2.0 BASIC RESPONSIBILITIES

2.1 Organizations of People, Information and Work

Organizations similar to that shown in Figure 2-1 are optimum and will probably evolve wherever IHOP is pursued. Differences from traditional organizations are:

- the shipbuilding firm is very much involved in basic design,
- unified control of man-hour budgets, schedules and material, *including purchasing,* are assigned to the production control department,
- assignment of the production effort to two departments each concerned with an inherently different type of work, i.e., hull construction and outfitting,
- subdivision of the production departments into shops specialized by problem areas, an aspect of group technology,
- subdivision of the design department into groups by problem areas, and significantly
- assignment of production engineers (also called field or process control engineers) to the production departments and throughout shops.

The necessary grouping of information is reflected in the design and work-instruction processes for hull construction depicted in Figure 2-2. What is represented may be called *dual grouping* which first addresses a hull by functional systems such as shell, decks, longitudinal and transverse bulkheads, frames, webs, etc. A transition is shown wherein the design information is reorganized by blocks (zones) regardless of the hull systems represented. The requirements for the reorganization are specified by a hull planning (HP) group which is made up of production engineers assigned to the hull construction department including the various hull construction shops.

Because of their input, dual grouping addresses both how to design and how to produce. The system-by-system formats for key plans facilitate functional design and owner and regulatory approvals. The zone-by-zone format for yard plans, specified by production engineers, facilitates their management of stage-plan preparation for erection, assembly, subassembly and parts fabrication.[1] Dual grouping addresses both how to design and how to produce.

Figure 2-3 shows the paths of process flows for hull construction and outfitting which progress independently at first and later merge. The merged flows, through erection, constitute IHOP. Each process lane is divided into stages and is specially equipped to produce interim products of a particular manufacturing family, i.e., of a particular problem area. Information grouped by zone, problem area and stage, i.e., a work instruction or stage plan, provides information necessary for processing a particular interim product through a specific stage of a specific flow lane.

The HP group also requires that information produced during transition design be grouped to match work *yards* (also work cells); i.e., regions of significance for administrative purposes. A work yard usually consists of a number of contiguous stages within a process flow. Typically yard plans are organized to correspond with process flows for flat blocks, curved blocks, fore and aft body blocks and engine-room blocks.

2.2 Considerations for Early Hull Construction Planning and Scheduling

A singular problem that shipbuilding managers are confronted with is how to get their production people involved in basic design. The most competitive shipbuilders have met this challenge by their employment of one or two production engineers in each shop and by formalizing a *basic planning* effort which is implemented simultaneously with basic

[1] Throughout this publication the word *assembly* is used interchangeably with *block assembly* and *subassembly* is used interchangeably with *sub-block assembly*.

