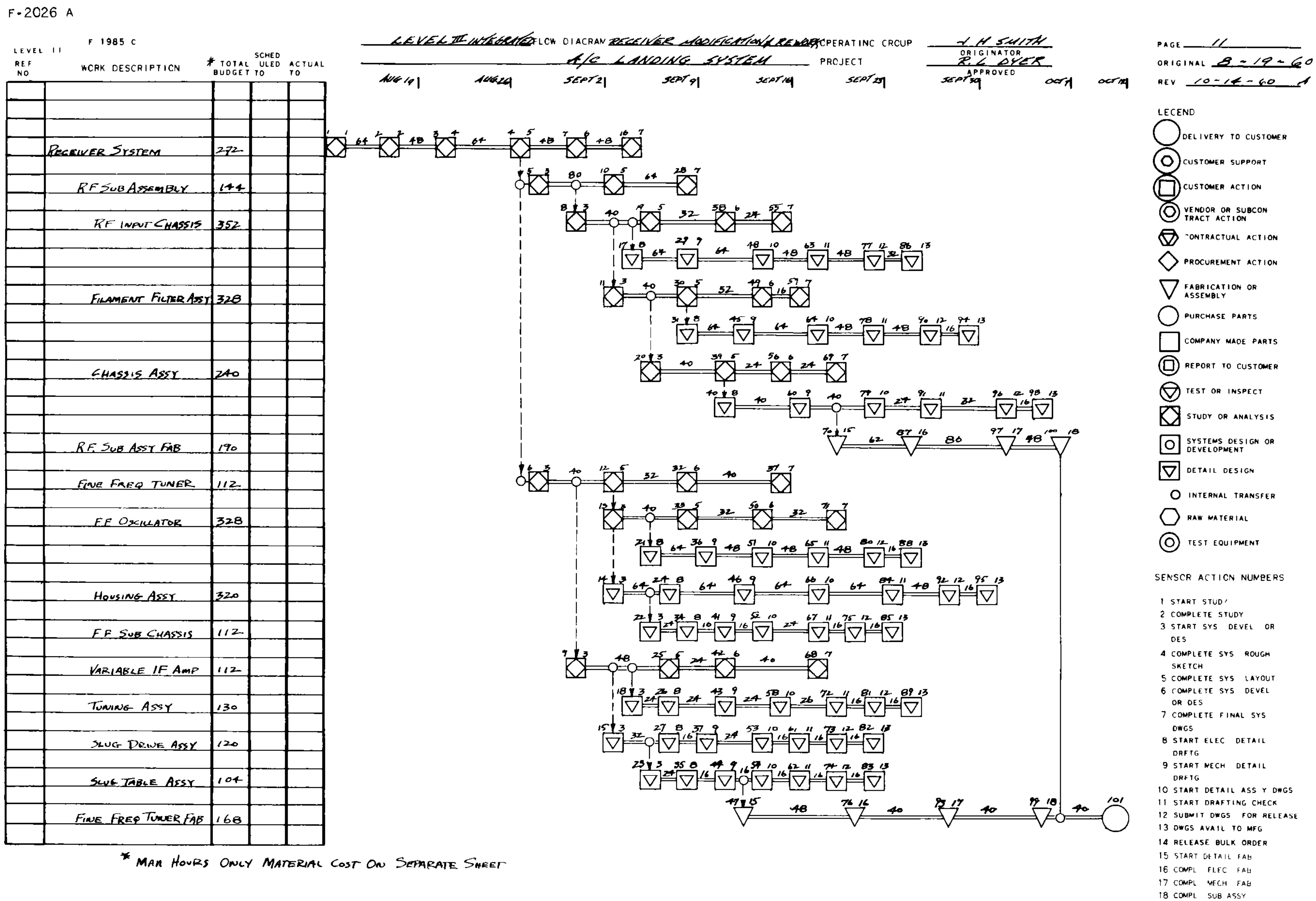

Figure 5-4 Level III Integrated Flow Chart

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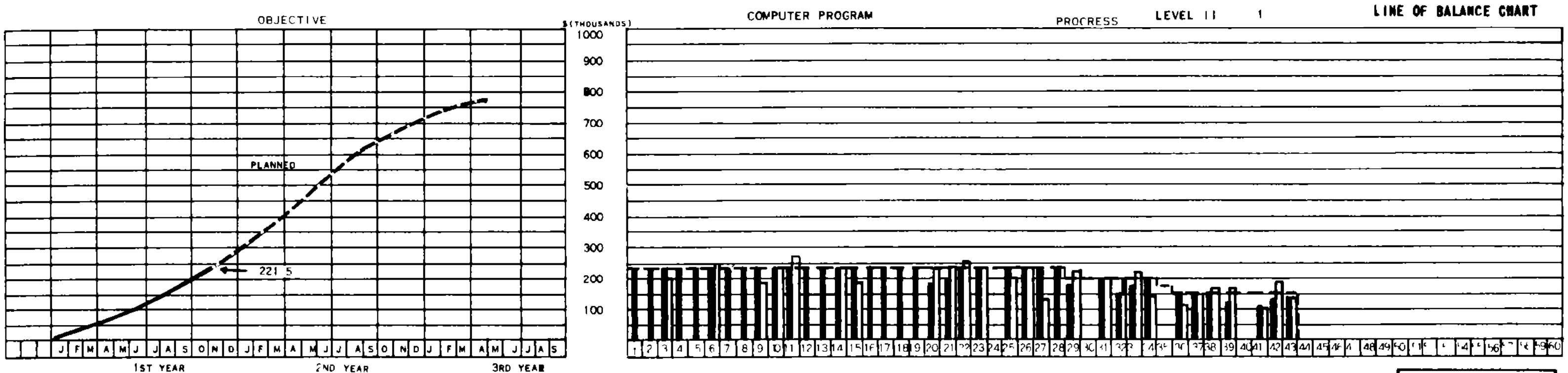

LEVEL III	SENSOR IDENTIFICATION	LEVEL I
1 1 & 10	1 RECEIVE CONTRACT	1
2 1 & 5	2 START D F G STUDY PROGRAM	2
2 4 & 8	3 COMPL STUDY TIMING TECHNIQUES	3
3 1 & 3	4 START STUDY PROGRAM TIMING UNIT SYS	3
3 4 & 6	5 START MECH & ELEC DES PROGRAM & TIME UNITS	5
2 6 & 9	6 COMPL LOGIC SOLVING INTERPOLATION FORMULAS	4
4 1	7 START STUDY DRUM UNIT SYS	4
3 7 8	8 START MECH & ELEC DES PROGRAM & TIMING UNIT	5
4 3 & 5	9 COMPL SYS ROUGH SKETCHES DRUM SYS	16
3 10 & 13	10 COMPL STUDY PROGRAM & TIME SYS	5
2 11 12	11 COMPL STUDY DATA REDUCTION	10
5 1	12 START DEVEL MATRIX & CONVERTER UNITS	5
7 1	13 START POWER SUPPLY STUDY	6
4 6 16	14 COMPL STUDY CONFIGURATION	16
4 2 & 18	15 COMPL FINAL SYS DWGS DRUM STUDY	16
7 2 & 10	16 START MECH & ELEC DES PWR SUPPLY	7
5 7 & 4	17 START DES MATRIX & CONVERTER UNITS	19
6 1	18 START DEVEL COMPARATORS & INTERPOLATORS	8
7 11 & 21	19 START DET DRFTG PWR SUPPLY	9
3 14 & 22	20 COMPL ELEC DES PROGRAM & TIME UNITS	14
2 14 & 18	21 COMPL STUDY PROGRAM FOR D F G	10
4 7 & 39	22 COMPL SYS DWGS DRUM MAPPING	16
5 5 6	23 START DET DES MATRIX & CONVERTER UNITS	19
6 1 & 5	24 START DESIGN COMPARATORS & INTERPOLATORS	21
3 23 & 25	25 COMPL MECH DES PROGRAM & TIME UNITS	14
5 7 & 10	26 COMPL DEVEL MATRIX & CONVERTER UNITS	19
7 18 & 25	27 COMPL STUDY POWER SUPPLY	11
8 1	28 START DET FAB	12
4 9 & 67	29 COMPL FINAL SYS DWGS MAGNETIC HEADS	16
6 6 & 10	30 START DET DES COMPARATORS & INTERPOLATORS	21
5 11 & 15	31 COMPL ELEC DES MATRIX & CONVERTER UNITS	19
3 26 & 39	32 AVAIL TO MFG DETAIL ELEC DES PROGRAM & TIME UNITS	14
4 16 & 78	33 COMPL FINAL SYS DWGS HOUSING DES	16
7 26 & 31	34 COMPL ELEC DES PWR SUPPLY	13
6 8 & 15	35 COMPL DEVEL COMPARATORS & INTERPOLATORS	21
7 29 & 35	36 COMPL MECH DES PWR SUPPLY	13
5 16 & 35	37 COMPL MECH DES MATRIX & CONVERTER UNITS	19
3 28 & 44	38 AVAIL TO MFG DET MECH DES PROGRAM & TIME UNITS	14
4 23 & 91	39 AVAIL TO MFG DET ELEC DES DRUM UNIT	16
6 16 & 24	40 COMPL ELEC DES COMPARATORS & INTERPOLATORS	21
8 2 & 15	41 START SUB ASSY FAB	15
4 31 & 94	42 AVAIL TO MFG DETAIL MECH DES DRUM UNIT	16
7 36 & 55	43 AVAIL TO MFG DETAIL ELEC DES PWR SUPPLY	17
5 21 & 40	44 AVAIL TO MFG DETAIL ELEC DES MATRIX & CONVERTER UNITS	19
6 25 & 32	45 COMPL MECH DES COMPARATORS & INTERPOLATORS	21
7 50 & 71	46 AVAIL TO MFG DET MECH DES PWR SUPPLY	18
6 28 & 39	47 AVAIL TO MFG DET ELEC DES COMPARATORS & INTERPOLATORS	21
5 38 & 62	48 AVAIL TO MFG DET MECH DES MATRIX & CONVERTERS	19
8 13 & 32	49 COMPL DET FAB	20
6 40 & 52	50 AVAIL TO MFG DET MECH DES COMPARATORS & INTERPOLATORS	21
8 17 & 45	51 COMPL SUB ASSY FAB	22
8 32 & 60	52 COMPL FINAL ASSY UNIT	23
9 1	53 START TEST & ADJUST D F G	24
9 2 & 21	54 COMPL TEST POWER SUPPLIES	28
9 15 & 40	55 COMPL TEST RACK UNITS	32
9 22 & 60	56 COMPL TEST & ADJUST D F G	38
10 1	57 START CUSTOMER ACCEPTANCE	42
10 2 & 15	58 COMPL CUSTOMER ACCEPTANCE	42
10 12 & 25	59 SUBMIT DEVEL REPORT	43

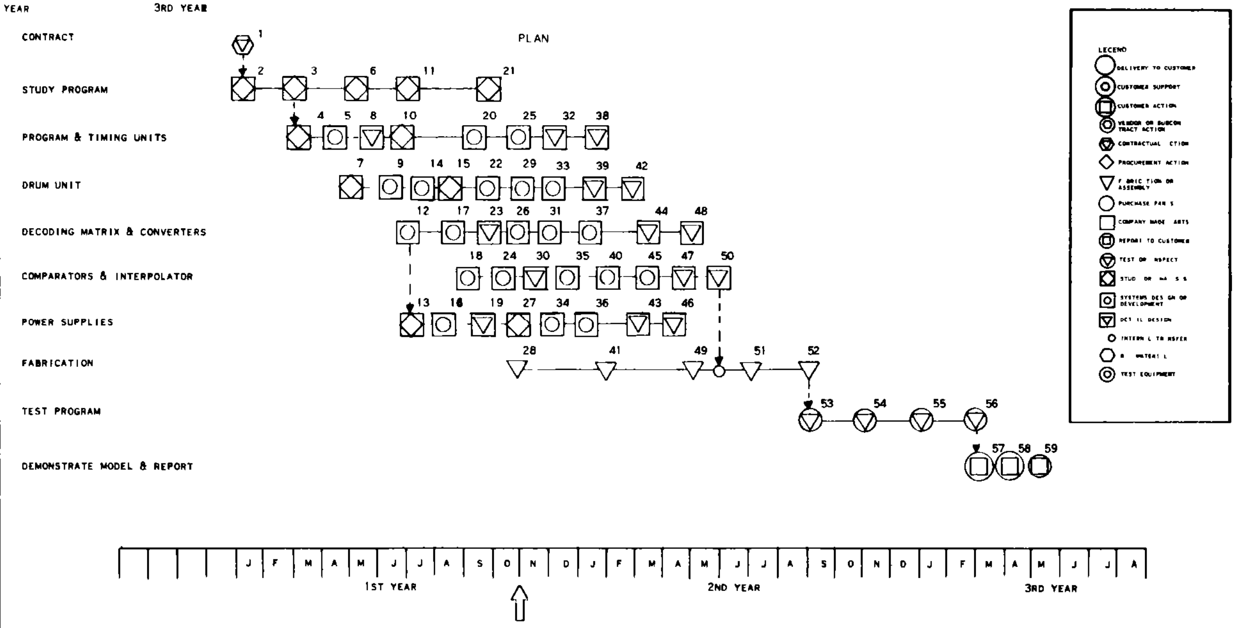

Figure 5-5 Level II Line of Balance Chart

	Level III		Level II
Class	Sensor Action Number	Work Description	Related Sensor
Systems Work	1.	Start study	Start study
	2. 3. 4.	Complete study Start system development or design Complete system rough sketches	Complete system Rough sketches
	5. 6. 7.	Complete system layout Complete system development or design Complete final system drawings	Complete Final system Drawings
Subsystems Work	1. 2. 3. 4.	Start study Complete study Start sub system development or design Complete sub system rough sketches	Complete Sub system Rough Sketches
	5. 6. 7.	Complete sub system layout Complete sub system development or design Complete final sub system drawings	Complete Final Subsystem drawings
Electrical Detail	8. 10. 11.	Start electrical detail drafting Start detail assembly drawings Start drafting check	Start Drafting check Electrical detail
	12. 13. 14.	Submit drawings for release Drawings available to manufacturing Release bulk order	Complete detail Electrical drafting
Mechanical Detail	9. 10. 11.	Start mechanical detail drafting Start detail assembly drawings Start drafting check	Start Drafting check, Mechanical detail
	12. 13. 14.	Submit drawings for release Drawings available to manufacturing Release bulk order	Complete Detail Mechanical drafting

Figure 5-6 Table of Suggested Sensor Groupings

5.12 During the history of applying Line of Balance to development programs, a number of different ways of indicating progress have been proposed and tried. Probably the most frequent suggestion is one which proposes some method of assigning weights to the relative importance of accomplishing the task represented by the various sensors. All of these recommendations have a common fault: they overlook, entirely, the fact that as project managers our interest lies less in what has been done than it does in detecting what has not been done, in discovering the things that are impeding progress. The intrinsic cost of a horseshoe nail is not an accurate gauge of its worth, if for want of that nail a battle will be lost. So also in measuring the failure to reach a sensor, when it is a limiting item and threatens or halts progress, at that time it certainly becomes the most important factor in the entire project and has a weight that is not less than that of any other measurable accomplishment.

5.13 For any specified date, then, progress is indicated on a Level II chart by the height of a series of vertical bars, each keyed by identifying number to a corresponding sensor on the project plan. The height of this bar is determined in the following manner:

5.13.1 From the cross-reference list, identify the Level III sensors which correspond to the Level II sensor under consideration;

5.13.2 From the Level III chart, determine the number of Level III sensors that were scheduled for completion by the date of the survey;

5.13.3 Determine the number of Level III sensors that were actually completed as of the date of the survey;

5.13.4 Calculate the ratio of sensors completed to sensors scheduled for completion;

5.13.5 Draw a line of balance for the date of the survey for the Level II sensor in question;

5.13.6 Represent the progress to date by a solid bar extending above the base line; and

5.13.7 Express the value of this progress as a percentage of the distance from the base line to the line of balance, which is equal to the ratio determined in 5.13.4.

5.14 Credit for accomplishment is given only after a task has been completed in its entirety. No credit is allowed for sensors completed ahead of schedule inasmuch as any limiting sensor must be identified.

Representing Expenditures

5.15 A direct contrast between the progress made and the expenditures recorded against any given Level II sensor is afforded by a second bar which adjoins the bar representing progress. The height of the expenditures bar is calculated in much the same manner as for determining progress:

5.15.1 From the cross-reference list, identify the Level III sensors which correspond to the Level II sensor under consideration;

5.15.2 From the Level III chart, identify the sensors that were scheduled for completion by the date of the survey;

5.15.3 Total the budgeted manhours and material required to complete the work represented by the sensors isolated in 5.15.2;

5.15.4 From the financial status report, determine actual expenditures against the task to the date of the survey;

5.15.5 Calculate the ratio of expenditures made to budgeted costs;

5.15.6 Represent the expenditures to date as a plain bar extending above the base line; and

5.15.7 Express the value of these expenditures as a percentage of the distance from the base line to the line of balance, which is equal to the ratio determined in 5.15.5.

5.16 A sensor which merely indicates the start of an action or the receipt of some supporting input will not have an expenditure associated with it. Under such conditions, there will be only a single bar to reflect progress.

Constructing the Line of Balance

5.17 For a development project, the level of the line of balance for the date of the survey is determined in the following manner:

5.17.1 Referring to the "objective" section of the Line of Balance chart, erect a perpendicular to the base line at the point indicated by the date of the survey;

5.17.2 Mark the point where this perpendicular intersects the curve for the planned objective;

5.17.3 Project this intersection to the vertical axis of the "program progress" section of the Line of Balance chart; and

5.17.4 Continue the projection of this line horizontally until it extends across all bars having reference to sensors which are scheduled for completion by the date of the survery; this constitutes the line of balance for sensors occuring on or before the date of the survey.

5.18 The level of the line of balance for any sensor scheduled to occur subsequent to the date of the survey is determined in the following manner:

5.18.1 Referring to the "objective" section of the Line of Balance chart, erect a perpendicular to the base line at the point corresponding to the date of the sensor's scheduled occurrence;

5.18.2 Determine the height of the ordinate at the point where this perpendicular intersects the curve for the planned objective;

5.18.3 Determine the vertical coordinate of the planned objective as indicated for the date of the survey;

5.18.4 Measure the difference between 5.18.2 and 5.18.3 and subtract from 5.18.3;

5.18.5 The resulting dimension is the level of the line of balance for the date selected.

5.19 The project line of balance is constructed by joining the several segments constructed as described in 5.17 and 5.18. The resultant represents the minimum level of accomplishment that will satisfy project requirements.

5.20 Deviations from planned progress are visually apparent in the form of bars that extend above or fail to meet the line of balance.

Level I Line of Balance Chart

5.21 The Level I Line of Balance chart is designed to provide the FAA project manager and the contractor's top management with a concise view of the program status. It is a further distillation of the information presented in the Level II chart and should reflect all major actions required by the overall project plan.

5.22 Sensors should be provided to show the project status in such areas as;

5.22.1 Administrative action

5.22.2 Engineering action

5.22.3 Manufacturing action

5.22.4 Purchasing action

5.22.5 Acceptance

5.22.6 Contractual actions

5.23 As in the case of the Level II chart, cost information should be available for each sensor indicated on the Level I chart. Progress and expenditures are displayed in the same manner as described for the Level II chart, except that the ratios are those calculated by contrasting the scheduled and accomplished sensors noted on the Level II chart.

5.24 In establishing a Level I chart, it is important to cover all elements of the program, missing none. The project should be broken down into major systems and major subsystems, using appropriate sensors to identify the actions required. From the standpoint of clarity, the number of major categories should be restricted to six or eight levels. The number of sensors, as before, should never exceed 100, preferably being on the order of 60 to 80. Careful selection of action and decision points will play a major part in making the Level I chart a valuable tool for the aid of management.

Chapter VI THE APPRAISAL

Chapter VI

THE APPRAISAL

6.1 It must be thoroughly understood that although the Line of Balance technique is a highly effective tool for the use of management, it in no way can be considered a substitute for management. The information presented on a Line of Balance chart and in its accompanying reports, therefore, should be examined critically by the project manager. It often will be found that the so-called statement of a problem is in reality only a manifestation of the problem and not the root of the real difficulty.

6.2 It might be said, for example, that detail designs have not been released. This in itself is not the trouble. We must look behind the failure in order to find the genuine nature of the fault.

6.2.1 These are some of the questions that might well be asked under such conditions:

Is manpower lacking?

Is there a shortage of special skills?

Has the breadboarding proven incorrect?

Was preliminary design completed on time?

Have all necessary inputs been received?

6.3 Or in another area, perhaps, it is stated that certain technical data have not been received and in consequence that work has been halted.

6.3.1 We might well ask ourselves these questions:

Did we clearly define the requirements?

If cost was involved, did we issue a purchase order for these data?

If not available, what substitutes can we use?

Did we allow sufficient lead time?

Is it reasonable to expect these data at this stage of development?

6.4 Again, lying behind an apparently innocent condition may be found impending bottlenecks of one kind or another: of demands for critical facilities, shortages of highly specialized tools or equipment, unavailable talents and skills, perhaps even a lack of financial support or unrest among the shop personnel. By putting matters in the proper perspective, we can search out the underlying causes for deviation from the plan and take action to correct them.

6.5 Any appraisal would be incomplete without careful review of project requirements, seeking out critical or conflicting conditions, probing for matters requiring special skills or test equipment, revealing over-loading or manpower shortages or an unfulfilled need for government furnished equipment or contractor facilities.

6.6 The charts only serve to point out such problems and the order in which they should be studied. The lowest numbered sensors are those which are scheduled for earliest completion. These, then, should be attacked first. Are we behind? It is possible that we should consider the assignment of more manpower, placing them on overtime or instituting a second shift. Maybe our problem is generated by the lack of technical skill, requiring us to provide personnel of greater experience. Was the estimate wrong in the first place, or have changes been introduced without a corresponding alteration in the budget and stretch-out in time?

6.7 Having identified and isolated our problems, the next step is to gauge their impact on the program. If some purchased parts will be four weeks late, how shall we recover the lost time? Can we use available substitutes? Can we change the assembly plan? Will the contingency factor cover this expected slippage? How can we alter the program to meet this new condition?

6.8 Just as it can be misleading to hear only one side of a story, so can it be inconclusive to examine only one part of a Line of Balance chart. Let us say that a plot of actual costs falls below the level of planned expenditures. This could mean a more efficient performance than was anticipated. It could also mean that we are well behind schedule by reason of not having started soon enough or with sufficient force. Read in conjunction with other features of a Line of Balance chart, the true facts should be readily apparent.

6.9 Armed with this knowledge, we are now in a position to determine what actions are required to keep the program on schedule. With the elimination of rumors and other incorrect or misleading information, false starts and waste motion can be avoided, allowing the concentration of full attention on matters of concern to the project. Controversial items generally do not become issues when a Line of Balance chart is used in the manner intended. Because it provides an ideal method of communication by which facts are clearly presented, there is small reason for disagreement over the action that is best suited to correct any given set of conditions. If responsibilities are clearly defined and the nature and time of all occurrences are prescribed, the causes for many internal problems will disappear.

6.10 Communications among and between Government, contractors, subcontractors, and vendors can be improved by use of Line of Balance as the means for reporting against an approved plan. Adequately designed to suit the requirements of the project, a Line of Balance reporting system will not only show what must be done, by whom and when, but it will also reflect the timing and consequence of required action. Do not overlook the utility of the Line of Balance channel as a means of communicating with subordinates, of indicating decisions and actions taken. All that is needed to provide such information is the addition of a suitable sensor at the appropriate place.

6.11 Subcontractors should be called upon to prepare Line of Balance charts covering work for which the subcontractor is responsible. Routine reports from vendors should contain forecasts of their ability to complete the next ensuing sensors on time, in addition to which they should, of course, include a statement of the work accomplished during the reporting period. While no project manager can assume responsibility for a subcontractor's operation, it often will be possible for the project manager to render real assistance by indicating the urgency or importance of subcontracted work, by using his influence or the power of his office, to obtain improved priorities. A tickler file will be of value here in keeping track of external actions that are required and the complementing actions and decisions that project management is obligated to render.

6.12 Only after this type of study and analysis has been completed can a responsible manager consider his project adequately programmed and ready for presentation. After that, he must be prepared to make rapid adjustments whenever the changing situation demands, to update his information at frequent intervals and continually to appraise and monitor the progress being made. Line of Balance reduces this stupendous task to a manageable and routine work assignment.

Chapter VII PRESENTING THE SURVEY ANALYSIS

Chapter VII

PRESENTING THE SURVEY ANALYSIS

7.1 Full benefit from the survey cannot be realized until the study is complete, the data analysed and tested, and results appraised and, finally, the feedback loop closed by means of a presentation to management.

