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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Flexible Production Scheduling System

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The material on which the contents are based was compiled by a team for which overall management was provided by Y. Ichinose, President of IHI Marine Technology, Inc., New York City. Y. Okayama, Deputy Senior Manager, IHI International Division, Tokyo, is the principal author. He was assisted by T. Hatsuzaki, S. YAiro, F. Morimoto, K. Sayama, and T. Hotehama, all Senior Engineers in production organizations of IHI's Kure Shipyard. Editing and some supplemental writing was performed by L.D. Chirillo assisted by J.F. Curtis of Manufactured Systems, Inc., Seattle, Washington.

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FOREWORD

In Japan the word takuto *is* used when referring to implementation of integrated schedules for different types of work such as inherent in shipbuilding. Takuto is derived from the German word taktstock which means *baton.* In the takuto concept, the principle operating manager of a shipyard is envisioned as a conductor who controls many musicians to insure the same tempo. Given that schedules for different types of shipbuilding work are integrated and based on ranges of variation for processes in statistical control, anyone being ahead of schedule when building ships becomes as detrimental as an orchestra member who exceeds the prescribed tempo.

Just as a conductor, in realizing a musical composition, directs a change in tempo, the principle operating manager, e.g., when adopting an improved work method, directs changes in tempo (updates schedules). For both the music conductor and the manager, the overriding need is to maintain integration.

But, unlike an orchestra conductor, who in the extreme might apply a little "taktstock" on the head of someone as a reminder to maintain tempo, in the takuto concept, controls for insuring adherence to schedules are decentralized. Schedules are organized in tiers so that daily-schedule lapses are apparent to workers, weekly to immediate supervisors, hi-weekly to the next level of supervision, and so on. That is, for each lapse the organization of schedules prompts a reaction by a level of supervision commensurate with the seriousness of the situation.

The control responses are: transfer of man-power from work flows that are ahead of schedule to those that are behind, use of overtime, and obtaining assistance from subcontractors. Of these, the first alternate is the most effective and also the most dependent upon some degree of trade flexibility.

The methods described herein are those developed by Ishikawajima-Harima Heavy Industries Co., Ltd. for controlling shipyard workloads. By adaptation they are applicable to other shipyards which employ product-oriented manufacturing systems.

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1.0 INTRODUCTION

A schedule which is developed in phases is far more effective than a schedule which attempts a level of detail beyond the progress of design.

Prerequisites for scheduling that result in high performances by production processes and constant improvements in a scheduling system are:

- accurate information of material volume (total materials required) corresponding with each level of design development,
- a system for first assessing all materials required in large groups or units and, as each design phase develops, for refining all material requirements into small groups or units,
- statistically acquired parameters, based on past performances, which associate man-hours normally required with each material group or unit so as to accurately predict work volume (material volume x parameter = work volume),
- timely preparation of drawings, material lists and purchase order specifications,
- effective material management systems for material procurement and marshaling per schedules, and
- procedures for workload leveling and for regulating the rate of work.

A traditional system work breakdown is impractical for applying the first three of the above prerequisites. System-by-system approaches involve difficulties in estimating work volume. Production supervisors in charge of different systems are, to a large degree, left to coordinate among themselves. Each supervisor is relatively uninformed beforehand of other supervisors! work that will take place in the same region at the same time. As a consequence, work is characterized by competition for access and rework without corporate knowledge afterwards of the problems encountered. Mischarges of labor man-hours for work performed are prevalent. Materials and man-hours are not sufficiently related.

A product approach permits the principals of Group Technology to be exploited. Work packages classified by zone/problem area/stage are envisioned even as contract design starts. Problems inherent in the implementation of such work packages, i.e., producing distinct interim products (parts, subassemblies and assemblies) on production lines, are much more apparent beforehand. Work performed which was classified by problems, regardless of interim-product differences, is readily analyzed by statistical methods. The analyses constantly direct managers, supervisors and workers to the most immediate problems. Also, the analyses keep current for future work, the parameters needed for accurately relating materials to required man-hours.

While there may be other solutions to the problem of estimating work volumes for different end products, this publication describes the methods applied by Ishikawajima-Harima Heavy Industries co., Ltd. (IHI) which is a world leader in the application of a product work breakdown structure for constructing ships, particularly one of a kind, and for simultaneously constructing end products other than ships. Thus, the Flexible-Production Scheduling System (FPSS) described herein is compatible with earlier publications which describe other aspects of IHI's manufacturing approach. [1]

1.1 Logic and Principles

As compared to other manufacturing endeavors, shipyard operations are unique. Contract design is regarded as a vital part of the manufacturing process and the time between contract award and delivery for each end product is set at an optimum duration in order to achieve the lowest overall cost. Particularly as compared to automobile and home appliance manufacturing, where design and material definition are completed before sales efforts begin, most design details of shipyard end products are not known until a considerable period after contract award.

Reliance is placed on production engineers devising a build strategy in time to guide the start of contract design. As subsequent design phases produce more knowledge, reliance is placed on phased refinement of the build strategy until a level is reached where production engineers provide tactical requirements that are to be included in the final design products; literally work instructions per zone/area/stage. Most of the work so classified is readily performed as organized work flows. Thus, reliance is also placed on production lines (also called process lanes or work flows) which anticipate tiers of interim products classified by problem categories instead of design simils.rities. The process lanes are divided into distinct work stages as shown in Figure 1-1. Ideally, the facilities for such work flows are arranged so that minor flows support major flows with minimal need for transporting interim products from sites where they are completed to sites where they are needed.

Emphasis on organizing material in like manner with commensurate refinements as design phases unfold, simplifies scheduling. This approach contrasts remarkably with traditionalists who schedule without evidence of work volume scientifically derived from material volume. Their only option is to produce detailed production schedules using mostly information that was available from the onset. Such schedules, based on insufficient and inaccurate inputs, are a significant reason for productivity stagnation. They are insufficient to regulate process flows. Man-hour losses are inevitable.

Effective schedules are also based on best known work methods, work processes in statistical control (i.e., having predictable and repeatable outputs), and integration. Thus, schedule accuracy means that work is being executed per schedule, not late or not early. Such shipyard schedules, like airline schedules, require exact compliance. If departure is too early, would-be passengers are left behind. If flight time is longer than scheduled, passengers are late. If any aspect of ship consiiruction proceeds too fast or too slow, integration is lost and costs rise. Schedules are ineffective unless they reflect expected ranges of variation for work processes performing normally, i.e., work processes in statistical control. In other words, schedule accuracy means that both required man-hours and time durations are known beforehand. Statistical control is essential. Effective schedules are made on the basis of certainty. [2]

[1] Other pertinent National Shipbuilding Research Program (NSRP) publications include: "ProductWork Breakdown Structure - Revised December 1982", Integrated Hull Construction, outfitting and painting - May 1983", "Design for Zone Outfitting - September 1983", "Pre-Contract Negotiation of Technical Matters - December 1984", "Product Oriented Material Management - June 1985", and "Shipyard Organization and Management Development - October 1985".

[2] For a discussion on statistical control, see Page 5of the NSRP publication "ProcessA nalysisV ia Accuracy Control - Revised August 1985".

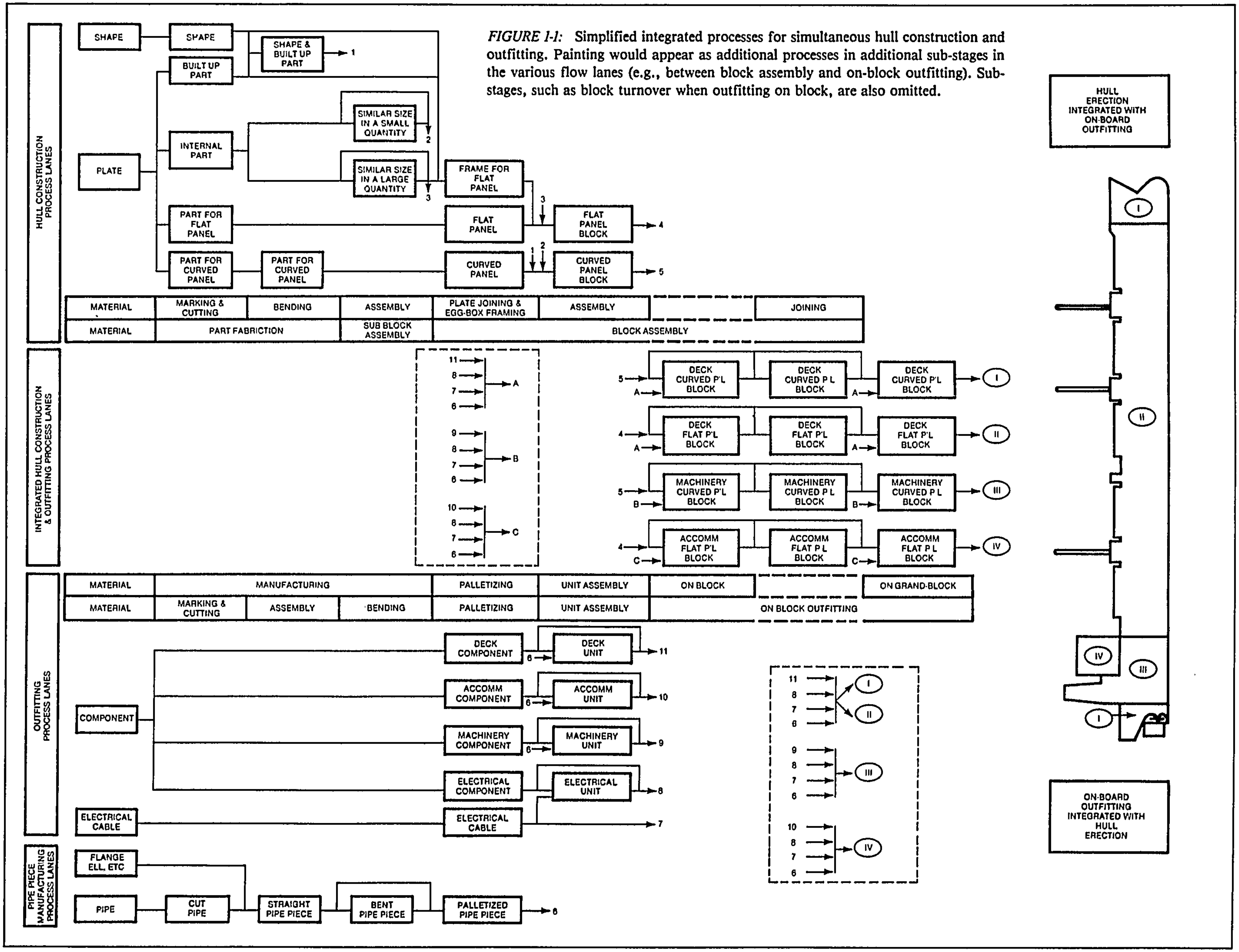

FIGURE 1-1: Simplified integrated processes for simultaneous hull construction and outfitting. Painting would appear as additional processes in additional sub-stages in the various flow lanes (e.g., between block assembly and on-block outfitting). Sub-stages, such as block turnover when outfitting on block, are also omitted.

Achieving certainty involves consideration of accuracy level, flexibility range and integration of schedules" Figure 1-2 illustrates the conceal of accuracy level which primarily addresses reducing daily man-hour consumption without shortening production duration. Flexibility range is illustrated in Figure 1-3 which shows normally distributed man-hour variations per work packages of the same classification that when averaged yield the same man-hour total scheduled per month. Figure 1-4 emphasizes the need for a scheduling system to integrate design and material procurement activities with production activities in a shipyard master schedule. The schedules for all such activities must be coordinated. Subgroups within each activity must coordinate with each other and with corresponding subgroups of the other two activities.

FPSS employs a statistical approach and integrates activities such as production planning, scheduling and engineering, design, material procurement, and production and achieves high quality schedules. Successful implementation of FPSS requires support, see Figure 1-5, as follows:

- application of Frame Scheduling Method (FS14),
- coordination by Integrated Hull Construction, Outfitting and Painting (IHOP) Scheduling and Tracking,
- operation by Decentralized Production Planning, Scheduling, and Engineering, and
- assurances for On-Schedule Availability of Information and Resources work instructions, manpower, material, facilities, etc.). [3]

The support elements are described in Chapter 2.0. Their effectiveness is directly related to the degrees of achieved modularization and standardization, not only for raw materials and finished components but also, for interim products, production process lanes, design procedures and documentation, material management procedures, etc.

1.2 Consistency in the Organization of Work, People and FPSS

The organization of any type of scheduling system, of *work* and of people should be on the same basis for maximum effectiveness. Also, work volumes should be hierarchically organized and should be assigned times and durations level by level. This consistent division is prerequisite for manpower allocations by groups that are also hierarchically organized and managed.

For example, when welding replaced riveting a product work breakdown became natural and hull blocks evolved. Eventually, some shipbuilders recognized blocks and prerequisite subassemblies and parts as products. They abandoned system orientation as they realized that further productivity gains were dependent upon adopting a hierarchical organization of people specialized along product lines.

1.2.1 PWBS and FPSS

FPSS will not operate well without parallel development of a Product Work Breakdown Structure (PWBS). PWBS provides for separation of work hierarchically so that numerous interim products are planned as needed to construct an end product. In the Zone Outfitting Method (ZOFM), for example, each interim product is regarded as a work package for which assorted materials (regardless of system) are marshaled per a specific material list of fittings (MLF) in order to comprise a "pallet". Thus the terms work package, pallet and MLF are used synonymously as hey each represent outfitting work associated with a particular zone/area/stage. [4]

[3] As of January 1986, computers are employed in IHI shipyards for calculating the parameters needed to accurately relate materials to man-hours. Scheduling per se is performed manually.

[4] An effective PWBS consistent with Figure 1-1 and the FPSS described herein is described in the National Shipbuilding Research Program (NSRP) publication "Product Work Breakdown Structure - Revised December 1982". Therein, particular note should be made of Figures 1-6 through 1-13 which describe the hierarchical manufacturing levels accompanied by product classifications for the Hull Block Construction Method (HBCM), Zone Outfitting Method (ZOFM), Zone Painting Method (ZPlll), and Pipe Piece Family Manufacturing (PPFM).

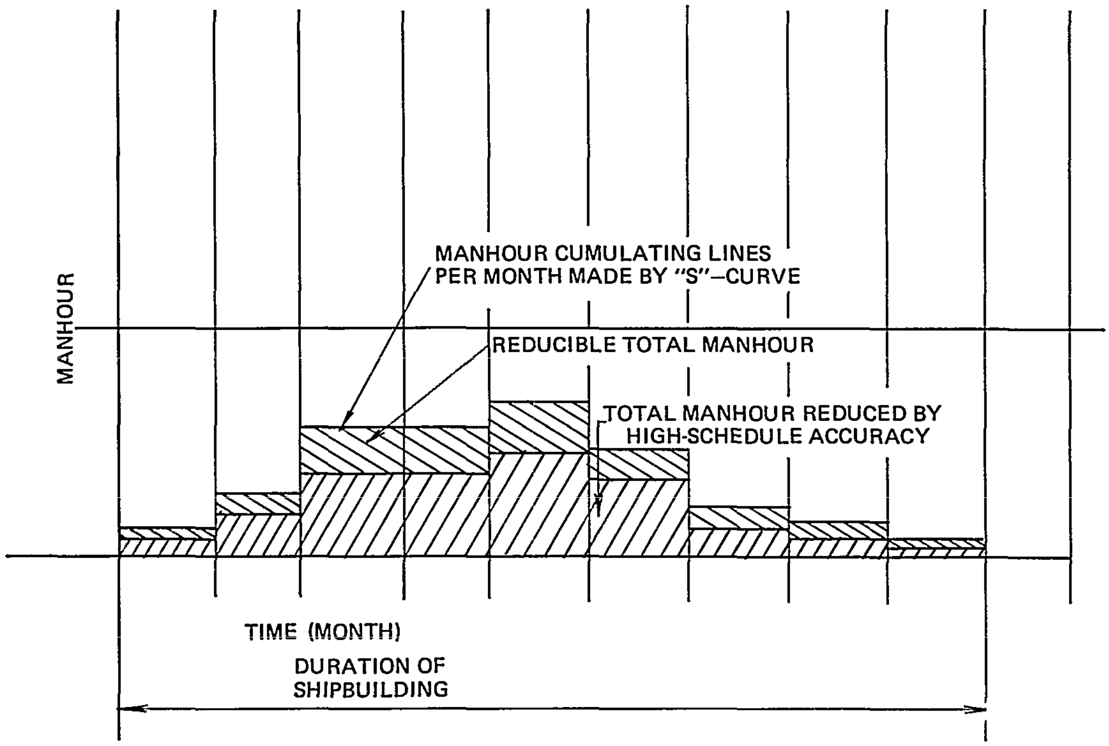

FIGURE 1-2: Schedule Accuracy Level. Productivity is increased by decreasing man-hours required and/or decreasing the overall duration required. Schedule accuracy applies to the former. At first, ways should be found to improve schedule accuracy, e.g., eliminating idle time due to late design and material which will reduce man-hours required per unit time.

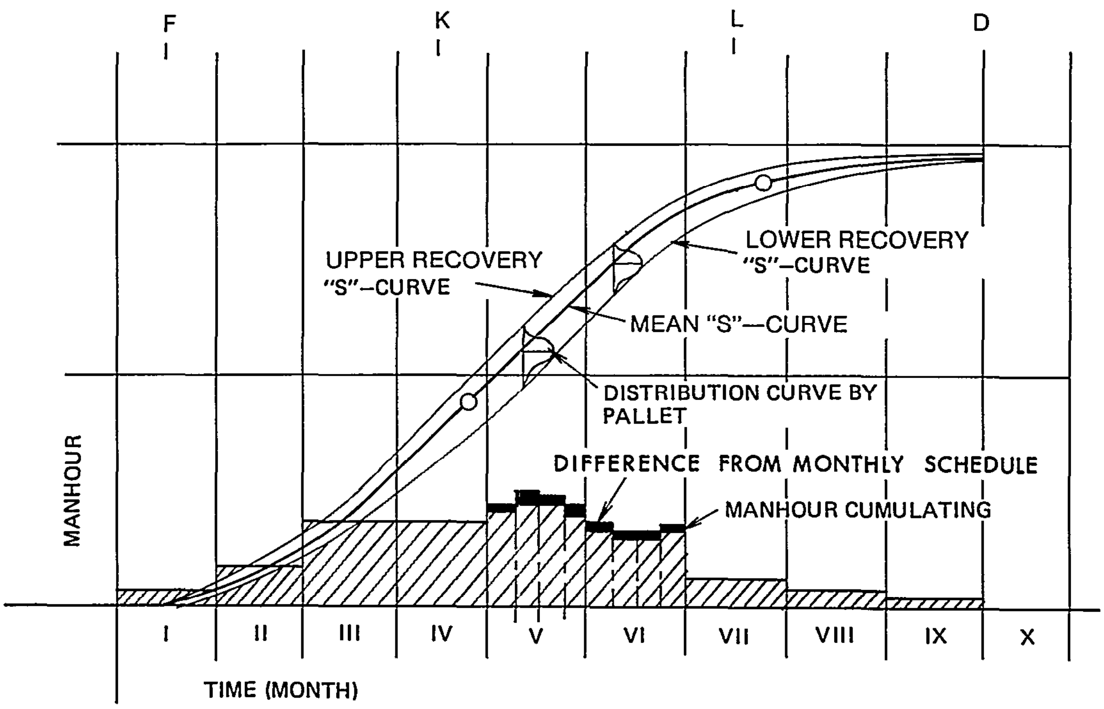

FIGURE 1-3: Mode of "S" curve and Manhour Cumulative Line. Note predicted man-hour consumption by month as shown for month IV. Shorter-term forecasts are by week as shown for month V where man-hours are expected to exceed the mean during some weeks and be less than the mean for other weeks so as to be offsetting. Thus, regardless of prediction by month or week (long term or short term), the total man-hours per month remains the same. Such distributions, represented by the bell-shaped curves shown, are the basis for schedule recovery. The man-hour cumulative curve changes in differentiation as frames become smaller but remains constant in integration.

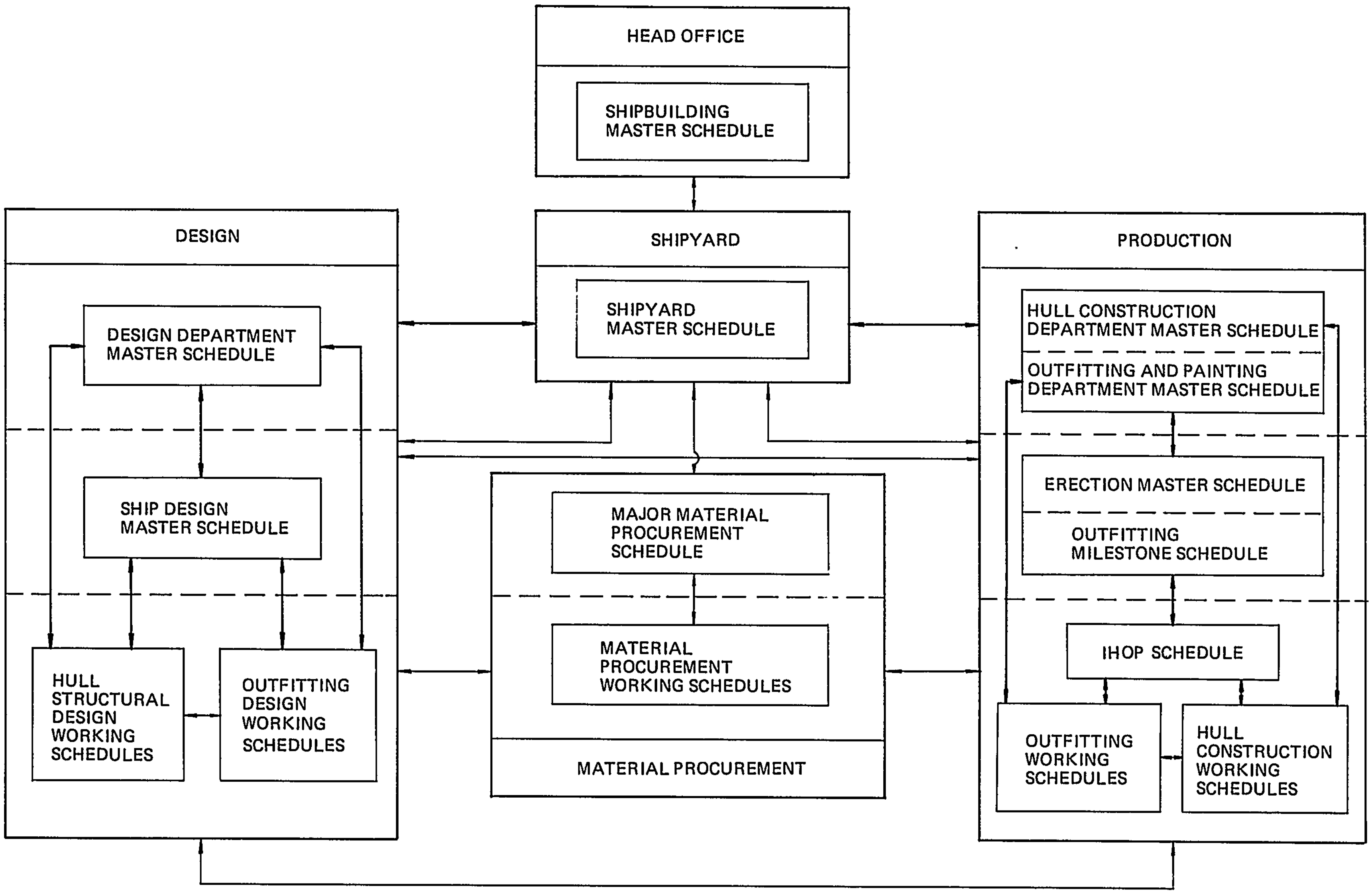

FIGURE 1-4: Scheduling System Flow for Shipbuilding Activities.

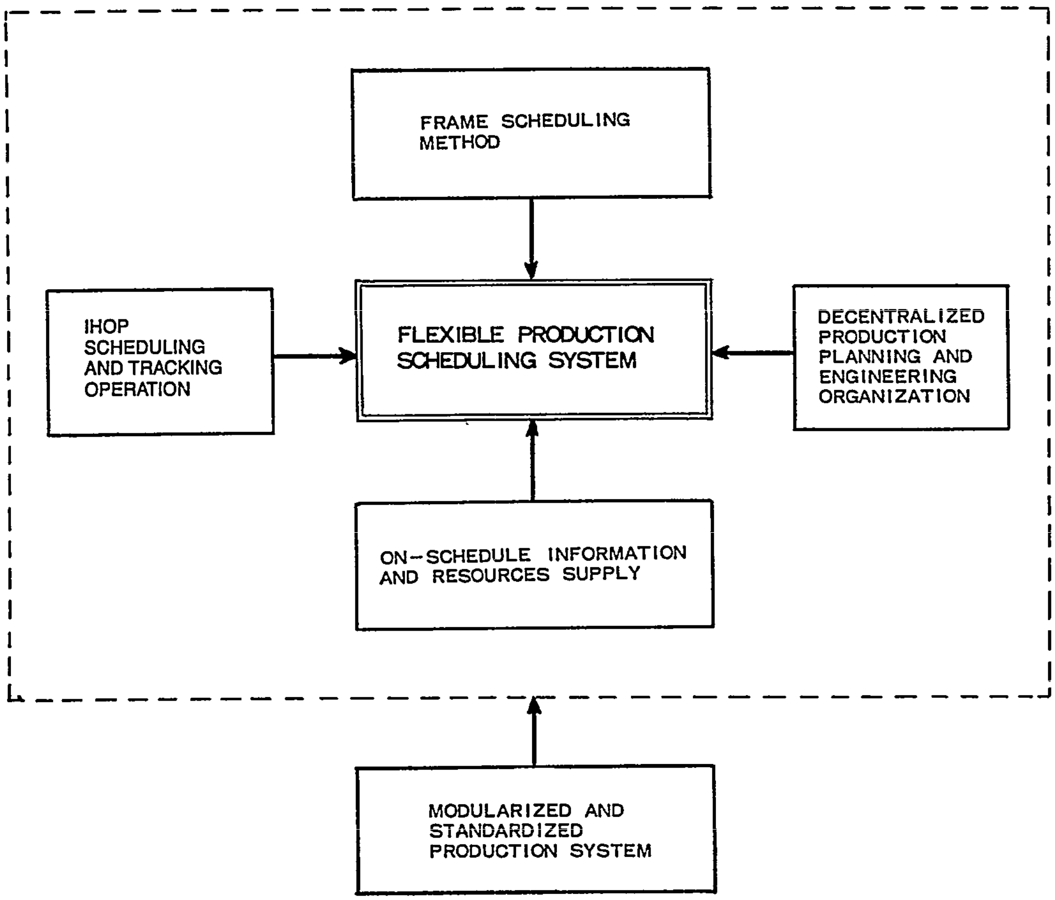

FIGURE 1-5: Relationship between Flexible Production Scheduling System and Supporting Facilities.

The breakdown into interim products is governed by the concept of Group Technology (GT). Pallets for the same hierarchical level, and grouped by area/stage, represent work of the same nature and, more or less, have the same man-hour requirements within the statistical allowable range illustrated in Figure 1-3. In other words, those having the same classification which require more than the mean man-hours so as to cause schedule slippages are offset by those which require fewer man-hours according to a normal distribution. This statistical approach, which requires expertise in the classification of work packages, produces realistic allocations of man-hours and enables the lowest-level supervisors to participate in regulating production lines in order to achieve schedule adherence.

1.2.2 Organization of Work

A sequence of stages is a process lane. A portion of a lane, i.e., a few work stations, contiguous in a process lane or across process lanes can be grouped as a process yard. For example, for producing a curved panel the work stations for collecting resources, fitting, welding, and finishing comprise a process yard organized within a process lane. Grouping the marking & cutting stations for built-up part, internal part, and part for flat panel is an example of a process yard organized across process lanes. Theoretically, each yard is managed by a foreman and each station is managed by an assistant foreman. Based on a foreman's experience, shipyard size and workload, a foreman may be assigned more than one yard. Of course, a very experienced foreman can supervise more process yards than a recently appointed foreman.

1.2.3 Organization of People

While process lanes are organized to match the nature of interim products, the same organization and the process yard concept serve for budgeting man-hours.

The left side of Figure I-6 shows the organization of production acti.vitities in a typical IHI shipyard when shipbuilding activities peaked, circa 1974. It describes an organization which matches a hierarchical division of work by problem categories. There is no single production department. Instead, because they each address an inherently different type of work, there are separate departments for hull construction, outfitting and painting. Each department is subdivided into fabrication and assembly sections which are primarily specialized by problem category. For example, within the hull construction department there is a separate shop for part fabrication and separate sections for sub-block assembly, block assembly, and erection. [5]

Similarly within the outfitting department there is a specialized shop for pipe-piece fabrication and separate sections for assembly work per various regions of a ship. The shops and sections are subdivided into process yards and relate to process lanes as previously described. Most process yards involve several trades.

Shops and sections are, in effect, separate factories each of which produces a specific product line. The workers and their assistant foremen collectively, the foremen, and the shop managers are generalists to the degrees required by their product lines. Primary focus is on man-hours per product, rather than man-hours per trade. Thus, the right side of Figure 1-6 shows man-hour costs primarily collected by process flows (problem areas).

The hierarchical product organization facilitates a standardized scheduling framework within which each level is controlled by a level above while being responsible for producing a unique and more definitive schedule. Each level also has responsibilities and authority for making and controlling man-hour budgets, allocating and leveling manpower, monitoring man-hour consumption and production progress, and evaluating productivity.

A compatible grouping of design information for predicting material volume, and of course work volume, is very necessary. Such grouping of information is facilitated by a form of product organization of design people which matches production's product organization; see Figure 1-7. Otherwise, developing process lane work instructions and the information needed for a FPSS is difficult.

Another important prerequisite for FPSS is a high degree of coordination between people who are concerned with interim products of the various manufacturing levels. For example, in both the Hull Structural Design Group and the Hull Construction Department, coordination is needed between levels, i.e., parts fabrication, sub-block assembly, block assembly and hull erection.

1.2.4 Cost Center System and Production Organization

The Cost Center System (CCS) for Manpower Cost Classification should match product organized process lanes. As shown in Figure *I-6* which is not detailed below the shop/section level, nearly all costs are derived from process flows, i.e., per problem area.

Note should again be made that Figure I-6 is a representation of an IHI shipyard organization when workloads in Japanese shipyards peaked in about 1974. In the decade following, commensurate with the shipbuilding recession and a 45% work force reduction, painting was abolished as a department and organized as a section in the outfitting department. Sub-block assembly and block assembly were assigned to a single section manager, and subsequently, the separate hull construction and outfitting departments were combined into a single production department.

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[5] As noted in the NSRP publication "Product Work Breakdown Structure - Revised December 1982", the different types of work, due to inherent differences, are hull construction, outfitting, and painting. Each is subdivided by "fabrication" and "assembly". Painting is rationalized as assembly work (joining a pigment to a surface is regarded as an assembly process). In IHI shipyards this distinction also applies to the organization of production people. Shops deal with fabrication such as the manufacture of hull parts and pipe pieces. Sections are responsible for asaembly work only. Shop has the connotation of a fixed work place. Section implies flexibility and movement to wherever work is to be performed. The distinction is used throughout this publication.

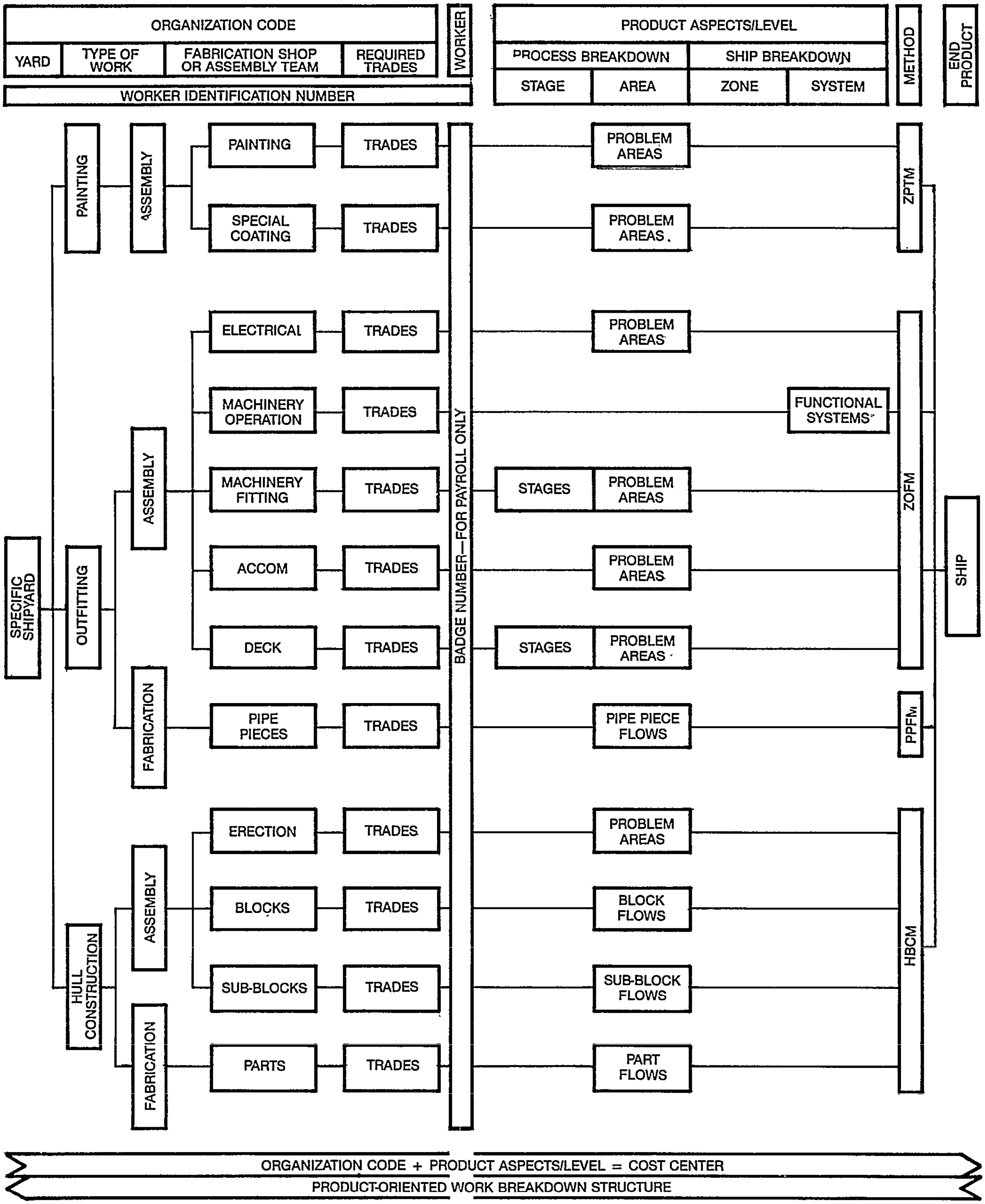

FIGURE 1-6: Each line depicts a typical cost center. The shipyard organization by product specialties is seen when looking from left to right. The Product Work Breakdown Structure is seen when looking from right to left. As they exactly match, costs per product are readily obtained just by monitoring the output of each work flow, i.e., problem area. As shown, some costs are necessarily collected by system or stage, e.g., costs for installing and operating a main engine, testing, and special welding.

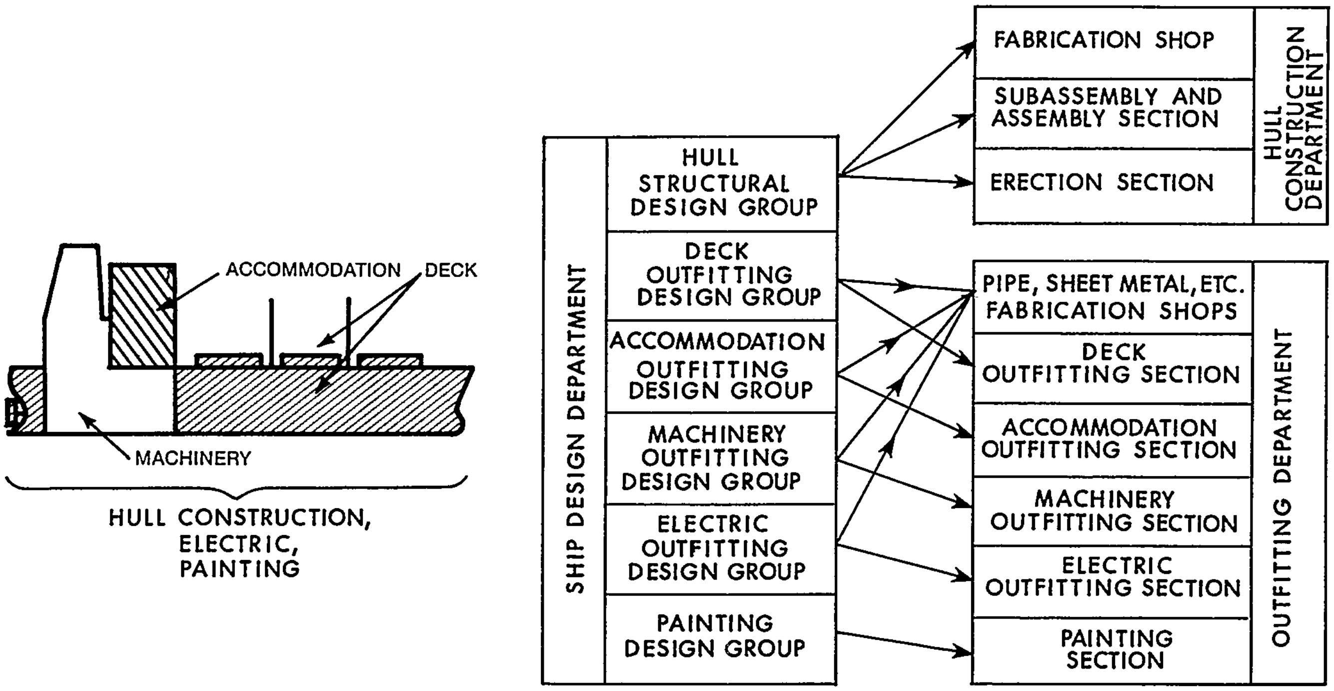

FIGURE 1-7: Product Organization. A product organization for design and a matching product organization for production, as shown, are necessary to effectively exploit Group Technology in shipyards. In lieu of being specialized along functional lines, people are specialized by product. Each organizational entity becomes expert in solving fabrication or assembly problems for hull construction, deck, accommodation, machinery, electric, or painting (H, DAME, P). For warships, the organization shown is supplemented with a Weapons Design Group and a corresponding Weapons Outfitting Section.

For budgeting and cost monitoring purposes, the organization of process lanes remains unchanged except for the introduction of new technology. Despite the massive contraction, the shipyard organization by process lanes still matches the product work breakdown structure. Should there ever again be a shipbuilding boom, the existing organization of process flows is the base upon which the production organization could expand.

The organization shown in Figure 1-6 remains applicable as long as requirements exist for large numbers of interim products of varying designs, i.e., as long as Group Technology is justified. But, fewer managers and supervisors are required as work loads diminish. Those who remain, in a way, occupy "multi-hat" jobs as they have to think separately in behalf of each type of work to achieve production planning, scheduling, and engineering suitable for IHOP. For example, the manager for a single production department would, to some extent, be acting as if simultaneously in charge of separate departments for hull construction, outfitting, and painting.

The fewer fabrication-shop and assembly-section managers would also have such multiple responsibilities. Each of the fewer foremen would have jurisdiction over more process yards and, perhaps, each assistant foreman would be assigned more than one work stage. Regardless of the fewer people involved in management and supervision, the organization of work at the lowest level would continue to match the product work breakdown and the FPSS would continue to be most effective.

CCS, being product (zone) oriented, not system oriented, readily yields production progress and productivity indices as given in Figure 1-8. Each Cost Center Code identifies manpower charges for a number of the same class of work packages (products) completed per unit time and separately totaled for each production management level, i.e., assistant foreman, foreman, fabrication shop or assembly section manager, department manager and shipyard manager.

TYPE OF WORK				MANPOWER EXPENDITURE INDEX	PRODUCTION PROGRESS INDEX	PRODUCTIVITY INDEX
	HULL CONSTRUCTION	FAB	PART	MHRS/UT	FABRICATED WT/UT	MHRS/FABRICATED WT
		ASSEMBLY	SUB-ASSEM	" "	SUBASSEMBLY WT/UT SUBASSEMBLY Wp/UT	MHRS/SUBASSEMBLY WT SUBASSEMBLY Wp/MHR
			ASSEM	" "	ASSEMBLY WT/UT ASSEMBLY Wp/UT	MHRS/ASSEMBLY WT ASSEMBLY Wp/MHR
			ERECT	" "	ERECTED WT/UT ERECTED Wp/UT	MHRS/ERECTED WT ERECTED Wp/MHR
	OUTFITTING	FAB	PPFM	" "	MANUFACTURED WT/UT MANUFACTURED PIECES/UT	MHRS/MANUFACTURED WT MHRS/MANUFACTURED PIECES
		ASSEMBLY	DECK	"	PARAMETRIC-COMPONENT WT/UT	MHRS/PARAMETRIC-COMPONENT WT
			MACH	"	"	"
			ACCOM	"	"	"
			ELECT	" " "	LAID CABLE LENGTH/UT CONNECTED CABLE PIECES/UT PARAMETRIC-COMPONENT WT/UT	MHRS/LAID CABLE LENGTH MHRS/CONNECTED CABLE PIECES MHRS/PARAMETRIC-COMPONENT WT
	PAINT	ASSEM	I	"	COATED SQUARE METERS/UT	MHRS/COATED SQUARE METER

FIGURE I-8: Indices for Monitoring Man-hours Spent, Progress and Productivity. MHR: man-hour. UT: unit time. WT: weight. Wp: a parametric length for welding which takes into account weld size, type and position. Parametric-component WT: weight of only fittings for which the ratios WT/UT and MHRS/WT remain almost constant. The indices for Pipe Piece Family Manufacturing (PPFM) are applied separately to each flow lane.

2.0 FPSS SUPPORTING ELEMENTS

2.1 Frame Scheduling Method

The Frame Scheduling Method (FSM) is the key for applying a Flexible Production Scheduling System (FPSS).

"Frame" as used herein means to enclose as if in a border. Thus, the matter which constitutes design in its earliest phase can be examined in a few relatively large frames. Ipso facto, rough quantification of material volume and, through application of parameters, rough quantification of work volume are simultaneously framed.

At the beginning, frames are large with relatively vague matter enclosed. As a design develops in phases, frames are subdivided until the matter contained within each subdivision, being subjected to more and more attention, is sufficient in detail to be an accurate reflection of required work. The few large frames containing relatively vague information, the more numerous intermediate frames enclosing more descriptions, and the many final frames containing accurate details, represent a hierarchical breakdown.

Usage of the term time frame is common. But, as described in the foregoing the terms material frame and work frame are also valid.

Figure 2-1 displays the sequential flow involved in FSM. FSM's progress phase by phase is from the biggest and "roughest" frames which address projects for the coming two or three years (Shipyard Master Schedule), to the smallest and "finest" frames for activities on specific days (Daily Work Schedule). When an improvement, such as the introduction of a new machine, justifies changing a schedule, the schedules above and below in the hierarchy, as well as coincident schedules, are changed as appropriate. Schedules always maintain their linkage in the hierarchy.

Where statistical accuracy control is commanded, nominal improvements in work methods occur almost on a daily basis. While one improvement might not stimulate a change in a higher tier schedule, the cumulative affects of more than one could provoke a change even in a master schedule. [1]

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[1] In IHI, because statistical accuracy control (A/C) clearly identifies how work processes are performing and most problems as being common to management's system, workers submit an average of one beneficial suggestion per person per month. This extraordinary suggestion rate results in bit-by-bit methods improvement virtually on a daily basis. As the cumulative affect is significant, upper tier schedules are frequently revised and marketing people are notified accordingly.

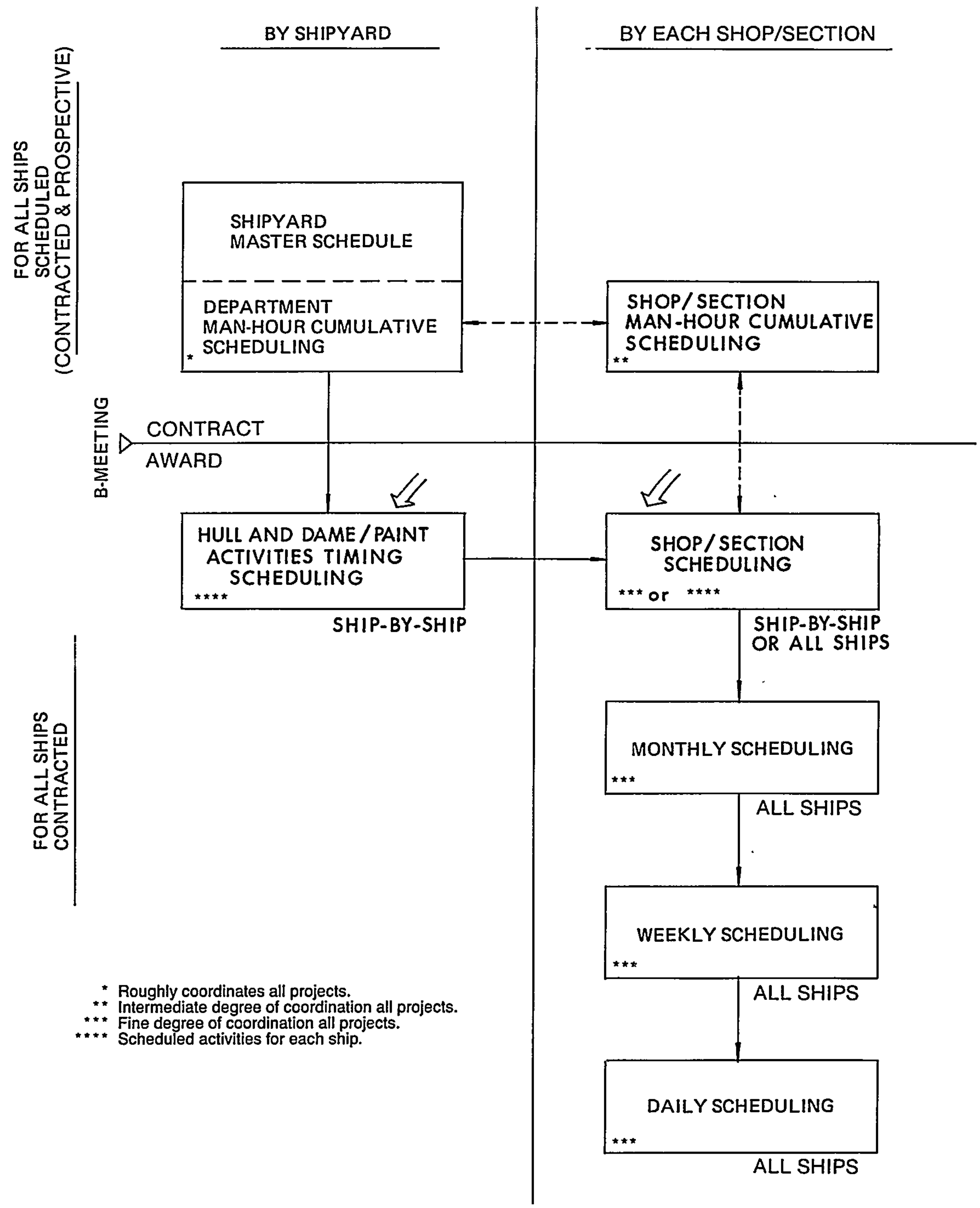

FIGURE 2-1: Scheduling Sequence. Arrows designate scheduling that must be integrated with the IHOP and Design Schedules.

Figure 2-2 is a tabulation of different levels of frames for:

o design,

o material definition", and

o man-hour allocation.

With regard to Figure 2-3 which particularly displays the hierarchical nature of FSM:

o Each shop/section schedule shown is for a specific ship, i.e., they are made ship by ship and shop/section managers are responsible for their preparation. Each applies to a relatively long period, usually *6* months for hull construction and 12 months for outfitting, and is updated every 2 months for hull construction, and upon completion of material lists by systems (KLS) and again upon completion of MLF for outfitting. For outfitting, an initial shop/section schedule is based on the known material volume after pallets are defined on a transition drawing, i.e., after systems and zones are interrelated. It is used for establishing material procurement and drawing issue schedules and, afterwards, is updated with the material volumes of defined pallets. Each shop/section schedule indicates:

  - a shop's/section's key milestones,
  - work periods for each summary unit,
  - work volumes by number of workers per craft, and
  - number of workers per craft for each 10 working days.

o A monthly schedule applies to work to be performed for all ships by a single process yard during the coming 1½ months for hull construction and 2 months for outfitting. It is sometimes called a yard schedule such as for an on-unit outfitting yard, on-block outfitting yard, and on-board outfitting yard. A monthly schedule is the responsibility of a foreman.

The work volumes for each monthly schedule are calculated from the parametric component weights which appear on the MLF associated with each pallet. Monthly schedules are updated every 2 weeks for hull construction and monthly for outfitting. Each indicates:

a process yard's detailed milestones,

work periods per pallet,

pallet work volumes, and

number of workers Per craft for each 5 working day;. As shown in Figure 2-2 the scheduling process, starting at a large frame (master schedule level), continues to weekly schedules for which assistant foreman are responsible. Daily schedules are the concern of workers and are usually not formally prepared.

All schedules are coordinated with each other and are the basis for assessing progress during a weekly meeting of each shop's/section's production engineers and, sometimes, foremen. Acting for the shop/section manager, production engineers redistribute manpower, authorize specific amounts of overtime, assign surplus work to subcontractors, and update schedules, if necessary with carry-over notations as shown in Figure *2-3.*

Figure 2-.4 shows an FSM logic model. It illustrates how to:

o imagine work frames,

0 group work frames in large summary units, and

0 sequence and schedule work frames.

Work from lofting to final painting are each represented as a large work frame plotted against a time frame. As more concrete work instructions are developed, subdivisions of these frames to represent subordinate schedules assure their coordination.

FRAME LEVELS \ ACTIVITIES	DESIGN	MATERIAL DEFINITION		MANHOUR ALLOCATION	
		LIST	GROUPING BY ZONE AND SYSTEM	SCHEDULE	GROUPING BY FRAMES AND FRAME GROUPS
LARGE	BASIC	MLB	— DAME — 4 DIGITS *	MASTER	— F,K,L,D — H,O,P
MEDIUM	FUNCTIONAL	MLS	— DAME/ PURCHASE ZONE — 4 DIGITS	SHOP OR SECTION	— FRAMED ZONE — PROCESS YARD/ SHOP OR SECTION
SMALL	TRANSITION	PALLET DEFINITION	———	———	———
	WORK INSTRUCTION	MLF MLP MLC	— DAME/PALLET — 9 DIGITS/PIECE NO.	MONTHLY	— PALLET — F-GROUP
				WEEKLY	— PIECE/PALLET — AF-GROUP

F - Start Fabrication
K - Keel Laying
L - Launching
D - Delivery

H - Hull Construction
O - Outfitting
P - Painting

F - Foremen
AF - Assistant Foremen

MLB - Material list prepared during basic design which is used for preparing a Budget Control List.

* At this level, estimates and counts of all required materials are grouped system by system and described by at least the first four of a nine-digit material code. That is, all materials are accounted for at least by material classes and estimated quantities.

FIGURE 2-2: Frame Levels Relative to Activities for Outfitting.

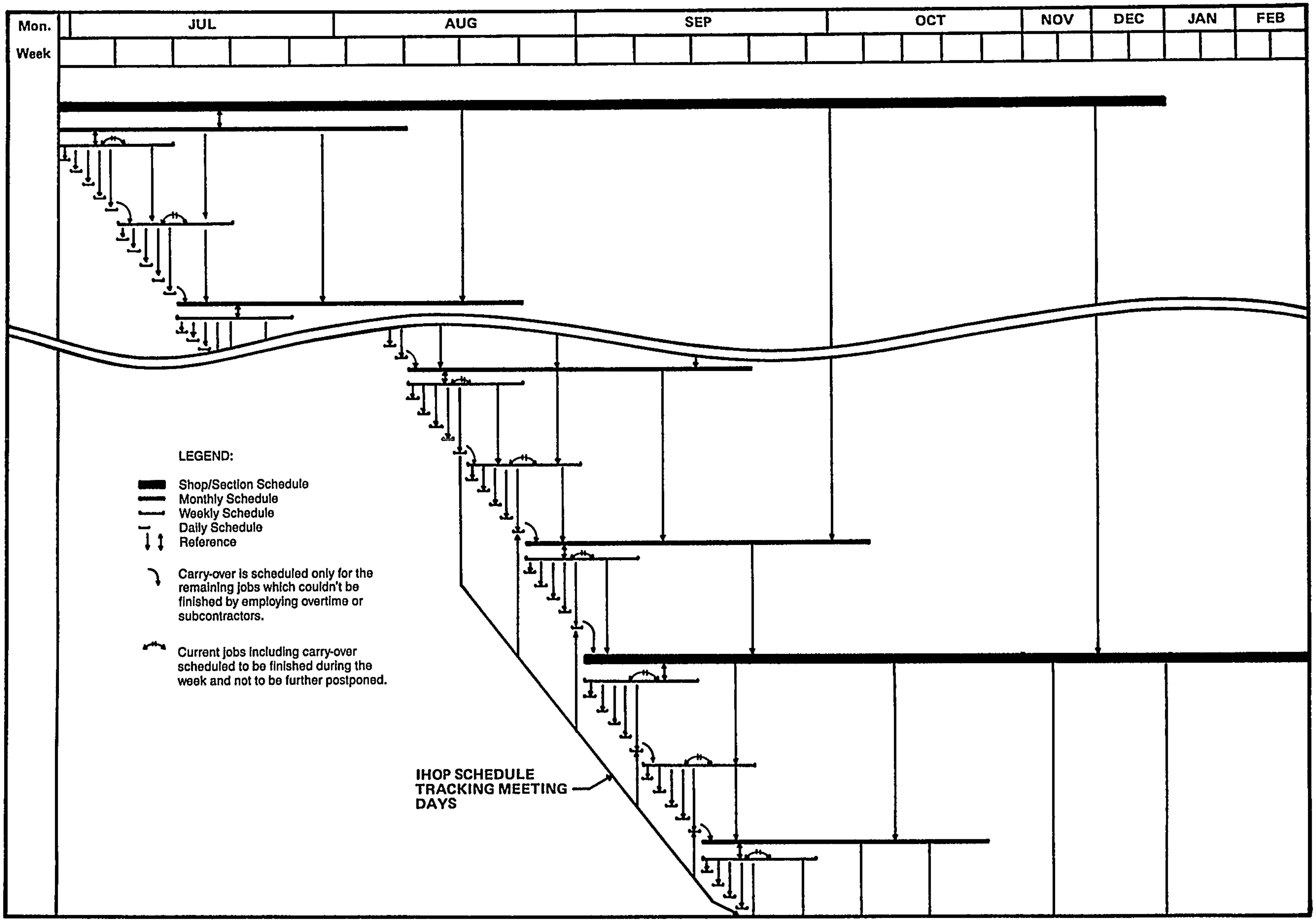

FIGURE 2-3: Logic of the Frame Scheduling Method.

2.2 Integrated Hull Construction, Outfitting and Painting (IHOP) Scheduling and Tracking Operation

IHOP requires great cooperation between all shipyard functionaries. Hull construction design and production engineers are required to have understanding of outfitting and painting needs. "Integrated planning is achieved by discussion, trade-offs and ultimately mutual consent. The overriding goal is an increase in productivity for an entire shipbuilding system." [2]

Integration of the Zone Outfitting Method (ZOFM) and Zone Painting Method (ZPTM) into the production processes for the Hull Block Construction Method (HBCM) necessitates coordination of their scheduling and tracking operations as shown in Figure 2-5.

With simultaneous reference to Figures 2-4 and 2-5, note is made that hull block erection work is scheduled first (Figure 2-4 shows that the pyramid method *will* be used and the block next to the forward engine-room bulkhead will be the first to be erected). Afterwards, other work, including outfitting and painting, is scheduled before and after the scheduled erection of each block by moving backward and forward in time respectively and within the large frames designated.

Tracking operations are conducted at weekly meetings similar to that described in Part 2.1.

2.3 Decentralized Production Planning, Scheduling, and Engineering

2.3.I Decentralization

Decentralized production planning, scheduling and engineering is very practical for FSN and IHOP scheduling and tracking. At the same time decentralization promotes so-called top-down/bottom-up and lateral information interchanges in a tree-structured network. Production engineers and other planning, scheduling, and engineering staff functionaries having real responsibilities at every level, are readily able to:

o prepare realistic integrated schedules,

o anticipate production realities, e.g., manpower and facilities available, progress ahead or behind schedule, etc., and

o regulate process flows to insure their coordination and conformance with higher tier schedules.

Production planning and engineering functions, specifically including scheduling, are decentralized. People having such responsibilities are distributed as shown in Figure 2-6. The Production Control Department shown in Figure 2-6, acting for the Shipyard Manager, is responsible for maintaining the Shipyard Master Schedule (top-down) and for providing information (bottom-up) about resource availability which permits corporate headquarters to maintain a Shipbuilding Division Master Schedule.

Similar top-down/bottom-up, plus lateral, information exchanges take place at each of the succeeding levels, i.e., by departments', shops', and sectionsl planning, scheduling, and engineering staffs, and by foremen and assistant foremen. At the highest levels, strategic information is exchanged. At the lowest levels, the information exchanged is tactical in nature.

2.3.2 Consistency of Organization and Schedule Levels

Figure 2-7 illustrates a typical organization breakdown and consistent schedules for each of the following levels:

o shipyard,

0 department,

0 shop,

0 foreman (F-group),

0 assistant foremen (AF-group), and

0 worker.

In accordance with the decentralization of responsibility, each level has certain authority to schedule as noted in the right side of Figure 2-7. What appears to be illustrated on the left side of the figure is a hierarchical organization similar to the organization charts of many bureaucracies. But, at each level there is scheduling authority in addition to other production planning and engineering authority. Each level prepares its own schedule within the given framework provided by the next highest schedule.

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[2] "Integrated Hull Construction, Outfitting and Painting - May 1983", NSRP, p.2.

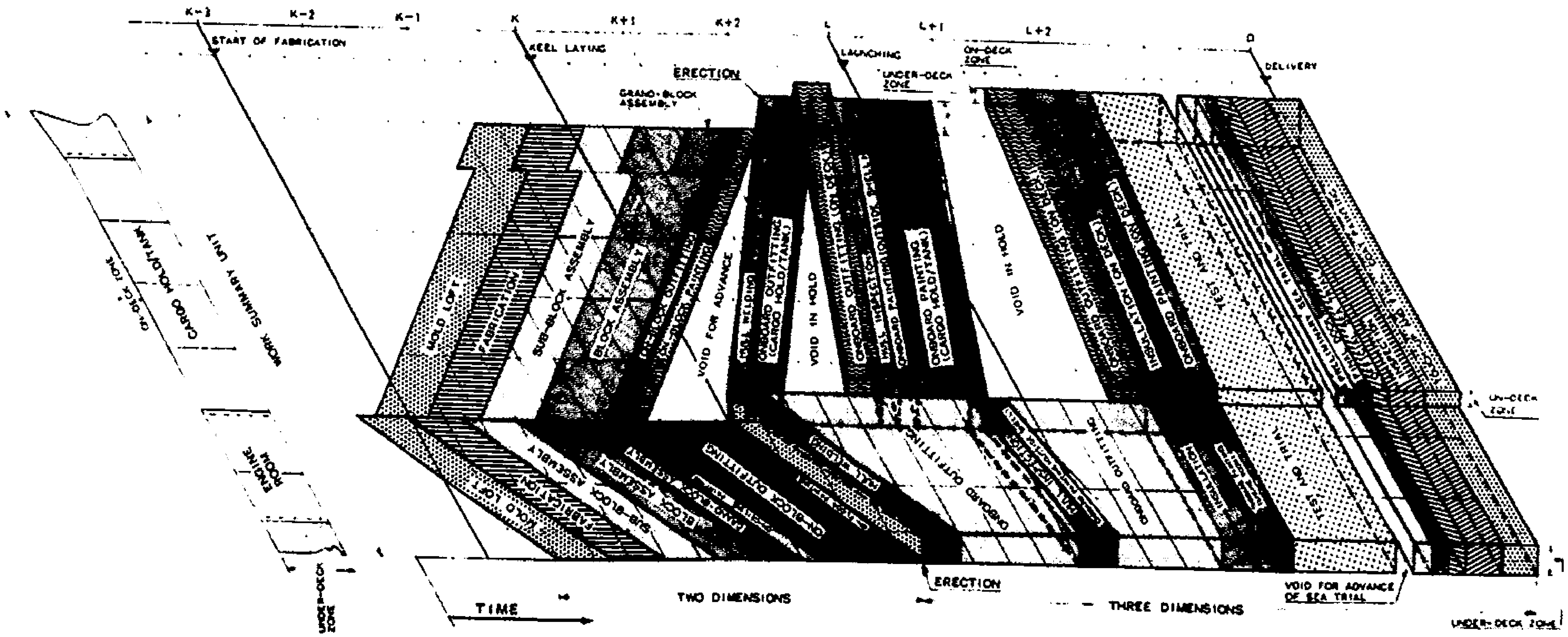

FIGURE 2-4 Frame Scheduling Method Logic Model. Frames for work before hull block erection are represented in two dimensions. Frames for remaining work are represented three dimensionally in order to distinguish work for "on deck zone" from "under-deck zone".