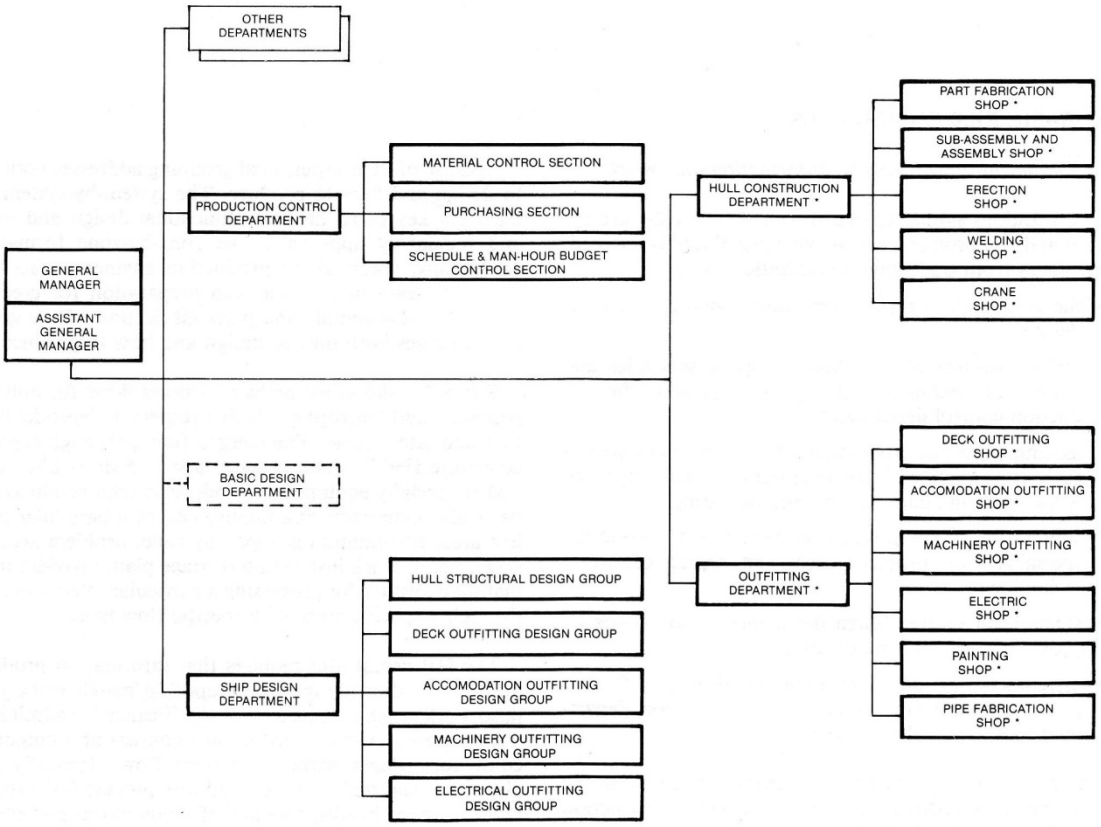

FIGURE 2-1: The organization shown facilitates integrated hull construction, outfitting and painting (IHOP). Control of basic design by the shipbuilding firm, regardless of where the basic design group is located, is vital. Another significant prerequisite is assignment of production engineers to the hull construction and outfitting departments and throughout shops. An ideal managerial career would feature the following assignments: field engineer, mold loft; field engineer, erection shop; engineer, any outfit design group, field engineer, machinery outfitting shop; field engineer, painting shop; shop manager or senior production engineer in the hull construction or outfitting department; manager of hull construction or outfitting department; manager of production control department; assistant general manager and general manager. The organization shown is that for the IHI Kure Shipyard which in 1982 delivered seven *different* ships varying in size from 29,900 to 294,700 and totaling 710,000-deadweight tons. When the workload was significantly greater, a separate department was in charge of painting and there were separate shops for subassembly and assembly. The basic design group is located in IHI's headquarters about 600 miles from Kure. Thus, the basic design group is somewhat like an independent design firm assisting the shipyard to develop contract plans. The same communication problems have to be overcome.