7.2 Arrangements for a conference of this kind should be carefully planned in consultation with the contractor. The time, location, and personnel to be invited to the presentation should be specified so as to insure that all phases of the operation are adequately covered. It seems almost unnecessary to point out that top management should attend, and each department concerned should be represented by an official having authority to speak for the department's operation. Proper representation is extremely important to the success of the meeting for it would be time wasted were the members without sanction to make decisions and act upon them.

7.3 The purpose of the presentation is to bring to top management a vivid picture of the project status, revealing to each cognizant official the existing situation within his own sphere of responsibility. Thus, the purchasing agent will be apprised of matters relating to purchased parts, the machine shop superintendent of contractor-made parts, the chief engineer of design releases, and the general manager of the over-all situation.

7.4 Time allotments for each portion of the presentation should be carefully budgeted so that the entire meeting will not last longer than forty-five minutes to an hour. It often will be found worthwhile for the group leader and his colleagues to conduct such private rehearsals as are necessary to insure a concise, logically developed and clear presentation.

7.5 It is customary to divide the program into three phases: the introduction, a review of the facts, and a summary of the survey team's observations. In the group leader's introductory comments the underlying principles of Line of Balance should be brought forth, and the reasons for this particular analysis should be outlined. It is well to stress that the information about to be presented was derived from plant records and therefore represents nothing additional to the requirements of normal, accepted management practices. Data were invariably obtained from responsible authorities and, in certain notable instances, from the physical examination of work accomplished. The methods used to develop the data should be explained along with appropriate comment on how the information was assembled, verified and cross-checked. There probably would be merit in repeating that the facts and figures are those which were furnished by the contractor or his staff, and remained unaltered by arranging them in the manner called for by the conventions of the technique. As the final step of this first phase, the group leader might wish to indicate in a general way, the method of compilation, the relationship between the various levels of Line of Balance charts, and the need for each.

7.6 In the next phase of the presentation, other members of the survey team should be called upon to interpret each of the Line of Balance charts, remembering that many of the listeners are unfamiliar with the technique and so will require explanation of some fairly elementary features. It most often will be desirable to assign responsibility for presenting detailed information to the specialist in each such area. Having consideration that these men are specialists and because of this they probably failed to make broad contacts during the survey, it is likely then that some of them will be unacquainted with a number of those present. Introductions will clarify the situation and help toward an understanding of what has been done, and by whom.

7.7 As a conclusion to the conference, the group leader will summarize the findings of the survey group and make pertinent observations concerning existing or threatening problems to which responsible management should give special attention. He will point out the recommended actions required by the contractor, or others, to maintain the project on schedule and, as the basis for measuring performance, emphasize the importance of updating the charts on a regular schedule.

7.8 After the team has completed its presentation, company executives may be called upon to comment on the results of the survey and the information presented on the charts. It is sometimes advisable to leave the charts on exhibition for a time after the formal presentation has ended, so that they will be available for use in connection with individual questions, comments and discussion.

Chapter VIII CONTINUING ANALYSIS

Chapter VIII

CONTINUING ANALYSIS

Importance of Updating

8.1 Once the Line of Balance installation has been made it is vitally important to make certain that the facts will be kept up to date. The responsibility for insuring that the updating is done promptly and adequately is one which the FAA/BRD project manager cannot delegate to others. Even though the primary responsibility for updating the development information is that of the contractor's management, it also is essential that the FAA/BRD project manager review and approve the feedback system.

8.2 A one-time Line of Balance survey provides only a still picture of the development process as of the date that the survey was made. Accordingly, its usefulness is limited. It is the regular investigation and periodic updating of the Line of Balance chart that results in the greatest good and provides a basis upon which action can be taken to maintain the project on schedule.

8.3 Any changes that occur in the objective, in the plan, or in the progress, and those necessitating contractual changes or deviations from planned funding, will be brought into immediate focus by this recurring review. As a result, preventive or remedial measures can be instituted promptly and at points where they are needed. The effectiveness of these actions can be judged quite readily and decisions made as to whether any additional effort is required.

Process of Updating

8.4 The working level supervisor himself is the source of the updating information. It is his responsibility to monitor progress and cost at the operating level. Under the Line of Balance method, this is accomplished by verifying the completion of the tasks shown on the flow diagrams. Cost information is collected by means of the established work order numbering system, and reported back to working supervision in the form of a tab run such as is to be seen in figure 8-1.

8.5 The information developed from the Level III flow diagrams is applied to the Level II charts for updating purposes. The number of Level III sensors completed as of the survey date, divided by the number of sensors scheduled for accomplishment, governs the height of the corresponding bar representing accomplishment on the Level II chart. Completed sensors which are not scheduled for accomplishment as of the survey date are not counted in arriving at the completion ratio. The reason for this, of course, is to point out the limiting sensors.

8.6 The expenditure bar of a Level II sensor is determined by establishing the actual costs (translating the manhours and material into cost) and dividing the figure by the scheduled cost. This ratio is then applied against the Line of Balance to indicate the extent to which the group of sensors are operating below, equal to, or exceeding the planned cost.

8.7 The Line of Balance should be drawn for every progress bar that is scheduled for action during the period covered by the survey. Because the line is derived with respect to time, the level of the Line of Balance on all succeeding charts will continue to change until the work has been completed.

8.8 In preparing the Level I chart, the group of Level II sensors which are combined

CRN	DEPT	DES	ORD	PH	TOT BUD	TD BUD	TD ACT	BI-WKLY	WKS-08-12-08-19 1960
10980	562	TAC. MECH. D & D	423	7			610.1	36.0	
10980	525	TAC. MECH. D & D	423	8			62.0		
10980	562	TAC. MECH. D & D	423	8			138.3		
10980	562	TAC. MECH. D & D	423	9			461.0	8.0	
10980	562	TAC. MECH. D & D	423	10			708.4	8.0	
					2355.0*	*	6932.8*	269.0*	
10980	526	TAC. ELEC. D & D	424				20.0		
10980	562	TAC. ELEC. D & D	424				20.0 CR		
10980		TAC. ELEC. D & D	424	1	10480.0		CR		
10980	526	TAC. ELEC. D & D	424	1			2974.3		
10980	562	TAC. ELEC. D & D	424	1			1792.4		
10980	526	TAC. ELEC. D & D	424	2			180.0		
10980	562	TAC. ELEC. D & D	424	2			45.5		
10980	526	TAC. ELEC. D & D	424	3			193.1		
10980	562	TAC. ELEC. D & D	424	3			250.8		
10980	526	TAC. ELEC. D & D	424	4			417.4		
10980	562	TAC. ELEC. D & D	424	4			142.5		
10980	526	TAC. ELEC. D & D	424	5			949.8		
10980	562	TAC. ELEC. D & D	424	5			2801.9	708.3	
10980	562	TAC. ELEC. D & D	424	6			246.9	111.4	
10980	526	TAC. ELEC. D & D	424	7			233.2		
10980	562	TAC. ELEC. D & D	424	7			158.0	4.0	
10980	562	TAC. ELEC. D & D	424	8			567.2		
10980	562	TAC. ELEC. D & D	424	9			1614.8	70.9	
10980	562	TAC. ELEC. D & D	424	15			7.5	7.5	
					10480.0*	*	12575.3*	902.1*	
10980	562	ECM-SYST TEST	425	5	.		2.0		
					*	*	2.0*	*CR	
10980	521	ECM-REPORT PREP	426	1	.		204.5		
10980	522	ECM-REPORT PREP	426	1			8.0		
10980	524	ECM-REPORT PREP	426	1			12.0		
10980	552	ECM-REPORT PREP	426	1			410.4	12.0	
10980	562	ECM-REPORT PREP	426	5			8.0		
					*	*	642.9*	12.0*	
10980	525	R/A SHOP SUPPORT	479	1	.		8.0		
10980	562	R/A SHOP SUPPORT	479	1			758.6	256.1	
10980	562	R/A SHOP SUPPORT	479	3			38.0		
10980	562	R/A SHOP SUPPORT	479	7			4.0		
					*	*	808.6*	256.1*	
10980	580	GRP ADMIN ACCESS	600	1	500.0		101.1		
					500.0*	*	101.1*	*CR	
10980	584	ACCESS SYS DES	612	20	.		16.0		
					*	*	16.0*	*CR	
10980	584	PWR SYS DES	622				16.5		
10980		PWR SYS DES	622	1	90.0		CR		
10980	584	PWR SYS DES	622	1			4.0		
10980	584	PWR SYS DES	622	23			259.8		
					90.0*	*	280.3*	*CR	

Figure 8-1 Tab Run

to form a Level I sensor are also measured from the standpoint of progress and cost. The same system is used to calculate the percentage of completion and expenditures for the Level I charts as was described above for the Level II chart.

8.9 To update the objective section of the charts, the pertinent cumulative expenditures are plotted on each related Level II chart, and the total of all is drawn on the Level I chart.

Frequency of Review

8.10 It is necessary to make an orderly review of the program on a periodic schedule. Subject to any special requirements of the contractor or the FAA project manager, the following time intervals are recommended:

Review	Frequency
a. Level III Flow Diagram	Prepare once a week and report every two weeks.
b. Level II charts	Review and report every two weeks.
c. Level I charts	Review and report once a month... The cut-off date should be the end of the contractor's accounting month...

8.11 Because of the lag in collecting cost information, there is usually a delay of not less than one to three weeks before the actual expenditures are available. This delay often can be reduced to about seven to ten days by speeding up the collection and processing of the time cards and material obligations. An additional week may be allowed for the preparation and submission of charts, making a normal allowable 15 to 20 days between the end of the accounting period and the finish of its posting on the Line of Balance reports.

Format of Reporting

8.12 Progressing the Line of Balance installation is accomplished through routine reports which pinpoint deviations from the plan. In addition to updating of the flow diagram, the Level II charts and the Level I charts, there are several supporting reports which identify the current problem areas and indicate action which has been or can be taken to alleviate the situation. These reports contain a statement of deviations, the cost status information, and any recommendations for management's consideration and attention.

Deviation Reports

8.13 The deviation reports will furnish the FAA/BRD project manager with necessary supporting information on current or anticipated problem areas. Under the Line of Balance system the deviation reports are invariably prepared at the operating level and are intended to reflect deviations from the plan shown on the flow diagram. These reports are then analyzed and integrated to be used as a deviation report for the related Level II charts. Finally, there should be prepared a consolidated deviation report applying to the

Level I chart reporting any existing problems which may affect planned progress.

8.14 The quality and accuracy of the deviation reports are extremely important if they are to be of use in appraising the progress of the contract. It is essential to define the problem clearly and succinctly, and all corrective action already taken or recommended should be unequivocally stated. During the early period of an installation, there is a marked tendency to describe the symptoms rather than the roots of the problems. Therefore, considerable probing may be required initially to acquaint the supervisor, the contractor's project manager, the contractor's top management and the FAA/BRD project manager with the type of information that is needed in the communication chain.

8.15 A Level II deviation report for developmental electronic equipment is exemplified by figures 8-2a, 8-2b, and 8-2c. It will be seen that the problem areas of the program have been defined as follows:

1. Delay in the basic systems layout for the comparators and interpolators requiring schematic tie-in.

2. Space allotted for magnetic heads inadequate.

3. Delay due to inability to find standard value transistors for buffer amplifier design.

The following action has been taken or is in process:

1. Assigned additional specialist to the staff for the study of the program.

2. Authorized overtime work to solve the configuration problem.

3. Purchasing is seeking other sources in its search for standard value transistors for the buffer amplifier design. Also there is a back-up design if the standard transistors cannot be procured.

Unless additional corrective action can be taken, the final drawings will be two to three weeks late in being made available to manufacturing.

The Review Process

8.16 An orderly system of review is essential to the operation. Because feedback of cost and progress information provides the supervisor with the most effective means of monitoring progress, he should follow these items closely and report to the project manager, concerning any anticipated or actual deviations from the plan.

8.17 The flow diagrams should be available for reference and kept current so that they can be monitored by the persons directly involved in the operations. This action insures the recognition of responsibility both for performance and for accomplishment. It also gives both the supervisor and the project manager the early opportunity to note and correct impending deviations from the schedule. It is vitally important nonetheless that the number of individual flow charts be held to an absolute minimum so as to avoid unnecessary paper work. The individual flow diagram forms should be used to their full capacity and made to serve more than just a single limited operation wherever it is possible to

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DEVIATION REPORT

FXXXXXXXX Level II - I Chart PAGE 1 PROJECT Computer Program DEPT. R & D PERIOD Oct. 28

ORIGINATOR R. J. Clark SUPERVISOR D. Dunbar

SENSOR STATUS

COMPLETE TO DATE 1 to 17, 18, 19, 22, 23, 25 to 28 SCHEDULED THIS PERIOD 24 to 28 COMPLETE 25 to 28 INCOMPLETE 20, 21, 24

SENSORS DEVIATING FROM SCHEDULE

NO.	ACTION DENOTED BY SENSOR	PROBLEM	ACTION TAKEN	INTEGRATED FLOW DIAGRAM DATE	CURRENT EST. DATE
20	Compl. Elec. Design Program and time units	Delay due to inability to find standard value transistors for buffer amplifier design.	Purchasing has attempted to find additional sources of specialized transistors. Supplement design is being developed for use if the transistors cannot be procured.	Sept. 1	Nov. 15
21	Complete study program for DFG	Basic systems layout for the comparators and interpolators require schematic tie-in. Arithmetic unit required more time than anticipated.	An additional specialist was added to the staff on Sept. 1 .	Sept. 15	Nov. 15
24	Start design comparators and interpolators	Because of the problem in item 21 start of development (Item 18) was delayed and has prevented completion of this task as scheduled.	Design will be started using preliminary data and will be revised as firm information is available.	Oct. 1	Nov. 24
29	Complete final systems drawings magnetic heads	Space alloted for magnetic heads was inadequate. Therefore, the layouts for the magnetic heads was not complete on Sept. 9. Two weeks were required by mech. configuration design to increase space. As a result, the program slipped 2 weeks.	Overtime was allotted to solve the configuration problem .	Nov. 4	Nov. 18

Figure 8-2 Deviation Report (Sheet 1 of 3)

F-2046

DEVIATION REPORT

XXXXXXXXXX Level II - I Chart PAGE 2 PROJECT Computer Program DEPT. R & D PERIOD Oct. 28

ORIGINATOR R J. Clark SUPERVISOR D. Dunbar

SENSOR STATUS

COMPLETE TO DATE 1 to 17, 18, 19, 22, 23, 25 to 28 SCHEDULED THIS PERIOD 24 to 28 COMPLETE 25 to 28 INCOMPLETE 20, 21, 24

SENSORS DEVIATING FROM SCHEDULE

NO.	ACTION DENOTED BY SENSOR	PROBLEM	ACTION TAKEN	INTEGRATED FLOW DIAGRAM DATE	CURRENT EST. DATE
30	Start detail design comparators and interpolators	Problem stated in Item 24 prevents starting this task as scheduled.	Additional drafting personnel will be applied to expedite completion.	Nov. 15	Dec. 30
32	Avail. to Mfg. detail design program and time units	Late completion of electrical design to Oct. 1 resulted in a 4 week slippage in this area.	Additional drafting personnel will be allocated.	Nov. 30	Dec. 15
33	Complete final systems drawings housing design	Configuration redesign to allow more space for magnetic heads requires redesign of drum housing layouts.	Unaffected portions of housing systems drawings will be sent to design and drafting. One additional specialist is being added to systems work	Nov. 25	Dec. 16
35	Complete development comparators and interpolators	See Item 21	See Item 21	Dec. 26	Jan. 30
39	Avail. to Mfg. detail design drum unit	Because of slippage in Item 29 drafting is behind schedule.	Overtime will be applied in the checking areas.	Jan. 27	Jan. 27

Figure 8-2 Deviation Report (Sheet 2 of 3)

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DEVIATION REPORT

XXXXXXXXXX Level II - I Chart PAGE 3 PROJECT Computer Program DEPT. R & D PERIOD Oct. 28

ORIGINATOR R. J. Clark SUPERVISOR D. Dunbar

SENSOR STATUS

COMPLETE TO DATE 1 to 17, 18, 19, 22, 23, 25 to 28 SCHEDULED THIS PERIOD 24 to 28 COMPLETE 25 to 28 INCOMPLETE 20, 21, 24

SENSORS DEVIATING FROM SCHEDULE

NO.	ACTION DENOTED BY SENSOR	PROBLEM	ACTION TAKEN	INTEGRATED FLOW DIAGRAM DATE	CURRENT EST. DATE
40	Complete elec. design comparators and interpolators	See Item 24	See Item 24	Feb. 1	Feb. 15
32	Avail. to Mfg. detail design program & time units	Late completion of electrical design to Oct. 1 resulted in a 4 week slippage in this area.	Additional drafting personnel will be allocated.	Nov. 30	Dec. 15
41	Start Sub-assembly fab.	Because of late releases, start of sub-assemblies will be delayed.		Jan. 31	Feb. 15
42	Avail to Mfg. detail mech. design drum unit	Behind in drafting, cabling and housing design because of eng. changes to allow more space.	Additional drafting personnel will be allocated.	Feb. 24	Mar. 10

Figure 8-2 Deviation Report (Sheet 3 of 3)

do so. While it is impossible to provide a fixed ratio of the number of individual flow diagrams to a Level II chart because it would vary so greatly from project to project, it does seem that a single Level II chart, or its equivalent Level III Integrated Flow Charts, can be made to represent not less than ten to twelve individual flow diagrams.

8.18 Deviation reports should be carefully reviewed by the supervisors. If need arises, conferences with cognizant personnel will develop a clearer picture of the program status and the required corrective action.

8.19 The detailed review process usually will be followed by bi-weekly meetings of the contractor's project manager and his staff for discussion of the Level II Line of Balance chart and its corresponding deviation report. In preparation for these meetings there should be a review of the Level III deviation reports and problem areas. The agenda for the meeting will provide for an examination of all deviations from the Level II plan, with special emphasis on clarifying the problem areas and specifying the actions that are required to alleviate the situation. With advance planning and proper chairmanship, the meetings can be limited to an hour, or at most an hour-and-a-half.

8.20 The ultimate step in continuing analysis is the preparation of the Level I chart and its deviation report for the FAA/BRD project manager. The completeness of the report as well as the speed with which it is submitted are factors having an important bearing on the efficacy of management. When deviations appear on the Level I charts, it would be appropriate for the FAA/BRD project manager to request the related Level II charts and deviation reports. Under ordinary circumstances, a project manager should expect to be kept advised of significant deviations on a daily basis, receiving his initial notification within forty eight hours of its detection. For this purpose, a significant deviation may be defined as one that threatens to cause an overrun, a delay in delivery, or a compromise in performance.

8.21 While not an integral part of the Level I Line of Balance report, a project manager may wish to transmit his report under cover of a letter giving a brief summary of the situation, a comparison of the original bid, the contract prices, the actual costs being experienced, and other pertinent details. Because of the very limited distribution of such a letter, it would serve also as the means for communicating information or recommendations of a private nature. The form appearing as figure 8-3 has been found convenient by one contractor for internal use within the company as an enclosure to a letter of the type just described. With little effort, it can be modified to satisfy the needs of most other contractors.

8.22 For the orderly review of progress and the determination of actions required by FAA/BRD, joint monthly status meetings have been found desirable. These sessions afford an opportunity for open discussion of matters having mutual interest, to request additional comments on the program status, and to secure further amplification of the problem areas. The decisions should be formally recorded and transmitted to participating members of the joint group for follow-up action. By careful joint planning, these meetings will serve to develop a mutuality of interest and coordination in dealing with matters affecting program status.

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(CONTRACT)

CONTRACTUAL DATA

	DATE
DATE OF CONTRACT	
ORIGINAL CONTRACT PRICE OF PRIME EQUIPMENT	$
ORIGINAL CONTRACT PRICE OF OTHER ITEMS	$
CURRENT CONTRACT PRICE OF PRIME EQUIPMENT	$
CURRENT CONTRACT PRICE OF OTHER ITEMS	$
AUTHORIZED CHANGES AWAITING NEGOTIATION (PRIME ONLY)	$
AUTHORIZED CHANGES AWAITING NEGOTIATION (OTHER ITEMS)	$
ORIGINAL CONTRACT DELIVERY DATE	
ADJUSTED CONTRACT DELIVERY DATE	
DELIVERY DATE REPORTED TO CUSTOMER	
DATA FREEZE DATE	
TYPE OF CONTRACT	

REMARKS

SUBMITTED BY

CURRENT COST STATUS

DATE

A. ITEM 1					
ITEM	ORIG. EST.	BID	CONTRACT	EXPENDED	EST. @ COMP.
MFG. HRS.					
ENG. HRS.					
R & D HRS.					
PUBL. HRS.					
SERVICE HRS.					
MAT'L DOLLARS					
FACTORY COST					
SELLING PRICE					
B. OTHER ITEMS					
MFG. HRS					
ENG. HRS.					
R & D HRS.					
PUBL. HRS.					
SERVICE HRS.					
MAT'L DOLLARS					
FACTORY COST					
SELLING PRICE					

REMARKS

SUBMITTED BY

Figure 8-3 Contract and Financial Data Form

Chapter IX THE DPC PHASE B PROGRAM

Chapter IX

THE DPC PHASE B PROGRAM

9.1 FAA experience in installing its management control system for the Data Processing Central at NAFEC affords an excellent means of demonstrating the application of Line of Balance to a major development program. For simplicity and clarity, the data included have been modified in order to provide a more instructive example and, therefore, should not be interpreted as an accurate plan or schedule of that activity. This case study illustrates the broad range of responsibilities which must be suitably integrated in order to obtain adequate control. The description of the means by which widely diversified activities of large numbers of personnel were directed, and the method that was used to coordinate the efforts of all contributing contractors, should prove extremely beneficial to any task manager who is faced with the necessity of establishing controls over a development program.

Historical Background

9.2 The DPC program was initiated by the Airways Modernization Board, now BRD of FAA. Its objective was the development of a semi-automatic air traffic control data processing and development system which could be applied to the national air traffic control system. This was a large, complex undertaking involving the design, fabrication, test, and evaluation of an air traffic control system including equipment employing digital computers and visual display.

9.3 The test and evaluation of this system (referred to as Phase B) required effective employment of many personnel of diverse talents (engineers, traffic control specialists, computer programmers) and appropriate scheduling of financial resources. Starting in early November 1959, the Test and Experimentation Division of the BRD located at NAFEC was assisted by supporting contractors in the making of a Line of Balance installation. This initial effort was limited to Group I equipment, and consisted of the preparation of individual flow diagrams, a Level III Integrated Flow Chart and a Level II Line of Balance Chart. Subsequently, Line of Balance controls were extended over Groups II and III equipment and the installation was fully established prior to the end of March 1960.

Equipment Grouping

9.4 Better to allow testing and evaluation programs to be conducted in parallel, the Phase B equipments had been divided into three categories, each of which was capable of performing certain more or less independent air traffic control functions. Group I was comprised of equipment related to the enroute sector; Group III equipment was concerned with the transition and terminal portion of the air traffic control program, while Group II was termed the System Application Peel Off (SAPO) Group and was intended to provide an abbreviated system test capability prior to the availability of the complete system test complex.

Planning Effort

9.5 In addition to that associated with the three above named equipment groups, certain additional planning effort was required to bring these individual enterprises into a cohesive whole. This would cover operational programming, support programming, cable design and manufacture, system coordination, the design and production of suitable test equipment, and the establishment and operation of a test environment.

Planning the Installation

9.6 The DPC installation of Line of Balance was to be made under the direction of the Experimentation and Evaluation Branch of BRD, using contractor assistance to supplement the work to be done by the T&E Division engineering staff. The basic assumptions and ground rules for chart preparation, initially, were to be proposed by the contractor and reviewed or adjusted as necessary to meet the requirements of the task manager. Individual flow diagrams next were to be prepared within the established bounds prescribed by each responsible supervisor, whether contractor or FAA, and then combined into Level III Integrated Flow Charts as a test for feasibility. These Level III Charts next would be carefully examined by NAFEC management from the standpoint of computer capacity, availability of test equipment, readiness of installation area, probability of achieving a manpower build-up of the order envisioned and of the type required, and obtaining necessary authorizations and approvals, or other factors of like import.

9.7 Having accomplished this feasibility check and assured the practicability of the plan, the next sequential step was that of preparing the appropriate Level II Charts. This task fell to the supervision of the Technical Operations Unit, which activity also would be assigned responsibility for developing the Level I Line of Balance chart covering the entire Phase B, DPC project.

9.8 Because identical plans were proposed and carried out for each equipment group, and because the development of the data for each such group follows a very similar pattern, in the interest of brevity and clarity this discussion will be concentrated on events which are incident to Group I activity.

Getting Started

9.9 At the time of initiating this installation, there was in existence a tentative plan for the test and evaluation of Groups I, II and III equipment. Because of the urgency of getting started, a decision was made to utilize as much as possible of the plan as it then stood (figure 9-1) in lieu of preparing the customary Provisional Level I chart. The plan was adjusted calendar-wise and brought into line with the changes that had occurred between the date of the latest revision and the date of the survey. Thereafter this chart was treated and used as though it had been prepared in the standard Line of Balance format for a Provisional Level I chart.

