

INTERN EXPERIENCE AT
FLUOR ENGINEERS AND CONSTRUCTORS, INC.

AN INTERNSHIP REPORT

by

Boma Thompson Afiesimama

Submitted to the College of Engineering
of Texas A&M University
in partial fulfillment of the requirement for the degree of
DOCTOR OF ENGINEERING

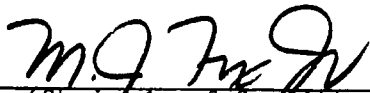
August 1982

Major Subject: Industrial Engineering

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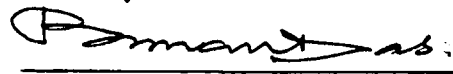
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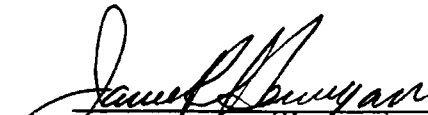
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August 1982

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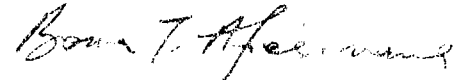
Dear Sir:

Notice of Confidential Material
Boma T. Afiesimama: Internship Report

Please be advised that some of the material in my report for the Doctor of Engineering Internship at Fluor Engineers & Constructors, Inc., Houston, Texas, is proprietary information. Such material may thus be considered confidential by the Company.

May I therefore request that the report be released to parties outside the University only with due permission from Fluor Engineers & Constructors, Inc.

Sincerely,



Boma T. Afiesimama

BTA/cr
cc: Earle Jansen
Dr. M. J. Fox, Jr.

ABSTRACT

Intern Experience at Fluor Engineers and Constructors, Inc.

Houston Division. (August 1982)

Boma Thompson Afiesimama, B.S.E., University of Michigan

M.Eng., Texas A&M University

Chairman of Advisory Committee: Dr. M. J. Fox, Jr.

This report documents the author's internship experience with Fluor Engineers and Constructors, Inc., a subsidiary of Fluor Corporation, at Houston, Texas, during the period January 5, 1981 through January 7, 1982. It is intended to establish that this experience meets the objectives of the Doctor of Engineering internship.

Following an examination of the internship objectives, Fluor's organizational structure, approach, and management philosophy are overviewed. The major project undertaken during the internship is introduced and its technological basis briefly discussed. The author's specific work assignments and contributions in the Cost and Scheduling Department, all in the area of project control engineering, are then presented. The work assignments include cash-flow forecasting; risk analysis; computerized cost control, analysis, and reporting; development, analysis, maintenance and reporting of CPM and bar chart schedules on a segment of the refinery project the internship was involved with; and manpower utilization and productivity studies. Finally, aspects of project management to which the intern was exposed through association and observation during the internship are discussed.

It is thus demonstrated that both the program and personal objectives of the internship were in fact met.

TO GOD ALMIGHTY

who gives life and all of its resources: time, opportunity, ability, etc.

ACKNOWLEDGEMENTS

Hardly does anyone successfully complete a meaningful project without the kind and faithful support of a host of good people. It is therefore with much gratitude that I will like to express my appreciation to all those who have contributed in various forms to the success of my internship experience at Fluor and graduate studies at Texas A&M University.

Many thanks to Dr. M.J. Fox, Jr., who has so graciously drawn from his long experience in academia and industry to counsel and guide me through my entire graduate school years. Thanks also to the other committee members, Dr. J.K. Hennigan, Dr. Biman Das, Dr. Alberto Garcia, Dr. A.V. Wolfe, Dr. C.B. Parnell, Jr., Dr. D.W. David and Professor J.L. Sandstedt for their support.

I am very grateful to Mr. J.E. Wendt, who was primarily responsible for my opportunity to intern at Fluor, for his guidance through most of the internship. Special thanks to Mr. E.E.A. Jansen, my supervisor during all of the internship, for his faithful support and encouragement. He is well deserving of much credit for the success of the intership; he took over the responsibilities of the Intern Supervisor after Mr. Wendt left on an overseas assignment. Thanks also to my colleagues at Fluor who made the 12-month internship a pleasant experience.

Finally, to my wife Jane and my son Oribi (Boma, Jr.) I will like to say "A million thanks for your encouragement and sacrifices."

TABLE OF CONTENTS

	Page
ABSTRACT	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
LIST OF FIGURES	viii
LIST OF TABLES	ix
CHAPTER I. INTRODUCTION	1
Purpose	1
Position	1
Internship Objectives	2
Report Organization and Scope	4
CHAPTER II. THE FLUOR SYSTEM	6
Organizational Structure and Operations	6
Organizational Approach	16
A typical Project Cycle	23
CHAPTER III. PROCESS TECHNOLOGY OF THE PROJECT	33
Project Overview	33
Petroleum Refining	35
Hydrogen Production	46
Process Summary	51
CHAPTER IV. WORK ASSIGNMENTS AND CONTRIBUTIONS	54
Cost Engineering	54
Scheduling Engineering	62
Miscellaneous Tasks	66

TABLE OF CONTENTS (cont'd)

	Page
CHAPTER V. PROJECT MANAGEMENT	71
Role on the Task Force	72
Relationship with Cost/Scheduling	74
What it takes	74
Problems	78
CHAPTER VI. SUMMARY AND CONCLUSION	80
REFERENCES	82
APPENDICES	83
Appendix A. Cost & Scheduling Engineering Functions .	84
Appendix B. Intern Supervisors' Resume	86
Appendix C. Final & Preliminary Internship Objectives	93
Appendix D. Monthly Internship Progress Reports . . .	96
Appendix E. Intern Supervisor's Internship Appraisal .	108
VITA	111

LIST OF FIGURES

Figure	Page
1. Divisional Grouping at Fluor Corporation	8
2. Fluor Corporate Top Management	9
3. Fluor Engineers & Constructors, Inc.	12
4. Organization Chart, Fluor E & C, Houston	14
5. Task Force Organization Chart	21
6. Six Phases of Project Engineering	27
7. Typical Project Schedule	31
8. Artist's Rendition of Project	36
9. Resid Hydrodesulfurization	40
10. Steam Reforming	49
11. Refinery Modernization	52

LIST OF TABLES

Table	Page
1. Process and Support Facilities in Project	34
2. Typical Crude Oil Fractions	39

CHAPTER I

INTRODUCTION

PURPOSE

This report relates the author's twelve-month internship experience with Fluor Engineers and Constructors, Inc. (hereinafter referred to as Fluor or the Company), in order to establish that the objectives of the internship have been met.

POSITION WITH COMPANY

The internship was served in the Cost and Scheduling Department, with the formal designation of Associate Cost/Scheduling Engineer, under the direct supervision of Mr. Earle E.A. Jansen as Control Team Manager. Appendix A contains brief descriptions of Cost and Scheduling engineering functions. Mr. Jack Wendt, General Manager of Cost and Scheduling, was the intern supervisor through much of the twelve-month life of the the internship. He was subsequently assigned to an overseas project near the end of the internship, and Mr. Jansen then became the Intern Supervisor. Mr. Wendt and Mr. Jansen hold degrees in electrical engineering and mechanical engineering, respectively. Their resumes are attached in Appendix B.

The format and style of this report are patterned after articles published in AIEE Transactions (December 1981).

INTERNSHIP OBJECTIVES

Doctor of Engineering Internship Objectives fall under two major categories, namely, program objectives defined by the College of Engineering as general conditions which all internships must meet, and personal objectives defined by the intern for a particular internship. Personal objectives should be consistent with program objectives.

Program Objectives

The Student Manual [8:8] indentifies two objectives for Doctor of Engineering internships, namely:

- (a) to enable the student to demonstrate his ability to apply his knowledge and technical training by making an identifiable contribution in an area of practical concern to the organization or industry in which the internship is served, and
- (b) to enable the student to function in a non-academic environment in a position where he will become aware of the organizational approach to problems in addition to traditional engineering design or analysis. These may include, but are not limited to, problems of management, labor relations, public relations, environmental protection, and economics, for example.

Personal Objectives

Program objectives (a) and (b) above emphasize contribution and broad exposure, respectively. Accordingly, the following final objectives were defined to reflect the general guidelines.

1. Become familiar with the Process Industry Technology.
2. Take responsibility for cost engineering on one aspect of a project.
3. Develop a manual of major cost reports.

4. Learn the essence of scheduling engineering.
5. Observe management practices at the project level.

Objective (1) above was designed to provide, along with the author's preliminary objectives,¹ the requisite general background for operating effectively at Fluor, whose activities center around the process industry. Objectives (2) and (3) reflect the contribution guideline of the program objectives, while (4) and (5) address the broad-exposure condition.

Later developments in the course of the internship warranted modifications of the above objectives--modifications which, in the author's opinion, enhanced the value of the internship. Because of a decision at the end of the fourth month of the internship to transfer to the scheduling engineering section of the department from the cost section, objective (4) was modified to entail active scheduling responsibilities for a section of the project, and objective (2) became an involvement with cost engineering assignments affecting the entire project. Work toward objective (3) was also discontinued for a number of reasons, one being the transfer out of the cost section. Others have to do with doubts regarding the value of the proposed manual of major cost reports to the Company. As the organizational approach at Fluor

¹Preliminary objectives were defined prior to starting the internship, as required by Doctor of Engineering Internship policy, and were replaced by the final objectives two months into the internship. See Appendix C for approved listings of both sets of personal objectives.

was better understood, it became increasingly clear that in view of the varying characteristics of projects, a standard cost reports manual would not be useful. Moreover, each project could have a different project manager who may prefer a different cost reporting system. Also, since the current project would be nearly through by the time the proposed manual would be completed, the cost effectiveness of continuing work on the manual was doubtful. These considerations were presented to the intern supervisor and, with his approval, work toward objective (3) was subsequently discontinued. However, the preliminary work done will be discussed in chapter IV of the report.

REPORT ORGANIZATION AND SCOPE

Subsequent portions of the report are organized in a similar progression as the personal objectives. First, some background information is provided. Two areas of Fluor's background are considered, one being the company's structure and operations at the corporate through the project levels, and the other covering the basic process technology of the project on which the internship was served.