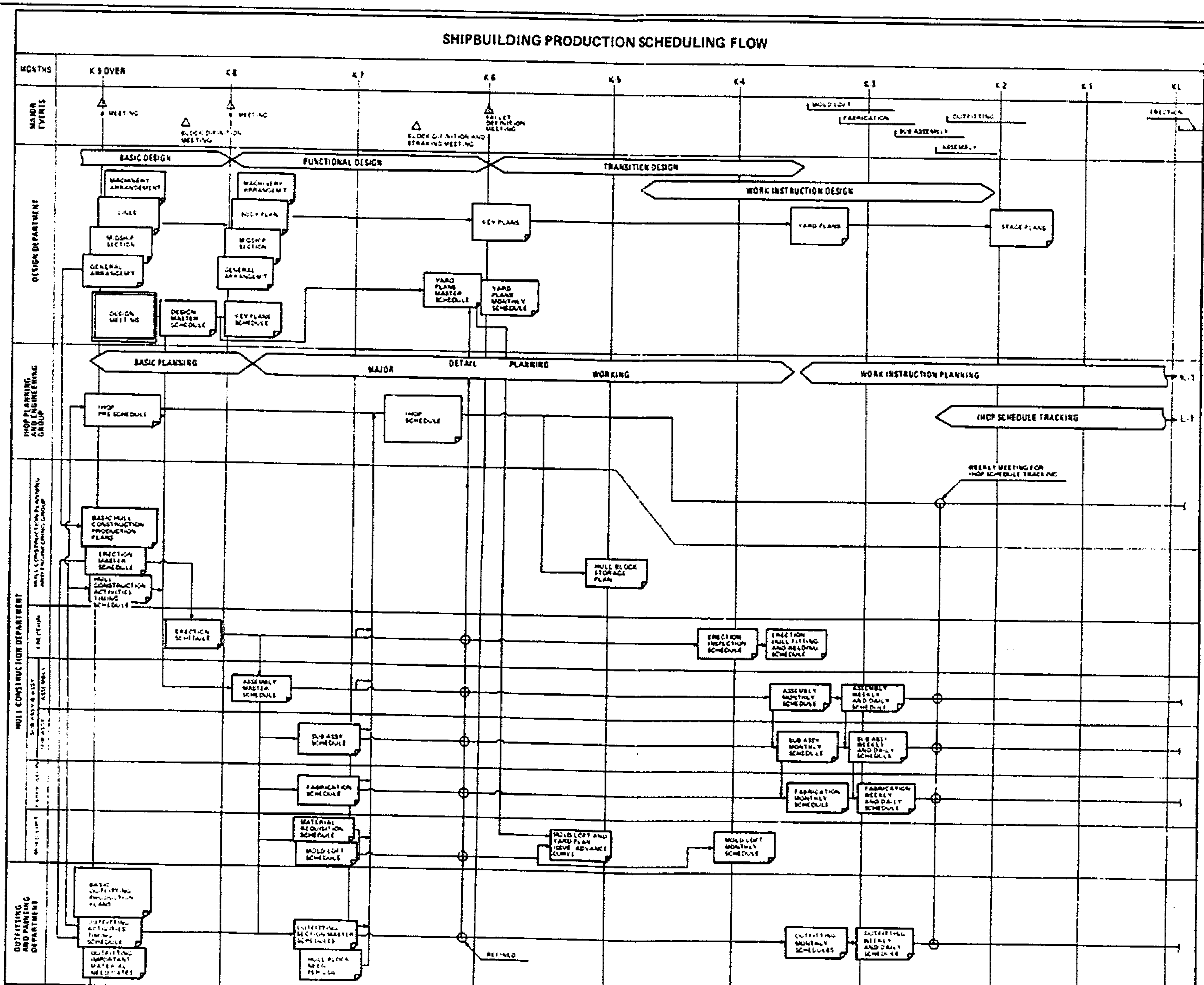

FIGURE 2-5: Shipbuilding Production Scheduling Flow

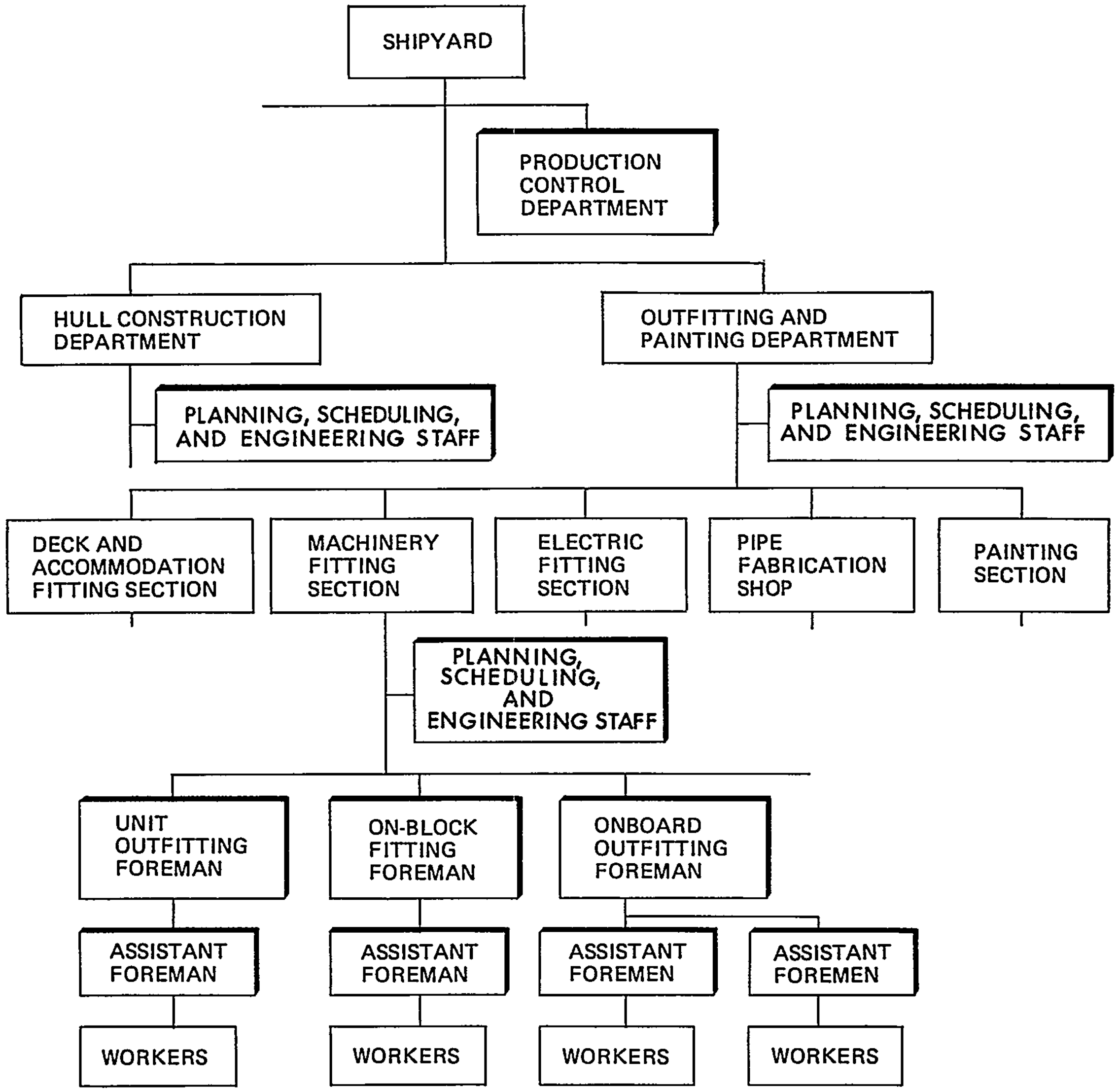

FIGURE 2-6: Decentralized Production Planning, Scheduling and Engineering. Boxes designated by bold lines indicate where production planning, scheduling and engineering responsibilities are delegated. Big facility changes are studied at the department level. Staff or field engineers at the shop/section have charge of many functions, e.g., budgeting man-hours and material, scheduling, production engineering, etc.

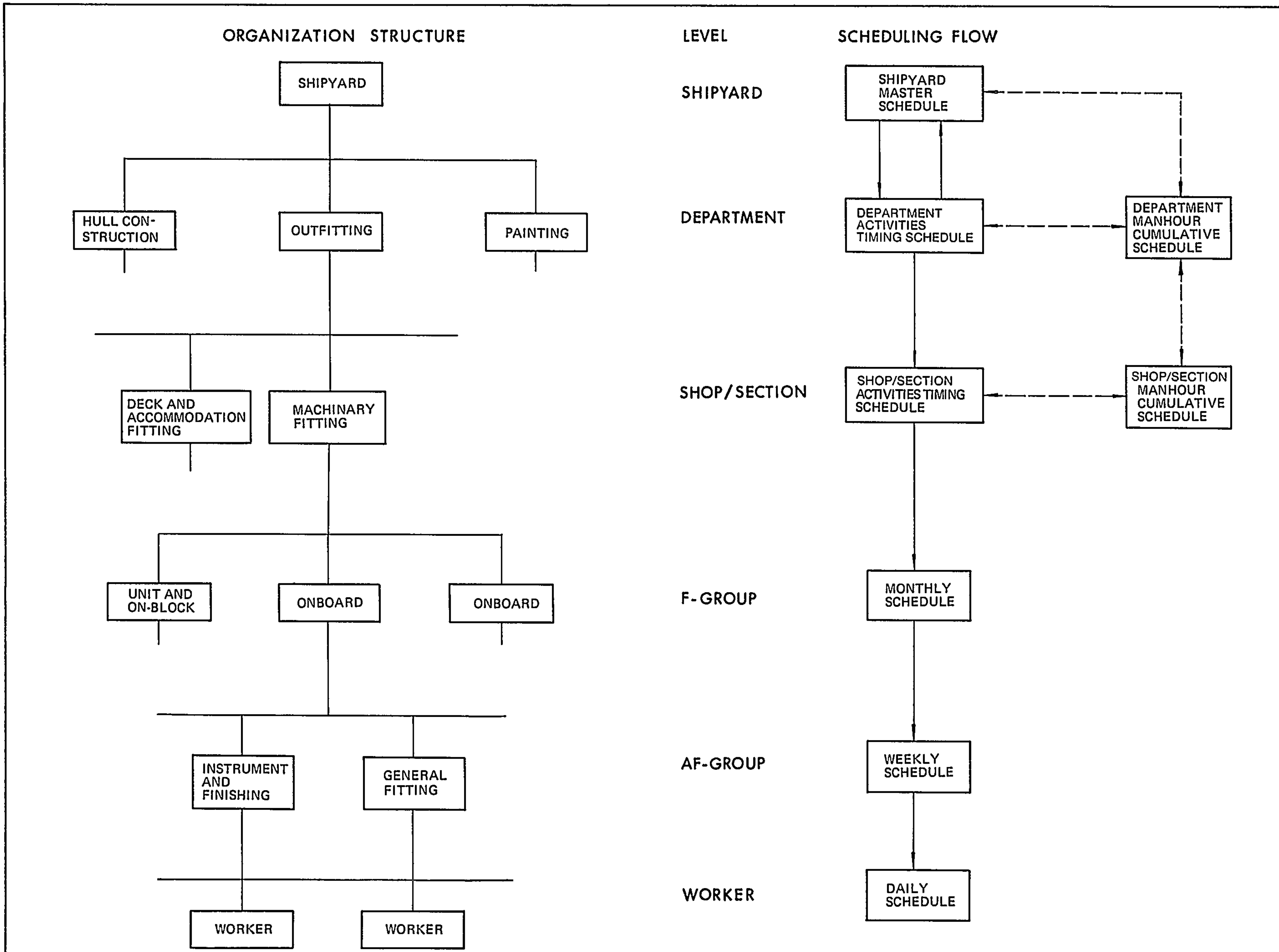

FIGURE 2-7: Consistent Organization Structure and Scheduling Flow. Both are decentralized in accordance with the same concept.

2.3.3 Tree-Structured Network Organization

Per framed orders that come down through the tree-structured organization, each worker reports progress, behind or ahead of schedule, to an aosisant foremen. Such reports are used by assistant foremen to update weekly schedules. If something could delay the start of work at a following stage of the work flow, the assistant foreman reports to a foreman. The latter coordinates with other foremen, updates a monthly schedule and/or, when necessary, reports to the production engineer-in-charge. The latter coordinates with other engineers-in-charge and if the delay affects a shop/section schedule, reports to the shop/section manager who would coordinate with other shop/ section managers. Coordination takes place among people at the same level as well as up and down between levels. The tree-structured network, as shown in Figure 2-8, operates like casting fishnets of different meshes. Nets from small to large mesh "catch" problems of "sizes" that are commensurate with the resolution authority that exists at each level. [3]

2.4 On-Schedule Availability of Information and Resources

From preparation of a build strategy before contract award, until the start of work in response to the last work package, successful implementation of FPSS is dependent upon timely information and resources such as:

0 drawings and other end products prepared by designers,

0 manpower available,

0 facilities including jigs and tools, and

0 materials including interim products.

Omission or late preparation of any one, disrupts efforts by production engineers to achieve effective analyses, decisions, implementation, control and feedback.

Untimely availability of information and resources require schedule changes which, for a particular level, could be beyond its resolution latitude or even the resolution latitude of the next highest level. Continued delays or an accumulation of such delays cause escalation to higher schedule levels and ultimately postponement of a ship's delivery. Coordination of low-tier schedules is necessary even for support activities by design and material managers.

The various lead times, in addition to manufacturing lead times, for a material procurement example are shown in Figure 2-9. Such lead times also apply to required information and other resources.

The need for reliable schedule inputs also emphasizes why shipyard managers have to deal with fewer suppliers with whom they have relatively great experience. Adopting a limited number of vendor catalog items (about three per functional requirement) as shipyard standards with reliable scheduling data, among other prerequisites, has been found by leading shipbuilders to be more effective than selection of materials based on low bids only. [4]

Obviously, the various production planning and engineering staffs which have scheduling responsibilities have to standardize and systematize their activities in concert with design and material managers. Figure 2-10 shows the necessary information flows that are required to produce integrated schedules that truly predict how work will be performed.

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[3] The system is supported by a human-oriented organization to facilitate participation by all members. See “Strength and Weaknesses of Japanese Management”, by Jiro Tokuyama, Kenshu, The AOTS Quarterly, published by The Association for Overseas Technicsl Scholarships, Tokyo, Summer 1985, pp. 6

[4] The same philosophy is given from a materialmanager’s point of viewin “Product Oriented Material Management - June 1985”, NSRP, p.3, and from an accuracy control engineer’s point of view in “Process Analysis Via Accuracy Control - Revised August 1985”, NSRP, p.8.

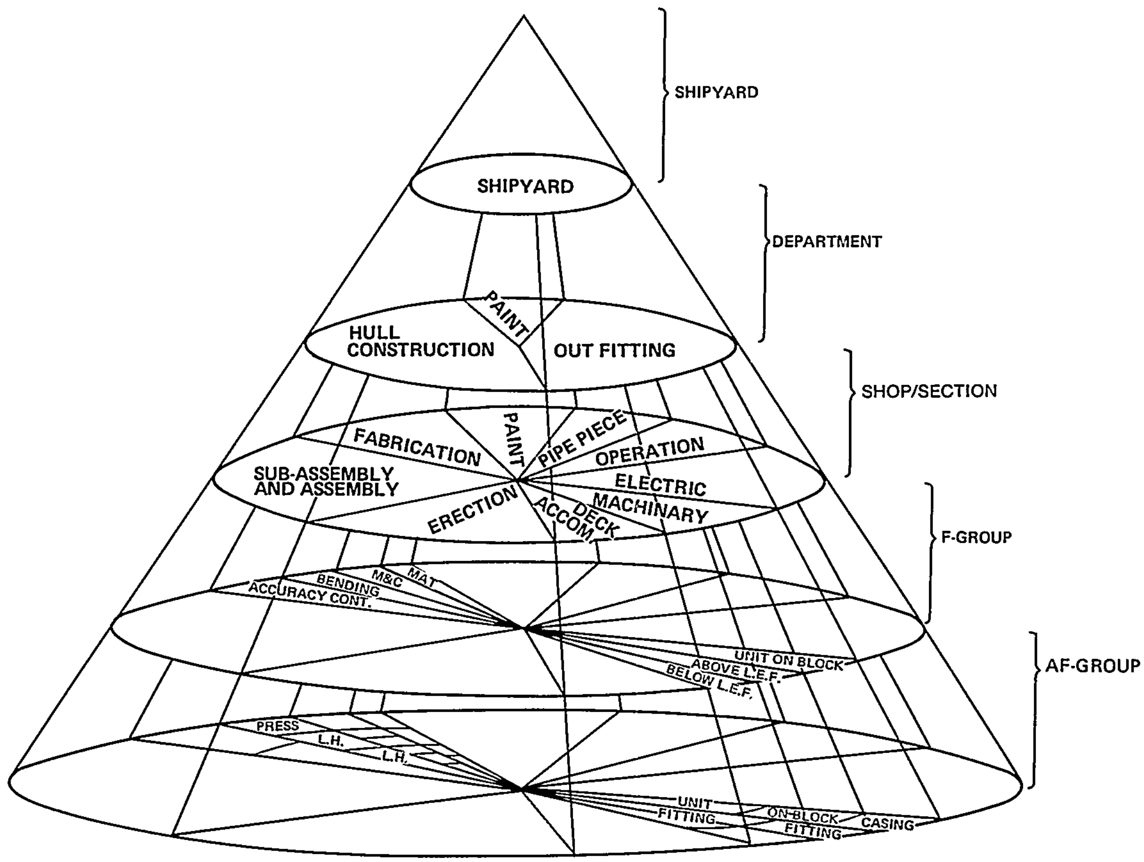

FIGURE 2-8: Tree-structured Network Organization. Each entity on every level is connected upward, downward and horizontally.

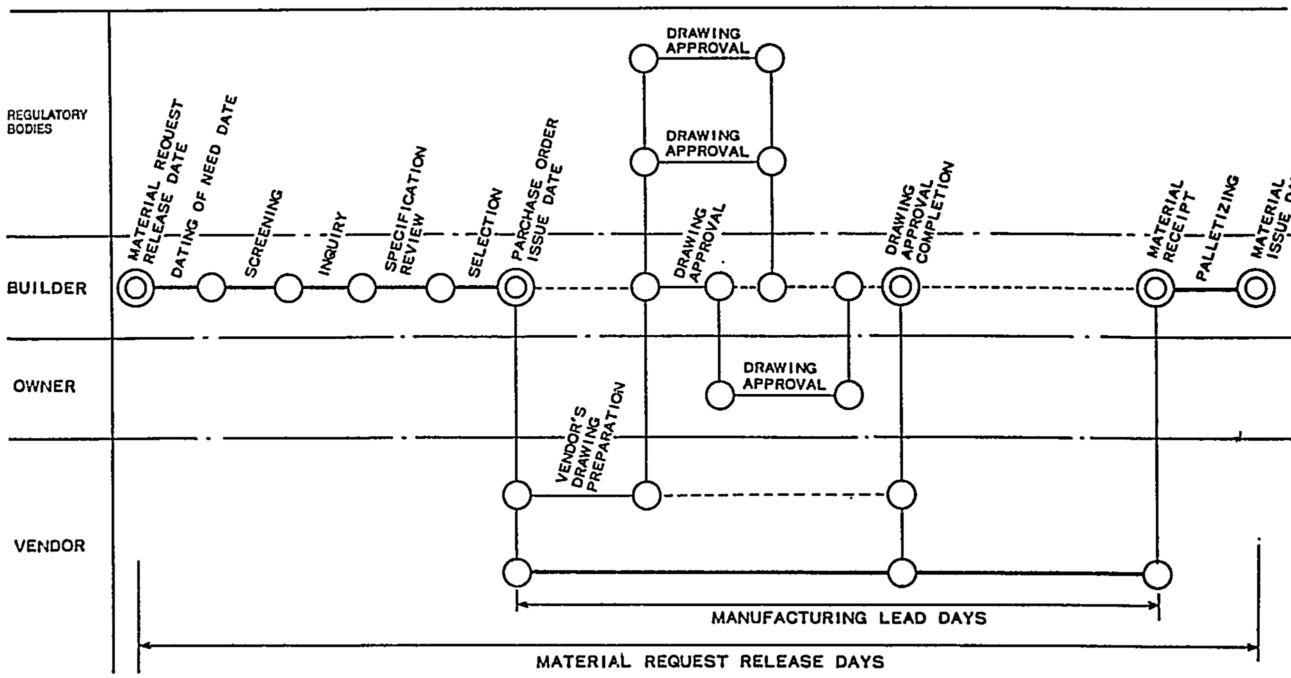

FIGURE 2-9: PERT presentation of a typical schedule for material procurement.

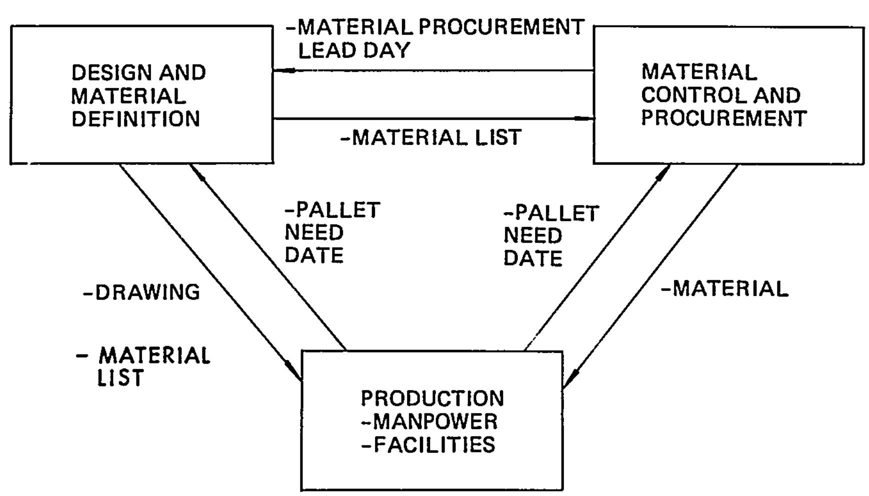

FIGURE 2-10: Information Interchange for On-schedule Information and Resources Supply.

3.0 SHIPYARD MASTER SCHEDULE

3.1 General

The shipyard manager controls the integration of production schedules with design and material procurement schedules. This coordination function ia vital. Further, the shipyard manager controls the delegation of authority per management level, i.e., department, shop/section, foreman, and assistant foreman. As the most effective way to maintain such controls, usually the next senior manager in the shipyard is assigned as the head of the production control department who reports directly to the shipyard manager as shown in Figure 3-1. In practice the heads of the Hull Construction, Outfitting, and Painting Departments (or the head of the Production Department) report to the Shipyard Manager through the Production Control Manager.

An additional prerequisite for effective control is assignment of purchasing, subcontracting and material control responsibilities to the production control department as also shown in Figure 3-1. Immediately acting for the shipyard manager, the production control manager readily balances top-level allocations of materials and man-hours with schedules. [1]

So organized, the shipyard manager assisted by the production control department produces a shipyard master schedule which consists of:

° long-term schedules and assessments for the future with a manning plan,

° specific ship schedules based on IHOP, and

o design and material lead-time assessments for schedule integration.

Aside from being the top-level frame from which lower level frames are derived, the shipyard master schedule is used for establishing sales' goals and keeps the top manager apprised of requirements for manpower and facilities relative to contracts in hand and to contracts contemplated in a sales plan.

Within the production control department, the production control section is responsible for actually preparing and maintaining the shipyard master schedule for the shipyard manager. The purchasing and subcontracting section contributes by performing material procurement research and maintaining files of up-to-date and reliable material lead-times as required for master scheduling.

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[1] The linkage of purchasing, material control and scheduling responsibilities also facilitates open-end labor subcontracts with delegation of triggering action to shop/section managers. When it becomes apparent that subcontractor assistance is needed to insure schedule adherence, a shop/section manager is not encumbered with bureaucratic procedures. Labor subcontracts are entered into and managed by the shops/sections. They are processed through the Purchasing Section only as a formality. This is consistent with each shop/section being a clear-cut cost center, i.e., the equivalent of an independent factory specialized along product lines. This again illustrates the singular benefit of a product organization, i.e., preoccupation with cost per product rather than the oftentimes amorphous cost per system.

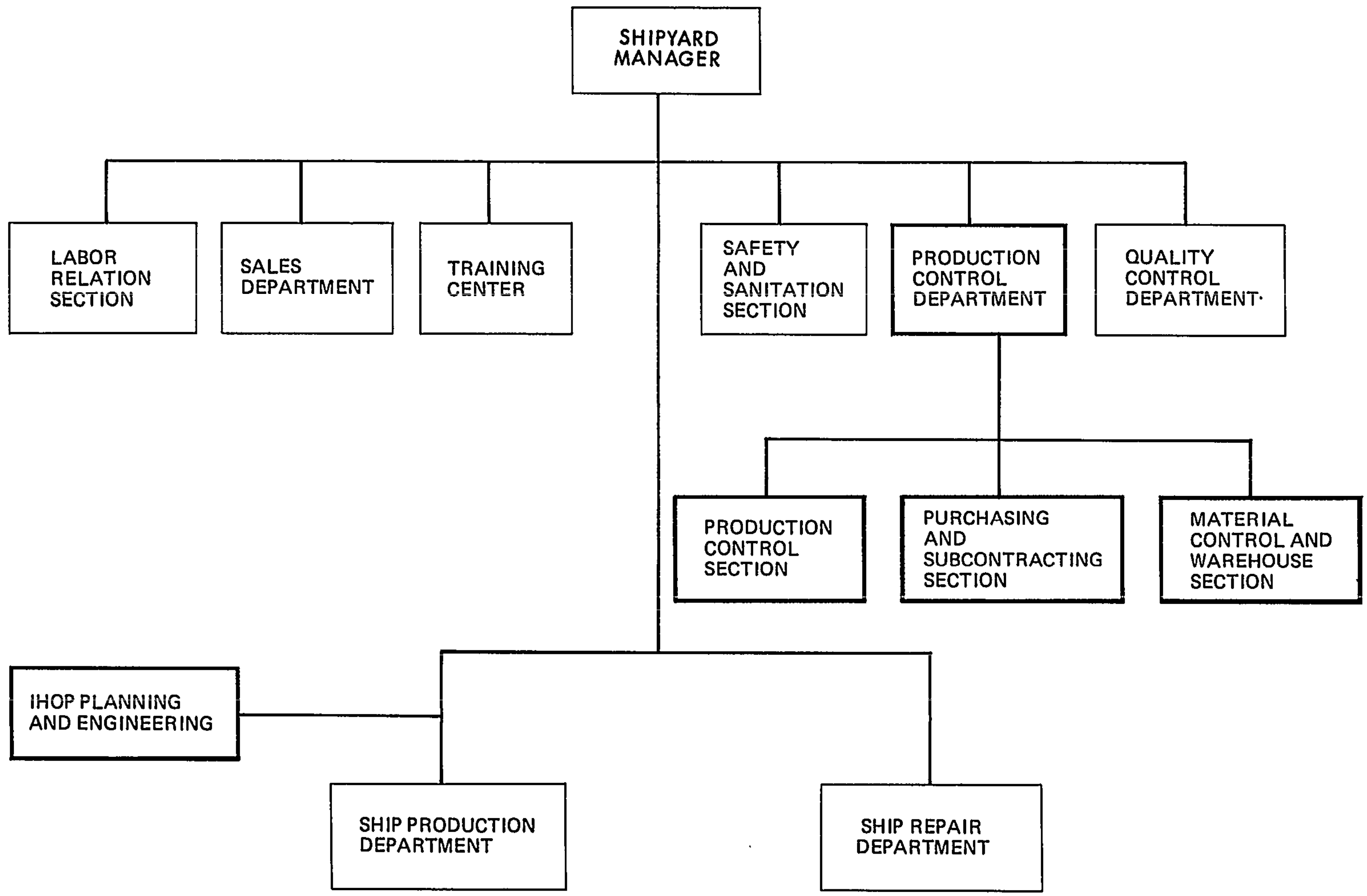

FIGURE 3-1: Delegation of Principal Scheduling Functions. Bold lines indicate organizations having principal scheduling functions assigned by the Shipyard Manager.

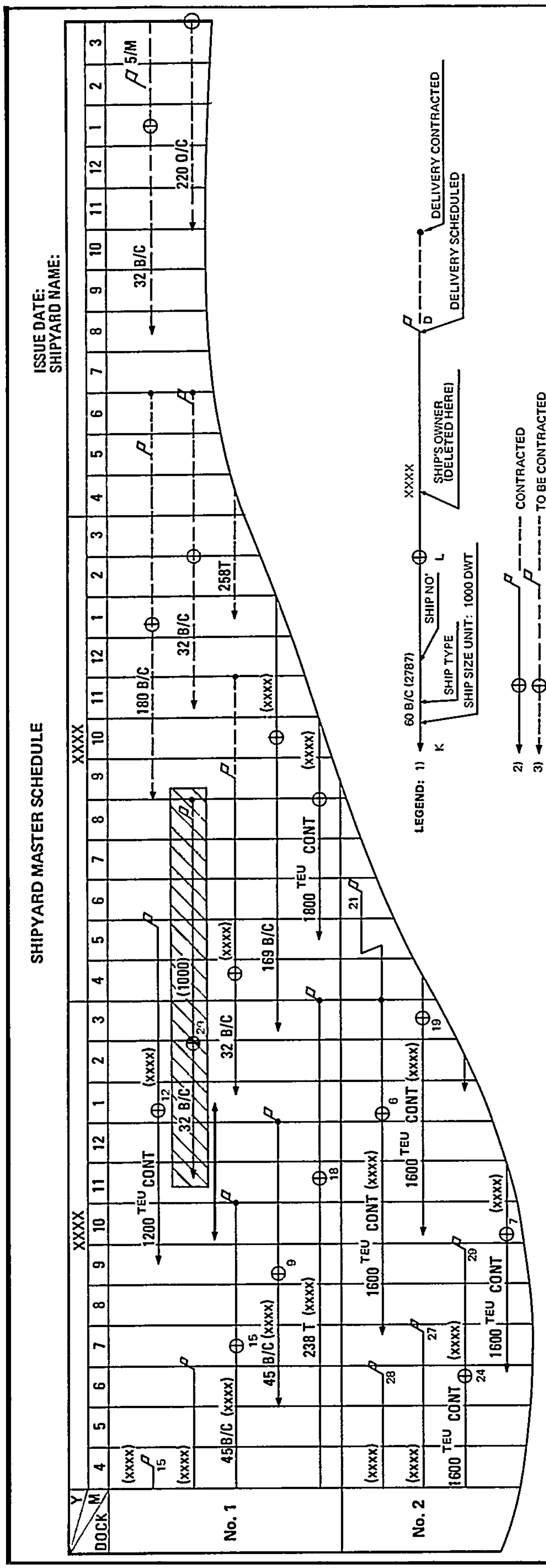

FIGURE 3-2: Shipyard Master Schedule.

The typical Shipyard Master Schedule shown in Figure 3-2, appears very simple. But, the simplicity is deceiving because its preparation requires integration with Man-hour Cumulative Schedules (S-curves) and with lead times for major material items, and deliberate consideration.

Figure 3-3 shows the various interests that are involved in maintaining a shipyard master schedule. This schedule must be maintained by a shipyard manager so as to constantly advise corporate management and the shipyard's various managerial staffs of the shipyard's current and future capacity for normal performance of work.

For master scheduling, great emphasis is placed on the shipyard managerls functions during marketing efforts. Programs for contracts not yet awarded are the ones that involve unknown factors for which the shipyard manager must plan and make calulated risk decisions. There is great need for consultations with managers of production, production control (purchasing section), sales, and design in order to assess department capacities, the material market, and other relevant factors such as the worldwide market for ships of various types.

When a contract is awarded and as more information becomes available, responsibilities for development of finer and smaller frame schedules are assumed by the hierarchical organization. The Shipyard Manager, through the Production Control Department, monitors to insure that such subsequent preparation of schedules conforms with the shipyard master schedule, schedules are consistent with each other, and that schedules are being implemented. The Shipyard Manager, through the Production Control Department, insures that timely measures are taken at reasonable costs to prevent delays.

In order to achieve such operations, emphasis is placed on Man-hour Cumulative Schedules for coordination and decision making. At this frame level, the schedules should be based on statistical data of past performances and should be accurate. Of course, special attention is given to drawing issue and material delivery dates for critical items.

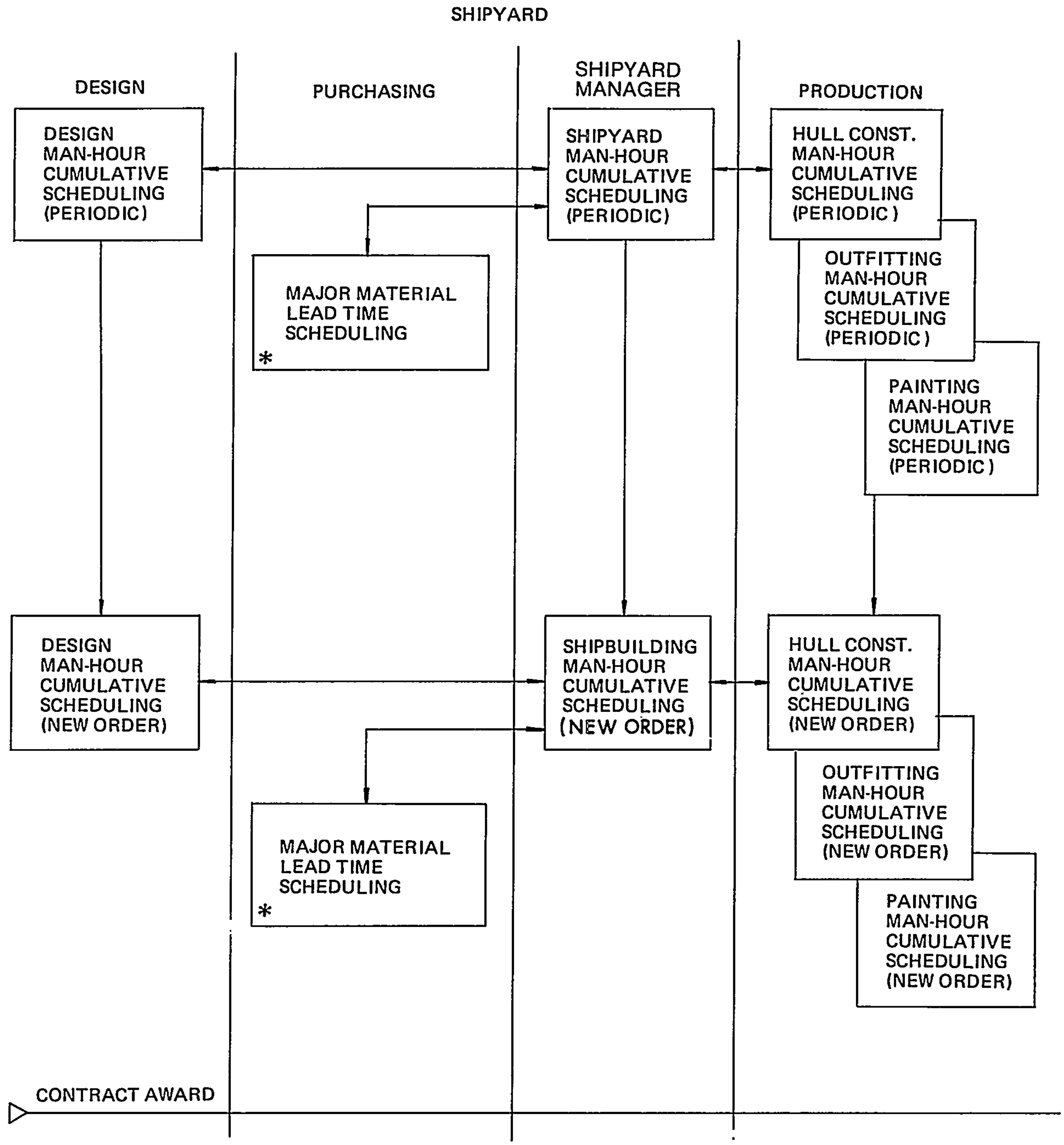

FIGURE 3-3: Shipyard Level Scheduling Sequence. The Major Material Lead Time Schedule is updated daily. The asterisks designate two blocks which are actually the same activity. The bottom block so designated simply represents added effort when a new ship is ordered.

FRAME / SCHEDULE	TIME		WORK VOLUME INDICATION			RESPONSIBILITY
	PERIOD	UPDATED	SUMMARY UNIT	SUMMARY PERIOD	PARAMETER	
SHIPYARD MASTER SCHEDULE (PERIODIC)	6 YEARS	EVERY 3 MONTHS	SHIPYARD/ SHIP NO., (CONTRACTED AND SCHEDULED) BETWEEN MAIN MILE-STONES (FABRICATION START, KEEL-LAYING, SLIDING, LAUNCHING, DELIVERY)	MONTH	DEPARTMENT MANHOUR CUMULATION (DESIGN, HULL CONSTRUCTION, OUTFITTING, PAINTING) AND MAJOR MATERIAL LEAD TIME	SHIPYARD MANAGER
SHIPYARD MASTER SCHEDULE (NEW ORDER)	6 YEARS	EVERY NEW ORDER (INCLUDING PROBABILITY)	– DITTO –	– DITTO –	– DITTO –	– DITTO –

FIGURE 3-4: Details of Scheduling at Large Frame Level.

At the earliest phase for which a schedule is required, there is relatively little design and material information. Establishing a fine-frame schedule is nonsense as it would be unreliable. Schedule deviations would become routine. Initial schedules are practical only when they are large framed and realistically based on history. Further, only large-frame schedules are needed during the earliest phases of ship construction.

The Shipyard Manager updates the Master Schedule periodically and whenever a contract is awarded in order to be able to quickly and accurately respond to future inquiries. During negotiations for and upon award of a contract, the Production Control Department acting for the Shipyard Manager:

- collects and coordinates all department cumulative man-hour schedules and major-material lead-time schedules,
- gives a feasible delivery date to the sales department to be used for negotiating a contract delivery date,
- assigns fabrication start, keel laying, and launching dates on the shipyard master schedule for each contract awarded, and
- approves all department cumulative man-hour schedules and major-material lead-time schedules.

Within the frames so established and limits needed for coordination with other departments, each department acts freely in a solemn agreement to honor start and finish dates.

Figure 3-4 describes the frames at the level of a shipyard master schedule, i.e., the frames which are of the largest size.

3.2 Shipyard Master Schedule (Periodic)

Periodic preparation of a Shipyard Master Schedule (Periodic) is per the flow shown in Figure 3-5. The master schedule is derived periodically from the production schedule and serves for planning the shipyard's future production strategy. The format used, as shown in Figure 3-2, facilitates insertions and deletions as new orders and marketing prospects materialize.

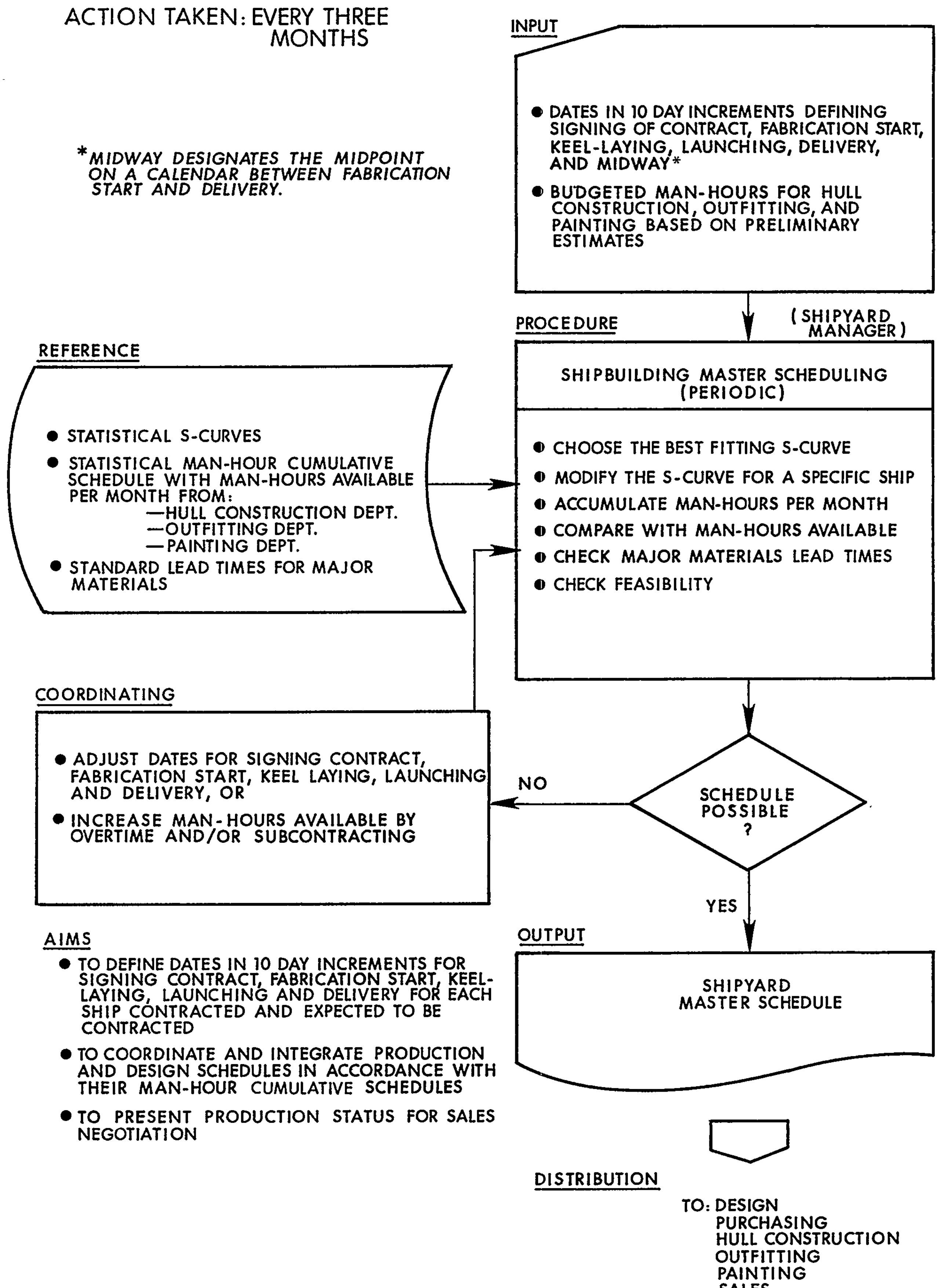

FIGURE 3-5: Shipyard Master Scheduling (Periodic).

3.2.1 Prerequisites

The prerequisites for a shipyard master schedule are the:

° hull construction, outfitting and painting man-hour cumulative schedules,

° design man-hour cumulative schedule, and

° major-material lead-time schedule.

3.2.2 Procedure

a. Choose the S-curve most adaptable to the specific ship and adjust it as necessary to achieve a best fit. Distribute the budgetary man-hours month by month per the S-curve selected.

b. Redraw the S-curve to fit the man-hours available.

c. Add the man-hours of all S-curves for each month in a given period as shown in Figure 1-2.

d. Compare the monthly accumulated man-hours with the man-hours available at the shipyard.

e. Check major long-lead time materials to ascertain whether they can be delivered in time to meet need dates in production schedules. If some are not going to be available in time, the need dates must be modified accordingly. Otherwise, the schedule is not feasible.

Steps a. through d. determine the capacity of the shipyard in a large frame sense. They could be eliminated from this scheduling level if the master schedules of each department were of high quality. Then, they could substitute for the shipyard S-curve.

3.2.3 Coordinating

If a schedule is found to be infeasible, the dates for fabrication start, keel laying, launching, and delivery are modified to match realistic production and material delivery dates. Adjacent schedules for other ships are adjusted within ranges that permit recovery of any incurred delays. If not possible, the matter is referred to the Shipyard Manager as the only alternative left is to increase the availability of manpower through the use of overtime work and/or subcontractors.

3.2.4 Issue, Updating and Recovery

Master schedules are issued frequently enough, every three months and upon receipt of each new order, so that revisions are not normally required. No provision is made for recovering delays in implementation since master schedules are not intended to be used for control of actual work. If something unexpected delays a milestone such as keel laying, recovery for delivery as scheduled is attempted on lower activity schedules.

3.3 Shipyard Master Schedule (New Order)

Preparation of a Shipyard Master Schedule (New Order) is per the flow shown in Figure 3-6. The purpose of this schedule is to coordinate all pertinent operations when a new order is likely to be awarded. When the occasion coincides with a periodic issue, the periodic issue is omitted.

Preparation involves inserting the key dates for the new order in the schedule and adjusting key dates for projects already in the schedule as necessary to accommodate work for the new order. Adjustment of an existing schedule can be done much faster than preparing a new master schedule.

An essential aim of the Shipyard Master Schedule (New Order) is to quickly provide the new workload status for the sales department.

3.3.1 Prerequisites

The Shipyard Manager requires the Design, Hull Construction, Outfitting and Painting Departments to verify that their man-hour cumulative schedules are realistic. In turn, the departments require similar checks by their shops/sections. Such active participation in the scheduling operation by the people directly involved in implementing schedules contributes to awakening their interest and sense of responsibility for adhering to schedules.

3.3.2 Procedure

a. Check the S-curve used in the periodic schedule. If necessary replace it with a more suitable curve.

b. Revise the cumulative monthly man-hour requirements taking into account the man-hours available. If necessary adjust the man-hour accumulations for ships adjacent in the schedule.

c. Compare the total cumulative monthly man-hour requirements with the man-hours available. In doing this, check the man-hour accumulations for each department against the sum for its shops.

d. Check the need dates and lead times, including lead times for preparation of purchase specifications, for critical major materials.

e. Verify that the Shipbuilding Master Schedule (New Order) thus determined:

 is realistic,

 authorizes the individual man-hour cumulative schedules prepared by the Design, Hull Construction, Outfitting and Painting Departments, and

 includes the Purchasing Section's major material lead time schedule.

Steps a. through c. finalize a shipyard master schedule for a new order by specifying key dates in a large frame sense. The process does not include checks of the detail schedules which will control individual shops.

3.3.3 Coordinating

If the checking process discloses that the lead times for critical major materials are not being accommodated the following action should be taken:

° adjust the dates of keel laying, launching and delivery, or

° increase the man-hours available by arranging for overtime work or for subcontractors.

3.3.4 Issue, Updating and Recovery

A Shipyard Master Schedule (New Order) is issued when a new order is received or is imminent, or when a special request is received from the sales department. Updating is routinely accomplished by the Shipyard Master Schedule (Periodic). If something unexpected delays a milestone such as keel laying, recovery for delivery as scheduled is attempted on lower activity schedules.

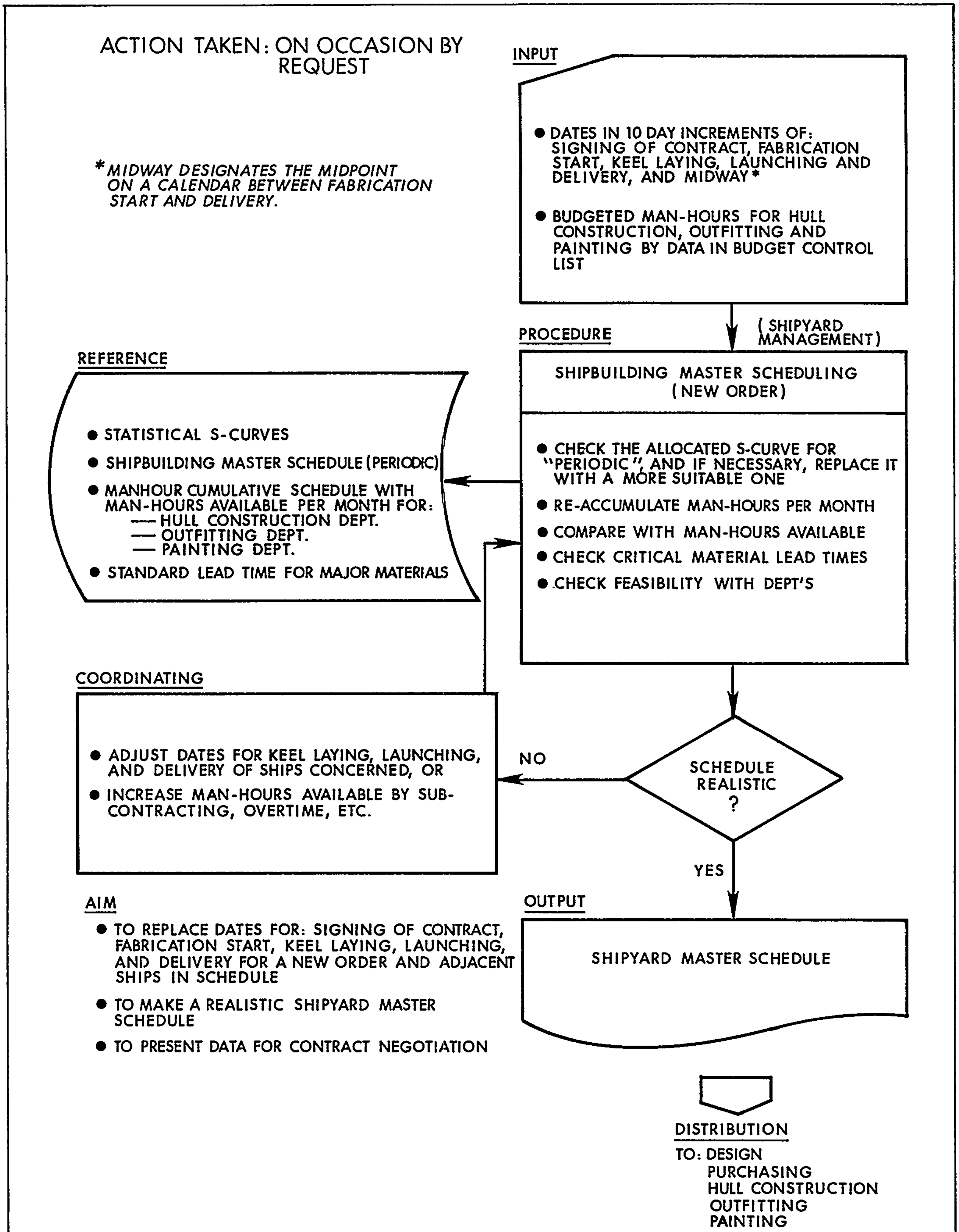

FIGURE 3-6: Shipyard Master Scheduling (New Order).

4.0 HULL BLOCK CONSTRUCTION METHOD

Hull construction schedules are key instruments because they also influence the effectiveness of outfitting and painting operations. Necessarily, production engineers who have hull construction responsibilities have to have knowledge of and assume a degree of leadership for outfitting and painting during the preparation of integrated schedules. Hull construction schedules must be based on sound logic because they comprise the framework upon which design, material procurement, outfitting, and painting people base their commitments to a master schedule.

A hull construction schedule which attempts to optimize only hull construction processes is sure to entail sacrifice of efficiency in the other departments. Such losses more than offset the purported hull construction gain and eventually jeopardize even the hull construction schedule. Thus, the Shipyard Manager insures that other disciplines are represented during the establishment of a hull construction schedule. An effective tool for ensuring the necessary coordination by the diverse participants is the Flexible Production Scheduling System (FPSS).

4.1 Organization

Figure 4-1 shows an organization in which hull construction production planning, scheduling, and engineering responsibilities are distributed at the shipyard, department, and shop/section levels.

Within the Hull Construction Department, schedules are produced level by level for creating long-, medium-, and short-term schedules for work flows typically organized as in Figure 1-1. They are used for:

° defining time frames,

° allocating man-hours,

° tracking, i.e., determining when specific flows are ahead or behind schedule,

° adjusting for recovery of time frames scheduled, and

° obtaining reliable feedback for both producing better schedules and improving the scheduling system.

In accordance with the principle of decentralization, people at each level have authority to act and further delegate. They periodically or occasionally communicate with and/or report to:

° their peers in other departments, and

° People in levels above and below.

As shown in Figure 4-1 the Hull Construction Department is organized to match the zone/problem area/stage classifications that reflect a product work breakdown. For all work other than hull erection, the various trades needed to produce products of a particular classifications are grouped under a single foreman (F-group) per the process yard concept. In contrast, the erection section is grouped by trade because process yards are impractical. Therefore, when coordinating erection activities for several ships, a prime factor is coordination of the output of the process yards. This different grouping of workers entails different scheduling methods.

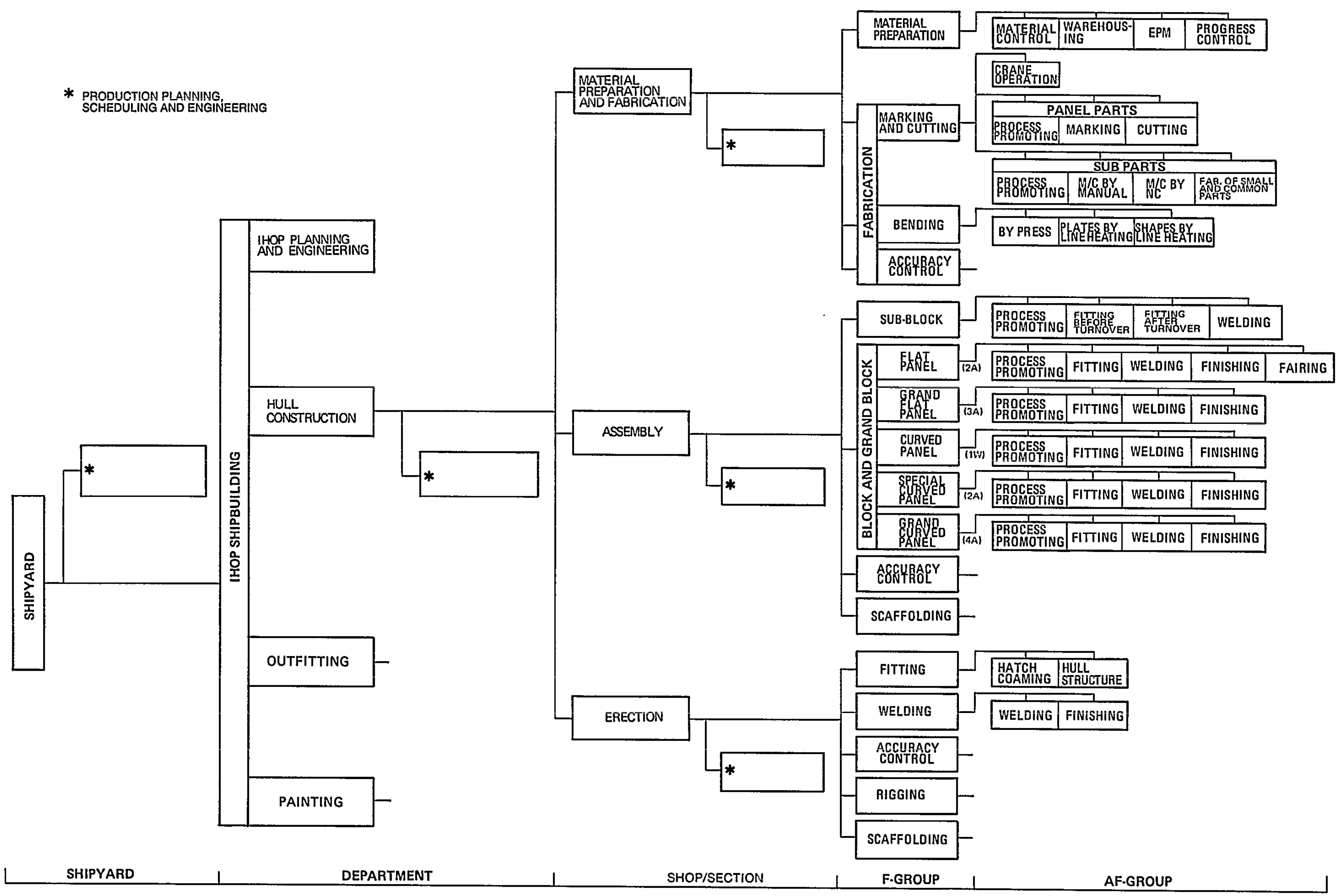

FIGURE 4-1: Model Organization for a Hull Construction Department.

4.2 Frame Scheduling Method

Hull Construction Department schedules are prepared in the sequence shown in Figure 4-2. Within frames prescribed for the various levels, people at each level prepare schedules as tabulated in Figure 4-3. As shown in Figure 4-2, the Man-hour Cumulative Schedules (Periodic and New Order) are needed for preparing a Shipyard Master Schedule and for governing lower-tier schedules.

Some traditional schedule flows are sequenced as shipyard master, production control and production execution schedules and seem, at first sight, to follow the sequence shown in Figure 4-2. But, the concepts of man-hour accumulation and backward scheduling are lacking. Backward scheduling means starting with the required completion date of an operation and obtaining man-hour requirements from statistical analysis of past performances in order to schedule a start date.

For hull construction, backward scheduling utilizes the date of erection of each block as a date to be held firm and from which to count backward. Time frames are allowed for painting, on-block outfitting, block assembly, sub-block assenbly and parts fabrication. Such backward scheduling with man-hour accumulations eliminate superfluous time periods between activities. Then, interim products flow so as to occupy workers and facilities without intermissions. Eliminating intermissions is necessary for avoiding wasteful loss of time during production.

The sizes of frames for hull scheduling are presented in Figure 4-3. The changes in sizes from large to small as design and material definition progress, represents scheduling refinement.

As design and material definition progresses, that which is encompassed by a frame is described by its parametric weight. The weights are translated into required man-hours by conversion factors or parameters that are specific per shipyard, per frame level, and per interim product. Start dates are accurately determined from required dates with due regard for man-hour accumulations. Traditional practice is to specify only start and completion dates for each activity. Starting dates prescribed without minimizing the time reserved for each job, results in needless large time intervals between actual completion of interim products and their required dates for a following work process.

Another shortcoming of traditional scheduling is the use of the same size frames and same parameters throughout the entire scheduling process. The same rule-of-thumb data is relied upon despite the fact that more definitive information becomes available as design progresses. The resulting schedules are impractical and often have to be significantly revised midway in a project with serious affect on a master schedule. Such disasters are avoided by constantly refining work volumes commensurate with design refinement.

The recommended scheduling procedure described in the following incorporates the previously described support elements, i.e.:

° Frame Scheduling Method (FSM),

° Integrated Hull Construction, Outfitting and Painting (IHOP) Scheduling and Tracking,

° Decentralized Production Planning, Scheduling, and Engineering, and

° On-Schedule Availability of Information and Resources.

4.3 Man-Hour Cumulative Scheduling (Periodic)

4.3.1 General

The pertinent activity flow is depicted in Figure 4-4.

° Purpose:

- to review the Shipbuilding Master Schedule from the standpoint of man-hour availability, and
- to coordinate the overall man-hour distribution between departments.

° Prerequisites:

- Shipyard Master Schedule, and
- past records of the relationships between steel weight and production man-hours used.

° Frames

Subjects treated: ships (and end products other than ships) contracted and expected to be contracted.

Unit: department.

Period: monthly, ideally for a 3-year span (market circumstances may preclude sufficient foresight for 3-years ahead).

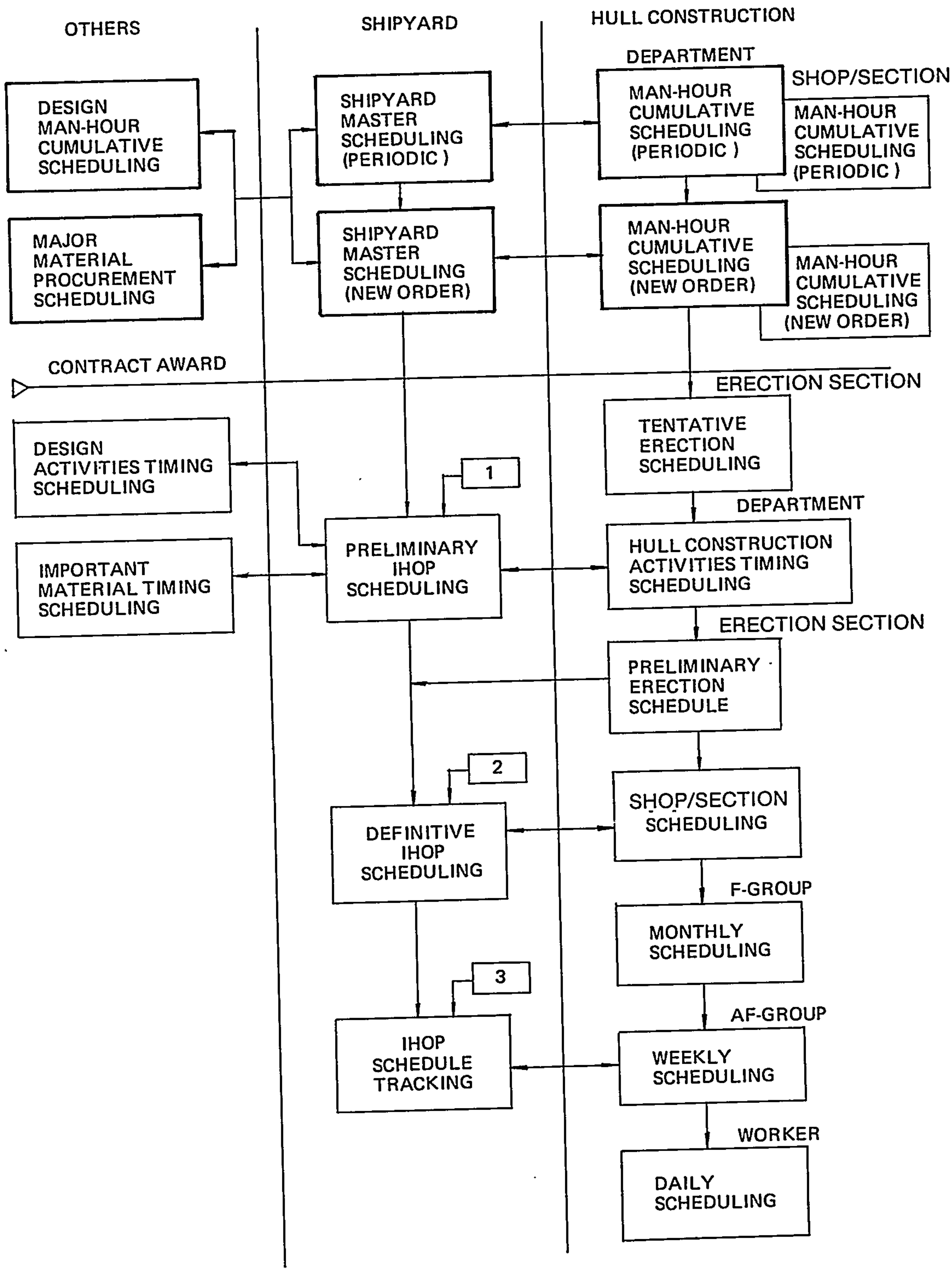

FIGURE 4-2: Sequence for Hull Construction Scheduling. Numbers 1 through 3 indicate inputs of outfit scheduling of commensurate level.

SCHEDULES	TIME		WORK VOLUME INDICATION			RESPONSIBILITY
	PERIOD	UPDATED	SUMMARY UNIT	SUMMARY PERIOD	PARAMETER	
DEPARTMENT OR SHOP/SECT. MAN-HOUR CUMULATIVE SCHEDULE	3 YEARS (DEPT.) 1.5 YEARS (SHOP/SECT.)	EVERY 3 MOS. (DEPT.) EVERY 6 MOS. (SHOP/SECT.)	FKLD/SHIP/ DEPARTMENT OR SHOP/ SECTION	MONTH	S-CURVE	DEPARTMENT OR SHOP/SECTION MANAGER
HULL CONST. ACTIVITIES TIMING SCHEDULE	A SHIPBUILDING PERIOD	NOT RELEVANT	GROUP OF BLOCKS/SHIP	NOT RELEVANT	STATISTIC DURATION	DEPARTMENT MANAGER
SHOP SECTION SCHEDULE	6 MONTHS	EVERY 2 MONTHS	INTERIM PRODUCT/ SHIP/ PROCESS YARD	10 WORKING DAYS (2 WEEKS)	–WELDING LENGTH (ROUGH)	SHOP/SECTION MANAGER
MONTHLY SCHEDULE	1.5 MONTHS	EVERY 2 WEEKS	INTERIM PRODUCT/SHIP/ PROCESS YARD/ STATION	5 WORKING DAYS (1 WEEK)	–WELDING LENGTH (ACCURATE) –NUMBERS PER CRAFT	FOREMAN
WEEKLY SCHEDULE	2 WEEKS	EVERY WEEK	INTERIM PRODUCT/ SHIP/PROCESS YARD/STATION	1 DAY	–NUMBERS PER CRAFT –WORKER NAME	ASSISTANT FOREMAN
DAILY SCHEDULE	1 DAY	EVERY DAY	INTERIM PRODUCT/ SHIP/PROCESS YARD/STATION	HOURS	–WORKER NAME	WORKER

FIGURE 4-3: Details of Schedule Frames for Hull Construction.