Group I Equipment

9.10 As has been stated previously, the enroute functions of the DPC were to be discharged by Group I equipment. All of the functions to be performed were broken down into five categories: Function 1, Flight Plan Processing and Distribution; Function 2, Automatic Updating of Flight Plan Information, Function 3, ANC Conflict Prediction; Function 4, Bright Radar Display; and, Function 5, Flow Control. The technical testing and evaluation of these functions were arbitrarily divided between Group I and Group II equipment, with Functions 1, 3 and 5 being tested with the former.

9.11 Included in Group I were the following equipments:

1 Data Processor
1 Buffer Drum
5 File Drums

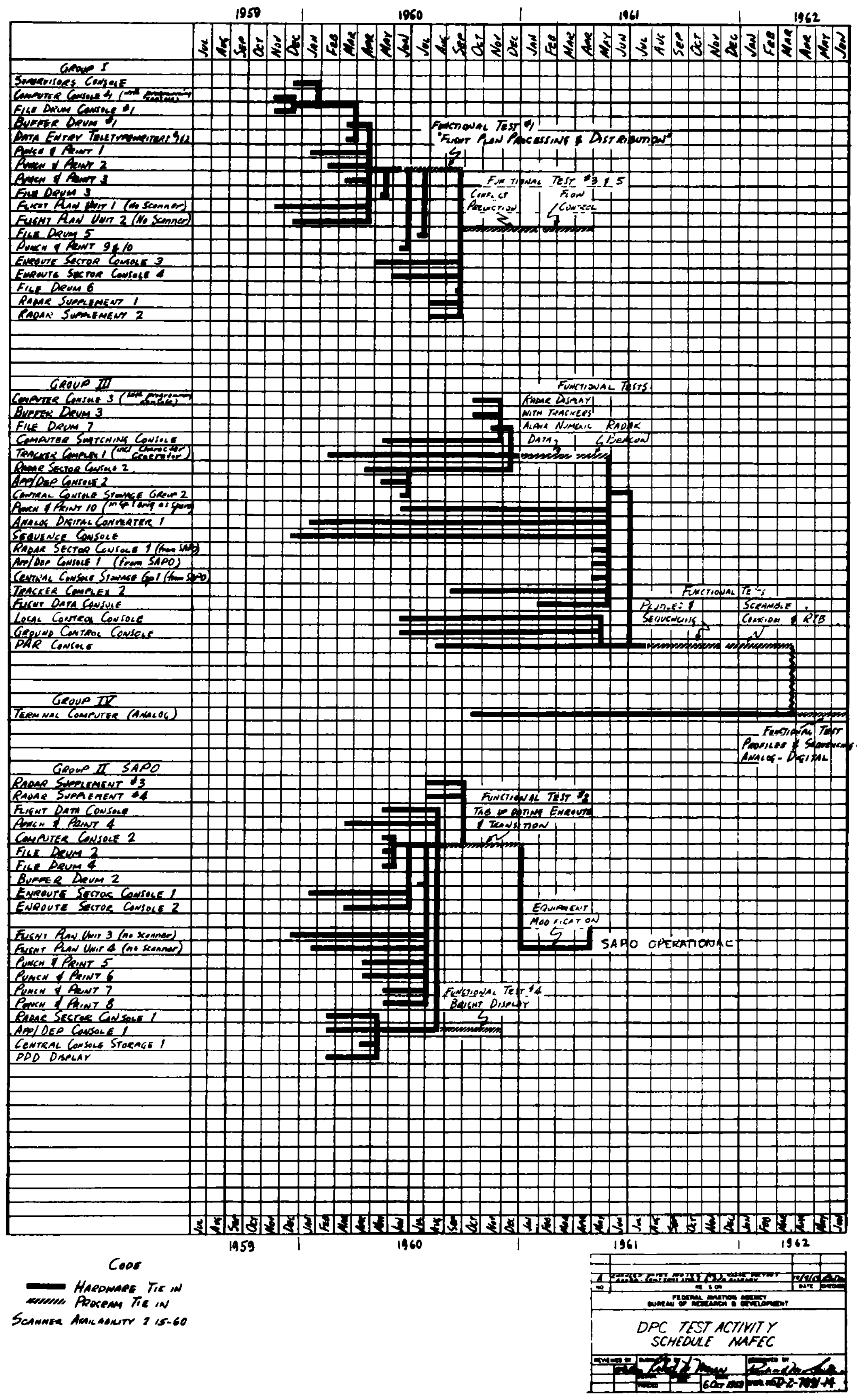


Figure 9-1 NAFEC - Provisional Level I

2 Enroute Sector Consoles
6 Punch and Printers
2 Flight Plan Groups
1 Flow Control Console
Assorted Teletype Equipment

Group I responsibilities also included any operational programs and technical programs which might be deemed necessary to prove the assigned functional areas, the interconnection and test of the various units of hardware and their tie-in to the data processor itself.

Ground Rules and Assumptions

9.12 Preliminary to starting the program analysis, the Task Manager and the Contractor agreed upon certain ground rules and assumptions which were to be used in preparing the Individual Flow Diagrams and the Level III charts. Some of these rules were adopted from conventional or standard practices, others were tailored to fit the situation as will be seen by the following:

9.12.1 Delivery of equipment to NAFEC will be in accordance with the current delivery schedule.

9.12.2 Standard test equipment will be furnished by FAA as required, on not less than thirty days advance notice of peak requirements.

9.12.3 Special test equipment will be available when required.

9.12.4 Requirements for design and drafting services will be satisfied by FAA personnel.

9.12.5 Spare parts will be furnished in the following manner:

Peculiar spares and assemblies will be provided by the contractor;

Bulk spares will be provided by FAA or under call contract with the supplier;

Replacement of used spares will be made by FAA or under call contract with the supplier.

9.12.6 Repair of spare assemblies or major units will be made by separate calls on the contractor.

9.12.7 Any major equipment rework will be handled under separate arrangement.

9.12.8 FAA will provide, install, and maintain Government furnished equipment as required.

9.12.9 Test and verification programs for interconnection to adjacent centers will be supplied by FAA in accordance with the pertinent System Functional Test Specification.

9.12.10 NAFEC will provide on-base model shop facilities as required.

9.12.11 FAA will maintain all special test equipment.

9.12.12 The probability factor for time and cost estimates will be 70-80 percent.

9.12.13 Level III charts will reflect only the effort to be expended by the contractor and will not include services provided by the FAA.

9.12.14 Once approved, Level III charts will not be altered without coordination between the contractor and the Task Manager.

9.12.15 Work will not be performed unless it appears on an approved Level III chart.

9.12.16 Budgets will be established in accordance with the estimates appearing on Level III charts.

9.12.17 The contractor will develop and maintain all Level III charts relating to his work.

9.12.18 FAA will develop and maintain all Level II and Level I charts.

9.12.19 Expenditures will be reported by Level II chart, by track number, and by sensor.

9.12.20 Integrated Flow Diagrams will be used as the basis for reporting Level III deviations.

Task Breakdown and Analysis

9.13 It was decided that Phase B effort would be assigned to some recognizable element of the DPC project so that the various tasks and sub-tasks could be categorized and related. It was found, in general, that they could be associated with the functional characteristics of the ATC system, with the installation and tie-in of specific pieces of equipment, with some sub-system or system test, or with the specifications and writing of the data processor programs. At this point it appeared reasonable to separate the Group I tasks into the following areas:

9.13.1 Interconnection Test Specifications;

9.13.2 Interconnection Test Programs,

9.13.3 Installation, Installation Test and Interconnection Test of·

Input/Output Teletype Equipment
Flight Plan Groups
"R" Register Equipment
Flight Strip Punch and Printers
Data Processor and associated equipment;

9.13.4 Equipment Maintenance Procedures;

9.13.5 Equipment Maintenance Programs;

9.13.6 Sub-system Functional Test Specifications,

9.13.7 Sub-system Functional Tests;

9.13.8 System Functional Test Specifications,

9.13.9 System Functional Tests; and,

9.13.10 Planning and Control of the Operation.

Measurement of Tasks

9.14 Each of these task areas was studied with a view toward separating it into component parts so that they could be measured for work content. Estimators were enjoined to use actual experience on comparable equipment whenever possible, and to use the most considerate judgment when extending past experience into unknown areas. Although there was to be included no built-in estimate for catastrophic-type failures, it was contemplated that appropriate allowances would be made for anticipated problem areas and for any other expected delays or difficulties. All subtasks were further sub-divided each of them being individually estimated for the manhours necessary to complete any one phase. At the same time equal consideration was given to the cost of materials that would be required at various times, and these were entered separately as additional factors for consideration in executing the program.

Individual Flow Diagrams

9.15 Using guide lines established by the ground rules and assumptions previously promulgated under direction of project management, working level supervisors proceeded to prepare individual flow diagrams for each of the tasks that had been set forth as the result of the task analysis.

Manpower Requirements

9.16 Then, by totalling the individual manhour estimates for given calendar periods, it was easy to determine the build-up in manpower that the work required. It was observed that a portion of this strength could be transferred from the work force that was currently engaged in the Phase A operation. The balance, of course, had to be recruited or made up by other means. An increase in the length of the work week from 40 to 44 hours could provide some of the needed manpower. For the remainder required, plans were made to obtain the necessary authorization and to process personnel requisitions on an accelerated basis, past experience having shown that it required an appreciable time to obtain qualified talent of the type required. An historical factor also was applied to indicate probable success in recruiting for established grades, especially those accorded among senior engineers. To cover unseen contingencies, special engineering consulting services and any technical assistance required during installation or while making minor modifications, there was established an arbitrary allowance of 15% of the gross manhour requirements. This proved to be entirely adequate for the purpose intended.

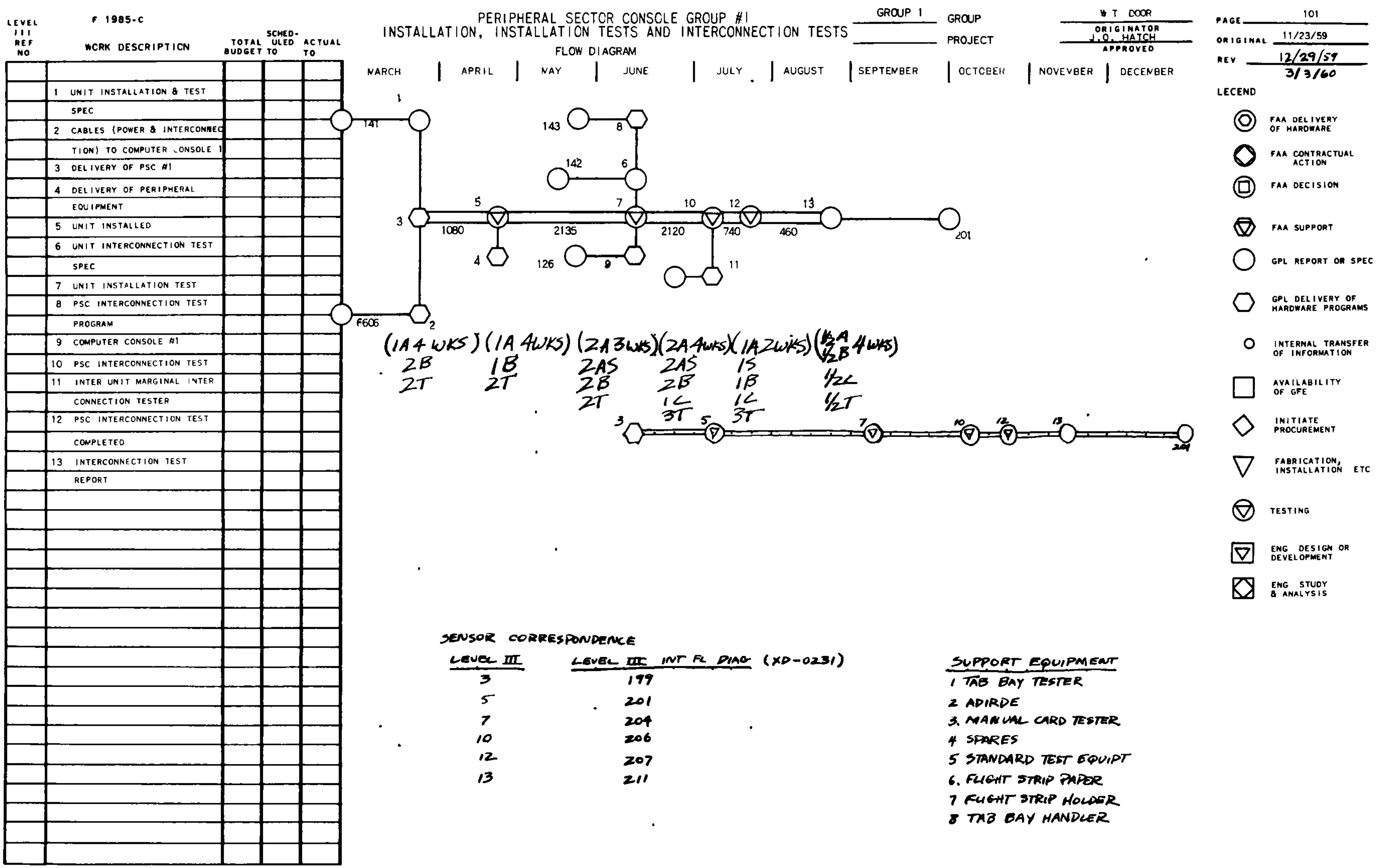


Figure 9-2 Individual Flow Diagram for Peripheral Sector Console

9.17 Figure 9-2, illustrating the plan for installing a Peripheral Sector Console and for conducting its installation and interconnection tests, is an example of a typical Individual Flow Diagram as it comes from a working level supervisor. As in this instance, it often will be found that the format and symbology is not according to prescribed standards. But if the basic information is provided, the project manager will be well advised to make the necessary corrections himself, rather than to generate additional paper work and disgruntle his working level supervisors. At some later time, say before the next report is due, it might be well to meet with the individual concerned for the purpose of pointing out any desired corrections and the necessity for standard presentation.

9.18 The Individual Flow Diagram shown in figure 9-2 represents the schedule for installing and testing a Peripheral Sector Console (PSC) as the plan was originally conceived. Sensor 3 indicates that PSC 1 would be delivered during the third week of March 1960 along with necessary power and interconnecting cables to computer console 1 (sensor 2) and with the unit installation and test specifications that are represented by sensor 1. This diagram also shows that the installation should be completed by the third week in April 1960, with a planned expenditure of 1080 manhours. The final event in the sequence was to take place during the third week of August 1960, with the release of an interconnection test report, sensor 13.

9.19 As frequently happens, it was not possible to proceed as intended, in this case because delivery of the peripheral sector console was delayed until June 1960. Being no more than a working document for departmental use alone, the individual flow diagram was informally altered in pencil by the responsible supervisor, who did not consider it necessary to redraft the diagram on that account.

Inputs and Outputs

9.20 One of the very valuable benefits that is an outgrowth of preparing individual flow diagrams and Integrated Flow Charts, is the so-called Input-Output list. This consolidated list enumerates the supporting actions, services or materials that must be provided to each working level supervisor if he is to perform his assigned tasks and deliver his designated outputs on time. This listing includes not only the nomenclature and description of the pertinent sensor, but also the date that the input is expected, an identification of the activity that is responsible for furnishing it, a cross-reference to other Line of Balance charts on which the action or items is represented, the date when the input (or output) is required to be available, and the name of the cognizant working level supervisor. A representative page from the Input/Output list for the Group I Integrated Flow Chart is reproduced in figure 9-3 as an example of a form that can be used to make an orderly comparison of the requirements of the plan with the prospective availability of the items called for by the supervisors.

The Group I Integrated Flow Charts

9.21 In the case under study, all of the information presented on Group I Individual Flow Diagrams was brought together on a pair of Level III Integrated Flow Charts so that the overall plan could be examined in combination. One of these Integrated Flow Charts is shown in Figure 9-4a. The arrangement of somewhat more than 300 sensors shows that the equipment was grouped according to the way in which it was intended to tie into the computer. It can be seen that the Buffer equipment plan and the R Register equipment plan are arranged respectively above and below the Data Processor plan, the interrelationship being defined by vertical lines connecting mutually dependent events. Solid lines

LIST OF INPUTS/OUTPUTS

GROUP I, LEVEL III, I F D

Sensor No	Sensor Title	By	I/0	Date	Cross Reference	Date	Cognizance
35	Disposition Console Test Set	GPL	I	4/21/60			Holliday
36	Cables FPG No 1	GPL	I	4/21/60	6620	4/21/60	Bierman
37	Delivery of Disposition Console No 1	GPL	I	4/21/60	Delivered		Phase A
39	Availability of Installed FLIDEN Unit	FAA	I	5/ 7/60	Available		E Jones
40	Availability of 28 ASR Installed	FAA	I	5/ 7/60	--	5/ 7/60	D Rogers
48	FPG No 1 Test Report (15 Pages)	GPL	0	11/15/60	--		Tech Services
49	Cables Distribution Scanner	GPL	I	4/21/60	6628	4/21/60	Bierman
51	Delivery of Distribution Scanner	GPL	I	4/21/60	Delivered		
52	Availability of 28 RT Units Installed	FAA	I	5/ 7/60	--		D Rogers
55	Cables FPG No 2	GPL	I	4/21/60	6621	5/27/60	Bierman
56	Delivery of Disposition Console No 2	GPL	I	4/21/60	Delivered		Phase A
58	Availability of Installed FLIDEN Units	FAA	I	5 7/60	Available		E Jones
59	Availability of 28 ASR Installed	FAA	I	5/ 7/60			D Rogers
65	FPG No 2 Test Report (15 Pages)	GPL	0	11/ 1/60	--		Tech Services
66	Cables FPG No 3	GPL	I	4/21/60	6522	4/21/60	Bierman
67	Delivery of Disposition Console No 3	GPL	I	4/21/60	Delivered		Phase A
72	FPG No 3 Test Report (15 Pages)	GPL	0	11/ 1/60	--		Tech Services
73	Cables FPG No 4	GPL	I	4/21/60	6623	4/21/60	Bierman
74	Delivery of Disposition Console No 4	GPL	I	4/21/60	Delivered		Phase A
79	FPG No 4 Test Report (15 Pages)	GPL	0	8/ 1/60	--		Tech Services
81	Cables Adjacent Center Monitor	GPL	I	4/21/60	6626	4/21/60	Bierman
82	Delivery of Adjacent Center Monitoring Panel (2)	GPL	I	4/21/60	Delivered		Phase A
88	Adjacent Center Monitor Test Report (15 Pages)	GPL	0	11/15/60	--		Tech Services

Figure 9-3 Input/Output List for Level III IFC

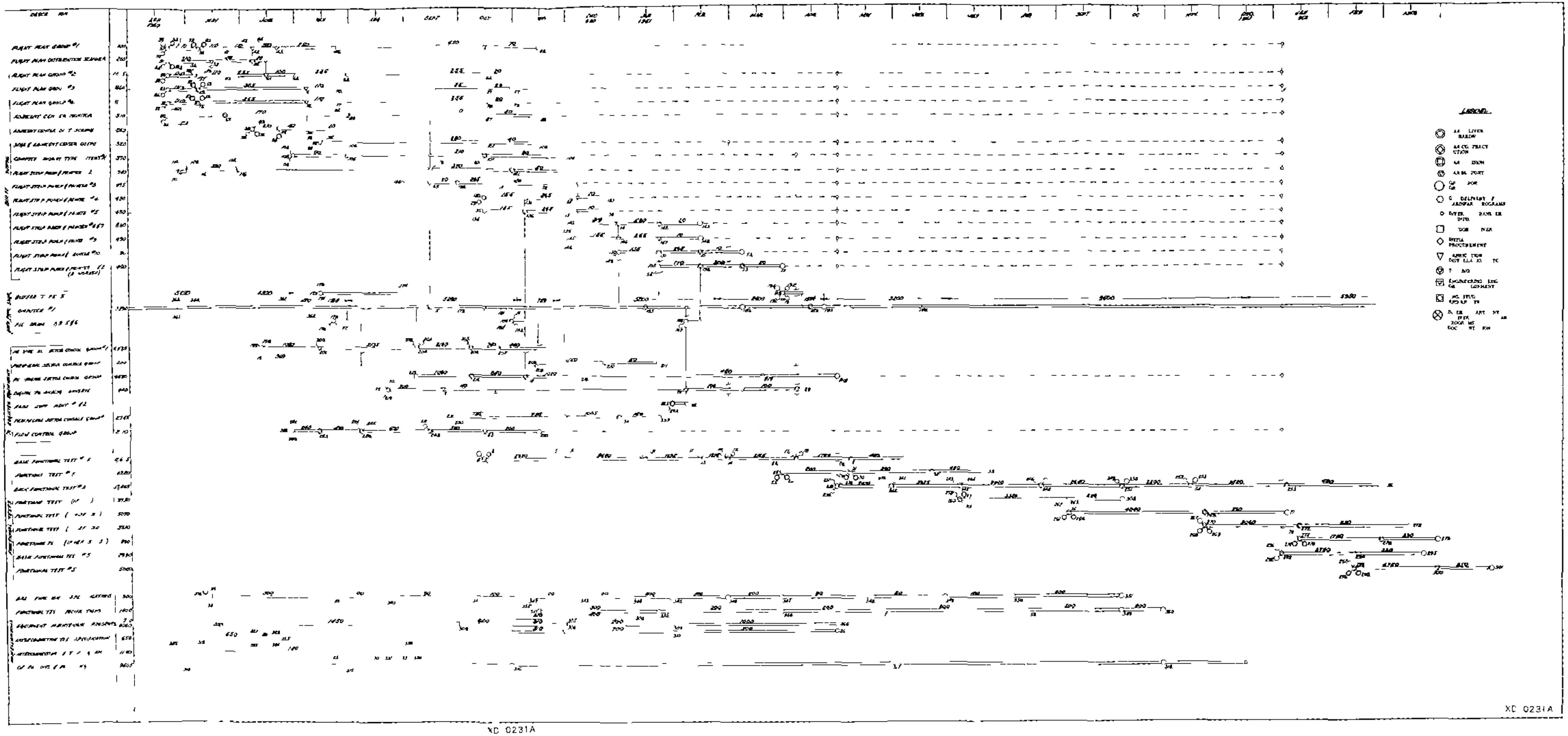


Figure 9-4a Level III Integrated Flow Chart Group I

1. Test Specification - 1A
2. Programming Package - 1A
3. Test Program
4. Complex Ready for Test
5. Test Specification - 1B
6. Programming Package - 1B
7. Test 1A Completed
8. Test Specification - 1C
9. Programming Package - 1C
10. Test 1B Completed
11. Test Specification - 1D
12. Programming Package - 1D
13. Test 1C Completed
14. Test Specification - 1E
15. Programming Package - 1E
16. Test 1D Completed
17. Basic Functional Test Specifications - 1F
18. Basic Functional Programming Package - 1F
19. Test IE Completed
20.
21.
22. Basic Functional Test IF Completed
23. Test Report
24. UNIVAC ATC-DPC Interconnection Test Program
25. UNIVAC Program
26. UNIVAC
27. Complex Ready for Interconnection Test
28. Functional Test (1F) Test Specification
29. Functional Test (1F) Test Data
30. UNIVAC Verification Program
31. Complex Ready for Functional Test - 1F
32. Functional Test 1F Completed
33. Functional Test 1F Test Report
34. Disposition Console Installation & Test Specifications
35. Disposition Console Test Set
36. Cables
37. Delivery of Disposition Console #1
38. Disposition Console Installed and Tested
39. Availability of Installed Fliden Unit
40. Availability of 28 ASR Installed
41. #37, 39, 40 Interconnected
42. Interconnection of Flight Plan Group #1 to Distribution Scanner
43. Interconnection Test Specifications
44. Interconnection Test Programs
45. Flight Plan Group #1 Components Interconnected
46. Flight Plan Group #1 Interconnection Test Completed
47. Computer Interconnection Test Completed
48. Test Report
49. Cables
50. Distribution Scanner Test Set (FAA)
51. Delivery of Distribution Scanner
52. Availability of 28 RT Units Installed

Figure 9-4b Sensor Identification IFC (Sheet 1 of 7)