Considered next are the specific work assignments through which the author's contributions were made. The cost engineering activities are discussed, followed by the scheduling engineering activities. This section concludes with a discussion of miscellaneous activities which require integration of cost and scheduling skills within the scope of Fluor's job descriptions. Then follows a discussion of project

management aspects to which the author was exposed, during the internship, through association with and observation of area project managers and the project director.

Some of the information used in this report constitutes privileged information and is thus being used with proper concern for proprietary restraints. As a result, no mention of clients or vendors, exact dollar values, and job locations will be made. The discussion of process technology will be particularly restricted to general principles. Also, for security reasons, no samples of the results of specific work assignments will be included in the chapter on work assignments and contributions.

CHAPTER II

THE FLUOR SYSTEM

ORGANIZATIONAL STRUCTURE AND OPERATIONS

Corporate Level

Founded in 1890 as a general construction firm, Fluor has since grown to become a highly diversified, multi-national corporation. Much of this growth occurred only during the last two decades in response to a surge in demand for engineering and construction services within the energy industries. A merger with Ocean Science and Engineering in 1967 resulted in extra capacity to provide products and services for offshore drilling and completion operations, which in turn caused the establishment of Fluor Ocean Services, Inc. in 1968. During the same year, two oil field supply companies--Republic Supply Company and Kilsby Tube Supply Company--were added to Fluor. A subsequent consolidation of Western Offshore Drilling and Exploration Company, and Coral Drilling, Inc. produced Fluor Drilling Services, Inc., a major multi-national drilling contractor. In 1969, the engineering and construction division of Utah Construction and Mining Company was acquired, which, eight years later, became Fluor Mining and Metals, Inc. Later acquisition of Colorado Oil Corp., and a power company added Fluor Oil and Gas Corp. and Fluor Power Services as new attachments to Fluor Corporation [1]. Daniel International, a large constructor of various industrial and

commercial facilities, was acquired by Fluor in 1977. Only in 1980, the newest member of the Fluor family, St. Joe Minerals Corporation, was added.

This history of mergers and acquisitions has made Fluor Corporation a gigantic contractor in the design, engineering, procurement, construction and management of process plants, pipelines, and related facilities for the petroleum, natural gas, petrochemical, chemical, synthetic fuels, and mining and metallurgical industries; of marine and offshore facilities for the oil and gas industry; and of nuclear and fossil fueled power plants for the electric utility industry.

Figure 1 illustrates the breakdown of the corporation into various divisional groupings. Due to diversity of operations and the multinational character of these operations, the organizational chart is structured along functional lines and by geographical location. Figure 2 shows the flow of the top management responsibility among the divisional groupings. Six functional groupings can be identified from both Figures 1 and 2. A brief description of each grouping and its corresponding operations is proper, in order to develop an appreciation for the functional uniqueness between them.

Industrial Piping and Oil Field Supplies. This grouping comprises two California-based wholly owned subsidiaries of Fluor, Republic Supply Company and Kilsby Tubesupply Company. Republic distributes various items to the oil industry. Kilsby is a distributor of various steels, carbon, stainless and alloy, and aluminum, filling needs for both manufacturers and industrial users, domestically.

FLUOR CORPORATION

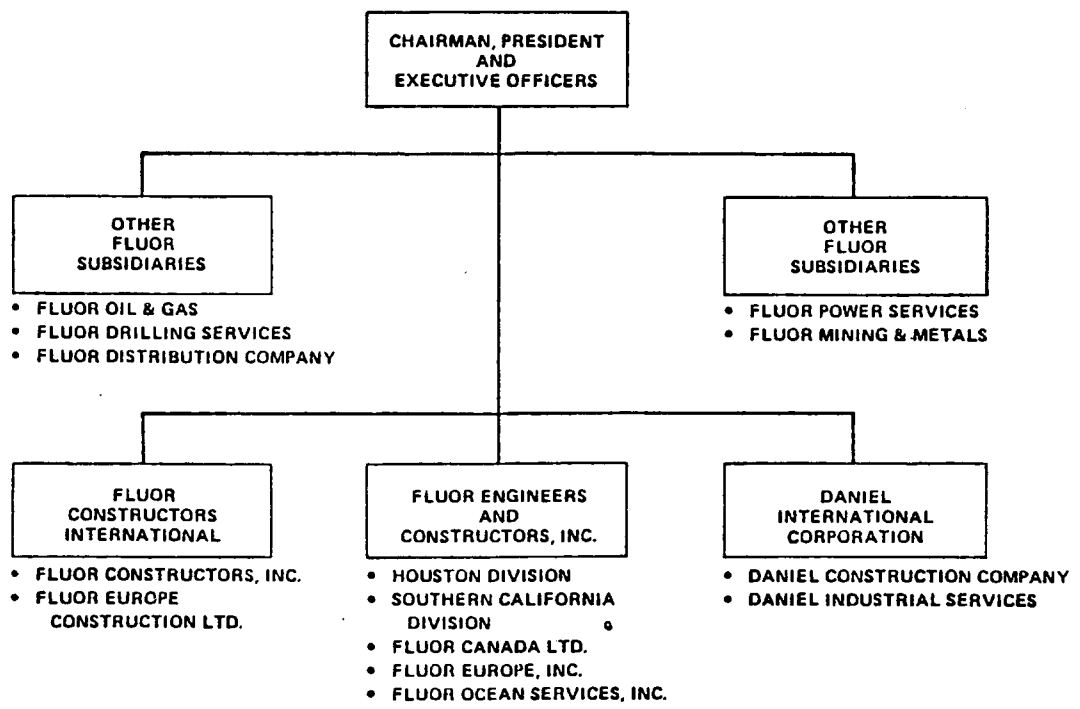


FIGURE 1: Divisional Groupings at Fluor

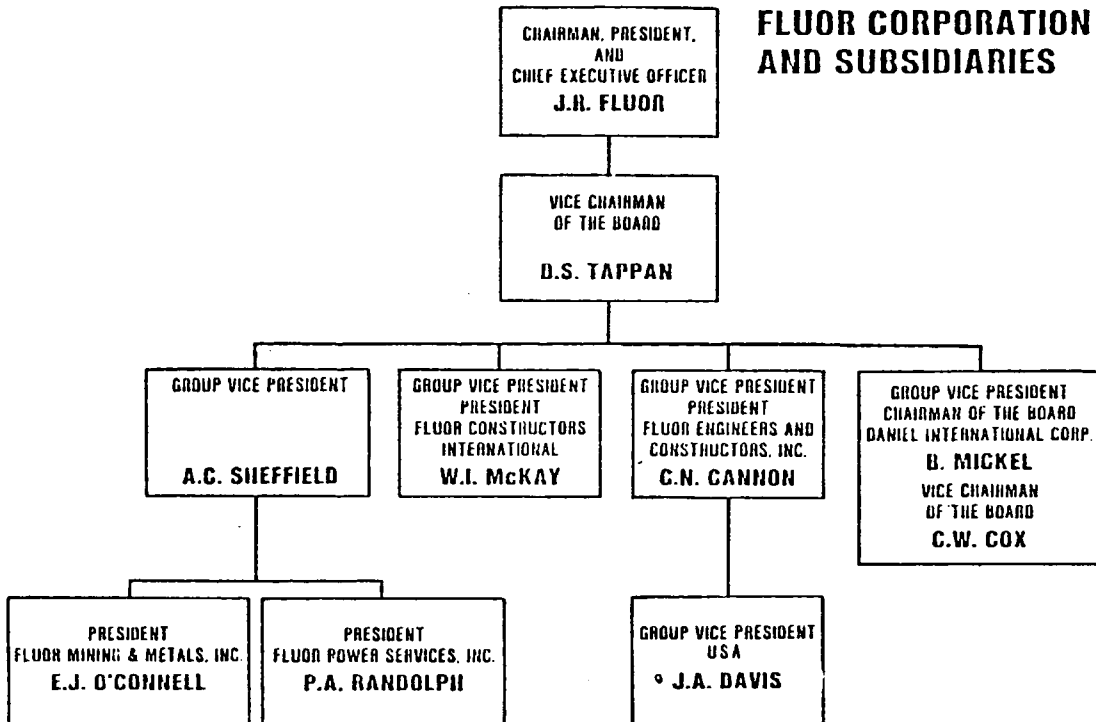


FIGURE 2: Fluor Corporate Top Management

Offshore and Pipeline Engineering and Construction Management.

Fluor Oceans Services, Inc., a wholly owned subsidiary of Fluor Corporation with headquarters in Houston, furnishes the oil and gas industry with various onshore and offshore pipeline, production, and marine facility design, engineering and construction management services.

Mining and Minerals Engineering and Construction. Both St. Joe Minerals, Corp. and Fluor Mining and Metals, Inc. fall under this grouping. They engage in design, engineering and construction for the mining and metallurgical industries, on a multi-national scale.

Electric Power Plant Engineering and Construction. Fluor Power Services renders a complete range of services to the power industry, including fuel studies, site evaluation, licensing, environmental impact studies, engineering, procurement, construction and plant startup.

General Constructors. This group of companies performs only construction services. It comprises Fluor Constructors International and Daniel International, both wholly owned subsidiaries of Fluor Corporation. Fluor Constructors directs union shop construction while Daniel operates open shop construction services.

Process Plant Engineering and Construction. This group of companies--Fluor Engineers and Constructors, Inc.--performs what may well be the Corporation's major operation, namely, the engineering and construction of refineries, petrochemical facilities, and other process

plants. Figure 3 shows the multi-national character of the group, with permanent offices in Houston, Texas; Irvine, California; Calgary, Canada; London and Manchester, England; Haarlem, The Netherlands; and Dusseldorf, West Germany.

A close similarity in organization exists among all operating departments of Fluor's engineering-construction permanent offices, covering such areas as basic procedures, design data and standards. This permits ready exchange of ideas, information, design and key personnel. Furthermore, Fluor's normal methods of process and mechanical design, project scheduling, cost reporting and control, and accounting are programmed on electronic computing equipment for interchangeable use by all offices. Each divisional office is organized and staffed to act as an independent entity in the total responsibility of project execution. Legal and insurance services are provided at the corporate level.