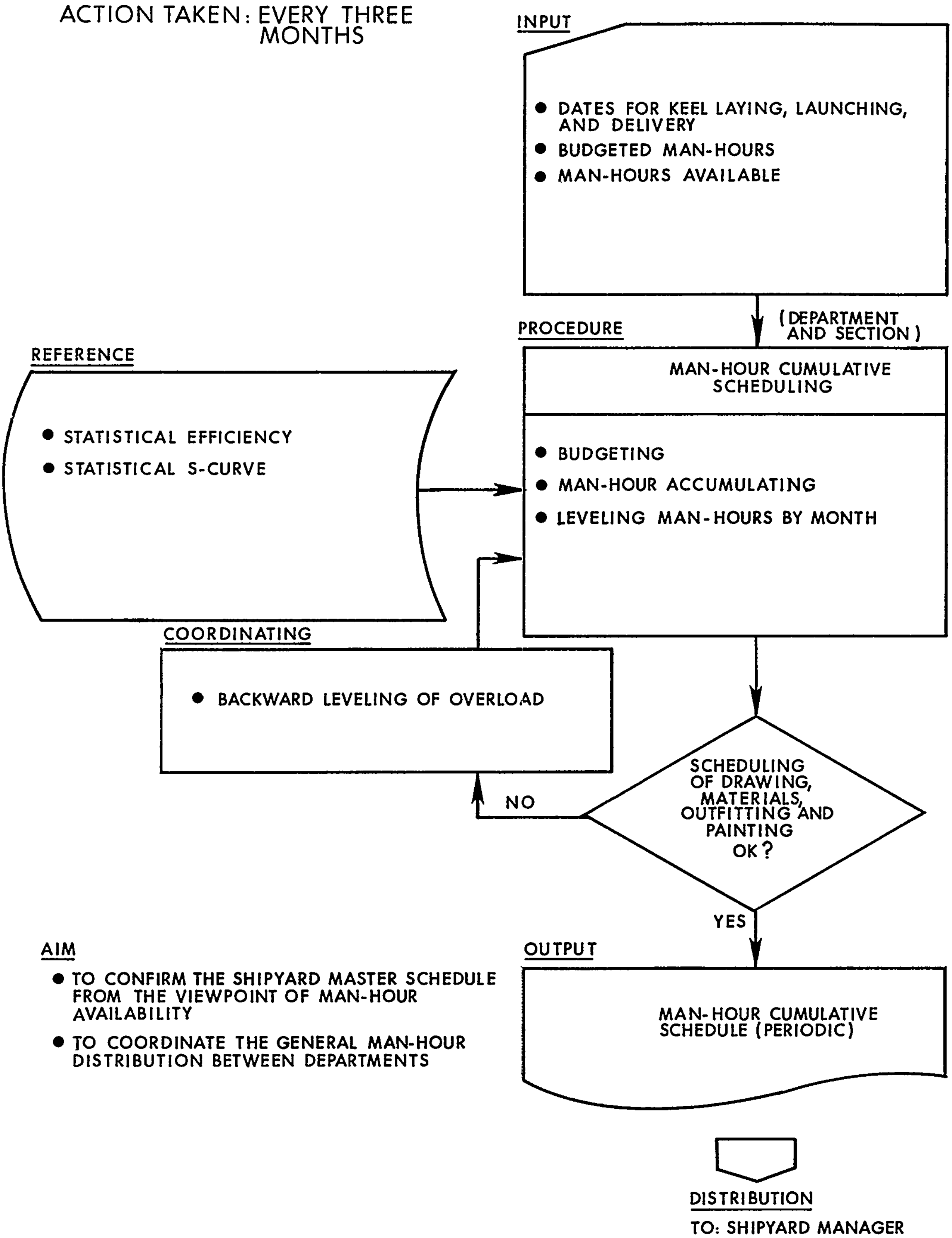

FIGURE 4-4: Man-hour Cumulative Scheduling (Periodic).

4.3.2 Procedure

° Budget Compilation

- Variables specified: type of ship and hull-steel weight.

- Estimating work volumes: For each ship type, the shipyard maintains in its historical file a plot of man-hours required versus hull-steel weight. Thus, the estimated hull-steel weight for a contemplated ship is readily converted into estimated work volume. As similar ships may not have been built in the recent past, the shipyard manager may judgementally modify this work volume in order to reflect current productivity.

° Man-hour Accumulation

- Variables specified: percentages of total man-hours required that are estimated to be consumed at contract signing, fabrication start, keel laying, launching and delivery.

- Estimating work volumes for individual frames: Distribute the required work volumes estimated, month by month, along the S-curve selected.

° Leveling

- Comparison between work volume and man-hours available: Compare the work volumes estimated with the man-hours available which is derived from the number of workers. Record the discrepancies between the two on a monthly basis. The manager of the Hull Construction Department discusses the discrepancies with the other department managers in order to identify the best possible remedies.

  Measures for Leveling the Work Load: The proposed solutions which are presented to the shipyard manager could consist of any combination of: advancement of part of the activities which comprise work load peaks (this requires careful coordination with other departments as they would have to advance their interface milestones such as for drawing issue and material availability dates), redistribution of the work force, overtime work, and additional work shifts.

4.3.3 Coordinating

° Items

- Drawing issue situation, i.e, prospect of receiving drawings as scheduled.

- Major material availability situation, i.e., prospects of receiving major materials as scheduled.

- Reserving necessary work facilities is not relevant at this stage.

- Assessing the potential of other production process lanes, e.g., for outfitting and painting, operations.

° Coordination

- Taking into account the foregoing factors, advance activities on the schedule accordingly.

4.3.4 Output Data and Timing

° Output: See Figure A-1. [1]

° Timing: Every three months.

4.3.5 UPdating and Recovery

° Updating: Every three months.

° Recovery: Upon issue of the schedule, every three months, the man-hours allocated are checked against actual man-hours expended. The balance of allocated man-hours is determined and an estimate is made of man-hours required for completion. If the remaining man-hours are insufficient for the work remaining, *in* order to prevent delays, a request to revise the budgeted man-hours is addressed to the Shipyard Manager.

[1] Figures having numbers preceded by the letter "A" appesr in Appendix A.

4.4 Man-Hour Cumulative Scheduling (New Order)

4.4.1 General

The pertinent activity flow is depicted in Figure 4-5.

° Purpose

- to review and firmly confirm the Shipbuilding Master Schedule for a specific ship from the standpoint of man-hour availability.

° Prerequisites

Shipyard Master Schedule (Periodic)

- Budget Control List

° Frames

Subject treated: a specific ship.

Unit: departments and shops for their respective levels.

Period: each month from fabrication start to delivery.

4.4.2 Procedure

The procedure is the same as described for Part 4.3.2.

4.4.3 Coordinating

° Items

- Drawing issue situation. In the most serious sense, checks should be made concerning whether drawings are likely to be issued in time for production.
- Material availability situation. Most seriously, check whether steel materials are likely to be available in time to start fabrication.
- Reserving necessary work facilities is not relevant at this stage.

° Coordination

- Advance scheduled operations as necessary.

4.4.4 Output Data and its Timing

Output timing is on command from the Shipyard Manager.

4.4.5 Updating and Recovery

o Updating: Issued for every newly contracted ship. Not issued if the timing coincides with the issue of a Man-hour Cumulative Schedule (Periodic).

o Recovery is sought on the Man-hour Cumulative Schedule (Periodic). See Part 4.3.5.

4.5 Tentative Erection Scheduling

4.5.1 General

Tentative erection scheduling could be overtaken by preliminary erection scheduling if sufficent prerequisite data is available at this stage. The pertinent activity flow is depicted in Figure 4-6.

° Purpose

to develop the activities timing schedules for the hull construction, outfitting and painting departments.

to inform the hull design office of erection sequences.

to confirm the time frame allocated between keel laying and launching.

° Prerequisites

- General Arrangement
- Machinery Arrangement
- Midship Section
- Preliminary Block Arrangement

° Frames

Subject Treated: Specific ship.

Frame Size: Several erection blocks framed as a group, i.e., a block frame.

Time Period: Each day from keel laying to launching.

4.5.2 Procedure

° Determine the erection sequence on the preliminary block arrangement based on records of erection sequences employed for previously built ships.

° Level the numbers of block frames to be erected each week between keel laying and launching with reference to erection schedules for previously built ships.

° Man-hour Cumulation is not relevant.

° Comparison with man-hours available is not relevant.

4.5.3 Coordinating

This schedule simply serves as a work sheet for the preparation of preliminary schedules. Coordination with the schedules of other departments is performed on the preliminary schedules.

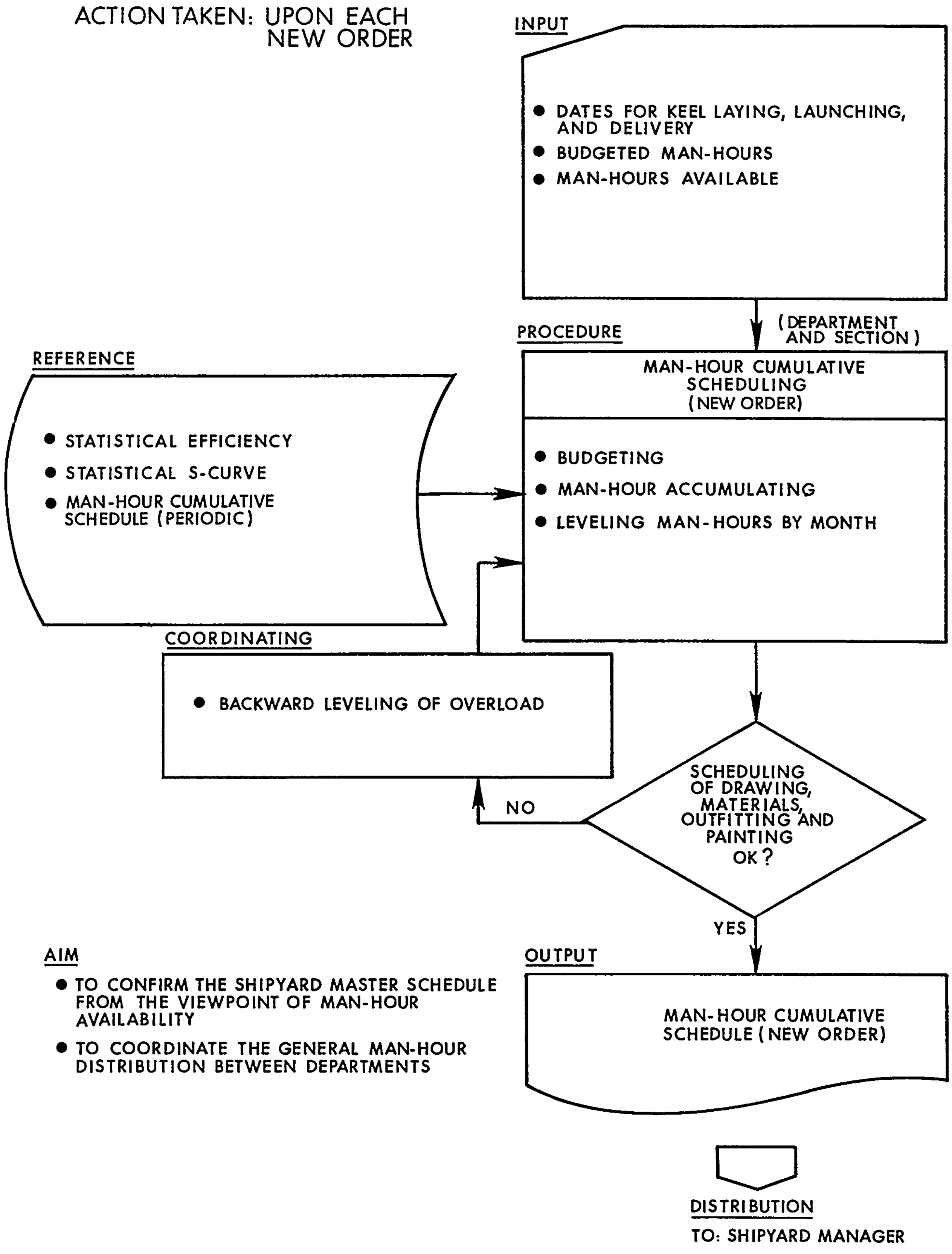

FIGURE 4-5: Man-hour Cumulative Scheduling (New Order).

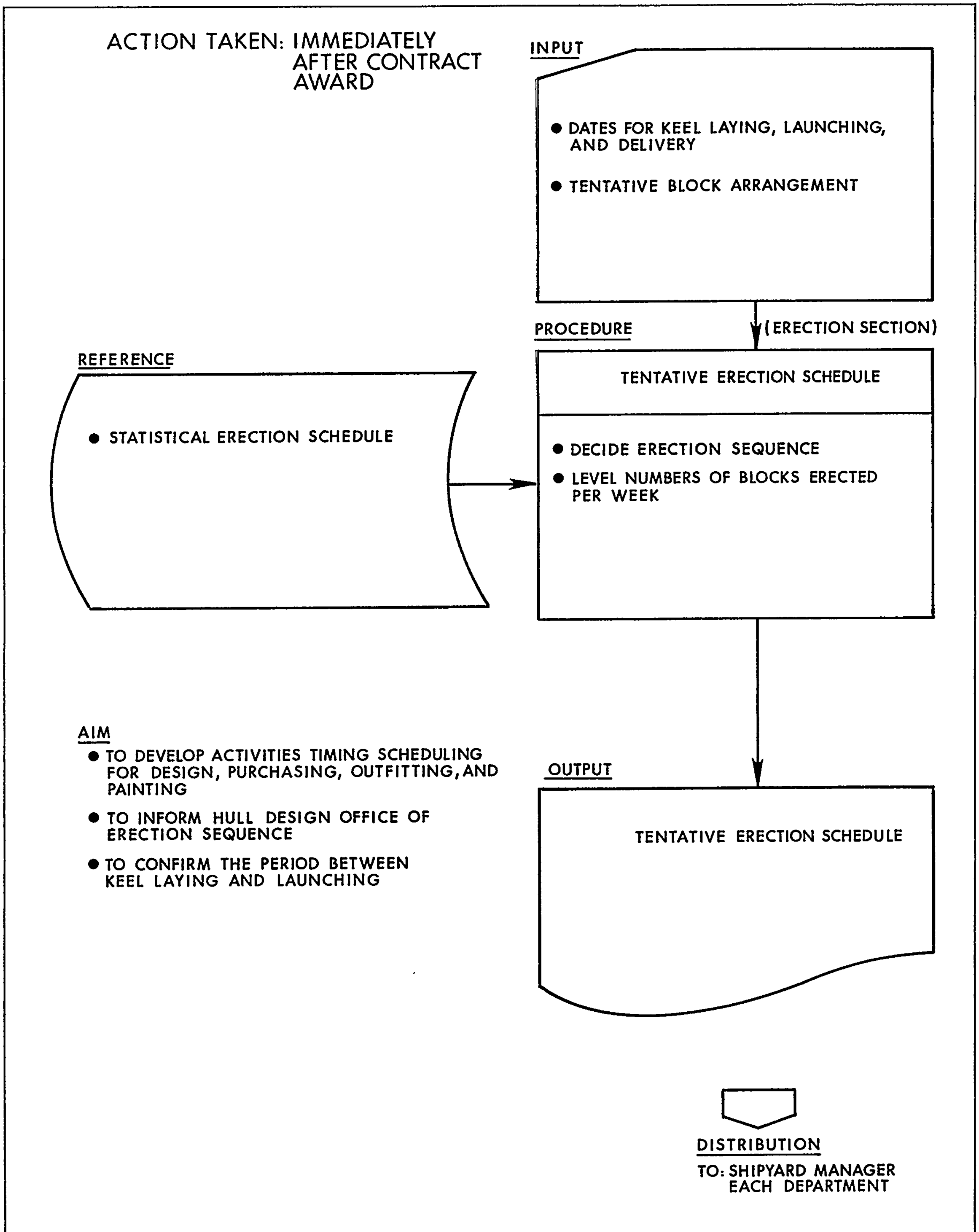

FIGURE 4-6: Tentative Erection Scheduling.

4.5.4 Output Data and Timing

° Output: See Figure A-2.

° Timing: After signing of a contract.

4.5.5 Updating and Recovery

° Updating: No updating is performed unless key milestones, e.g., keel laying and launching dates, are revised before issue of the preliminary erection schedule.

° Recovery is not relevant.

4.6 Hull Construction Activities Timing Scheduling

4.6.1 General

The pertinent activity flow is depicted in Figure 4-7.

° Purpose

- for the hull construction department to coordinate the activities timing schedule with other departments.

- to determine the starting and finishing points of frames and to estimate their work volumes.

° Prerequisites

- Block Arrangement

- Block Assembly Plan

- Machinery Arrangement

° Frames

- Subject Treated: Specific ship.

- Frame Size: Individual activities of the hull construction process for each frame of blocks.

- Time Period: each span of 10 workdays from keel laying to launching.

4.6.2 Procedure

o Determining the work volumes of block frames.

- Variables Specified: Type of ship and kind and size of blocks.

  Estimating Work Volumes: For each ship type and kind and size of blocks, the shipyard maintains in its historical file a plot of man-hours required versus block-steel weight. Thus, the estimated block-steel weight for a contemplated block is readily converted into estimated work volume. As similar blocks may not have been built in the recent past, the Hull Department manager may judgementally modify this work volume in order to reflect current productivity.

° Determining the starting and finishing dates for assembly and fabrication, and the deadline dates for drawing and material issues per block frame.

- Obtain erection dates per block frame from the tentative erection schedule.

- Determine the starting and finishing for assembly and fabrication per block frame, and the drawing and material issue deadline dates by backward scheduling from the erection dates.

° Man-hour accumulation is not relevant.

° Comparison with man-hours available is not relevant.

° Leveling is not relevant.

4 . 6 . 3

° Items to be coordinated.

- Drawing issue deadlines: Verify that drawings can be issued by the dates needed for fabrication.

- Material issue deadlines: Verify that important materials can be issued by the dates needed for fabrication.

- Reserving necessary work facilities is not relevant at this stage.

- Other production process lanes: Have the outfitting and painting departments coordinate and finalize the durations and timing they require for outfitting and painting on-unit and on-block.

° Coordination

- If the timing of any activities, e.g., drawing and material issues, are revised for any reason, all ensuing fabrication, assembly, outfitting, and painting activities must be shifted accordingly and simultaneously in one stroke as shown in Figure 4-8. Shifting sporadically, as is traditional practice, interrupts the work sequence as illustrated in Figure 4-9. The intermittent distribution of such waiting periods lowers productivity.

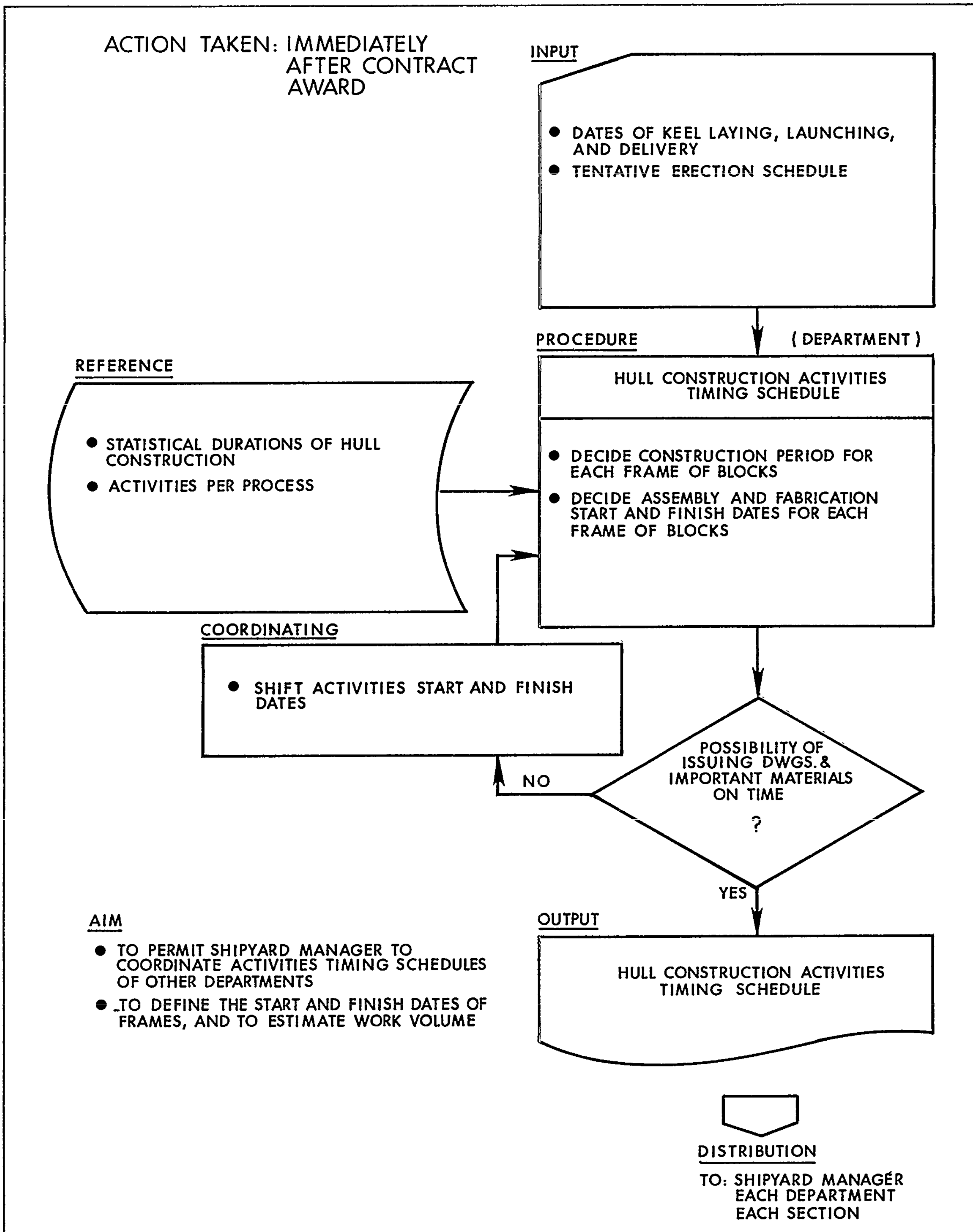

FIGURE 4-7: Hull Construction Activities Timing Scheduling.

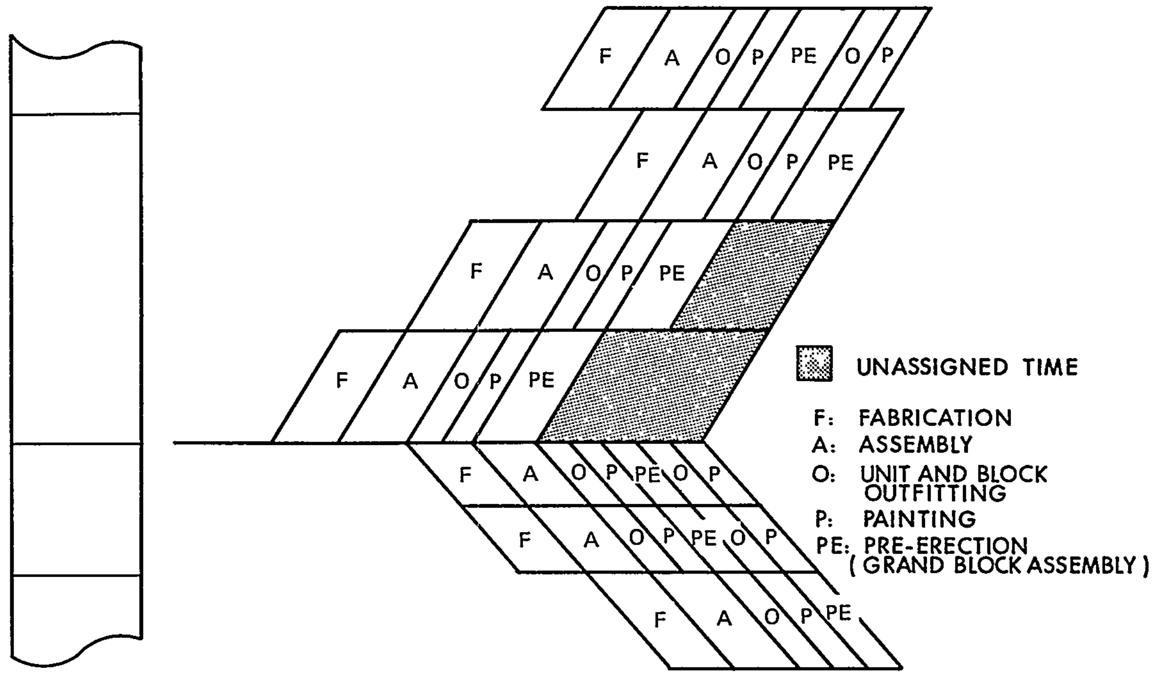

FIGURE 4-8: Shifting of Activities in FPSS. Normal performance of process flows is illustrated.

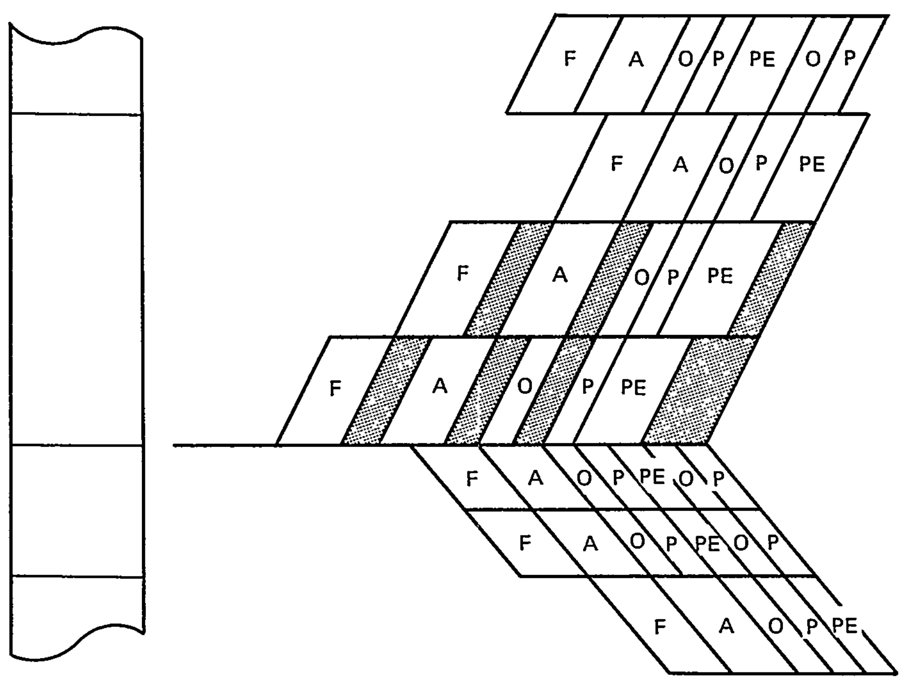

FIGURE 4-9: Shifting of Activities in Some Practice. Interruption of process flows with waiting periods lowers productivity.

4.6.4 Output Data and Timing

° Output: See Figure A-3.

° Timing: A few days after the tentative erection schedule is issued.

4.6.5 Updating and Recovery

° Updating: Not relevant.

° Recovery: Not relevant.

4.7 Preliminary Erection Scheduling

4.7.1 General

The pertinent activity flow is depicted in Figure 4-10.

° Purpose

to develop preliminary schedules for outfitting and painting.

- to develop preliminary IHOP schedules.

° Prerequisites

General Arrangement

Midship Section

Hull Construction Key Plans

Block Arrangement

Machinery Arrangement

Each department's activities timing schedule

Ieight of each block (estimated from hull construction key plans)

° Frames

- Subject Treated: Specific ship.

Frame Size: Block or grand block.

- Time Period: Each work day from keel laying (K) to launching (L)

4.7.2 Procedure

° Determine the final erection sequence.

° Determine the erection date for each block from work volume:

$$\text{No. of Blocks Erected/Day} = \frac{\text{Total No. of Blocks}}{\text{No. of Working Days between K \& L}}$$

$$\text{Weight of Blocks Erected/Day} = \frac{\text{Total Hull Steel Weight}}{\text{No. of Working Days between K \& L}}$$

° Level work load peaks for:

Numbers of blocks erected per day

Total weight of blocks erected per day

° Comparison with man-hours available is not relevant.

4.7.3 Coordinating

° Items to be coordinated.

Drawing issue deadlines are not relevant.

Material need dates are not relevant.

Operating facilities are not relevant.

Timing for landing main machinery (main engine, auxiliary boilers, diesel generators, etc.).

Timing for landing superstructure.

Timing of main accessories (shafts, propeller, rudder, steering engine, cranes, anchor chain, etc.).

° Coordination

Reduce as necessary the allocated durations of the different activities which relate to block erection.

- Modify as necessary the sequence for block erection.

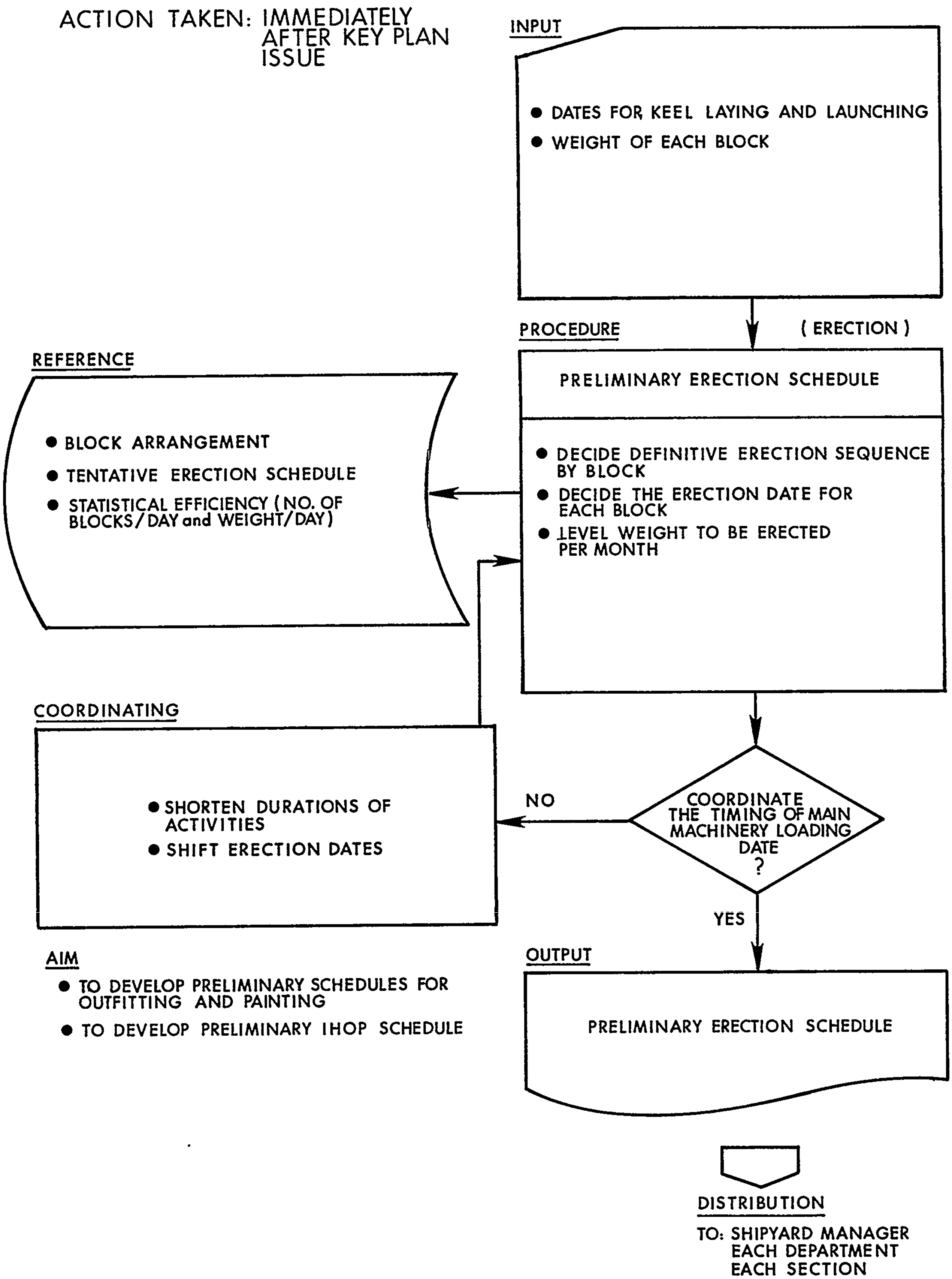

FIGURE 4-10: Preliminary Erection Scheduling.

4.7.4 Output Data and its Timing

o Output: See Figure A-4.

o Timing: Immediately after finalizing hull key plans.

4.8 Erection Section' Scheduling,

4.8.1 General

The pertinent activity flow is depicted in Figure 4-11.

0 Purpose

- To develop shop schedules for hull construction assembly and fabrication and for deck, accommodation, machinery and electrical (DAME) outfitting and painting operations.

- To develop a definitive IHOP Schedule.

- To confirm the definitive erection schedule and to develop a monthly schedule and the numbers of workers required for erection.

o Prerequisites

Erection joint lengths (meters) estimated from key plans.

- Main milestone dates supplied by the Outfitting Department for landing main machinery, shaft alignment, and keel sighting.

o Frames

- Subject Treated: Specific Ship.

Frame Size: Grand Block/Trade.

- Time Period: Each Work Day from K to L.

4.8.2 Procedure

o Determining the Activities Budget:

- Iielding Activity: For each type of ship and for each block problem category (flat, curved, special curved, etc.), the shipyard maintains in its historical file a plot of welding efficiency (meters/man-hour) versus hull-steel weight. Thus, after estimating the erection-welding length for a contemplated block, estimated work volume to erect the block is determined by the formula:

$$\text{Welding Man-hours} = \frac{\text{Erection Joint Length}}{\text{Welding Efficiency}}$$

- Shipfitting Activity: Based on the shipyards experience, man-hours for shipfitting are usually expressed as a multiple of welding man-hours. In the most effective shipyards the ratio of erection welding to erection fitting is as much as 2:1. This favorable ratio is attributed to statistical accuracy control.

o Determining the Work Force Required

Derive the numbers of welders required by means of the formula:

$$\text{Welding Man-days} = \frac{\text{Welding Man-hours}}{(\text{No. Work Days Allocated}) \times 8 \text{ hrs}}$$

The number of shipfitters required per day is determined in the same manner.

The work force required is a function of the number of work days allocated and vice versa. An optimum combination of the two should be chosen for determining the schedule.

° Matching the Work Force Required to that Available

Compare the required numbers of workers derived for each trade with formulas similar to those above with the man-hours available. For avoiding shortages in man power, shift activities in order to eliminate unassigned time between the work to be done by workers of different trades; see Figure 4-72 and 4-13.

4.8.3 Coordinating

0 Items to be coordinated

- Drawing issue deadlines are not relevant.

- Material issue deadlines are not relevant.

- Operating facilities availabilities are not relevant.

- Welding of heavy fittings on main structure must be completed before shaft alignment and keel sighting.

- Painting on board.

0 Coordination

Shift activities in such manner that no unassigned time remains between trades, see Figures 4-12 and 4-13.

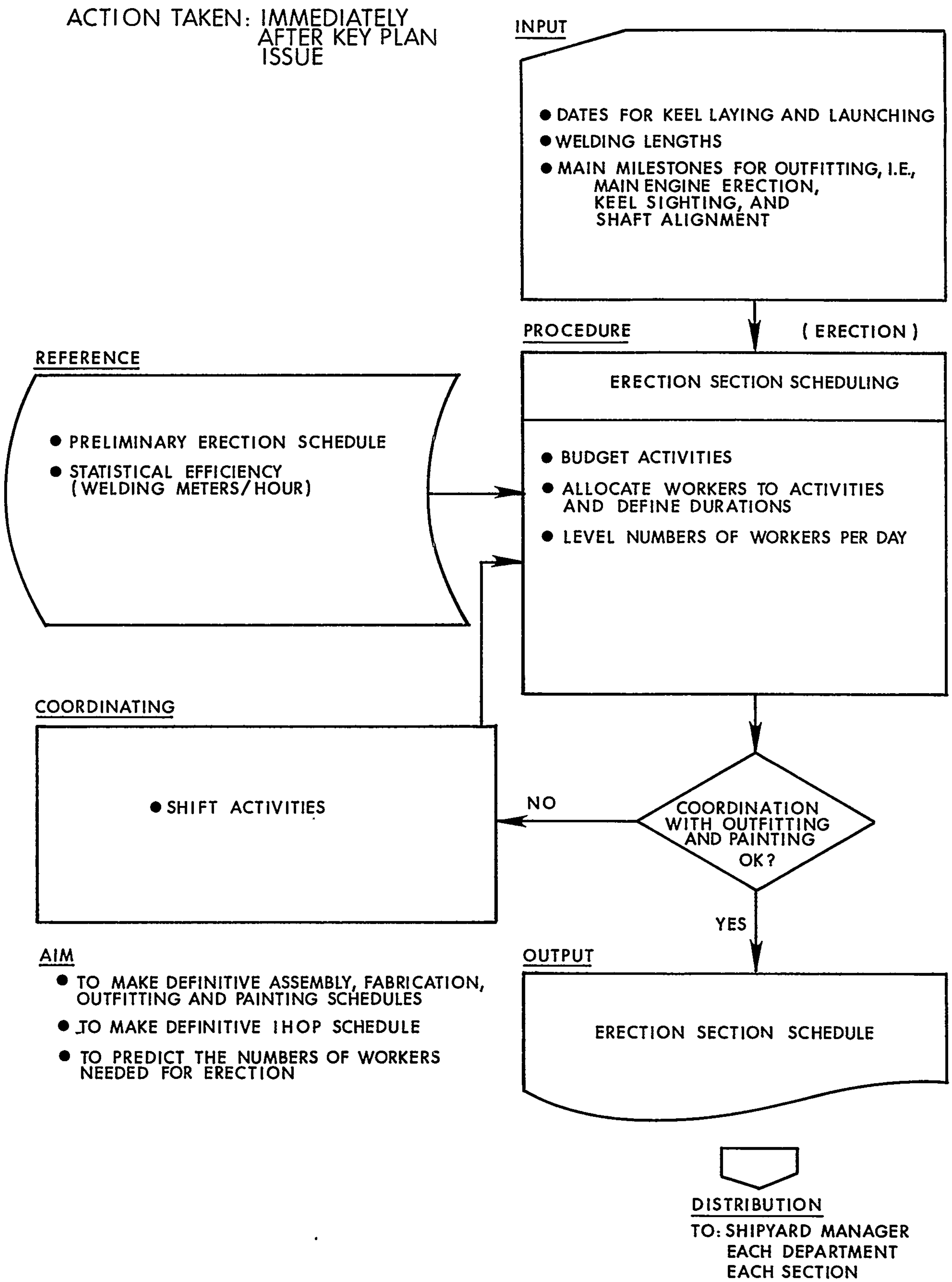

FIGURE 4-11: Erection Section Scheduling.

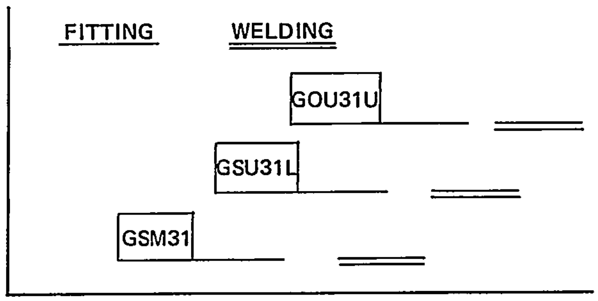

FIGURE 4-12: Shifting With Unassigned Time Between Trades.

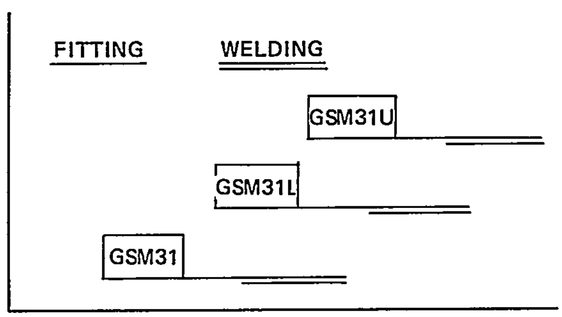

FIGURE 4-13: Shifting Without Unassigned Time Between Trades.

4.8.4 Output Data and Timing

- Output: See Figure A-5, which is actually a monthly schedule. It applies for shorter periods but is otherwise identical.

- Timing: One week after issue of key plans.

4.8.5 Updating and Recovery

- Updating

  No updating is required unless revisions are made in key milestones such as the dates for K and L.

- Recovery

  Employ this schedule to monitor work progress and for any delays revealed. Arrange for recovery within the monthly schedule.

4.9 Assembly Section Scheduling

4.9.1 General

The pertinent activity flow is depicted in Figure 4-14.

- Purpose
  - to develop shop schedules for fabrication and section schedules for deck, accomodation, machinery, and electrical (DAME) on-block outfitting and painting,
  - to develop the definitive IHOP schedule,
  - to determine the work force required for assembly, and
  - to develop the monthly schedule.

- Prerequisites
  - Assembly joint lengths (meters) for each sub-block, block, and grand block per process station, estimated from key plans.
  - Erection section schedule, and
  - On-unit and on-block outfitting durations.

- Frames
  - Subject Treated: Ships for which assembly work is progressing simultaneously.
  - Frame Size: Assembly/process yard/block for assembly, and sub-assembly/process yard/sub-block for subassembly.
  - Time Period: each work day for 6-months.

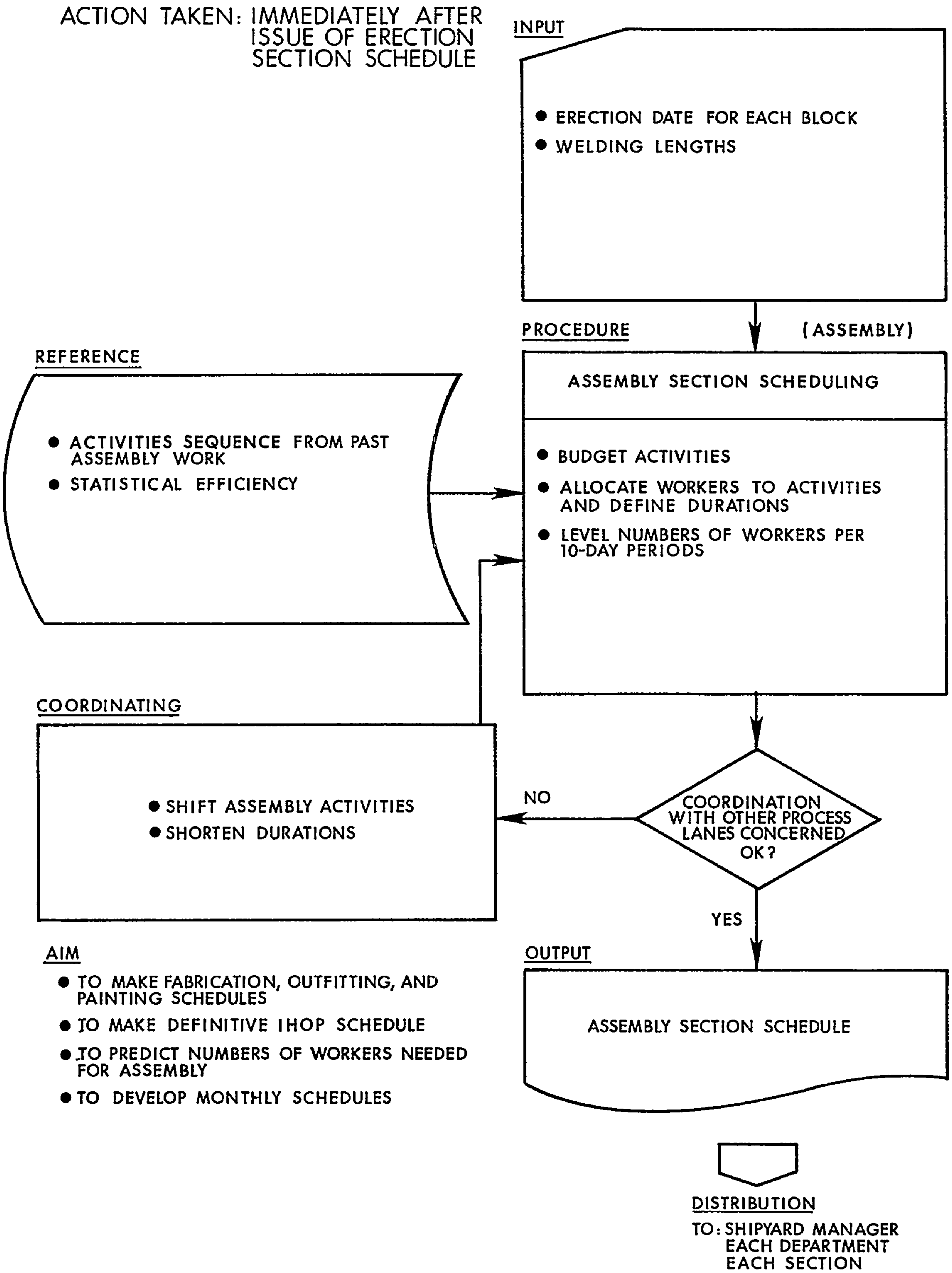

FIGURE 4-14: Assembly Section Scheduling.

4..9.2 Procedure

o Determining the Activities Budget

For each type of block (flat, curved, special curved, etc.) that constitutes a different problem category, the shipyard maintains in its historical file a plot of assembly efficiency (meters/man-hour) versus block weight. Thus, after estimating the assembly joint length for a contemplated block, estimated work volume is determined by the formula:

$$\text{Assembly Man-hours} = \frac{\text{Assembly Joint Length}}{\text{Assembly Efficiency}}$$

° Determing the Work Force Required

Derive the number of workers needed by the formula:

$$\text{Assembly Man-days} = \frac{\text{Assembly Man-hours}}{\text{(No. Work Days Allocated) x 8 hrs}}$$

o Matching Required to Available Man Power

Compare the number of workers derived for each trade by the formula given above for each 10 work days. Where the work load exceeds available man power, advance part of the overload, i.e,, perform work load leveling by advancing work in the schedule.

4.9.3 Coordinating

o Items to be Coordinated

Drawing issue deadlines are not relevant.

Material need dates are not relevant.

Indicate on the schedule the number of assembly work stations available each day. Level any shortage of work stations by advancing excess work activities. If leveling is not possible, some of the work might be done outside of the originally intended work stations.

Indicate on the schedule the number of block storage yards. In case of a shortage of stowage space, plan to stack two or three blocks, one on top of another in each storage yard as necessary.

- Other process lanes. The information required includes the part fabrication finishing date for each block, the timing and durations for on-unit and on-block outfitting and painting, and the possibility of meeting the erection date for each block.

° Coordination

shift assembly activities, and/fir

shorten the durations of activities as necessary.

4.9.4 Output Data and Timing

° Output: See Figure A-6’for block assembly and Figure A-7 for grand-block assembly.

° Timing: A few days after issue of the Erection Section Schedule.

4.9.5 Updating and Recovery

o Updating: Every two months (periodic) and when erection dates are revised.

o Recovery: Employ this schedule to monitor work progress. Regulate on the monthly schedule by adjustments in work-force distribution, arranging for overtime, etc.

4.10 Fabrication Shop Scheduling

4.10.1 General

The pertinent activity flow is shown in Figure .4-15.

0 Purpose

- To confirm the deadline dates for drawing issues and material availabilities.
- To develop a definitive IHOP schedule.
- To determine the work force requirements for fabrication.
- To monitor work progress and develop the monthly schedule.

o Prequisites

- Quantities of steel materials to be processed and number of parts to be bent (estimated from key plans for fabrication shop scheduling).

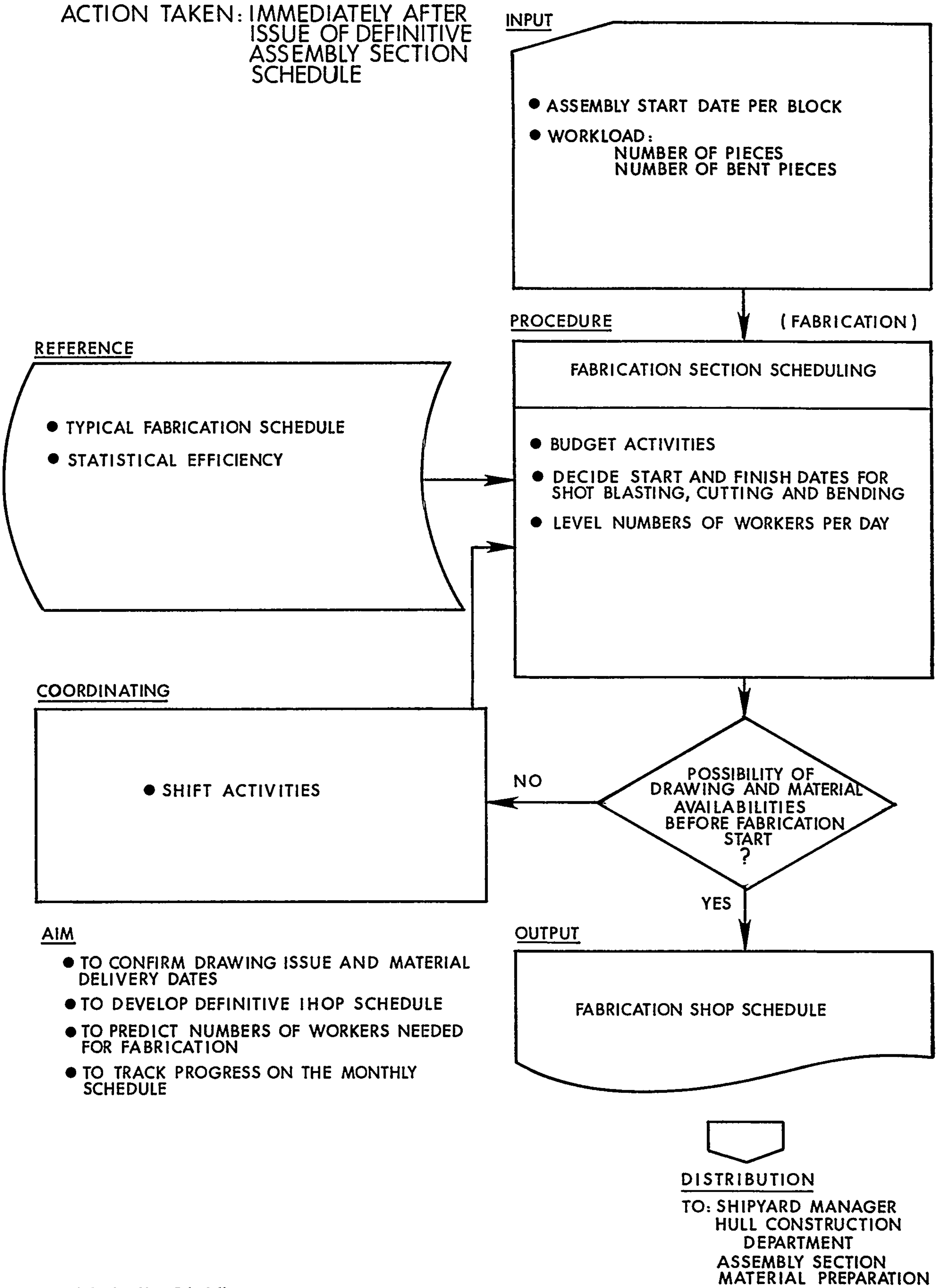

FIGURE 4-15: Fabrication Shop Scheduling.

o Frames

- Subject Treated: Ships for which fabrication work is progressing simultaneously.

  Frame Size: Fabrication/process yard/block. [2]

- Period: Each workday for the next 6 months.

4.10.2 Procedure

o Determine the Activities Budget

Part Fabrication Activity: For each type of part (parallel edge, non-parallel edge, internal and structural) and for each process yard, the shipyard maintains in its historical file a plot of fabrication efficiency (man-hours/part) versus number of fabricated parts. Thus, after estimating the number of parts to be fabricated for a contemplated block, estimated work volume to estimate parts required per block is determined by the formula:

Fabrication Man-hours =

(Fab. efficiency) X (No. Parts)

0 Determine Start and Finish Dates for the Different Work Stations:

Obtain dates that parts per block are required from the preliminary IHOP schedule. Then with a typical fabrication schedule from the shipyard's history, establish start and finish dates for blasting and priming, marking, cutting and bending stations.

0 Level conspicuous Desks in daily work force requirements"for each process yard.

4.10.3 Coordinating

o Items to be Coordinated

- Drawing issue deadlines are coordinated with the Design Department in order to be sure that drawings will be issued in time for fabrication.

- Material need dates are coordinated with the Material Procurement Section in order to be sure that materials will be available in time to start fabrication.

- Need for storage space for finished parts is coordinated with shop/section engineers.

- Coordination with other process lanes concerns issue dates after material preparation and subassembly starting dates.

o Coordination: Shift activities foreward or backward as necessary.

4.10.4 Output Data and its Timing

o Output: See Figures A-6 and A-7 which show schedules similar to a fabrication shop schedule.

o Timing: A few days after issue of the assembly section schedule.

4.10.5 Updating and Recovery

o Updating: Every two months and whenever there is a change to the assembly section schedule. Care must be taken to insure that drawing issue and material need dates always maintain their coordination.

0 Recovery: Emplov this schedule to monitor"progress of work. Regulate work speed on the monthly schedule by adjusting work force distribution, arranging for overtime work, etc. If drawings or materials are slightly delayed, arrange recovery on the monthly, weekly or daily schedules. If irrecoverable delays will affect assembly, bring the matter to the attention of the Hull Construction Department Manager for adjusting higher level schedules as necessary.

4.11 Monthly Scheduling

4.11.1 General

The pertinent activity flow is shown in Figure 4-16.

0 Purpose

To determine the work force distribution.

To distribute activity durations by trade.

To monitor the progress of work.

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[2] Traditional practice is to group parts to be fabricated by similarities in their configurations. The principal objectives are to reduce scrap rates and improve cutting efficiency. This practice introduces problems such as earlier need for drawings and need for long-term storage of finished parts. Grouping parts by block is more effective when all aspects of a shipbuilding system are considered.

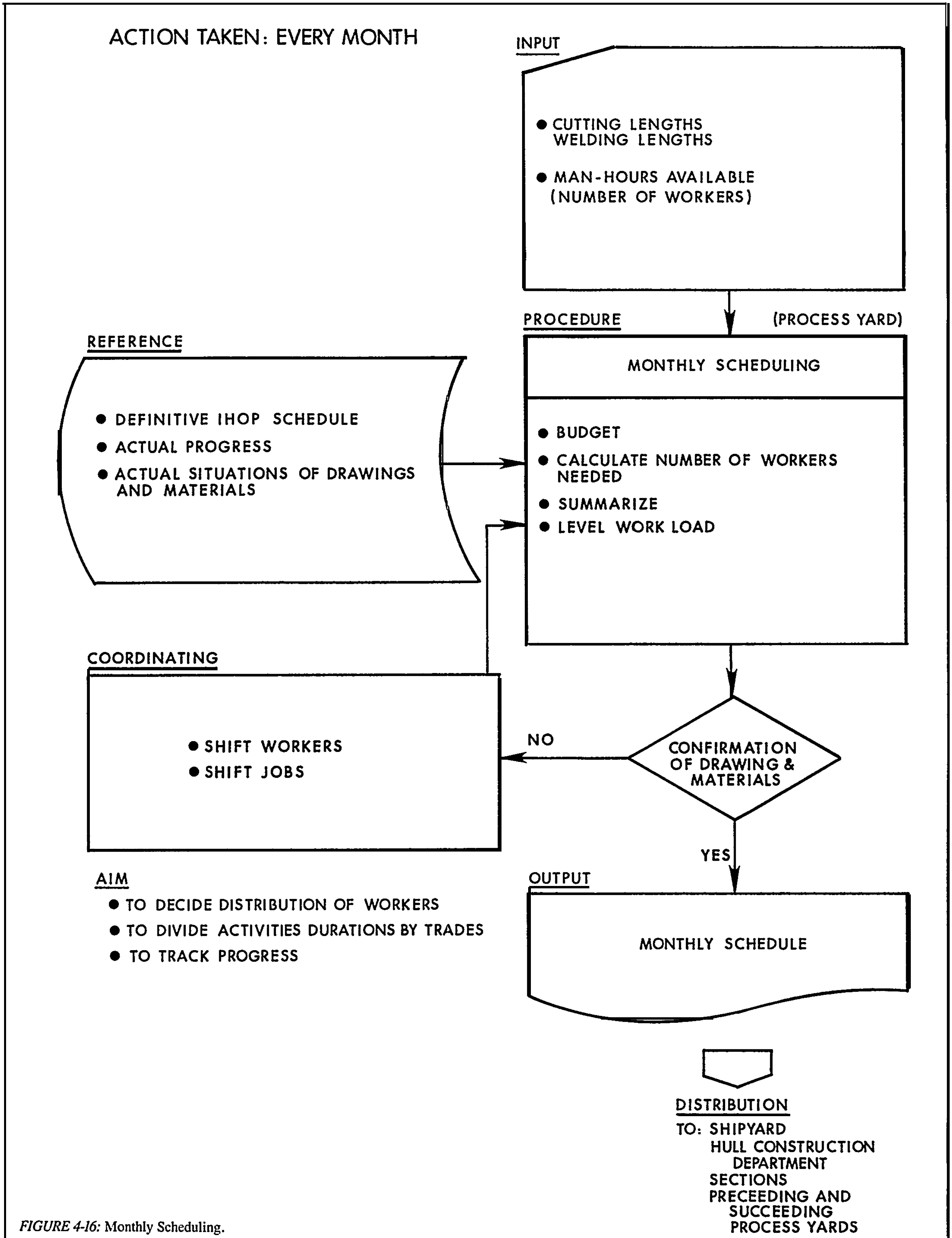

FIGURE 4-16: Monthly Scheduling.

o Prerequisites

Stage plans, i.e., work instructions per station (If not available in time for budgeting man-hours, use the man-hours budgeted in shop schedules.).

0 Frames

- Subject Treated: All ships for which work is to progress simultaneously, except for erection work which is to be on a ship-by-ship basis.

- Frame Size: process yard/trade.

- Time Period: Each workday for the next two months.

4.11.2 Procedure

o Determine man-hour budget.

0 Estimate the weekly work force requirements with the formula:

$$\text{Workers/week} = \frac{\text{Required Man-hours}}{\text{Allocated Weeks} \times 8 \times (\text{workdays/wk})}$$

0 Compare the work force requirements derived above with the man-weeks available for each process yard and for each trade.

0 Level any shortage of work force by arranging for work force redistribution, overtime work, and/or subcontracting.

4.11.3 Coordinating

o Items Requiring Coordination

Check the actual situations of drawing issues. Obtain confirmation from the Design Department on issue dates for drawings not yet issued.

Check the actual situations of material availabilities. Obtain confirmation from the Material Procurement Section for delivery dates of materials not yet issued.

- Reserve process work stations based on the shop/section schedules which govern the weekly schedules.

o Coordination

- Shift the work force as necessary between work stations, or if further necessary, between process yards to level work scheduled.

- While holding the Erection Schedule firm, change the sequence of blocks to be assembled.

While holding the Erection Schedule firm, plan certain interim products to be partially completed and designate them for completion in a follow process yard (advantage should be taken of any unassigned time that may be available).

4.11.4 Output Data and its Timing

o Output: See Figure A-8.

o Timing: The 25th of every month.

4.11.5 Updating and Recovery

o Updating: Every month.

o Recovery: The actual situations (advances or delays) at the end of each month, regarding construction, drawing issues and material availabilities, are reflected in the monthly scheduling for the ensuing month with arrangement for work force redistribution, overtime work, etc., as necessary to prevent escalation beyond another month.

4.12 Weekly Scheduling

4.12.1 General

The pertinent activity flow is shown in Figure 4-17.

0 Purpose

To determine the work force distributions to the various activities.

To confirm prospects of finishing the activities on schedule.

To coordinate hull construction activities with on-block outfitting and on-block painting within process yards.

o Prerequisites

Monthly Schedule

Determining and identifying drawings already issued.

Determining and identifying steel materials available.

Budgeted man-hours.

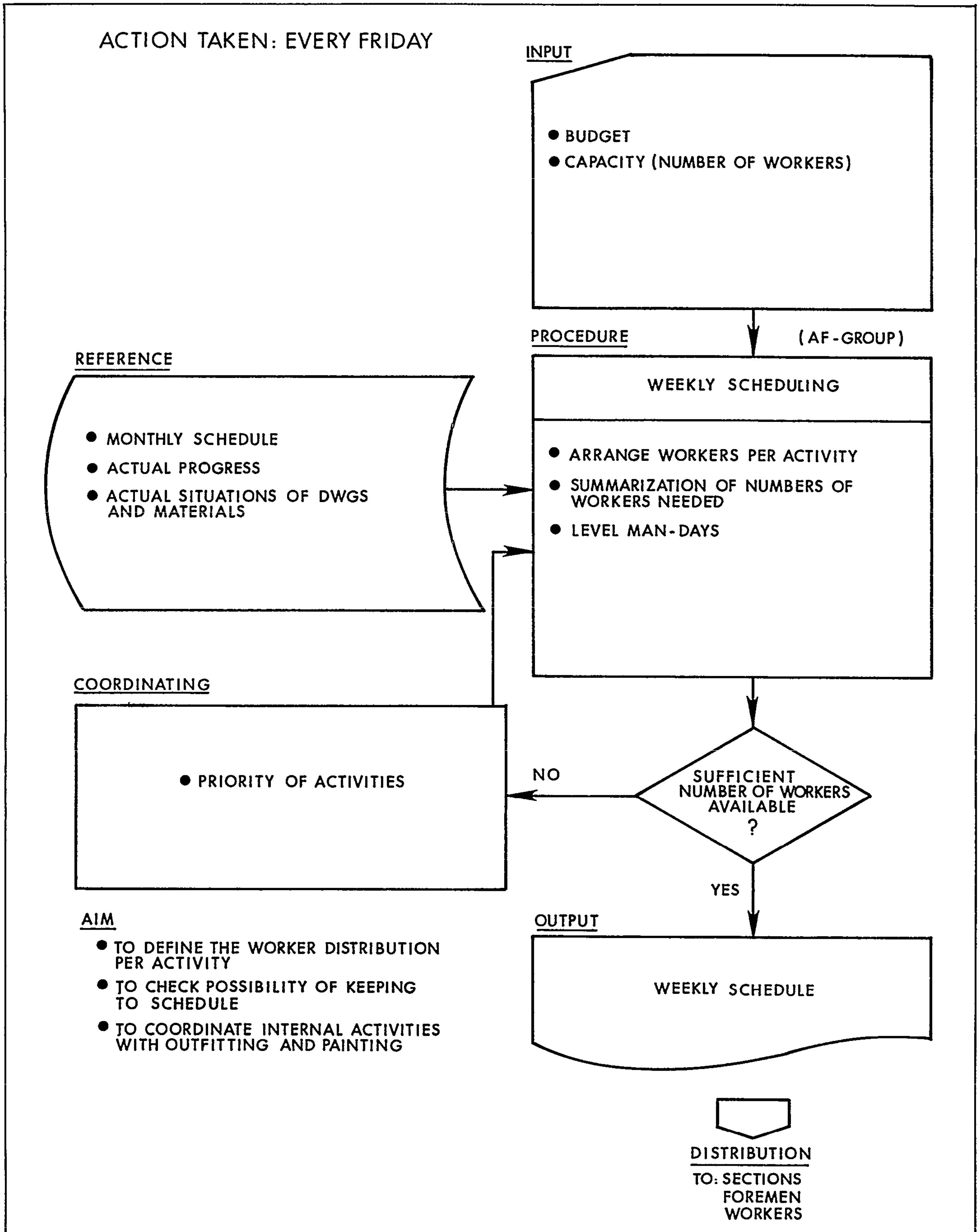

FIGURE 4-17: Weekly Scheduling.

o Frames

- Subject Treated: All ships for which work is to progress simultaneously, except for erection work which is to be on a ship-by-ship basis.

  Frame Size: Process Yard/Process Station/Trade.

- Time Period: Each workday for the next two weeks.

4.12.2 Procedure

o Distribute the daily work force to the required activities by means of the formula:

$$\text{Workers/day} = \frac{\text{Budgeted Man-hours}}{\text{(Allocated Workdays)} \times 8}$$

o Compare the daily work force requirements derived above with the daily man-hours available, process station by station and trade by trade.

o Level any shortage of work force by arranging work force redistribution, overtime work, and/or subcontracting.

4.12.3 Coordinating

Same as Part 4.11.3.

4.12.4 Output Data and its Timing

o Output: See Figure A-9.

o Timing: Every Friday.

4.12.5 Updating and Recovery

o Updating: Every Friday.

o Recovery: The actual situations (advances or delays) at the end of the week regarding construction, drawing issues and material availabilities, are reflected in the weekly schedules for the ensuing week with arrangements for work force redistribution, overtime work, etc., as necessary, and never escalated beyond another week.

4.13 Daily Scheduling

4.13.1 General

The pertinent activity flow is shown in Figure 4-18.

o Purpose

- To determine daily job assignment per worker.

- To coordinate progress including progress of on-block outfitting and painting.

- To coordinate the sequence of different types of work with drawing and material availabilities.

o Prerequisites

- Confirmed budgeted man-hours.

- List of workers' names.

o Frames

  Subject Treated: All ships for which work is to progress simultaneously, except for erection work which is to be on a ship-by-ship basis.

  Frame Size: Process Station/Trade/Worker.

  Time Period: Each hour for the next two days.

o Procedure

- Assign individual workers to the different activities based on the finalized weekly schedule.

4.13.3 Coordinating

Same as in Part 4.11.3.