53. Distribution Scanner Installed
54. Distribution Scanner Tested with RT Units
55. Cables
56. Delivery of Disposition Console #2
57. Disposition Console #2 Installed & Tested
58. Availability of Installed Fliden Units
59. Availability of 28 ASR Installed
60. #56, 58, 59 Interconnected
61. Interconnection of Flight Plan Group #2 to Distribution Scanner
62. Flight Plan Group #2 Components Interconnected
63. Flight Plan Group #2 Test Completed
64. Computer Interconnection Test Completed
65. Test Report
66. Cables
67. Delivery of Distribution Console #3
68. Disposition Console #3 Installed & Tested
69. Flight Plan Group #3 Interconnected to Distribution Scanner
70. Interconnection Test Completed
71. Computer Interconnection Test Completed
72. Test Report
73. Cables
74. Delivery of Disposition Console #4
75. Disposition Console #4 Installed & Tested
76. Flight Plan Group #4 Interconnected to Distribution Scanner
77. Interconnection Test Completed
78. Computer Interconnection Test Completed
79. Test Report
80. Unit Installation and Test Specification
81. Cables
82. Delivery of Adjacent Center Monitoring Panel (2)
83. Units Installed
84. Interconnection Test Program
85. Interconnection Test Specification
86. Units Interconnected with Distribution Scanner and Tested
87. Interconnection Test Completed
88. Test Report
89. Unit Installation and Test Specification
90. Cables
91. Distribution Scanner Test Set (FAA)
92. Delivery of Adjacent Center Distribution Scanner
93. Availability of 28RT Units Installed
94. Distribution Scanner Installed & Tested
95. Distribution Scanner Tested with 28RT's
96. Availability of 28RO's (2) Installed
97. Availability of 28ASR's (2) Installed
98. Cables
99. Installation of Units
100. Units Installed and Tested
101. Interconnection Tests Completed
102. Test Report
103. Unit Installation and Test Document
104. Cables Power and Interconnecting
105. Delivery of Computer Inquiry Typewriters (2)

Figure 9-4b Sensor Identification IFC (Sheet 2 of 7)

106. Units Installed and Tested
107. Unit Interconnection Tests Completed
108. Test Report
109. Unit Installation and Test Specification
110. Tape Control Sequences
111. Cables
112. Delivery of Punch and Printer No. 2
113.
114. Unit Installed
115. Flight Strip Holders and Paper
116. Unit Installation Test Completed
117. Interconnection Test Specification
118. Interconnection Test Program
119. Start of Interconnection Test
120. Interunit Marginal Test
121. Unit Interconnection Test Completed
122. Test Report
123. Cables
124. Delivery of Punch and Printer #3
125. Unit Installed
126. Unit Installation Test Completed
127. Interconnection Test Completed
128. Test Report
129. Cables
130. Delivery of Punch and Printer #4
131. Unit Installed and Tested
132. Interconnection Test Completed
133. Test Report
134. Cables
135. Delivery of Flight Strip Punch and Printer #5
136. Unit Installed and Tested
137. Interconnection Test Completed
138. Test Report
139. Cables
140. Delivery of Punch and Printer #6 & 7
141. Unit Installed and Tested
142. Interconnection Test Completed
143. Test Report
144. Cables
145. Delivery of Punch and Printer #9
146. Unit Installed and Tested
147. Interconnection Test Completed
148. Test Report
149. Cables
150. Delivery of Punch and Printer #10
151. Unit Installed and Tested
152. Interconnection Test Completed
153. Test Report
154. Cables
155. Delivery of Punch and Printer #1 & 2 (reworked)
156. Unit Installed and Tested
157. Interconnection Test Completed
158. Test Report
159. * Delivery of Computer #1
160. * Delivery of File Drum #1

Figure 9-4b Sensor Identification IFC (Sheet 3 of 7)

161. * Delivery of Installation and Interconnection Specs.
162. * Delivery of Checkout and Diagnostic programs
163. * Cables
164. * Power on Computer and File - both holding
165. * All Checkout Routines Tested
166. * Acceptance of Computer and File
167. * Cables
168. * Delivery of Installation and Interconnection Test Spec.
169. * Delivery of Sequence Console
170. * Sequence Console Ready for Operation with Computer
171. Cables
172. Delivery of Installation and Interconnection Test Specs.
173. Delivery of Buffer Type I
174. Delivery of Buffer Interconnecting Programs
175. Buffer Ready for Operation with Computer
176. Cables for File Drum #3
177. Delivery of Interconnection Box, Serial #3
178. Delivery of File Drum #3
179. File Drum #3 Ready for Operation with Computer
180. Cables
181. Delivery of Switching Unit
182. Delivery of Interconnection box, Serial #5
183. Delivery of Test Box
184. Delivery of File Drum #5
185. File #5 with Switching Unit Ready for Operation with Computer
186. Summary Report for Tapes
187. Cables
188. Delivery of File Drum #6
189. File Drum #6 Ready for Operation with Computer
190. Summary Report for Files
191. Cables
192. Delivery of Adapter Box and Test Equipment
193. Delivery of Checkout and Diagnostic Programs
194. Delivery of Installation and Interconnection Test Specs.
195. Delivery of Computer Console #4
196. Computer #4 Interconnected with Computer #1 through Switching Unit
197. Cables
198. Delivery of Unit Installation and Test Specs.
199. Delivery of Peripheral Sector Console #1
200. Delivery of Peripheral Equipment Testor or Equivalent
201. P.S.C. #1 Installed
202. Peripheral Sector Console Interconnection Test Program
203. P.S.C. #1 Interconnection Test Spec.
204. P.S.C. #1 Installation Test
205. Interunit Marginal Interconnection Tester
206. Peripheral Sector Console Interconnection Test Completed
207. Interconnection Test Report
208. Interconnection Test Program
209. Availability of Peripheral Sector Console Group #2 from Group II
210. P.S.C. #2 Interconnection Test Completed
211. Test Report
212. Cables
213. Delivery of PSC #3
214. P.S.C. #3 Installed
215. Installation Test Completed
216. P.S.C. #3 Interconnection Test Completed

Figure 9-4b Sensor Identification IFC (Sheet 4 of 7)

217. P.S.C. #3 Tested with Radar Supplement and D/A Converter
218. Test Report
219. Cables
220. D/A Converter Installation and Test Specs.
221. Delivery of D/A Converter
222. D/A Converter Installed and Tested
223. Test Report
224. Cables
225. Delivery of Radar Supplements #1 & #2
226. Radar Supplements Installed
227. Radar Supplement ties to D/A Converter
228. Complex Interconnected
229. Test Completed
230. Cables
231. Delivery of PSC Group #4
232. Unit Installed
233. Installation Test Completed
234. Interconnection Test Completed
235. Test Report
236. Basic Functional Test Program
237. Programming Package to Process Data as Previous plus and Transition of Updates
238. Basic Functional Test Spec. (1F + 2B)
239. Complex Ready for Test
240. Programming Package to Process Data as previous plus, update strips, update transition terminal and adjacent center
241. Basic Functional Test Specs (1F + 2F)
242. Test (1F + 2B) Completed
243. Programming Package to Process Data as Previous plus, Probe Insertion and Conflict Displays
244. Basic Functional Test Specs (1F + 2F + 3A)
245. Test (1F + 2F) Completed
246. Programming Package to Process Data as Previous plus, Display of Conflict requests
247. Basic Functional Test Spec. (1F + 2F + 3B)
248. Test (1F + 2F + 3A) Completed
249. Programming Package to Process Data as Previous plus, weather updated and display plus departure search and updates caused from ETD's
250. Basic Functional Test Spec. (1F + 2F + 3D)
251. Test (1F + 2F + 3B) Completed
252. Programming Package to Process Data as previous plus, flight plan tracking
253. Basic Functional Test Spec. (1F + 2F + 3E)
254. Test (1F + 2F + 3D) Completed
255. Test (1F + 2F + 3E) Completed
256. Test Report
257. Functional Test 1F + 2F Test Data
258. Functional Test #1F + 2F Test Specs.
259. UNIVAC Verification Test and Functional Test #1F + 2F Programs
260. Complex Ready for Test
261. Functional Test 1F + 2F + 3B Test Data
262. Functional Test 1F + 2F + 3B Test Specs.
263. Test 1F + 2F Complete Low Speed
264. UNIVAC Verification Test and Functional Test #1F + 2F + 3B Programs
265. Complex Ready for Test

Figure 9-4b Sensor Identification IFC (Sheet 5 of 7)

266. Functional Test 1F + 2F + 3E Test Data
267. Functional Test 1F + 2F + 3D Test Specs.
268. Test 1F + 2F + 3B Completed
269. UNIVAC Verification Test and Functional Test #1F + 2F + 3B Programs
270. Complex Ready for Test
271. Reports
272. Test 1F + 2F + 3D Completed
273. Reports
274. Functional Test 1F + 2F + 3E Test Data
275. Functional Test 1F + 2F + 3E Test Specs.
276. UNIVAC Verification Test and Functional Programs for Test 1F + 2F + 3E Complex Ready for Test
277. Complex Ready for Test
278. Test 1F + 2F + 3E Completed
279. Report
280. Cables
281. Flow Control Console Installation and Installation Test Specs
282. Delivery of Flow Control Console
283. Flow Control Console Installed
284. Interunit Marginal Tester Interconnection Test Specs
285. Interconnection Test Program
286. Interunit Marginal Tester Installation Test Completed
287. Interunit Marginal Tester Delivery
288. Interconnection Test Completed
289. Marginal Interconnection Test Completed
290. Test Report
291. Flow Control Programming Package
292. Basic Functional Test Specs 1F + 2F + 3E + 5
293. Complex Ready for Test
294. Test Completed
295. Test Report
296. Basic Functional Test #5 Test Data
297. Functional Test #5 Test Specs.
298. UNIVAC Verification and Test Programming
299. Complex Ready for Test
300. Test Completed
301. Test Report
302. Maintenance Test Philosophy
303. Test Report
304. Equipment Study
305. Special Test Program
306. Equipment Diagnostic Program
307. ON and OFF Line Routines
308. Routines
309. Flow Diagram and English Descriptions
310. Flow Diagram and English Translation
*311. Calls
*312. Schedules
*313. Assignments
314. Line Balance Charts
315. Engineering Reports
316. Progress Reports
317. Proposals
318. Recommended Calls
319. Unit Products Specs.
320. Adjacent Center Input, Interconnection Specs.

Figure 9-4b Sensor Identification IFC (Sheet 6 of 7)

321. Computer Inquiry Typewriter Interconnection Specs.
322. Flight Plan Group Interconnection Specs.
323. Adjacent Center (output) Interconnection Specs.
324. Punch and Printer Interconnection Specs.
325. Sage Output Interconnection Specs.
326. PSC and Flow Control Group Interconnection Spec
327. Start of Flow Diagrams
328. Supervisor Console Interconnection Program
329. PSC Group Interconnection Program
330. Punch and Printer Interconnection Program
331. Sage and Adjacent Center Output Interconnection Program
332. Computer Inquiry Typewriter Interconnection Program
333. Adjacent Center Input Interconnection Program
334. Flight Plan Group Interconnection Program
335. Interconnection Program tied together
336. AMB 58-1, AMB 58-2, FAA Drawing B-2-7091-14
337. Basic Functional Test Flow Diagram and English Translation
338. Basic Test Philosophy and Plan
339. Basic Functional Test Spec's (1A)
340. Basic Functional Test Spec's (1B)
341. Basic Functional Test Spec's (1C)
342. Basic Functional Test Spec's (1D)
343. Basic Functional Test Spec's (1E)
344. Basic Functional Test Spec's (1F)
345. Basic Functional Test Spec's (1F + 2B)
346. Basic Functional Test Spec's (1F + 2F)
347. Basic Functional Test Spec's (1F + 2F + 3A)
348. Basic Functional Test Spec's (1F + 2F + 3B)
349. Basic Functional Test Spec's (1F + 2F + 3D)
350. Basic Functional Test Spec's (1F + 2F + 3E)
351. Basic Functional Test Spec's (1F + 2F + 3F + 5)
352. AMB 58-1, AMB 58-2 FAA Drawing B-2-7091-14
353. Functional Test Flow Diagram and English Translation
354. Functional Test Philosophy and Plan
355. Functional Test Spec's (1F)
356. Functional Test Spec's (1F + 2F)
357. Functional Test Spec's (1F + 2F + 3B)
358. Functional Test Spec's (1F + 2F + 3D)
359. Functional Test Spec's (1F + 2F + 3E)
360. Functional Test Spec's (1F + 2F + 3E + 5)
361. Availability of High Speed Punch & Electronics
362. Delivery of Break Point Programmer
363. Delivery of Spoolers, Splicers, & Rewinders
364. Delivery of Tape Editing Console
365. Delivery of Flex-o-Writers
366. Equipment Maintenance Data Processor Diagnostic Programs (Tape Form) On & Off Line Data Processor Programs (Tape Form)
367. On & Off Line Data Processor Programs (Tape Form)
368. Availability of 28RO Units (2) Installed & Monitor Panel Tables (2)
369. Tab Bay Handler

* Action taken on these items prior to April 1, 1960

Figure 9-4b Sensor Identification IFC (Sheet 7 of 7)

indicate the tie-in of hardware to the computer, while dotted lines indicate the requirement of hardware for functional test. Two additional major groupings are represented on this Integrated Flow Chart; the Functional Test Program and the category "miscellaneous", which covered such matters as test specifications, maintenance programs, and the very important operations planning functions.

9.22 A second Level III Integrated Flow Chart was devoted to a representation of the Operational Programming, Management and Program Support, including training, indoctrination and technical writing efforts. Although not shown by example here, the information displayed on the two Level III Charts for Group I equipment was carefully coordinated and updated when required. It should be noted, for instance, that the revision in plan that is mentioned in paragraph 9.23 and crudely entered on the Individual Flow Diagram shown as figure 9-2, has been incorporated in the Level III Integrated Flow Chart appearing as figure 9-4a.

Necessary Adjustments

9.23 By combining Individual Flow Diagrams into the Level III Integrated Flow Charts, it was evident that a series of adjustments would be required to make the plan feasible. The most obvious of these had to do with computer utilization the demand was greatly in excess of capacity. By adopting a time sharing plan wherever possible, by eliminating all but the vitally necessary operations, by altering individual time sequences, by lengthening the work week and by effecting close cooperation between those using and maintaining the computer, the time required and the time available were brought into harmony. In like manner, an examination was made of the indicated requirements for all special test equipment. This necessitated a reconsideration of priorities and time factors as well as of availabilities. The latter, in turn, led to a review of FAA inputs and thence to contractual action with augmented project funding.

The Group I Level II Chart

9.24 Reference to figure 9-5 will reveal the manner in which information displayed on the Level III Integrated Flow Charts was condensed into one Level II Line of Balance Chart. This presentation illustrates the plan for bringing together and testing the major groups of equipment, the conduct of the technical program, the preparation of required reports, and the continuous process of administering the project. The method of synthesis followed established conventions, with a single sensor on the Level II Chart representing a related group of sensors appearing on the Level III Integrated Flow Charts. For example, Level II sensor 1, labelled "delivery of disposition consoles 1, 2, 3 and 4", is representative of the ten sensors on the Level III Chart which are circled in figure 9-6. Again, Level II sensor 14, "Flight Plan Groups 1, 2, 3 and 4—Installed and Tested with Flight Plan Distribution Scanner", has been caused to take the place of twelve other sensors which are clearly identified in figure 9-6. In a similar fashion, the remaining 347 sensors appearing on the Level III Charts have been categorized by the type of equipment, the function they are to perform or the calendar date that some measurable event is to take place. The result of this process of distillation is shown in figure 9-5a, wherein all of the events symbolized by the 369 Level III sensors are now represented by 95 sensor points on the Level II Chart. It will be seen that the estimated manhour expenditures noted on the Level III charts have been summarized on a monthly basis and now appear in a cumulative plot in the objective section of the Level II Chart. In this case, the curve shows an anticipated expenditure of about 150,000 manhours over the course of the two ensuing years.

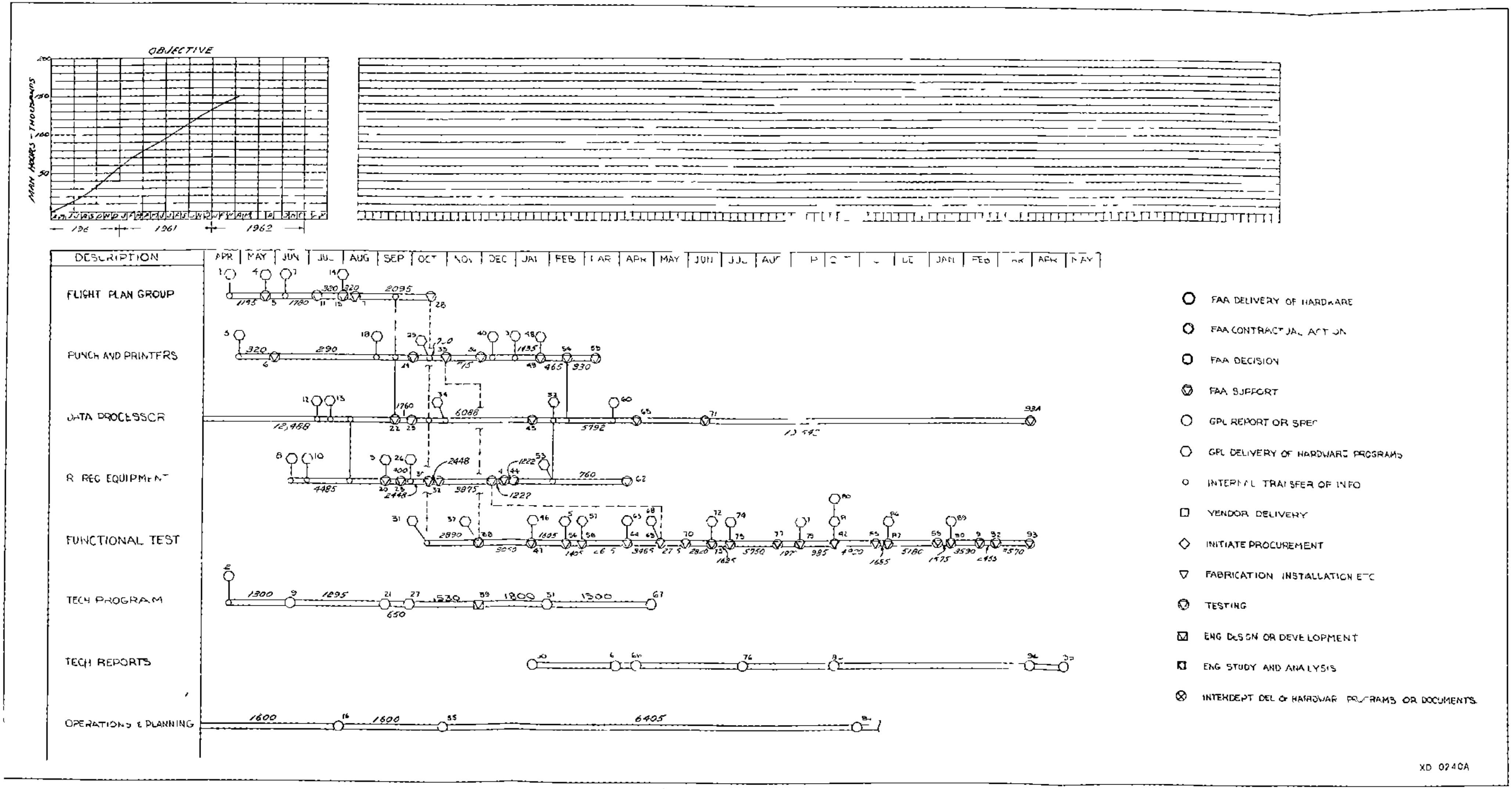


Figure 9-5a Level II Group I

Sensor No.	Description	References: Chart	References: Sensor No.
1.	Delivery of Disposition Consoles Nos. 1, 2, 3 and 4	A	34,35,36,37,55, 56,66,67,73,74
2.	Begin Interconnection Program Flow Diagrams	A	326,327
3.	Delivery of Punch and Printer No. 2	A	109,110,111,112
4.	Flight Plan Units Nos. 1, 2, 3, 4 Installed and Tested	A	38,39,40,57,58, 59,60,68,75
5.	Adjacent Center Monitors Delivered and Installed	A	80,81,82,83, 368
6.	Punch and Printer No. 2 Installed and Tested	A	114,115,116
7.	Delivery of Distribution Scanners Nos. 1, 2	A	49,50,51,89,90, 91,92
8.	Delivery of Peripheral Sector Console No. 1	A	197,198,199, 369
9.	Delivery of All Group I Interconnection Test Specifications	A	302,319,320,321, 322,323,324,325
10.	Delivery of Flow Control Console	A	280,281,282
11.	Distribution Scanners Nos. 1 and 2 Installed and Tested with RT's	A	52,53,54,93,94, 95
12.	Delivery of Buffer Type I and Programming Hardware	A	171,172,173,361, 362,363,364,365
13.	Delivery of File Drum No. 3	A	176,177,178
14.	Flight Plan Groups Nos. 1, 2, 3, 4 Installed and Tested with Flight Plan Distribution Scanner	A	42,43,44,45,46, 61,62,63,69,70, 76,77
15.	Adjacent Center Monitors Tested with Adjacent Center Distribution Scanner	A	84,85,86

Figure 9-5b Sensor Identification Level II (Sheet 1 of 7)

Sensor No.	Description	References: Chart	References: Sensor No.
16.	Administrative Report No. 1	A	314,315
17.	SAGE and Adjacent Center Output and Computer Inquiry Typewriters Nos. 1 and 2 Installed and Tested	A	96,97,98,99,100, 103,104,105,106
18.	Delivery of Punch and Printer No. 3	A	123,124
19.	Delivery of Peripheral Sector Console No. 3	A	212,213
20.	Peripheral Sector Console No. 1 Installed and Tested	A	200, 201 202,203,204
21.	All Group I Interconnection Test Programs Delivered	A	328,329,330,331, 332,333,334
22.	Buffer Type I Operating with Computer No. 1	A	174,175
23.	Digital to Analog Converter Delivered, Installed and Tested	A	219,220,221,222
24.	Punch and Printer No. 3 Installed and Tested	A	125,126
25.	File Drum No. 3 Operating with Computer No. 1	A	179
26.	Delivery of Peripheral Sector Console No. 4	A	230,231
27.	Interconnection Test Program Integration Completed	A	304,335
28.	Flight Plan Groups Nos. 1, 2, 3, 4 Operating with Computer No. 1	A	47,64,71,78,87, 101,107
29.	Delivery of Punch and Printers Nos. 4 and 5	A	129,130,134,135
30.	Flow Control Group Operating with Computer No. 1	A	283,284,285, 286,287,288, 289

Figure 9-5b Sensor Identification Level II (Sheet 2 of 7)

Sensor No.	Description	References Chart	References Sensor No.
31.	Delivery of Programming Package 1A, Delivery of ATCOM BUS and Error Programs, and IBM 709 Available for Program Assembly	B	10,24
32.	Peripheral Sector Console No. 1 Operating with Computer No. 1	A	205,206,207
33.	Punch and Printers Nos. 2 and 3 Operating with Computer No. 1	A	117,118,119,120, 121,127
34.	Delivery of File Drum No. 5 and Computer Switching Unit	A	180,181,182,183, 184
35.	Administrative Report No. 2	A	316
36.	Punch and Printers Nos. 4 and 5 Operating with Computer No. 1	A	131,132,136,137
37.	Delivery of Programming Package 1B	B	35
38.	Complete Basic Functional Test 1A	A	1,2,3,4,7,336, 337,338,339
39.	Complete Equipment Maintenance Program Study	A	305,306,307
40.	Delivery of Punch and Printers Nos. 6,7, and 9	A	139,140,144,145
41.	Peripheral Sector Console No. 3 Operating with Computer No. 1	A	214,215,216
42.	Peripheral Sector Console No. 2 Operating with Computer No. 1	A	208,209,210
43.	Delivery of Punch and Printer No. 10	A	149,150
44.	Peripheral Sector Console No. 4 Operating with Computer No. 1	A	232,233,234
45.	File Drum No. 5 and Switching Unit Operating with Computer	A	185

Figure 9-5b Sensor Identification Level II (Sheet 3 of 7)

Sensor No.	Description	References Chart	References Sensor No.
46.	Delivery of Programming Package 1C	B	48
47.	Complete Basic Functional Test 1B	A	5,6,10,340
48.	Delivery of Punch and Printers Nos. 1 and 2 (reworked)	A	154,155
49.	Punch and Printers Nos. 6, 7, and 9 Operating with Computer No. 1	A	141,142,146,147
50.	Report on Interconnection of "R" Register Equipment	A	211,218,223,235, 290
51.	Completion of Flow Diagrams and English Translations for Equipment Maintenance Programs	A	308,309,310
52.	Delivery of File Drum No. 6	A	187,188
53.	Radar Supplements Installed and Tested	A	224,225,226,227
54.	Punch and Printer No. 10 Operating with Computer No. 1	A	151,152
55.	Delivery of Programming Package 1D	B	53
56.	Complete Basic Functional Test 1C	A	8,9,13,341
57.	Delivery of Programming Package 1E	B	54
58.	Complete Basic Functional Test 1D	A	11,12,16,342
59.	Punch and Printers Nos. 1 and 2 Operating with Computer No. 1	A	156,157
60.	Delivery of Computer No. 4	A	191,192,193,194, 195
61.	Report on Interconnection of Buffer Equipment	A	48,65,72,79,88, 102,108,122,128, 133,138,143,148, 153,158

Figure 9-5b Sensor Identification Level II (Sheet 4 of 7)