Fluor also establishes project offices at any location in the world to provide specialized services on a need basis. Services in project offices range from total project management to design supervision, procurement, inspection, expediting, coordination of construction activities, or any combination thereof. Project offices are managed by supervisors assigned from the permanent offices, supplemented by qualified local personnel. Furthermore, in order to offer an integrated, international supply service in purchasing, inspection, expediting and material transportation, additional permanent procurement offices are maintained in Japan, Italy, and France.

FLUOR ENGINEERS AND CONSTRUCTORS

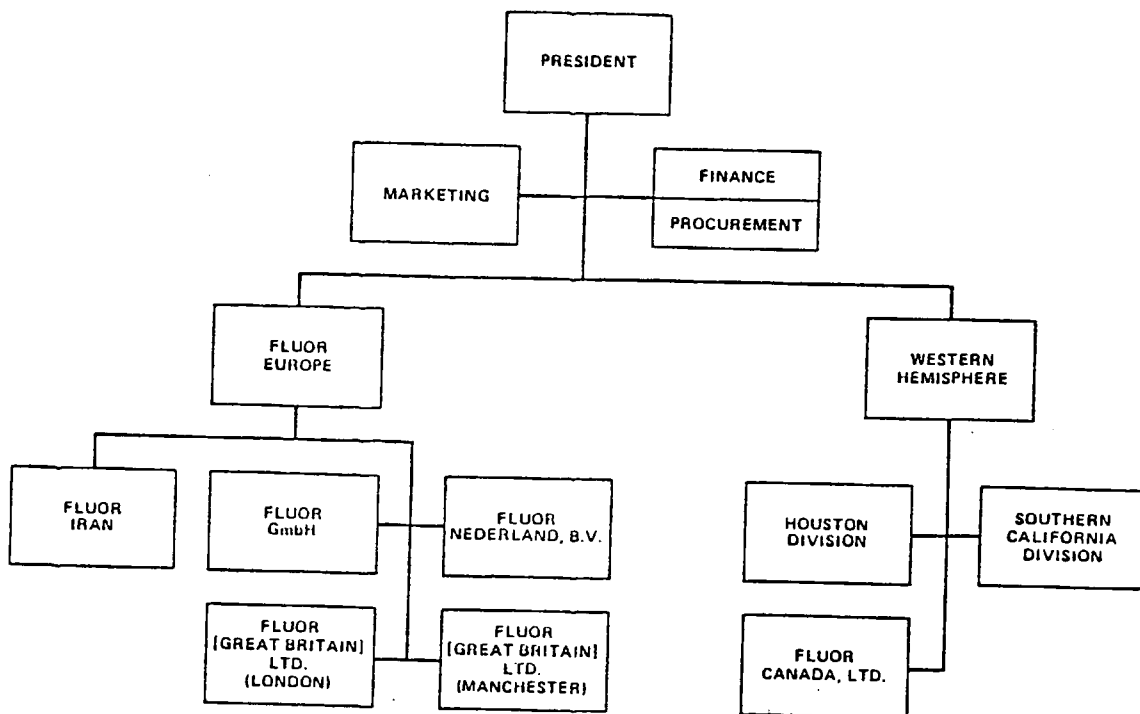


FIGURE 3: Fluor Engineers & Constructors- Group Organization Chart

For the purpose of this report, the Houston division is most relevant. The discussion of organizational structure and operations at the divisional level, which follows next, will therefore focus on the Houston division.

Divisional Level

The Houston division provides engineering, procurement and construction services to clients in the petroleum, petrochemical, natural gas, chemical, nuclear and related process industries. Established in 1948 with a staff of five (5), the Division holds a current staff level of nearly 3000 engineers, managers, designers and administrative employees. Facilities have accordingly expanded to include a current office space of over 600,000 square feet [3].

The Division is structured along functional lines, as shown in figure 4. This is not a rigid structure, however, as will be seen when project organizations are established for a specific project. When the various project organizations of the Division are superimposed on the Divisional organization chart, a matrix organization develops. While it is true that every position on the organization chart contributes to the Division's production effort, certain disciplines contribute more directly to the finished product. These have traditionally been called line functions. A brief description of the Houston Division's line functions follows.

Project Management. This group, though comprised of managers at the lower levels of Divisional management hierarchy, constitutes the top management of the task force--the "factory" that is directly

responsible for the final "product." Project management is responsible for all aspects of the project supervision and control. The control function is served using information provided by the cost and scheduling engineering team, which thus contributes to the final product only in a support role.

Design Engineering. This group, which consists of electrical, structural, vessel and piping engineering sections, is the largest engineering group. Its activities include performing all structural and civil engineering design, furnishing designs and specifications for process vessels, developing designs and specifications for all electrical power, light, instrumentation and wiring, and designing and modeling of all piping. The group is responsible for producing the final engineering product--the working drawings for the construction team.

Construction. The construction group plans, monitors and coordinates the construction activities related to the Division's projects.

Mechanical Engineering. Comprised of mechanical engineers, metalurgy engineers and rotating equipment specialists, this group is directly responsible for the mechanical integrity of machinery and equipment used in processing plants. Working in conjunction with clients, vendors and the field construction group, these engineers provide detailed specifications for equipment selection and bid analysis. The group also inspects welding procedures, final installation of equipment units and start-up operations.

Process Engineering. The process group comprises chemical engineers who provide basic plant design services, including heat and material balances, operating conditions and flow quantities analysis, duty specifications, flow sheets design, and utility requirement specifications. It also performs a process check of the completed facility and provides consulting services on plant start-up.

Control Systems Engineering. Working closely with process engineers, Control Systems engineers develop plant monitoring and control systems. The group's activities include process analysis, establishment of control and monitoring concepts, developing standards and guidelines, developing installation requirements, coordinating instrument requirements with design groups, inspection of equipment and their installation, developing check-out and calibration procedures and assisting in plant start-up.

Environmental Engineering. This group of engineers prepares designs and specifications for systems and equipment needed for compliance with environmental regulations and standards.

In concert, these groups constitute a ready staff pool from which the task force, discussed in the next section, draws its technical and management personnel.

ORGANIZATIONAL APPROACH

In general, organizational approach pertains to the way a particular organization combines and channels the various resources at its disposal to attain its defined objectives. Included in such an

approach are important elements such as the management philosophy and the exact mechanisms that are set up to pursue the company's objectives. Supposedly, the organization chart, by displaying the structure, and authority and responsibility relationships, addresses this issue. It, however, lacks adequate details, and thus cannot by itself provide the required information. For the purpose of this report, management philosophy at Fluor and the task force concept, Fluor's conglomerate means of production, will be considered.

Management Philosophy

Management philosophy consists of the set of beliefs to which the organizational management subscribes regarding the traditional management functions of planning, directing, controlling, coordinating, organizing and staffing. Every organization involved with the transformation of resources into a final "product" needs to be concerned about these functions. At Fluor, management philosophy is deeply colored by the strong consciousness that people constitute the mainstay of the company's business--as a service, rather than product, industry. The emphasis is therefore on managing people. Human relations--the tactful adjustment to personalities and circumstances to deal effectively with others--thus takes on a central position in the overall philosophy. Attitudes are also important. A positive mental position toward work assignments and company goals, and willingness and ability to work with others are very critical elements, especially in view of the task force approach which is Fluor's organizational vehicle for project implementation.

Client considerations provide strong rationale for Fluor's management philosophy. The satisfaction of the client, with whom the company has contracted to provide its services, is the ultimate objective. This is all the more important when the final "product" is a complex, capital-intensive, high technology and long-life structure. Moreover, unlike the case for a manufacturing company where the customer is often told the function of the product through advertising, Fluor's client typically has full knowledge of the final product expected, and must often provide specifications for the contractor. The proper execution of planning, directing, coordinating, organizing, controlling and staffing therefore becomes a primary concern to company management. Fluor must determine task requirements, set reasonable schedule and cost objectives, select the most effective systems and develop meaningful work plans to reach the objectives. Adequate division of the project into components, proper classification of work units, and creation of orderly and productive arrangements are indispensable. Effective assignment of responsibility and authority, with adequate follow-up guidance, is crucial. In staffing and training, result-orientation is stressed. Goals must be achieved in a timely and effective manner. Strong communication skills are particularly important in the face of the need to maintain frequent contact with clients, vendors, regulatory agencies and other Fluor offices. Equally important, or perhaps more so, is the technical knowledge of the staff; timely application of engineering principles and procedures is the key to maintaining both profit and the client's favor.

These principles are embodied in the task-force which is the organization most directly involved with a particular project. A discussion of the task-force concept therefore follows.

Task-Force Concept

Fluor executes its projects under the "Task-Force" concept of operation. The central element of the concept is the collecting of all home-office personnel assigned to a project to one location, forming the project organization under the overall supervision of a Project Manager or Project Director. The individuals making up the task-force are drawn from functional departments in the Division for their skills and experience in various disciplines necessary for the efficient and successful execution of the project. Some employees are assigned to the task-force on a part-time basis. This is often the case for service-group functions. In the Cost/Scheduling group, for example, part-time help from the main office is usually requested to supplement the efforts of task-force personnel for the preparation of cost estimates.

It is a basic requirement of the task-force concept that the Project Manager possess the responsibility and authority over all personnel assigned to the project, whether full-time or part-time, for the duration of their assignments. His authority is functional for costs, schedules, and overall results; administrative and technical authority remains with the Department heads involved.