4.13.4 Output Data and Timing

Output timing is at the start of jobs every morning.

4.13.5 Updating and Recovery

o Updating: Every morning.

o Recovery: Examine the progress of work made on the previous day and consider possible improvements by redistribution of the work force. If recovery of a delay is not possible by this means, the assistant foreman consults with the foreman about approaching the shop manager with a recommendation for overtime work.

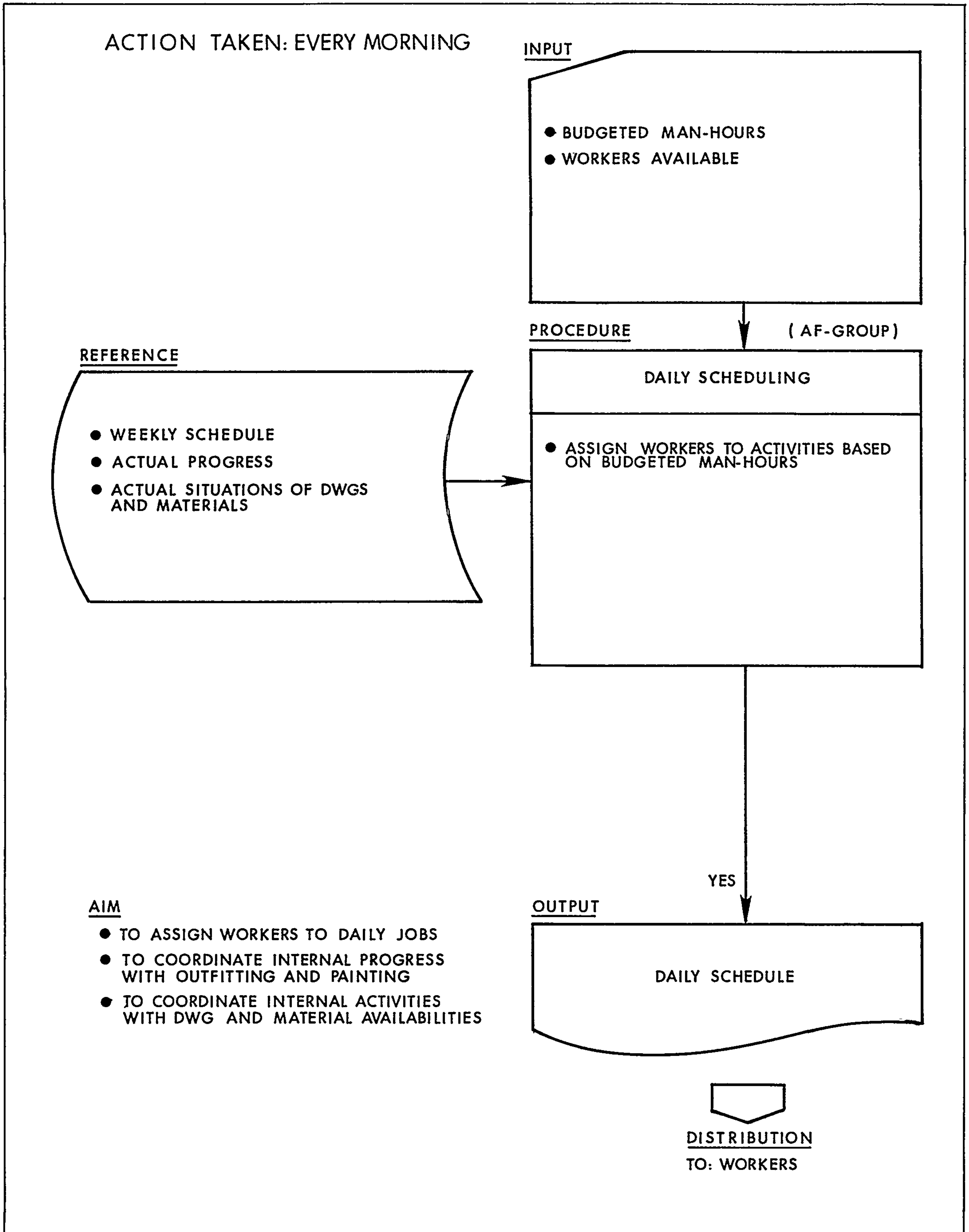

FIGURE 4-18: Daily Scheduling.

5.0 ZONE OUTFITTING METHOD

5.1 General

Outfit scheduling is one of the integration schemes which addresses outfit design and material procurement as well as hull construction and painting. The Flexible Production Scheduling System (FPSS) as applied to outfitting, also employs the four supporting elements describe in Chapter 2.0, i.e., Frame Scheduling Method, IHOP Scheduling and Tracking Operation, Decentralized Production Planning, Scheduling, and Engineering, and On-Schedule Availability of Information and Resources.

5.1.1 Frame Scheduling Method

The scheduling frames are successively refined from large to small as a shipbuilding process advances from contract award (at which time outfit scheduling is already underway) to delivery. The outfit schedule in the earliest phase is limited to accumulating total man-hours for large frames that are estimated to be required for each duration between milestones, i.e., start fabrication (F), keel laying (K), launching (L), and delivery (D). As the shipbuilding process further advances, frames are refined to enclose a group of pallets and later to reach a state where each frame corresponds to a single pallet. At the same time, frames of man-hour summary units are commensurately refined, i.e., to months, weeks and, days.

Outfit scheduling objectives are:

- o To determine that the timing of key milestones (F, K, L, and D) are satisfactory for outfitting.
- 0 To determine the need dates for drawing issues and important material arrivals.
- 0 To coordinate outfit work with processes for hull construction and painting.
- o To schedule detailed outfitting operations.

The refinement of frames is organized to suit these different scheduling objectives while maintaining accuracies commensurate with phases of design development.

5.1.2 lHOP Scheduling and Tracking Operation

IHOP scheduling is performed to integrate, to an optimum practical extent, all hull construction, outfitting (on-unit, on-block, and on-board), and painting processes. Improvement of overall outfitting is sought by maximizing on-block outftting when permitted by timing of block assembly and by lifting capacity. When blocks cannot be produced in time or when lifting capacity is not sufficient, outfitting is optimized through a combination of on-unit and on-block outfitting. Completed units are landed both on-block and "blue sky" on-board during hull erection.

The process calls for close coordination when dovetailing the inherently different types of work.

5.2 Organization

For properly executing the four supporting elements, traditional shipyard organizations are too centralized in production planning, scheduling, and engineering. This prevents sufficient coordination of schedules and schedule monitoring. That is, centralization precludes sufficient communications between those who plan and schedule and those charged with schedule execution.

Figure 5-1 shows a decentralized organization which features planning and scheduling responsibilities delegated to each level.

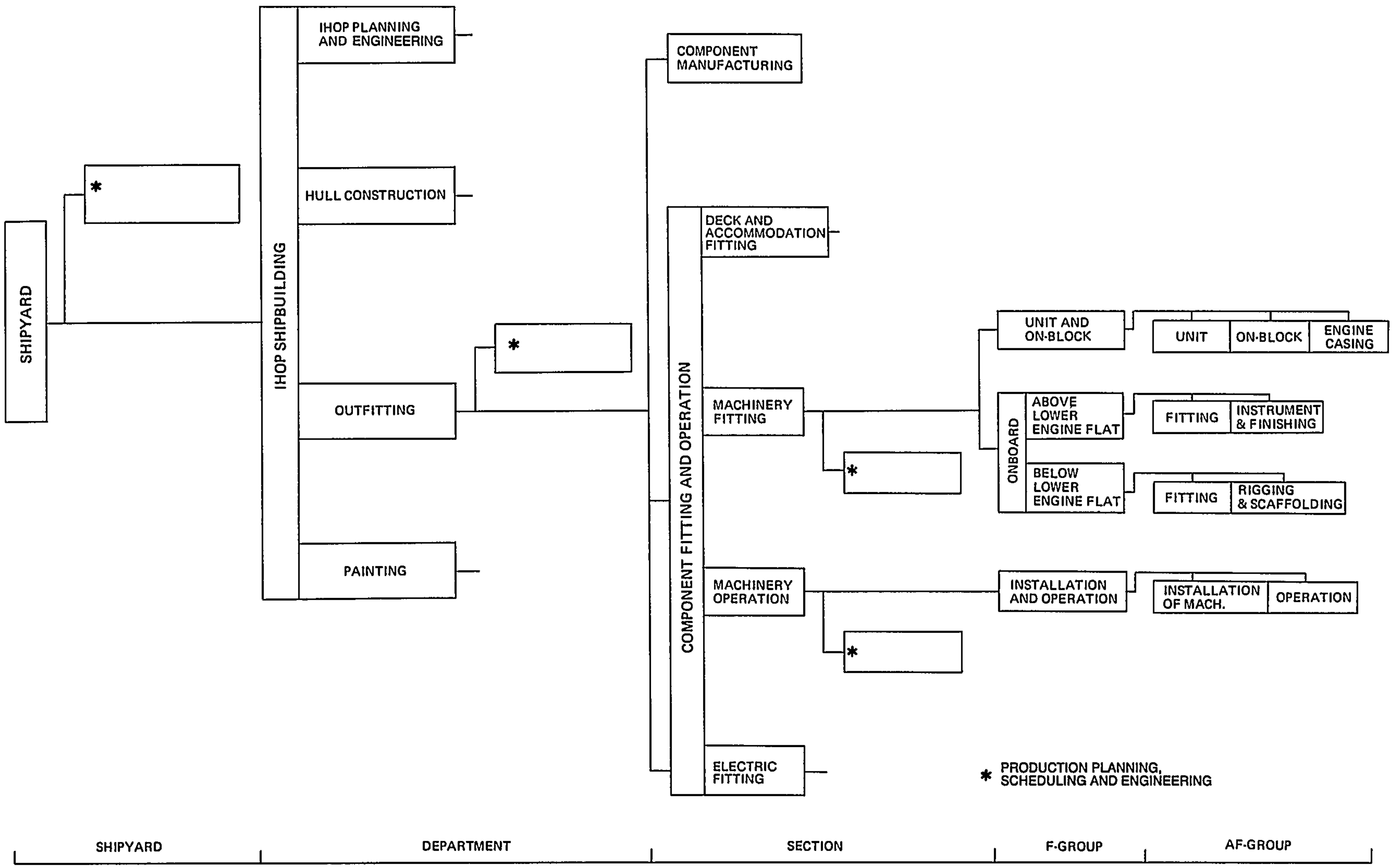

FIGURE 5-1: Model Organization for an Outfitting Department.

Being product oriented, the outfitting department may be regarded as being grouped by problem area as follows: manufacturing, fitting, and operation. Usually, in the most effective outfitting departments, manufacturing applies only to the production of pipe pieces, as in a Pipe Piece Fabrication Shop, as all other fittings are procured from suppliers and subcontractors. Fitting (assembly work) is subdivided so as to have sections specialized along product lines for deck, accommodation, machinery, and electrical (DAME). Operation applies to a section containing specialists for installation, light-off, test, and operation of certain systems, especially including main propulsion systems and any other large machinery systems of similar problem category.

With reference to Figure 5-1, the Machinery Fitting Section is divided into F-groups for: on-unit (Ist assemby level), on-block (2nd assembly level), engine casing special case of on-unit), and on-board (3rd assembly level) . The F-group for on-unit and on-block is subdivided into AF-groups as: on-unit (1st assembly level) and on-block (2nd assembly level). The F-group for on-board (3rd assembly level) is subdivided geographically, i.e, as above lower engine-room flat and below lower engine-room flat, and further subdivided into AF-groups, i.e., fitting instrument and finishing, and rigging and scaffolding.

The Operation Section has only one F-group which is subdivided into AF-groups for installation (e.g., landing and aligning a main engine and operation. The separation of this system-oriented section from the Machinery Fitting Section is to coordinate all DAME zone-by-zone responsibilities in a concerted effort to implement the final phase of a ship construction effort in a system-by-system manner. Having no independent operation sections, D, A, and E operational responsibilities are assumed by the D,A, and E Sections.

5.3 Frame Scheduling Method

The Outfitting Department prepares schedules per the sequence shown in Figure 5-2. Production engineers, foremen, and assistant foremen, as shown in Figure 5-1, prepare schedules within their frames as tabulated in Figure 5-3. The Outfitting Department is bound by the frames defined by F, K, L, and D as applied to the Hull Construction Department. Further, their schedules must be coordinated with the schedules produced by the Material Section and the Design, Hull Construction, and Painting Departments. Coordination is indispensable for scheduling on-block outfitting.

5.3.1 Flow

The flow described in Part 4.2.1 for hull construction is the same for outfit scheduling.

In order to incorporate the backward scheduling concept for outfitting, on-unit and on-block outfitting must be coordinated with the erection date for each block as shown on the tentative erection schedule. Also, on-unit and on-block outfitting must be coordinated with the Design Activities Timing Schedule and Important Material Procurement Schedule per the Preliminary IHOP Schedule.

On-board outfitting activities should be coordinated among the outfitting and painting sections by foreward scheduling from block erection dates. On-board operation activities, including sea trials, should be scheduled by moving backwards from the date of ship delivery. The activities between the block erection dates and the ship delivery date should be finally coordinated by both backward and foreward scheduling to prevent the activities of both groups from overlapping each other. This concept is modeled in Figure 2-4.

5.3.2 Frames

The work and time frames for scheduling successive phases of a construction effort are presented in Figure 5-3. This figure illustrates how the frames are successively refined from large to small mesh as a construction effort progresses. At each step of frame refinement the more accurate work volumes for more precise scheduling are derived from the latest drawings and their material lists. These, in the final level of design development, are per the pallets which were tentatively defined upon contract award and which were finalized during the pallet meeting. Therein, design and field engineers for DAME outfitting reached mutual agreement on the definition of pallets.

A pallet, i.e., a complete kit for each specific outfitting opportunity, is a key summary unit for outfitting equivalent to a block for hull construction. In a product work breakdown, both are defined by zone/problem area/stage.

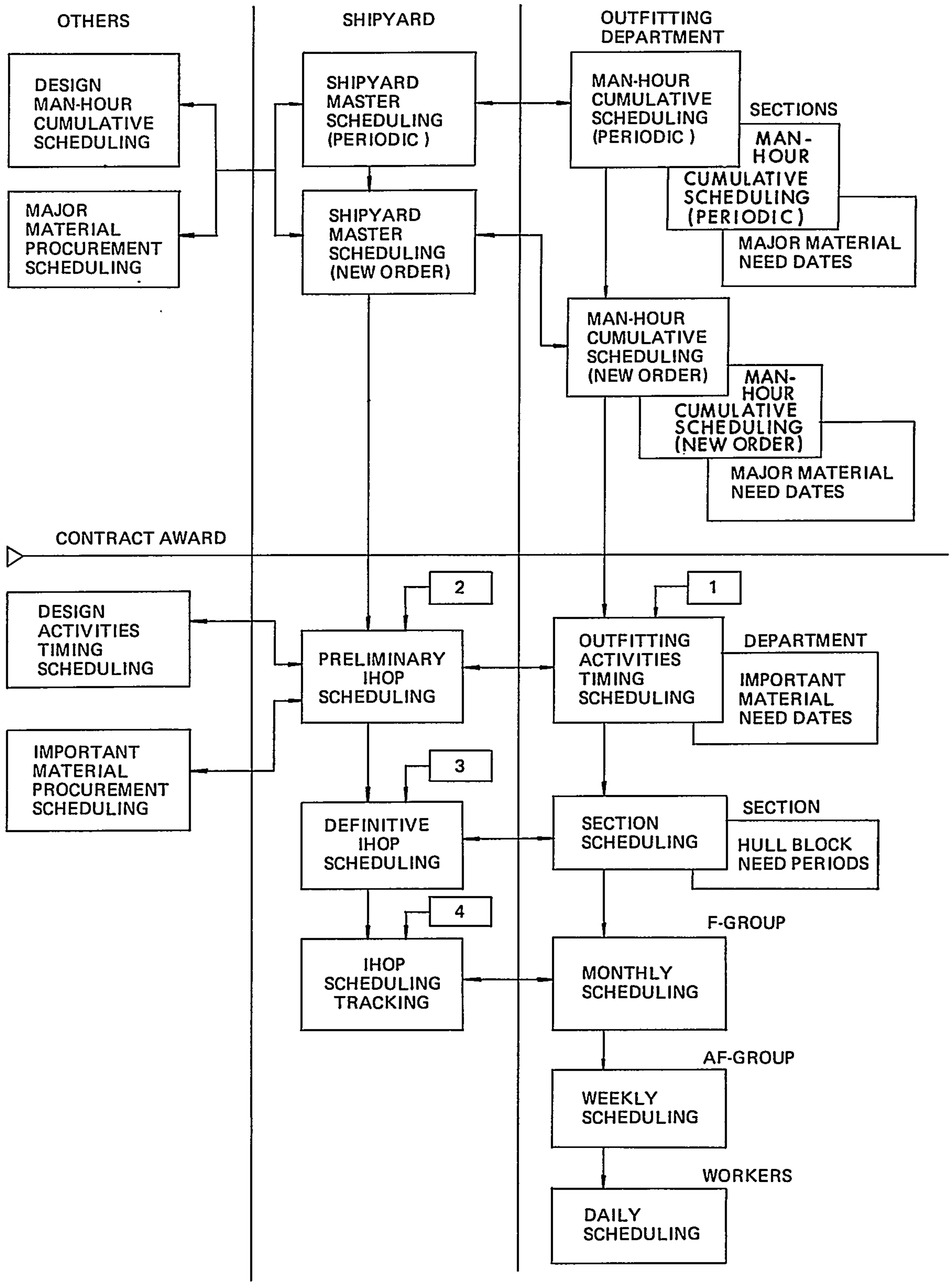

FIGURE 5-2: Sequence for Outfitting Scheduling. Number 1 indicates input of Tentative Erection Scheduling. Numbers 2 through 4 indicate inputs of hull construction scheduling of commensurate level.

FRAMES / SCHEDULES	TIME		WORK VOLUME INDICTIONS			RESPONSIBILITY
	PERIOD	UPDATED	SUMMARY UNIT	SUMMARY PERIOD	PARAMETER	
DEPARTMENT, SHOP OR SECTION MAN-HOUR CUMULATIVE SCHEDULE	3 YEARS (DEPT) 1.5 YEARS (SHOP/SECT.)	EVERY 3 MONTHS (DEPT) EVERY 6 MOS. (SHOP/SECT.)	FKLD/SHIP/ DEPARTMENT OR SHOP/SECTION	MONTH	S-CURVE	DEPARTMENT OR SECTION MANAGER
OUTFITTING ACTIVITIES TIMING SCHEDULE	A SHIPBUILDING PERIOD	NOT RELEVANT	GROUP OF ZONES/SHIP	NOT RELEVANT	PCW (BUDGET CONTROL LIST)	DEPARTMENT MANAGER
SECTION SCHEDULE	1 YEAR PER SHIP	K – 7 (PRELIMINARY) K – 3 (DEFINITIVE)	PROCESS YARD/ FRAMED ZONE/ SHIP/SECTION	10 DAYS	–PCW AND SPECIAL SYS. (ROUGH) –NUMBERS PER CRAFT	SECTION MANAGER
MONTHLY SCHEDULE	SHIPS FOR 2 MONTHS	EVERY MONTH	PALLET/ PROCESS YARD	5 DAYS	–PCW AND SPECIAL SYS. (ACCURATE) –NUMBERS PER CRAFT	FOREMAN
WEEKLY SCHEDULE	SHIPS FOR 2 WEEKS	EVERY WEEK	PALLET/ PROCESS YARD	1 DAY	–NUMBERS PER CRAFT –WORKER'S NAME	ASSISTANT FOREMAN
DAILY SCHEDULE	SHIPS FOR 1 DAY	EVERY DAY	PALLET/ PROCESS YARD/ CRAFT	HOUR	–WORKER'S NAME	WORKER

FIGURE 5-3: Details of Schedule Frames for Zone Outfitting. Process yard means on-unit, on-block, and onboard outfitting. PCW means parametric component weight. K—7 indicates the number of months before the pallet meeting. K—3 indicates the completion of MLF. As IHI shipyards became very proficient in zone outfitting, starting about 1975, monthly schedules were eliminated. As hull-construction productivity is far more dependent on smooth work flows, monthly scheduling is still performed for hull-construction.

5.4 Man-hour Cumulative Scheduling (Periodic)

5.4.1 General

The pertinent scheduling flow is shown in Figure 5-4.

0 Purpose

- To review the Shipyard Master Schedule for the compatibility of budgeted man-hours allocated to a ship contracted (or to be contracted) with the man-hours actually available to the Outfitting department.
- To serve as data on available production capabilities that is to be used by marketing people for soliciting new orders.
- To serve for adjusting the man-hours available on a long-term basis.
- To serve the Shipyard Manager for long-term adjustments of man-hour accumulations for the Hull Construction, Outfitting and Painting Departments.

o Prerequisites

- Shipyard Master Schedule
- Outfitting budgeted man-hours.

o Frames

- Subjects Treated: All ships contracted or to be contracted.
- Frame Size: Ship/Outfitting.
- Time Period: Monthly for the next three years.

5.4.2 Procedure

o From the shipyard's history of similar ships, choose the S-curve which best fits the circumstances being considered.

o From the curve selected, determine the man-hours accumulated at each of the key milestones as follows:

$$pi = \frac{Hei}{r}$$

where: p = percentage of man-hours accumulated at each of the key milestones

i = K, L or D

Hb = total budgeted man-hours

Hei = accumulated man-hours at each of the key milestones

o Superimpose the Shipyard Manager’s proposed K, L, and D dates for the contemplated ship and by employing the same percentages, plot the S-curve for the contemplated ship.

o Obtain the monthly man-hour distribution (the derivative in mathematics) from the contemplated ship.

o Insert the monthly man-hour distribution for the contemplated ship in the monthly man-hour distribution for all work both contracted and contemplated. Level excessive peaks by comparisons with the available monthly man-hours and shift dates within whatever limits existing contracted delivery dates permit. Alternatively, the peaks may be retained provided additional man-hours are budgeted. Obviously, the solution to be adopted must be the one selected by the Shipyard Manager.

5.4.3 Coordinating

Adjustments to eliminate differences between needed and budgeted man-hours are made by:

o substituting another S-curve, and

o adjusting available man-hours through:

- arranging for overtime work, and

  arranging for transfer of manpower from the Hull Construction Department to the Outfitting Department.

  If available man-hours are still insufficient, the Shipyard Manager must find a solution which could be a revision of key milestone dates. This alternative would require further negotiations with the proposed customer.

5.4.4 Output Data and Timing

o Output: See Figure A-1 which is similar to this schedule.

o Timing: Every month.

5.4.5 Updating and Recovery

o Updating: Performed regularly at one month intervals.

o Recovery: Not relevant.

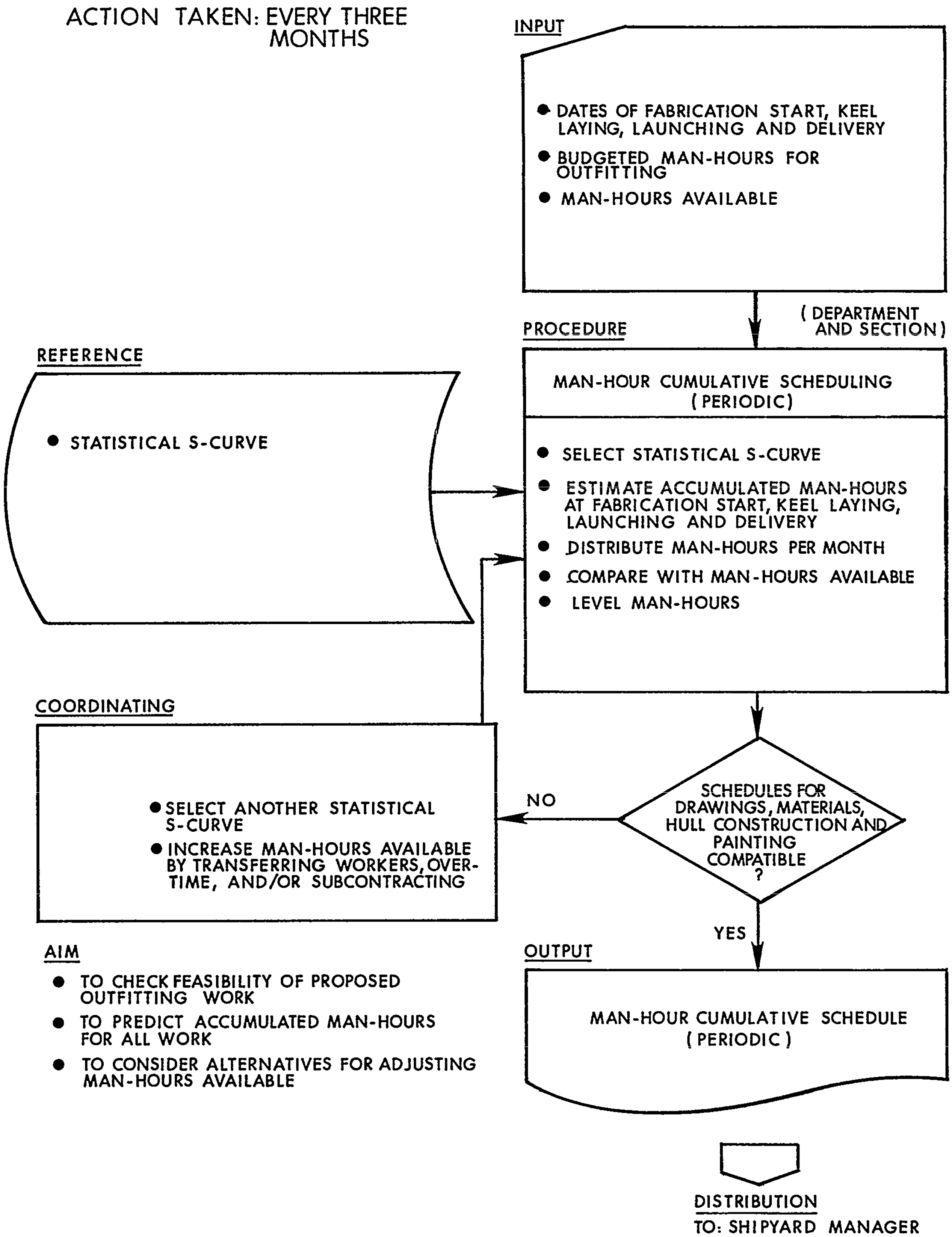

FIGURE 5-4: Man-hour Cumulative Scheduling (Periodic).

5.5 Man-hour Cumulative Scheduling (New Order)

5.5.1 General

The pertinent scheduling flow is shown in Figure 5-5.

0 Purpose

- For a specific ship newly contracted, to finalize dates for F, K, L, and D on the Shipbuilding Master Schedule.
- To serve as man-hour accumulation for outfitting scheduling.

o Prerequisites

- Estimated dates for F, K, L, and D from the Shipbuilding Master Schedule (Periodic).
- Work volume data from the Material Budget Control List.

o Frames

- Subjects Treated: Specific Ship.
- Frame Size: Department and shop/ section for their respective levels.
- Time Period: Monthly during the period from F to D.

5.5.2 Procedure

Same as in Part 5.4.2.

5.5.3 Coordinating

Same as described in Part 5.4.3.

5.5.4 Output Data and Timing

o Output: See Figure A-1 which is similar to this schedule.

o Timing: When directed by the Shipyard Manager.

5.5.5 Updating and Recovery

o Updating: Issued for each newly contracted ship. Not issued if the timing coincides with the issue of a periodic man-hour cumulative schedule.

o Recovery: Recovery is sought on the periodic man-hour schedule. See Part 5.4.4.

5.6 Major Material Need Dates Scheduling

5.6.1 General

Major materials are items whose availabilities are <u>likely to seriously affect</u> the key milestones K, L, and D. Thus, major materials include certain, but not all, main engines, castings, main switchboards, control consoles, etc. The pertinent scheduling flow is shown in Figure 5-6.

0 Purpose

- To determine at an early phase the need dates for purchase orders for major materials. As these materials require long-lead times they are placed on the critical path for the overall construction schedule.

o Prerequisite

- Shipbuilding Master Schedule

o Frames

Subjects Treated: Major Materials.

Frame Size: Individual major materials/ship.

Time Period: Every 10 days.

5.6.2 Procedure

The following criteria are applied:

o Main engine and Associated Components

As timing of main engine loading varies with the type of engine, checks have to be made to assure that the main engine and superstructure are loaded on board before launching. Thus, past records pertaining to similar engines have to be checked in order to establish start of and duration required for main engine loading relative to start of shaft sighting. With this information the need dates for the main engine and associated materials are determined.

0 Estimate from actual progress made in the past the dates by which materials are needed.

5.6.3 Coordinating

Acting for the Shipyard Manager, the Production Control department takes the initiative for coordinating the need dates of major materials between the design Department and the Purchasing Section. In an extreme case, the main engine may be scheduled for loading on board after launching. But, in such cases the Shipyard Master Schedule key milestones are not changed.

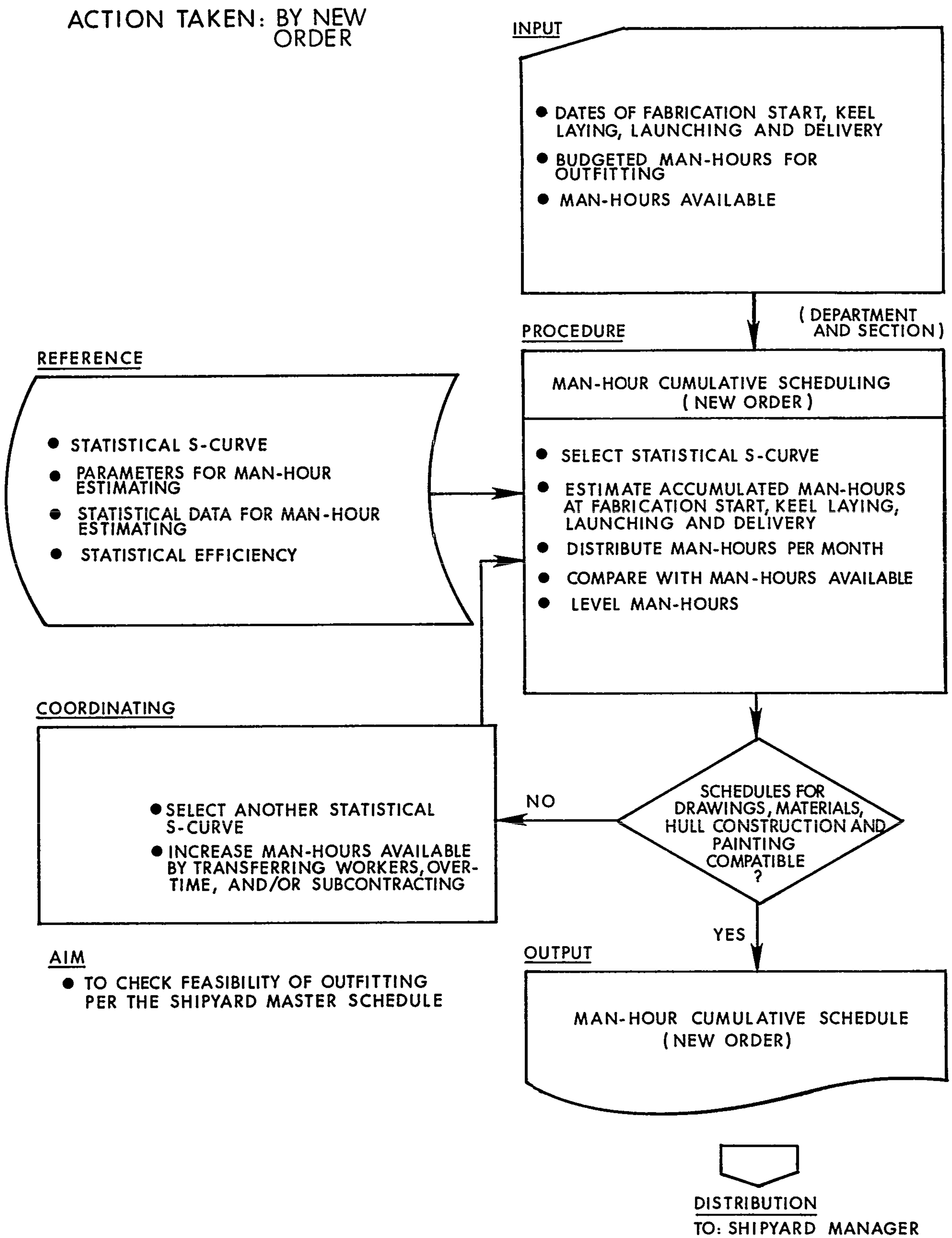

FIGURE 5-5: Man-hour Cumulative Scheduling (New Order).

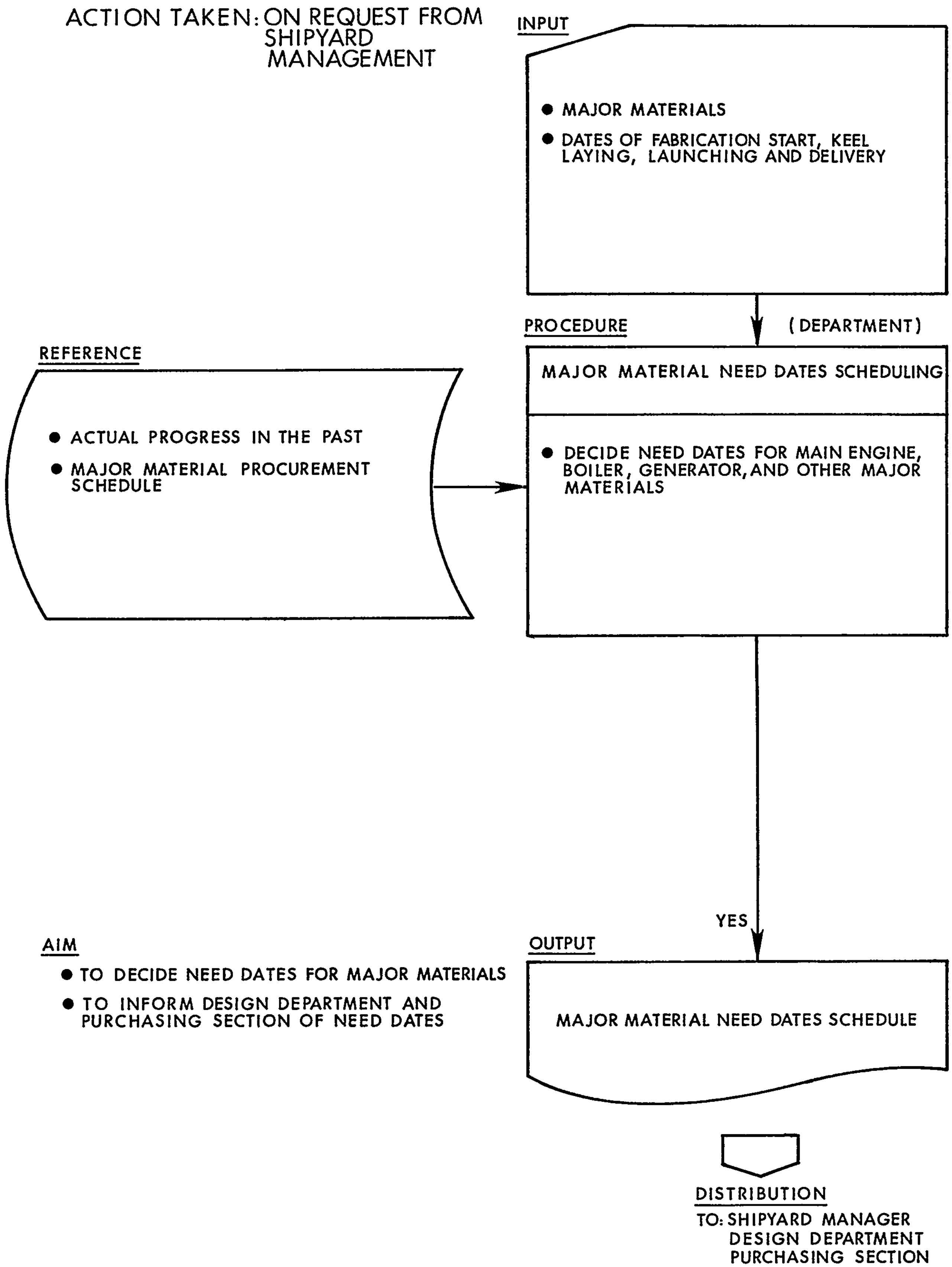

FIGURE 5-6: Major Material Need Dates Scheduling.

5.6.4 Output Data and Timing

o Output: See Figure A-13 which is similar, but greater in detail, than what is normally employed for major materials.

o Timing: On request from the Shipyard Manager prior to contract award.

5.6.5 Updating and Recovery

o Updating: Only in case the Shipyard Master Schedule is revised.

o Recovery: Not relevant.

5.7 Outfitting Activities Timing Scheduling

5.7.1 General

The pertinent scheduling flow is shown in Figure 5-7.

0 Purpose

- To develop the large-frame schedules needed to determine zone-by-zone and level-by-level, start and finish dates of outfitting activities for a specific contracted ship.

- To determine the need dates for drawing issues by the design department to meet the timing for outfitting activities at their respective zones and levels.

- To determine the need dates of important materials required for outfitting.

o Prerequisites

- Shipyard Master Schedule (New Order)

- Preliminary Block Arrangement

- Schedule of important materials need dates.

o Frames

- Subject Treated: Specific Ship.

Frame Size: Department/zone/level.

- Time Period: Monthly from F to D.

5.7.2 Procedure

o Determine the start and finish dates for on-block outfitting by each Section/zone.

Choose an on-block outfitting schedule from a similar previously built ship. If a suitable schedule is not available, select blocks that appear to have characteristics favorable for on-block outfitting by study of the General Arrangement and Preliminary Machinery Arrangement.

Choose from the Tentative Erection Schedule the first and last blocks by each section/zone on which on-block outfitting will take place. This is done for each section.

Determine the durations required for on-block outfitting work on the two blocks picked as prescribed above by reference to similar work on ships previously built.

Count backward from the date for erection of the first block the durations required for on-block outfitting and painting, to derive the start date of on-block outfitting and painting activities.

Count backward from the date for erection of the last block the duration required for painting, to derive the finish date of on-block outfitting.

o Determine the start and finish dates of unit assembly outfitting work by each section/zone. Utilize data from similar ships built in the past; change the dates to apply to the specific ship.

0 Determine the activities start and finish dates for on-board outfitting by each section/zone.

Start dates: Find on the Tentative Erection Schedule the erection data of the first block in each zone; the start date is that on which welding is completed on the first block.

Finish dates: The common finish date for on-board outfitting in all zones is the date of launching, except for work on the superstructure, for which the finish date for outfitting is immediately prior to start of testing.

0 Estimate from statistical data recorded on previously built similar ships, the start and finish dates for testing.

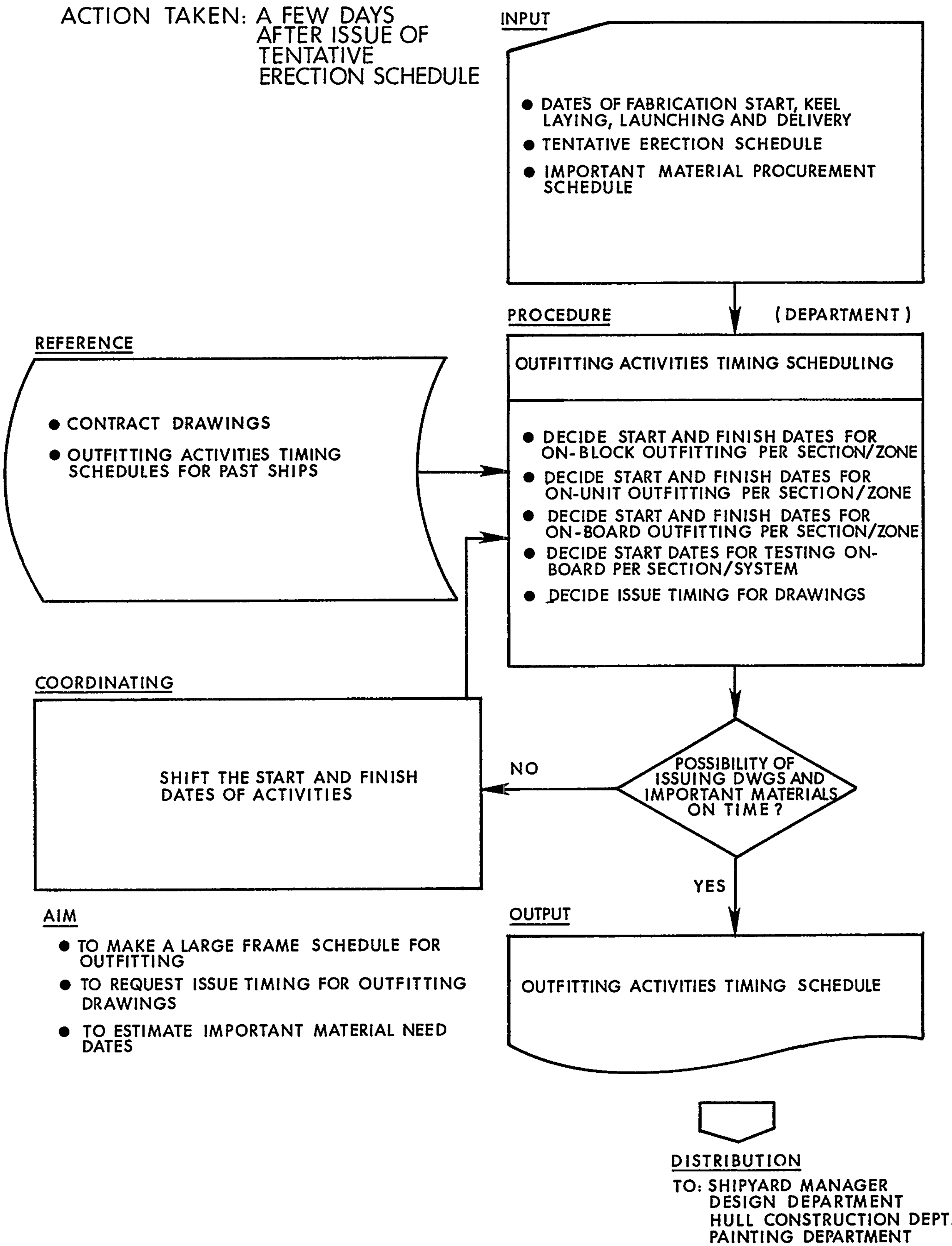

FIGURE 5-7: Outfitting Activities Timing Scheduling.

- o Determine the need dates for Material Lists (MLF, MLC, MLP) for each section/level (manufacturing and assembly); by counting backward using the lead times furnished by the production shop/section. Inform the design department of these need dates.

5.7.3 Coordinating

- o Items requiring coordination:

  Drawing issue deadlines; Check whether drawings can be issued by the dates needed for fabrication.

  Deadline of important material availability: Check whether the important materials can be available by the dates needed for assembly.

  Reserving necessary work facilities is not relevant.

  Other production process lanes: have the hull construction and painting departments coordinate and finalize the durations and timing prescribed for hull block assembly and erection, and on-block and onboard painting.

5.7.4 Output Data and Timing

- o Output: See Figures A-10, A-11, and A-12.
- o Timing: A few days after issue of the Tentative Erection Schedule.

5.7.5 Updating and Recovery

- o Updating: Not relevant.
- o Recovery: Not relevant.

5.8 Important Material Need Date Scheduling

5.8.1 General

Important materials are items of significance whose availabilities are not likely to seriously affect the key milestones K, L, and D. Thus, important materials include main engines, castings, main switchboards, control consoles, etc., that are reasonably available. The pertinent scheduling flow is shown in Figure 5-8.

- 0 Purpose

  To furnish the need dates for important materials requiring early ordering and to give the design department and purchasing section a schedule for important material procurement.

- 0 Prerequisites

  Shipyard Master Schedule (New Order)

  Preliminary Block Arrangement

  Tentative Erection Schedule

  General Arrangement

  Cabin Plan

  Preliminary Machinery Arrangement

  Material List

- o Frames

  Subject Treated: Important materials required for outfitting a specific ship.

  Frame Size: Individual important materials/ship.

  Time Period: 10 work-days, from F to D.

5.8.2 Procedure

- o Sort important materials per zone/level by examining the General, Preliminary Machinery, and Tentative Block Arrangements.
- 0 Determine the start dates of the different activities at each zone/level from the Outfitting Activities Timing Schedule.
- 0 Draft the Important Material Need Date Schedule.
- 0 Decide and list important material need dates:

  from the Tentative Erection Schedule, in combination with the milestones prescribed in the Shipyard Master Schedule, for materials such as main engines, shafts, rudder stocks, boilers, generators, main switchboards, engine-room consoles, and wheel-house consoles, that are loaded directly onboard (blue sky, i.e., without being incorporated in units or loaded on-block), and

  from the need dates, matching the start dates of relevant activities in each individual zone/level for important materials to be fitted on-unit or on-block (e.g., pumps, heat exchangers, ballast systems control valves).

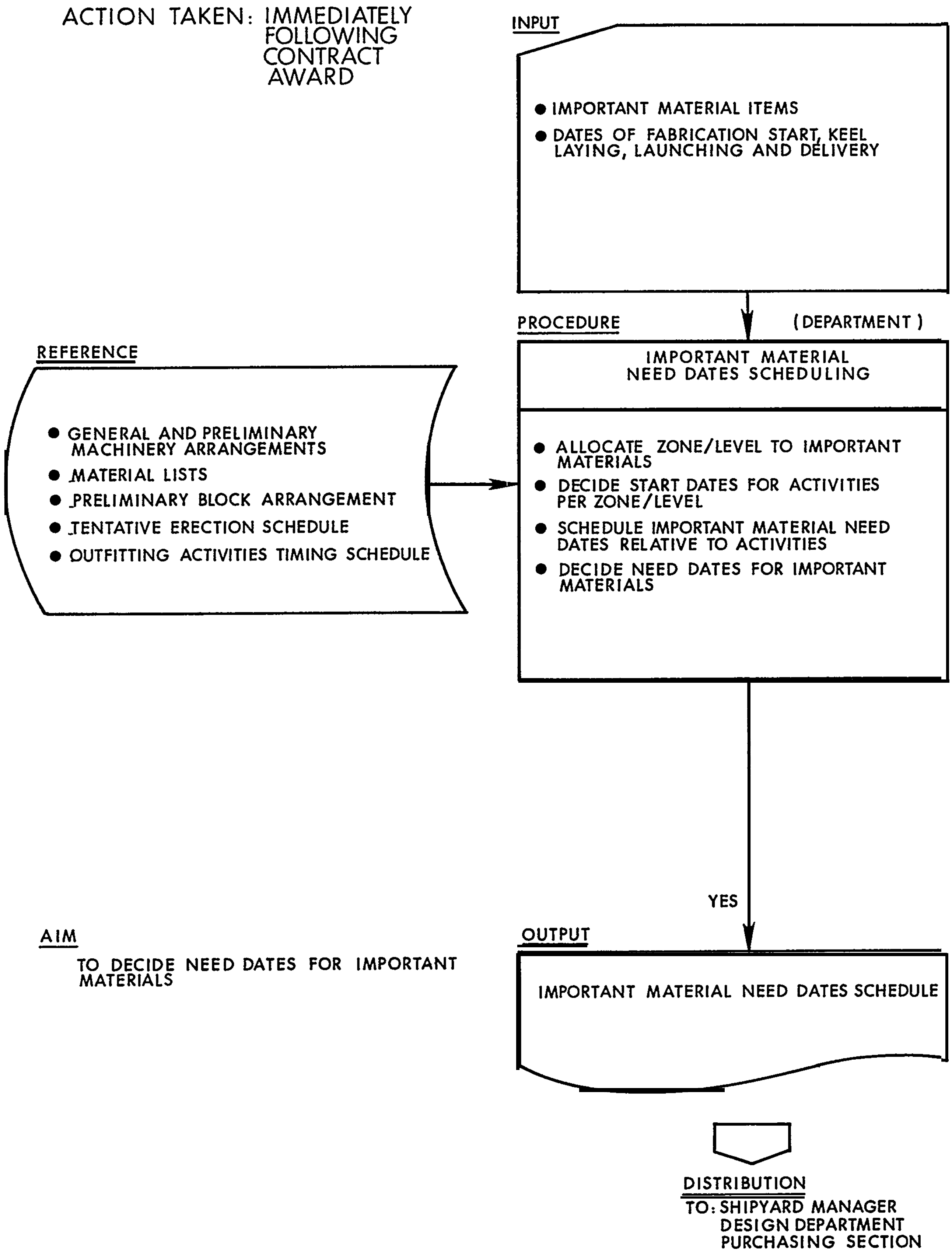

FIGURE 5-8: Important Material Need Dates Scheduling.

5.8.3 Coordinating

In behalf of the Shipyard Manager, the Production Control Department takes the initiative for coordinating the Outfitting Department with the Design Department and Purchasing Section for adjusting the delivery dates of important materials as necessary.

5.8.4 Output Data and Timing

o Output: See Figures A-13 and A-14.

o Timing: Immediately following contract award.

5.8.5 Updating and Recovery

o Updating: Not relevant.

o Recovery: Not relevant.

5.9 Preliminary On-board Outfitting Scheduling

5.9.1 General

The pertinent scheduling flow is shown in Figure 5-9.

0 Purpose

- To serve DAME sections as a basis for implementing on-board outfitting, and for preparing: the Definitive On-Board Outfitting Schedule, Outfit Component (In-house) Manufacturing Schedules, and On-Unit Outfitting Schedule.

- To serve for checking for delays in delivery of components required for outfitting.

0 Prerequisites

Outfitting Activities Timing Schedule

Preliminary Erection Schedule

Preliminary Block Arrangement

Composite Draft

Important material need dates.

0 Frames

- Subject 'Treated: Specific contract ship.

- Frame Size: Section/system.

- Time Period: 10 work-days, from F to D.

5.9.2 Procedure

o Derive the time intervals required for the activities in each section/zone:

- Estimate the manhours required from the weight of parametric components picked out from the Composite Draft (Also transition or right-of-way drawing which is superimposed on a Machinery Arrangement.).

- Derive the durations required for outfitting. [1]

0 Determine the start and finish dates for each activity.

The start and finish dates for each activity are already prescribed in the Outfitting Activities Timing Schedule. Since this schedule was prepared on the basis of data contained in the Tentative Erection Schedule, if relevant data is different in the Preliminary Erection Schedules, the start and finish dates will require revision.

0 Check any suspected delays in the delivery of important materials.

0 Accumulate the man-hours section by section and trade by trade in 10-day increments.

0 Level prominent peaks in estimated man-hours:

Level section by section and trade by trade.

In the leveling operation, do not hesitate to change the sequence of work among the trades within a section/zone.

Level the man-hours in 10-day increments.

Compile a report to the department manager concerning the deviations encountered between estimated and available man-hours. Large deviations reported require schedule revisions.

The S-curve used for man-hour accumulation is not modified.

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[1] For associating material with outfitting work volumes, weight is mostly used. Weight maybe parametric *or* non-parametric. Parametric means that weight is sufficiently related to work to be accomplished, to be used for defining a parameter for converting weight into man-hours required. Non-parametric weight usually applies to large machinery such as a main engine or diesel generator. Such items are addressed in separate work packages.

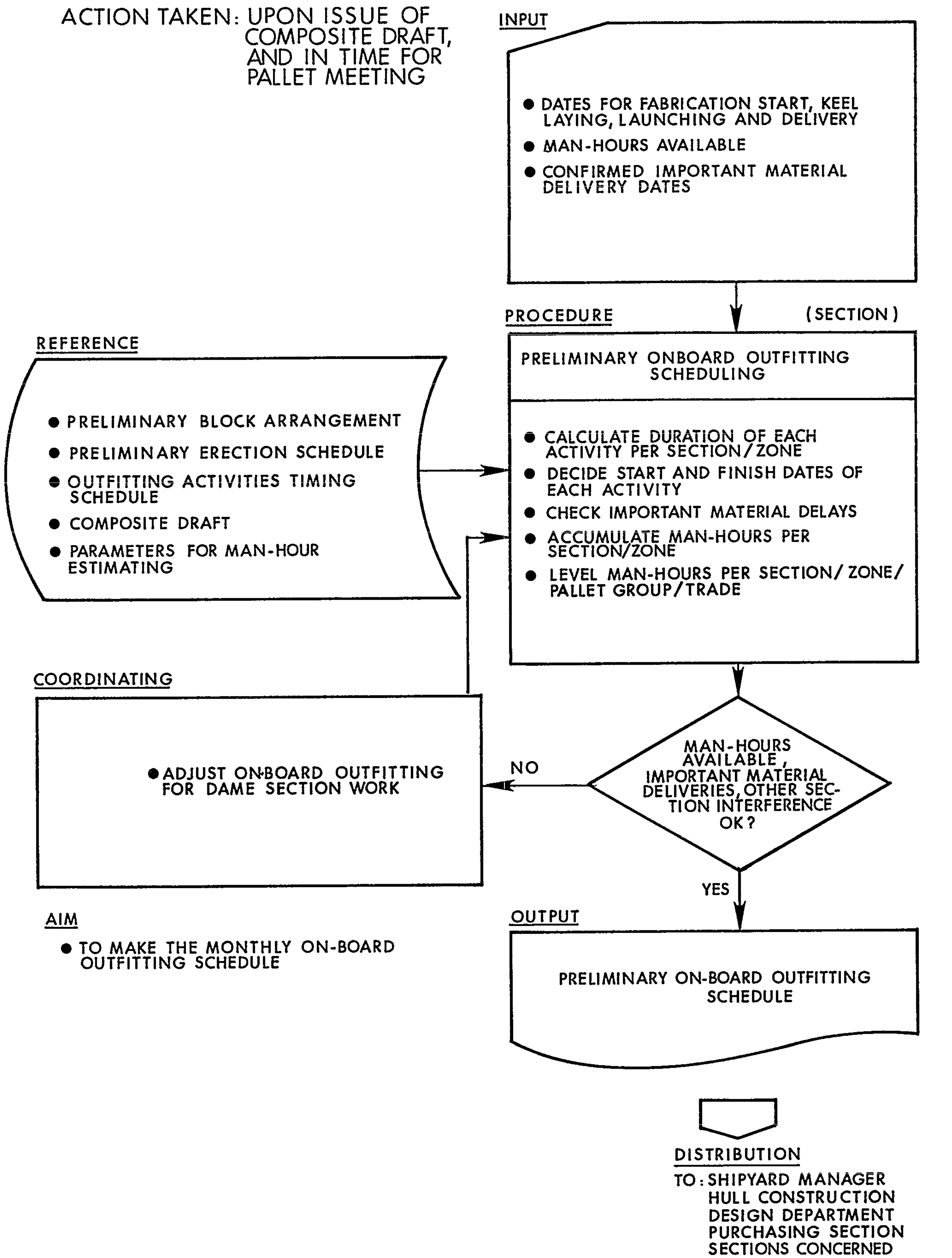

FIGURE 5-9: Preliminary On-board Outfitting Scheduling.

0 At this time there is no need to change the schedule for testing on-board as contained in the Outfitting Activities Timing Schedule.

5.9.3 Coordinating

The Outfit Department Manager takes the initiative in coordinating milestones marking interfaces between sections, e.g., main engine and superstructure landing. A Pallet Meeting is held with the DAME design groups to discuss the Preliminary On-board Outfitting Schedule to coordinate the neet dates of pipe piece drawings, manufacturing drawings, and work instruction drawings needed for each pallet.

5.9.4 Output Data and Timing

o Output: The Preliminary On-board Outfitting Schedule is similar, but less definitive than the schedule shown in Figure A-15.

o Timing: Upon issue of the Composite Draft and in time for the Pallet Meeting.

5.9.5 Updating and Recovery

o Updating: Not relevant except upon revision of the Shipyard Master Schedule. Modifications necessitated as a result of the Pallet Meeting are incorporated in the Definitive On-Board Outfitting Schedule.

0 Recovery: Not relevant. (The schedule is not intended for governing implementation of actual work.)

5.10 Preliminary On-Unit and On-Block Outfitting Scheduling

5.10.1 General

The pertinent scheduling flow is shown in Figure 5-10.

0 Purpose

- To govern implementation of on-unit and on-block outfitting of each section, and to prepare the Definitive On-Unit and On-Block Outfitting Schedules, and in-house shop manufacturing schedules.

- To check any important material delays that may be incurred.

- To serve in definitizing the Preliminary IHOP Schedule.

o Prerequisites

- Preliminary IHOP Schedule

- Composite Draft

- Information on delivery dates for important material.

o Frames

- Subject treated: Specific ships contracted, ship by ship.

  Frame Size: Section/unit or block.

- Time Period: 10 work-days from F to D.

5.10.2 Procedure

o Estimate the duration required for each unit for on-unit outfitting and for each block/stage for on-block outfitting:

- Estimate the man-hours required from the weight of the parametric components picked out from the Composite Draft.

- Estimate the durations required for outfitting.

0 Determine the activities start and finish dates for the units and for on-block outfitting associated with each block.

- On-block outfitting

  Finishing dates: As prescribed in the Preliminary IHOP Schedule.

  Starting dates: Derived from counting backwards from the finish dates using the durations determined above.

- Unit Outfitting

  Finishing dates: The day before start of on-block outfitting of the block on which each unit is to be landed. In the case of units installed independently on board, the day before start of activities in the zone in which the unit is to be landed as prescribed in the Preliminary On-Board Outfitting Schedule.

  Starting Dates: Derived by counting backward from the finishing date using the durations determined above.

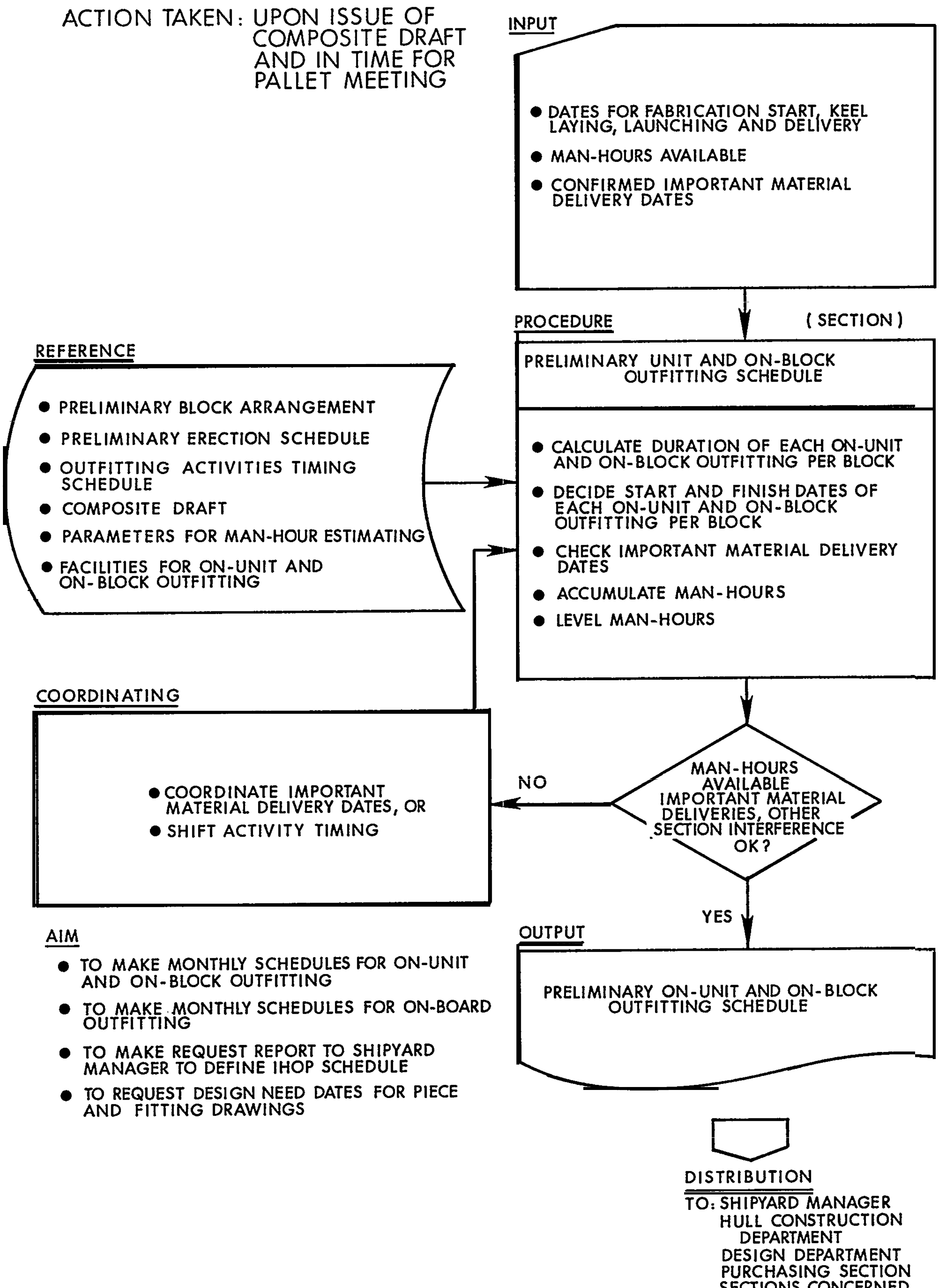

FIGURE 5-10: Preliminary On-unit and On-block Outfitting Scheduling.

5.10.3 Coordinating

- o Incompatibilities in delivery dates of important materials revealed upon checking the schedule are adjusted by coordination with the Purchasing Section.

- 0 In cases where certain important materials cannot be delivered in time for erection, their outfitting has to be shifted from on-unit or on-block to outfitting on-board.

5.10.4 Output Data and Timing

- o Output: The preliminary on-unit and on-board Outfitting Schedules are similar but less definitive than the schedule shown in Figure A-16.

- 0 Timing: Upon issue of the Composite Draft-and-in time for the Pallet Meeting

5.10.5 Updating and Recovery

- o Updating: Not relevant except upon revision of the Shipyard Master Schedule. Modifications necessitated as a result of the Pallet Meeting are incorporated in the Definitive On-Board Outfitting Schedule.

- o Recovery: Not relevant. (The schedule is not intended for governing implementation of actual work.)

5.11 Definitive On-Unit and On-Block Outfitting Scheduling

5.11.1 General

The pertinent scheduling flow is similar to that shown in Figure 5-10.

0 Purpose

- To develop an implementation schedule for governing on-unit and on-block outfitting from which is prepared the On-unit and On-block Monthly Schedules.

- To serve in preparing the outfit shops' manufacturing schedules.

- To serve in coordinating fitting drawing issue deadlines for on-unit and on-block outfitting.

o Prerequisites

- Preliminary IHOP Schedule.

- MLF's for on-unit and on-block outfitting.

o Frames

Subject Treated: A specific ship in the Shipyard Master Schedule.

Frame Size: Section/unit or Section/block per specific ship.

Time Period: man-hours accumulated in l-week intervals for a period of one year.

5.11.2 Procedure

- o Derive the activity duration required for each pallet per unit or block/stage.

  - Estimate the man-hours required for each activity from the parametric components picked out of the MLF.

  Note: If the resulting durations are found to exceed the corresponding intervals prescribed in the Definitive IHOP Schedule, reduce them to within the prescribed duration by increasing the number of workers to be assigned.

- 0 Determine the activities start and finish dates for the units and for on-block outfitting associated with each block.

  On-block outfitting

  Finishing Dates: As prescribed in the Definitive IHOP Schedule.

  Starting Dates: Derived by counting backward from the finishing dates using the durations derived above.

  On-unit outfitting: Same as for Preliminary On-un~t and On-block Outfitting Schedule described in Part 5.10.2.

- 0 Check outfitting component delivery dates.

  Check on the outfit shop manufacturing schedules, the completion dates of components required for on-unit and on-block outfitting. If any components are found to have incompatible or tight delivery dates, coordinate with the manufacturing shops.

- 0 Check important material delivery dates.

  Check the delivery dates of important materials. If any materials are found to have incompatible or tight delivery dates, coordinate with the Purchasing Section.

o Man-hour accumulation

Accumulate the man-hours in intervals of 5-work days separately for on-unit and on-block outfitting.

0 Leveling

First, independently level for on-unit and on-block outfitting activities.