Sensor No.	Description	References Chart	References Sensor No.
62.	Peripheral Sector Console No. 3 Operating with Digital to Analog Converter and Radar Supplements	A	217,228,229
63.	Delivery of Programming Package 1F	B	55
64.	Complete Basic Functional Test 1E	A	14,15,19,343
65.	File Drum No. 6 Operating with Computer No. 1	A	189
66.	Report on Interconnection and Hardware Tests of File Drums	A	190
67.	Equipment Maintenance Programs Complete	A	366,367
68.	Delivery of Programming Package 1F + 2B	B	59
69.	Complete Basic Functional Test 1F and UNIVAC Tie-In	A	17,18,22,24,25, 26,27,31,344
70.	Complete Basic Functional Test 1F + 2B	A	236,237,238,239, 242,345
71.	Computer No. 4 Operating with Computer No. 1	A	196
72.	Delivery of Programming Package 1F + 2F	B	66
73.	Complete Functional Test 1F (End Function 1)	A	28,29,30,32,342, 352,353,354,355
74.	Delivery of Programming Package 1F + 2F + 3A	B	73
75.	Complete Basic Functional Test 1F + 2F (Start Function 3)	A	240,241,245,346
76.	Report on Hardware Functional Test No. 1	A	23,33

Figure 9-5b Sensor Identification Level II (Sheet 5 of 7)

Sensor No.	Description	References Chart	References Sensor No.
77.	Complete Basic Functional Test 1F + 2F + 3A	A	243,244,248,347
78.	Delivery of Programming Package 1F + 2F + 3B	B	76
79.	Complete Functional Test 1F + 2F	A	257,258,259,260, 263,356
80.	Delivery of Programming Package 1F + 2F + 3C	B	84
81.	Delivery of Programming Package 1F + 2F + 3D	B	85
82.	Complete Basic Functional Test 1F + 2F + 3B	A	246,247,251,348
83.	Report on Hardware Functional Test No. 2	A	303
84.	Administrative Report No. 3	A	317,318
85.	Complete Basic Functional Test 1F + 2F + 3D	A	249,250,254,349
86.	Delivery of Programming Package 1F + 2F + 3E	B	94
87.	Complete Functional Test 1F + 2F + 3B	A	261,262,264, 265,268,357
88.	Complete Basic Functional Test 1F + 2F + 3E	A	252,253,255, 350
89.	Delivery of Programming Package 1F + 2F + 3E + 5 (End Function 3 - Start Function 5)	B	97
90.	Complete Functional Test 1F + 2F + 3D	A	266,267,269,270, 272,358
91.	Complete Basic Functional Test No. 5	A	291,292,293,294, 351

Figure 9-5b Sensor Identification Level II (Sheet 6 of 7)

Sensor No.	Description	References: Chart	References: Sensor No.
92.	Complete Functional Test 1F + 2F + 3D + 3E	A	274,275,276,277, 278,359
93.	Complete Functional Test No. 5 (End Function 5)	A	296,297,298,299, 300,360
94.	Report on Hardware Functional Test No. 3	A	256,271,273,279, 295
95.	Report on Hardware Functional Test No. 5	A	301
93A.	Complete Functional Testing Use of Computer		

Figure 9-5b Sensor Identification Level II (Sheet 7 of 7)

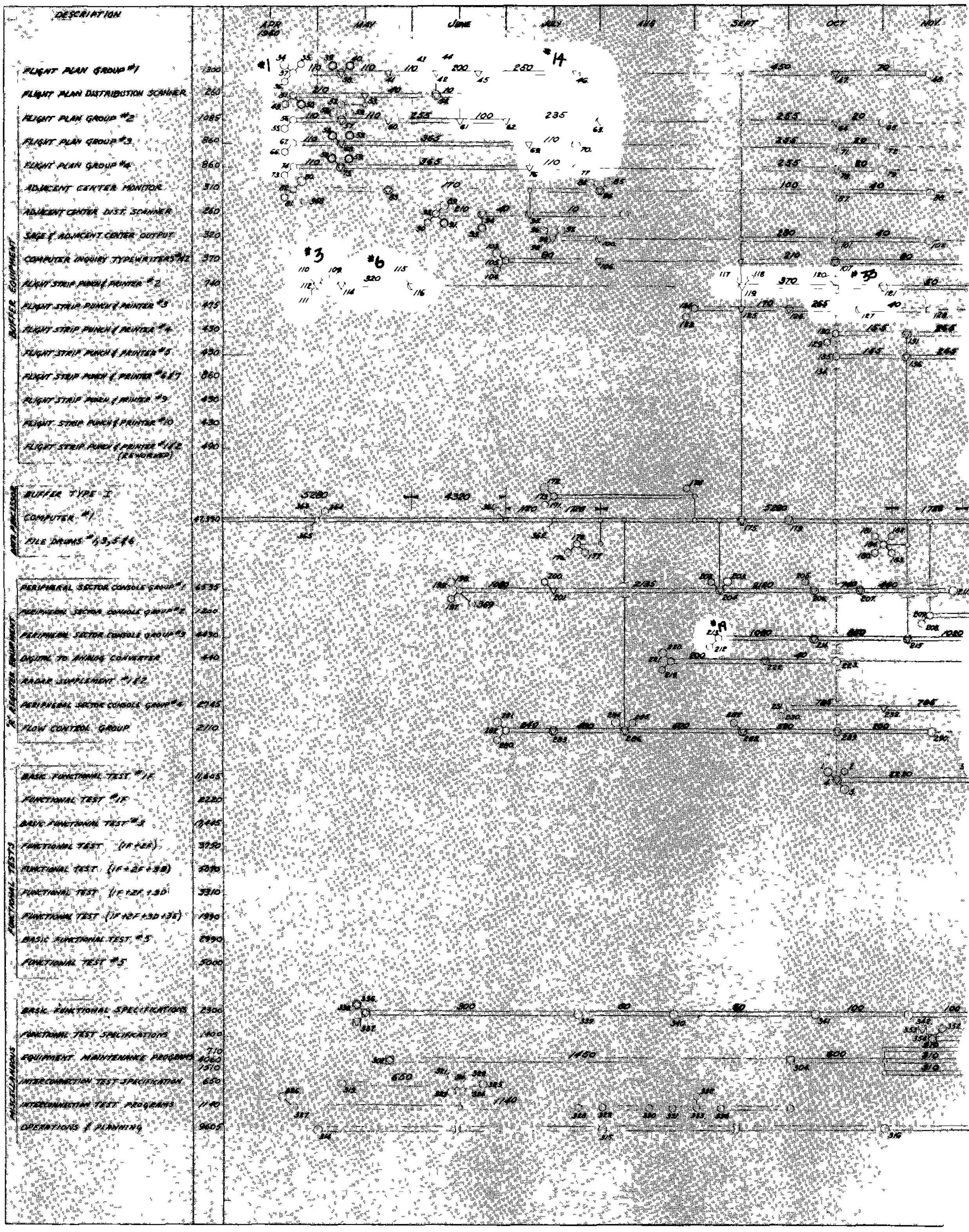


Figure 9-6 Sensor Grouping on Level III IFC

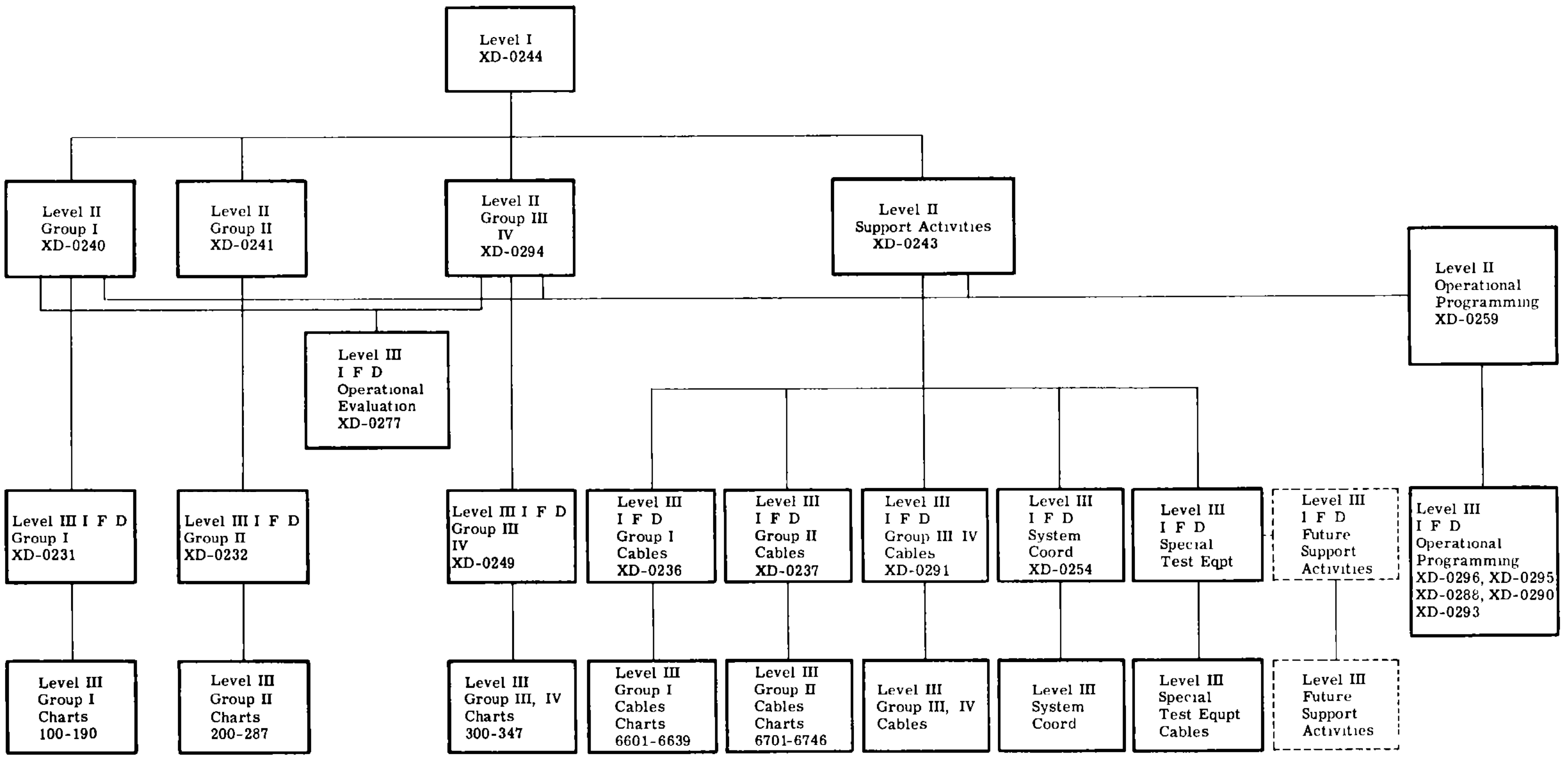


Figure 9-7 Chart and Diagram Structure

DPC Chart and Diagram Structure

9.25 While our review of the Phase B Program thus far has been confined to a discussion of the plans and programming for the Group I equipment, it should not be inferred from this that other parts of the program were being neglected. In reality, there was simultaneously instituted a parallel effort to develop Level III and Level II Charts for all other groups of equipment and support action. The nature and structure of Line of Balance charts and diagrams are summarized in the accompanying figure 9-7. This also illustrates the manner in which Level III charts were consolidated into Level II charts, and how these in turn were combined into a single Level I Line of Balance chart.

The Level I Chart

9.26 The Phase B Program for the Data Processing Central is summarized in its entirety by figure 9-8a, which projects the installation of the three groups of equipment and all functional and operational testing. As was true in the case of any Level II chart, each Level I sensor represents a group of sensors on some chart or charts of the next lower level, with progress and cost status reflecting the cumulative situation occupied by all related Level II sensor points.

9.27 The manner in which the cross-reference mechanism operates can be seen by referring to Level I sensor 4, "Delivery of Equipment Necessary to Begin Function No. 1", in figure 9-8a. This represents the four circled Level II sensors in figure 9-9, numbers 1, 4, 7 and 12. Other Level I sensors, such as numbers 8, 28, and 29, can be traced to their Level II counterparts by comparing figure 9-8a, the DPC Level I Chart, with the annotated Level II Chart shown in figure 9-9.

9.28 Not so clearly apparent, perhaps, but nonetheless similarly interrelated are the objective curves shown on the Level I and various Level II Charts. That appearing on the Level I Chart represents the estimated cumulative dollar expenditures for the entire program, while those curves on the Level II Charts are indicative only of the manhour expenditures for the category of effort represented by the chart. In this instance, the Level I objective curve shows a planned expenditure of somewhat more than 6 million dollars during the period 1 March 1960 to 28 February 1961. This sum, of course, includes material and other costs in addition to dollar equivalents of the estimated manhour expenditures shown on the various Level II Charts.

Progress Reports

9.29 To keep his Phase B Line of Balance installation continuously attuned to the changing situation, the Task Manager established a feedback type of reporting system. Lines of communication were prescribed as was also a mandatory schedule for the furnishing of reports from supporting contractors and other cognizant authorities. Having due consideration for the then existing state of affairs, progress information was to be made available on a weekly basis, using the Level III Integrated Flow Chart and an accompanying Deviation Report Form (see figure 9-10) as the media for expressing program status. Contractors were to maintain and update weekly the Level III Charts which delineated their responsibilities, whereas the Task Manager and his staff would discharge all duties associated with the internal reporting function. In addition, staff engineers would attend to the preparation, maintenance and updating of Level II Charts in accordance with the latest status reports. Reports from the contractor were never accepted blindly. In each instance they were routed via staff engineers who were cognizant of the actual situation and

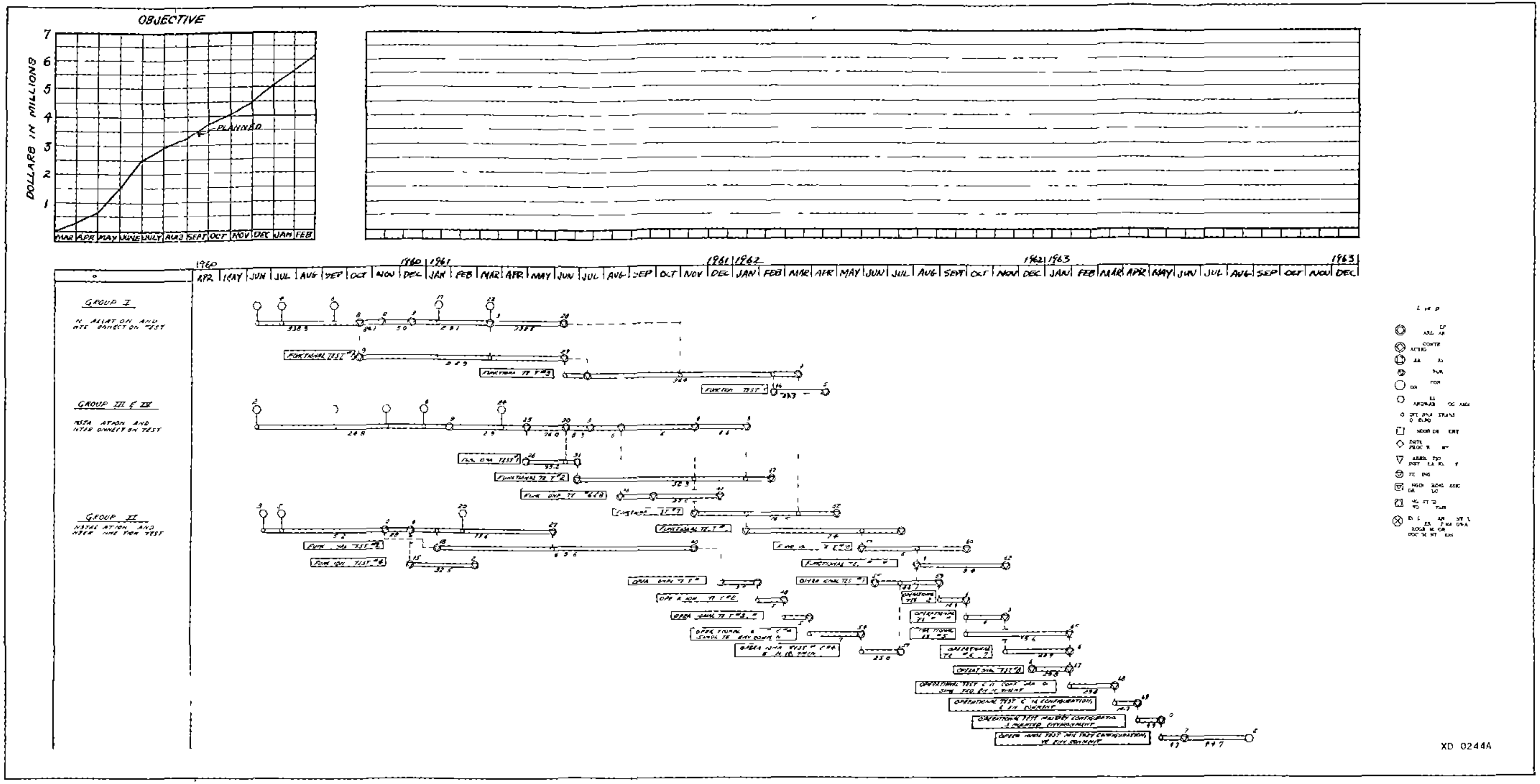


Figure 9-8a Level I ATC/DPC

SENSOR LIST FOR

ATC/DPC LINE OF BALANCE CHART

Sensor No.	Description	References Chart	References Sensor Nos.
1.	Delivery of Equipment Necessary for Functional Test No. 5	A	10
2.	Delivery of Equipment Necessary for Functional Test No. 7	C	1,3,5
3.	Delivery of Equipment Necessary for Functional Test No. 4	C	6
4.	Delivery of Equipment Necessary to Begin Functional Test No. 1	A	1,4,7,12
5.	Delivery of Equipment Necessary to Begin Functional Test No. 2	B	2,3
6.	Equipment Necessary to Begin Functional Test No. 3 Delivered	A	19
7.	Delivery of Equipment Necessary for Functional Test No. 2	C	12
8.	Equipment Necessary to Begin Functional Test No. 1 - Interconnected and Tested	A	5,11,14,15, 17,28,22,21, 2,9
9.	Begin Functional Test No. 1	A	16,31,35
10.	Equipment Necessary for Functional Test No. 5 - Interconnected and Tested	A	30
11.	Delivery of Equipment Necessary to Begin Functional Tests Nos. 6 & 8	C	4,9,15,17, 7,8
12.	Equipment Necessary to Begin Functional Test No. 2 - Interconnected and Tested	B	4,6,9,1,5
13.	Equipment Necessary to Begin Functional Test No. 3 - Interconnected and Tested	A	41

Figure 9-8b Sensor Identification Level I (Sheet 1 of 6)

Sensor No.	Description	References Chart	Sensor Nos.
14.	Equipment Necessary for Functional Test No. 4 - Interconnected and Tested	B C	14A 13,27
15.	Begin Functional Test No. 4	B	14
16.	Equipment Necessary to Complete Functional Test Nos. 6 & 8 Delivered	C	25,11,22, 24,31
17.	Equipment Necessary to Complete Functional Test No. 1 Delivered	A	3,18,29, 40,43,48, 13,34
18.	Begin Functional Test No. 2	B	17,18,13
19.	Equipment Necessary for Functional Test No. 7 - Interconnected and Tested	C	30
20.	Delivery of Equipment Necessary to Complete Functional Test No. 2	B C	11,7,20 2,10
21.	End Functional Test No. 4	B	26,23,28
22.	Delivery of Equipment Necessary to Complete Functional Test No. 3	A	8,26,52,60
23.	Equipment Necessary to Complete Functional Test No. 1 - Interconnected and Tested	A	6,24,33,36, 39,54,59,25, 45,27,39,51, 61
24.	Delivery of Equipment Necessary for Functional Test No. 1	C	28,35,43
25.	Equipment Necessary to Begin Functional Test No. 1 - Interconnected and Tested	C	39,47
26.	Begin Functional Test No. 1	C	16,15,26
27.	Equipment Necessary to Complete Functional Test No. 2 - Interconnected and Tested	B C	10,16,19,8, 29,12,32, 33,34A,15, 22,27,21,35 18,23,41,49, 54

Figure 9-8b Sensor Identification Level I (Sheet 2 of 6)

Sensor No.	Description	References Chart	References Sensor Nos.
28.	Equipment Necessary to Complete Functional Test No. 3 - Interconnected and Tested	A	20,23,32, 42,44,53, 62,65,71,69, 50,66
29.	Complete Functional Test No. 1	A	37,38,46, 47,55,56, 57,58,63, 64,69,68, 70,72,73,76
30.	Equipment Necessary to Complete Functional Test No. 1 - Interconnected and Tested	C	56
31.	Complete Functional Test No. 1, Group III	C	62,68,55
32.	Begin Functional Test No. 2	C	29,34,60
33.	Begin Functional Test No. 3	A	74,75
34.	Equipment Necessary to Begin Functional Test No. 1 - Interconnected and Tested	C	21,42,58,61, 57,67
35.	Equipment Necessary to Begin Functional Tests Nos. 6 & 8 - Interconnected and Tested	C	20,14,33, 48,65,69, 51,74,19
36.	Begin Functional Test No. 6	C	69A
37.	Begin Functional Test No. 8	C	70,75,76, 77
38.	Equipment Necessary to Complete Functional Test Nos. 6 & 8 - Interconnected and Tested	C	85,40,52, 37,44,53, 90,38,45, 66,78,81, 72,80
39.	Begin Functional Test No. 7	C	59,63,82, 79,83
40.	Complete Functional Test No. 2		

Figure 9-8b Sensor Identification Level I (Sheet 3 of 6)

Sensor No.	Description	References Chart	Sensor Nos.
41.	Complete Functional Test No. 6 & 8	C	88,89,93
42.	Begin Operational Test No. 1	B	47
43.	Equipment Necessary to Complete Functional Test No. 2 - Interconnected and Tested	C	84,87,92, 32,64,86
44.	Begin Functional Test No. 9	C	71,73,95, 94
45.	Complete Operational Test No. 1 and Begin Operational Test No. 2	B	52,45,48, 50,49
46.	Begin Functional Test No. 5	A	89,91,84
47.	Complete Functional Test No. 2 Group III	C	96,97.98
48.	Complete Operational Test No. 2 Begin Operational Test Nos. 3 & 4	B	54,51,53
49.	Complete Functional Test No. 3	A	77,78,79, 80,81,82, 85,86,87, 88,90,92, 83,94
50.	Complete Operational Test No. 3 and 4. Begin Operational Test Nos. 1 - 5 (Simulated Environment)	B	56,55,55A
51.	Complete Functional Test No. 5	A	93,95
52.	Complete Functional Test No. 7	C	100,103
53.	Begin Functional Test No. 10	C	91,101, 102,104
54.	Complete Operational Test No. 1 - 5 (Simulated Environment) Begin Operational Test Nos. 1 - 5 (Live Environment)	B	58,57
55.	Begin Operational Test No. 1	C	108

Figure 9-8b Sensor Identification Level I (Sheet 4 of 6)

Sensor No.	Description	References Chart	References Sensor Nos.
56.	Complete Functional Test No. 9	C	107,108
57.	Complete Operational Tests Nos. 1 - 5 (Live Environment)	B	60,59,61
58.	Begin Functional Test Nos. 1 - 10	C	99,105, 106
59.	Complete Operational Test No. 1 Begin Operational Test No. 2	C	109
60.	Complete Functional Test No. 10	C	109,110
61.	Complete Operational Test No. 2 Begin Operational Test Nos. 3, 4 & 5	C	112
62.	Complete Functional Test Nos. 1 - 10	C	111,112, 113
63.	Complete Operational Tests No. 3 and 4. Begin Operational Tests No. 6 and 7	C	113
64.	Begin Operational Test No. 8	C	118
65.	Complete Operational Test No. 5	C	120
66.	Complete Operational Tests Nos. 6 & 7	C	120
67.	Complete Operational Test No. 8 Begin Operational Tests - Civil Configuration Simulated Environment	C	120
68.	Complete Operational Test - Civil Configuration Simulated Environment Begin Operational Test Civil Configuration, Live Environment	C	121
69.	Complete Operational Test Civil Configuration - Live Environment Begin Operational Test - Military Configuration - Simulated Environment	C	122
70.	Complete Operational Test - Military Configurations - Simulated Environment Begin Operational Test - Military Configurations - Live Environment	C	123

Figure 9-8b Sensor Identification Level I (Sheet 5 of 6)

Sensor No.	Description	References Chart	Sensor Nos.
71.	Complete Operational Tests - Military Configurations - Live Environment	C	125
72.	Final Report - Operational Testing	C	126

Figure 9-8b Sensor Identification Level I (Sheet 6 of 6)