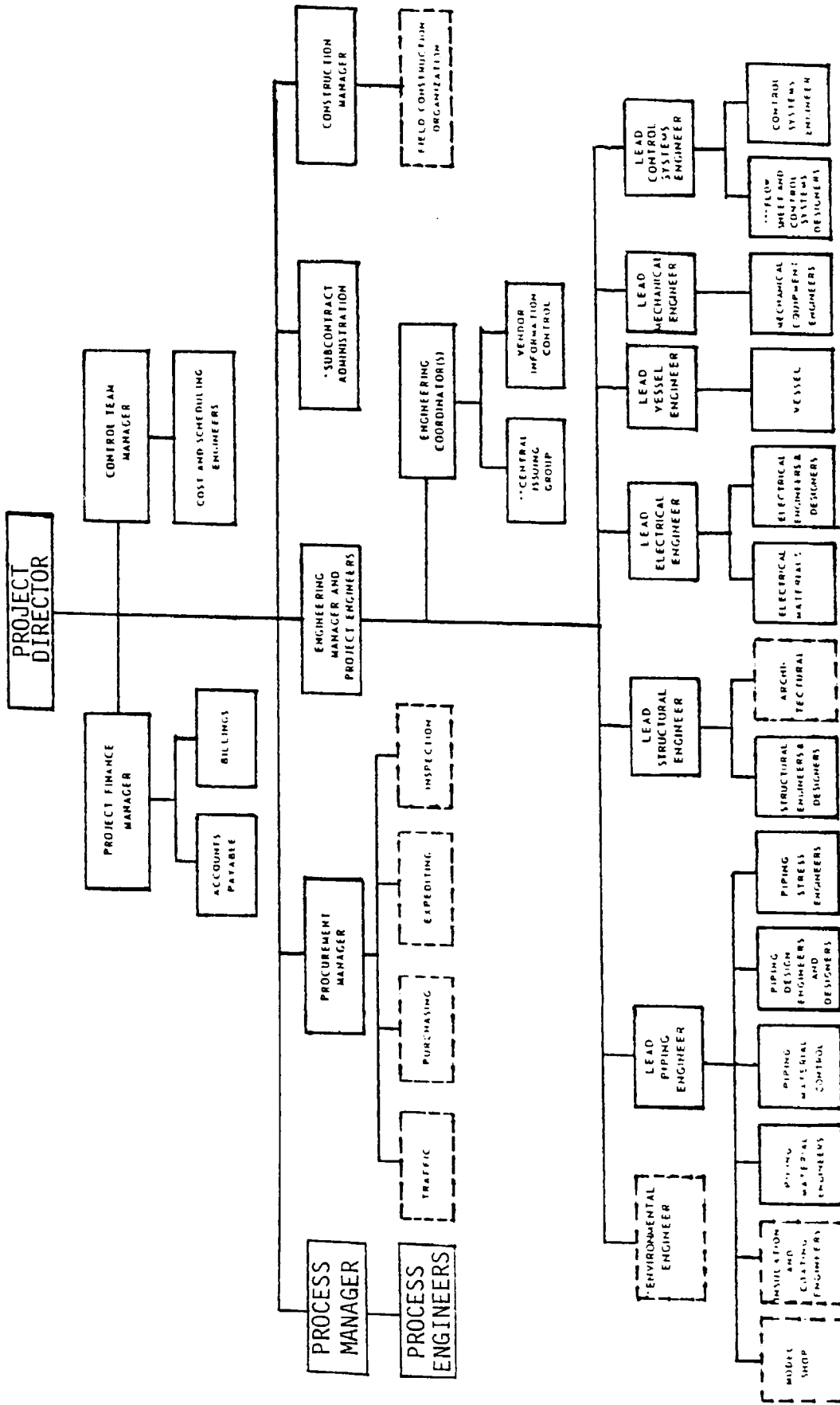
The task-force approach promotes efficiency by consolidating the work-force, while retaining the ability to apply Fluor's specialized

know-how to individual problems as required. It permits rapid communications, and provides the centralized control which the Project Manager needs to meet his responsibility.

Task-Force Organization

Task-force organization is synonymous with project organization. Projects vary in type and scope of work, and their organizations vary accordingly. The task-force size is flexible, ranging from a few individuals for a small project to a group of several hundreds for large projects. For a particular project, the size of the organization also varies from one phase to another, usually building up to a peak during periods of detailed design activity and tapering to a few people at the end of the project.

Figure 5 shows the organization chart for a medium-sized project. It embodies the functions necessary to establish an organization for a specific project. The individual characteristics, such as size, location, client, type of plant, form of financing, etc., dictate the exact organization. In general, small projects tend to combine functions and utilize more part-time assignments of personnel. This assures the benefits of task-force operations while achieving the efficiency appropriate for a small project. Very large projects, on the other hand, incorporate additional staff to provide the levels of management, report methods and administrative functions required. Thus Deputy Directors, Administrative Engineers and other administrative functions may be added. The general guideline is to add enough functions to allow the Project Director the time to attend to overall supervision of the project.



DASHED POSITIONS OF FUNCTIONS ARE NORMALLY NON TASK FORCE

** REPRESENTS FUNCTIONS THAT MAY NOT BE EMPLOYED ON ALL PROJECTS
 *** NOT USED BY HOUSTON DIVISION
 **** FLOW SHEET DESIGNERS PART OF PIPING GROUP IN HOUSTON DIVISION

FIGURE 5: Task Force Organization

At any given point in time, Fluor undertakes a number of projects simultaneously, each with its own task force. Superimposing the various task-force organizations on the Divisional structure modifies the latter from a functional to a matrix organization, with the attendant complexity. A matrix organization is characterized by dual or multiple managerial accountability and responsibility. In addition to the vertical lines of authority familiar to the functional organization, authority in the matrix organization flows along horizontal and diagonal lines. The Project Director enjoys no monopoly in decisions affecting the project, but operates in a decision-making matrix, sharing authority with Department functional managers. Thus, personnel assigned to the task force are responsible both to their functional superiors and the Project Director.

The matrix organization is particularly designed for the management of large and complex projects in the face of limited resources. Its advantages therefore necessarily include project integration, efficient use of resources, effective information flow and development of project management skills. It is, however, also plagued with a number of disadvantages, among which are chiefly, the potential for conflict between functional and project managements, and the difficulty of defining priorities between various projects with limited resources to allocate. Books on project management [4, 6, 9] provide detailed discussions on advantages and disadvantages of the matrix organizational structure.

A TYPICAL PROJECT CYCLE

The numerous activities which transpire from the identification of a project through its completion can be described in three major phases-- Identification and Securement, Implementation, and Commissioning.

Identification and Securement

This phase begins with the identification of the project and concludes with the negotiation of a contract with the client [10]. Project identification could occur through a variety of sources including a direct request for bids by a prospective client, informal contacts between Fluor managers and prospective client managers, trade bulletins, and U.S. embassies for overseas projects. Whichever the source, identification is followed by a Qualifications Proposal to the prospective client, summarizing Fluor's experience, special resources, qualifications and skills in the particular area of work. The prospective client, after examining all applicants, compiles a "short list," which is merely a reduced list of possible contractors. This is followed by a formal letter--"tender document," to affected contractors requesting them to submit detailed proposals for the project of interest. The tender document defines the project, its scope, need dates, and other required data. If included, Fluor then forwards a proposal covering both the technical and commercial aspects of the project.

Proposals. The technical aspect of the proposal essentially translates the client's scope of work as provided in the tender document into

its component process and support units. In turn, the process units are reduced to smaller work units with man-hour estimates, material requirements and costs. On a typical refinery-engineering and construction job, for example, component process units would include a hydrogen plant and desulfurization units; and support units would include various utility units, storage units, piping systems, etc. For each of these units, man-hour estimates to execute design, supervision, procurement, construction and other functions as may be needed are identified, in addition to material requirements. The technical aspect of the proposal also identifies potential vendors and licensors from whom Fluor might obtain materials and design models. A bar chart schedule of the work plan is also attached.

The commercial aspect of a proposal covers Fluor's terms for providing the proper services commensurate with the scope of work [7]. Included are such items as the schedule of salaries and labor rates for various classes of personnel, reproduction charges, computer charges and personnel policies. The commercial contract also states Fluor's reimbursement pattern, usually cost-plus. Under the cost-plus pattern Fluor is reimbursed for all direct costs incurred on the project within the approved scope of work; in addition, a fixed fee--usually a percentage of the direct costs--is required by the Company to cover overhead and profit. An alternative to the cost-plus reimbursement pattern is lump-sum, used by very few process-plant contractors. As implied in the name, in a lump-sum pattern, the contractor is reimbursed a single sum which is agreed-upon prior to execution of the project. Of course, both expected costs and profits would be factored into the single sum.

The lump-sum reimbursement pattern is not favored among process-plant contractors, primarily because of its obvious risks, especially within the context of life in the process industry. First, it is not easy to estimate with a reasonable degree of certainty the man-hour requirements of a given scope of work. Second, material prices often escalate significantly over the life of a project. In fact, even scope definitions of projects change over the duration of projects and their costs change accordingly, often significantly. Thus, process-plant projects entail too much variability for any profitable adoption of lump-sum reimbursement patterns. It is, however, possible that most small projects with well-defined scope of work would be executed on lump-sum terms.

Contract Negotiation. The last step in securing a project is contract negotiation. The potential client receives and evaluates proposals from contractors on its short list; and awards the project to one or more of them. It is not uncommon for the initial scope of work to be split between two or more contractors. For example, a project involving engineering, procurement, and construction may be awarded to three contractors each performing only one aspect of the project. Following the award of the project, the successful contractors are invited for contract negotiations. The contract covers all aspects of the project: project organization, cost reporting, reimbursement pattern, work schedule, responsibilities, procedures for scope modifications, etc. The completion of contract negotiation signals the official project "kick-off."

Having noted above that a contract may be awarded for one or more of engineering, procurement and construction, the rest of the discussion on project cycle will consider what follows the signing of a contract that covers all three aspects.

Implementation

Project implementation entails the mobilization of Fluor's technical, management, and other personnel under the task-force organization to execute the full scope--engineering, procurement and construction--of the project.

Engineering. In general, Fluor identifies six phases of engineering activity, namely: Conceptual engineering, Preliminary engineering, Design engineering, Early Production engineering, Production engineering, and Field Support engineering [3]. The major activities covered under these phases are listed in Figure 6. Only activities starting during a particular phase are identified. Many activities occur over more than one phase. The Conceptual engineering phase comprises activities which are definitional in nature. Material and equipment needs, space need, construction site characteristics, regulatory requirements, and the project characteristics are identified. The entire task-force effort is focused on planning and organizing. Each functional group breaks down its aspect of the job into manageable work units, identifies resource needs, defines alternative approaches and selects specific angles of attack.