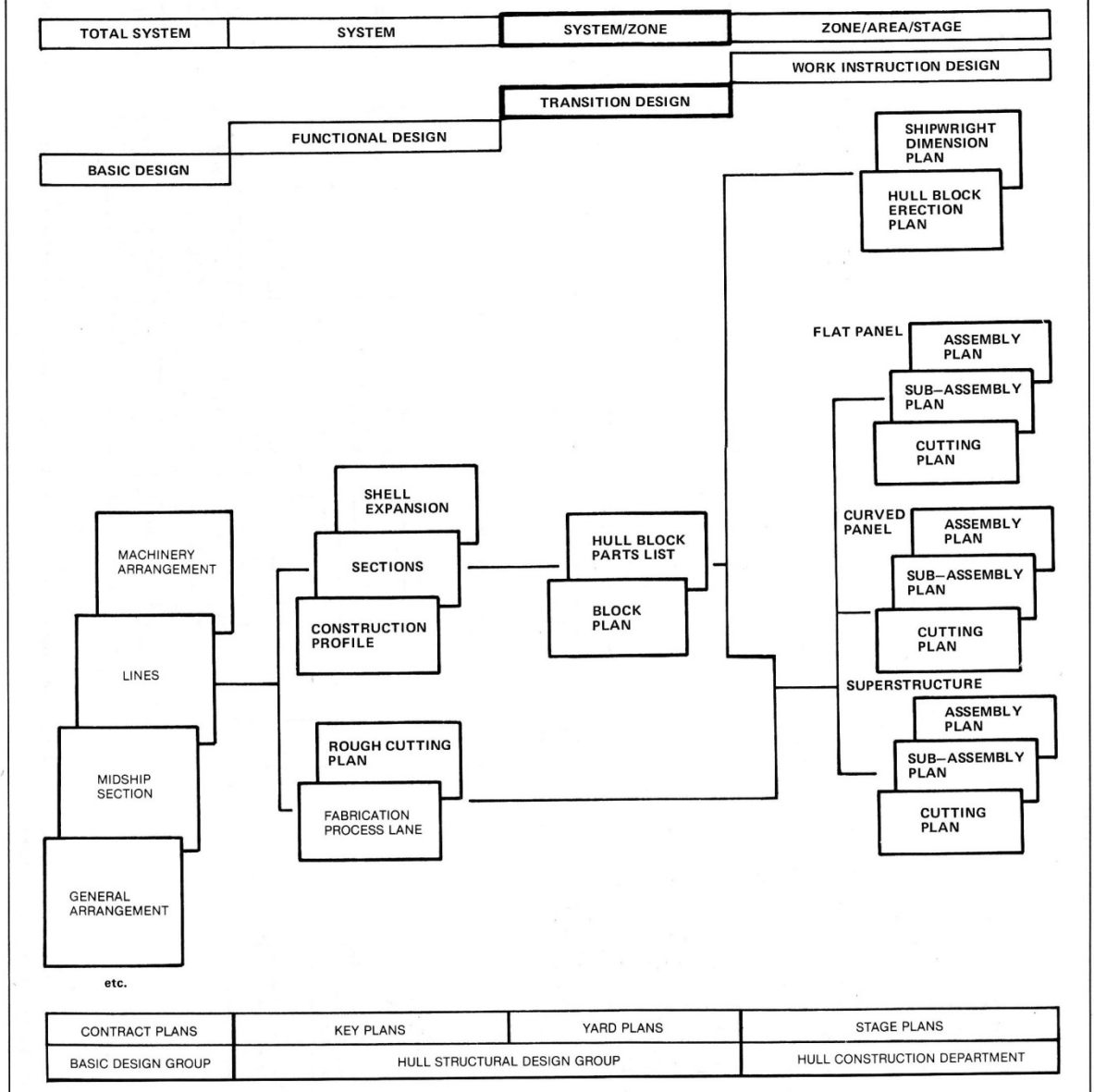

FIGURE 2-2: Production Oriented Design and Work Instruction Processes for Hull Construction. These processes should be regarded as the creation and organization of information. At first the information is organized by system to facilitate creation of a design and solicitation of owner and regulatory approvals. Then the information is reorganized by zone to reflect how the ship will be constructed.