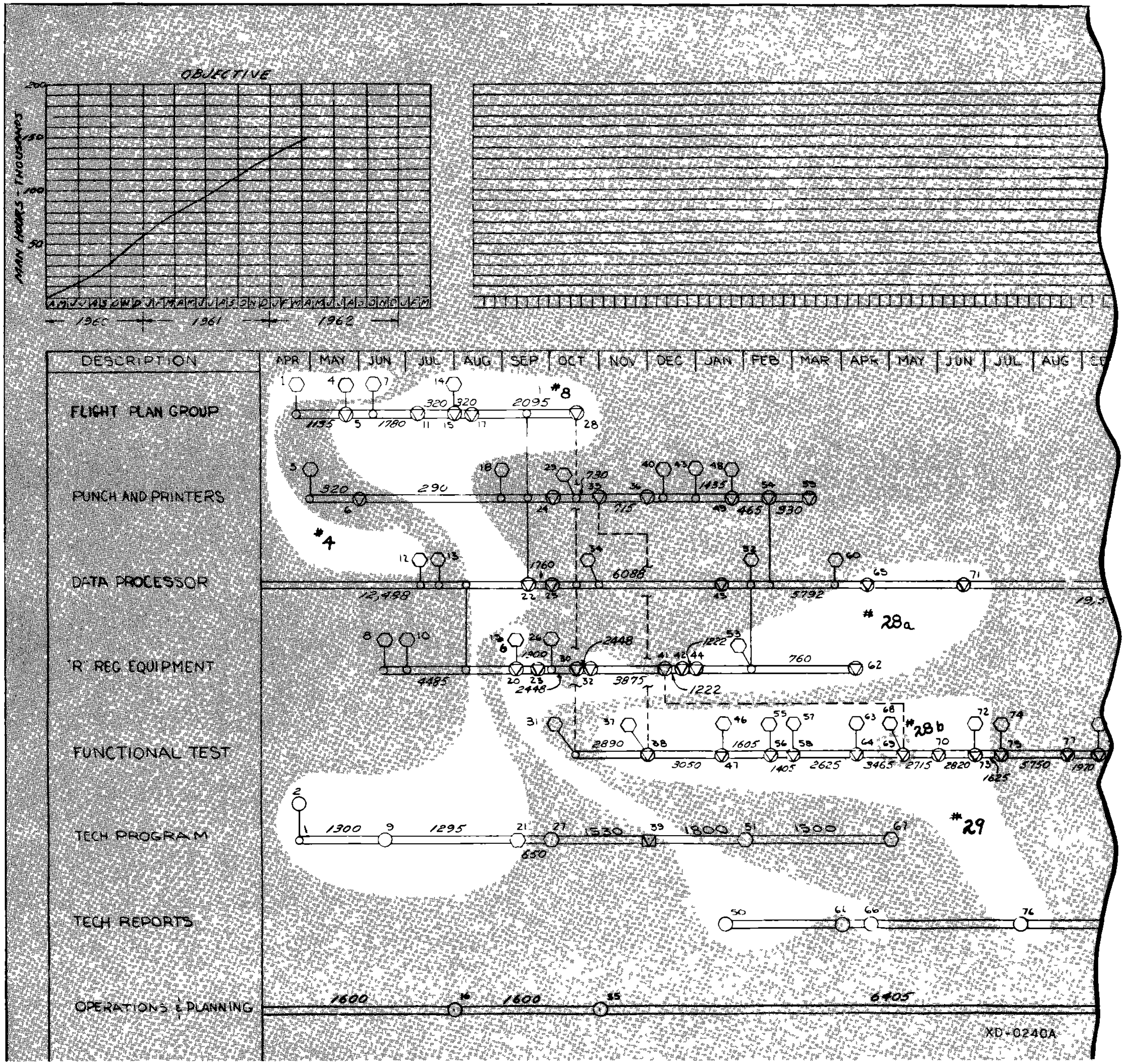


Figure 9-9 Sensor Grouping on Level II Chart

F-2046-A

PAGE ______ OF ______

DEVIATION REPORT

PERIOD COVERED TO ______ REPORTING ENGINEER ______ CHART REF. ______ TITLE ______

SENSORS SCHEDULED TO DATE ______ SENSORS SCHEDULED THIS PERIOD ______

SENSORS COMPLETED TO DATE ______ SENSORS COMPLETED THIS PERIOD ______

LEVEL REF.	SENSOR NO.	MET	NOT MET	DESCRIPTION	PROBLEM	ACTION TAKEN	IMPACT ON L.O.B. SCHEDULE AS OF ______

Figure 9-10 Deviation Report

who were expected to comment whenever their interpretation of the facts was at variance with the contractor's report. Weekly staff meetings were scheduled for reviewing the program situation and insuring that positive action was being taken to meet threatened or existing deviations from plan. While the several Level II Charts were kept current on a weekly basis, the Level I Chart was posted and distributed but once a month.

Cost Information

9.30 The feedback system also was designed to provide cost information of various kinds. Funds committed or reserved for material were treated as having been expended and were posted to the appropriate Level II Chart within one week after issue of an approved purchase request. Manhour expenditures were reported each Monday forenoon for work done the previous week. These data were furnished in the form of time sheets which a NAFEC facility converted into punched cards and summarized in two tab runs: one for total manhours expended on each task order, and one showing total manhours spent toward the accomplishment of each Level II sensor.

Account Numbers

9.31 Charges were collected by account numbers related directly to authorized work appearing on the Level II Line of Balance Charts. Account numbers were established in accordance with a simple system in which three digits identified the contract and three more were used to identify the task order against which time was being charged. Additional digits were used: to relate the expenditures to a Level II chart number, two digits; to a specific track on a Level II chart, two digits; to any sensor along a track, three digits. Missing digits were to be supplied by use of zeros as follows:

Contract No.	Task Order No.	Chart No.	Track No.	Sensor No.
XXX 166	XXX 006	XX 01	XX 03	XXX 019

To facilitate the accomplishment of short duration, high-priority, Phase B tasks requiring the services of design personnel not available at the test site, an open account was established at the contractor's plant against which such work might be allocated. Charges against these open accounts could be made only by formal written authority (generally limited to one man-week of effort) and were to be levied against established Phase B account numbers. To prevent any abuse of the open account privilege, it was ruled that nonemergency work, and any work in excess of one man-week, could not be handled by this method but must be processed under authority of some established Line of Balance Chart and a specific task order.

Posting the Expenditures

9.32 As part of their maintenance of the Line of Balance system, staff engineers were required to convert tabulated cost information into a graphic form for presentation on the Level I and Level II Charts. Using the accepted method of presentation and expressing cost performance as a ratio of planned to actual expenditures, the result was plotted against a standard of 100% as represented by a Line of Balance drawn for any accounting period in question.

9.33 Cost information for the Level I Chart was assembled by combining reported Level II costs in a manner identical to that in which the Level II sensors were grouped for representation thereon. For Level I purposes, expenditures were expressed in dollars so that the objective curve would show the cost of the entire program - material and man-hours - and provide a better overall comparison between anticipated and actual gross expenditures.

A Top-Level Presentation

9.34 Upon the completion of the Line of Balance charts, a meeting was held with representatives of BRD and contractor personnel to effect coordination with all parties concerned. This was accomplished by a presentation which was followed by more detailed study by small working groups of conferees. Each was assigned to concentrate its attention on the specified Integrated Flow Chart and program area to which it might best contribute.

9.35 A presentation was made to the Director of BRD to acquaint him with the work that had been accomplished and to present for approval the DPC Test and Evaluation Program. This included a discussion of the various factors that were considered in selecting the ground rules and assumptions that were adopted as planning guides. The schedule by which the work would be performed, and the manner in which the various task and sub-tasks were dovetailed, was illustrated by a full display of Integrated Flow Charts and their related Level II Charts. In each instance, the controlling features were examined and, when appropriate to do so, a description was given of back-up or alternate plans of execution. The entire program was then summarized by means of the Level I Chart which showed the overall plan and its cumulative total cost. The presentation also included the system of feedback and the means proposed for keeping the chart displays abreast of developments.

9.36 The plan as outlined by the Line of Balance technique was approved by the Director of BRD and implementation of the program was initiated.

9.37 This formally presented review and examination served to establish a mutual understanding of the problems that were present in the program and to point the way toward a common solution. The conference dispelled rumors and corrected existing aberrations of fact by bringing them into true and correct focus. In effect, the meeting reached agreement on a written language for communication, one that was not readily subject to misinterpretation. This ability to communicate in terms having mutual significance greatly facilitated the transmission of all subsequent status reports. Possibly the most beneficial result of the meeting was that of obviating the need for overly frequent consultation thereby eliminating time consuming and aggravating face-to-face meetings in force.

Chapter X MANAGING THE TEST AND EVALUATION PROGRAM OF THE DPC

Chapter X

MANAGING THE TEST AND EVALUATION PROGRAM OF THE DPC

10. 1 After completing the DPC Line of Balance installation, the Task Manager took advantage of the system to maintain a closed feedback loop and keep close tabs on performance. This, in consequence, made it possible for him to render decisions promptly and take action based on a foundation of factual accuracy. In each instance, he could count on Level III and Level II information being current within one week. His own reports each calendar month to the Director of BRD Washington on the DPC Phase B Program followed in the form of a Level I Line of Balance Chart showing the situation as of the close of the accounting period.

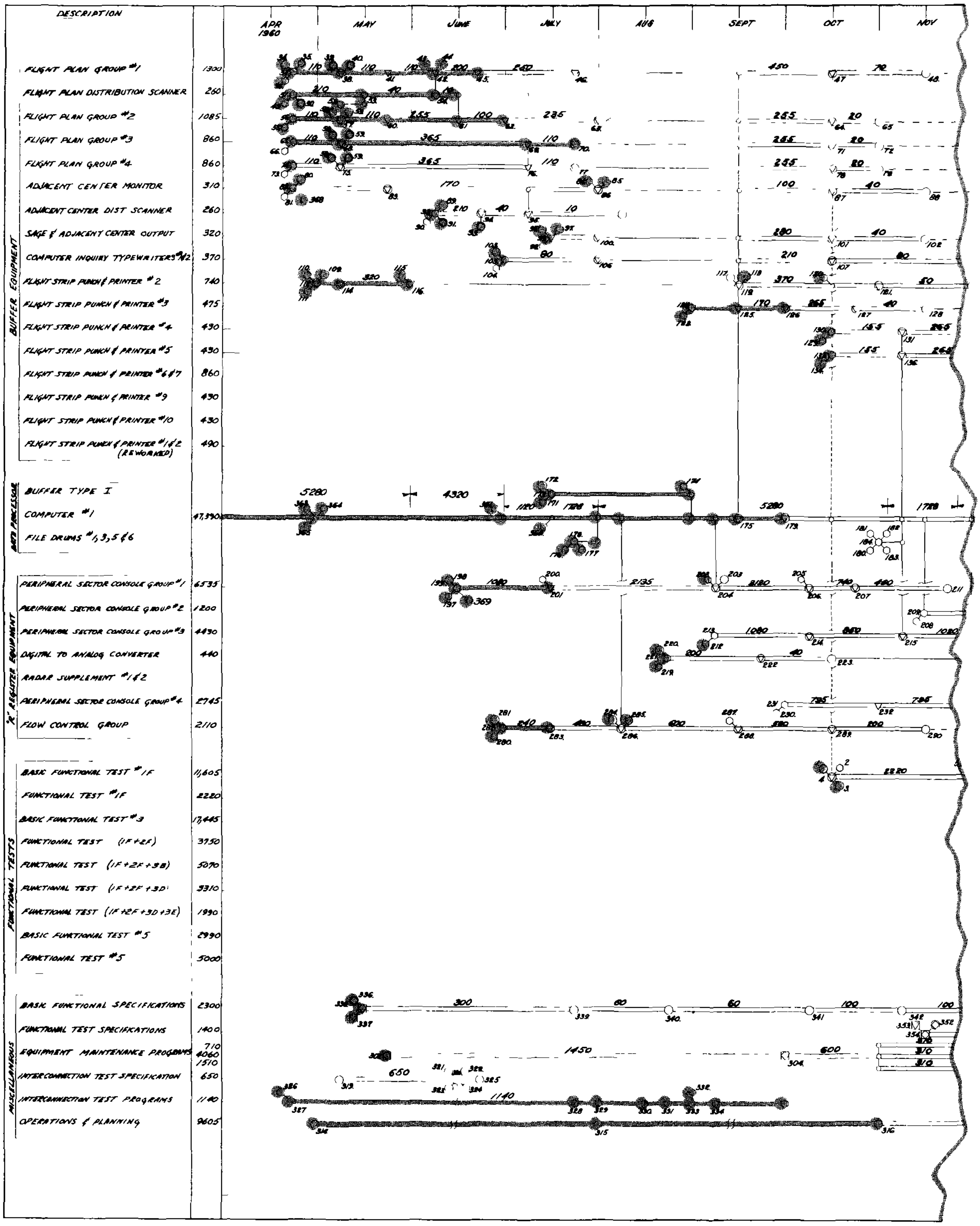
10. 2 For purposes of instruction, information pertaining to the period ending September 30, 1960, modified for illustration purposes, has been chosen to exemplify the way in which a Task Manager can take advantage of data that are furnished to him, and indicate the kind of information that should be routinely required.

Level III Deviation Reports

10. 3 The up-dating operation really begins with the contractor's preparation of updated charts and reports of actual or impending deviations from schedule, the underlying reasons therefor and what has been or what can be done about them. Reports such as these, illustrated by figures 10-1 and 10-2, were expeditiously examined and commented upon by the staff engineers who were most cognizant of the situation.

10. 4 This engineering review was intended to indicate the effect of such items as equipment delivery delays, the consequence of system design problems and the lack of specialized test equipment. For example, referring to figure 10-2, this portion of the Deviation Report for Flight Plan Groups 1, 2, 3 and 4 appearing on Integrated Flow Chart labelled XD-0231 indicates that Sensor 73, representing the availability of cables was not completed because changes in physical location of equipment in the test facility caused necessary test equipment to be rerouted to a different installation site. The report also shows that sensors 46, 63, 76 and 77 were not accomplished even though scheduled for completion prior to September 30, 1960. Sensors 46 and 63, Completion of Interconnection Tests, Flight Plan Groups 1 and 2, originally scheduled for the last two weeks in July, were delayed because of parity errors introduced by line transients occurring whenever the scanner is switched. This deviation report also tells the Task Manager that additional design engineers were assigned to investigate and take corrective action. It may be expected that some lost time will be regained through accelerated performance of remaining tests. Quite properly, the Task Manager was unwilling to accept the forecast that all these delays would have no effect on the program. In response to further investigation, the statement was defended by advancing the specious proposition that any adverse consequence was more than masked by other incipient delays, such as the expected delay in delivery of the computer buffer.

10. 5 Appreciation of the effect on the DPC test and evaluation of the delay in buffer delivery derived from deviation reports resulted in action by the program manager to expedite the buffer delivery. This delivery did in fact occur prior to September 30 and, therefore, the mitigating excuse advanced regarding the non-critical nature of the delays associated with Flight Plan checkout was invalidated. As a result, the particular engineer was forced to recognize his share of responsibility. This occurrence represents a prime example of the type of erroneous rationale that often will be encountered during the course of a development project. Analysis of this example reveals the potential of Line of



XD-0231A

Figure 10-1 Updated Level III IFC For Group I

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DEVIATION REPORT

PERIOD COVERED TO Sept 30, 1960 REPORTING ENGINEER A S. O'Hearn CHART REF. XD-0231A TITLE DPC Planning Integrated Flow Chart Group I

SENSORS SCHEDULED TO DATE 115 SENSORS SCHEDULED THIS PERIOD 2

SENSORS COMPLETED TO DATE 97 SENSORS COMPLETED THIS PERIOD 3

LEVEL II REF.	SENSOR NO.	MET	NOT MET	DESCRIPTION	PROBLEM	ACTION TAKEN	IMPACT ON L.O.B. SCHEDULE AS OF 9/30/60
1	73		X	Cables	New location established by FAA requires new cable design and re-routing	Routing being investigated by FAA in coordination with Facilities Group, who are following problem.	None, will conduct basic functional test in conjunction with FPC #1 and #2
14	46		X	Flight Plan Group #1 Interconnection Test Completed.	Switching of the scanner causes line transients which introduce parity errors in the flight plan group.	Design engineers have been called in to study the problem They will render report prior 10/10	None, Buffer not available
14	63		X	Flight Plan Group #2 Interconnection Test Completed	Same as above	Same as above	Same as above
14	76		X	Flight Plan Group #4 Interconnected to distribution scanner.	Unit not installed	See sensor #73	None, will make interconnection and perform test with FPC Nos 1, 2 & 3
14	77		X	Interconnection Test Completed	Unit not installed.	See sensor #73	Same as above.

Figure 10-2 IFC Deviation Report

Balance to allow "pinpointing" of problem areas and consequent action by appropriate levels of management to maintain the plan or, if required, to adjust the plan on the basis of firm facts.

10.6 Sensors 76 and 77, covering the interconnection and interconnection test of Flight Plan Group 4, were reported as not having been accomplished by reason of interference occasioned by the need to reroute and redesign Cables, sensor 73. This explanation was accepted as valid, as was also the statement that any lost time could be recovered by running the functional test of Flight Plan Group 4 concurrently with the tests on the other flight plan groups. This was known to be a practicable solution because of the ready availability of adequate test personnel and test equipment.

10.7 In a similar manner, the Task Manager carefully reviewed the situation concerning all other sensors which might be expected to deviate from the recognized schedule. He was never hesitant about calling for additional information whenever clarification was indicated or whenever it seemed desirable or necessary. With established facts conveniently at hand, the Task Manager found it possible to summarize the situation and present all significant and controlling information in the form of a Level II Line of Balance Chart and its accompanying Deviation Report.

Updating the Level II Chart

10.8 As the first step in preparing an updated Level II Chart, a comparison was made of the number of sensors scheduled for accomplishment to date and the number actually completed. For this purpose, the Task Manager found it convenient to tabulate the data in a form which tends to facilitate the task. For an example of the method that he used, refer to figures 9-6 and 10-1. He recorded the number and status of Level III sensors contained within each of the groupings corresponding to a Level II sensor in the following manner:

Level II Sensor Reference	Number of Level III Sensors Scheduled To Date	Number of Level III Sensors Completed To Date	Percent Complete
1	10	9	90
3	4	4	100
6	3	3	100
14	12	8	67
19	2	1	50
33	3	1	33

Figure 10-3 Level II - Level III Data Tabulation

The same pattern was followed for all remaining Level II Sensors and from the percentages so derived, the Task Manager determined the height that each bar would appear in the "Program Progress" section of his Level II Line of Balance Chart.

Budget Comparison Added

10.9 After the Task Manager had established dimensions for all Level II progress bars he expanded the scope of his data to include a direct comparison of the tab run report of manhours expended and the manhours budgeted for the same period, expressing the result as a ratio of these two figures. The tabulation he had contrived was now made to appear like this:

Level II Sensor No. Reference	No. of Level III Sensors Scheduled To Date	No. of Level III Sensors Completed To Date	Percent Complete	No. of Man-hours Expended To Date	No. of Manhours Budgeted To Date	Budget To Date in Percent
1	10	9	90	0	0	0
3	4	4	100	0	0	0
6	3	3	100	355	320	111
14	12	8	67	1056	1015	104
19	2	1	50	0	0	0
33	3	1	33	185	216	86

Figure 10-4 Level II Data Tabulation and Budget Comparison

These data enabled him to display his budget information in a form whereby accomplishment would be contrasted with cost, and cost with expectation.

Level II Deviation Report

10.10 Using the information provided to him by the Level III Integrated Flow Chart and its associated Deviation Report, the Task Manager next caused a report to be prepared showing all deviations from the established Level II schedule. The first page of this report appears as figure 10-5. It should be noted that the effect of the Level III deviations previously discussed are reflected without mutation in the higher level report. Any Level II deviation can be related directly to its fundamental cause by means of an IFC sensor identification number shown in the column headed "Problem". Ready reference to affected Level I sensors also is to be found in a separate column suitably titled.

Level II Report Completed

10.11 The FAA Task Manager recognized that the scale adopted for the objective curve was such as to make necessary some adjustment to the customary manner of striking a Line of Balance. For, if convention were followed, the resulting projection would have been inadequate as to scale, and might have disguised the true state of affairs. He adopted, under these conditions, a device that did not distort the picture but only magnified it to reveal any matter which was currently deserving of attention. For this reason he applied, in effect, an enlarging lens over a portion of the objective curve, increasing its scale so that details would be made more apparent. Figure 10-6 was constructed so as to expand the objective curve through September 30th, and raise the level of the line of balance for that date. Against this more readily visible standard, the Task Manager plotted progress and budget information as may be seen in figure 10-6, an updated version of the chart shown originally as figure 9-5a.

Generating the Level I Chart

10.12 It should not be surprising to find that preparation of the updated Level I Line of Balance Chart involves a series of operations which are very similar to those described in paragraphs 10.8, 10.9 and 10.10, covering the development of a Level II Chart for all Group I equipment. As was found to be the case in the earlier instance, the Task Manager started by preparing his Level I Deviation Report. The form used was the same one that he used previously. The only differences lay in the details of his entries, as will be found by examining figure 10-7, which reproduces a single page from among several comprising the Task Manager's Level I Deviation Report. Each reported or anticipated devi-

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DEVIATION REPORT

PERIOD COVERED TO Sept. 30, 1960 REPORTING ENGINEER J. Fanby CHART REF. XD-0240 A TITLE L O. B. Chart DPC Group I Level II

SENSORS SCHEDULED TO DATE 27 SENSORS SCHEDULED THIS PERIOD 4

SENSORS COMPLETED TO DATE 22 SENSORS COMPLETED THIS PERIOD 4

LEVEL I REF.	SENSOR NO.	MET	NOT MET	DESCRIPTION	PROBLEM	ACTION TAKEN	IMPACT ON L.O.B. SCHEDULE AS OF 9/30/60
4	1		X	Delivery of Disposition Consoles Nos. 1, 2, 3 and 4.	Cables (Sensor 73)* not available for console #4 due to revised disposition of equipment in SAPO area.	FAA and contractor cooperating in selection of more efficient arrangement	None, basic functional tests require availability of Flight Plan Groups 1 & 2, only.
8	14		X	Flight Plan Groups Nos. 1, 2, 3 and 4 installed and tested with Flight Plan Distribution Scanner.	Sensors 46 and 63 Scanner transients cause parity errors in Flight Plan Group.	Design engineers called to solve problem. Test rescheduled for period following buffer tie-in.	None
					Sensors 76 and 77, Flight Plan Group #4, delayed pending redesign and rerouting of cable.	Same as for Sensor #1.	None
6	19		X	Delivery of Peripheral Sector Console No. 3.	Equipment delayed two weeks for additional acceptance tests at the factory.	Installation crew made aware of delayed arrival. Will make advance arranagements for expedited installation after arrival.	None
23	33		X	Punch and Printers Nos. 2 and 3 operating with Computer No. 1.	Sensor 119, Start of Interconnection Test, awaiting completion of test specifications. *Sensor numbers refer to Level III I.F.C.	Assigned additional manpower to complete test specs by 10/4.	Delay in receipt of test specs will delay this portion of the program by 3 weeks but will not affect other portions of the overall project.