I. CONCEPTUAL ENGINEERING

General Contract Information and Standards; Overall Block
 Flow Diagram; Process Flow Diagram; Identify and Specify
 Package Units; Develop Major Equipment List; Mechanical
 Flow Diagrams; Process Data Sheets
 List of Electrical loads by Unit/Area
 Environmental Permit and Applications;
 Initial Bidders List
 Overall Plot-Plan; Geotechnical Reports and Topo. Maps
 Mechanical Engineering Project Functions and Front-End Engineering

II. PRELIMINARY ENGINEERING

Material Specification; Temporary Construction Facilities
 Offsite and Utility System Flow Diagrams; Line and Flow Summary;
 Flare Header Sizing
 Equipment Vendor Selection and Vessel Procurement;
 Engineer and Prepare Vessel RFQ Drawings
 Primary Rigging Plans
 Unit Plot Plans; Offsite Storage Tank Orientation;
 Piping Material Take-Offs
 Building Drawings; Piling Design; Site Preparation Drawings;
 Vessel and Equipment Foundations
 Size, Specify and Purchase Valves; Control Center Design
 and Instrumentation
 Area Classification

III. DESIGN ENGINEERING

Material Take-Offs; Vendor Data Review; Vessel Orientation;
 Vessel Ladders and Platforms
 Model Piping and Review; Piping Equipment Studies/Vessel Orientation
 Unit Location Control Plan; Pipe Stress;
 U/G Piping Plans; Pipeway Installation Plans
 Tank Foundation and Dike Drawings; Pipe Supports and Other Structures;
 Electrical Layouts; One Line Diagrams; U/G Electrical
 Drawings; Elementary Diagrams

FIGURE 6: The Six Phases of Project Engineering

IV. EARLY PRODUCTION ENGINEERING

A/G Piping Plans; Piping Isometrics
Finish Grading and Paving Drawings
Control System Location Plan
Electrical Connection Diagram; A/G Electrical Drawings

V. PRODUCTION ENGINEERING

Heat Trace Details and Press Summary
AFC Issues
Control Systems Connection Diagram

VI. FIELD SUPPORT ENGINEERING

Finish Electrical Material Take-Off; Finish Electrical
Connection Diagrams
Support Construction Activity

Figure 6 (Cont'd)

The Preliminary engineering phase is characterized by initial design activity. Material, equipment and process specifications are made. Ideas are translated into drawings on paper, and much of the work started in the conceptual stage is concluded during this phase.

The design engineering phase continues the design activity begun during the preliminary phase. Detailed specifications are incorporated, reviewing many of the drawings made in the previous phase. Procurement of materials and equipment is initiated, and various project management control mechanisms effected. At this point in the project, uncertainties narrow down and better estimates of project cost and schedules can be made.

The Early Production engineering phase is characterized by activities preparatory to construction. Design work on temporary construction facilities, started during the preliminary engineering phase, is completed. Field construction personnel are mobilized and delivery of construction material and equipment to the site is begun. Some drawings, especially those required for front-end construction work are sent to the client for approval.

The Production engineering phase represents the culmination of design effort in the project. Build-up of home-office personnel which reaches a peak during the design phase drops sharply at the end of this phase. Drawing approvals are obtained from the client for most drawings, and delivery of materials and equipments to the site begins during this phase. Management attention begins to shift from the home-office to field, and procurement coordination becomes critical. The home-office mobilizes a field unit which moves in with the construction organization

to act as liaison. By the end of the production engineering phase, the home-office organization is nearly completely disbanded.

The final phase of engineering, Field Support engineering, lasts the rest of the project life. Key personnel, usually management control personnel, work with construction personnel throughout the remaining life of the project.

Construction. Construction is obviously the ultimate objective for the entire project effort. The "products" of the engineering effort are translated into a viable physical plant, using more management and other personnel skills, and the materials and equipments purchased from various vendors. Construction activity ends with the testing and checkout of various sections of the plant for proper functioning. With a successful completion of this aspect of the project, Fluor effectively reaches the end of its responsibility to the client.

Figure 7 portrays the three aspects of project implementation as they occur over a typical project cycle, which usually has an approximate three-year duration. It clearly shows the degree of overlap characteristic of the various phases of project implementation.

Commissioning

Commissioning is a contractual exercise by Fluor to mark the successful completion of its obligation under the contract signed with the client. It may or may not include start-up, except for "turn-key" projects in which the contractor's obligation includes start-up of the plant. In practice however, contractors always witness the plant

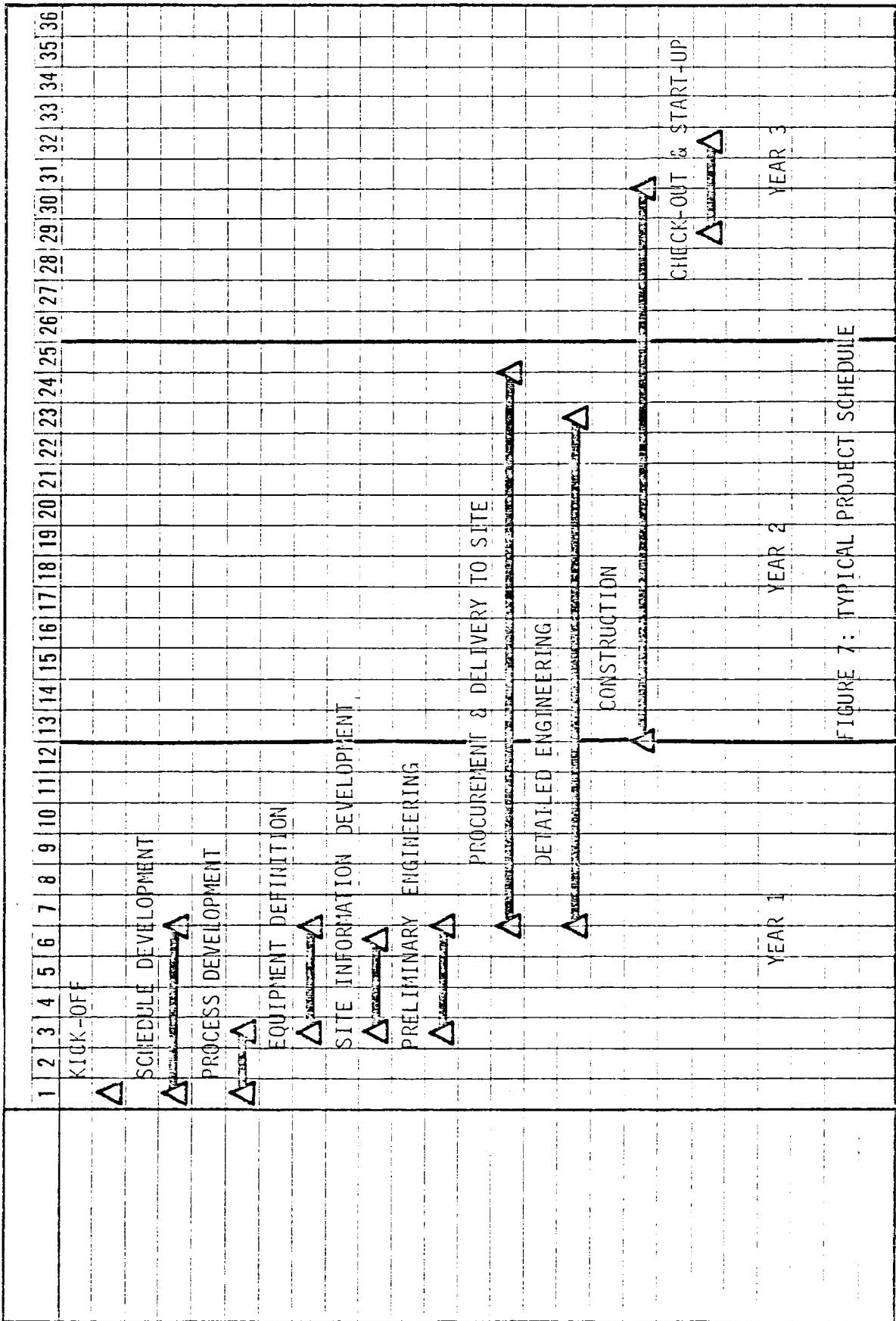


FIGURE 7: TYPICAL PROJECT SCHEDULE

start-up operations if only to give an impression of integrity. Commissioning is formally expressed in the Custody in Control letter which Fluor sends to the client at job completion.

This chapter has considered the organizational atmosphere of the internship in order to demonstrate the author's understanding of the Fluor approach to project implementation and provide a background for the rest of the report. The following chapter addresses the process basis for the particular project on which the internship was served. More than any other aspect of the project, the process technology represents the one area that is surrounded with proprietary precautions since many of the basic process designs are borrowed from various licensors. Therefore, the discussion of process technology will be limited to general principles that are easily obtained from the literature, with reference to the Fluor project only for illustrative purposes.

CHAPTER III

PROCESS TECHNOLOGY OF THE PROJECT

PROJECT OVERVIEW

The internship was served in an on-going Refinery Modernization project. An existing refinery is being upgraded to process high-sulphur crude. This project, valued at over \$300 million, consists of two segments designated as "Area 01" and "Area 02." In Area 01, Fluor has contractual responsibility for engineering, procurement, and construction of all process and supporting units; Area 02 involves only engineering and procurement. Construction responsibility for Area 02 was awarded to a different contractor.

Table 1 lists the specific physical facilities that define the scope of Fluor's work in both Area 01 and Area 02. The facilities in Area 01 constitute the process units--defined as those units of the plant that operate directly on the crude oil being processed. Also included in Area 01 are major support facilities primarily consisting of utility systems (electricity, steam, cooling water, and fuel oil), interconnecting piping systems, instrument control units, waste management units (sewage, acid gas and sour gas), and storage units. Area 02 facilities are all in the support category.

A brief description of the process units will be undertaken after the discussion of general petroleum refining processes presented in the following section. The author's internship engagement was primarily

Table 1. Process and support facilities in project scope.