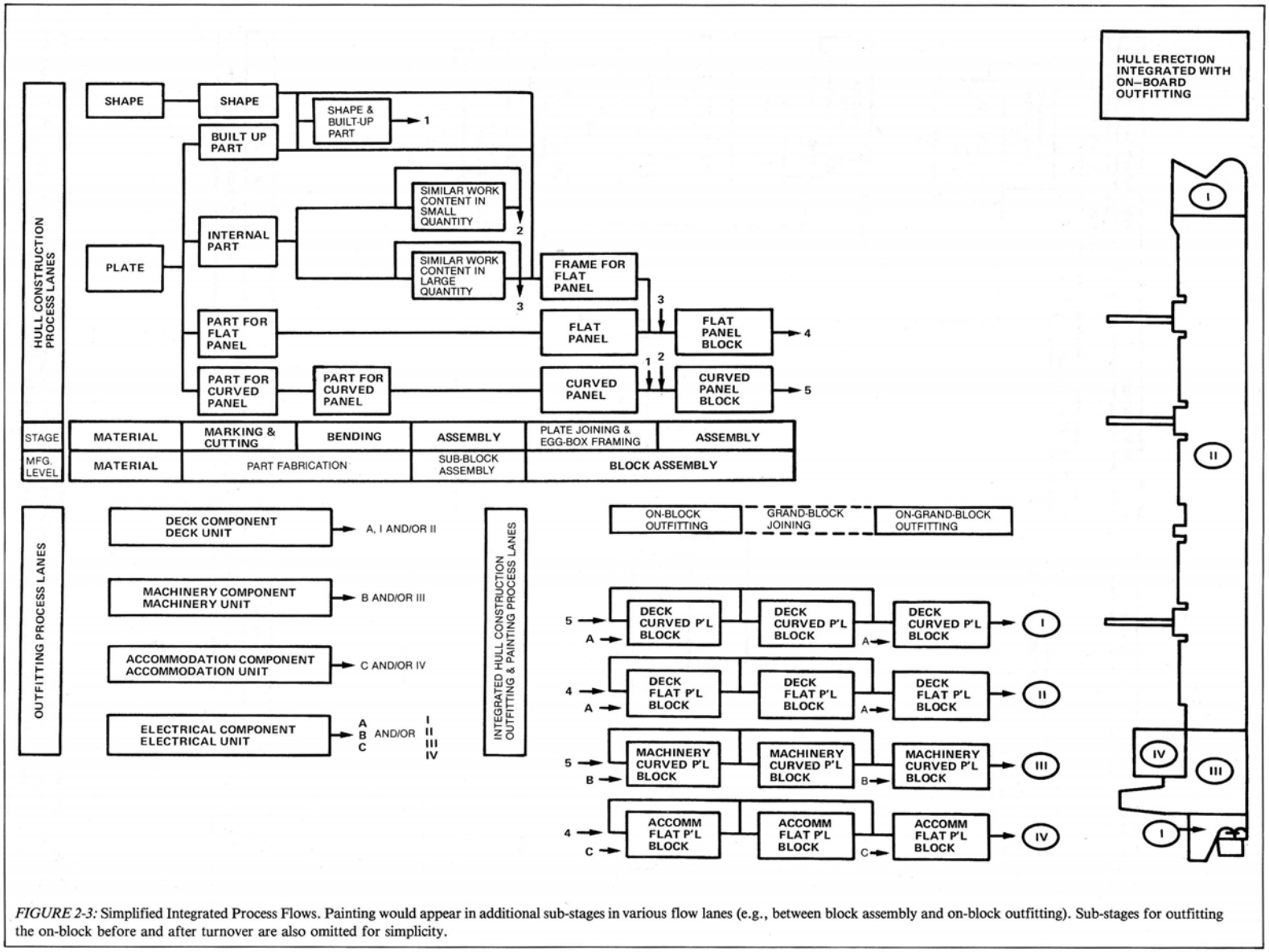

FIGURE 2-3: Simplified Integrated Process Flows. Painting would appear in additional sub-stages in various flow lanes (e.g., between block assembly and on-block outfitting). Sub-stages for outfitting the on-block before and after turnover are also omitted for simplicity.

design. The extent of each effort that is performed before contract award depends on:

- uniqueness and complexity of a proposed ship, and
- a shipbuilder's prior experiences with an owner.

During basic planning production engineers pre-define blocks. Guidance employed includes a proposed general arrangement, midship section, machinery arrangement, etc. for a contemplated ship as well as limitations or other conditions which relate to the effectiveness of a particular shipyard. Such considerations include need to:

- define blocks of maximum size and weight permitted by the shipyard's assembly and erection facilities,
- minimize the number of blocks, if necessary by joining blocks which are sized to facilitate assembly into grand blocks in order to exploit a large capacity crane at an erection site,
- identify assembly and erection processes consistent with safety and the need for block accuracy and rigidity,
- minimize scaffolding, lifting, turnovers, etc.
- identify blocks which can be used as patterns for other blocks in parallel midbody, and significantly need to
- identify preliminary zone, problem area and stage classifications for organizing work flows and, insofar as possible, equalizing the contents of work packages for block assembly, sub-block assembly and parts preparation.

Besides the foregoing, *block pre-definition* should consider how to:

- fit outfit components in cargo compartments,
- install machinery and fit other components in the engine room,
- arrange deck machinery, moorage fittings, etc., and
- perform more painting before hull erection.