Figure 10-5 Level II Deviation Report

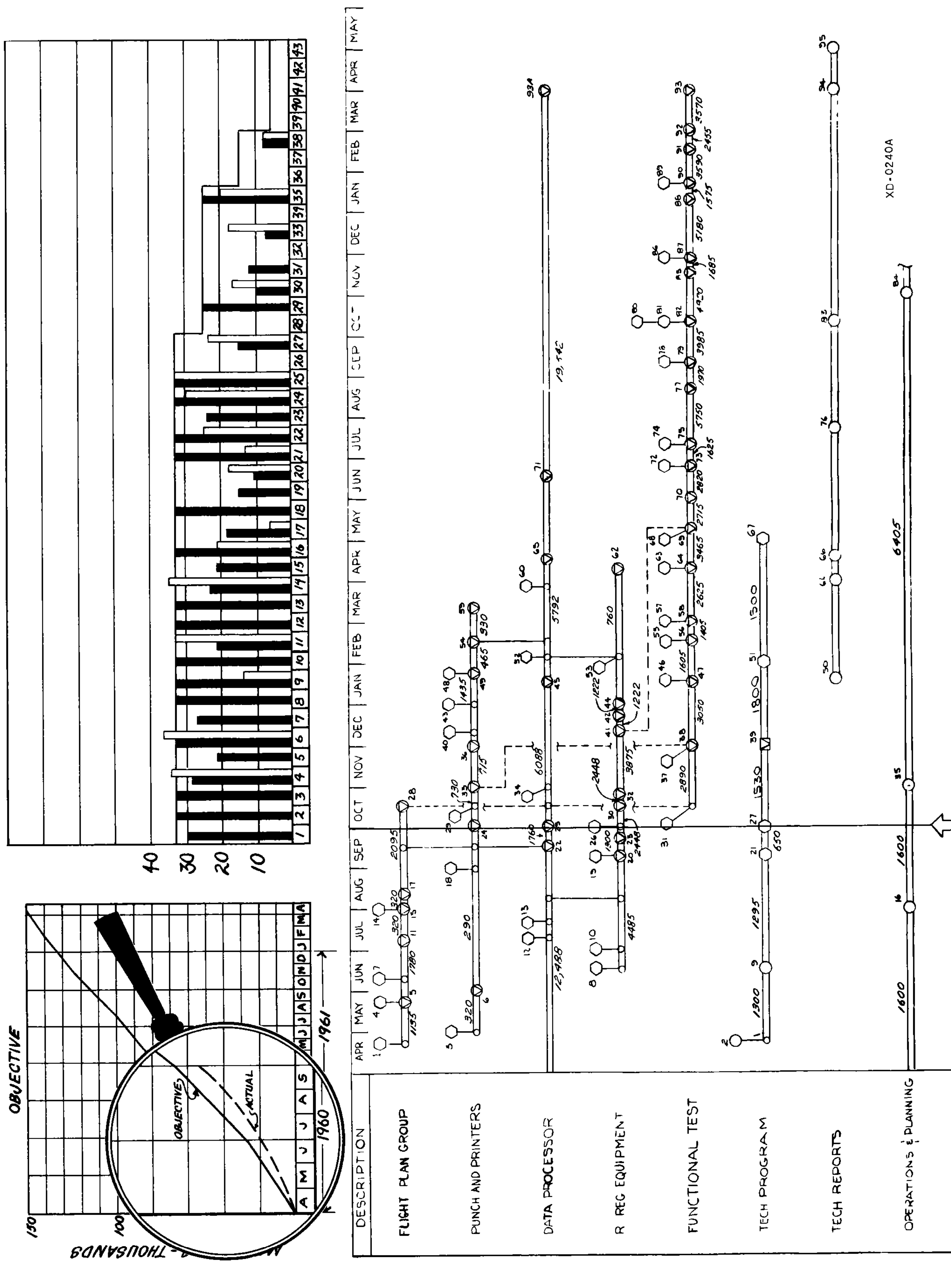

Figure 10-6 Updated Group I Level II Chart

F-2046-A

DEVIATION REPORT

PERIOD COVERED TO Sept 30, 1960 REPORTING ENGINEER S M Crott CHART REF. XD-0244A TITLE ATC/DPC Level I Line of Balance Chart

SENSORS SCHEDULED TO DATE 7 SENSORS SCHEDULED THIS PERIOD 2

SENSORS COMPLETED TO DATE 6 SENSORS COMPLETED THIS PERIOD 1

LEVEL II REF.	SENSOR NO.	MET	NOT MET	DESCRIPTION	PROBLEM	ACTION TAKEN	IMPACT ON L.O.B. SCHEDULE AS OF 9/30/60
1	4		X	Delivery of Equipment Necessary to Begin Functional Test No. 1.	Relocation of the SAPO area required cable design and prevented installation of Flight Plan Unit #4, Level II sensor #1 See also Level II Sensor #4 and #7	FAA and Contractor cooperating to expedite redesign and manufacture of cables.	No overall delay will ensue on this account because only Flight Plan Groups I and II are necessary to perform Functional Test #1
14	8		X	Equipment Necessary to Begin Functional Test No. 1 - Interconnected and Tested.	Flight Plan Groups 1, 2 & 4 have been delayed because of relocation SAPO area and unavailability of test specs.	Same as Sensor 4 plus installation of temporary cables. Assigned additional personnel for preparation of test specs.	Although work is progressing it appears probable that this situation will result in about three weeks delay in completion of the program.
19	6		X	Equipment Necessary to Begin Functional Test No. 3 Delivered.	Equipment delay of two weeks because of additional acceptance tests at the factory.	Installation crew has been alerted to make advance preparations and to expedite installation upon arrival at test site.	No delaying effect on overall program.
33	23		X	Equipment Necessary to Complete Functional Test No. 1 - Interconnected and Tested	Same as Sensor #8.	Same as Sensor #8	Same as Sensor #8

Figure 10-7 Level I Deviation Report

ation was given careful scrutiny and study in order to devise, if possible, some alternate method of working around the problem. Even though the only solution might lay in rescheduling some event, such change was to be accomplished without alteration to any approved Line of Balance chart, all allowable deviations from the established schedule being carried forward as discrepancies until otherwise discharged, or until some sufficient reason had developed to warrant a complete re-evaluation of the plan.

10.13 Remembering that Level I reports are factored on total dollars rather than on manhours, budget comparisons were made on that basis, and allowances incorporated for changes in the forecast burden rate or any other element affecting total price and total cost. Data so related can be conveniently presented in the form suggested by figure 10-8, thus:

Level I Sensor No. Reference	No. of Level II Sensors Sched. To Date	No. of Level II Sensors Compl'd. To Date	Percent Complete	$ Expended To Date	$ Budgeted To Date	Budget Ratio in%
4	4	1	25	None	None	None
6	1	0	0	None	None	None
8	9	4	44	103,640	259,100	42
23	2	2	100	6,080	7,600	80

Figure 10-8 Level I Data Tabulation and Budget Comparison

10.14 Calculations indicating program progress require no more than simple arithmetic. The sensor list for ATC/DPC Level I Chart indicates that Sensor 4 represents four measurable events on the Group I Level II Chart, i.e. sensors 1, 4, 7 and 12. Of these, we had direct knowledge from figure 10-5 that Level II sensor number 1 was only 90 percent complete and sensor numbers 4 and 7 somewhat less than that. By another portion of the Deviation Report, the Task Manager was made aware that sensor number 12 had been completed in its entirety. Inasmuch as numbers 1, 4 and 7 were reported less than 100 percent complete, however, they could not be counted at all. The Level I Chart, then, shows sensor number 4 as having a 25 percent status because only one out of four of its related Level II sensors had been accomplished. In like manner, the status of other Level I sensors was calculated and recorded on the Level I Data Tabulation and Budget Comparison Form exemplified by figure 10-8.

The Updated Level I Chart

10.15 The Task Manager used the information he had prepared in tabular form to update his Level I Line of Balance Chart. Figure 10-9 was so derived.

10.16 From this graphical representation it can be seen that, with respect to Group I Equipment, Functional Test 1 will be delayed a few weeks because of certain difficulties being experienced in the flight plan area. Functional Test 3 may or may not have difficulty, depending on the results of factory acceptance tests. It is apparent that the project will be in trouble if unit shipment is delayed longer than two weeks. Finally, there is no real problem connected with Functional Test 5 inasmuch as a cushion of about one year's time is available within the schedule.

10.17 Referring to Group II equipment, it is evident that this portion of the project is free from fault because Functional Test 2 is exactly on schedule and Functional Test 4 is progressing well ahead of time.

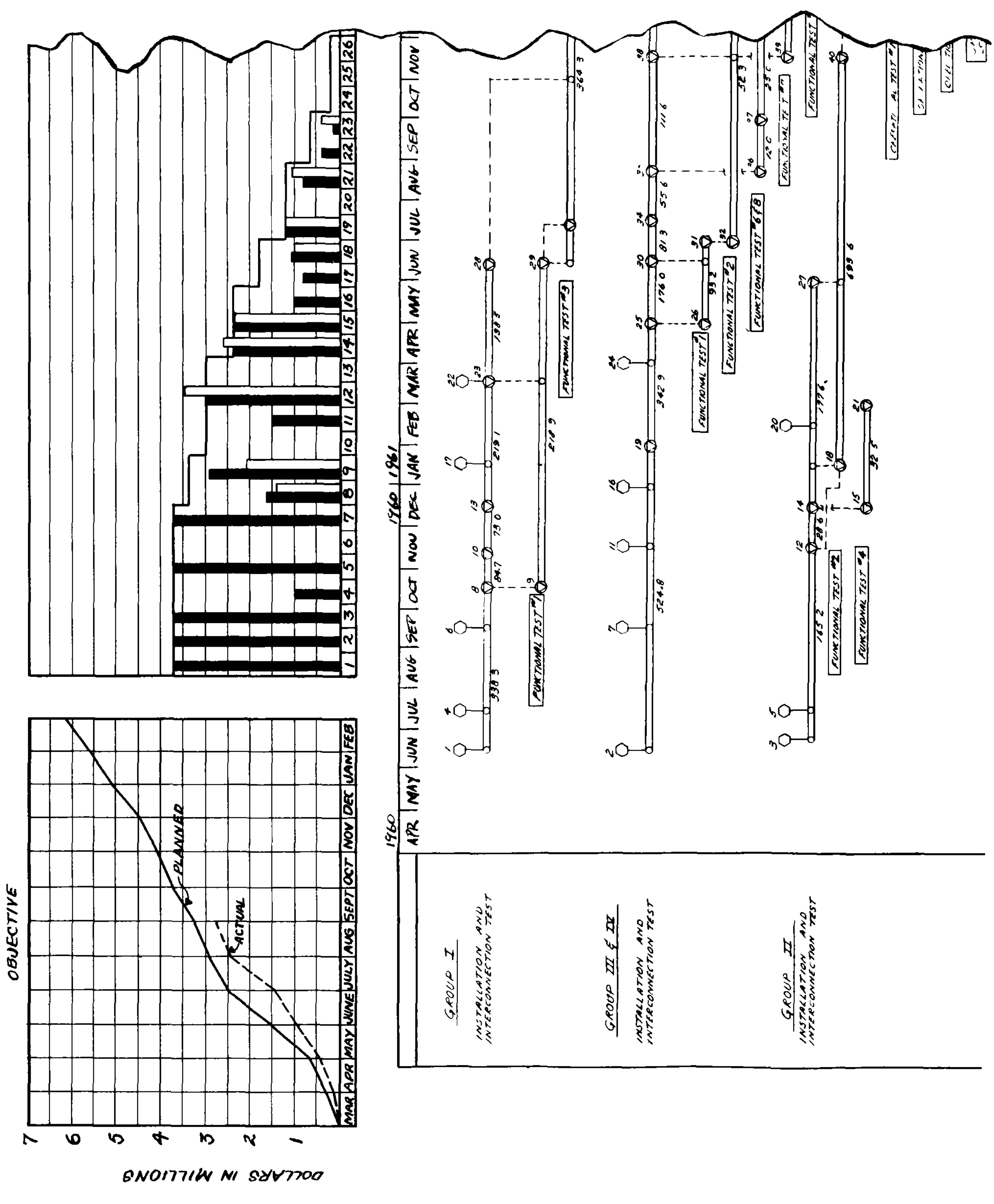

Figure 10-9 Updated Level I Chart

10.18 The Task Manager also was able to look at the status of Group III equipment and be confident that functional testing in this area was on or ahead of schedule in every particular.

Conclusions

10.19 It was demonstrably proven that significant benefits accrued to the DPC Phase B Program through the installation and use of the Line of Balance management control system. In brief, Line of Balance:

10.19.1 forced a realistic appraisal of the program objectives and scope;

10.19.2 generated clear understanding of individual responsibilities to meet overall objectives;

10.19.3 fostered disciplined performance;

10.19.4 introduced improved methods of cost control by the issuance of "calls" identified by task, track, and Level II sensor;

10.19.5 provided the means for relating cost to performance and appraising the result,

10.19.6 provided clear channels of communication within the project, between the project and its supporting contractors, between FAA/BRD and NAFEC, and within FAA/BRD:

10.19.7 promoted a joint approach to the solution of impending difficulties;

10.19.8 identified the objectives to facilitate performance by a team effort;

10.19.9 instilled an appreciation of the need for sound program planning; and

10.19.10 provided the Director of BRD with information to make beneficial overall program adjustments and to facilitate Agency DPC planning implementation.

APPENDIX

Glossary

Selected Reference Material

Standard Practice Instruction

Role of the Planning and Administration Group

Position Description for Director of Plans and Administration

Position Description for Assistant Director of Plans and Administration

Position Description for Manager of Program Planning

Position Description for Plans Programmer II

Position Description for Plans Programmer I

GLOSSARY

Assumption - One of the assumed conditions on which the project plan has been formulated.

Bar - One of the features appearing on a Line of Balance chart which, read in conjunction with the line of balance, affords a measure of program progress and budget status.

BRD - The Bureau of Research and Development, Federal Aviation Agency, Washington, D.C.

Budget - The authorized man hour and dollar limitation on expenditures for performing a given task.

Closed Loop - An information reporting system that provides appropriate feedback to authority.

Commitment - Funds available for obligation without further certification as to their availability.

Critical Assets - Facilities, equipment or manpower that are high value items or are in short supply.

CRN - Contract reference number.

Current Total Estimate - The sum of the estimated cost to complete and the total expended to date.

Dead Time - Time during which no work is scheduled to be performed or time spent unprofitably as when waiting for material or information.

Deviation Report - a) A list of the sensors which are not on schedule, their effect on delivery, the reason for their not being on schedule, and what is being done to correct the situation; b) The Standard form that is used to report deviations from the established plan.

DPC - a) An evolutionary system being developed by the FAA/BRD for the systematic modular application of automation to the National Air Traffic Control System. Equipments comprising this system are being assembled at NAFEC for Test and Evaluation prior to field application of initial modules; b) The Data Processing Central at NAFEC.

E & E - Experimentation and evaluation.

Expenditure (of funds) - Payment of funds to the party concerned upon receipt of appropriately signed vouchers or other equal evidence of work accomplishment.

FAA - The Federal Aviation Agency.

FAA/BRD - The Bureau of Research and Development, Federal Aviation Agency.

Feedback - As used herein, the reversion of information concerning a given operation to responsible authority.

GFE - Government furnished equipment or material.

Ground Rules - Operating guidelines for the preparation and development of the Line of Balance charts and diagrams.

Individual Flow Diagram - The work plan and budget for a given task, expressed in standard Line of Balance symbology.

Input - A requirement which must be supplied by an outside source in order to execute an assigned responsibility.

Integrated Flow Chart - a) A composite of several related individual flow diagrams, showing their interrelationships; b) A Level III Flow Chart.

Internal Transfer - The movement of information or material from one group inside the project to another.

Known - A task for which there is historical cost and performance data.

Level I Chart - A graphic device for the use of top management, synthesizing the elements appearing on all subordinate Level II and Level III Line of Balance charts.

Line of Balance - a) A management technique for gauging, collecting, measuring, and presenting facts - time, cost and accomplishment - all measured against time; b) A time and accomplishment standard against which progress is measured.

Man-Hour - A unit of work performed by one man in one hour.

NAFEC - a) The National Aviation Experimental Center, Atlantic City, N. J.; b) Any test and experimental facility operated by the Bureau of Research and Development Federal Aviation Agency.

Objective - That portion of a Line of Balance chart providing a graphic display of planned expenditures (expressed in man hours or dollars) against time.

Obligation - A binding agreement in writing between the parties thereto including Government agencies, in a manner and form and for a purpose authorized by law, executed before the expiration of the period of availability for obligation of the appropriation or fund concerned for certain special goods to be delivered, real property to be purchased or leased, or work or services to be performed.

Output - A product or service which one must furnish to others at a stated time.

Overrun - The act of exceeding an established budget, a term frequently used in connection with Cost-Plus-Fixed-Fee contracts.

Plan - That portion of a Line of Balance chart which gives a graphic depiction of the interrelationship of tasks to be performed and the time schedule for their completion.

Program Progress - That portion of a Line of Balance chart providing graphic representation of the tasks actually completed.

Project - As used herein, the research and development effort which produces a usable end item or service.

Project Manager - The titular head of a project.

Provisional Level I Chart - The Line of Balance diagram of a tentative plan for accomplishing a project, for use in establishing the first-cut, broad-gauge limits and features to be considered.

Resident Representative - The in-plant agent of an organization for which certain work is being performed.

SAPO - Service Application Peel-Off System

Sensor - A symbol representing a measurable event in the prosecution of a program or project, sometimes called a milestone.

Sensor Action Number - A one- or two-digit number which identifies the action symbolized by the sensor to which it applies.

Sub System - A significant part of a system, having an individual function and identity.

Sub Task - A subordinate part of a work assignment.

Symbol - One of 20 conventional signs for indicating some phase of development, manufacture or procurement.

System - A group of projects for administration and management.

Task - a) As used here, one of the several elements of a project which, together, comprise the whole; b) a unit of research and development effort associated with a project which because of its difficulty or uniqueness is administered as a separate entity.

Task Analysis - An orderly notation of specific work assignments together with some measure of their magnitude.

Task Manager - The responsible authority charged with the successful prosecution of a unit of research and development effort.

Top Management - The president or general manager of a company and his immediate staff, or equivalent Government officials.

Track - A group of sensors which are disposed along a single horizontal line in the program plan.

Unknown - A task for which there is no record of cost and performance information.

Updating - The process of bringing information up to date.

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STANDARD PRACTICE INSTRUCTION

SUBJECT: PROGRAM PLANNING

REVIEWED: [signature] PROCEDURES MANAGER APPROVED: [signature] PRESIDENT

1.0 PURPOSE

1.01 To establish the procedure and responsibilities required for program planning and production analysis through the use of the Line of Balance System.

2.0 FORMS

F-1985	Integrated Flow Diagram
F-2026	Line of Balance Chart
F-2042	Engineering Test Daily Activity Report
F-2046	Deviation Form
F-2060	Contract and Financial Data

3.0 INDEX

General Definitions....................4.0
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Processing F-2060, Contract and Financial Data Form........6.06

4.0 GENERAL DEFINITIONS

4.01 Line of Balance is a methodical system for measuring, selecting, interpreting and presenting essential facts from the preliminary development of the bid stage throughout the engineering and manufacturing stages of an end item.

4.02 The Line of Balance is divided into two phases:

1. Planning of the Prototype - This entails the layout against a background in time of the essential steps to be taken in the engineering and manufacturing phases of the prototype
2. Planning of Production Units - This entails the breaking down into its principal elements from the receipt of raw materials in the plant to completion of the end product - all measured against the background of time. This analysis must provide a picture which is capable of presenting, instantly, all important production facts.

4.03 Line of Balance technique presents deviations from the plan, making it possible for management to examine the sensitive or controlling elements and then make quick decisions based upon facts furnished from the Line of Balance flow chart which contains the following principal elements

1. The Program Plan - which sets forth the controlling tasks to be accomplished, the man-hours required, the sequence of development and the interrelationships between tasks - all measured against time.

2. The Planned Objective - which represents the goal, as well as the performance, to be met in terms of dollar expenditures for labor and material for selected key points, measured against time, as shown under the program plan.

3. The Program Progress as reflected by bar graphs corresponding to the numbered sensors in the program plan.

4. The Program Schedule or Line of Balance - which compares actual accomplishments with those which previously were forecast, thus serving to pinpoint problem areas.

4.04 Deviations Reports indicate the reason(s) for departure from the Line of Balance and describe the corrective action taken for each departure.

4.05 The reports resulting from the Line of Balance System are:

a. Management Summary - which consists of Financial Data and Recommended Management Action. This report is distributed only to Corporate Officers.

b. Line of Balance Report - which consists of the elements described in paragraph 4.03 above, and the Project Deviation Report, and is distributed to all Corporate Officers, the Manager of Manufacturing, Manager of Budgets, Contracts Manager, and Project Managers.

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5.0 GENERAL RESPONSIBILITIES

5.01 Functional Group Manager (with the assistance of the Program Planning Group)

1. Prepares breakdown of project design tasks, assigned to him, into significant elements. This breakdown is made initially in the course of bid preparation and updated periodically thereafter.

2. Develops and agrees on a budget for each significant element of design tasks assigned.

3. Develops and maintains Supervisors' Control Boards daily to show, graphically, the progress of each job.

4. Prepares Detailed Flow Diagrams and Flow Diagram Deviation Reports.

5.02 Manager of Engineering Test

1. Prepares breakdown of project tasks assigned to him into significant elements. This breakdown is made initially in the course of bid preparation and updated periodically thereafter.

2. Develops and agrees on a budget for each significant element of the project task assigned to him.

3. Prepares Flow Diagrams and Daily Activity Reports.

5.03 Controller's Staff Assistant

1. Maintains and makes available to the Manager of Program Planning the information listed on F-2060 per paragraph 6.06.

2. Assists the Project Manager in establishing financial budgets for the approval of the Executive Vice President, Development and Engineering, and the Controller.

3. Reports substantial differences in contract amount and amount budgeted.

4. Releases budget before work is begun.

5. Records all costs and assures that the cost to complete is figured from, and identified with specific cut-off dates.

5.04 Project Manager (with the assistance of the Program Planning Group)

1. Prepares Integrated Flow Diagram (breakdown of design in major blocks) which includes budget hours, actual hours to date and total current estimated hours to complete. This breakdown is made initially in the course of bid preparation and updated periodically thereafter.

2. Audits Supervisors' Control Boards.

3. Develops and recommends budget for approval.

4. Indicates problem areas on the Integrated Flow Diagrams from an analysis of Bi-Weekly Deviation Reports.

5.05 Manager of Program Planning

1. Assists in the establishment of each project's planning beginning with the bid stage until it is well established and monitors it thereafter.

2. Aids in the preparation of Integrated Flow Diagrams and Supervisors' Control Boards; prepares and issues Line of Balance Charts.

3. Prepares and issues monthly Project Deviation Report for management, indicating the nature of the deviations and what has been done about them.

   a. Prepares above report in collaboration with the Staff Assistant to the Controller, the Project Manager and the Managers of the Functional Groups.

4. Sends Deviation Reports, plus contractual data required for customer reports, to the Contracts Department. However, Sales determines the information to be furnished to the customer.

5. Serves as a clearing house for suggestions for improving or simplifying the Program Planning System.

6. Prepares Management Summary Report for distribution to the Corporate Officers.

7. Establishes schedule for monthly submission of F-2060.

5.06 Contracts Administrator

1. Complete F-2060, Contract and Financial Data Form monthly per paragraph 6.06.

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6.0 DETAILS OF PROCEDURE

6.01 Processing of F-1985, Flow Diagram

6.011 Operating Department

1. Prepare F-1985 upon receipt of Design Order or as requested for bid or estimating purposes.

Caption	Entry
Flow Diagram	Identifies specific activity covered by work being performed.
Simulation Group	Department Title performing work.
Project	Name of project.
Originator	Signature
Approved	Supervisor's signature
Page	Page number
Originated	Date F1985 originated
Rev.	Date of last revision to F-1985
Work Description	Identifies each task to be planned.
Total Est.	Estimated manhours required for total task shown in plan.
Actual Hours to Date	Manhour expenditure used on task from start or program.
Plan	Sets forth (against a background of time) the controlling points in the sequence of development for task identified in work description. Each control point is identified with a standard sensor (paragraph 6.05). Numbers sensors, to left, in sequence as they occur in time. Numbers sensors to right to denote action using action numbers from legend block. Shows the interrelationship between task shown or F-1985 and to major task of other operating functions. Indicates number of manhours required between sensors.

2. Updates F-1985 concurrent with changes.

3. Forwards copy of F-1985 to the Project Manager initially and periodically thereafter per Deviation procedure outlined in paragraph 6.04.

4. Forwards copy of F-1985 to the Manager of Program Planning initially and periodically thereafter per Deviation procedure outlined in paragraph 6.04.

6.012 Project Manager

1. Reviews F-1985 and evaluates supporting groups' progress.

2. Takes action indicated by F-1985.

3. Prepares F-1985, Integrated Flow Diagram, showing major sensor points of task being performed by supporting Engineering and Manufacturing groups.

4. Obtains Manufacturing's approval (Production Control Manager) of plan set forth on F-1985, Integrated Flow Diagram.

5. Forwards original F-1985, Integrated Flow Diagram, to Manager of Program Planning.

6. Maintains all F-1985's concerning his project in historical file.

6.013 Manager of Program Planning

1. Reviews F-1985. Evaluates progress of supporting group for each project and measures effect on other active programs.

2. Reviews F-1985, Integrated Flow Diagram, received from Project Manager. Evaluates the plan with respect to other active programs and contract requirements.

3. Approves and distributes per distribution list maintained by the Program Planning Department.

4. Maintains Historical File of F-1985 from all projects.

5. Uses F-1985's to prepare monthly Line of Balance Reports to top Management.

6.02 Processing of F-2026, Line of Balance Chart

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6.021 Plans Programmer

1. Prepares F-2026 using data from the following sources:

   a. Financial data supplied by the Controller's Staff Assistant.
   b. F-1985, Detailed Flow Diagram
   c. F-1985, Integrated Flow Diagram
   d. F-2046, Deviation Reports

Caption	Entry
Plan	Sets forth the controlling task to be accomplished, the sequence of development and interrelationship between task - all measured against time. Uses approved sensor symbols to illustrate control points. Numbers sensors in sequence as they occur in time.
Sensor Identification	Lists by number and in series the action indicated by the numbered sensors shown in the plan.
Objective	Sets forth the goal, as well as the performance, to be met in terms of dollar expenditure for labor and material for selected key points, measured against time, as shown under the Program Plan.
Progress	From a point on the planned objective representing the time of reporting, projects a forecast line across the progress block. This line is to represent 100% accomplishment against the planned objective. Constructs bar graphs corresponding to actual accomplishment for each sensor to the reporting date.