I. Area 01

- Hydrogen Production Plant
- Atmospheric Residuum Desulfurization Unit
- Sulfur Recovery Unit
- Tail Gas Unit
- Amine Regeneration
- Sour Water Stripping Unit
- Cooling Tower
- Instrument/Utility Air System
- Electrical Distribution (13.8 KV)
- Nitrogen System
- Sewers
- Interconnecting System
- Fuel Oil System
- Sulfur Storage
- Control House
- Acid Gas Flare
- Sour Gas Flare

II. Area 02

- Sulfur Loading Facilities
- Waste Water Treatment
- Electrical Distribution
- Interconnecting Systems
- Fire Protection Systems
- Sewers
- Hydrocarbon Flare
- Topped Crude Storage System

in the hydrogen production plant; as such, a more detailed description of this plant will be covered. No further description of support systems will be made, as they are mostly self-explanatory (Table 1).

Figure 8 is an artist's rendition of the process units in Area 01. It shows the geographical configuration of the process facilities listed in Table 1. The Atmospheric Residuum Desulfurization (ARDS) unit is by far the largest of the four process facilities--accounting for about 42 per cent of the total direct field cost, and about 45 per cent of the total direct field man-hours on the project. Next in size is the Hydrogen Plant with 22 per cent of the total direct field cost and 13 per cent of the total direct field man-hours. Direct field cost accounts for about 60 per cent of the total project cost; and direct field man-hours constitute approximately 56 per cent of the total man-hours estimated to go into the project. Other areas of expending dollars and man-hours include Indirect Field and Home Office.

PETROLEUM REFINING

The objective of petroleum refining is to maximize the yield of various petroleum products from crude oil. There are various kinds of crudes, usually identified by density, by sulfur content, or by source. When classified by the sulfur content, a high sulfur crude is said to be "sour" while a low-sulfur crude is described as "sweet". Also, there is a host of petroleum products, including lubricating oils, waxes, solvents, road oils, asphalt, petrochemicals, fuels, etc.

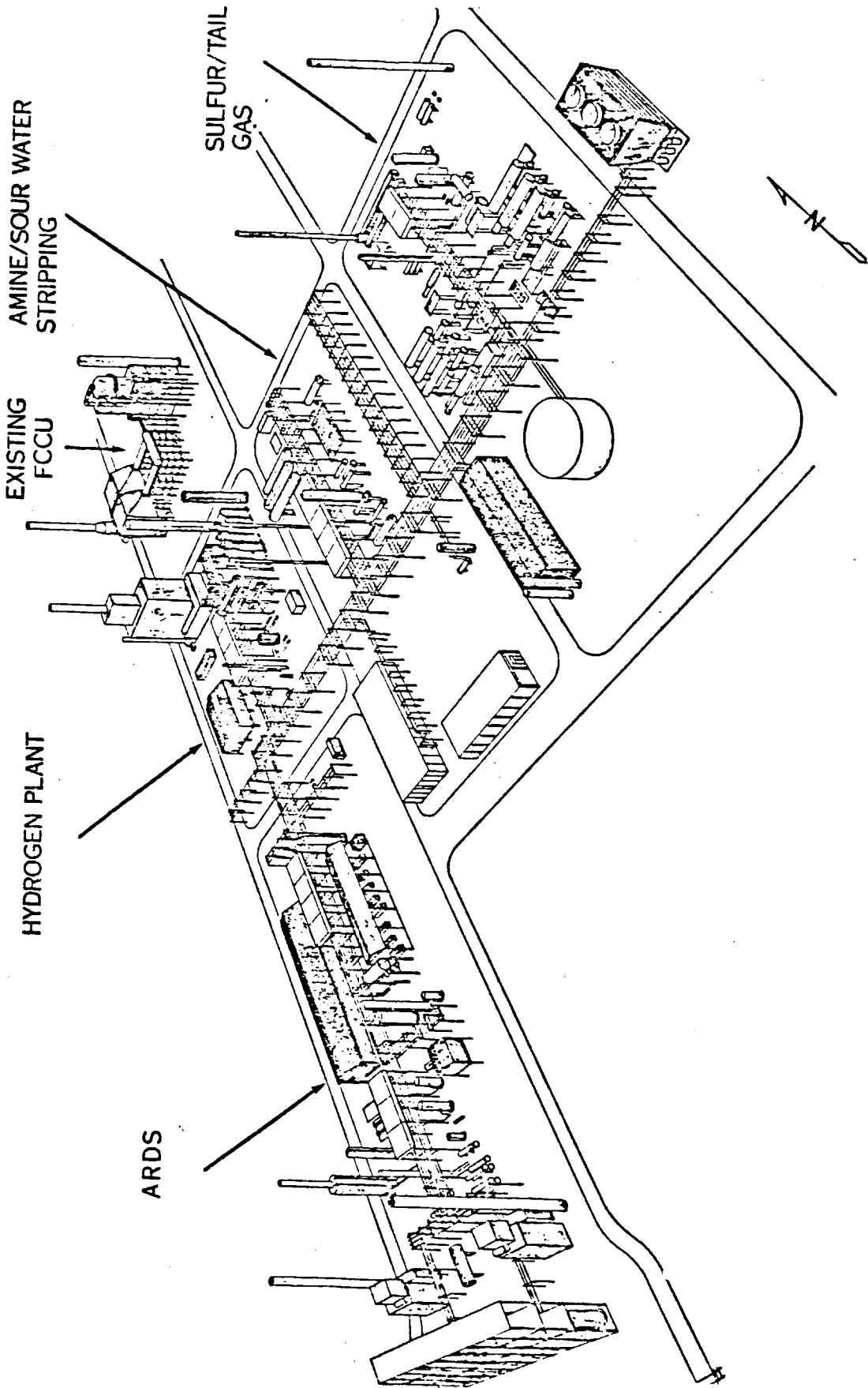


Figure 8. Artist's Rendition of Refinery-Modernization Project.

The specific design of a refinery usually depends on the type of crude being processed and the desired end products. For the purpose of this report, only fuels-producing refining is considered, such fuels including gasoline and fuel oils.

A typical fuel-producing refinery is comprised of the following basic processes: (1) crude distillation, (2) catalytic reforming, (3) catalytic cracking, (4) catalytic hydrocracking, (5) alkylation, (6) thermal cracking, (7) hydrotreating, and (8) gas concentration [1:225]. To these primary processes are added auxiliary processes involving treatment units for liquid and gas purification, waste-management and pollution-control systems, cooling-water systems, units to recover hydrogen sulfide from gas streams and convert it to elemental sulfur or sulfuric acid, electric power stations, steam-production facilities, and storage facilities. These auxiliary facilities have heretofore been referred to as "support systems".

Each of the above processes will now be briefly discussed, with reference to the Fluor project as appropriate for illustrative purposes.

Crude Distillation

Crude distillation, one of the first in the sequence of refining processes, involves using single or multiple fractionating columns¹

¹Fractionating columns are cylindrical vessels equipped with numerous trays through which hydrocarbon vapors can pass in an upward direction. Each tray contains a layer of liquid through which the vapors can bubble and the liquid can flow continuously under gravity from one tray to the next one below.

to separate the crude oil into parts, usually identified by their boiling-temperature ranges. The fractions, as the parts are called, then become feeds for subsequent processing to yield various desired products.

A crude distillation unit usually comprises two sections, one performing at atmospheric pressure and the other under vacuum. In the atmospheric-pressure section, the crude is heated to partial vaporization and introduced into the fractionating column near the bottom. As the vapors pass through the succession of trays, they become lighter (lower in molecular weight and more volatile), and the liquid flowing downward becomes progressively heavier. This counter-current action results in a separation of hydrocarbons by boiling points; and the fractions can be withdrawn from the trays, the lighter gases from the top trays and heavier fractions with higher boiling points at the lower trays. The process leaves a bottom liquid stream, called the atmospheric residue, which is then subjected to vacuum distillation. During this phase, the atmospheric residue is further heated and introduced into a vacuum chamber where vapor and liquid are separated by a single-stage flash [1:226]. The results are a high boiling-range gas oil and a non-distillable residual pitch.

Table 2 summarizes the typical fractions that result from crude distillation, and their respective boiling ranges [12:100].

Table 2. Typical crude oil fractions.

<u>Fraction</u>	<u>Boiling Range °F</u>
Light Straight-run ¹	below 200
Naphtha	180-420
Light gas oil	420-650
Heavy gas oil	650-1050
Residues	above 1050

¹This fraction generally contains all hydrocarbons lighter than C₇ in the crude, and consists primarily of native C₅ and C₆ families. It can be stabilized to remove the C₄ and lighter hydrocarbons which are routed to a central gas-concentration unit for further resolution [1:226].

In order to minimize corrosion of equipment, a crude oil distillation unit is generally preceded by a Desalter, which reduces the inorganic salt content of raw crudes. The desalted crude is then subjected to the atmospheric distillation process described above.

The Fluor project does not include any work on a crude distillation unit. However, the Atmospheric Residuum Desulfurization (ARDS) unit--a part of Fluor's scope of work--is fed by existing crude distillation units. As implied in the name, the ARDS unit essentially diminishes the sulfur content in the atmospheric residue originating from the crude distillation process.