- On-unit Outfitting: Maintain the finish dates and level the work load peaks by advancing the timing of some on-unit outfitting activities with due consideration given to compatibility with preceding activities for on-unit outfitting and for uncommitted facilities.

- On-block Outfitting: Level by shifting some on-block outfitting activities within the frames prescribed in the Preliminary IHOP Schedule.

If the above independent leveling does not reduce work load peaks sufficiently, proceed to combined leveling for on-unit and on-block outfitting. In doing this, arrange to have on-unit work performed during the slack period for on-block outfitting.

Note: It must never be forgotten that increasing the portion of on-unit and on-block and reducing that of on-board outfitting is the key to enhancing productivity. No effort should be spared in arranging the man-hours available to permit the maximum amount of work to be done on-unit and on-block before shifting any activity to on-board.

5.11.3 Coordinating

o On-unit and on-block outfitting is inherently liable to large fluctuations in work load. Attempts to bear an excessive work load within a section without being able to obtain workers from other sections leads to redundant staffing within the Outfitting Department. Shifting groups of workers from underloaded to overloaded sections is essential for enhancing overall outfitting productivity.

o Coordinate availability dates for outfit components manufactured both in-house and outside (see Part 5.11.2).

o Coordinate the timing of fitting drawing issues with the design department.

5.11.4 Output Data and Timing

o Output: See Figure A-16.

o Timing: Upon issue of MLF's for on-unit and on-block outfitting and in time for preparation of Monthly On-unit and On-block Outfitting Schedules.

5.11.5 Updating and Recovery

o Updating: Not relevant except upon revision of the Shipyard Master Schedule (schedule modifications are incorporated in the monthly schedule).

o Recovery: Not Relevant.

5.12 Definitive On-Board Outfitting Scheduling

5.12.1 General

The pertinent scheduling flow is similar to that shown in Figure 5-9.

0 Purpose

- To develop an implementation schedule for governing on-board outfitting from which is prepared the on-board monthly schedules and the shop component manufacturing schedules. (Testing on-board is not included in this schedule.)

o Prerequisites

- Definitive Block Arrangement and Erection Schedule

- Preliminary On-board Outfitting Schedule

o Frames

Subject Treated: Specific contracted ship.

Frame Size: Section/on-board zone.

Time Period: 10-day intervals from F to D.

5.12.2 Procedure

o Derive the duration required for on-board outfitting for each pallet.

Estimate the man-hours required for on-board outfitting for each pallet.

Derive the durations required for on-board outfitting for each pallet.

o Determine the pallet sequence.

Within an on-board zone the sequence of pallets is in accordance with the Erection Schedule.

o Determine timing.

Start dates for individual zones are those prescribed in the Preliminary On-board Outfitting Schedule.

The timing for individual pallets is determined from the fitting sequence section by section and trade by trade.

o Man-hour accumulation.

Accumulate man-hours section by section and trade by trade in increments of 5 days.

5.12.3 Coordinating

o Obtain confirmation from the design department on fitting-drawing issue dates.

o Coordinate with the manufacturing shops and purchasing section on delivery dates of outfit components.

5.12.4 Output Data and Timing

o Output: See Figure A-15.

0 Timing: Before Preparation of the first-monthly on-board nutfitting schedule and prior to start of on-board outfitting on a specific ship.

5.12.5 Updating and Recovery

o Updating: Not relevant (modifications to schedule are incorporated in the Monthly Schedule).

o Recovery: Not Relevant.

5.13 On-Board Testing Scheduling

5.13.1 General

The pertinent scheduling flow is shown in Figure 5-11.

This schedule governs the fitting, adjustment and testing conducted on-board of main engine, shafting, rudder, steering gear, boiler, generator and such other equipment.

o Purpose

- To plan the staff organization required.

- To assemble and prepare the equipment and consumables required.

o Prerequisites

- Definitive On-board Outfitting Schedule.

o Frames

- Subjects Treated: Specific contracted ship.

  Frame Size: Section/system/stage.

- Time Period: 5 work day increments from F to Il.

5.13.2 Procedure

o Determine the sequence to be adopted for testing based on testing schedules from ships previously built.

0 Determine the start and finish dates for testing per system/stage. With the finish dates set to be in accordance with the Definitive On-board Outfitting Schedule, arrange the tests in the sequence previously determined. Count backwards on the schedule to derive the start and finish date of each test.

0 Accumulate the man-hours in frames of one work-week, section by section and trade by trade.

0 Level work load peaks. If this operation calls for shifting milestones, consult the section managers concerned for their instructions. Upon shifting the milestones, the section managers report the facts to the department manager.

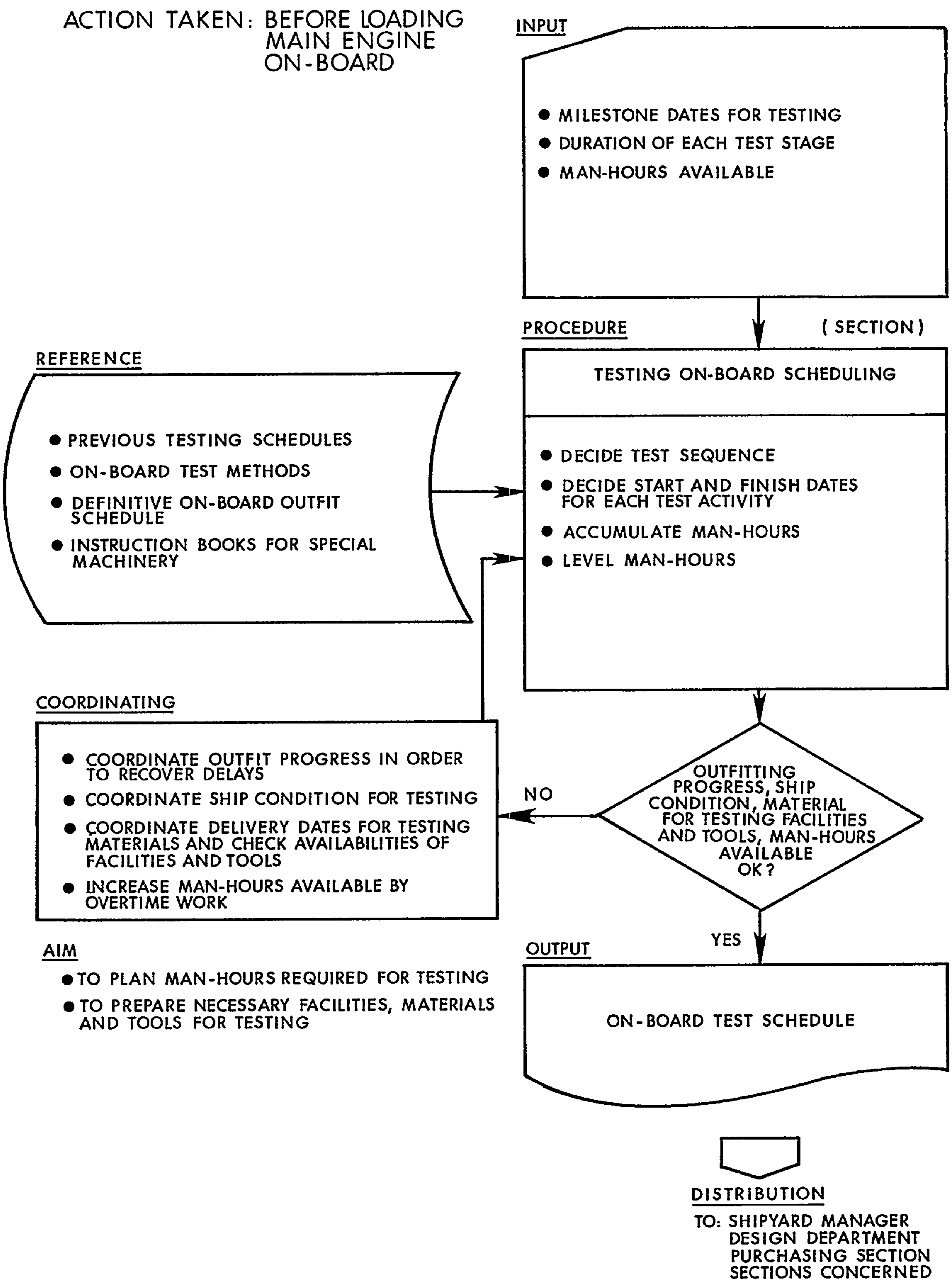

FIGURE 5-11: Testing On-board Scheduling.

5.13.3 Coordinating

- o Check progress of outfitting work to see that testing can proceed as scheduled. If necessary, coordinate and prompt those in charge of outfitting to expedite their work.
- o Coordinate with the dock master, ship trim, draft, mooring and other conditions required for proceeding with tests.
- o Coordinate with the Purchasing Section on availability of consumables (fuel oil, lubricating oil, chemicals, etc.) required for testing.
- o Coordinate with the department manager if man-hours required are found to exceed the man-hours available.

5.13.4 Output Data and Timing

- o Output: See Figure A-17.
- o Timing: Before loading the main engine on-board

5.13.5 Updating and Recovery

Not relevant unless the Definitive On-board Outfitting Schedule is revised.

5..14 Monthly~ Scheduling

5.14.1 General

The pertinent scheduling flow is shown in Figure 5-12.

0 Purpose

- To develop the schedule from which to generate the Weekly Schedule that will govern actual work. Also to check on availabilities of drawings and materials. (When the Design and Outfitting Departments and the Purchasing Section have lots of experience in coordinating with each other, the Monthly Schedule is not needed.)

o Prerequisites

- Definitive IHOP Schedule
- Definitive On-unit and On-block Outfitting Schedules
- Definitive On-board Outfitting Schedule
- Outfit Component Manufacturing Schedule

o Frames

- Subject Treated: Ships for which outfitting is proceeding simultaneously.
- Frame Size: Process yard (F-group)/ pallet.
- Period: 1 workweek over a period of 2 months.

5.1.4.2 Procedure

The Monthly Schedules cover periods of two months in order to govern the implementation of all outfitting activities. The first month represents an updated version of the preceding monthly schedule, revised with due consideration given to its effect on the schedule for the second month.

- o Determine the start and finish dates for individual activities per pallet. Update the schedule for the first month with the primary view of remedying the deviations from the previous monthly schedule revealed by the latest information on work progress. Due consideration is given to work priorities. Delays should be recovered within the first month.
- o Accumulate the man-hours trade by trade in frames of one workweek.
- o Level peaks in work load trade by trade in frames of one workweek.

5.14.3 Coordinating

- o Man-hours available: The section engineers take the initiative in coordinating between foremen for arranging mutual reinforcements.
- o Scheduling coordination between outfit sections: The section managers arrange the coordination at their discretion, except when the zone frames on the Outfitting Activities Timing Schedule are shifted. In such cases the Outfitting Department Manager undertakes coordination.
- o Ascertaining the need dates for components and drawings: The Production Control Department Manager takes the initiative in coordinating between the Design, Production Control and Outfitting Departments. Once coordinated, every department acts on the basis of information governing the second month to ensure the availability of components and drawings according to the schedule. The Naterial Control Section and the manufacturing shops act on the basis of information governing the first month to make pallets available per schedule.

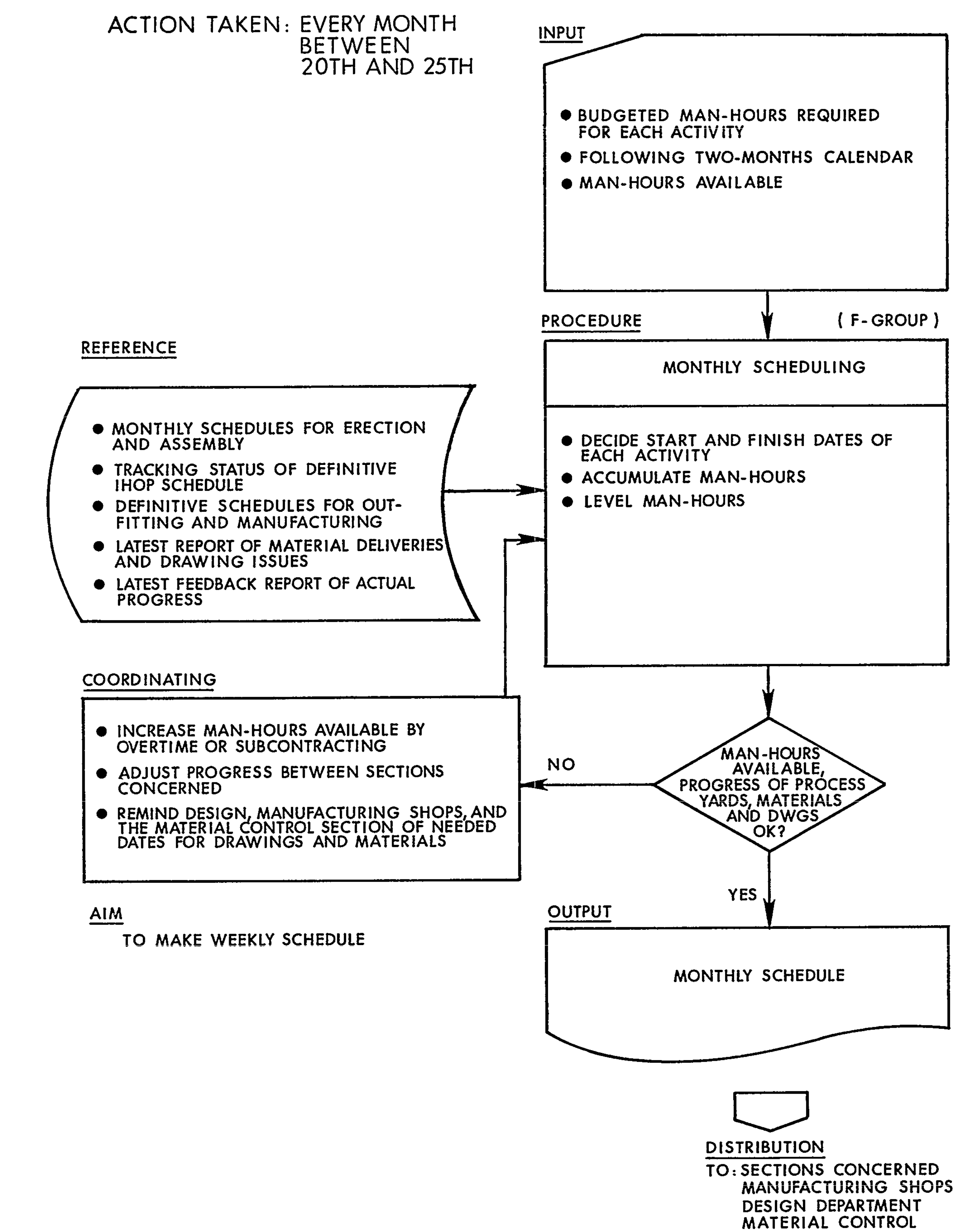

FIGURE 5-12: Monthly Scheduling.

5.14.4 Output Data and Timing

o Output: Similar to but less definitive than the weekly schedules shown in Figures A-18, A-19, and A-20.

0 Timing: Issued every month between the 20th and the 25th.

5.14.5 Updating and Recovery

The substance of the first month is updated in the weekly schedule; that of the second month in the monthly schedule for the following month.

5.15 Weekly Scheduling

5.15.1 General

The pertinent scheduling flow is shown in Figure 5-13.

o Purpose

- To allocate individual activities to workers.

- To provide information for palletizing and designating pallet destinations.

- To facilitate planning utilization of cranes, reservation of working facilities, and preparation of jigs.

o Prerequisites

- The monthly schedule if prepared; otherwise the section schedules.

o Frames

- Subject Treated: Ships for which outfitting is proceeding simultaneously.

- Frame Size: Process station (AF-group)/pallet.

- Time Period: 1 work day over a period of 2 weeks.

5.15.2 Procedure

o Determine pallet priorities.

o Determine pallet start and finish dates.

o Allocate specific pallets to workers.

5.15.3 Coordinating

Not relevant (already undertaken at weekly meetings based on the tracking $tatus of the Definitive IHOP Schedule).

5.15.4 Output Data and Timing

o Output: See Figure A-18 for on-block, Figure A-19 for on-board and Figure A-20 for operation and test.

o Timing: Weekly.

5.15.5 Updating and Recovery

The substance of the first week is updated in the Daily Schedule. That of the second week is updated in the weekly schedule for the following week. Recovery must be made in the first week.

5.16 Daily Scheduling

5.16.1 General

The pertinent scheduling flow is shown in Figure 5-14. The weekly schedule on which an A/F tracks the work progress can be used as a daily schedule for workers.

o Purpose

- To determine activity implementation on a daily basis.

- To recover delays incurred on the weekly schedule.

o Prerequisite

- Weekly Schedule

o Frames

Subjects Treated: Ships for which outfitting is proceeding simultaneously.

Frame Size: Worker.

Period: One (1) work-day.

5.16.2 Procedure

o Each A/F assigns duties to workers based on activity priorities.

o Each A/F compensates for worker absences in order to meet activity priorities.

5.16.3 Coordinating

Not relevant.

5.16.4 Output and timing

Instructions are issued verbally or marked on the weekly schedule every morning.

5.16.5 Updating and Recovery

Not relevant. At the end of each day, work remaining is reported verbally for recovery on the following day.

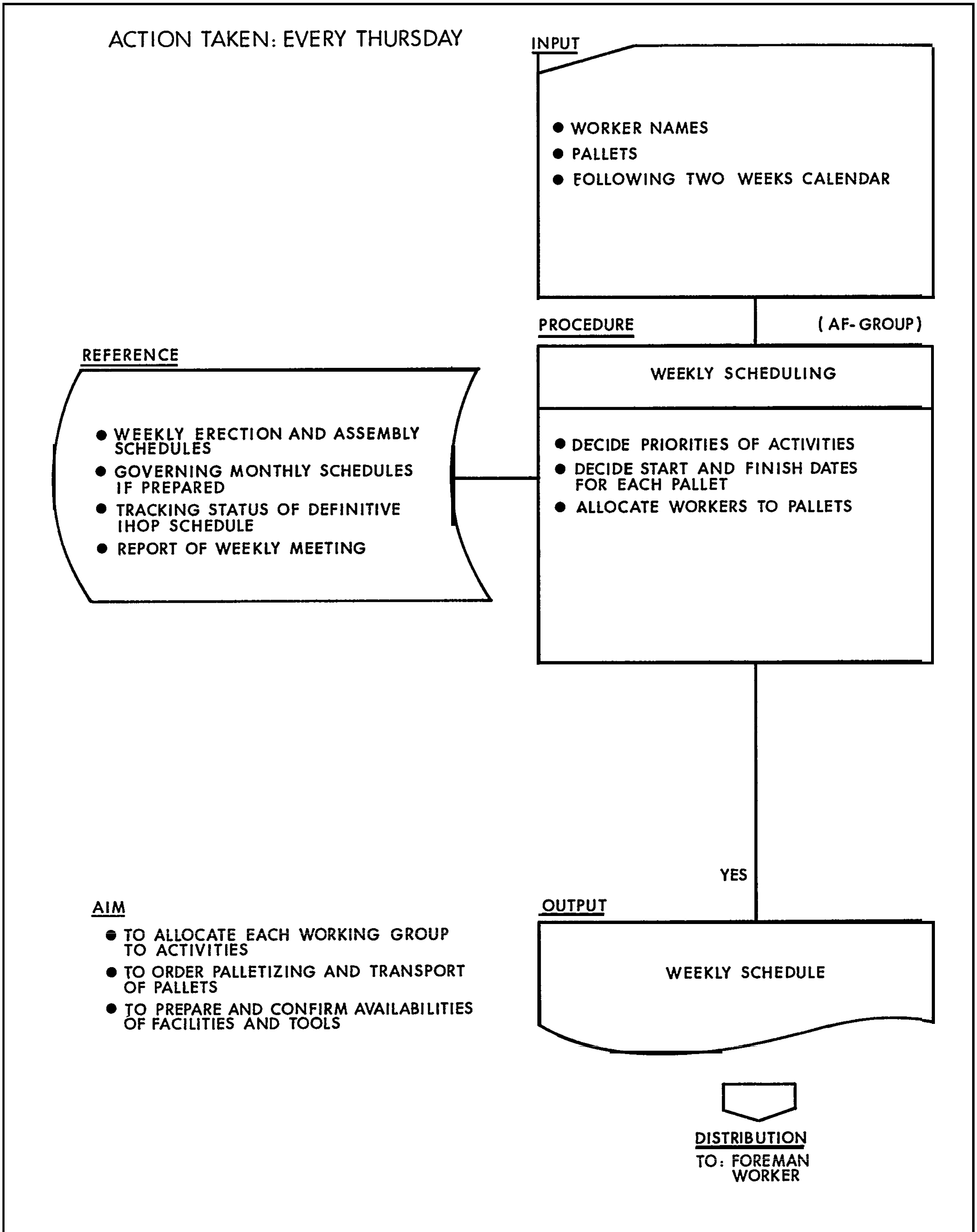

FIGURE 5-13: Weekly Scheduling.

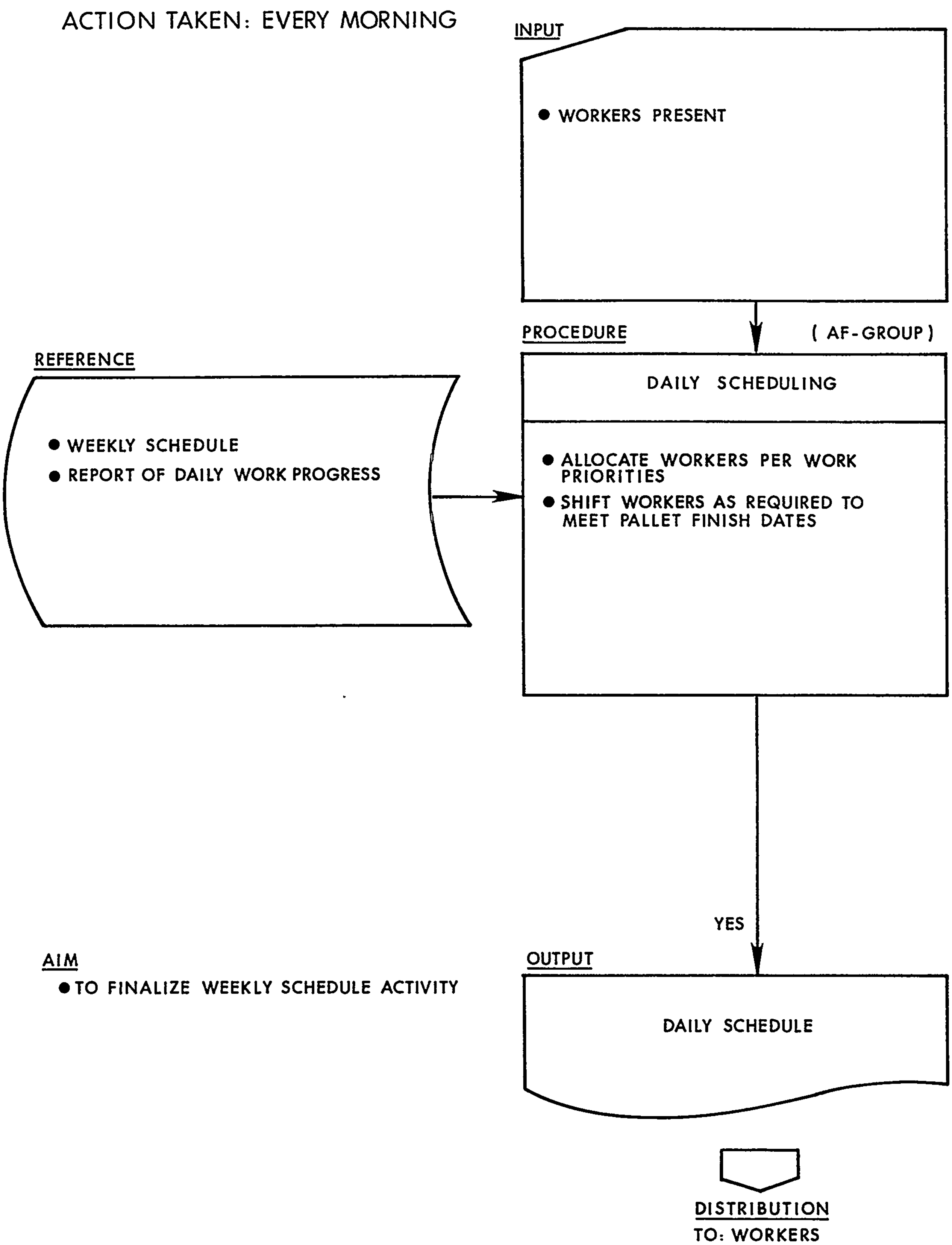

FIGURE 5-14: Daily Scheduling.

6.0 ZONE PAINTING METHOD

6.1 General

Painting scheduling constitutes one of the shipbuilding activities timing integration schemes. It consists of integrating specified painting processes with preceding and succeeding hull construction and outfitting processes. The four FPSS-supporting elements, described in Chapter 2.0, also apply.

6.1.1 Frame Scheduling Method

This method is applied for zone painting in the same manner as for zone outfitting. The frames are developed from large to small and are defined depending on those sized for hull construction and zone outfitting.

6.1.2 IHOP Scheduling and Tracking Operation

Ideally, zone painting is planned to apply paint on-block, including the final coat, as much as possible. This approach facilitates schedule adherence as well as leveling painters' man-hours by distributing painting work earlier and in accordance with an S-curve distribution. In contrast, traditional shipyards experience a peak in painting man-hours just before delivery with large percentages of painting rework.

6.2 Organization

Painting planning and scheduling is decentralized and implemented by each level of the painting organization as shown in Figure 6-1. From the viewpoint of work type, painting is inherently different from hull construction and outfitting, is rationalized in the same manner, and for shipyards with very large workloads, justifies department status. Where workloads are small, painting is organized as a section which reports to one of the other departments. Regardless of its organizational status, the presence of production (painting) engineers and its division into F-groups and AF-groups remains the same. That is, work flow by problem category and the cost collection system continue to exactly match.

The Paint Section is phased by level into F-groups for on-block and on-board. The first is grouped into AF-groups by process yard for flat blocks or curved blocks. The second is grouped into F-groups for on-board allocation of work which may be implemented at a building berth or outfitting quay. Each is sub-grouped into AF-groups for on-board work and services such as facilities control including maintenance and safety control (i.e., working conditions, gas levels, respirators, ventilation, etc.).

6.3 Frame Scheduling Method

The Painting Section prepares their schedules for each level in a sequence as shown in Figure 6-2. People at each level prepare schedules as tabulated in Figure 6-3. Their work always involves advance coordination with hull construction and outfitting schedulers.

6.3.1 Flow

The Painting Department produces the man-hour cumulative schedule periodically and for each new order in the same way as the hull construction and outfitting departments.

To integrate backward scheduling for hull construction and outfitting with painting, the activities for on-block painting are coordinated with the start and finish dates for block assembly and on-block outfitting by the Preliminary IHOP Schedule. The activities for on-board painting are coordinated with the Erection Section and the DAME outfitting sections by foreward scheduling from K to L and separately from L to D.

6.3.2 Frames

The work and time frames at every level of scheduling are presented in Figure 6-3.

As design of hull structure and outfit components progress, designers produce painting areas for each on-block and on-board work instruction.

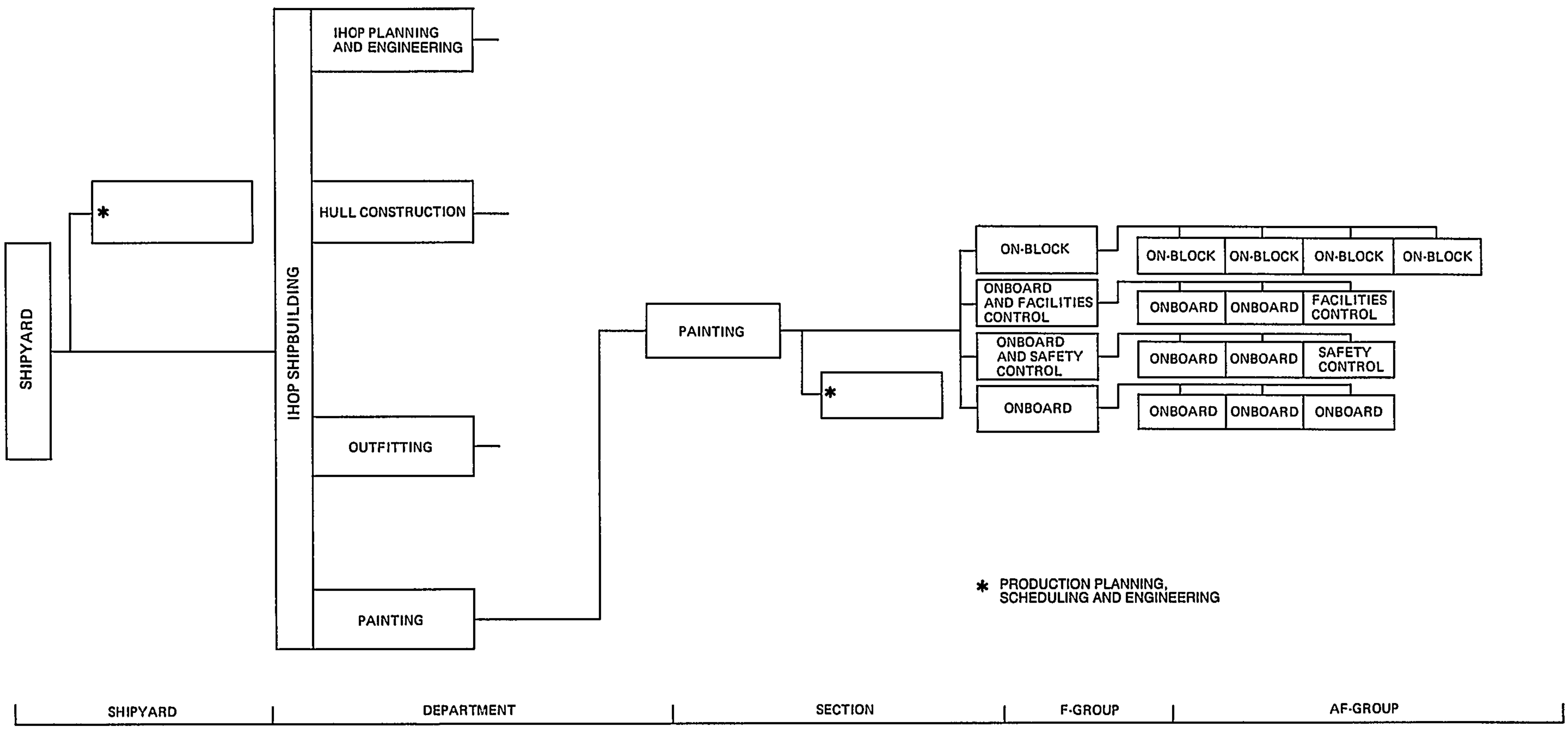

FIGURE 6-1: Model Organization for a Painting Department.

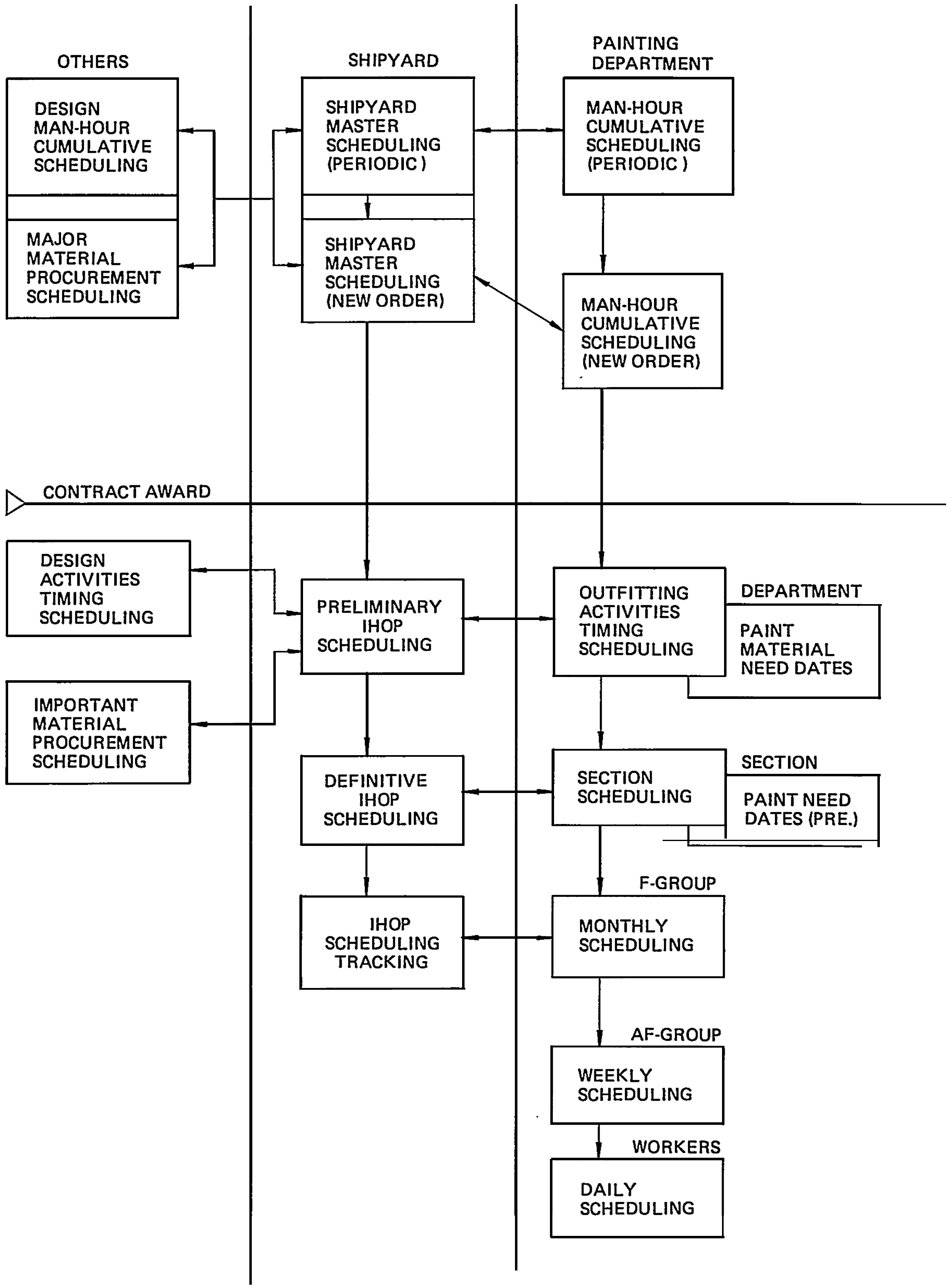

FIGURE &2: Sequence for Painting Scheduling. When there are not large enough workloads to justify a separate Painting Department, the scheduling responsibilities shown for the department level should be performed by the Painting Section.

FRAMES / SCHEDULES	TIME		WORK VOLUME INDICTIONS			RESPONSIBILITY
	PERIOD	UPDATED	SUMMARY UNIT	SUMMARY PERIOD	PARAMETER	
DEPARTMENT OR SECTION MAN-HOUR CUMULATIVE SCHEDULE	3 YEARS OR 1.5 YEARS	EVERY MONTH	FKLD/SHIP/ DEPARTMENT OR SECTION	MONTHS	S-CURVE	DEPARTMENT OR SECTION MANAGER
OUTFITTING ACTIVITIES TIMING SCHEDULE	A SHIPBUILDING PERIOD	NOT RELEVANT	GROUP OF ZONES/SHIP	NOT RELEVANT	AREA (BUDGET CONTROL LIST)	DEPARTMENT MANAGER
SECTION SCHEDULE	A SHIPBUILDING PERIOD	K–7 (PERLIMINARY) K–3 (ON-BLOCK), K + 1 (ONBOARD) (DEFINITIVE)	ZONE/SHIP	10 DAYS	– AREA (ROUGH)	SECTION MANAGER
ON-BLOCK OR ONBOARD SCHEDULE	SHIPS FOR 2 MONTHS	EVERY MONTH	BLOCK OR COMPARTMENT	10 DAYS	–AREA (ACCURATE) –NUMBERS PER CRAFT	FOREMAN
WEEKLY SCHEDULE	SHIPS FOR 2 WEEKS	EVERY WEEK	BLOCK OR COMPARTMENT	1 DAY	–NUMBERS PER CRAFT	ASSISTANT FOREMAN
DAILY SCHEDULE	SHIPS FOR 1 DAY	EVERY DAY	BLOCK OR COMPARTMENT	HOURS	–WORKER'S NAME	WORKER

FIGURE 6-3: Details of Schedule Frames for Zone Painting. Because scheduling painting activities is relatively simple, weekly painting schedules are prepared ship by ship. In contrast, weekly scheduling for outfitting applies to all ships.

The same concept adopted for hull construction and outfitting is applied to painting. The department (or section) level prepares man-hour cumulative schedules and the section and lower levels prepare their own schedules. As shown in the various outfitting activities timing schedules, Figures A-10, A-11, and A-12, painting activities' periods are allocated based on coordination provided by the IHOP Schedule.

6.4 Man-Hour Cumulative Scheduling (Periodic)

6.4.1 General

The pertinent schedule flow is shown in Figure 6-4.

0 Purpose

- To review the Shipyard Master Schedule for compatibility of budgeted man-hours allocated to a ship contracted (or to be contracted) with the painting man-hours available.

- To serve as data on available production capability which marketing people need for soliciting new orders.

- To serve for adjusting man-hours available on a long-term basis.

- To serve the shipyard management in long-term adjustment of man-hour accumulation between design, painting, outfitting, and hull construction departments.

o Prerequisites

- Shipyard Master Schedule

  Budgeted painting man-hours

o Frames

  Subjects Treated: All ships contracted or to be contracted.

  Frame Size: Ship/painting

  Period: Monthly over a period of 3 years.

6.4.2 Procedure

- From the shipyard's history of similar ships, choose the S-curve which best fits the circumstances being considered.

From the curve selected, determine the man-hours accumulated at each of the key milestones as follows:

$$P_i = \frac{He_i}{Hb}$$

where: P = percentage of man-hours accumulated at each of the key milestones

i = K, L or D

Hb = total budgeted man-hours

Hei = accumulated man-hours *at* each of the key milestones

Superimpose the Shipyard Manager's proposed K, L or D dates for the contemplated ship and by employing the same percentages, plot the S-curve for the contemplated ship.

Obtain the monthly man-hour distribution (the derivative in mathematics) from the contemplated ship.

Insert the monthly man-hour distribution for the contemplated ship in the monthly man-hour distribution for all work contracted and contemplated. Level excessive peaks by comparison with the available monthly man-hours and shift dates within whatever limits existing contracted delivery dates permit. Alternatively, the peaks may be retained provided additional man-hours are budgeted. Obviously, the solution to be adopted must the one selected by the Shipyard Manager.

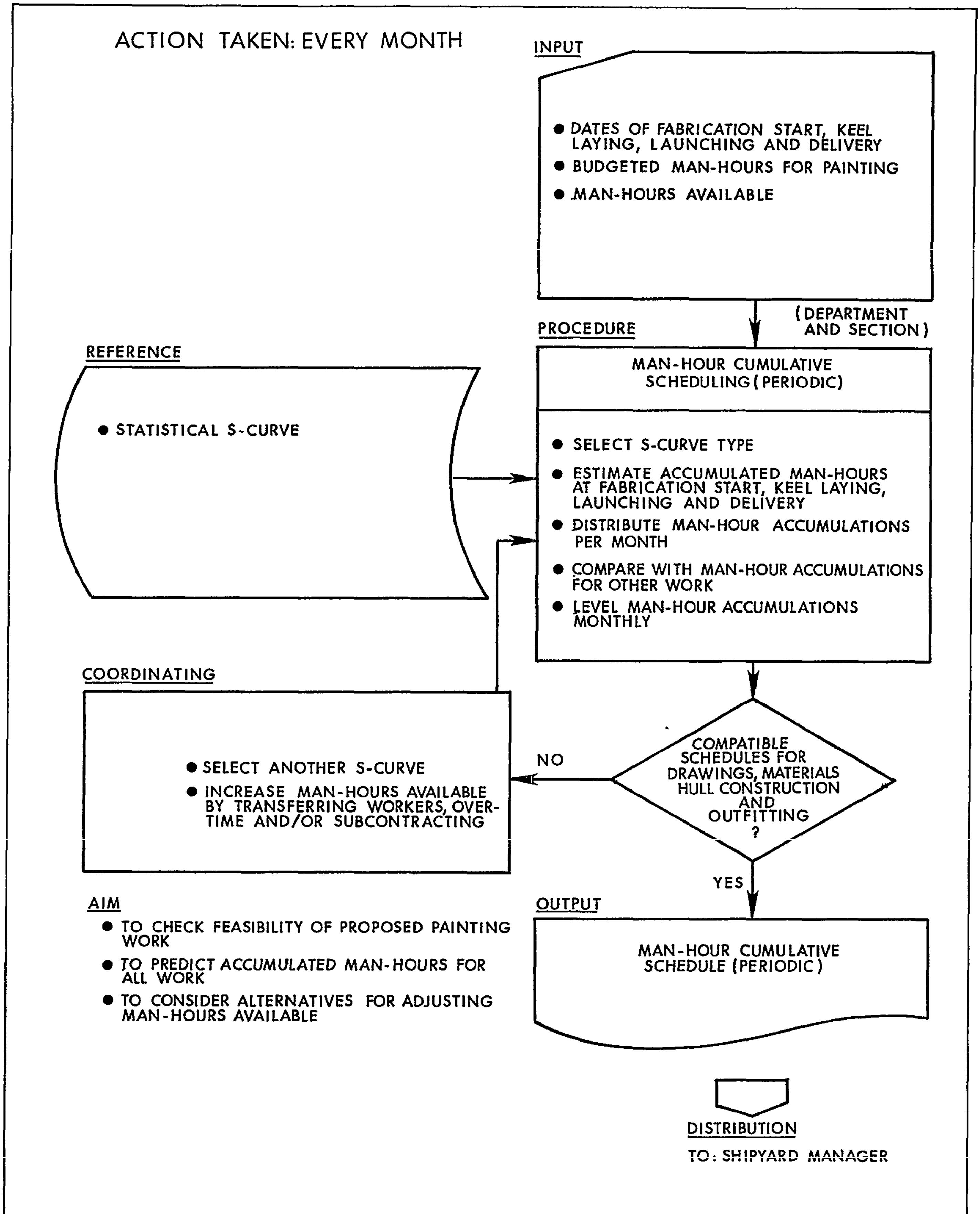

FIGURE 6-4: Man-hour Cumulative Scheduling (Periodic).

u6.4.3 Coordinating

Adjustments to eliminate differences between needed and budgeted man-hours are made by:

o substituting another S-curve, and

o adjusting available man-hours through:

arranging for overtime work, and

arranging for transfer of manpower from the Hull Construction and Outfitting Departments to the Painting Department.

arranging to have excess work undertaken by subcontractors.

If available man-hours are still insufficient, the Shipyard Manager must find a solution which could be a revision of key milestone dates. This alternative would require further negotiations with the proposed customer.

6.4.4 Output Data and Timing

o Output: See Figure A-1 which is similar to this schedule.

o Timing: Every month.

6.4.5 Updating and Recovery

o Updating: Performed regularly at l-month intervals.

o Recovery: Hot relevant.

6.5 Man-hour Cumulative Scheduling (New Order)

6.5.1 General

The pertinent scheduling flow is shown in Figure 6-5.

0 Purpose

- For a specific ship newly contracted, to finalize dates for F, K, L, and D on the Shipbuilding Master Schedule.

- To serve as man-hour accumulation for painting scheduling.

o Prerequisites

- Estimated dates for F, K, L, and D from the Shipbuilding Master Schedule (Periodic).

- Work volume data from the Material Budget Control List.

o Frames

Subjects Treated: Specific Ship.

Frame Size: Department and shop/section for their respective levels.

Time Period: Monthly during the period from F to D.

6.5.2 Procedure

Same as in part 6.4.2.

6.5.3 Coordinating

Same as described in Part 6.4.3.

6.5.4 Output Data and Timing

o Output: See Figure A-1 which is similar to this schedule.

o Timing: When directed by the Shipyard Manager.

6.5.5 Updating and Recovery

o Updating: Issued for each newly contracted ship. Not issued if the timing coincides with the issue of a periodic man-hour cumulative schedule.

o Recovery: Recovery is sought on the periodic man-hour schedule. See part 6.4.4.

6.6 Painting Activities Timing Scheduling

The Painting Activities Timing Schedule is generated in the Outfitting Activities Timing Schedule with the concept described in Part 5.7.

6.7 Preliminary On-Block Painting Scheduling

6.7.1 General

The pertinent scheduling flow is shown in Figure 6-6.

0 Purpose

To prepare the Definitive On-block Painting Schedule.

To check for delays that may be incurred in painting material deliveries.

To serve in preparing the Definitive from the Preliminary IHOP Schedule.

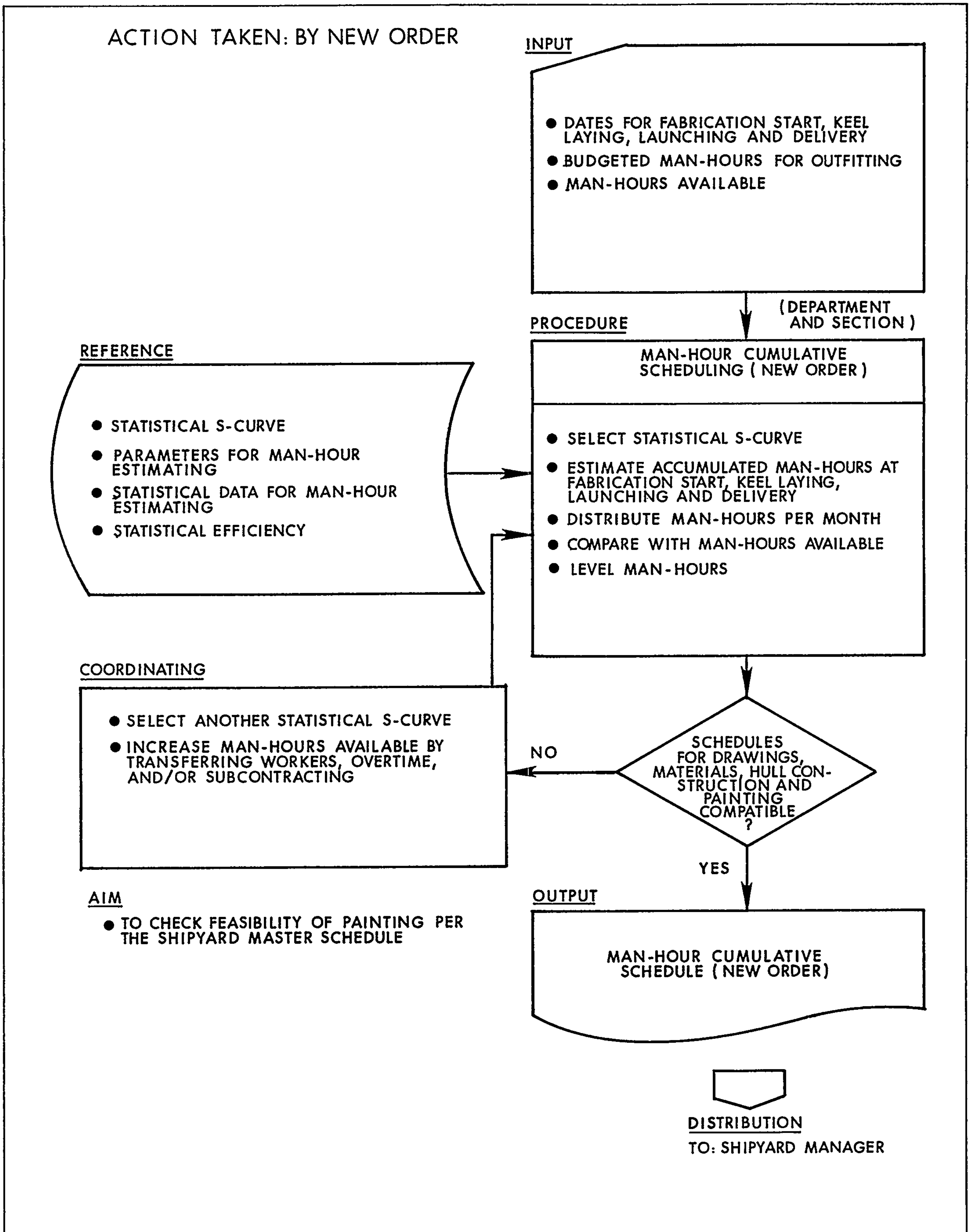

FIGURE 6-5: Man-hour Cumulative Scheduling (New Order).

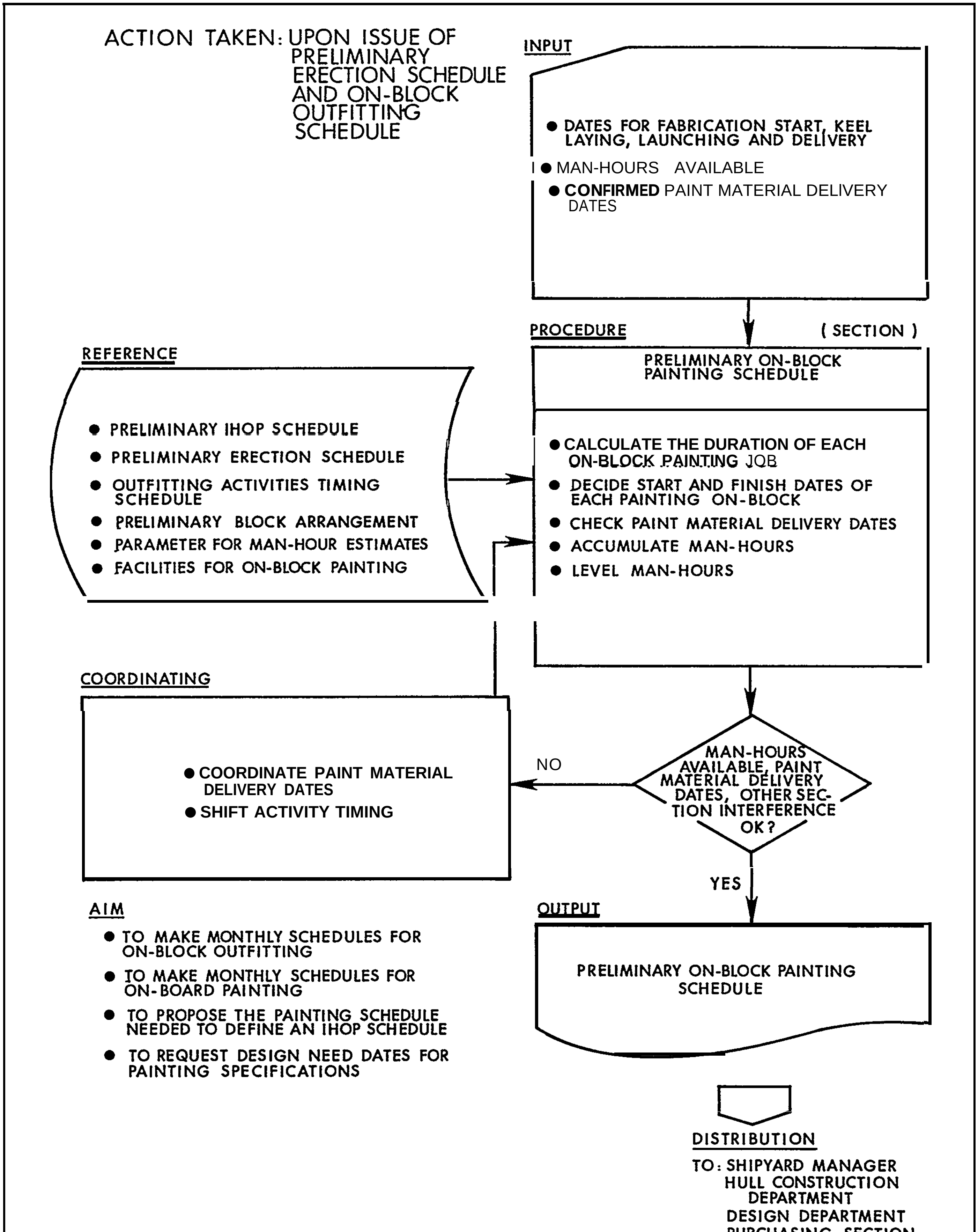

FIGURE 6-6: Preliminary On-block Painting Scheduling.

o Prerequisites

- Preliminary IHOP Schedule

- Preliminary Block Arrangement

- Information on delivery dates for painting materials.

o Frames

- Subject Treated: Specific ship contracted.

  Frame Size: Section/block.

- Time Period: 10 days from F to D.

6.7.2 Procedure

o Estimate the durations required for painting work on each block/stage for on-block painting:

- Estimate the man-hours required from each area/block as determined from the Preliminary Block Arrangement.

- Estimate the durations required.

o Determine the start and finish dates of activities for painting on-block:

  Finish Dates: As prescribed in the Preliminary IHOP Schedule.

  Start Dates: Derived by counting backward from the finish dates the duration determined above.

6.7.3 Coordinating

o Incompatibilities in delivery dates of painting materials, revealed upon checking the schedule, are adjusted by coordination with the Purchasing Section.

o In cases where certain painting materials cannot be delivered in time, some painting work has to be shifted from on-block to on-board.

6.7.4 Output Data and Timing

o Output: The Preliminary On-block Painting Schedule is similar but less definitive than that shown in Figure A-21.

0 Timing: Upon release of the Preliminary Erection and Preliminary IHOP Schedules.

6.7.5 Updating and Recovery

o Updating: Not relevant except upon revision of the Shipyard Master Schedule. Any modifications necessitated because of changes in the Block Arrangement are incorporated in the Definitive On-block Painting Schedule.

o Recovery: Not relevant (schedule is not intended for governing implementation of work).

6.8 Preliminary On-board Painting Scheduling

6.8.1 General

The pertinent scheduling flow is shown in Figure 6-7.

0 Purpose

- To serve the Painting Section as basis for implementing on-board painting and for preparing the Definitive On-board Painting Schedule.

- To serve in checking for eventual delays in delivery of materials required for painting.

o Prerequisites

- Outfitting Activities Timing Schedule

- Preliminary Erection Schedule

- Preliminary Block Arrangement

- Composite Draft

- Painting material need dates

o Frames

- Subject Treated: Specific ship contracted.

  Frame Size: Section/zone.

- Time Period: 10 workdays from K to D.

6.8.2 Procedure

o Derive the time intervals required for activities per section/zone:

- Estimate the man-hours required by areas to be painted as determined from the Preliminary Block Arrangement.

- Derive the durations required for painting.

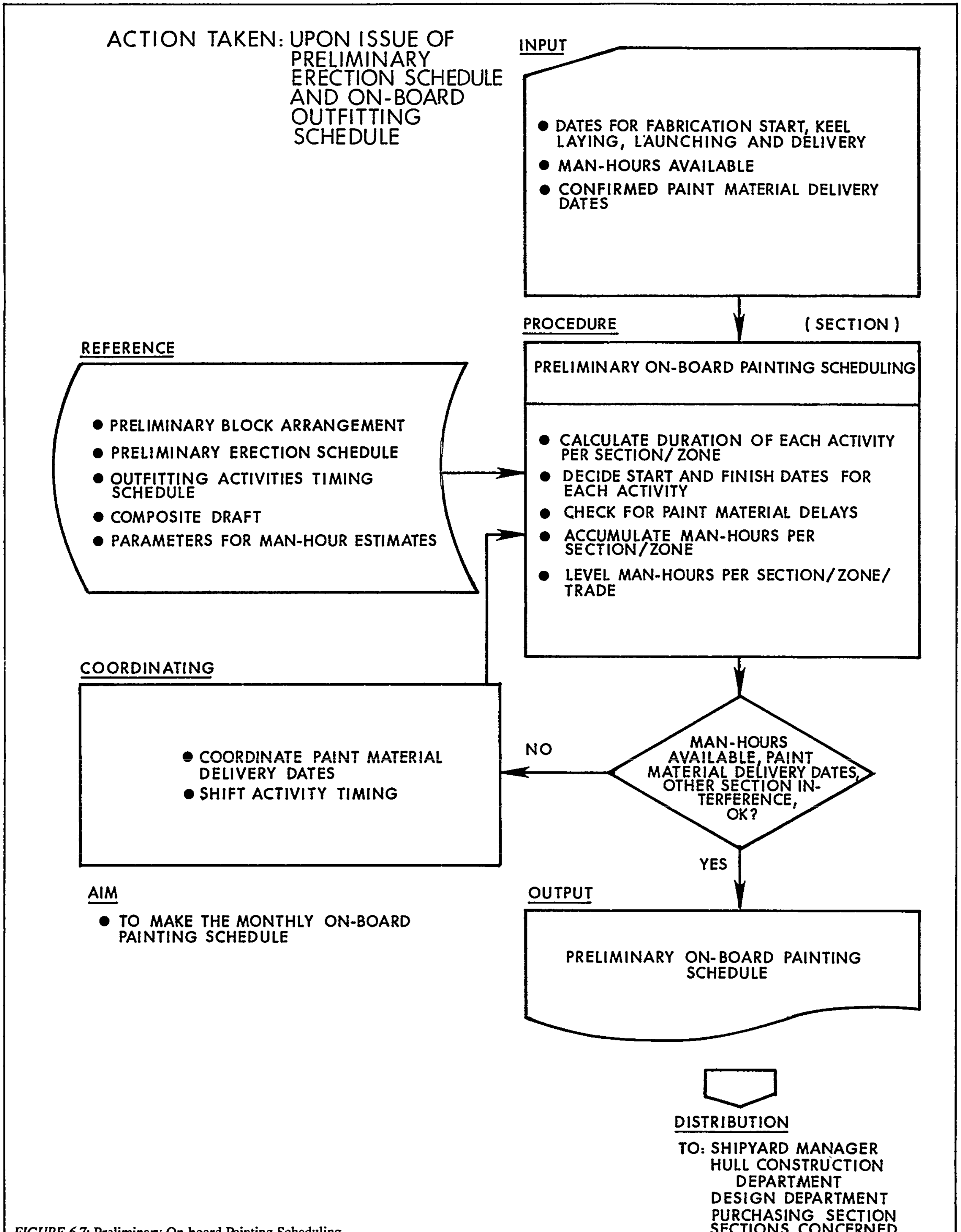

FIGURE 6-7: Preliminary On-board Painting Scheduling.

- o Determine the start and finish dates of each activity:
  - The start and finish dates of each activity are already prescribed in the Outfitting Activities Timing Schedule. But, this schedule was prepared on the basis of data contained in the Tentative Erection Schedule. If relevant data are revised between the Tentative and Preliminary Erection Schedules, the start and finish dates must be revised commensurate with any change.
- o Check for any delays in the delivery of materials required for painting.
- o Accumulate man-hours trade by trade in meshes of 10 days.
- o Level prominent peaks in estimated man-hours:
  - Level trade by trade.
  - Level man-hours in meshes of 10 days.
  - Report to the department manager deviations encountered between estimated and available man-hours. Large deviations require measures to be adopted for schedule revision.
  - The S-curve used for man-hour accumulation is not modified.

6.8.3 Coordinating

Department manager takes the initiative in coordinating milestones marking interfaces between sections.

6.8.4 Output Data and Timing

- o Output: The Preliminary On-board Painting Schedule is similar but less definitive than that shown in Figure A-22.
- o Timing: Upon issue of the Preliminary Erection and On-board Outfitting Schedules.

6.8.5 Updating and Recovery

- o Updating: Not relevant except upon revision of the Shipyard Master Schedule. Any modifications necessitated because of changes in the Painting Process Master Plans (traditional Paint Schedule) are incorporated in the Definitive On-board Painting Schedule.
- o Recovery: Not relevant as this schedule is not intended for governing implementation of work.

6.9 Definitive On-Block Painting Scheduling

6.9.1 General

The pertinent scheduling flow is similar to that shown in Figure 6-6.

- 0 Purpose
  - To develop the schedule governing on-block painting from which the On-block Monthly Schedule is prepared.
- o Prerequisites
  - IHOP Schedule
  - Painting Process Master Plan
  - Block Assembly Guidance Plan
- o Frames

  Subjects Treated: Each specific ship in the Shipyard Master Schedule.

  Frame Size: Section/block.

  Time Period: Man-hours accumulated in intervals of 10 work days from F to D.

6.9.2 Procedure

- o Derive the durations required for the activities to be performed on each block/stage:
  - Estimate the man-hours required for each activity using areas to be painted as provided by designers. Select a parameter (man- hours/ square meter) which reflects inherent problems based on a study of the Block Assembly Guidance Plan. If the resulting durations are found to exceed the corresponding intervals prescribed in the Definitive IHOP Schedule, reduce them to within the prescribed durations by increasing the number of work groups.
- o Determine the start and finish dates of activities for each block:

  Finish dates: As prescribed in the Definitive IHOP Schedule.

  - Start dates: Derived by counting backward from the finish dates the time intervals determined above.
- o Check the delivery dates of painting materials. If any materials are found to have incompatible or tight delivery dates, coordinate with the Purchasing Section.

- o Accumulate man-hours for each 10-day interval.
- o Level by shifting some on-block painting activities within the frames prescribed in the Definitive IHOP Schedule.

6.9.3 Coordinating

- o Coordinate the duration of painting activities with the block assembly and DAME outfit assembly sections.

6.9.4 Output Data and Timing

- o Output: See Figure A-21.
- 0 Timing: Upon issue of the Painting Process Master Plan for on-block painting and in time for preparation of the Monthly On-block Outfitting Schedule.
- 0 Updating and Recovery

  Not relevant except upon revision of the Shipyard Master Schedule (modifications are incorporated in the monthly schedule).

6.10 Definitive On-Board Painting Scheduling

6.10.1 General

The pertinent scheduling flow is similar to that shown in Figure 6-7.

- 0 Purpose
  - To develop the schedule governing on-board painting from which the On-board Monthly Schedule is prepared.
- 0 Prerequisites
  - Definitive Block Arrangement
  - Erection Schedule
  - Preliminary On-board Painting Schedule
- o Frames

  Subject Treated: Specific ship contracted.

  Frame Size: Section/zone.

  Time Period: 10 workdays from K to D.

6.10.2 Procedure

- o Derive the duration required for on-board painting each zone:
  - Estimate man-hours required.
  - Derive the durations required.
- 0 Determine timing:
  - Start dates for the zones are those prescribed in the Preliminary On-board Painting Schedule.
  - Finish dates are derived by using the durations and counting foreward from the start dates.
- 0 Accumulate man-hours in meshes of 10 workdays.
- 0 Level by shifting as necessary the timing of work per zone, but without exceeding the finish dates prescribed for individual zones in the Preliminary On-board Painting Schedule.

6.10.3 Coordinating

- o With the erection and DAME sections concerned and the Purchasing Section, coordinate delivery dates for require painting materials.

6.10.4 Output Data and Timing

- o Output: See Figure A-24.
- o Timing: Before preparation of the first Monthly On-board Painting Schedule and prior to start of on-board painting on a specific ship.

6.10.5 Updating and Recovery

Not relevant (revisions are incorporated in the monthly schedule for actual implementation).

6.11 Monthly Scheduling

The Monthly Schedule (all ships) may be skipped, because painting is rather simple. Work packaging and estimating man-hours can readily be accomplished from the Definitive On-block and On-board Schedules (ship by ship). In case a monthly schedule is required the procedure is similar to that for outfitting as described in Part 5.14.

6.12 Weekly Scheduling

6.12.1 General

The pertinent scheduling flow is shown in Figure 6-8.

o Purpose

To allocate individual activities on a daily basis for each type of painting work, i.e., surface preparation, number of coats, kind of paint, and full coat or touch-up.

To provide requisite information on painting materials and job sites.

To permit planning for the utilization of cranes, reservation of facilities including scaffolding, and preparation of tools.

o Prerequisites

Monthly Schedule or the Definitive On-block and On-board Painting Schedules.

o Frames

- Subject Treated: Each specific ship.

- Frame Size: AF-group.

Time Period: Each day over a period of 2 weeks

6.12.2 Procedure

o Determine the sequence of painting work including touch-up.

o Determine the start and finish dates for each paint coat per painting zone/block. (For painting purposes, a block can be divided into painting zones, e.g., for the underwater part, boot topping, etc.)