Also, assessment of the efficiency of *block-assembly processes* in terms of durations, numbers of required resources, accuracy needed and quality of work circumstances, requires the following to be evaluated collectively:

- determinations of outfitting on-block or on-grand block,
- ease of outfitting and painting processes, and
- avoidance of damage to painted surfaces and to fittings when turning over or otherwise handling blocks.

As much as an erection master schedule must ultimately control sequenced durations for mold loft, fabrication, subassembly, assembly, and erection work, an integrated schedule must control all of the foregoing plus durations, appropriately interspaced, for outfitting and painting stages. The first manifestation of such integrated control is an *IHOP pre-schedule.*

2.3 Interaction Between Designers and Production Engineers

Early and continued interaction between design and production people assigned responsibilities for hull construction, outfitting and painting is critical for successful integration of their different concerns. Meetings should be frequent for the purpose, as simply shown in Figure 2-4, of making known the requirements for efficient outfitting and painting in time for them to be incorporated in hull structural drawings.

Hull concerns which will be affected as a consequence of the increased consideration for in-process outfitting and painting include straking, block boundaries, holes to be cut in structure such as for passage of pipes, reinforcements for heavy outfit components, and the block erection sequence to insure that it is consistent with plans to land large machinery items.

The first integrated planning effort, see Figure 2-5, addresses block pre-definition and for a first-of-a-kind or complex ship, could require consideration of the:

- general arrangement of main piping and valves in holds,
- main engine and auxiliary machinery arrangement,
- compartment and access arrangement,
- accomodation arrangement,
- general arrangment of deck piping and mooring machinery and fittings,
- basic plans for landing the main engine,
- painting schedule which outlines special requirements for certain areas and which addresses paint types and processes, and
- estimated weight for blocks and outfit components in order to insure that they could be lifted by cranes at the building site.

Much depends on all participants in block pre-definition having a good understanding of the entire shipbuilding system. Their pre-definition is the basis for quickly establishing the *erection master schedule* and the IHOP pre-schedule. The HP group necessarily assimilates outfitting and painting requirements and coordinates with the hull design schedule before producing the IHOP pre-schedule.

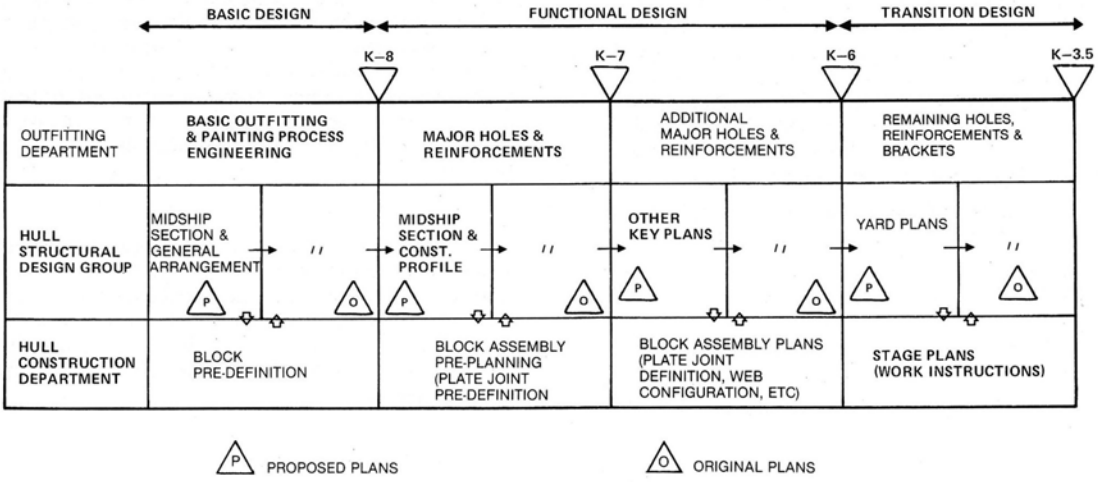

FIGURE 2-4: Integration of Design Data with IHOP Planning. During distinct phases, starting with basic design, the hull structural design group submits *proposed* plans (including those for painting) to field engineers in the outfitting and hull construction departments. These reviewers then make known their requirements which must be included before issue of *original* hull structural plans. For the first-of-a-kind 100- to 150-thousand deadweight-ton ship, other dates of interest are typically: start fabrication K-2, launching K + 4 and delivery K + 7.