The basic process principle underlying the operation of the ARDS unit is demonstrated in the flow schematic of Figure 9. Fresh filtered feed, desalted crude or distillation residu, is mixed with hydrogen

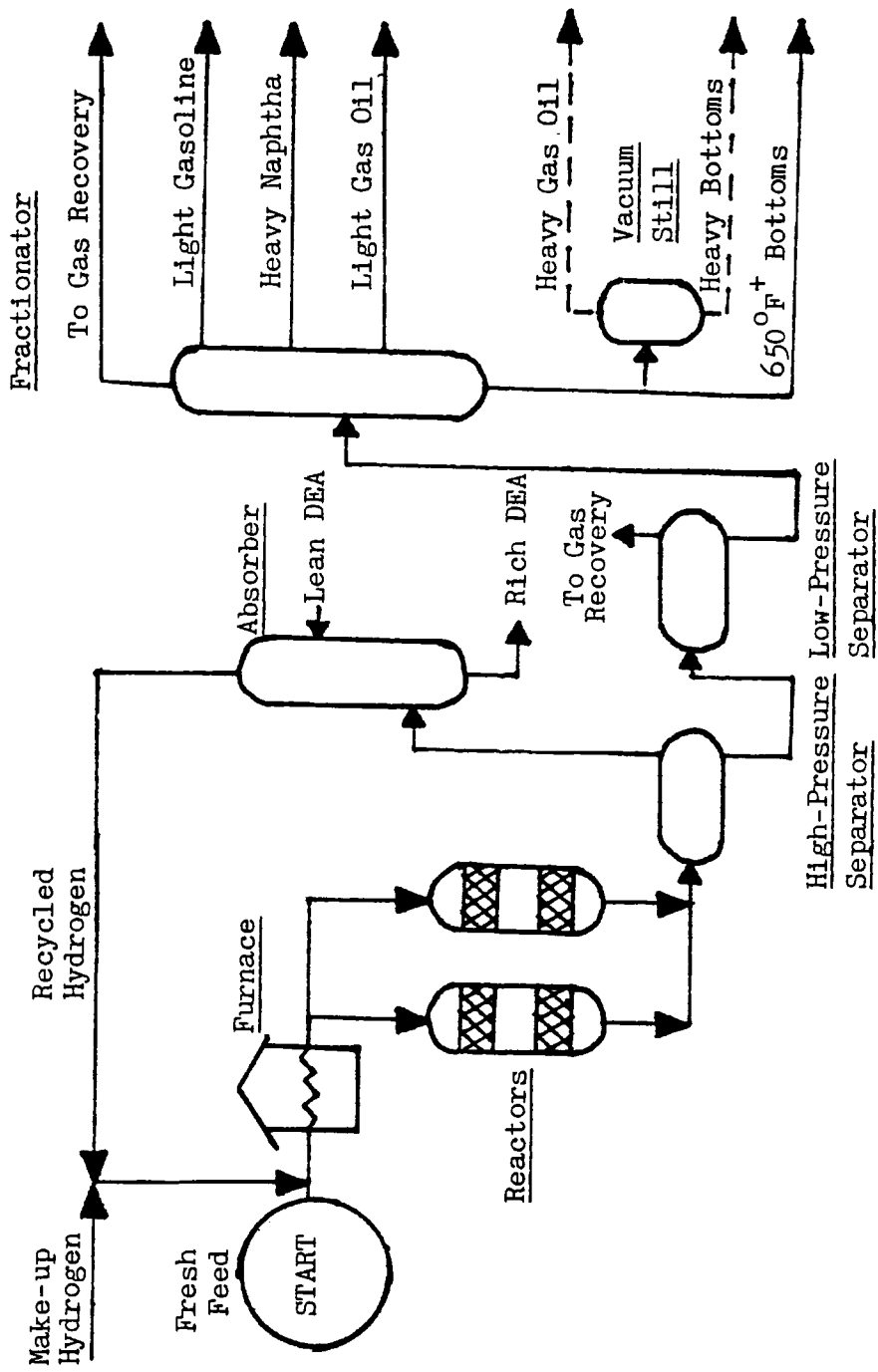


Figure 9. Resid Hydrodesulfurization
 Source: "1978 Refining Process Handbook," Hydrocarbon Processing Vol. 57 No. 9
 (September 1978) : 149.

and recycled gas under high temperature. This mixture is then charged through the reactors over catalytic media. Here formation of hydrogen sulfide (H_2S) is enhanced. The reactor effluent is then passed sequentially through a high-pressure flash separator, a low-pressure flash separator and a fractionating column respectively. Thus, a combined application of pressure and temperature controls results in effective isolation of the sulfur content in the feed from the fractions of the feed. The ARDS unit, based on a Gulf-licensed design, yields H_2S --forwarded to a sulfur plant for conversion to elemental sulfur--and low-sulfur fractions which include naphtha, distillate, gas oil and residue. Actually, the sulfur content in the component yields varies between fractions, with the residue retaining the highest amount. Also, the sulfur content of the yields depends on the severity of the hydrodesulfurization employed. The severity can be controlled by application of proper catalyst types and quantities in the reactors, proper levels of hydrogen, and temperature controls.

Catalytic Reforming

Catalytic reforming entails the rearrangement of the molecular structure of hydrocarbons over a catalytic medium. The usual objectives are to upgrade the antiknock characteristics of naphthas in order to convert them to premium fuels with above 90-octane ratings, to produce high yields of $C_5 - C_8$ aromatics for petrochemical feedstocks, and to produce liquid petroleum gas (LPG) from naphthas while upgrading them.

Catalysts and process conditions are usually selected for maximization of the particular objective. Hydrogen is a major by-product of the process.

A number of specific designs are available. In the Fluor project, catalytic reforming is employed in the production of hydrogen, which is in turn used in the hydrodesulfurization process of the ARDS unit. A detailed description of reforming will therefore be undertaken under the section on hydrogen production.

Most designs of catalytic reforming require the pretreatment of the feedstock to remove nonhydrocarbons which poison the noble-metal catalysts, used in the reforming, by reducing or destroying their activity and selectivity. Catalyst poisons include sulfur, nitrogen, oxygen and organic compounds of arsenic and palladium. The usual treatment involves passage of hydrogen (hydrogenation) over catalytic media under proper temperature-pressure conditions.

Cracking Processes

Cracking includes all reactions in which a hydrocarbon molecule is broken into two or more smaller fragments. Thus the objective of cracking processes is the reduction in size of the hydrocarbon molecule, primarily by breaking of carbon-carbon bonds. There are three main kinds of cracking--thermal cracking, catalytic cracking, and catalytic hydrocracking.

Thermal Cracking. Thermal cracking achieves the reduction of hydrocarbon molecules by application of heat. Two forms of thermal

cracking have generally been employed, thermal coking and viscosity breaking (visbreaking). In coking, heavy residual stocks are converted into gas, gasoline, distillates, and coke with the objective of maximizing the yield of distillates. Light distillates are used in the production of domestic and industrial heating oils; heavy distillates are further subjected to catalytic cracking to create gasoline. Gasoline from thermal coking can be blended into motor fuels after suitable treatment. Coke, regarded as a by-product of the coking process, can be useful as a fuel in steam generation and, where it meets purity and other specifications, in the manufacture of carbon electrodes and aerospace components.

Viscosity breaking reduces the viscosity of heavy residues by a mild thermal cracking. The slightly cracked products are then separated by distillation into gas, gasoline, a light distillate, and a fuel-oil residue having a considerably lower viscosity than the feedstock. The visbroken residue could be further reduced in viscosity by blending with certain oils to produce marketable fuel oil.

Catalytic Cracking. This form of cracking is employed to create gasoline, C_3/C_4 olefins, and isobutane by selective decomposition of heavy distillates over a catalyst [1:231]. The specially prepared catalysts, often referred to as "zeolite catalysts" because they are modified hydrated-alumina silicates, enable the production of gasoline with substantial proportions of high-octane-number hydrocarbon components such as aromatics.

The Fluor project does not include work on catalytic cracking units but both the ARDS unit and an existing crude distillation unit provide the heavy-residue feed that is charged into the existing fluid catalytic cracker (FCC) unit.

Hydrocracking. Hydrocracking is a cracking process that utilizes both hydrogen and catalysts, usually different from those employed in catalytic cracking. It can thus be seen as a hydrogenation of the feedstock under high pressure in a catalytic medium. A number of differences between hydrocracking and catalytic cracking have been identified [1:233]. In contrast to those from catalytic cracking, products from hydrocracking are not olefinic, they are not as high in octane number and have a higher naphthene content. The lower aromatic content of distillates from hydrocracking renders them useful components of jet fuels and other products requiring low aromatic content. All hydrocracked products are low in sulfur because of the resulting formation of H_2S . Hydrocracking processes also accommodate a wider range of feedstocks, including heavy distillates and solvent extracts from high organometallic residuals.

Alkylation

Alkylation refers to the chemical combination of isobutane with any one or a combination of propylene, butylenes, and amylenes--all olefins--to form a mixture of highly branched paraffin that has a high antiknock rating and good stability [1:236]. The reaction occurs in

a catalytic medium, with either sulfuric acid or hydrofluoric acid as the catalyst. Blends of butylenes and propylenes form the olefinic portion of the feedstock used in refining; and they are typically made from catalytic cracking. The other portion of the feed, isobutane, could come from hydrocracking, catalytic reforming or natural gas.

Hydrotreating

Hydrotreating is a specialized form of hydrogenation, involving liquid hydrocarbons subjected to mild or severe conditions of hydrogen pressure in a catalytic medium in order to improve their quality. The use of this process in various United States refining facilities has been considerably accelerated over the years due to the evolution of catalytic reforming technology which provides significant quantities of hydrogen as by-product.

Hydrotreating processes utilize a wide spectrum of feedstocks, ranging from light fractions of gasoline to heavy residual stocks. The numerous applications of the process include (1) pretreatment of naphtha feeds for catalytic reforming; (2) desulfurization of distillate fuels; (3) improvement of the burning quality of jet fuels, kerosines and Diesel fuels; (4) improvement of color, odor, and storage stability of various fuels and petroleum products; (5) pretreatment of catalytic cracking feeds and cycle oil (a distillate of catalytic cracking which boils above gasoline) by removal of metal, sulfur, and nitrogen, and by reduction of polycyclic aromatics; (6) upgrading of lubricating-oil quality; (7) purification of light aromatic by-products of cracking

processes; and (8) reduction in sulfur content of residual fuel oils as in the ARDS unit of the Fluor project. In many of these applications, the hydrotreatment yields hydrogen sulfide, ammonia, and water which are easily removed from the hydrotreated liquid product by stripping in a stabilization unit [1:236].

Gas Concentration

Gas concentration processes involve the collection of gaseous product streams from various processing units and physically separating them to provide a C_3/C_4 stream as feedstock for alkylation and a C_2 and lighter stream that is used to meet process heat requirements within the refinery.