6.12.3 Coordinating

Not relevant (already undertaken at weekly meetings based on progress compared to the Definitive IHOP Schedule).

6.12.4 Output Data and Timing

o Output: See Figure A-25 for on-block and Figure A-26 for on-board.

o Timing: Weekly.

6.12.5 Updating and Recovery

Undertaken on the Daily Schedule.

6.13 Daily Schedule

6.13.1 General

The pertinent scheduling flow is shown in Figure 6-9. The Weekly Schedule on which an A/F tracks work progress can be used as a daily schedule for workers.

o Purpose

To determine activity implementation on a daily basis.

- To recover delays incurred on the Weekly Schedule.

o Prerequisite

- Weekly Schedule

o Frames

Subjects Treated: A specific ship.

- Frame Size: Worker.

- Period: One work-day.

6.13.2 Procedure

o Each A/F assigns duties to workers based on activity priorities.

o Each A/F compensates for worker absences in order to meet activity priorities.

6.13.3 Coordinating

Not relevant.

6.13.4 Output and Timing

Instructions are issued verbally or marked on the weekly schedule every morning.

6.13.5 Updating and Recovery

Not relevant. At the end of each day, work remaining is reported verbally for recovery on the following day.

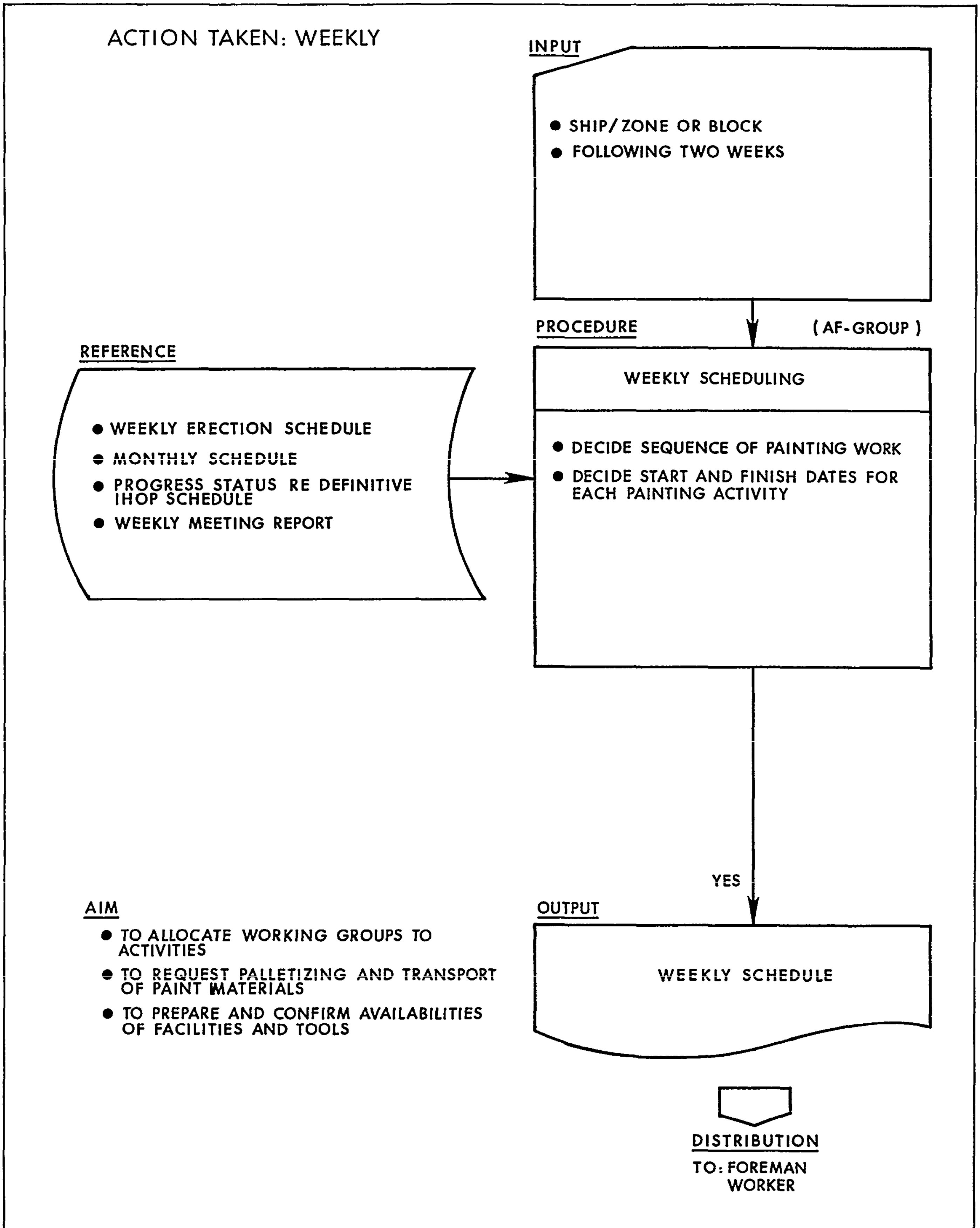

FIGURE 6-8: Weekly Scheduling.

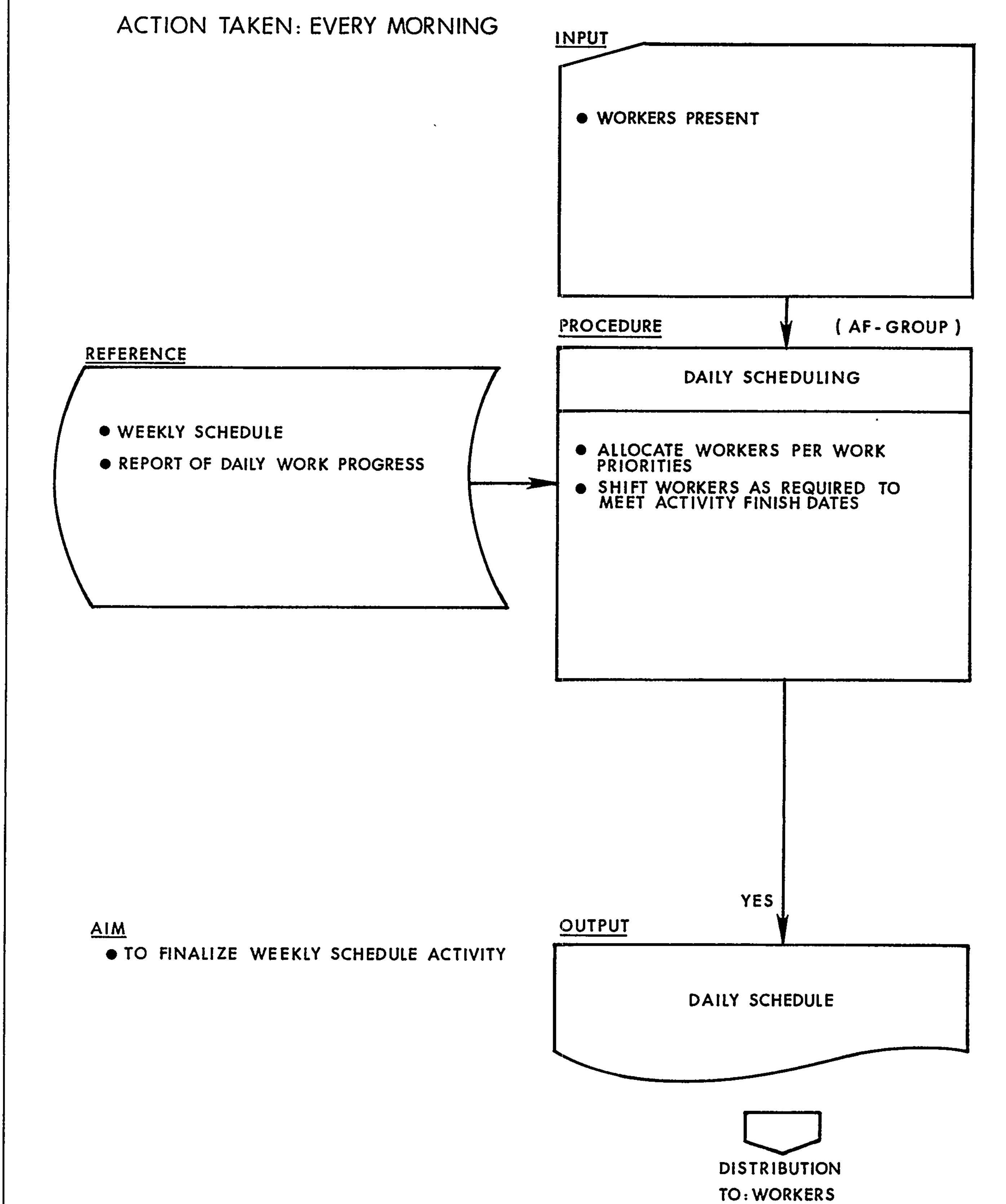

FIGURE 6-9: Daily Scheduling.

7.0 INTEGRATED HULL CONSTRUCTION, OUTFITTING, AND PAINTING (IHOP)

7.1 General

IHOP requires interdepartmental information exchanging and coordination especially for design, material procurement, production planning, scheduling and engineering. For effective IHOP operations a product-oriented organization is essential. [1]

7.1.1 Frame Scheduling Method

The IHOP Schedule is prepared twice, preliminary and definitively, for coordinating hull construction, outfitting, and painting activities to prepare each block for erection. Backward scheduling is performed:

- o for each block *or* for each grand block as erected,
- o in sequence for mold loft, fabrication, sub-block assembly, block assembly, grand block assembly, on-block outfitting and on-block painting,
- o in order to prescribe a duration for each activity, and
- o for each ship to be erected.

The Preliminary IHOP Schedule is a yardstick for shop/section schedules, and the Definitive IHOP Schedule is made after their coordination. As shop/section schedules cover all ships and an IHOP Schedule addresses each ship, their coordination achieves realistic durations and timing for each activity.

7.1.2 IHOP Tracking Operation

An IHOP Schedule is a powerful tool for monitoring current production progress, trouble shooting, and recovering delays to prevent them from affecting future progress. During the period from fabrication start to launching, the ship manager in charge of a specific ship chairs a weekly progress meeting and uses the IHOP Schedule for tracking, i.e., to identify deviations of actual progress. The consequence of such meetings is to maintain the coordination of process yards by providing inputs for updating weekly and monthly schedules. [2]

7.2 Organization

Shops in traditional shipyard organizations are too independent to coordinate their activities enough for effective IHOP scheduling. Usually, scheduling and production activities are not within the same organizations. A tree-structured network which features decentralization and combines responsibilities for production engineering, planning, scheduling and execution is necessary for effective coordination.

Another unique point is that IHOP scheduling coordinates processes sequentially for work organized both ship by ship and block by block. Thus, each shop/section schedule, while maintaining coordination with other shop/sections schedules, features workload leveling even when more than one ship is being produced simultaneously. As the block-by-block approach facilitates ideal scheduling for all shop/sections, the scheduling matrix manifested by an IHOP Schedule satisfies the needs of both ship and shop/section managers.

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[1] See the NSRP publication “Shipyard Organization and Management Development - October 1985”.

[2] Each ship manager’s weekly meeting is usually attended by production engineers and foremen from concerned fabrication shops and assembly sections. The ship manager, a former shop or section manager, is relatively senior and has keen understanding of the overall shipbuilding system. Each ship manager reports directly to the Shipyard Manager.

SCHEDULES	TIME		WORK VOLUME INDICATION			RESPONSIBILITY
	PERIOD	UPDATION	SUMMARY UNIT	SUMMARY PERIOD	PARAMETER	
PRELIMINARY IHOP SCHEDULE	A SHIP BUILDING PERIOD	BY DEFINITIVE IHOP SCHEDULE	PROCESS YARD/ BLOCK/ SHIP	MONTH	–WEIGHT OF BLOCK –WORKING DAYS (PAST DATA)	IHOP MANAGER
DEFINITIVE IHOP SCHEDULE	– DITTO –	BY WEEKLY TRACKING	– DITTO –	– DITTO –	– WEIGHT OF BLOCK – WORKING DAYS (SECTION SCHEDULE)	– DITTO –

FIGURE 7-1: Details of Schedule Frames for IHOP.

7.3 Frame Scheduling Method

The IHOP Planning and Engineering Department, having status equivalent to the Hull Construction, Outfitting and Painting Departments, prepares IHOP Schedules for each contracted ship. This department is responsible for IHOP Schedules, both Preliminary and Definitive, within the frames tabulated in Figure 7-1. The Preliminary IHOP Schedule is a proposal to the shop/sections concerned. The Definitive IHOP Schedule is a result of subsequent coordination.

7.3.1 Flow

Figures 4-2, 5-2, and 6-2 model activity flow for IHOP scheduling and coordination.

7.3.2 Frames

As shown in Figure 7-1, the time and work frames are the same for the Preliminary and Definitive IHOP Schedules. The preliminary schedule is based on historical data. The definitive schedule incorporates changes which reflect current shop/section circumstances.

7.4 Preliminary IHOP Scheduling

7.4.1 General

The pertinent scheduling flow is shown in Figure 7-2.

o Purpose

- To develop the definitive schedules for hull construction.
- To confirm drawing issue and material availability deadlines.
- To determine the timing and durations of on-unit and on-block outfitting and painting.
- To determine the important material lead time schedule.

o Prerequisites

- Tentative Erection Schedule
- Block Assembly Plan
- On-block Outfitting Duration Schedule
- Weight of each block.

o Frames

- Subject Treated: Specific ship.
- Frame Size: Integrated activities for hull construction, outfitting and painting.
- Time Period: Each work day, from fabrication start to erection.

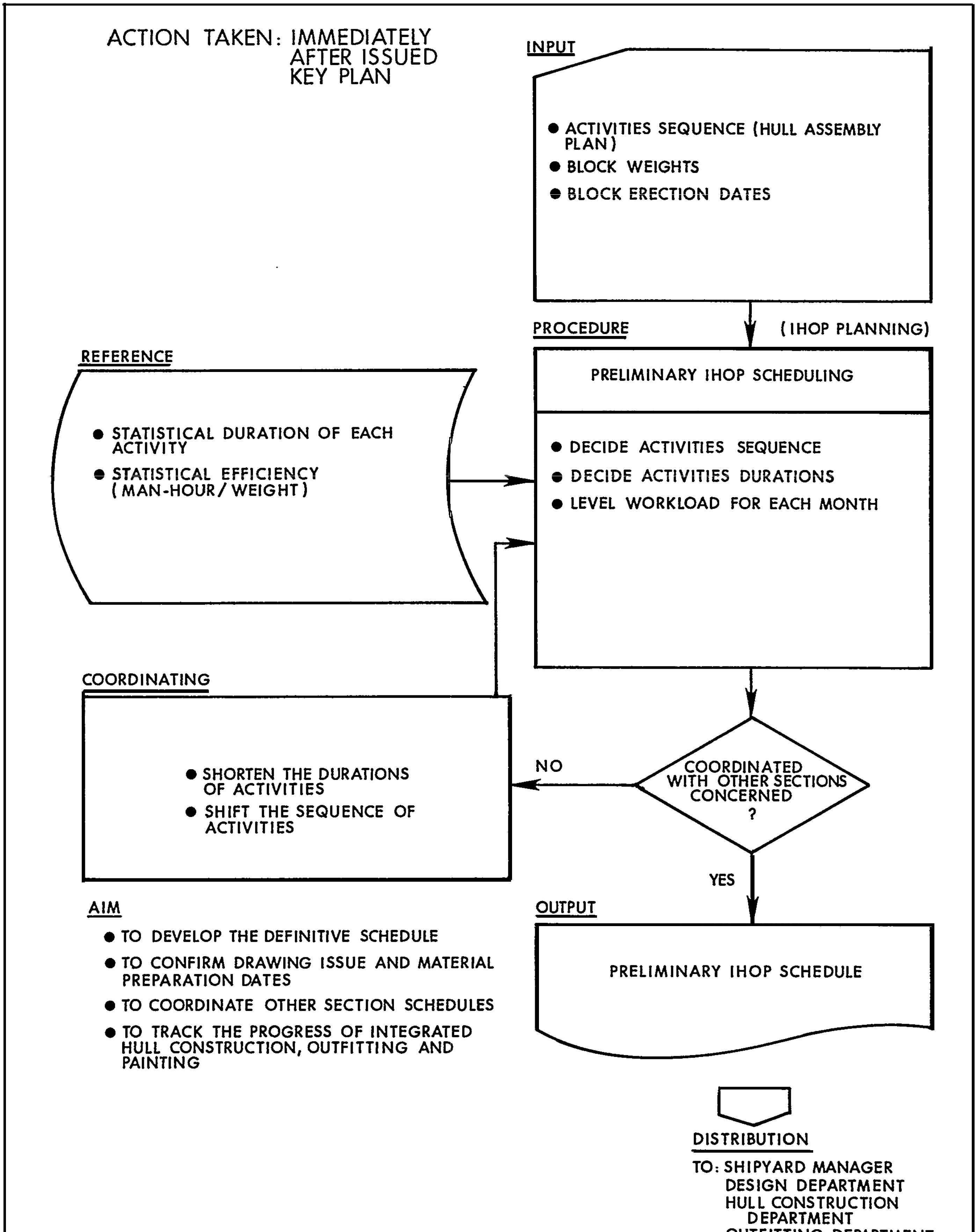

FIGURE 7-2: Preliminary IHOP Scheduling.

7.4.2 Procedure

o Determine the activities sequence from the assembly plan.

o Determine activities duration.

For each type of block (flat, curved, special curved, etc.) that constitutes a different problem category, the shipyard maintains in its historical file a plot of durations required for outfitting and painting on-block versus block weight. Thus, block weight is used to obtain the duration necessary to make a rough analysis. After the durations are backward scheduled from block erection dates, significant overlaps or peaks are eliminated so as to uniformly load work stations for the different processes (fabrication, sub-assembly, assembly, on-block outfitting and on-block painting).

o Comparison with man-hours available

For each type of block (flat, curved, special curved, etc.) that constitutes a different problem category, the shipyard also maintains in its historical file a plot of outfitting and painting efficiency versus block weight (man-hours/ton). However, such curves are not very exact as the man-hours required for assembling the many different outfit components vary widely. Therefore, the efficiencies obtained from these curves should only be used as baselines from which factors should be added or subtracted based on a production engineer's judgement.

With the rough assessment of outfitting and painting man-hours so obtained, compare the resulting monthly man-hour requirements with the man-hours available. Adjust any overload that may be found by shifting backwards simultaneously in one stroke, and not sporadically; see Figures 4-8 and 4-9.

7.4.3 Coordinating

o Items requiring coordination

- Drawing issue deadlines: To have necessary drawings issued in time for fabrication.

- Material need dates: To have necessary materials available in time for fabrication.

- Operating facilities: Not relevant.

- Timing and durations for on-unit and on-block outfitting and painting.

o Coordination

- Reducing the durations of activities: If it is found that drawing issue or material availability should not be in time for fabrication, and that adequate margins do not exist betweeen activities, the durations allocated for the relevant activities should be shortened so as to maintain next level schedule adherence.

- Modifying the sequence of activities: If the sequence of activities requires modification in order to eliminate overloading or for any other purpose, shift simultaneously in one stroke all activities involved; see Figures 4-8 and 4-9.

7.4.4 Output Data and Timing

o Output: See Figure A-23.

o Timing: Immediately after contract award.

7.4.5 Updating and Recovery

o Updating: Not relevant.

o Recovery: Not relevant. It will be replaced with the Definitive IHOP Schedule.

7.5 Definitive IHOP Scheduling

7.5.1 General

The pertinent scheduling flow is shown in Figure 7-3.

o Purpose

- To finalize the need dates for drawing and material issues.

- To coordinate all department schedules block-by-block.

- To monitor the actual progress of work.

o Prerequisites

- Erection Section Schedule

- Assembly Section Schedule

- Fabrication Shop Schedule

- DAME outfitting section schedules.

- Painting Section Schedule

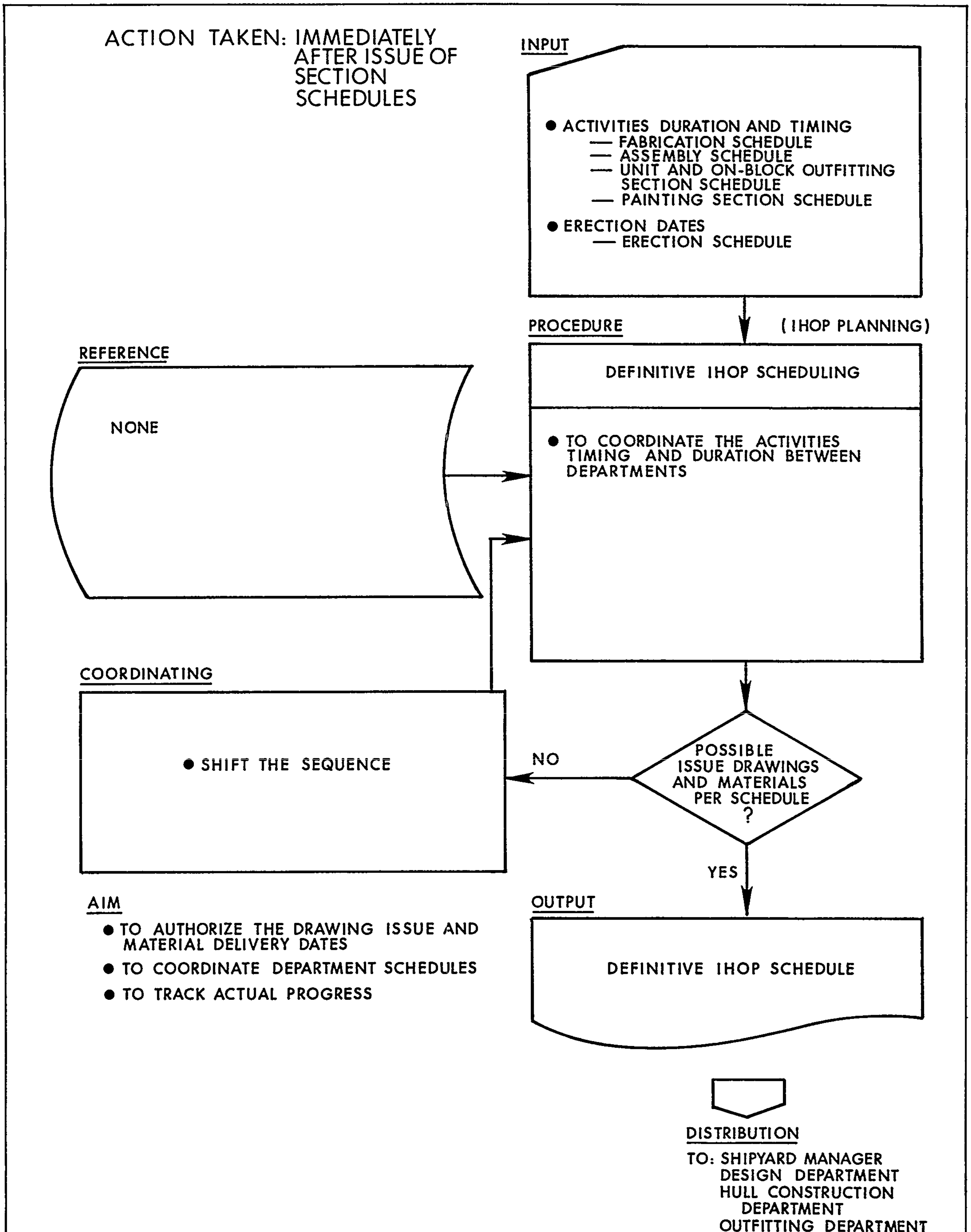

FIGURE 7-3: Definitive IHOP Scheduling.

o Frames

- Subject Treated: Specific ship.

  Frame Size: Individual activities by IHOP processes.

  Time Period: Monthly from mold loft start to launching for a specific ship.

7.5.2 <u>Procedure</u>

The only coordination needed for this scheduling operation is to arrange timing of activities for each block to suit the process yards of concerned sections. The timing and durations of all activities have already been finalized on the fabrication shop schedule, the assembly section schedule, on-block outfitting section schedule and the painting section schedule as a consequence of shop/section reviews of the Preliminary IHOP schedule.

7.5.3 <u>Coordinating</u>

o Items requiring coordination:

  Drawing issue deadline dates with the Design Department.

- Materials availability deadline dates with the Material Section.

- Durations and timing of activities with the Hull Construction Department.

- Durations and timing of on-unit and on-block outfitting operations with the Outfitting Department.

- Durations and timing of painting operations with the Painting Department.

o Coordination

- Shifting the sequence: Same as in Part 4.6.3; see Figure 4-8. Shift activities in one stroke, not sporadically bit by bit, as in Figure 4-9.

7.5.4 <u>Output Data and Timing</u>

o Output: See Figure A-24.

o Timing: Immediately after shop/section schedules are issued.

7.5.5 <u>Updating and Recovery</u>

Not relevant.

8.0 PIPE PIECE FAMILY MANUFACTURING

8.1 General

Pipe Piece Family Manufacturing (PPFM) schedules are derived by backward scheduling from pallet need dates. PPFM activities relate to outfitting in the same way that part fabrication activities relate to assembly work for hull construction. But, parts for each block are scheduled to be fabricated simultaneously. In contrast, pipe pieces for many DANE pallets are fabricated simultaneously as means for idealizing pipe shop operations. The four supporting FPSS elements described in Chapter 2.0 are also applicable to PPFM. The family manufacturing concept is also applicable for other outfit components, such as, vent ducts, ladders, pipe supports, cable hangers, machinery foundations, etc., whenever they are required in large quantities characterized by varying designs. [1]

8.1.1 Frame Scheduling Method

Frames are developed from large to small as a design develops from basic through functional and transition design, and finally, to work instruction design.

8.1.2 IHOP Scheduling and Tracking Operation

PPFM is planned on the basis of pallet need dates for pipe pieces. PPFM planners are only nominally involved in contributing information for an IHOP Schedule. However, they coordinate their manufacturing schedule with the outfit planners for on-unit, on-block and on-board outfitting.

8.2 Organization

PPFM planning and scheduling is implemented by each level of the pipe piece manufacturing shop. None are involved in producing pipe piece sketches and on-unit, on-block and on-board fitting. Such work belongs to the Design Department and the DAME fitting sections respectively. Figure 8-1 models a pipe piece manufacturing shop organization which is structured under the Outfitting Department and serves only to supply palletized pipe pieces to the DAME outfit assembly sections.

The shop is phased by level into two F-Groups. One is for manufacturing and the other is for other activities. The first is grouped into AF-groups by families of pipe diameters, etc., and the second is grouped into AF-groups by process stations such as for surface treatment (pickling and painting), testing and palletizing and off-line manufacturing. Material preparation belongs to the first F-group because it is a process which necessarily precedes manufacturing processes.

8.3 Frame Scheduling Method

The shop prepares schedules for each level in sequence as shown in Figure 8-2. The planners of each level prepare schedules within their frames as tabulated in Figure 8-3. They never prepare schedules without advance coordination with DAME outfitting planners both for obtaining proposed pallet need dates and for advising what is feasible based on man-hour availability in the pipe shop. Then, normal lead times per pipe piece family are applied by backward scheduling from pallet need dates in order to determine piece-by-piece start dates.

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[1] See the NSRP publication "Pipe piece *Family* Manufacturing - March 1982".

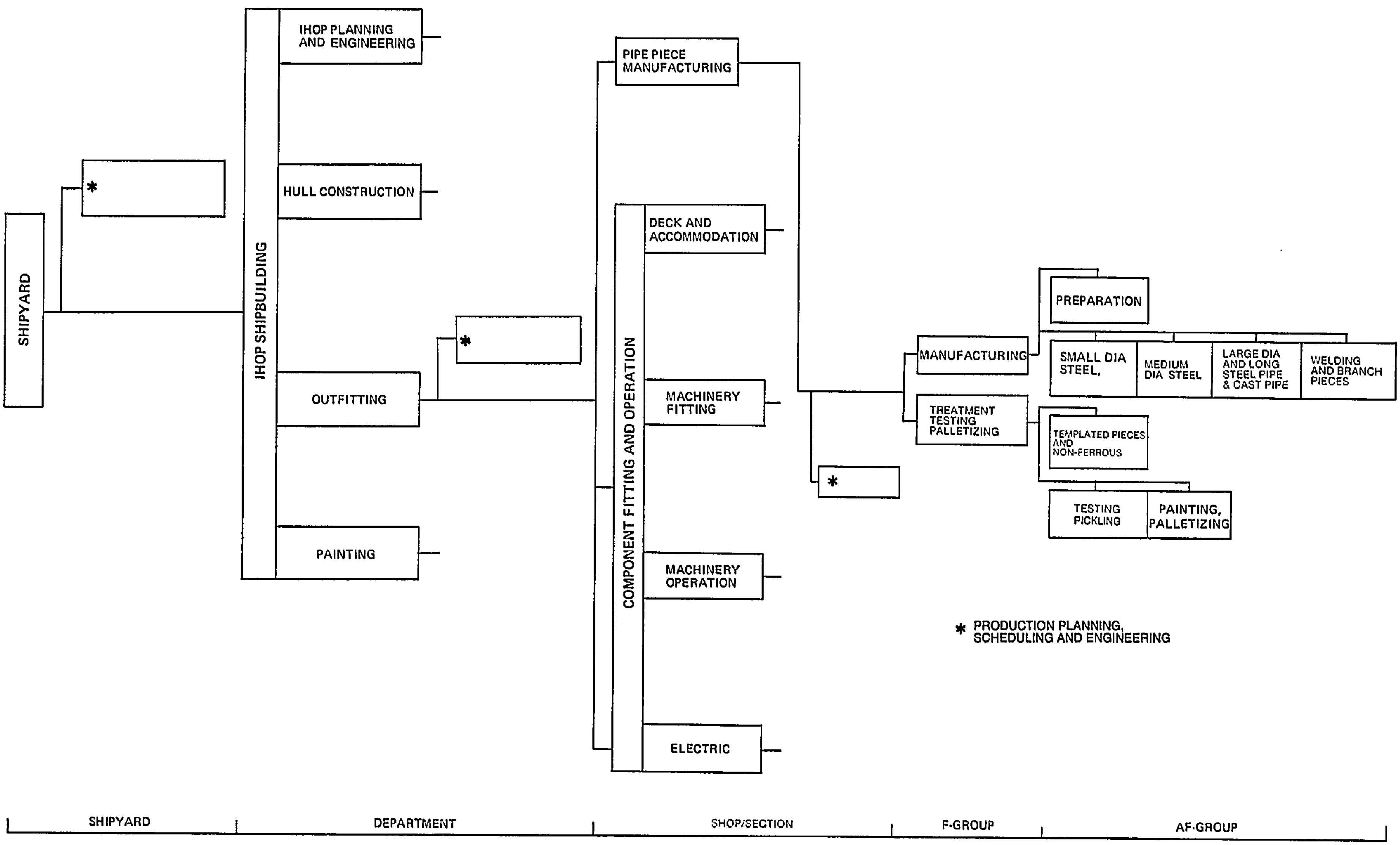


FIGURE 8-1: Model Organization for Pipe Piece Manufacturing.

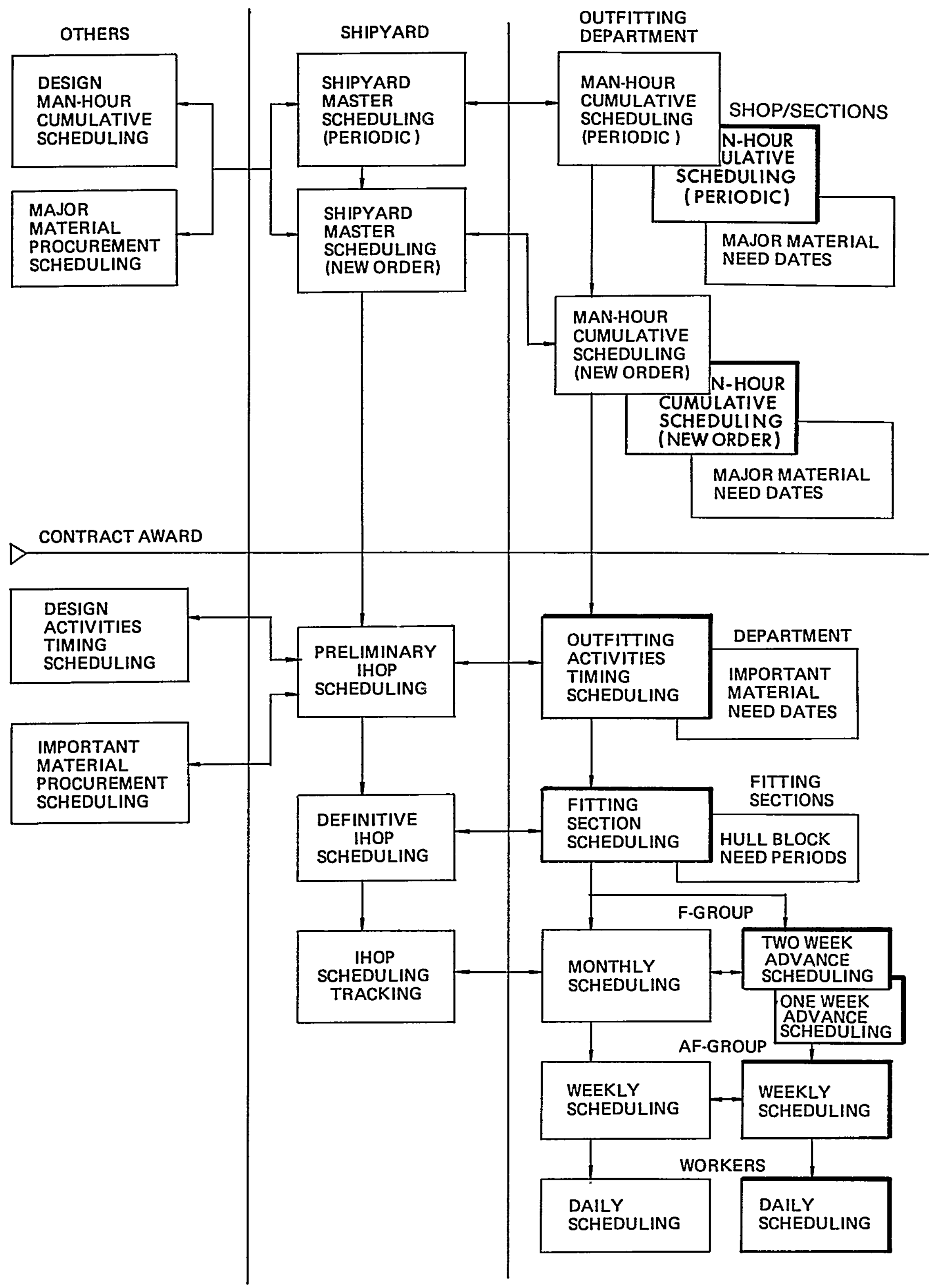


FIGURE 8-2: Sequence of Pipe Piece Manufacturing Scheduling is shown by bold boxes.

FRAMES / SCHEDULES	TIME		WORK VOLUME INDICTIONS			RESPONSIBILITY
	PERIOD	UPDATED	SUMMARY UNIT	SUMMARY PERIOD	PARAMETER	
SHOP MAN-HOUR CUMULATIVE SCHEDULE	1.5 YEARS	EVERY 6 MONTHS	FKLD/SHIP/SHOP	MONTHS	S-CURVE	SHOP MANAGER
OUTFITTING ACTIVITIES TIMING SCHEDULE	A SHIPBUILDING PERIOD	NOT RELEVANT	FRAMED ZONE/SHIP/	NOT RELEVANT	WEIGHT (BUDGET CONTROL LIST)	SHOP MANAGER
SHOP SCHEDULE	SUBSTITUTE USER'S (FITTING) SECTION SCHEDULES.					
TWO WEEK ADVANCE SCHEDULE	SHIPS FOR WEEK AFTER 2 WEEKS	FRIDAY MORNING BEFORE 2 WEEKS	FAMILY/PALLET	1 WEEK	–PARAMETERIC MANUFACTURING HOURS	FOREMAN
ONE WEEK ADVANCE SCHEDULE	SHIPS FOR WEEK AFTER 1 WEEK	FRIDAY MORNING BEFORE 1 WEEK	LINE/FAMILY	1 WEEK	–PARAMETRIC MANUFACTURING HOURS	FOREMAN
WEEKLY SCHEDULE	SHIPS FOR NEXT WEEK	FRIDAY AFTERNOON OF THE PRECEDING WEEK	FAMILY/LINE/ PROCESS STATION/ DIAMETER	1 WEEK	–PARAMETRIC PIECE NUMBERS/ STATION	ASSISTANT FOREMAN
DAILY SCHEDULE	SHIPS FOR 1 DAY	EVERY DAY	FAMILY/LINE/ PROCESS STATION/ DIAMETER/ PIPE PIECE DWG.	1 DAY	–PIPE PIECE DRAWING NUMBER/WORKER	WORKER

FIGURE 8-3: Details of Schedule Frames for Pipe Piece Family Manufacturing. Parametric manufacturing hours are derived from past data.

The grouping of such dates thin a fixed duration, usually one week, determines a work lot. As the efficiency (man-hours/pipe piece) is different for each family and the contents for each pallet vary widely, man-hours/work lot vary widely. Reliance is placed on a select group of sub-contractors to absorb the fluctuating part of each work lot.

8.3.1 Flow

Working with the DAME sections, the shop produces a man-hour cumulative schedule, periodically and for each new order as evidence of the shop's man-hour availability.

In order to integrate backward scheduling for outfitting on-unit, on-block and on-board with PPFM, the start date of work is determined from the lead times for manufacturing. The work load should be leveled in an attempt to match man-hours available both in-house and in subcontractors plants by advancing pipe piece start dates or obtaining agreement from the DAME sections to postpone pallet deliveries.

8.3.2 Frames

The time and work frames at each scheduling level are presented in Figure 8-3.

The shop prepares a cumulative schedule for a duration of eighteen months which is updated every six months and on the occasion of a new ship contract. The Outfitting Department prepares the activities timing schedule for the DAME sections and the Pipe Shop. The DAME sections determine pallet need dates which include the need dates for pipe pieces. The latter dates determine required finish dates for manufacturing pipe pieces.

Each lower level schedule is coordinated with others on the same level.

8.4 Man-Hour Cumulative Scheduling (Periodic)

8.4.1 General

The pertinent scheduling flow is shown in Figure 8-4.

0 Purpose

- To review the Shipyard Master Schedule and Outfiting Man-Hour Cumulative Schedule for the compatibility of budgeted man-hours allocated to a ship contracted (or to be contracted) with the man-hours actually available to the Shop.

  To serve as data on available production capabilities that is to be used by marketing people for soliciting new orders.

  To serve for adjusting the man-hours available on a long-term basis.

  To serve the department manager for long-term adjustments of man-hour accumulations between the shop/ sections.

o Prerequisites

- Shipyard Master Schedule
- Outfitting Man-hour Cumulative Schedule
- Budgeted man-hours for manufacturing.

o Frames

- Subjects Treated: All ships contracted or to be contracted.

  Frame Size: Ship/Manufacturing.

- Time Period: Monthly over a period of 1 .5 years.

8.4.2 Procedure

o From the shipyard's history of similar ships, choose the S-curve which best fits the circumstances being considered.

0 From the curve selected, determine the man-hours accumulated at each of the key milestones as follows:

$$Pi = \frac{Hei}{Hb}$$

where: P = percentage of man-hours accumulated at each of the key milestones

i = K, L or D

Hb = total budgeted man-hours

Hei = accumulated man-hours at each of the key milestones

0 Superimpose the shipyard manager's proposed K, L or D dates for the contemplated ship and by employing the same percentages, plot the S-curve for the contemplated ship.

0 Obtain the monthly man-hour distribution (the derivative in mathematics) from the contemplated ship.

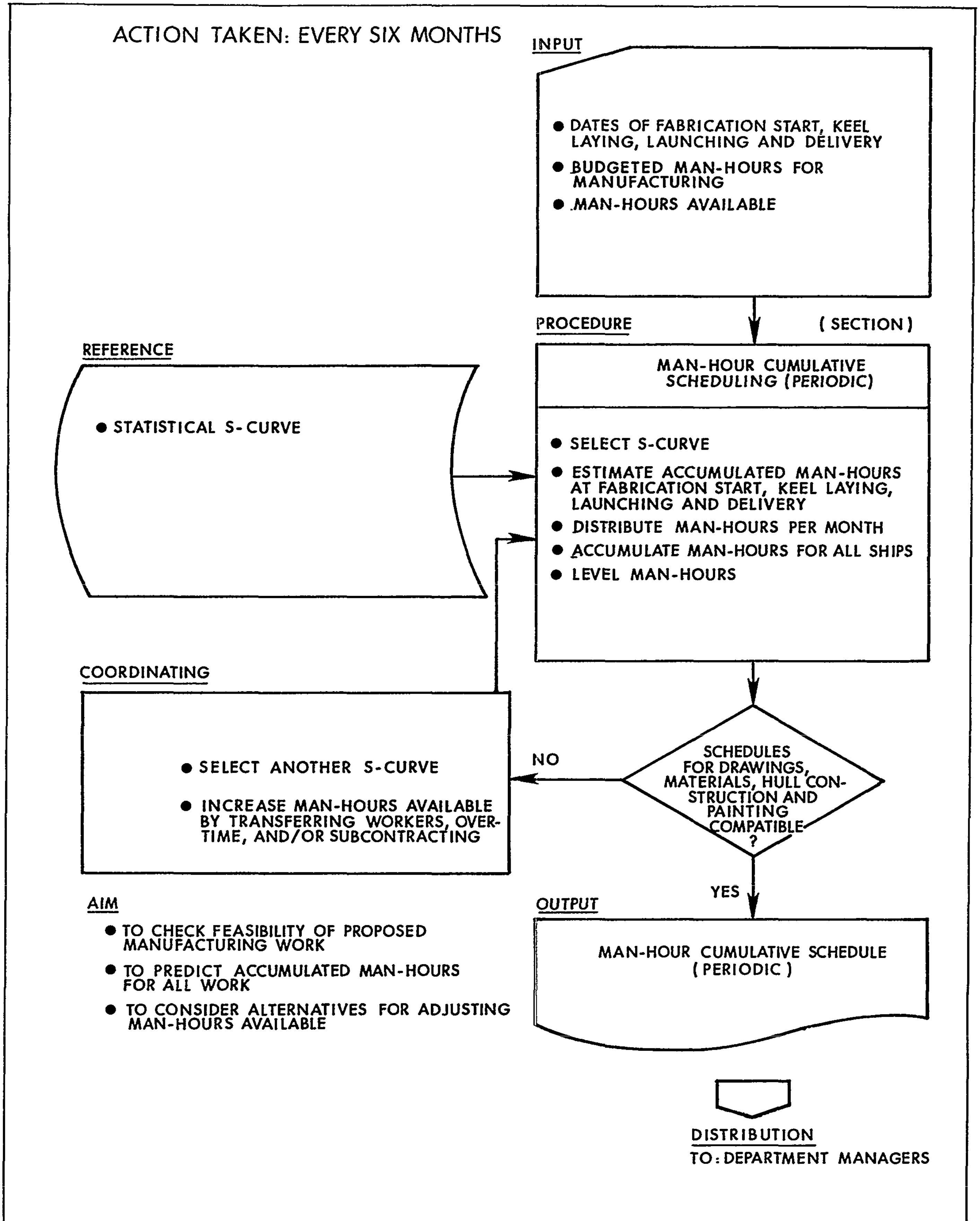


FIGURE 8-4: Man-hour Cumulative Scheduling (Periodic).

o Insert the monthly man-hour distribution for the contemplated ship in the nonthly man-hour distribution for all work contracted and contemplated. Level excessive peaks by comparison with the available monthly man-hours and shifting dates within whatever limits existing contracted delivery dates permit. Alternatively, the peaks may be retained provided additional man-hours are budgeted. Obviously, the solution to be adopted must the one selected by the Shipyard Manager.

8.4.3 Coordinating

Adjustments to eliminate differences between needed and budgeted man-hours are made by:

o substituting another S-curve, and

o adjusting available man-hours through arranging for transfer of manpower from the Hull Construction Department to the Outfitting Department and through arranging for overtime work.

If available man-hours are still insufficient, the Shipyard Manager must find a solution which could be a revision of key milestone dates. This alternative would require further negotiations with the proposed customer.

8.4.4 Output Data and Timing

o Output: See Figure A-1 which is similar to this schedlue.

o Timing: Every 6 months.

8.4.5 Updating and Recovery

o Updating: Performed regularly at intervals of 6 months.

o Recovery: Not relevant.

8.5 Man-Hour Cumulative Scheduling (New Order)

8.5.1 General

The pertinent scheduling flow is shown in Figure 8-5.

o Purpose

- For a specific ship newly contracted, to finalize dates for F, K, L, and D on the Shipbuilding Master Schedule.

- To serve as man-hour accumulation for outfitting scheduling.

o Prerequisites

- Estimated dates for F, K, L, and D from the Shipbuilding Master Schedule (Periodic).

- Work volume data from the Material Budget Control List.

o Frames

Subjects Treated: Specific Ship.

Frame Size: Department and shop/section for their respective levels.

Time Period: Monthly during the period from F to D.

8.5.2 Procedure

Same as described in Part 5.5.2.

8.5.3 Coordinating

Same as described in Part 5.5.3.

8.5.4 Output Data and Timing

o Output: See Figure A-1 which is similar to this schedule.

o Timing: When directed by the Department Manager.

8.5.5 Updating and Recovery

o Updating: Same as described in Part 5.5.5.

0 Recovery: Recovery is sought on the periodic man-hour- cumulative schedule. See Part 8.4.4.

8.6 PPFM Activities Timing Scheduling

The PPFM Activities Timing Schedule is generated in the Outfitting Activities Timing Schedule by the same concept described in Part 5.7.

8.7 Shop Scheduling

A shop level schedule for PPFM is not required because the DAME section schedules give the need dates for pallets for on-unit, on-block and on-board outfitting. This information is all that is needed for preparing the Two-Week Advance Schedule.

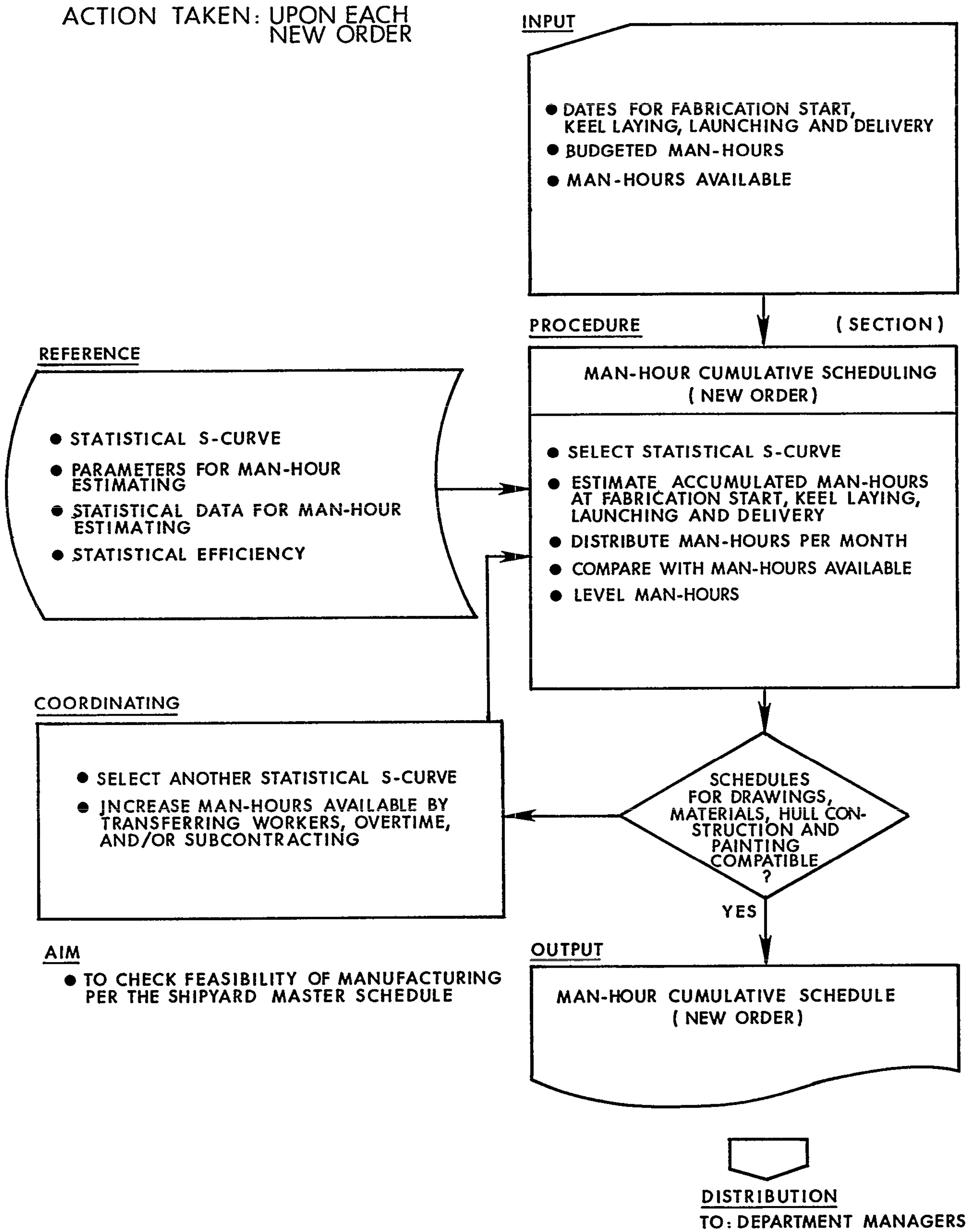


FIGURE 8-5: Man-hour Cumulative Scheduling (New Order).

8.8 Two-Week Advance Scheduling

8.8.1 General

The pertinent schedule flow is shown in Figure 8-6.

0 Purpose

- To develop information from which to prepare a One-Week Advance Schedule that will govern actual implementation of manufacturing work.
- To develop a week-by-week work load plan including overtime and subcontracting work.

o Prerequisites

- Pallet need dates.
- Pipe piece manufacturing drawings.

8.8.2 Procedure

The Two-Week Advance Schedule covers the manufacturing activities for the workweek after the next two weeks from its issue (e.g., if the schedule is issued on Friday, 13 September, it applies to the work week starting Monday, 30 September; see Figure A-27).

o The manufacturing starting dates per pipe piece is computed by the formula:

PPsd = PPnd - PPlt

Where: PPsd = Manufacturing start date for each pipe piece

PPnd = Pallet need date for each pipe piece

PPlt = Lead time for a pipe piece by family

o Group into the PPFM work lot per week all pipe pieces having start dates which are in the same week.

o Calculate and accumulate the man-hours required for the work lot.

o Advance (A) the work load by pallet/pipe piece family to level the man-hours required. Or, with permission of the concerned I)AME section, postpone (P) the work load by pallet/pipe piece family to the succeeding week.

8.8.3 Coordinating

o Man-hours available

The shop engineer takes the initiative, with the shop manager's permission, to provide for overtime and subcontracting.

0 Shifting the work load

The shop engineer coordinates the shifts in:

- Pallet issue dates to succeeding weeks with concerned DAME section engineers.
- Drawing issue dates to preceding weeks with the concerned DAME work-instruction designers.

8.8.4 Output Data and Timing

o Output: See Figure A-27 for weekly work load and A-28 for leveling by pipe piece family.

o Timing: Every Friday morning.

8.8.5 Updating and Recovery

o Updating: Automatically updated and recovered by the One-Week Advance Schedule.

o Recovery: Not relevant.

8.9 One Week Advance Scheduling

8.9.1 General

The pertinent scheduling flow is shown in Figure 8-7.

0 Purpose

- To develop the One-Week Advance Schedule that will govern the Weekly Schedule.
- To develop the schedule which distributes the work load consistent with in house and subcontractor available man-hours.

o Prerequisites

- Pallet need dates.
- Pipe piece manufacturing drawings.

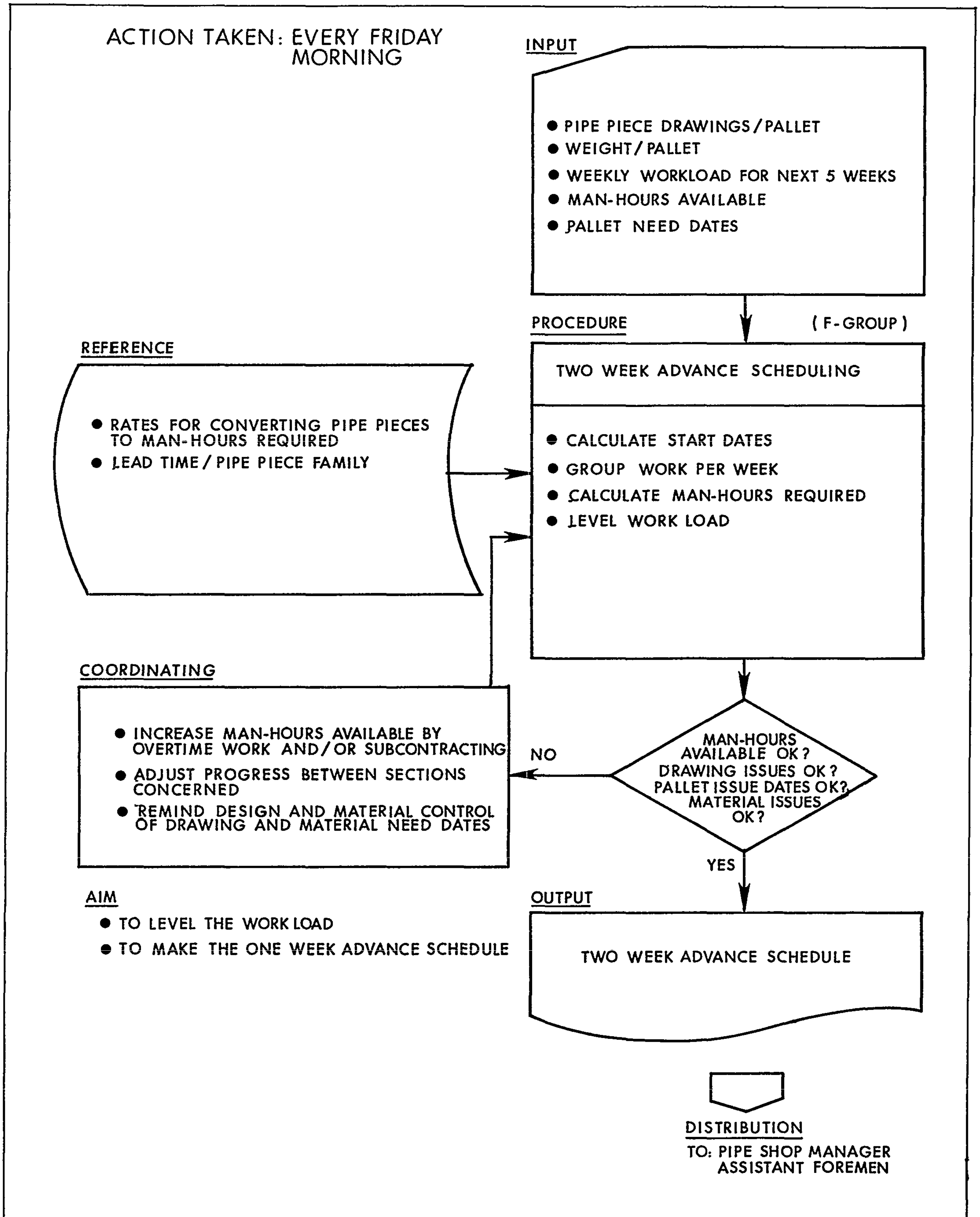


FIGURE 8-6: Two Week Advance Scheduling.

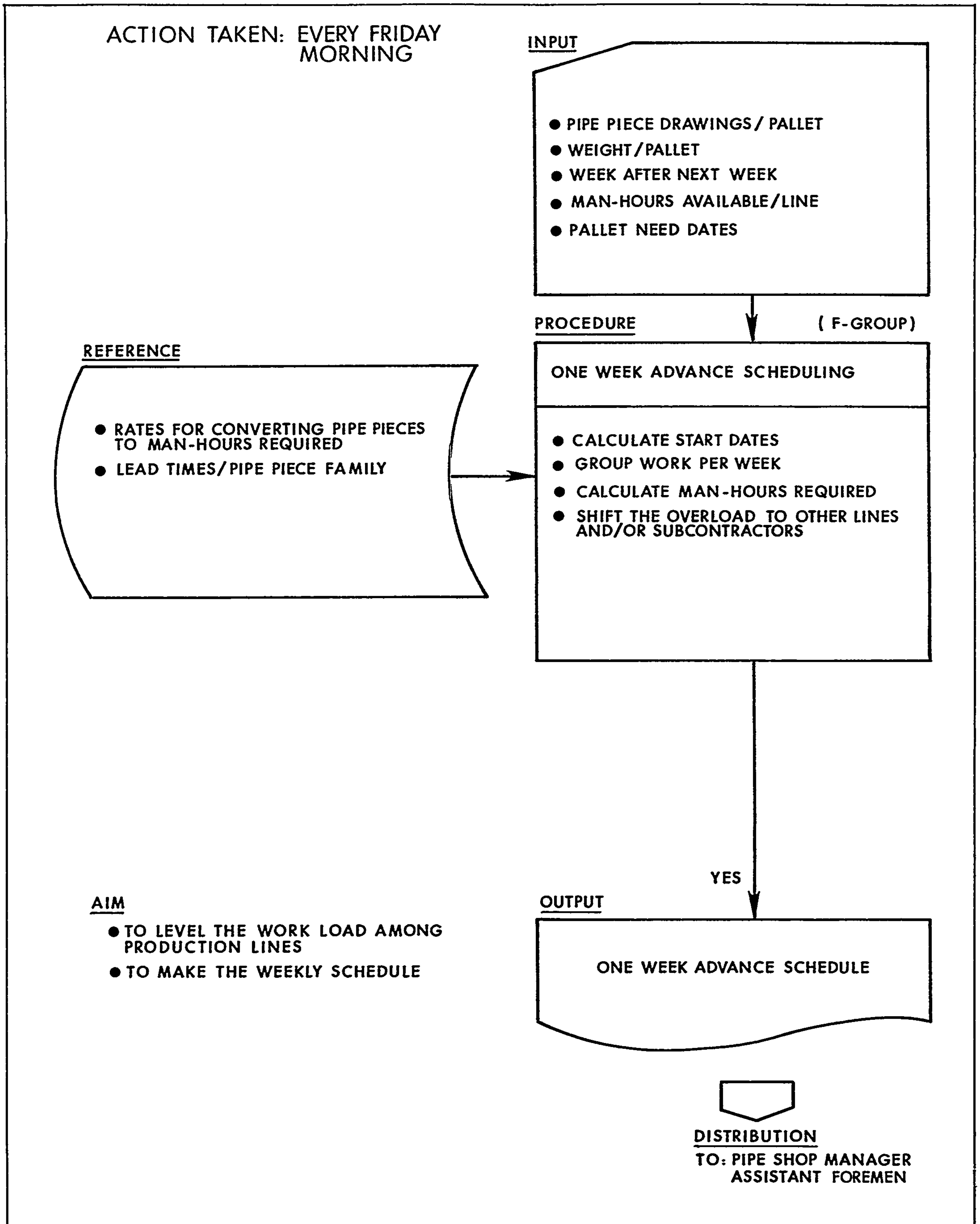


FIGURE 8-7: One Week Advance Scheduling.

o Frames

- Subjects Treated: All ships.
- Frame Size: Process yard (Line)/ pipe piece family (PPF).
- Time Period: 1 week for 1 week ahead.

8.9.2 Procedure

The One-Week Advance Schedule covers the manufacturing activities for the work week after the next week from its issue (e.g., if the schedule is issued on Friday, 13 September, it applies to the work week starting Monday, 23 September; see Figure A-29).

o Calculate and accumulate the man-hours required for the work lot as in Part 8.8.2.

0 Shift some work load by production line/PPF to other production lines or to subcontractors consistent with available man-hours.

8.9.3 Coordinating

Not relevant.

8.9.4 Output Data and Timing

o Output: See Figure A-29 for work load by production line and A-30 for work load by PPF.

o Timing: Every Friday morning.

8.9.5 Updating and Recovery

Undertaken on the Weekly Schedule.

8.10 Weekly Scheduling

8.10.1 General

The pertinent schedule flow is shown in Figure 8-8.

0 Purpose

- To schedule the daily work load station by station and yard by yard.

o Prerequisites

- One Week Advance Schedule
- Pipe piece manufacturing drawings.
- Number of pipe pieces which are carried over to the next week.

o Frames

- Subjects Treated: All ships.

Frame Size: Process station/yard.

- Time Period: 1 week.

8.10.2 Procedure

The Weekly Schedule covers a seven workday period which includes a Friday, the entire work week following, and the very next Monday; see Figure A-31. Thus, successive weekly schedules intentionally overlap by 2 work days. The data is updated from that of the previous week.

o Confirming the work load

- Check the unfinished pipe pieces per process station.
- Check the pipe pieces to be manufactured in the next week.
- Confirm the total work load for the next week.

o Distributing the work load

Distribute the pipe pieces to be manufactured day by day and station by station.

o Leveling man-power

Shift workers from one station to another within or outside yards, as necessary. Workers are usually assigned to specific stations from where they are only temporarily moved for the purpose of leveling work loads.

8.10.3 Coordinating

Not relevant.

8.10.4 Output Data and Timing

o Output: See Figure A-31 for small diameter pipe, A-32 for medium diameter, and A-33 for large diameter.

o Timing: Every Friday morning.

8.10.5 Updating and Recovery

Undertaken on the Daily Schedule.

8.11 Daily Schedule

8.11.1 General

The pertinent scheduling flow is shown in Figure 8-9. The Weekly Schedule on which an A/F tracks the work progress can be used as a daily schedule for workers.

o Purpose

- To determine activity implementation on a daily basis.
- To recover delays incurred on the Weekly Schedule.

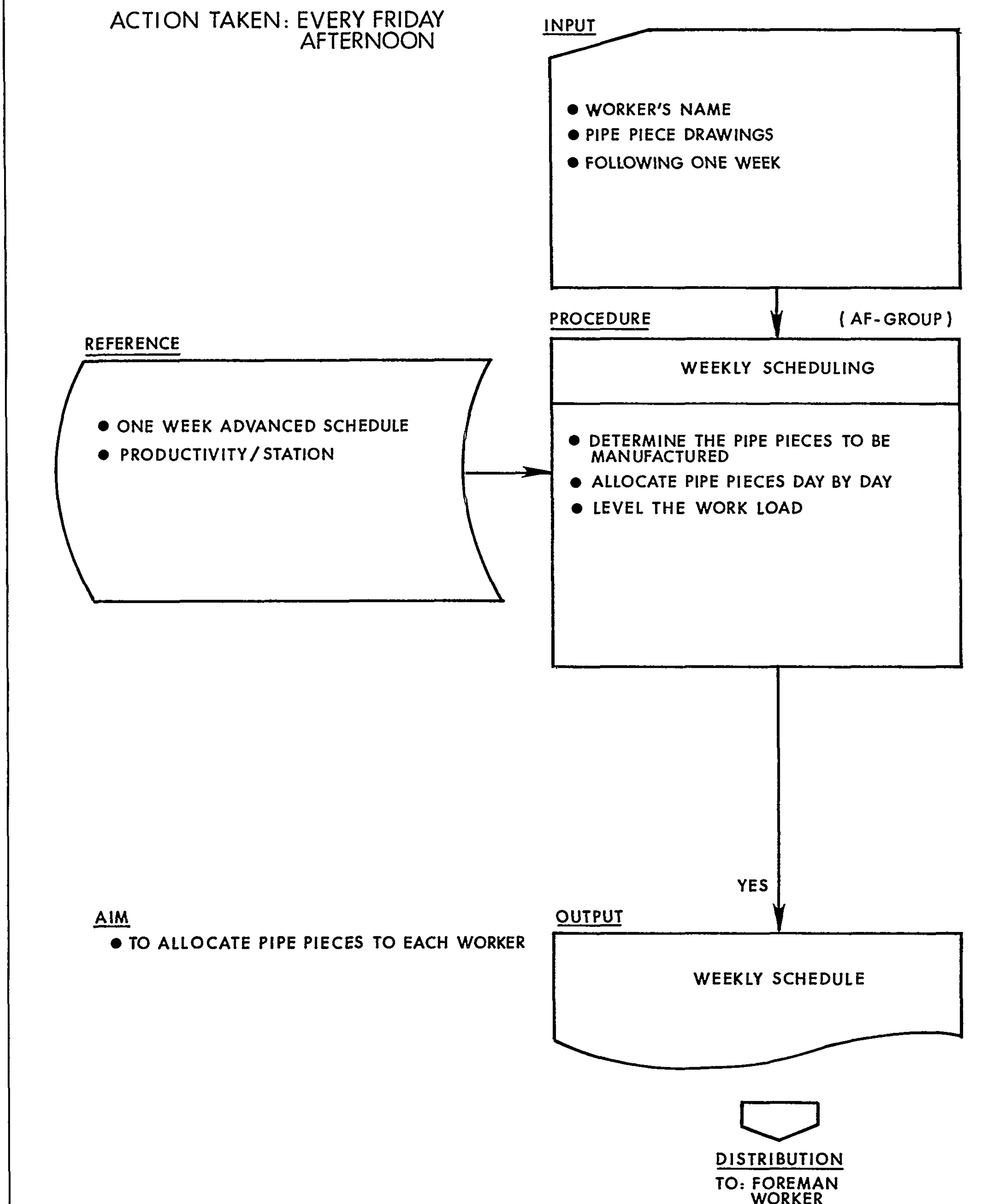


FIGURE 8-8: Weekly Scheduling.