The IHOP pre-schedule indicates dates for erection, assembly, fabrication, drawings, material requisitions, etc. It controls the derivation of all subsequent schedules. Thus, approval of the IHOP pre-schedule by department managers and the top manager is a matter of extreme importance.

After basic planning further joint discussions address *block definition* and *block assembly pre-guidance*. Items needed to support pertinent decisions are:

- job specifications for outfitting and painting for each side (frame and non-frame) of each category of hold blocks, i.e., bottom, side shell, longitudinal and transverse bulkheads, deck, etc.,
- job specifications for outfitting and painting for each side of fore, aft and engine-room blocks, and
- capacity limits of outfitting and painting facilities and equipment.

The end product is an *assembly master schedule* from which a *shop pre-schedule* is prepared which proposes control of the various shops in the hull construction department. The preparation of these schedules requires the HP group to consider productivity and accuracy during block-by-block studies. The block assembly pre-guidance process addresses every stage starting with joining plates (to form the panel upon which the block will be assembled) until the block is ready for erection. The pre-guidance is sufficient for review by field engineers for outfitting and painting. After assimilation, adjustments and mutual agreement, the assembly processes per block are finalized in *block assembly guidance* and in IHOP and *shop schedules*. They are the fundamental means for controlling on-block outfitting and painting.

Because of the integrated planning, hull construction scheduling is inescapably dependent on:

- outfitting and painting schedules for each distinctive region of the ship, e.g., deck, machinery and accomodation,[2]
- on-block outfitting and painting schedules for each category of hold blocks, and
- on-block outfitting and painting schedules for each fore, aft and engine-room block.

These schedules are incorporated in the *IHOP schedule* which indicates the sequence of stages and stage durations for each block starting from the issue date for required block-by-block yard plans until block erection dates.

[2] *Deck* refers to any region that is not *machinery* or *accomodation*. Thus, *deck* includes cargo holds and tanks.