2. Forwards F-2026 to the Manager of Program Planning accompanied by a listing of items below Line of Balance.

6.022 Manager of Program Planning

1. Reviews Line of Balance Chart and list of Items Below the Line of Balance.

2. Approves and distributes F-2026 and list of Items Below the Line of Balance per distribution list maintained by the Manager of Program Planning.

6.03 Processing of F-2042, Engineering Test Daily Activity Report

6.031 Engineering Test Crew

1. Prepares F-2042 (in triplicate) at the end of each shift as follows:

Caption	Entry
Originator	Names of crew members
Date	Date form is prepared
Simulator	Model of simulator
No. of Days on Simulator	Number of days reporting crew has been assigned to the simulator.
Days ahead of assigned work or Days behind assigned work	No. of days ahead of Flow Diagram plan. No. of days behind Flow Diagram plan.

Will next series number check point be made on schedule?

Yes	Check (√) if next series check point will be reached in allotted time per Flow Diagram.
No	Check (√) if next series check point will not be reached in allotted time per Flow Diagram.

Body of Report

a. State check points working from - to always.

b. Explains problem(s) preventing the crew from meeting next check point according to plan.

c. If problem is such work can continue on assigned task but will not be completed as planned notes additional time required.

d. If problem is such work cannot continue on task notes check points abandoned and states check points of new assignment.

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2. Forwards F-2042 to the trainer lead man daily.

6.032 Trainer Lead Man

1. Receives F-2042 (in triplicate) from every crew assigned to trainer.
2. Files triplicate copy of F-2042.
3. Updates trainer copy of Flow Diagram posting crew progress.
4. Forwards original and duplicate F-2042 to Trainer Supervisor daily.

6.033 Trainer Supervisor

1. Takes corrective action.
2. Notes corrective action taken on F-2042.
3. Forwards original and duplicate F-2042 to the Manager of Engineering Test on the same day.

6.034 Manager of Engineering Test

1. Takes corrective action.
2. Notes corrective action taken on F-2042.
3. Sends original F-2042 to the Manager of Quality Assurance on same day.
4. Sends duplicate F-2042 to Project Manager on the same day.

6.035 Manager of Quality Assurance

1. Takes corrective action.
2. Files F-2042.
3. Advises Manager Engineering Test of action taken.

6.036 Project Manager

1. Updates detail Flow Diagram.
2. Takes corrective action.
3. Files F-2042.
4. Advises Manager Engineering Test of action taken.

6.04 Processing of F-2046, Deviation Report

6.041 Operating Department

1. Prepares F-2046 (in triplicate) on Bi-Weekly basis.

Caption	Entry
Flow Diagram	Flow Diagram title
Page	Page number of Flow Diagram deviation report is made against.

Caption	Entry
Project	Name of project per Flow Diagram.
Dept.	Name of reporting department.
Period	Date of last report and date of new report.
Originator	Originator's signature.
Supervisor	Responsible supervisor signs.
Sensor Status Complete to Date	Sequence numbers of sensors completed to date of report.
Scheduled This Period	Sequence numbers of sensors scheduled to be completed to date of report.
Complete	Sequence numbers of sensors completed during reporting period.
Incomplete	Sequence numbers of sensors which were scheduled for completion but which were not completed during reporting period.
Sensors Deviating from Schedule No.	Sequence number of sensor deviating from schedule.
Action Denoted by Sensor	Sensor name and action for which the sensor identifies.
Problem	Briefly explains problem preventing department from meeting sensor as planned.
Action Taken	Briefly explain any action taken by department to solve problem.
Schedule Date	Date sensor was scheduled to be completed.in accordance with the integrated Flow Diagram.
Current Est. Date	Current estimate of date on which action denoted by sensor will be completed.

[illegible]

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2. Updates F-1985, Flow Diagram and reproduces 2 copies.
3. Attaches copy of F-1985 to F-2046.
4. Forwards original F-2046 and copy of F-1985 to the Project Manager.
5. Forwards duplicate F-2046 and copy of F-1985 to the Manager of Program Planning.
6. Maintains Historical File.

6.042 Project Manager

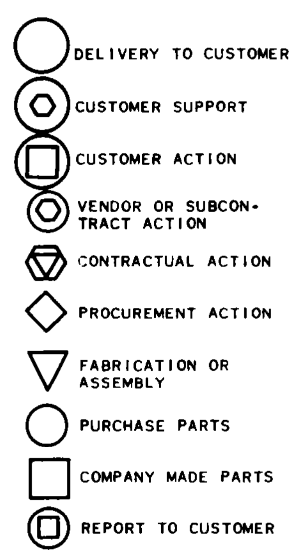
1. Reviews Deviation Report and evaluates progress of project.
2. Takes corrective action.
3. Maintains Historical File.
4. Uses information set forth on Deviation reports (Including corrective action taken by him) during his monthly review of the integrated Flow Diagram.

6.043 Manager, Program Planning

1. Reviews Deviation Report and evaluates deviations from plans as they affect the project being reported on and other projects currently active.
2. Maintains Historical File.
3. Uses information set forth on Deviation Report in preparation of monthly Line of Balance Reports.

6.05 Approved Sensor Symbols

6.051 The following symbols are to be used to identify sensor points in plans shown on F-1985, Flow Diagram and F-2026, Line of Balance chart.



TEST OR INSPECT

STUDY OR ANALYSIS

SYSTEMS DESIGN OR DEVELOPMENT

DETAIL DESIGN

INTERNAL TRANSFER

RAW MATERIAL

TEST EQUIPMENT

═══ Connecting sensors indicates work flow

─── Connecting sensors indicates material or sub-assembly flow

– – – Used to show interrelationship of task or information flow.

6.06 Processing F-2060, Contract and Financial Data Form

6.061 The applicable Contracts Administrator monthly prepares (in typewritten form) F-2060 as follows

Caption	Entry
Contract	Contract number
Date	Date of report
Date of Contract	Contract award date
Original Contract Price of Simulator	Original contract price of simulator.
Original Contract Price of Other Items	Original contract price of items other than the simulator.
Current Contract Price of Simulator	Current contract price of simulator.
Current Contract Price of Other Items	Current contract price of other items.
Authorized Changes Awaiting Negotiation (Sim. only)	Estimated amount of authorized changes awaiting negotiation on the simulator only.

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Authorized Changes Awaiting Negotiation (Other Items)	Estimated amount of authorized changes awaiting negotiation on contract items other than the simulator.
Original Contract Delivery Date	Original contract delivery date of simulator.
Adjusted Contract Delivery Date	Current contract delivery date of simulator.
Delivery Date Reported to Customer	Delivery date reported to customer.
Data Freeze Date	Data freeze date if applicable.
Type of Contract	CPFF,FPI, FP, etc.
Submitted By	Signature of applicable Contracts Administrator.

6.062 The Contracts Administrator forwards F-2060 to the Controller's Staff Assistant.per schedule established by the Manager of Program Planning.

6.063 The Controller's Staff Assistant completes (in typewritten form) F-2060 for each contract monthly as follows:

Caption	Entry
Original Estimate (By Cost Element)	Estimate supplied to the Bid Committee by the operating Division.
Bid (By Cost Element)	Proposal to customer by Bid Committee.
Contract (By Cost Element)	Contract Amount
Expended (By Cost Element)	Amount expended to date.
Estimate at Completion (By Cost Element)	Amount required by operating Division to complete contract.
Submitted By	Signature of Controller's Staff Assistant.

6.064 The Controller's Staff Assistant forwards completed F-2060's to the Manager of Program Planning.per established schedule.

6.065 The Manager of Program Planning:

1. Receives completed F-2060's monthly from the Controller's Staff Assistant.

2. Reproduces copies of F-2060 to be included in monthly report per distribution list maintained by the Manager of Program Planning.

3. Files original F-2060 as company confidential information.

Role of the

PLANNING AND ADMINISTRATION GROUP

1. Objective

To promote the integrated operation of the various Divisions by developing master plans and coordinated schedules for major systems developments, by aiding in the establishment of uniform reporting techniques and procedures, by measuring accomplishments against established programs and program requirements, by coordinating the development of standard operating procedures for program administration, and by maintaining a centralized status reporting system.

2. Duties

The functions of the Planning and Administration Group are divided into the following categories:

(a) the development of integrated program plans covering the life of the contract from bid stage to delivery of the completed systems equipment;
(b) coordinating and furthering the plans, programs and schedules of supporting Divisions;
(c) monitoring the development and preparation of major systems bid proposals.

3. Specific Functions

A. Master Planning

Master Planning is responsible for:

1. Instituting a system for scheduling and status reporting;
2. Participating in major systems bidding activity and assisting the Director of Programs Management in the preparation of bid proposals;
3. Programming performance requirements and the schedule of allocated tasks to be accomplished;
4. Cooperating with the various Divisions in establishing the inter-relationships of work priorities and arranging for progress reports;
5. Developing standard techniques for analyzing the total work content and material or equipment costs necessary to satisfy program requirements;
6. Participating with the Director of Program Management in the conduct of routine reviews in order to effect coordinated effort and to identify anticipated problem areas within the various systems programs;
7. Preparing and maintaining work load, manpower, and facilities information and relating future requirements to estimated sales forecasts and approved Corporate objectives;

8. Coordinating with the various Divisions in developing current and long-range corporate plans;
9. Evaluating the impact of proposed systems changes on overall program plans and schedules;
10. Compiling and interpreting schedule and budget projections for systems development.

B. Other

The Planning and Administration Group is responsible for insuring proper internal coordination of Corporate actions with respect to:

1. The analytical review of technical specifications, bid proposals and contract or letter agreements;
2. The development of basic and detailed technical sales proposals and technical reports.

4. Relationship

A. With the Corporate Officers:

1. Provides current contract status and delivery reports and identifies problem areas.
2. Aids in compiling and interpreting schedule and budget projections.
3. Prepares special reports on selected phases of the operation.
4. Participates in the development of current and long-range corporate plans.

B. With the Divisions:

1. Provides techniques for collecting and analyzing bid and performance information as an aid to the other operating Divisions.
2. Coordinates the development of master schedules for major systems development.
3. Monitors Division performance against approved master plans.
4. Provides assistance in determining manpower and facility requirements.

POSITION DESCRIPTION

of

DIRECTOR OF PLANS AND ADMINISTRATION

1. Scope and Objective

The Director of Plans and Administration coordinates the development of integrated corporate plans and programs, and continuously monitors progress and performance relating to major systems contracts. He directs the operations of the Plans and Administration Group and is responsible for the economical and efficient discharge of its assigned functions and duties. He coordinates Corporate action in developing long-range plans for future business activity and prepares plans for corporate guidance under mobilization or other emergency conditions.

2. Regular Duties

2.1 Develops program plans and policy or presents other recommendations for the approval of the President, and introduces timely revisions when appropriate.

2.2 Proposes uniform procedures and standard practices and analyses methods and design with a view toward improving administrative, operating and control systems.

2.3 Institutes suitable controls for all aspects of program plans to permit reliable prediction of trends and interpretation of current performance.

2.4 Develops a compatible system for the issuance of work orders and work authorizations for implementation of plans.

2.5 Maintains sufficient over-all program coordination to anticipate problems, to supply necessary interpretation and amplification of plans, and to negotitate changes in the plans.

2.6 With the concurrence of responsible Division authority, recommends a system of work orders to maintain the desired balance between the relationships of cost, timing and product performance.

2.7 Furnishes such operations services as may be required, including special reports and analyses.

2.8 Gauges the impact of design changes on established programs and aids in the planning for their introduction.

2.9 Coordinates the development of corporate long-range plans by obtaining individual Division statements of sales objectives, development programs, facility studies and operating forecasts and by making appropriate consolidation of them as a correlated whole.

2.10 Initiates studies of Corporate growth capabilities and the feasibility of expansion and diversification to accomplish long-range plans.

2.11 Keeps management advised of actual or anticipated deviations from approved plans and policies.

2.12 Coordinates the development of generalized mobilization plans under broad assumptions of possible emergency conditions.

2.13 Causes the development and issuance of Standard Procedures relating to programming and scheduling and the techniques to be used in presenting such information.

2.14 Assists in the development of methods for analyzing and improving administrative and operating controls.

2.15 Correlates the preparation of major systems bid proposals, bid estimates and specifications, and provides administrative assistance therefor.

2.16 Performs such other duties as may be assigned.

2.17 Executes the general responsibilities common to all executives and supervisors.

3. Authority

3.1 Types and Extent of Authority

3.1.1 Has line authority over all personnel assigned to the Plans and Administration Group.

3.1.2 Has functional authority to acquire timely and complete information relating to operational performance under established and prospective plans and schedules.

3.1.3 Has functional authority to meet major system suppliers and manufacturers, and with customers, in performance of his regular and special duties.

3.1.4 Has functional authority to incur qualified expenses in the maintenance of customer relations and the promotion of company interests.

3.1.5 Has staff authority to recommend to Division executives appropriate policy and action for the administrative control of current and prospective programs and operations.

3.1.6 Has functional authority to prescribe the nature and format to be used in reporting program and schedule performance.

3.1.7 Has staff authority to review specifications, bid proposals and contracts, and to make appropriate recommendations.

4. Accountability

4.1 Accountable for the efficient operation of the Plans and Administration Group.

4.2 Accountable for the timely review and analysis of Corporate administrative and operating performance.

4.3 Accountable for the identification of Corporate and customer responsiblities in satisfaction of major systems requirements.

4.4 Accountable for the performance of such additional duties as may be assigned.

5. Qualifications

5.1 Academic degree in one or more of the following fields:

Engineering, Business Administration, Industrial Management

5.2 Not less than twelve years experience in senior administrative positions.

5.3 Thorough familiarity with fundamentals and principles of program planning and contract administration.

5.4 Additional requrements are:

5.4.1 An aptitude for analytical study.

5.4.2 The ability to express himself lucidly, both verbally and on paper.

5.4.3 The qualities of good leadership and mature judgement.

POSITION DESCRIPTION

for

ASSISTANT DIRECTOR OF PLANS AND ADMINISTRATION

1. Scope and Objectives

Under the general direction of the Director of Plans and Administration, the Assistant Director of Plans and Administration is responsible for the development of plans and systems for the coordinated operation of the various Divisions. His objective is to improve the profitability, efficient operation and growth of the corporation by aiding in the formulation of operating policies and plans.

2. Regular Duties

2.1 In the absence of the Director of Plans and Administration, acts on his behalf within the full scope of his delegated authority.

2.2 Develops policies and procedures for the effective functioning of the Program Planning Group, including the institution of systems for progress reporting, in furtherance of improved program performance.

2.3 Monitors execution of major systems plans and schedules, developing new methods of control for analysis of program operations in order to predict future problem areas and develop plans to eliminate them.

2.4 Receives and evaluates workload/manpower/facilities information.

2.5 Reviews bid sheet data, historical performance, current workload, projected capacity and performance, and delivery forecasts.

2.6 Develops agenda and conducts regular program review meetings for top management. Presents overall problems and delineates problem areas in order to stimulate decisions and initiate follow-up action.

2.7 Aids in the establishment of compatible planning procedures throughout the Corporation.

2.8 Maintains an information center for the review of program status and the prediction of completion dates.

2.9 In cooperation with the heads of all operating Divisions, participates in the establishment of current and long range corporate plans and monitors company progress at regular intervals. This includes:

2.9.1 Collecting, analyzing and preparing reports to compare actual and currently projected sales with prior forecasts for the company's products.

2.9.2 Recommending future manpower and facilities support for fulfillment of approved planning objectives.

2.9.3 Correlating planning information into a balanced corporate operating plan.

2.10 Performs such other duties as may be assigned by the Director of Plans and Administration.

2.11 Executes the general responsibilities common to all executive and supervisory positions in the company.

3. Authority

3.1 Types of Authority

3.1.1 Exercises direct line authority over Planning Group personnel.

3.1.2 Exercises functional authority over operational authorities insofar as their performance affects the development of plans and schedules.

3.2 Line and functional authority of the Assistant Director of Plans and Administration is delegated to that position by the Director of Plans and Administration with the approval of the President.

3.3 Exercises authoritative action in cases exemplified by, but not limited to:

3.3.1 Issuing instructions to the operating Divisions as to the development and format of performance schedules.

3.3.2 Instituting methods and procedures for the development of sound plans and schedules.

3.3.3 Participating in internal and external conferences relating to programs and schedules.

3.3.4 Directing the operations of the Program Planning Department.

4. Accountability

4.1 The Assistant Director of Plans and Administration is responsible for the supervision, selection and training of all assigned Planners and Schedulers.

4.2 He develops necessary plans and schedules to insure coordinated operation of the various Divisions.

4.3 He is responsible for providing timely advice to Management of anticipated problems and recommending courses of action for their solution.

5. Qualifications

5.1 Academic degree in one or more of the following fields:

Industrial Management, Business Administration

5.2 Not less than ten years experience in the field of master planning, with special emphasis on engineering and manufacturing programming.

5.3 The maturity, experience and judgement to recognize and solve complex managerial problems.

5.4 The qualities and personality that facilitate conference management and leadership.

POSITION DESCRIPTION

for

MANAGER OF PROGRAM PLANNING

1. Scope and Objectives

Under the general direction of the Director of Plans and Administration, the Manager of Program Planning is responsible for the development of plans and schedules for the coordinated operation of the various divisions. His objective is to improve the profitability, efficient operation and growth of the company by aiding in the formulation of operating policies and plans.

2. Regular Duties

2.1 Develops policies and procedures for the effective functioning of the Program Planning Department, including the institution of a system for scheduling and status reporting, in furtherance of improved project performance;

2.2 Keeps management advised continuously of the current and the forecast status of contracts, revealing areas of anticipated weakness;

2.3 Receives and evaluates workload/manpower/facilities information and judges plant capacity to accept proposed contracts;

2.4 Reviews bid sheet data and, in consideration of historical performance, current workload, projected capacity and performance, verifies delivery estimates;

2.5 Defines performance requirements to insure successful performance on new projects or contracts;

2.6 Participates in project activities and aids in guiding them toward the fulfillment of assigned tasks;

2.7 Maintains an information center for the review of project status and the prediction of shipping or completion dates;

2.8 In cooperation with and aided by the chiefs of all operating Divisions, acts as coordinator for the development of current and long-range corporate plans and monitors company progress at regular intervals. This includes:

2.8.1 Collecting, analyzing and preparing reports to compare actual and currently projected sales with prior forecasts for the company's products.

2.8.2 Recommending future manpower and facilities support for fulfillment of approved planning objectives.

2.8.3 Correlating planning information into a balanced company operating plan.

2.9 Performs such other duties as may be assigned by the Director of Plans and Administration; and,

2.10 Executes the general responsibilities common to all executive and supervisory positions in the Company.

3. Authority

3.1 Types of Authority

3.1.1 Exercises direct line authority over all Planning Department personnel.

3.1.2 Exercises functional authority over other operational Departments insofar as their performance affects the development of plans and schedules.

3.2 Line and functional authority of the Manager of Program Planning is delegated to that position by the Director of Plans and Administration with the approval of the President.

3.3 Exercises authoritative action in cases exemplified by, but not limited to:

3.3.1 Issuing instructions to the operating Departments as to the development and format of performance schedules.

3.3.2 Instituting methods and procedures for the development of sound plans and schedules.

3.3.3 Participating in internal and external conferences relating to programs and schedules.

3.3.4 Directing the operations of the Program Planning Department.

4. Accountability

4.1 The Manager of Program Planning is responsible for the supervision, selection and training of all Planners and Schedulers.

4.2 He develops necessary plans and schedules to insure coordinated operation of the various Divisions.

4.3 He is responsible for providing timely advice to management of anticipated problems and recommending courses of action for their solution.

5. Qualifications

5.1 Academic degree in one or more of the following fields:

Industrial Management, Business Administration

5.2 Not less than ten years experience in industrial programming and manufacturing analysis.

5.3 The maturity, experience and judgement to recognize and solve complex managerial problems.

5.4 The qualities and personality that facilitate conference management and leadership.

POSITION DESCRIPTION

for

PLANS PROGRAMMER - II

1. Scope and Objective

Under the general direction of the Manager of Program Planning, the Plans Programmer II assists in the development of plans and schedules for coordinating the operation of the various divisions. His objective is to improve the profitability and efficiency of the Company by monitoring performance, analysing problems and reporting deviations from approved plans.

2. Regular Duties

2.1 Develops program schedules, Line-of-Balance analyses, project status reports and detailed summaries of manpower requirements for the approval of the Manager of Program Planning.

2.2 Keeps informed of the current status of specified projects and notifies the Manager of Program Planning of the cause, effect and corrective action taken by the Project in case of deviation from established plans, and recommends appropriate action to alleviate or obviate problem areas.

2.3 Reviews and evaluates workload/manpower/facilities information and aids in the formulation of recommendations regarding ability to accept and fulfill proposed contracts, having consideration for plant capacity, manpower available and other pertinent factors.

2.4 Reviews bid sheet data and, in consideration of historical performance, current workload, projected capacity and performance advises the Manager of Program Planning on validity of delivery estimates.

2.5 Recommends performance schedules and selection of appropriate check points to aid the Project Manager in achieving successful performance.

2.6 Monitors project activities and provides administrative consultation and guidance to facilitate the fulfillment of assigned tasks.

2.7 Collects and maintains selected project status information in order to verify predicted completion dates.

2.8 Participates in the coordination and development of current and long range corporate plans, including the collection of data and the preparation and analysis of reports.

2.9 Performs such other duties as may be assigned by the Manager of Program Planning.

3. Authority

3.1 Types of authority

3.1.1 Exercises no direct line authority.

3.1.2 Exercises limited functional authority over others insofar as their performance is required for the development of plans and schedules.

3.2 Functional authority of the Plans Programmer is delegated to that position by the Manager of Program Planning with the approval of the Executive Assistant.

3.3 Exercises authoritative action in cases exemplified by, but not limited to:

3.3.1 Instructing the operating departments concerning the development and format of planning information.

3.3.2 Instituting methods and procedures for the development of sound plans and schedules.

3.3.3 Participating in conferences relating to programs and schedules.

4. Accountability

4.1 The Plans Programmer is accountable for the performance of his regular and special duties.

4.2 He is accountable for the security and safe keeping of all classified matter and Company-owned property in his custody.

5. Qualifications

5.1 An academic degree in one or more of the following fields: Engineering or Industrial Management.

5.2 At least four years experience in industrial planning or manufacturing analysis.

POSITION DESCRIPTION

for

PLANS PROGRAMMER - I

1. Scope and Objective

Under the direction of the Manager of Program Planning, the Plans Programmer I assists in the development of plans and schedules for coordinating the operation of the various divisions. His objective is to aid in the monitoring of performance, the analysis of problems encountered and the reporting of deviations from approved plans.

2. Regular Duties

2.1 Prepares program schedules, Line-of-Balance reports, project status reports and tabulated reports of manhour expenditures for the approval of the Manager of Program Planning.

2.2 Keeps informed of the current status of specified projects and notifies the Manager of Program Planning of the cause, effect and corrective action taken by the Project in case of deviation from established schedules, and recommends appropriate action to alleviate or obviate problem areas.

2.3 Reviews workload/manpower/facilities information and aids in the formulation of recommendations regarding ability to accept and fulfill proposed contracts, having consideration for plant capacity, manpower available and other pertinent factors.

2.4 Studies bid sheet data and, in consideration of past experience, current workload, projected capacity and performance, appraises the validity of delivery estimates.

2.5 Recommends performance schedule and selection of appropriate check points as an aid to the Project Manager in achieving successful performance on new projects or contracts.

2.6 Monitors project activities and provides administrative consultation to facilitate the fulfillment of assigned tasks.

2.7 Collects and maintains selected project status information in order to verify predicted completion dates.

2.8 Assists in the coordination and development of current and long range plans, including the collection of data and the preparation or analysis of reports.

2.9 Performs such other duties as may be assigned by the Manager of Program Planning.

3. Authority

3.1 Types of authority

3.1.1 Exercises no direct line authority.

3.1.2 Exercises limited functional authority over others insofar as their performance is required for the development of plans and schedules.

3.2 Functional authority of the Plans Programmer is delegated to that position by the Manager of Program Planning with the approval of the Executive Assistant.

3.3 Exercises authoritative action in cases exemplified by, but not limited to:

3.3.1 Instructing the operating departments concerning the development and format of planning information.

3.3.2 Instituting methods and procedures for the development of sound plans and schedules.

3.3.3 Participating in conferences relating to programs and schedules.

4. Accountability

4.1 The Plans Programmer is accountable for the performance of his regular and special duties.

4.2 He is accountable for the security and safe keeping of all classified matter and Company-owned property in his custody.

5. Qualifications

5.1 An academic degree in one or more of the following fields: Engineering or Industrial Management.

5.2 At least two years experience in industrial planning or manufacturing analysis.

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