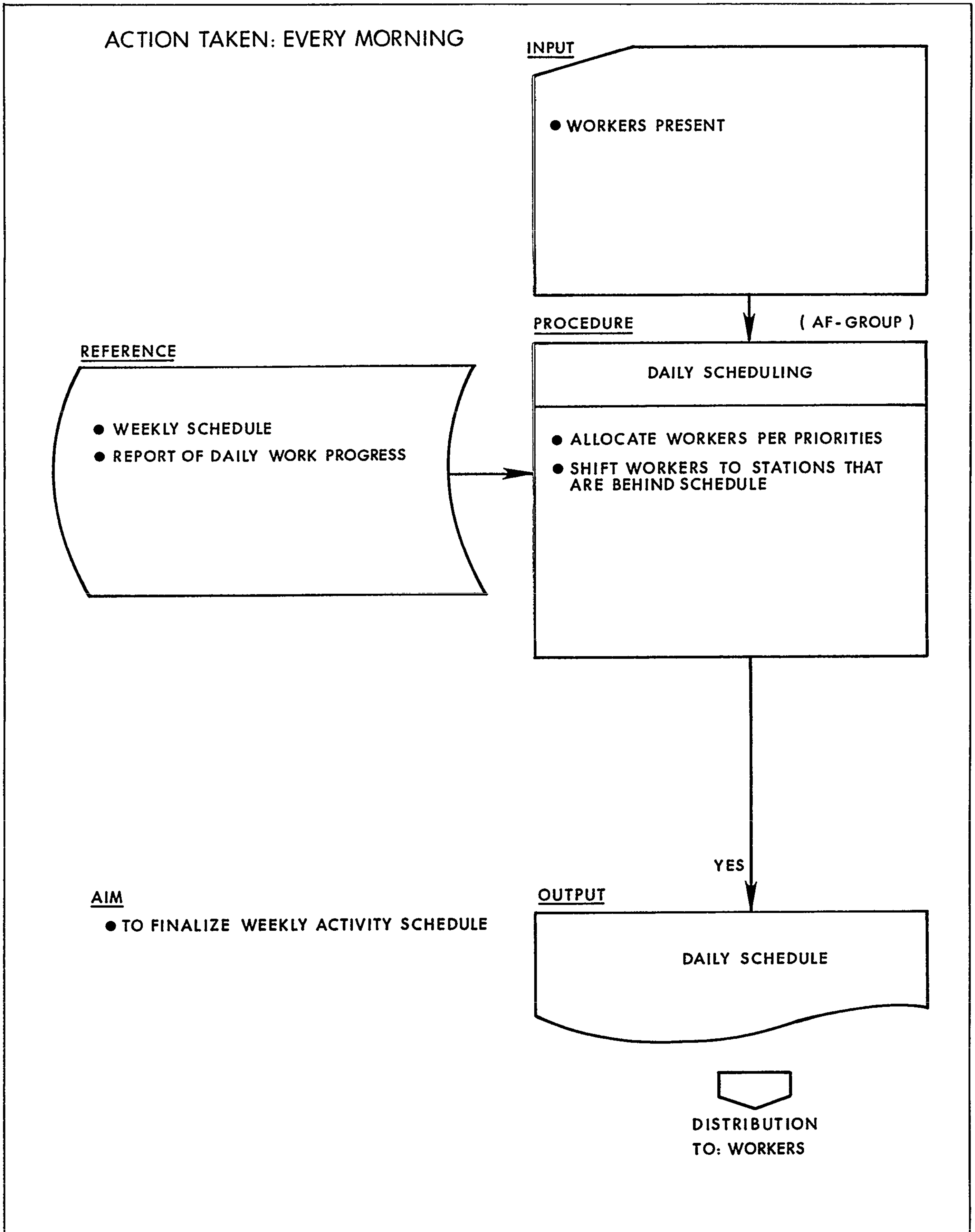


FIGURE 8-9: Daily Scheduling.

o Prerequisite

  - Weekly Schedule

o Frames

  - Subjects Treated: All ships.
  - Frame Size: Worker.
  - Period: One workday.

8.11.2 Procedure

o Each A/F assigns duties to workers based on activity priorities.

o Each A/F compensates for worker absences in order to meet activity priorities.

8.11.3 Coordinating

Not relevant.

8.11.4 Output and Timing

Instructions are issued verbally or marked on the weekly schedule every morning.

8.11.5 Updating and Recovery

Not relevant. At the end of each day, work remaining is reported verbally for recovery on the following day.

APPENDIX A

Examples of Various Schedules

HULL CONSTRUCTION MAN-HOUR CUMULATIVE SCHEDULE

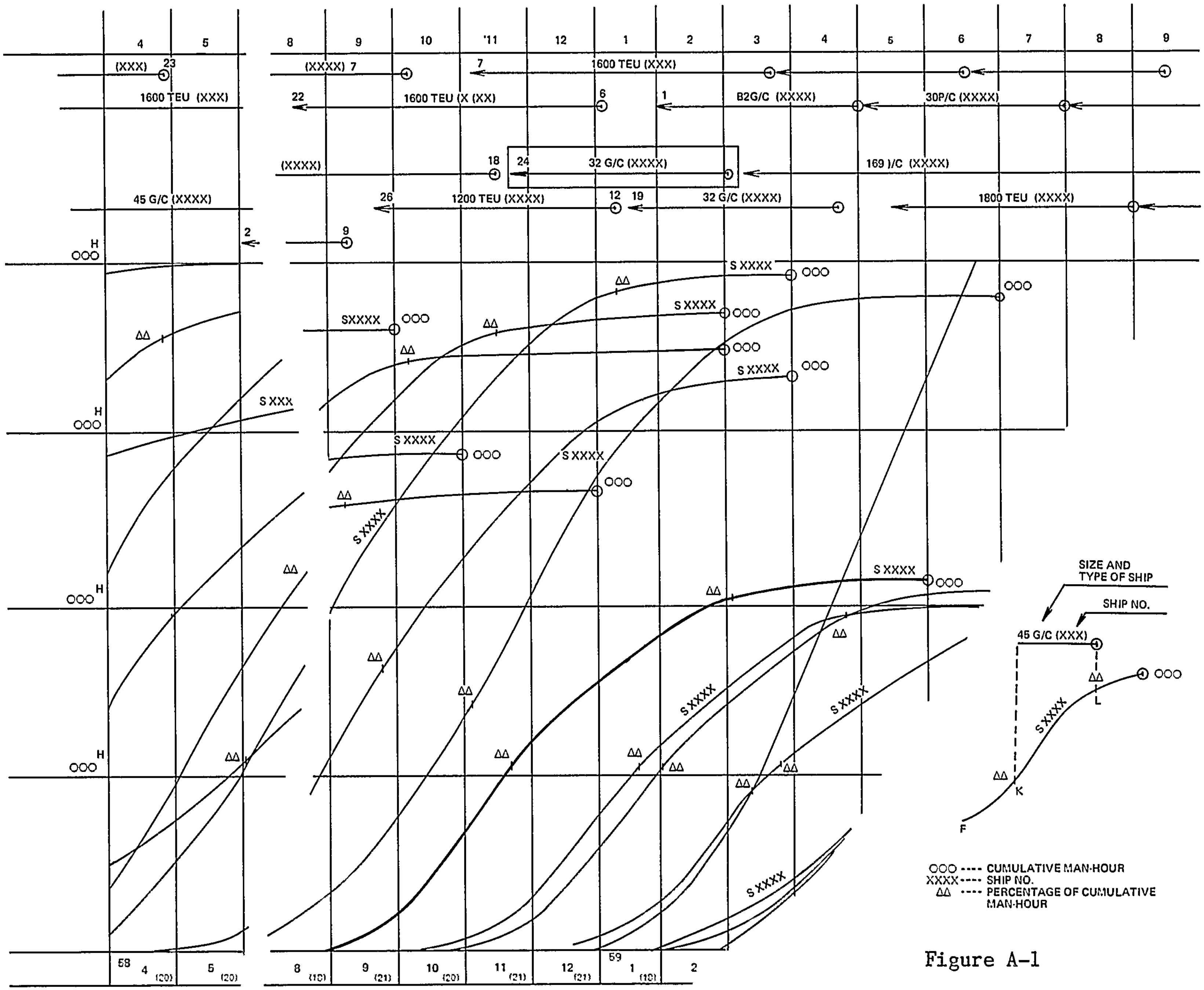
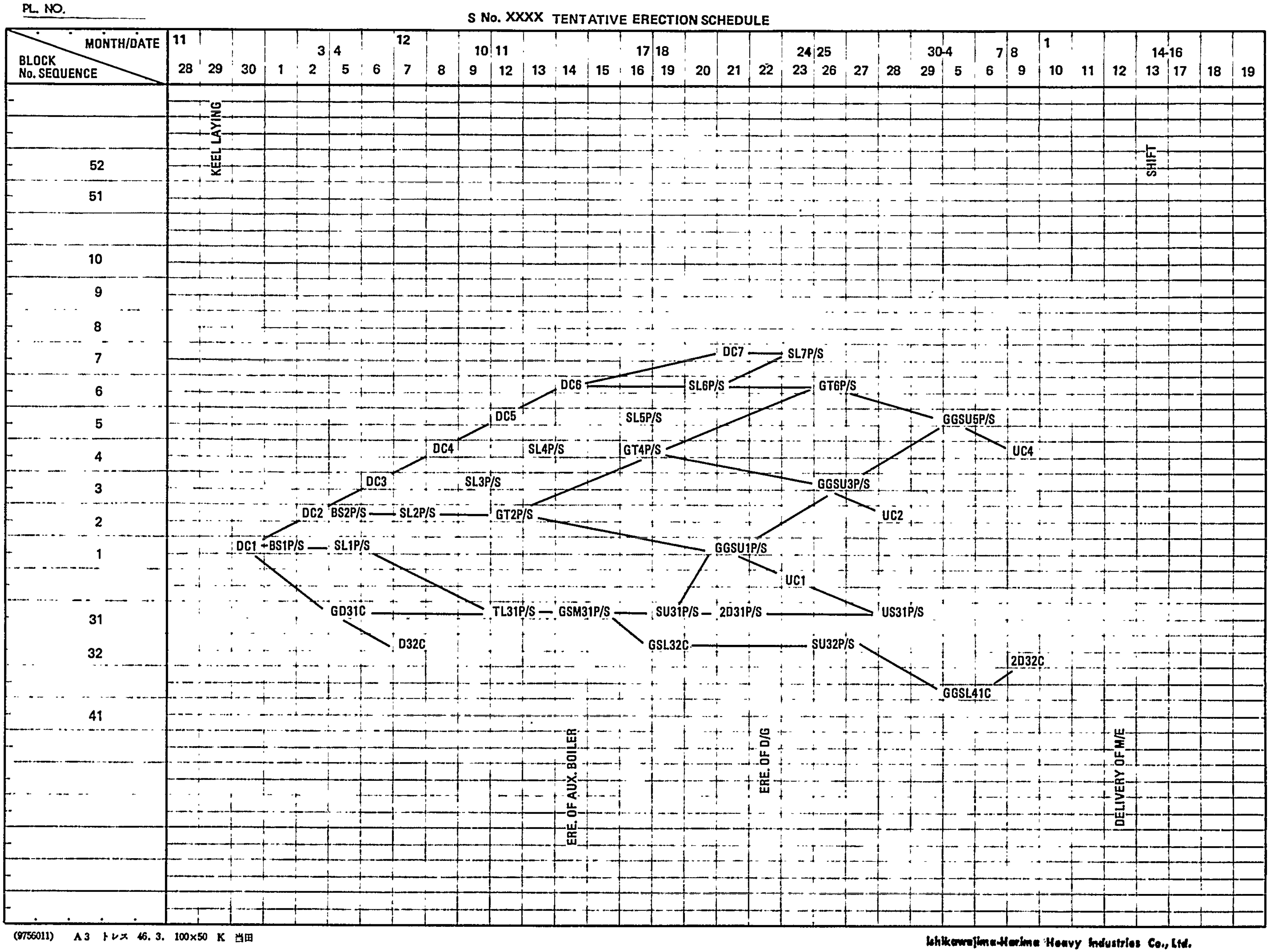
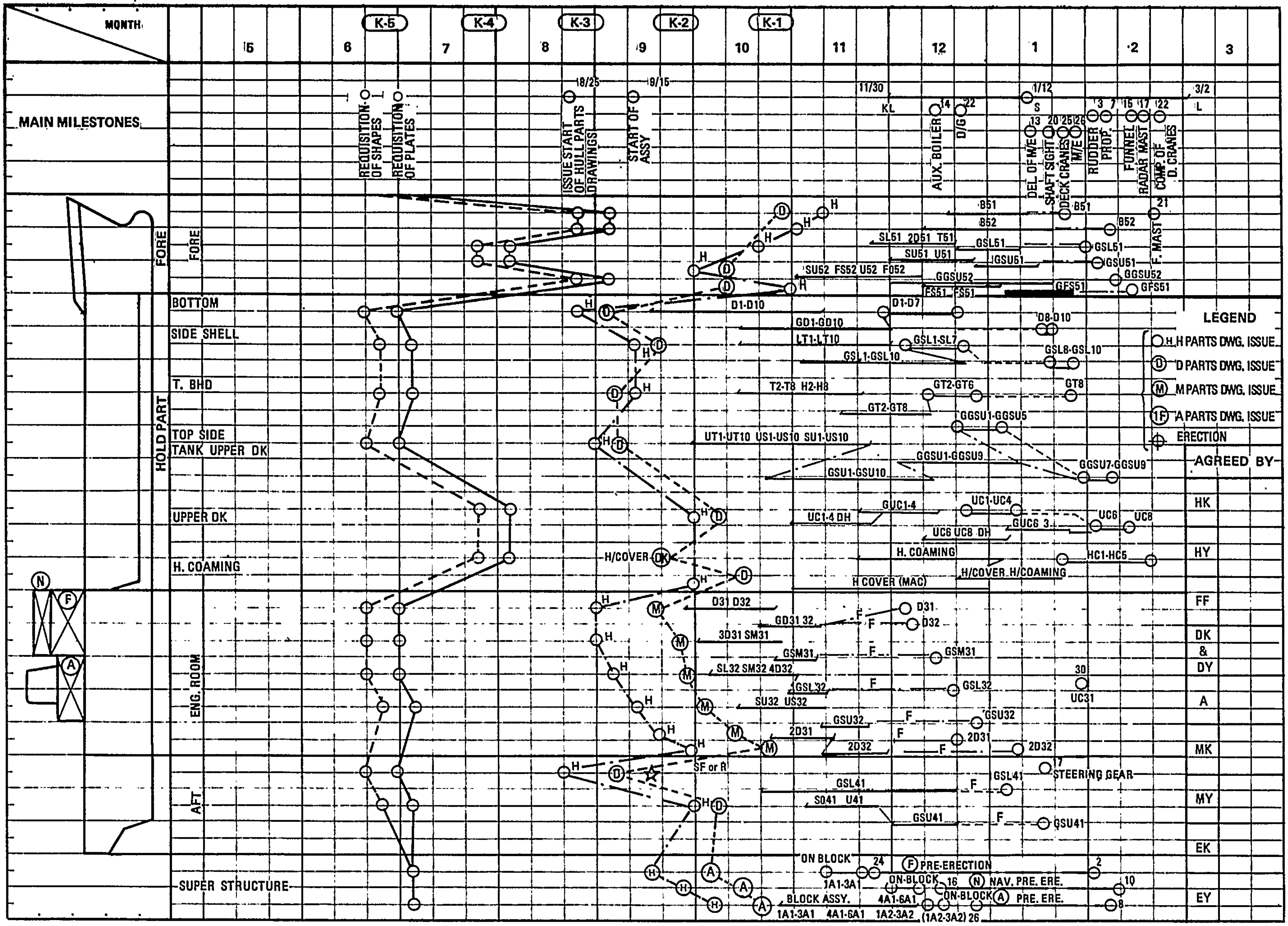


Figure A-1


PL. NO.
S No. XXXX TENTATIVE ERECTION SCHEDULE
MONTH/DATE
BLOCK No. SEQUENCE
11 28 29 30 1 2 3 4 5 6 12 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30-4 5 6 7 8 9 1 10 11 12 13 14-16 17 18 19
52
51
10
9
8
7
6
5
4
3
2
1
31
32
41
KEEL LAYING
SHIFT
DC1
BS1P/S
SL1P/S
DC2
BS2P/S
SL2P/S
GT2P/S
DC3
SL3P/S
DC4
SL4P/S
GT4P/S
DC5
SL5P/S
DC6
SL6P/S
GT6P/S
DC7
SL7P/S
GGSU5P/S
UC4
GGSU3P/S
UC2
GGSU1P/S
UC1
GD31C
TL31P/S
GSM31P/S
SU31P/S
2D31P/S
US31P/S
D32C
GSL32C
SU32P/S
GGSL41C
2D32C
ERE. OF AUX. BOILER
ERE. OF D/G
DELIVERY OF M/E
(9756011) A 3 トレス 46. 3. 100×50 K 当田
Ishikawajima-Harima Heavy Industries Co., Ltd.
Figure A-2

PL. NO.

S No.XXXX HULL CONSTRUCTION ACTIVITIES TIMING SCHEDULE



(9756011) A3 トレス 46. 3. 100×50 K 当田

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Figure A-3

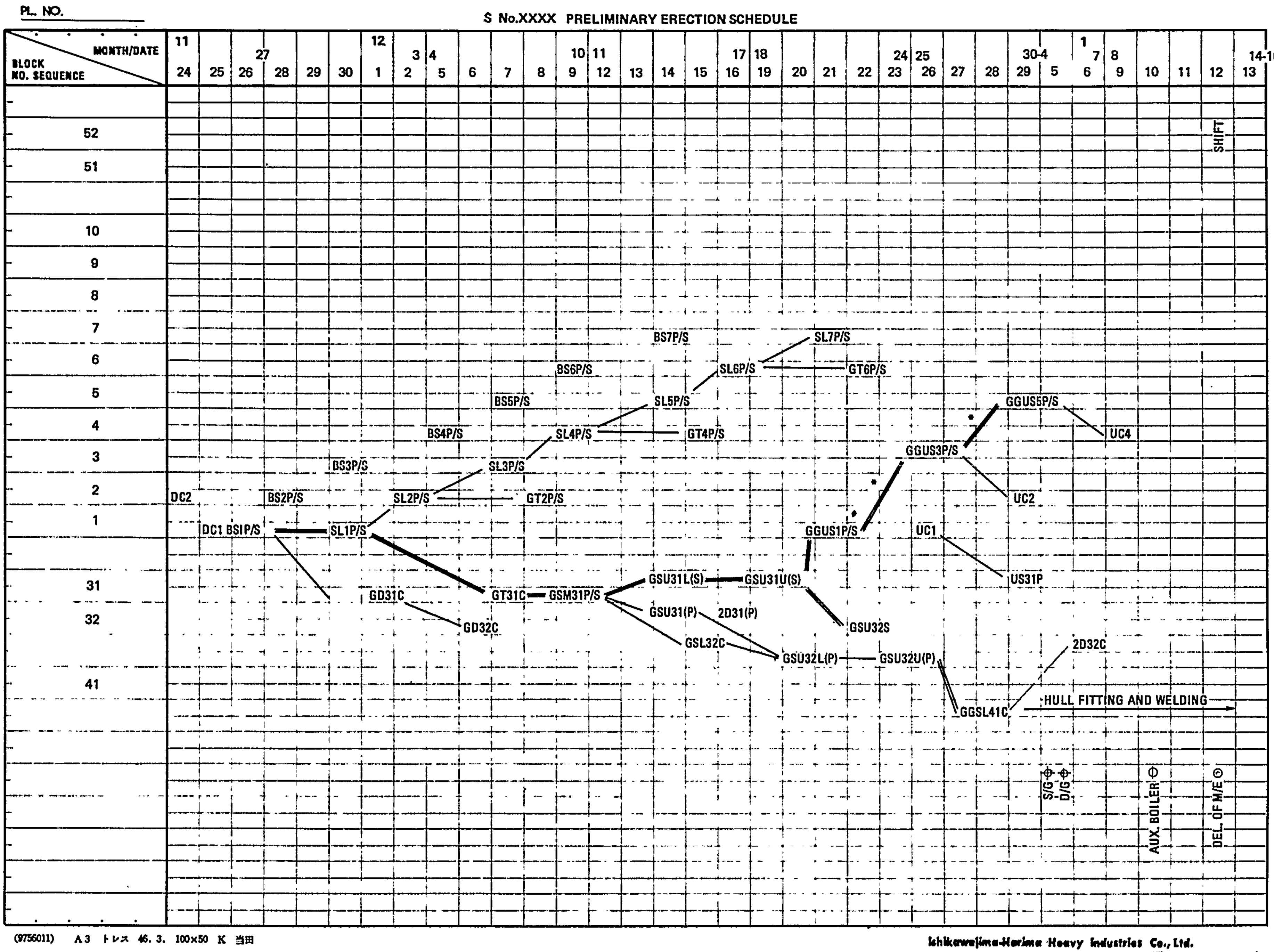
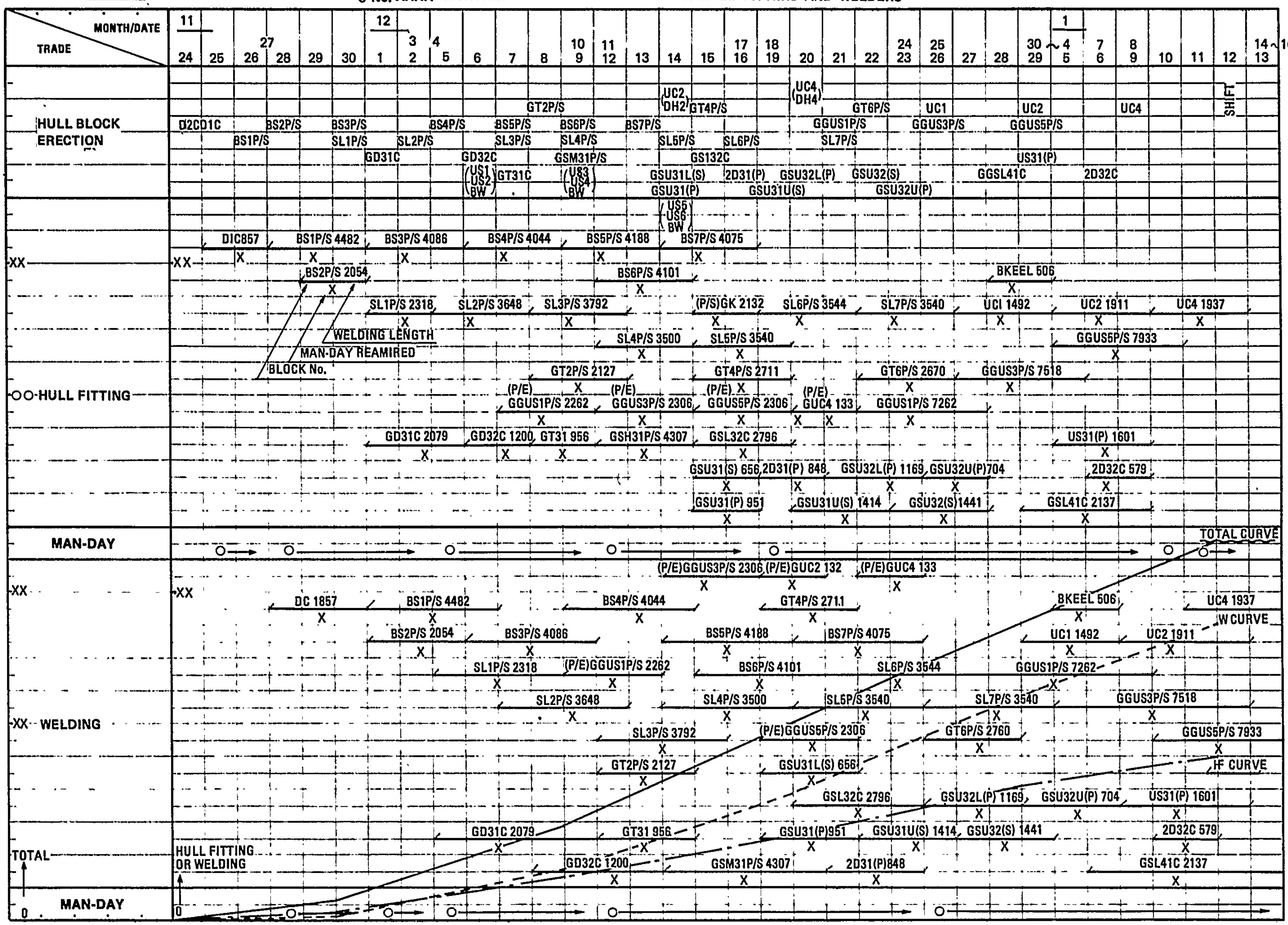

PL. NO.
S No.XXXX PRELIMINARY ERECTION SCHEDULE
MONTH/DATE
BLOCK NO. SEQUENCE
52
51
10
9
8
7
6
5
4
3
2
1
31
32
41
SHIFT
BS7P/S
SL7P/S
BS6P/S
SL6P/S
GT6P/S
BS5P/S
SL5P/S
GGUS5P/S
BS4P/S
SL4P/S
GT4P/S
UC4
BS3P/S
SL3P/S
GGUS3P/S
DC2
BS2P/S
SL2P/S
GT2P/S
UC2
DC1 BS1P/S
SL1P/S
GGUS1P/S
UC1
GSU31L(S)
GSU31U(S)
US31P
GD31C
GT31C
GSM31P/S
GSU31(P)
2D31(P)
GSU32S
GD32C
GSL32C
GSU32L(P)
GSU32U(P)
2D32C
HULL FITTING AND WELDING
GGSL41C
S/G
D/G
AUX. BOILER
DEL. OF M/E
(9756011) A3 トレス 46. 3. 100×50 K 当田
Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-4

PL. NO.

S No. XXXX MONTHLY ERECTION SCHEDULE FOR HULL FITTERS AND WELDERS



A-6

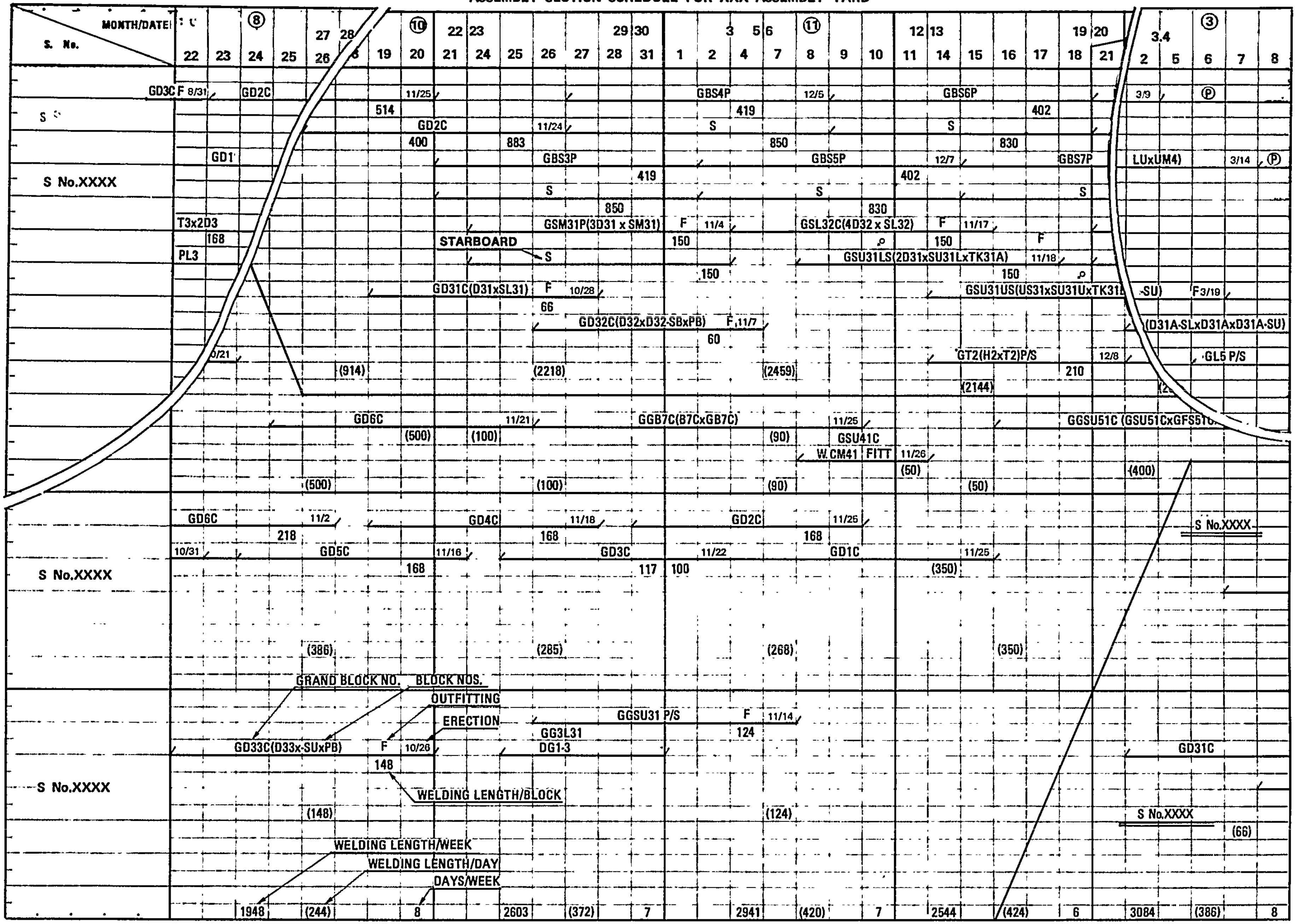
(9756011) A3 トレス 46. 3. 100×50 K 当田

Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-5

PL No.

ASSEMBLY SECTION SCHEDULE FOR XXX ASSEMBLY YARD



A-7

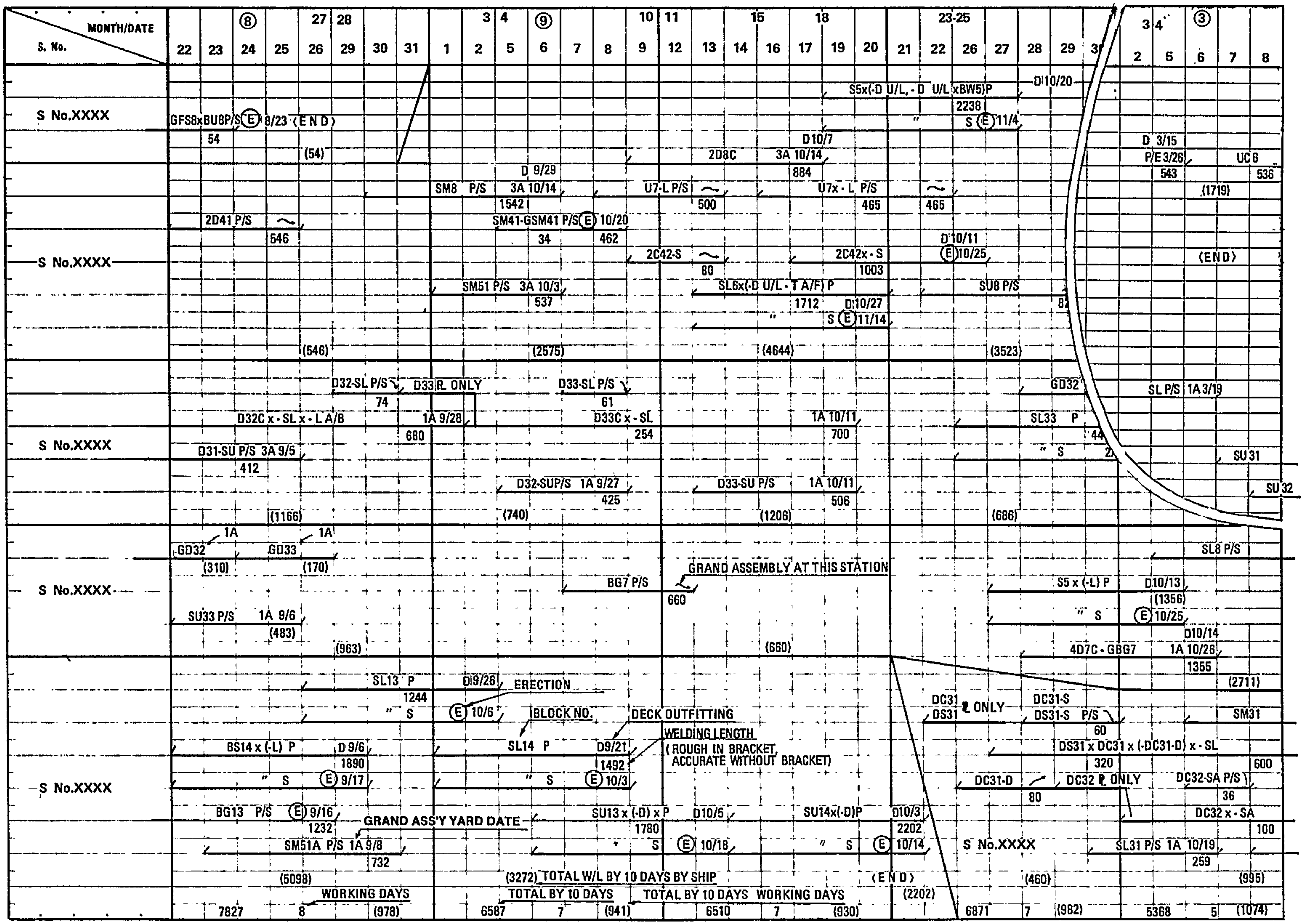
(9756011) A3 トレス 46. 3. 100×50 K 当田

Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-6

PL. NO.

ASSEMBLY SECTION SCHEDULE FOR X X ASSEMBLY YARD



(9756011) A3 トレス 46. 3. 100×50 K 当田

Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-7

XX ASSEMBLY YARD MONTHLY SCHEDULE

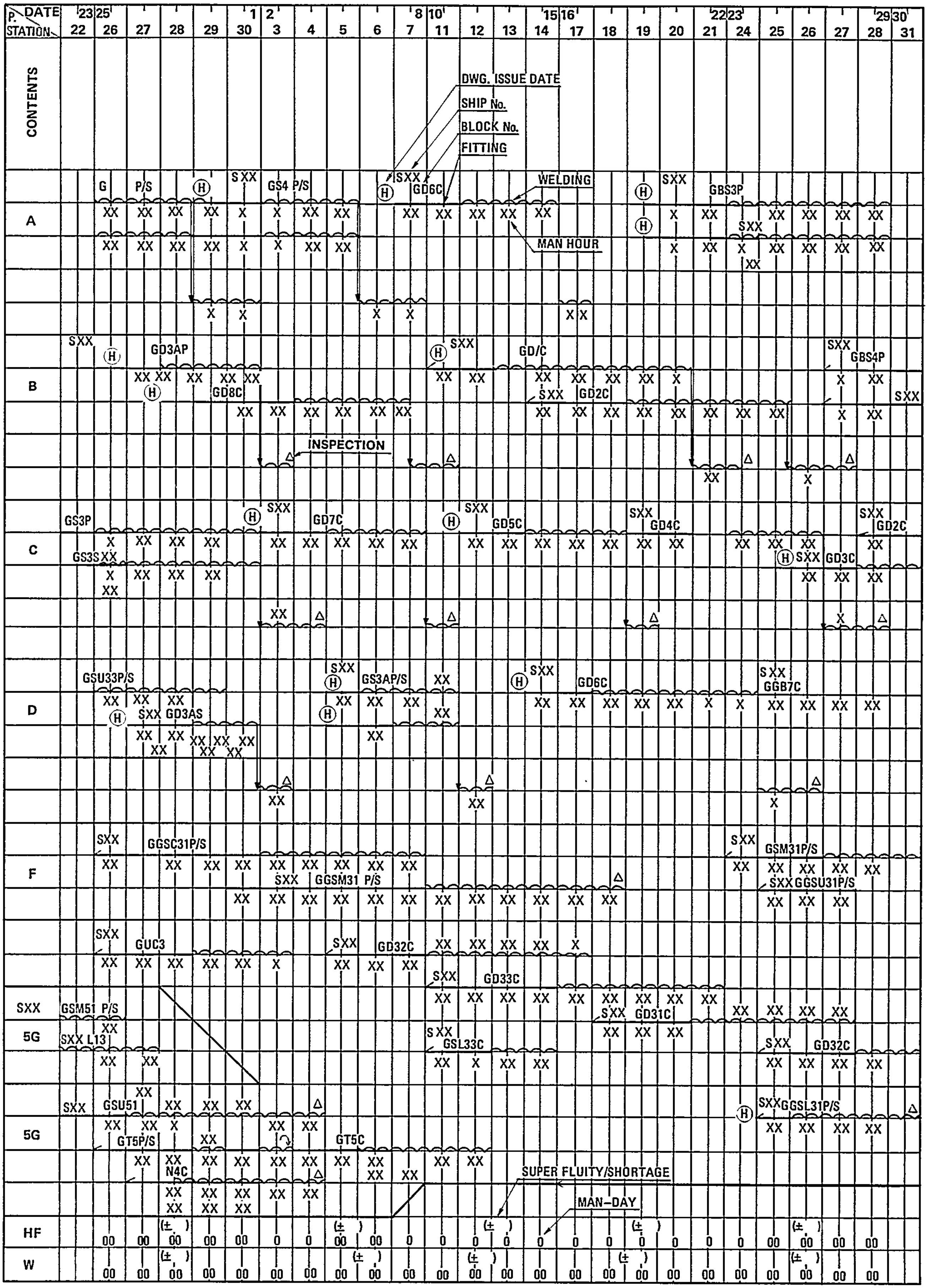


Figure A-8

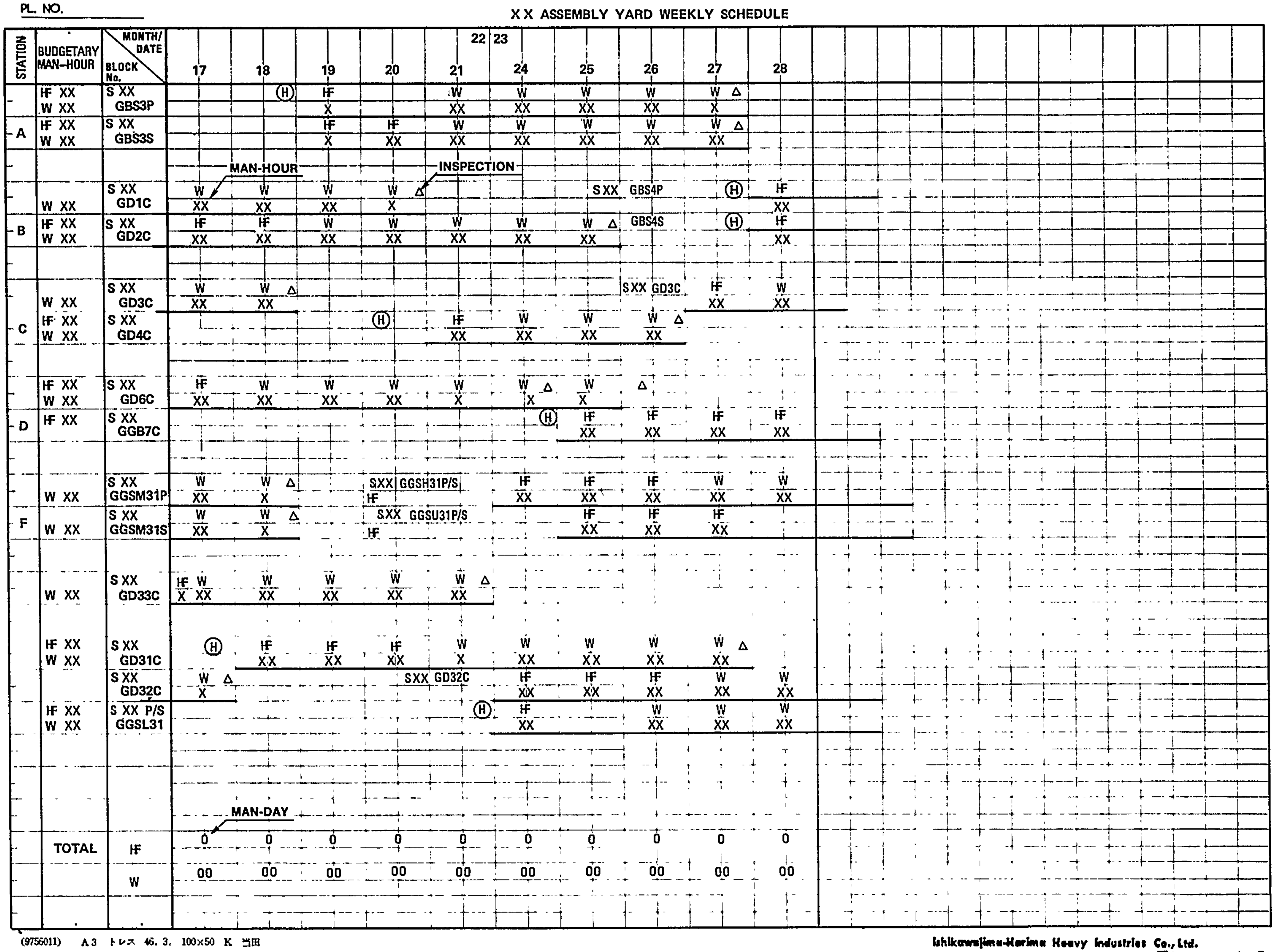
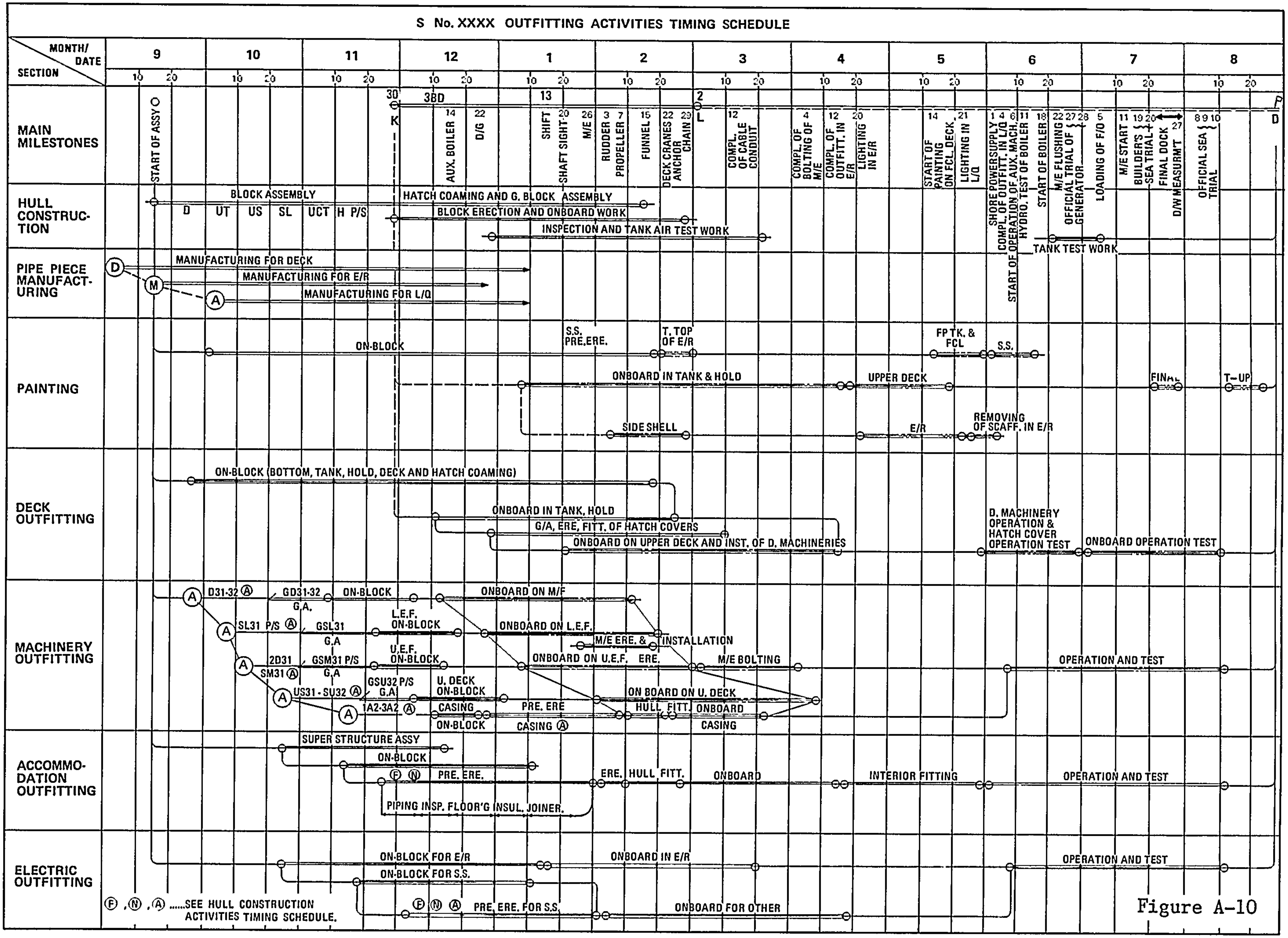

PL. NO.
XX ASSEMBLY YARD WEEKLY SCHEDULE
STATION
BUDGETARY MAN-HOUR
MONTH/DATE
BLOCK No.
17
18
19
20
21
22
23
24
25
26
27
28
A
B
C
D
F
S XX GBS3P
S XX GBS3S
MAN-HOUR
INSPECTION
S XX GD1C
S XX GBS4P
S XX GD2C
GBS4S
S XX GD3C
SXX GD3C
S XX GD4C
S XX GD6C
S XX GGB7C
S XX GGSM31P
SXX GGSH31P/S
S XX GGSM31S
SXX GGSU31P/S
S XX GD33C
S XX GD31C
S XX GD32C
SXX GD32C
S XX P/S GGSL31
MAN-DAY
TOTAL
HF
W
(9756011) A3 トレス 46. 3. 100×50 K 当田
Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-9



S No. XXXX OUTFITTING ACTIVITIES TIMING SCHEDULE
MONTH/ DATE
SECTION
9
10
11
12
1
2
3
4
5
6
7
8
MAIN MILESTONES
START OF ASSY
AUX. BOILER
D/G
SHIFT
SHAFT SIGHT
M/E
RUDDER
PROPELLER
FUNNEL
DECK CRANES
ANCHOR CHAIN
COMPL. OF CABLE CONDUIT
COMPL. OF BOLTING OF M/E
COMPL. OF OUTFITT. IN E/R
LIGHTING IN E/R
START OF PAINTING ON FCL DECK
LIGHTING IN L/Q
SHORE POWERSUPPLY
COMPL. OF OUTFITT. IN L/Q
START OF OPERATION OF AUX. MACH.
HYDRO. TEST OF BOILER
START OF BOILER
M/E FLUSHING
OFFICIAL TRIAL OF GENERATOR
LOADING OF F/O
M/E START
BUILDER'S SEA TRIAL
FINAL DOCK
D/W MEASURMT
OFFICIAL SEA TRIAL
HULL CONSTRUC-TION
BLOCK ASSEMBLY
D
UT
US
SL
UCT
H P/S
HATCH COAMING AND G. BLOCK ASSEMBLY
BLOCK ERECTION AND ONBOARD WORK
INSPECTION AND TANK AIR TEST WORK
TANK TEST WORK
PIPE PIECE MANUFACT-URING
MANUFACTURING FOR DECK
MANUFACTURING FOR E/R
MANUFACTURING FOR L/Q
PAINTING
ON-BLOCK
S.S. PRE.ERE.
T. TOP OF E/R
FP TK. & FCL
S.S.
ONBOARD IN TANK & HOLD
UPPER DECK
FINAL
T-UP
SIDE SHELL
E/R
REMOVING OF SCAFF. IN E/R
DECK OUTFITTING
ON-BLOCK (BOTTOM, TANK, HOLD, DECK AND HATCH COAMING)
ONBOARD IN TANK, HOLD
G/A, ERE, FITT. OF HATCH COVERS
ONBOARD ON UPPER DECK AND INST. OF D. MACHINERIES
D. MACHINERY OPERATION & HATCH COVER OPERATION TEST
ONBOARD OPERATION TEST
MACHINERY OUTFITTING
D31-32
GD31-32
G.A.
ON-BLOCK
ONBOARD ON M/F
SL31 P/S
GSL31
G.A
L.E.F. ON-BLOCK
ONBOARD ON L.E.F.
M/E ERE. &
INSTALLATION
2D31
SM31
GSM31 P/S
G.A
U.E.F. ON-BLOCK
ONBOARD ON U.E.F.
ERE.
M/E BOLTING
OPERATION AND TEST
US31 - SU32
GSU32 P/S
G.A
U. DECK ON-BLOCK
ON BOARD ON U. DECK
1A2-3A2
CASING
ON-BLOCK
PRE. ERE
CASING
HULL FITT.
ONBOARD CASING
ACCOMMO-DATION OUTFITTING
SUPER STRUCTURE ASSY
ON-BLOCK
PRE. ERE.
ERE.
HULL FITT.
ONBOARD
INTERIOR FITTING
OPERATION AND TEST
PIPING INSP. FLOOR'G INSUL. JOINER.
ELECTRIC OUTFITTING
ON-BLOCK FOR E/R
ONBOARD IN E/R
OPERATION AND TEST
ON-BLOCK FOR S.S.
PRE. ERE. FOR S.S.
ONBOARD FOR OTHER
F, N, A ......SEE HULL CONSTRUCTION ACTIVITIES TIMING SCHEDULE.

Figure A-10

PL. NO.

S No.XXXX ONBOARD OUTFITTING ACTIVITIES TIMING SCHEDULE

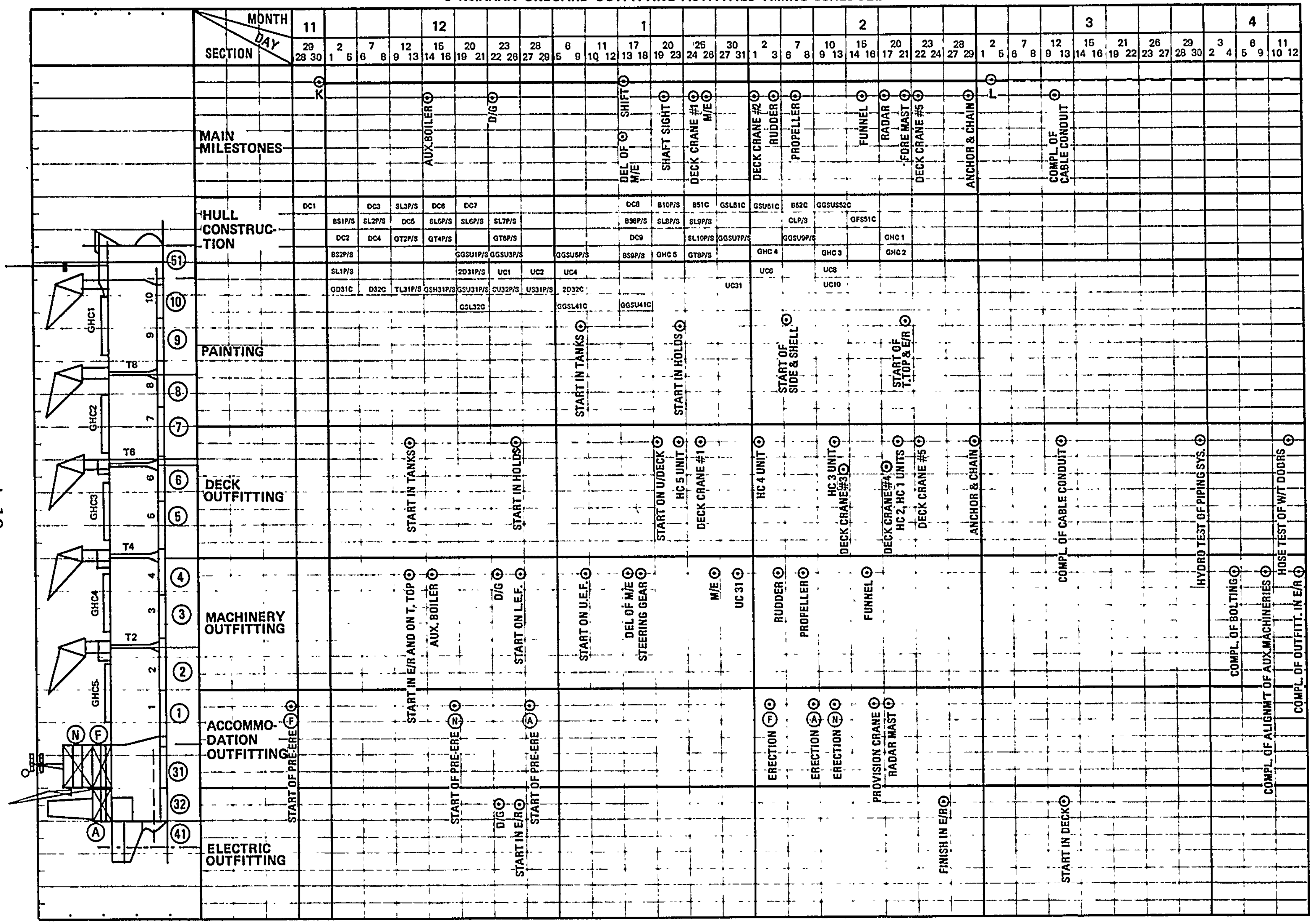


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Figure A-11

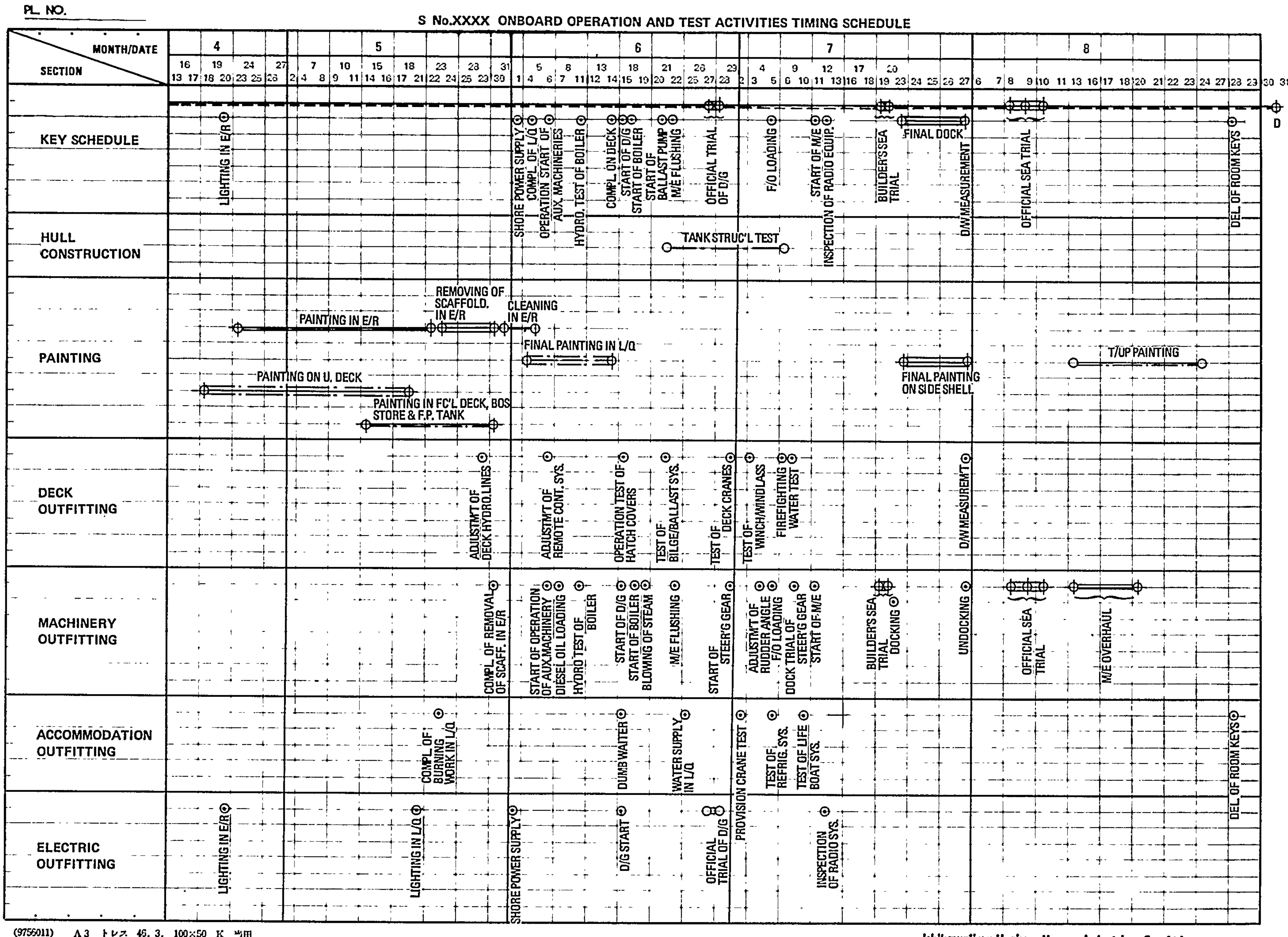
PL. NO.
S No.XXXX ONBOARD OPERATION AND TEST ACTIVITIES TIMING SCHEDULE
MONTH/DATE
SECTION
4
5
6
7
8
KEY SCHEDULE
LIGHTING IN E/R
SHORE POWER SUPPLY
COMPL. OF L/Q
OPERATION START OF AUX. MACHINERIES
HYDRO. TEST OF BOILER
COMPL. ON DECK
START OF D/G
START OF BOILER
START OF BALLAST PUMP
M/E FLUSHING
OFFICIAL TRIAL OF D/G
F/O LOADING
START OF M/E
INSPECTION OF RADIO EQUIP.
BUILDER'S SEA TRIAL
FINAL DOCK
D/W MEASUREMENT
OFFICIAL SEA TRIAL
DEL. OF ROOM KEYS
D
HULL CONSTRUCTION
TANK STRUC'L TEST
PAINTING
PAINTING IN E/R
REMOVING OF SCAFFOLD. IN E/R
CLEANING IN E/R
FINAL PAINTING IN L/Q
PAINTING ON U. DECK
PAINTING IN FC'L DECK, BOS STORE & F.P. TANK
FINAL PAINTING ON SIDE SHELL
T/UP PAINTING
DECK OUTFITTING
ADJUSTM'T OF DECK HYDRO.LINES
ADJUSTM'T OF REMOTE CONT. SYS.
OPERATION TEST OF HATCH COVERS
TEST OF BILGE/BALLAST SYS.
TEST OF DECK CRANES
TEST OF WINCH/WINDLASS
FIREFIGHTING WATER TEST
D/W MEASUREMENT
MACHINERY OUTFITTING
COMPL. OF REMOVAL OF SCAFF. IN E/R
START OF OPERATION OF AUX.MACHINERY
DIESEL OIL LOADING
HYDRO TEST OF BOILER
START OF D/G
START OF BOILER
BLOWING OF STEAM
M/E FLUSHING
START OF STEER'G GEAR
ADJUSTM'T OF RUDDER ANGLE
F/O LOADING
DOCK TRIAL OF STEER'G GEAR
START OF M/E
BUILDER'S SEA TRIAL
DOCKING
UNDOCKING
OFFICIAL SEA TRIAL
M/E OVERHAUL
ACCOMMODATION OUTFITTING
COMPL. OF BURNING WORK IN L/Q
DUMB WAITER
WATER SUPPLY IN L/Q
PROVISION CRANE TEST
TEST OF REFRIG. SYS.
TEST OF LIFE BOAT SYS.
DEL. OF ROOM KEYS
ELECTRIC OUTFITTING
LIGHTING IN E/R
LIGHTING IN L/Q
SHORE POWER SUPPLY
D/G START
OFFICIAL TRIAL OF D/G
INSPECTION OF RADIO SYS.
(9756011) A3 トレス 46. 3. 100×50 K 当田
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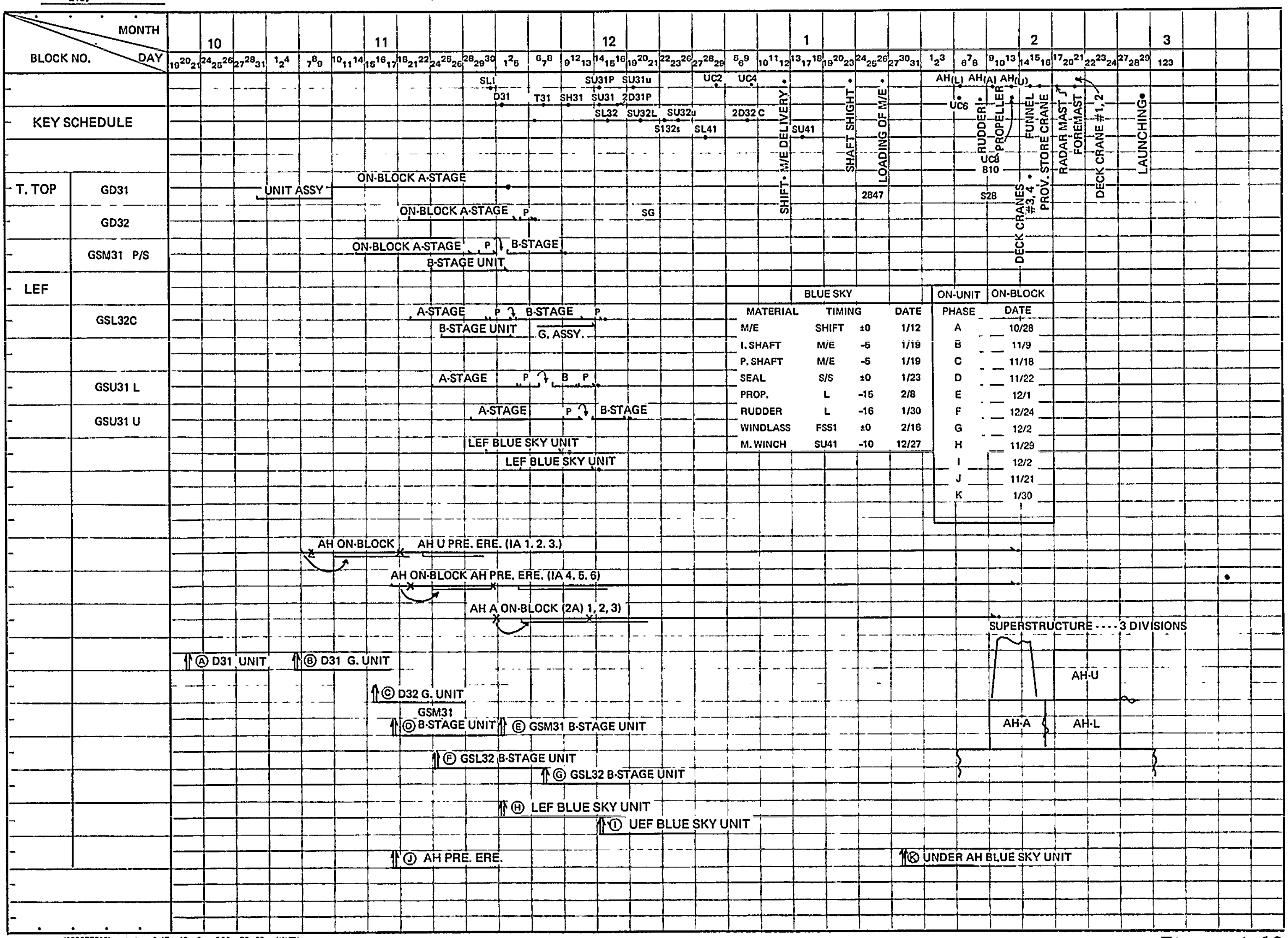
Figure A-12

PL. No.