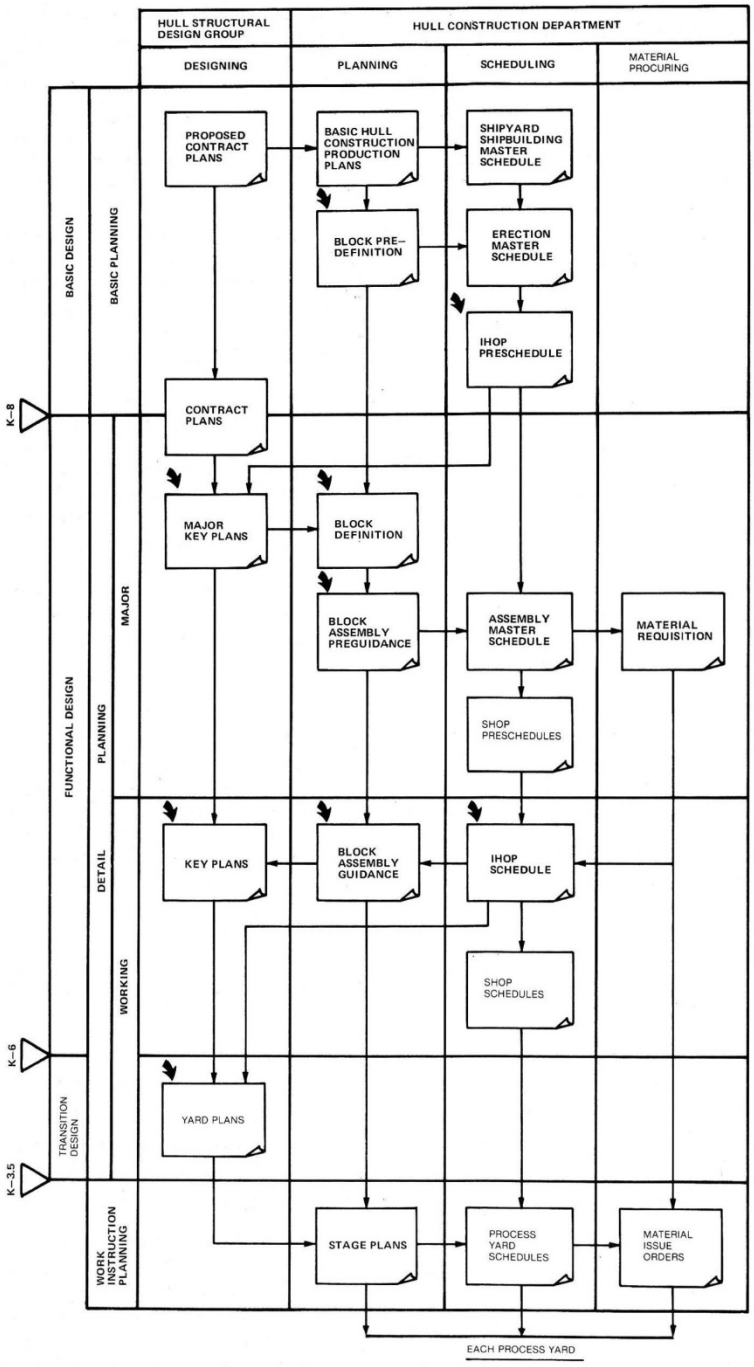

FIGURE 2-5: Coordinated Progress of Design with Planning and Scheduling by the Hull Construction Department. Design progresses in three distinct phases: *basic, functional and transition.* Planning and scheduling by the Hull Construction Department proceed through four phases: *basic, detail (major), detail (working) and work instruction.* The arrows indicate inputs by designers and field engineers concerned with outfitting and painting. Necessarily, certain schedules address all ships being built simultaneously, e.g., the shipyard shipbuilding master schedule, the assembly master schedule and the shop and process-yard schedules. The completion of basic design and planning before formalization of contract plans as shown, is ideal for first-of-a-kind or complex ships.

Clearly, Figure 2-5 shows that the HP group has to assume lead responsibilities. Outfitting and painting considerations are in a sense superimpositions on basic planning and scheduling for hull construction. However, creating the combination and controlling its continuous refinement until IHOP plans and schedules are sufficiently detailed for absolute control of flow lanes, requires members of the HP group to understand the overall shipbuilding system. Further, it requires a degree of production engineering sophistication not normally encountered in traditional hull construction departments. In the most effective shipyards, *production engineers for hull construction* are basically concerned with how to:

- divide a ship into blocks,
- assemble blocks, and how to
- *devise an IHOP schedule.*

2.4 Responsibilities of the Hull Structural Design Group

The hull structural design group is sub-divided into a *key-plan subgroup* and a *yard-plan subgroup*. Each is sub-divided into two sections in order to better administer the:

- preparation of drawings, as distinguished from
- performance of analytical tasks, e.g., strength calculations, vibration analyses, and data input for computer processing.

2.4.1 *Key-plan subgroup* responsibilities relate to functional design, e.g.:

- input of key plan data for computer processing such as for lines fairing (station offsets), structural lines (frame offsets) and shell expansion,
- hull structural development for existing and new type ships,
- strength and vibration analyses, and
- producing key plans, e.g., for:
  - structural scantling plans (stern, bow, cargo compartments, and engine-room construction),
  - stern frame,
  - rudder, rudder stock and carrier,
  - main engine and other foundations such as for boilers and generators, and
  - welding schemes.

2.4.2 *Yard-plan subgroup* responsibilities pertain to transition design and include:

- input of yard-plan data for computer processing such as for preparing a body plan (frame offsets), parts generation, etc.
- producing drawings such as for templates for castings and pin-jig settings,
- block plans (yard plans) including development of structural details,
- hull parts lists, and
- fabrication plans for foundations.

The block plan is a unique presentation of hull structural design. Some traditional shipbuilding firms still provide their hull construction departments with system-oriented structural drawings. In order to plan the assembly of a block, references have to be made to a number of different drawings. Ideally, a block plan is a compact booklet which applies to a group of adjacent blocks, of the same problem area, and which combines information contained on the various system drawings into one zone-oriented format.

Minimal work instructions are included in block plans as work instructions are more appropriately prepared under the direction of the HP group. A block plan is a working master plan or yard plan on which the transformation from system to zone has been made. A block plan is indispensable for creating effective IHOP stage plans.

2.5 Production Planning, Mold Loft and Shops

The functions assigned to a hull construction department include production planning as well as mold loft and shop work. The fabrication and assembly efforts are divided among shops as shown in Figure 2-1 so that responsibilities match the division of stage plans shown in Figure 2-2 and the division of process flows shown in Figure 2-3. In other words, the way the hull construction department is organized reflects a product-oriented work breakdown structure.

In the above described manner, expertise in preparing cutting plans is matched to expertise in marking and cutting for parts fabrication, expertise in preparing subassembly plans is matched to the organization concerned with sub-block assembly and so on. Stage plans classified by zone/area/stage by virtue of such classifications describe what is to be processed and the information needed to perform work during a stage of a particular work flow. When man-hours required are related by some characteristic, such as weight or welding length, workload forecasts by flow lane, stage or any combination of stages can be readily determined. Shops are supported by other divisions of the hull construction department, specifically, the HP group, mold loft, stage-plan group, welding shop and crane shop.

2.5.1 Hull Planning Group responsibilities are:

- all of the planning and scheduling, including incorporation of outfitting and painting concerns, as designated for the hull construction department in Figure 2-5;
- preliminary control data
  - weight by structural system, i.e., by flat shell plate, curved shell plate, internal structure separately for that cut by manual, numerical control (N/C) or other methods and built-up longitudinals and rolled shapes,
  - block weight and welding length,
  - sub-block weight and welding length,
  - erection welding by parametric length, i.e., taking into account weld size, type and position, and
  - scaffolding planks per hull region, i.e., by hold, engine room, fore, aft and outside shell;

- fabrication data
  - process lanes,
  - rough cutting plan, and
  - scrap ratio;
- preparation of other required plans
  - sub-block and block assembly process plans,
  - erection welding plan for both manual welding and automatic welding,
  - scaffolding master plan, and
  - lifting master plan;
- feedback to design department
  - shrinkage allowance per block,
  - designation of margins per block,
  - plate edge preparation, and
  - block erection sequence;
- hull accuracy control (A/C) plan; and
- operation of the welding laboratory.

2.5.2 Mold loft responsibilities include:

- cutting-plan data, e.g., N/C tape, film for electrophotographic marking, parts-size drawings, such as a size list for flat bar,
- bending data, e.g., templates for bending, twisting, etc.,
- pin-jig settings, and
- feedback to hull structural design group concerning excess allowances, edge preparations, etc.

2.5.3 Stage-plan section responsibilities address the preparation of work instructions (stage plans) which include:

- marking data for assembly, e.g., steel measuring tapes for layout of block assembly marks, finish-cut dimensions per block, etc.;
- sub-block assembly process data
  - sub-block assembly plan, and
  - sub-block assembly fitting plan for lifting pads, guide pieces, scaffolding supports, etc.;
- block assembly process data
  - block assembly plan,
  - block lifting instruction plan,
  - fitting plan for lifting pads, guide pieces, scaffolding supports, etc., and
  - pin-jig settings for curved-block assembly:
- erection process data
  - shipwright dimensions plan, i.e., block alignment instructions,
  - scaffolding arrangement plan,
  - hull block arrangement handbook, and
  - block-support arrangement plan;
- work control-data
  - sub-block assembly weight,
  - block assembly weight,
  - sub-block assembly welding length,
  - block assembly welding length, and
  - erection welding parametric length; and
- material procurement
  - definition and listing,
  - requisitioning,
  - remnant control, and,
  - scrap control.

2.5.4 Welding shop responsibilities address:

- welding for erection processes only.

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