S NO. XXXX IMPORTANT MATERIAL NEED DATE SCHEDULE



BLUE SKY			
MATERIAL	TIMING		DATE
M/E	SHIFT	±0	1/12
I. SHAFT	M/E	-5	1/19
P. SHAFT	M/E	-5	1/19
SEAL	S/S	±0	1/23
PROP.	L	-15	2/8
RUDDER	L	-16	1/30
WINDLASS	FS51	±0	2/16
M. WINCH	SU41	-10	12/27

ON-UNIT	ON-BLOCK
PHASE	DATE
A	10/28
B	11/9
C	11/18
D	11/22
E	12/1
F	12/24
G	12/2
H	11/29
I	12/2
J	11/21
K	1/30

(099875602) A 3 上45 49. 1. 100×30 K (当田)

Figure A-13

S. No.

IMPORTANT MATERIAL NEED DATE TABLE

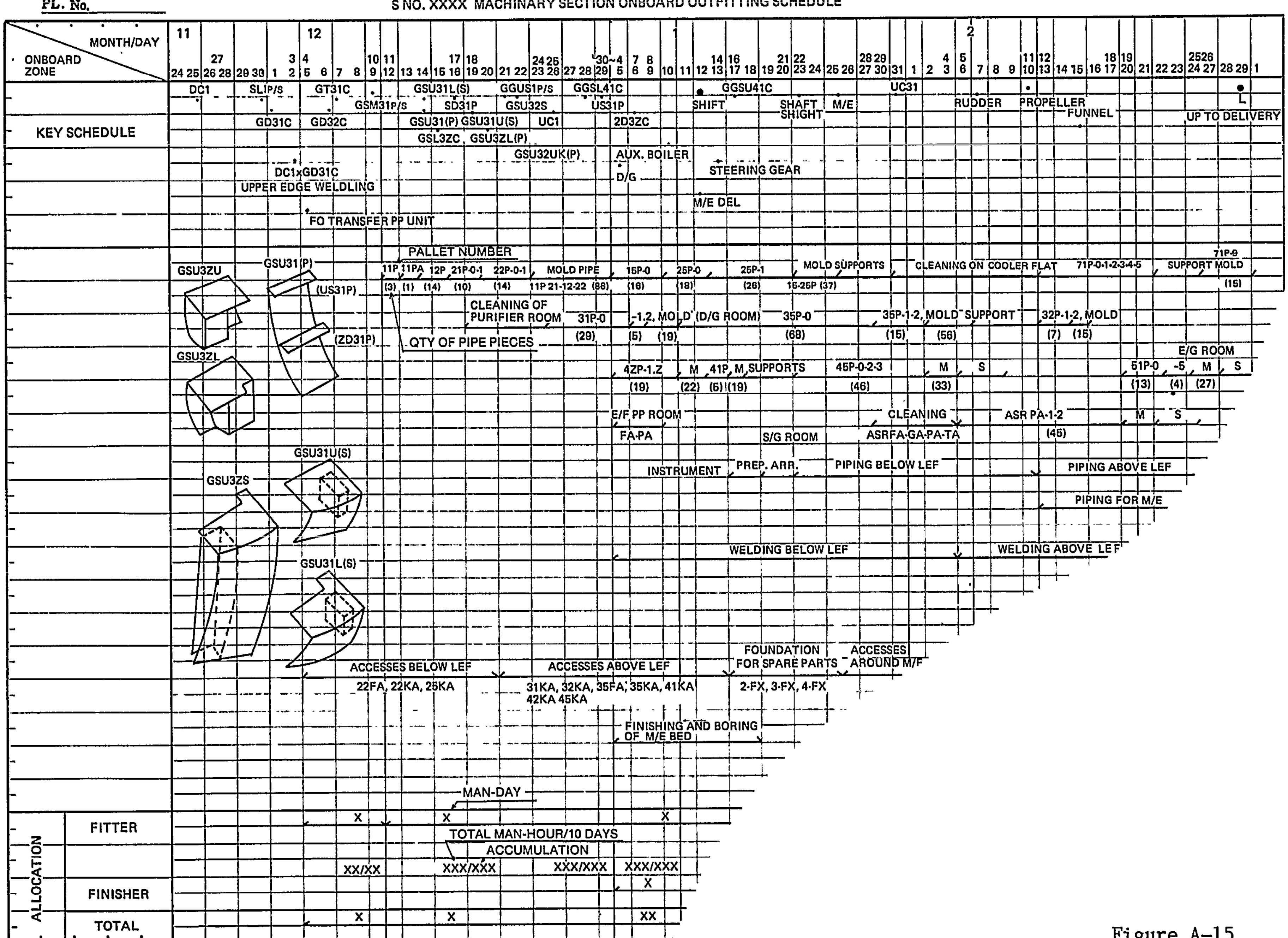
D.W.G. NO.	DESCRIPTIONS	Q'TY.	N. DATE	N. DATE COND. ALT. COND.	N. PACKAGE	XXXX								
						ORIG.	ALT 1	ALT 2						
XXXXXXXX	MAIN DIESEL ENGINE			SLIDE ± o		1/13	1/13	1/12						
XXXXXXXX	MAIN DIESEL GENERATOR		△2	SU32 E-2 2D32c E-1		12/23	12/19	1/5						
XXXXXXXX	ELECT. BALLANCER			SU41 E-2			59 1/12	1/12						
XXXXXXXX	SHAFT GENERATOR			M/E E-2			39 1/24	1/24						
XXXXXXXX	AUX. BOILER		△2	 2D32c E-3		12/14	12/9	12/28						
XXXXXXXX	EXH. GAS ECONOMIZER			J + 10		12/18	12/1	12/5						
XXXXXXXX	INTERMEDIATE SHAFT			M/E E-5		1/6	1/19	1/19						
XXXXXXXX	PROPELLER SHAFT			M/E E-5										
XXXXXXXX	PROPELLER			L-15		2/8	2/10	2/8						
XXXXXXXX	STERN TUBE BEARING			S.S ±10		1/12	1/20	1/23						
XXXXXXXX	STERN TUBE SEAL ASS'Y			S.S ±10										

S.S. ···· SHAFT CENTER SIGHTING

Figure A-14

PL. No.

S NO. XXXX MACHINARY SECTION ONBOARD OUTFITTING SCHEDULE

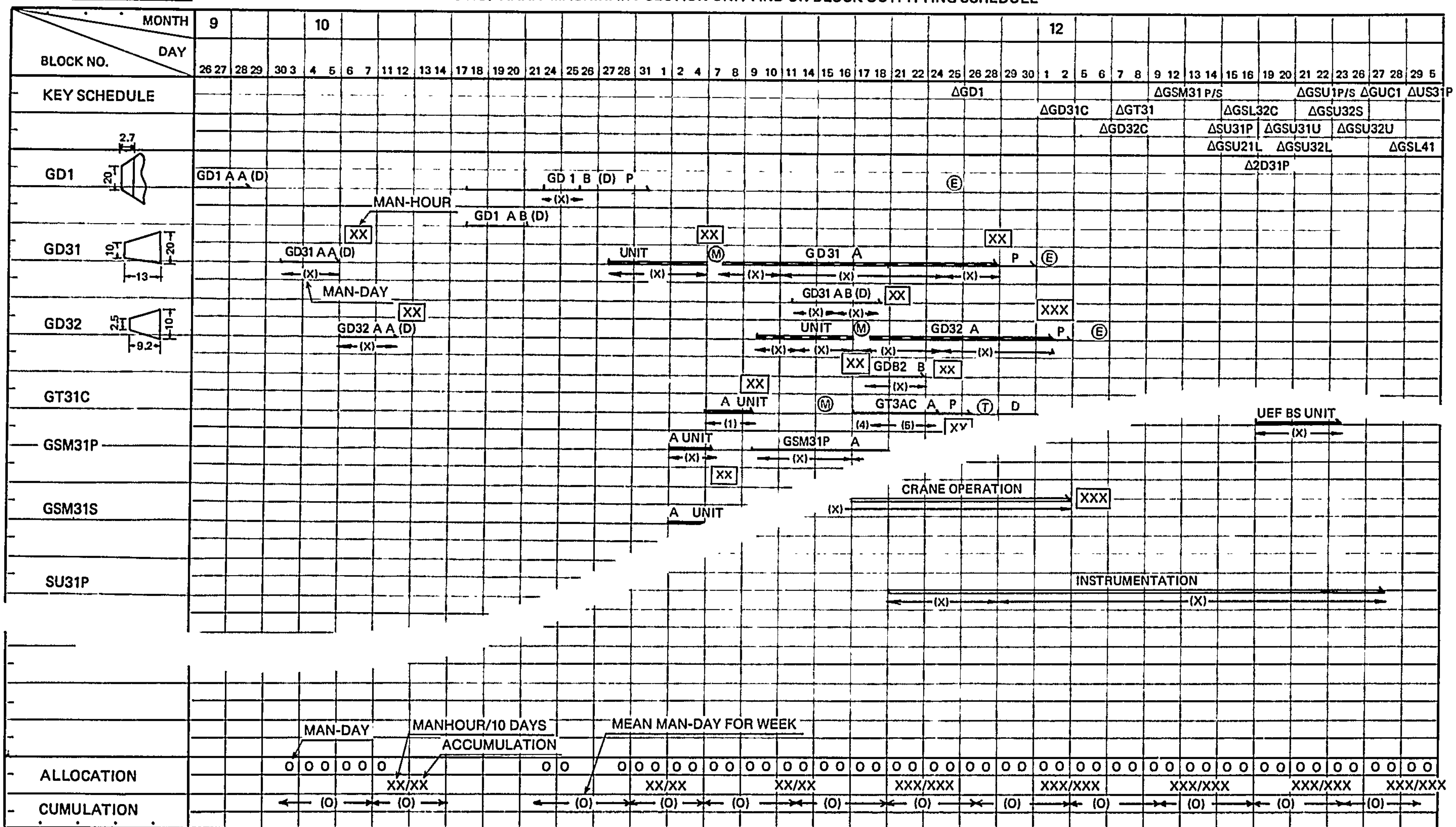


(099875602) A3 上45 49. 1. 100×30 K (当田)

Figure A-15

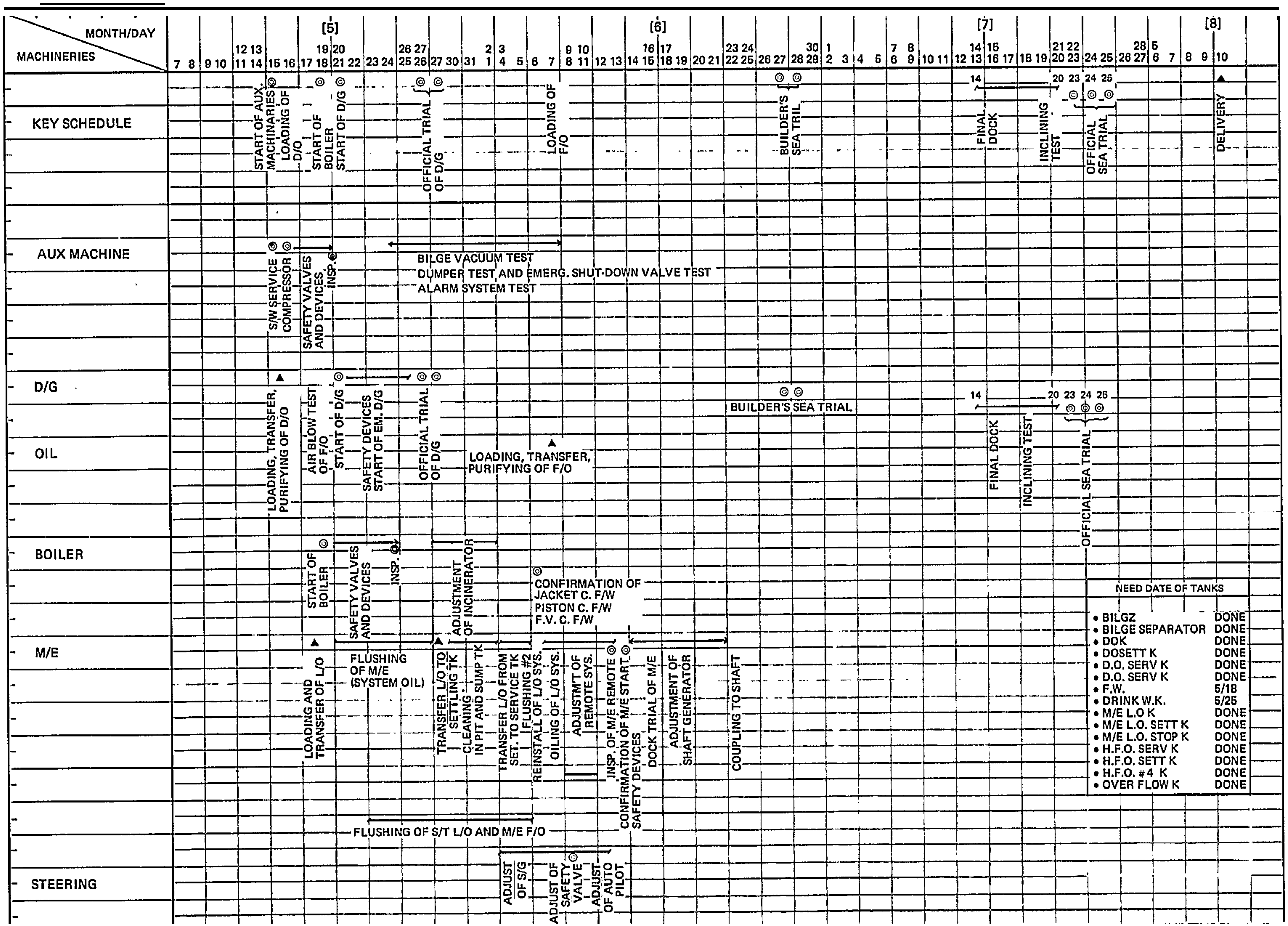
PL. No.

S NO. XXXX MACHINARY SECTION UNIT AND ON-BLOCK OUTFITTING SCHEDULE



(099875602) A3 上45 49. 1. 100×30 K (当田)

Figure A-16


MONTH/DAY
MACHINERIES
[5]
[6]
[7]
[8]
KEY SCHEDULE
START OF AUX. MACHINARIES
LOADING OF D/O
START OF BOILER
START OF D/G
OFFICIAL TRIAL OF D/G
LOADING OF F/O
BUILDER'S SEA TRIL
FINAL DOCK
INCLINING TEST
OFFICIAL SEA TRIAL
DELIVERY
AUX MACHINE
S/W SERVICE COMPRESSOR
SAFETY VALVES AND DEVICES, INSP.
BILGE VACUUM TEST
DUMPER TEST AND EMERG. SHUT-DOWN VALVE TEST
ALARM SYSTEM TEST
D/G
LOADING, TRANSFER, PURIFYING OF D/O
AIR BLOW TEST OF F/O
START OF D/G
SAFETY DEVICES START OF EM. D/G
OFFICIAL TRIAL OF D/G
BUILDER'S SEA TRIAL
FINAL DOCK
INCLINING TEST
OFFICIAL SEA TRIAL
OIL
LOADING, TRANSFER, PURIFYING OF F/O
BOILER
START OF BOILER
SAFETY VALVES AND DEVICES
INSP.
ADJUSTMENT OF INCINERATOR
CONFIRMATION OF JACKET C. F/W PISTON C. F/W F.V. C. F/W
M/E
LOADING AND TRANSFER OF L/O
FLUSHING OF M/E (SYSTEM OIL)
TRANSFER L/O TO SETTLING TK
CLEANING IN PIT AND SUMP TK
TRANSFER L/O FROM SET. TO SERVICE TK
REINSTALL OF L/O SYS. (FLUSHING #2)
OILING OF L/O SYS.
ADJUSTM'T OF REMOTE SYS.
INSP. OF M/E REMOTE
CONFIRMATION OF M/E START SAFETY DEVICES
DOCK TRIAL OF M/E
ADJUSTMENT OF SHAFT GENERATOR
COUPLING TO SHAFT
FLUSHING OF S/T L/O AND M/E F/O
STEERING
ADJUST OF S/G
ADJUST OF SAFETY VALVE
ADJUST OF AUTO PILOT
NEED DATE OF TANKS
• BILGZ DONE
• BILGE SEPARATOR DONE
• DOK DONE
• DOSETT K DONE
• D.O. SERV K DONE
• D.O. SERV K DONE
• F.W. 5/18
• DRINK W.K. 5/25
• M/E L.O K DONE
• M/E L.O. SETT K DONE
• M/E L.O. STOP K DONE
• H.F.O. SERV K DONE
• H.F.O. SETT K DONE
• H.F.O. #4 K DONE
• OVER FLOW K DONE

(099875602)

SNO. XXXX, XXXX GROUP OO

WEEKLY SCHEDULE (ON-BLOCK)

MONTH/DAY	(17)	(18)	(21)	(22)	(24)	(25)	(26)	(28)	(29)	(30)	12/(1)	12/(2)
KEY SCHEDULE												
NEED DATE OF PALLETS AND PREPARATION OF TOOLS		S NO. XXXX	XZD31S-0 XZD31S-1	X098-1 X117-0 X117-1 X117-2	X098-0 X115-0 X117-3, 4, 5	Y096-0 X171-0 X173-0 YM3501-0, 1 X031-0		X136-0 X186-0 XUS31S-0, 1	YM3501-8	X176-0 X099-0 X099-1	BZXGSU41P-O 41S-O B4XZAZP-O	
BLOCK NO. / WORKERS NAMES												
D31		FLOOR PLATES, REACH RODS, HANDRAILS					TO ONBOARD					
D32		B4YM13GH	14GH	13K0~2	14K-0~2				TO ONBOARD			
D33		B4YM15P-0~9	YH15K-0~3	YM15GH-0								
						UNIT		B4Y096-0		GT3ICA	B4X099-1	
D31		B4Y 053-0	B4Y 037-0	B4Y 054-0	B4Y 081-0	B4YH11P-0~4	B4YM12P-C~4		11K-0 12K-0			
D32		B4Y 061-0	B4Y 116-0	B4YM 15P-1~4	B4YM15K-0							
SU(A)			B4XZD31S-0 B4XZD31S-1		B4X098-0 B4X115-0		SM(B) (P)	B4X 171-0 B4X 173-0		B4X 186-0		B4XZAZP-0 CH
SM(B) (S)				B4X098-1	B4X 117-0	117-1	117-2	117-3	117-4	117-5	B4X099-0	
						SL32(B) C	B4YM 3501-0 B4X031-0		3501-1 B4X136-0	3501-8		SU41C(A) BZXGSU41PO SO
								SU31U (A)	B4XUS31 S-0 S-1		SU3ZS B4X176-0	
MAN-DAY B/A												
MAN-HOUR B/A												
GROUP'S EVENTS												
PATROL AFTER WORK												
CRANE SCHEDULE												

OO XXXX

28D

XXXX

OO XXXX UNIT

Figure A-18

S. No. XXXX WEEKLY SCHEDULE (ON-BOARD OUTFITTING) SECTION XXX GROUP XXX

MONTH/DAY		2/6	2/7	2/8	2/9	2/10	2/13	C.C.
PALLET NEED DATE & EVENTS / NAME		BM71P --0--4 --1--5 --2 --3	ZM42P ZM45P		3Z MEETING CH ERECTION			
XX		ZM 12P-9) 18 PCS. (MOLDED) ZM 11P-9)			VALVE 2 PCS. T4ZM71P--0 2 pcs T4ZM71P--1 3 pcs	T4ZM71--2 20 pcs.		
		B4X186 1 pc. B4X171 4 pcs.				VALVE 1 PCS. B/FLANGE 1 PCS.		
XX		ZM41P	ASSY T4BZD3ZC-D	PIPE 18 PCS.	ASSY T4BZD32C-1		ZM4ZP--0, ZM45P--0	
		(MOLDED)		VALVES 7 PCS.	PIPE 12 pcs. VALVE 7 pcs.			
XX		ZM25KA--0 2 pcs	FLOOR PLATE 2 pcs.	ZM7KA--1 INC. LADDAR	ASSY T4BZD32C		ZM45KA--0	
		ZM22FA--0 TROLLEY BEAM		TELBX				
XX		ZM31P--9	45 PCS.	IN WAY OF COMPRESSOR		ASSY COMPRESSOR		
XX			ZM35P--0	94 PCS.				
XX			T2ZASRPA-1	PIPE 40 PCS.	VALVES 18 pcs.	SIGHTGLASS 1 pcs.		
ALLOC.	XXXX	X	X	X	X	X	X	
	XXXX	X	X	X	X	X	X	

Figure A-19

S. No. XXXX WEEKLY SCHEDULE (OPERATION AND TEST) SECTION XXX GROUP XXX

MONTH/DAY	5/28	29	30	31	1	2	C.C.
KEY SCHEDULE / NAME			D/G OFFICIAL TRIAL				
M/E XX	TAKING OUT OF AND LANDING OF OIL	PREPARATION OF FLUSHING No. 2		INSP. CLEANING	FILL. OF L/O FROM L/O SETT. TK TO SUMP TK.		
XX		PREPARATION OF F/O FLUSHING		FLUSHING			
AUX. XX		COMPRESSOR SAFETY DEVICE	INSP. BILGE SUCTION TEST	INSP. DUMPER OPER.	INSP. EMERG. SHUT-DOWN VALVE	INSP.	
BOILER XX			INSP. BOILER SAFETY DEVICE	INCINERATOR ADJUSTMENT INSP.			
	INSP. CLEANING OF EMER. D/G F/O TK	EMER. D/G START D/O 5 DRUMS L/O 40 lit.	6/4 OFF. SEA TRIAL				
ALLOC. XX	X	X	X	X	X	X	
ALLOC. XX	X	X	X	X	X	X	

Figure A-20

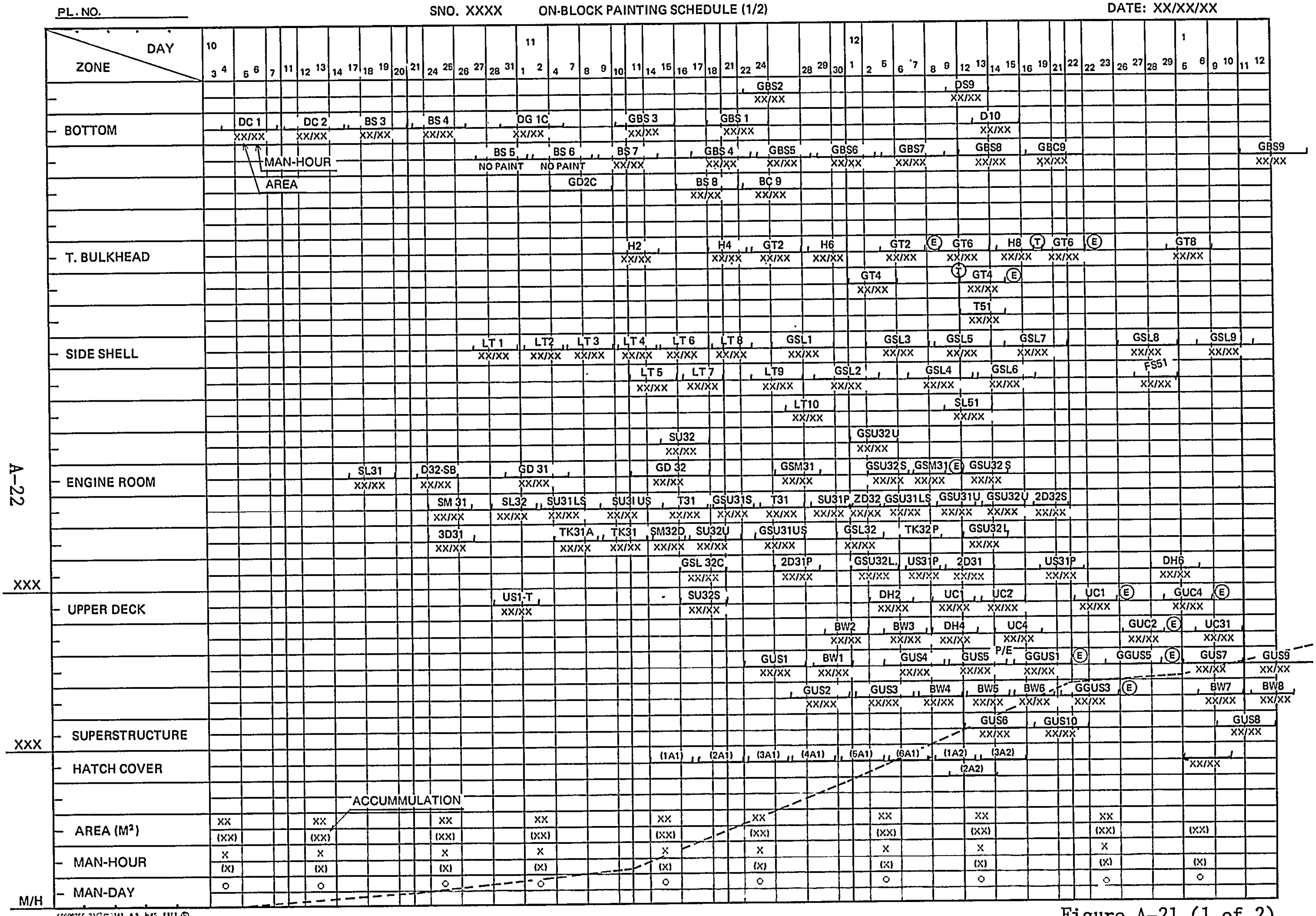


Figure A-21 (1 of 2)

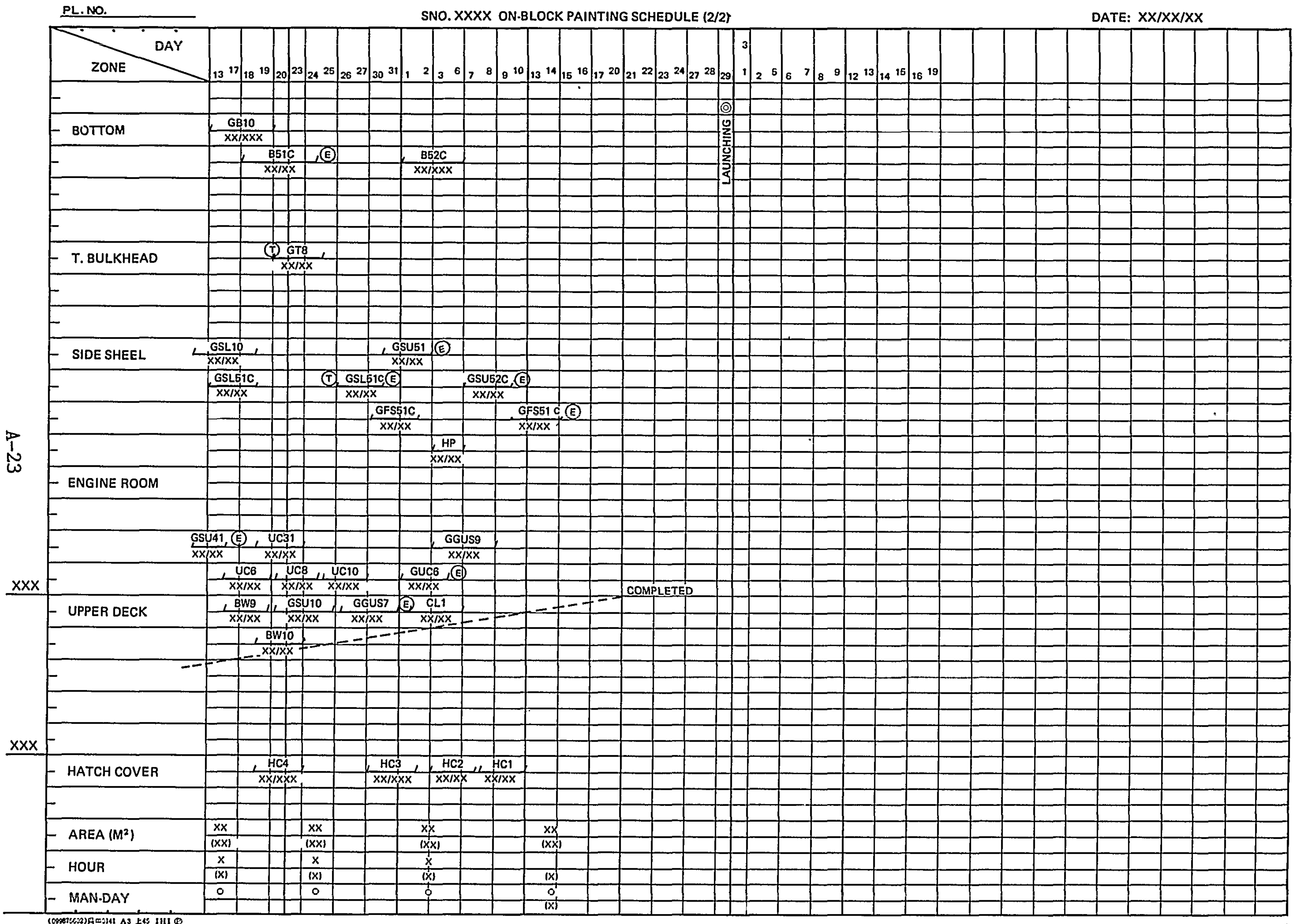


Figure A-21 (2 of 2)

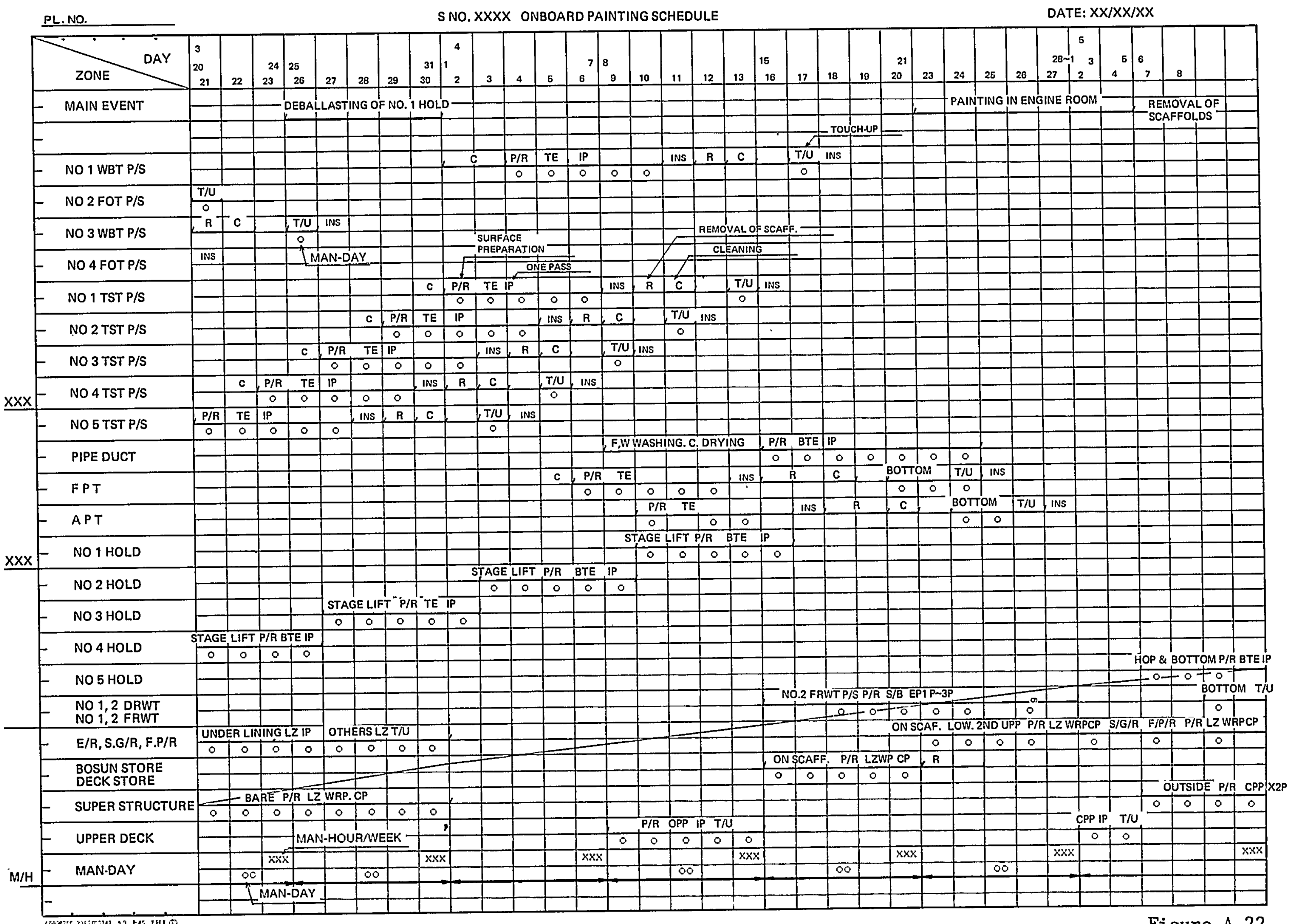
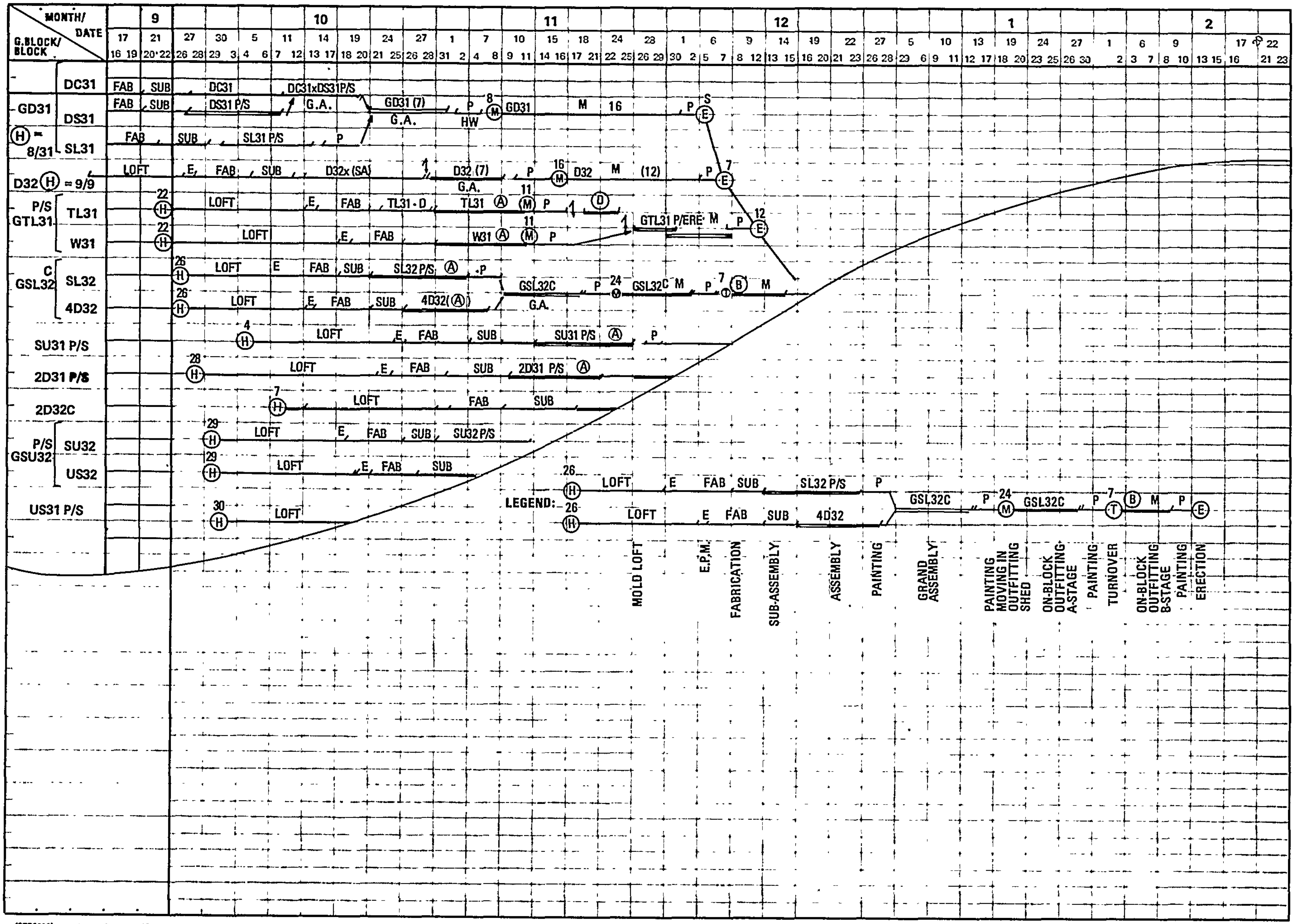

PL. NO.
S NO. XXXX ONBOARD PAINTING SCHEDULE
DATE: XX/XX/XX
DAY
ZONE
MAIN EVENT
DEBALLASTING OF NO. 1 HOLD
PAINTING IN ENGINE ROOM
REMOVAL OF SCAFFOLDS
TOUCH-UP
NO 1 WBT P/S
NO 2 FOT P/S
NO 3 WBT P/S
NO 4 FOT P/S
NO 1 TST P/S
NO 2 TST P/S
NO 3 TST P/S
NO 4 TST P/S
NO 5 TST P/S
PIPE DUCT
F P T
A P T
NO 1 HOLD
NO 2 HOLD
NO 3 HOLD
NO 4 HOLD
NO 5 HOLD
NO 1, 2 DRWT
NO 1, 2 FRWT
E/R, S.G/R, F.P/R
BOSUN STORE
DECK STORE
SUPER STRUCTURE
UPPER DECK
MAN-DAY
MAN-DAY
SURFACE PREPARATION
ONE PASS
REMOVAL OF SCAFF.
CLEANING
F,W WASHING. C. DRYING
BOTTOM
STAGE LIFT P/R BTE IP
STAGE LIFT P/R TE IP
HOP & BOTTOM P/R BTE IP
NO.2 FRWT P/S P/R S/B EP1 P~3P
ON SCAF. LOW. 2ND UPP P/R LZ WRPCP S/G/R F/P/R P/R LZ WRPCP
UNDER LINING LZ IP
OTHERS LZ T/U
ON SCAFF. P/R LZWP CP
OUTSIDE P/R CPP X2P
BARE P/R LZ WRP. CP
P/R OPP IP T/U
CPP IP T/U
MAN-HOUR/WEEK
XXX
M/H

Figure A-22

PL. NO.

S No. XXXX PRELIMINARY IHOP SCHEDULE



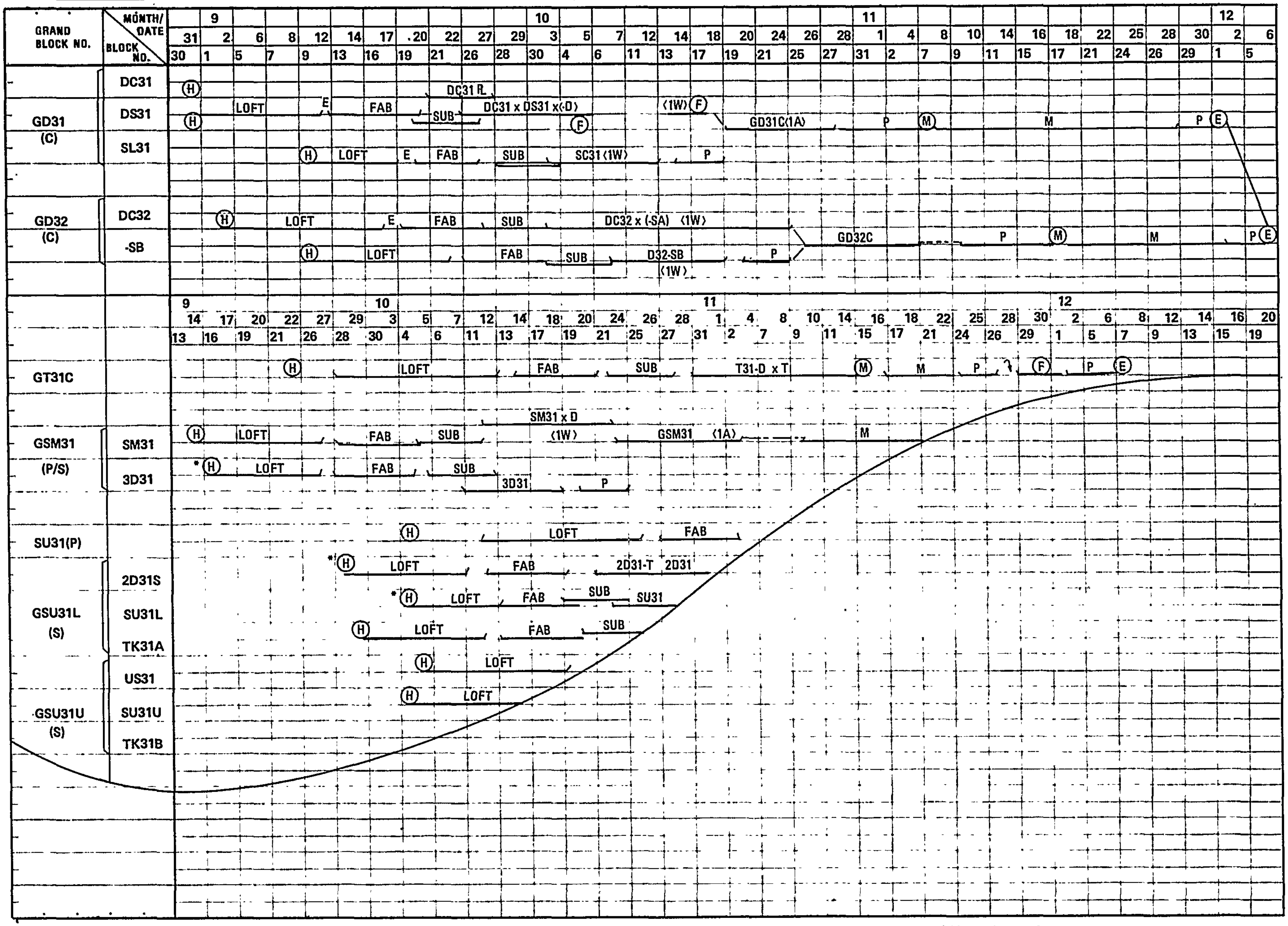
(9756011) A3 トレス 46. 3. 100×50 K 当田

Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-23

PL. NO.

S No.XXXX DEFINITIVE IHOP SCHEDULE



(9756011) A3 トレス 46. 3. 100×50 K 当田

Ishikawajima-Harima Heavy Industries Co., Ltd.

Figure A-24

PL. NO. ____________

S NO. XXXX ON-BLOCK PAINTING WEEKLY SCHEDULE

DATE: XX/XX/XX

BLOCK	PROCESS YARD	10/27	28	29	30	31	11/1	2	3	4	5	6
		KINDS OF PAINTING AND PAINTING										
GD1C	1A	P/R TEAC P/R DTE P/ROK P/R TB XX XX (X) XX XXX	VTAC 1P ~ 2P 2XXX ○			TE T/U BTE T/U SPAF 1P~2P (X) 2XX	SPAF 3P XX (X)					
GD2C	1A		MAN-HOUR AREA x 2			P/R TEAC P/R BTE P/R TE P/R RPO XX XX (X) XX XX	VTAC 1P ~ 2P 2XX (X)	BTE TE T/U SPAP 1P ~ 2P (X) 2XX		SPAP 3P XX (X)		
GBS3 P/S	1A											
GBS4 P/S	2W	TE T/U										
GBS7 P/S	2W											
LT 1 P/S	2W		P/R TE P/R BTE P/R LZ XX XX (X)			TE, ETE T/U WRP 1P (X) XX						
LT 2 P/S	2W						P/R TE P/R BTE XX XX (X)			TE, BTE T/U (X)		
LT 3 P/S	2W							P/R BTE, P/R TE XX (X) XX		TE, BTE T/U (X)		
LT 4 P/S	2W									P/R TE P/R BTE XX XX (X)		
LT 5 P/S	2W											
GD31	1A		INS.			P/R TEAC P/R TE P/R BTE P/R RPO XX XX XX XX (X)	VTAC 1P ~ 2P 2XX (X)	TE ETE T/U SPAF 1P ~ 2P (X)		INS. SPAF 3P XX (X)		
GD32	1A											
SM31 P/S	1A	P/R TEAC P/R EAC P/R TE P/R LZ XX XX (X) XX XX	TAC 1P EAC2P WRP 1P XX XX (X) XX									
3D31 P/S	SUBCON	P/RTE P/R LZ XX (X) XX										
SU31LS	1W									P/R EA P/R CAC P/R LZ XX XX (X)		
TK31A	2A											
SL32 P/S	1W					P/R TEAC P/R EAC P/R LZ XX (X) XX XX	VTAC1P EAC 2P WRP 1P XX XX XX (X)	EBT 1P XX (X)				
US1-T P/S	SUBCON	P/R BTE P/R LZ XX (X) XX	WRP 1P, ETE T/U XX (X)									
P/R AREA		XXXX	XXXX			XXXX	XXX	XXX				
PAINTING AREA		XXXX	XXXX			XXX	XXXX	XXX		XXX		
AREA/DAY		XXX	XXX			XXX	XXX	XXX		XXX		
MAN-DAY		OO	OO			OO	OO	OO				

(099875032)月∩0141 A3 上45 1H1 ©

Figure A-25

SNO. XXXX ONBOARD PAINTING WEEKLY SCHEDULE

DATE: PREPARED BY:

ZONE \ DAY		3 (3) SAT	(4) SUN	5 MON	6 TUE	7 WED	8 THU	9 FRI	(10) SAT	(11) SUN	12 MON	13 TUE	14 WED	15 THU	16 FRI	17 SAT
KEY SCHEDULE																
NO. 4 WBT (P)	P/R = ISC-B			DE-RUST	DE-RUST	B GRADE INS. PAINT	T/U	INS. ON STAFF			REMOVAL OF SCAFF. CLEAN.	REMOVAL OF SCAFF. CLEAN.	T/U		INS.	
	P = TEISO μ			O	O	O	O	O					O		O	
AREA X R = HOURS (P/R) AREA X R = HOURS (P)																
NO. 4 WBT(S)				CLEANING	CLEANING	DE-RUST	DE-RUST	B GRADE INS. PAINT			T/U	INS.	REMOVAL OF SCAFF. CLEAN	REMOVAL OF SCAFF. CLEAN	T/U	
						O	O	O			O					
AREA X R = HOURS (P/R) AREA X R = HOURS (P)																
E/R W.B. TANK	P/R = ISC-B WBT			WBT	DE-RUST	B GRADE INS. PAINT	T/U	INS.								
	P = TEISOμ			O	O	O	O	O								
AREA X R = HOURS (P/R) AREA X R = HOURS (P)																
AREA X R = HOURS(P/R)	P/R = ISC–B							DE-RUST			DE-RUST	B GRADE INS. PAINT	T/U	INS.		
AREA X R = HOURS(P)	P = TEISOμ							O			O	O	O			
AREA X R = HOURS(P/R)	P/R = ISC–B									LOT	DE-RUST	B GRADE INS. PAINT	T/U	INS.		
AREA X R = HOURS(P)	P = OIL COAT										O	O				
INSIDE OF SUPERSTRUCTURE	P/R = ICC–B						2ND OK ~ NAV DK DE-RUST	2ND OK ~ NAV DK PAINT		→	DE-RUST →	DE-RUST →	PAINT →	DE-RUST →	INS.	
	P = LZIP						O	O			O	O	O	O	O	
AREA X R = HOURS(P/R) AREA X R = HOURS(P)																
MAN-DAY				O	O	OO	OO	OO								

Figure A-26

******** WEEKLY WORK LOAD ********

85/09/13

	WEEK	PC.	W/T	RATE	FROM		TO
>	85 094	703	49.9	790.9	85,09,24	-	85,09,29
>	85 095	1,263	50.0	1,139.0	85,09,30	-	85,10,06
>	85 101	560	26.9	358.6	85,10,07	-	85,10,13
	85 102	1,026	34.1	754.3	85,10,14	-	85,10,20
	85 103	1,177	39.4	869.0	85,10,21	-	85,10,27
	85 104	1,343	39.9	1,102.0	85,10,28	-	85,11,04
	85 111	760	24.1	553.2	85,11,05	-	85,11,10
	85 112	889	27.1	692.1	85,11,11	-	85,11,17
	85 113	469	13.2	296.7	85,11,18	-	85,11,24

Figure A-27: Two Week Advance Scheduling. Weekly Work Load. Regarding the top three rows, note that the fourth week in September (85 094) and the first week in October (85 101) are underloaded while the week in between (85 095) is overloaded. Thus, some pallet start dates in the week 095 are advanced to week 094 and some are postponed to week 101 by leveling by PPF; See Figure A-28.

******** LEVELING BY PPF ********

WEEK: 85 095

85/09/13

SNO	PALLET NO.	PC	RATE	WEIGHT	START(O)	START(R)	REVISED
XXXX	T4A2D32P-2	2	0.6	46.4	851003	851003	
XXXX	T4A2D32P-3	9	8.9	163.1	851003	851003	
XXXX	T4A2D32P-4	5	3.4	80.2	851003	851003	
XXXX	T4A2D32S-1	10	6.3	164.8	851003	851003	
YYYY	B4X096---1	10	10.4	165.3	851004	851010	P
YYYY	B4X328---1	6	5.4	54.3	851004	851010	P
XXXX	T3A1A1C--0	17	10.6	316.9	851004	851004	
XXXX	T3A1A1P--0	25	23.1	768.8	851004	851004	
YYYY	T2AH2P---0	1	0.4	5.8	851004	850927	A
YYYY	T2AH2S---0	2	1.3	39.9	851004	850927	A
XXXX	T4A2C32--1	2	1.8	82.9	851004	851004	
XXXX	T4A2C32--3	7	5.1	154.3	851004	851004	
XXXX	T4A2C32--2	4	1.5	163.8	851004	851004	
XXXX	T3A1A1S--0	23	20.7	432.4	851004	851004	
XXXX	T4AGSU33P1	1	1.0	55.8	851004	851004	

(O) - original P - postponed
(R) - revised A - advanced

Figure A-28: Leveling by Pipe Piece Family (PPF).

******** WORK LOAD BY LINE ********

WEEK: 85 095 85/09/13

			RATE		
LINE	PC.	WEIGHT	H1	WH	TOTAL
> PA	154	4459.6	48.2	70.2	118.5
91	15	563.1	7.7	19.1	26.9
41	164	7813.9	82.7	88.2	171.0
12	171	1333.8	49.6	38.0	87.7
11	97	747.2	28.7	28.4	57.2
21	88	5426.6	22.5	25.6	48.2
33	17	29.7	4.2		4.2
01	111	1415.8	22.6	23.5	46.2
> 43	53	26038.9	91.6	277.5	369.2
02	44	478.3	14.2	21.7	35.9
42	73	4541.5	27.1	46.8	73.9
22	24	1819.7	9.4	19.6	29.1
23	28	12494.7	19.7	63.8	83.6
32	33	134.0	4.7	0.1	4.9

******** WORK LOAD BY LINE ********

WEEK: 85 095 85/09/13

			RATE		
LINE	PC.	WEIGHT	H1	WH	TOTAL
> PA	196	19138.8	113.1	253.6	366.9
91	15	563.1	7.7	19.1	26.9
41	164	7813.9	82.7	88.2	171.0
12	171	1333.8	49.6	38.0	87.7
11	97	747.2	28.7	28.4	57.2
21	88	5426.6	22.5	25.6	48.2
33	17	29.7	4.2		4.2
01	111	1415.8	22.6	23.5	46.2
> 43	11	11359.7	26.7	94.1	120.8
02	44	478.3	14.2	21.7	35.9
42	73	4541.5	27.1	46.8	73.9
22	24	1819.7	9.4	19.6	29.1
23	28	12494.7	19.7	63.8	83.6
32	33	134.0	4.7	0.1	4.9

Figure A-29: One Week Advance Scheduling. Weekly Work Load. The upper printout indicates that in-house Line 43 is overloaded. The lower printout shows that some pallets from Line 43 were shifted family by family to subcontractors (Line PA). The status after leveling is shown in the lower printout of both this Figure and Figure A-30.

****** WORK LOAD BY PPF ******

WEEK: 85 094 85/09/13

	********** M **********				********* F/E *********				***** M/F/E *****		
PPFM	LINE	PC.	RATE	WEIGHT	LINE	PC.	RATE	WEIGHT	PC.	RATE	WEIGHT
..	..	.	..	..	..	.	..	..	.	..	..
..	..	.	..	..	..	.	..	..	.	..	..
07B	> 43	7	49.5	1508.1	> 43	17	49.5	3726.7	24	99.0	5234.9
06B					23	26	75.6	9140.8	26	75.6	9140.8
06A					> 43	8	17.1	661.2	8	17.1	661.2
3G0					32	33	4.8	134.0	33	4.8	134.0
09E					43	4	89.0	7514.4	4	89.0	7514.4
08A					> 43	6	54.9	3122.0	6	54.9	3122.0
08E					23	2	7.8	3553.8	2	7.8	3553.8
09B					> 43	4	77.2	5661.0	4	77.2	5661.0
03B	41	6	12.1	150.5	41	8	8.9	139.9	14	21.0	290.4
04A	41	1	1.5	20.5	41	9	14.6	604.8	10	16.1	625.4
0P5	43	1	0.8	192.6	43	3	7.7	728.9	4	8.6	921.6
QG9					11	1	0.4	10.0	1	0.4	10.0
..	..	.	..	..	..	.	..	..	.	..	..
..	..	.	..	..	..	.	..	..	.	..	..
TOTAL		XXX	XXX.X	XXXXX.X		XXX	XXX.X	XXXXX.X	XXX	XXX.X	XXXXX.X

(M - Machinery F - Deck & Accomodation E - Electrical)

****** WORK LOAD BY PPF ******

WEEK: 85 094 85/09/13

	********** M **********				********* F/E *********				***** M/F/E *****		
PPFM	LINE	PC.	RATE	WEIGHT	LINE	PC.	RATE	WEIGHT	PC.	RATE	WEIGHT
..	..	.	..	..	..	.	..	..	.	..	..
..	..	.	..	..	..	.	..	..	.	..	..
07B	> PA	7	49.5	1508.1	> PA	17	49.5	3726.7	24	99.0	5234.9
06B					23	26	75.6	9140.8	26	75.6	9140.8
06A					> PA	8	17.1	661.2	8	17.1	661.2
3G0					32	33	4.8	134.0	33	4.8	134.0
09E					43	4	89.0	7514.4	4	89.0	7514.4
08A					> PA	6	54.9	3122.0	6	54.9	3122.0
08E					> 23	2	7.8	3553.8	2	7.8	3553.8
09B					PA	4	77.2	5661.0	4	77.2	5661.0
03B	41	6	12.1	150.5	41	8	8.9	139.9	14	21.0	290.4
04A	41	1	1.5	20.5	41	9	14.6	604.8	10	16.1	625.4
0P5	43	1	0.8	192.6	43	3	7.7	728.9	4	8.6	921.6
QG9					11	1	0.4	10.0	1	0.4	10.0
..	..	.	..	..	..	.	..	..	.	..	..
..	..	.	..	..	..	.	..	..	.	..	..
TOTAL		XXX	XXX.X	XXXXX.X		XXX	XXX.X	XXXXX.X	XXX	XXX.X	XXXXX.X

Figure A-30: Work Load by Pipe Piece Family (PPF).

MONTH/WEEK: **SMALL BORE PIPE PIECE MANUFACTURING SCHEDULE**

	(F)	(M)	(T)	(W)	(TH)	(F)	(M)
MARKING AND CUTTING	9/3 50$^{\phi}$-157 157	40$^{\phi}$-135 135	40$^{\phi}$-134 134	32$^{\phi}$-27 25$^{\phi}$-40 20$^{\phi}$-36 15$^{\phi}$-27 130	9/4		
JOINING OF STRAIGHT PIPE PIECE	9/3 50$^{\phi}$-90 90	40$^{\phi}$-135 135	40$^{\phi}$-26 26	32$^{\phi}$-4 25$^{\phi}$-29 20$^{\phi}$-28 15$^{\phi}$-18 79	9/4		
WELDING OF STRAIGHT PIPE PIECE	9/3 50$^{\phi}$-90 90	40$^{\phi}$-135 135	40$^{\phi}$-26 26	32$^{\phi}$-4 25$^{\phi}$-29 20$^{\phi}$-28 15$^{\phi}$-18 79	9/4 MONTH/WEEK		
BENDING BY BENDER	9/3 50$^{\phi}$-90 90	50$^{\phi}$-29 40$^{\phi}$-65 94	40$^{\phi}$-92 92	32$^{\phi}$-9 25$^{\phi}$-36 20$^{\phi}$-14 15$^{\phi}$-21 80	9/4 DIAMETER NUMBERS OF PIPE PIECES		
JOINING OF BENT PIPE PIECE	9/2 40$^{\phi}$-90 20	40$^{\phi}$-50 15$^{\phi}$-29 32$^{\phi}$-3 25$^{\phi}$-22 20$^{\phi}$-2 106	9/3 50$^{\phi}$-67 67	40$^{\phi}$-70 70	40$^{\phi}$-38 32$^{\phi}$-23 61	25$^{\phi}$-11 20$^{\phi}$-8 15$^{\phi}$-9 9/4 28	TOTAL/DAY OF NO. OF PIPE PIECES
JOINING OF BRANCH PIPE PIECE	9/2 25-6 15$^{\phi}$-1 9	9/3 50$^{\phi}$-3 3	40$^{\phi}$-23 23		32$^{\phi}$-1 1	25$^{\phi}$-1 15$^{\phi}$-2 3	
WELDING OF HIGH GRADE PIPE PIECE	9/2 40$^{\phi}$-114 25$^{\phi}$-6 15$^{\phi}$-1	40$^{\phi}$-70 32ϕ-3	25$^{\phi}$-22 9/3 50$^{\phi}$-10 20$^{\phi}$-2 15$^{\phi}$-29	50$^{\phi}$-57	40$^{\phi}$-60	40$^{\phi}$-48 32$^{\phi}$-10	32$^{\phi}$-13 25$^{\phi}$-11 20$^{\phi}$-8 15$^{\phi}$-9
MACHINING OF PIPE PIECE					50$^{\phi}$-18 40$^{\phi}$-14 32$^{\phi}$-2 25$^{\phi}$-3		

Figure A-31

MONTH WEEK:

MIDDLE BORE PIPE PIECE MANUFACTURING SCHEDULE

	(F)	(M)	(T)	(W)	(TH)	(F)	(M)
MARKING AND CUTTING	9/2 65$^{\phi}$-57 9/3 65$^{\phi}$-20	9/2 Piller-10 9/3 65$^{\phi}$-70	65$^{\phi}$-75	80$^{\phi}$-36 100$^{\phi}$-40	125$^{\phi}$-65 150$^{\phi}$-10	150$^{\phi}$-33 200$^{\phi}$-16 9/4	
JOINING OF STRAIGHT PIPE PIECE	9/2 80$^{\phi}$-7 65$^{\phi}$-40	65$^{\phi}$-33 9/3 65$^{\phi}$-25	65$^{\phi}$-68	80$^{\phi}$-29 100$^{\phi}$-35	100$^{\phi}$-8 125$^{\phi}$-39 150$^{\phi}$-10	150$^{\phi}$-9 200$^{\phi}$-6 9/4	
WELDING OF STRAIGHT PIPE PIECE	9/2 80$^{\phi}$-27 65$^{\phi}$-25	65$^{\phi}$-48	9/3 65$^{\phi}$-50	65$^{\phi}$-43 80$^{\phi}$-10	80$^{\phi}$-19 100$^{\phi}$-35	100$^{\phi}$-8 125$^{\phi}$-39 150$^{\phi}$-10	150$^{\phi}$-9 200$^{\phi}$-6 9/4
BENDING BY BENDER	9/2 150$^{\phi}$-2 125$^{\phi}$-25 80$^{\phi}$-5	80$^{\phi}$-7 65$^{\phi}$-28	9/3 65$^{\phi}$-41	65$^{\phi}$-39	80$^{\phi}$-32 100$^{\phi}$-10	100$^{\phi}$-35 125$^{\phi}$-10	125$^{\phi}$-19 150$^{\phi}$-11 200$^{\phi}$-3
JOINING OF BENT PIPE PIECE	P 9/1 54$^{\phi}$-18 20$^{\phi}$-5 125$^{\phi}$-7 150$^{\phi}$-11 200$^{\phi}$-11	P 150$^{\phi}$-10 65$^{\phi}$-3 125$^{\phi}$-8 50$^{\phi}$-7 100$^{\phi}$-5 40$^{\phi}$-1 80$^{\phi}$-7 9/2 200$^{\phi}$-10	9/2 200$^{\phi}$-12 150$^{\phi}$-12 125$^{\phi}$-30	100$^{\phi}$-19 80$^{\phi}$-14 65$^{\phi}$-17 P 200$^{\phi}$-4	P 9/3 150$^{\phi}$-3 65$^{\phi}$-15 125$^{\phi}$-5 100$^{\phi}$-19 80$^{\phi}$-9 65$^{\phi}$-8	65$^{\phi}$-67	80$^{\phi}$-21 P 200$^{\phi}$-11 100$^{\phi}$-46 200$^{\phi}$-5 125$^{\phi}$-29 150$^{\phi}$-8 150$^{\phi}$-28 125$^{\phi}$-5 100$^{\phi}$-18 80$^{\phi}$-9 65$^{\phi}$-7
WELDING OF BENT PIPE PIECE							

Figure A-32

MONTH/WEEK:

LARGE BORE PIPE PIECE MANUFACTURING SCHEDULE

DAY / W. STATION	(F)	(M)	(T)	(W)	(TH)	(F)	(M)
MARKING AND CUTTING	250φ-3		9/3 850φ - 1 750φ - 1 450φ - 1 400φ - 4	400φ - 11 350φ - 2	300φ-5 250φ-14		
JOINING OF STRAIGHT PIPE PIECE	259φ-3		9/3 750φ-1	400φ-4 350φ-2	250φ-7		
WELDING OF STRAIGHT PIPE PIECE	250φ-3		9/3 750φ-1	400φ-4 350φ-2	250φ-7		
JOINING AND WELDING OF BRANCH PIPE PIECE	9/1 550φ-1 9/2 300φ-1 250φ-5				350φ-2		250φ-1
JOINING OF BENT PIPE PIECE		9/2 600φ-2 300φ-1 250φ-2	9/3 850φ - 1 450φ - 1 400φ -3	400φ-6	400φ-2	300φ-5	250φ-7 P 350φ-1 250φ-9
WELDING OF BENT PIPE PIECE							
LONG LENGTH PIPE PIECE (> 5.5M)	9/1 650φ-7	550φ-2 300φ-3 257φ-2	250φ-2 200φ-2 9/2 650φ-4	650φ-2 550φ-1 350φ-2	300φ-7 250φ-2	250φ-4 200φ-6	150φ-3 550φ-2 125φ-3 300φ-8 750φ-1 250φ-2

Figure A-33