HYDROGEN PRODUCTION

The previous discussion of hydrotreating reveals the importance of hydrogen in many petroleum refining activities. In fact, it is said that over 30 per cent of refining activity in the United States involves hydrotreating [1:235]. Fluor's desulfurization project, in particular, depends heavily on hydrotreating as previously mentioned under the discussion of the ARDS process. Moreover, much of the author's internship involved activities related to the hydrogen production plant. A consideration of the hydrogen production process is thus relevant to a discussion of the process technology of the internship project.

Fluor's hydrogen production process for the refinery modernization project consists of four major steps, namely; pretreatment of the feed,

desulfurization of the feed, steam reforming; and purification of the product hydrogen.

Feeds and Pretreatment

The design of the hydrogen plant is based on a production capacity of 50 MMSCFD (million standard cubic feet per day) of hydrogen using any of several feedstock combinations of natural gas, flash gas and naphtha. Because the plant primarily processes gaseous feeds, the feedstock is first pretreated to separate the liquid hydrocarbons. The resulting gaseous component is then forwarded for desulfurization.

Desulfurization

The desulfurization at this point only serves to extract the sulfur content of the feed which can poison the nickel catalyst used in the subsequent reforming process. It proceeds in two steps. First the preheated feedstock is passed over a cobalt/molybdenum medium which converts any elemental sulfurs and mercaptans (sulfur containing hydrocarbons) into hydrogen sulfide, in the presence of hydrogen. The resulting mixture is then passed over a zinc oxide catalyst which converts the H_2S into zinc sulfide. This completes the desulfurization process, and the hydrocarbon stream is now ready to enter the next step, steam reforming.

Hydrogen-Steam Reforming

It was pointed out in a previous discussion of catalytic reforming that hydrogen is a by-product of all reforming activities usually intended

to rearrange the molecular structures of hydrocarbons in order to upgrade the antiknock characteristics of naphthas or produce aromatics from selected fractions of naphthas. The objective of the hydrogen plant is to maximize the production of hydrogen and catalytic reforming constitutes the primary means for accomplishing this objective. Steam reforming--catalytic reforming in the presence of steam--accomplishes the objective of maximizing the hydrogen yield from catalytic reforming.

Figure 10, a Foster Wheeler Corporation design, demonstrates the basis process involved in steam-reforming. The desulfurized feedstock is mixed with superheated steam and the mixture passed over a catalytic medium--usually nickel for natural gas feedstock, may be something else for naphthas--in the main reforming unit at temperatures ranging from 1,400°F to 1,600°F [10:165]. The resulting gas contains hydrogen, carbon monoxide, carbon dioxide, and excess steam. This gas is cooled and passed through a shift converter where the carbon monoxide is further exposed to steam over two beds of catalyst, converting it to hydrogen and carbon dioxide. A hydrogen-rich gas emerges at this point, under the design used in the Fluor project, which is then cooled and delivered for purification. In other cases, a carbon dioxide-rich gas emerges, which is scrubbed to isolate as much of the carbon dioxide as possible [10:165]. Any remaining carbon oxides are converted to methane by passing over a nickel-based catalyst in the methanator at high temperatures.

Thus the reforming process converts methane to hydrogen by steam treatment as shown in the following chemical equations:

Desulfurizer

Reformer

Shift Converter

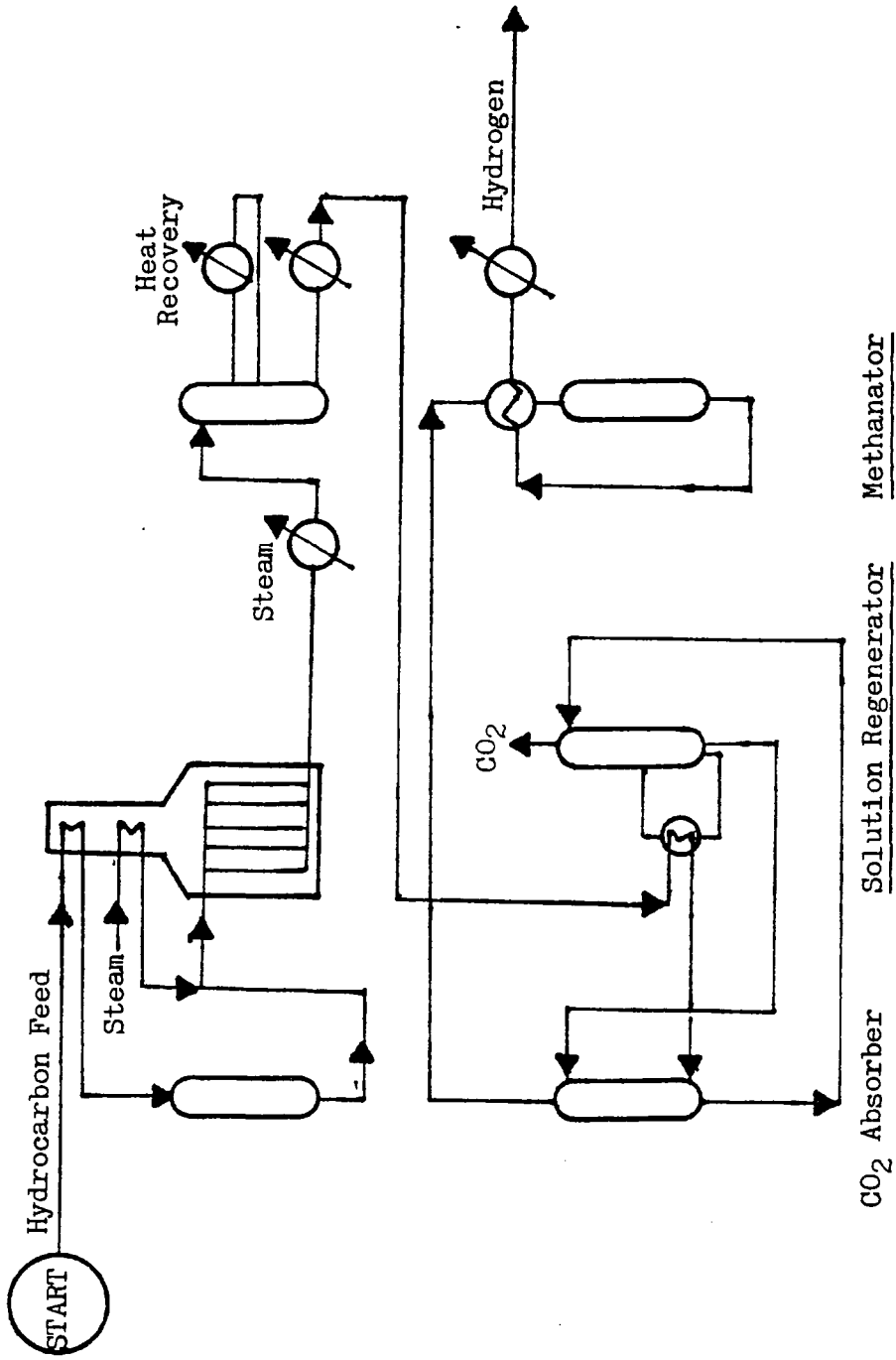
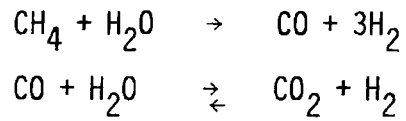


Figure 10. Steam Reforming.

Source: "Gas Processing Handbook," Hydrocarbon Processing Vol. 58 No. 4 (April 1979) : 165.



Of course, the extent of these reactions is governed by thermodynamic conditions. Methane conversion could be enhanced by one or more of (1) increase in temperature, (2) decrease in pressure, and (3) increase in the steam-to-carbon ratio. The carbon monoxide conversion--which proceeds over a chromia-promoted iron oxide catalyst (at high temperature) or a zinc oxide copper catalyst (at low temperature)--and hence the hydrogen yield could be enhanced by increasing the steam concentration.

Purification

The above reforming process produces, along with hydrogen, some remnant carbon dioxide, carbon monoxide, water, methane, and nitrogen which constitute an impurity in the desired hydrogen. The objective of the purification process is therefore, to remove these foreign elements from the hydrogen stream.

The Fluor project uses a purification unit, based on advanced Pressure Swing Adsorption (PSA) techniques, licensed by Union Carbide Corporation. The PSA process uses ten adsorbent beds over which the hydrogen stream flows; and it operates on alternating cycles of adsorption and regeneration. During the adsorption phase, feed gas enters an adsorber which contains appropriate adsorbents to remove the impurities. Following adsorption, adsorbents are regenerated through an alternating sequence of depressurization and repressurization of the adsorbers,

thus preparing the system for the next cycle of adsorption. A completely automatic unit, the PSA is capable of yielding up to 99.9999%- pure hydrogen [10:164].

The hydrogen production process ends with filtration of the yield from the PSA unit to remove dust. The filtered hydrogen is then sent to the ARDS unit. The plant is designed to produce hydrogen with varying purity depending on the feedstock used. Helium and nitrogen by-products may result from using some natural gas feedstocks.

PROCESS SUMMARY

Previous sections of this chapter have presented a comprehensive, but brief, description of the process technology relevant to Fluor's refinery-modernization project on which the author served his internship. The purpose of this section is to capsulize the major process components of the project.

Figure 11 shows the major process units of the project, consisting of the Hydrogen Plant, the Atmospheric Residuum Desulfurization (ARDS) unit, the Amine Regeneration/Sour Water Stripping unit, and the Sulfur Recovery/Tail Gas unit. As was previously noted, the project aims at providing the extra capability of processing high-sulfur crude in an existing refinery; as such the ARDS unit represents the core of the project. The other units play only a supportive role.

The Hydrogen Plant provides the ARDS unit with hydrogen which is the primary agent for desulfurizing the sour crude. The ARDS unit produces,

- | | |
|-------------------------|---------------------------------|
| 1. Sour reduced crude | 15. SCOT Tail Gas |
| 2. Sweet reduced crude | 16. Stack Gas |
| 3. Naphtha | 18. Sour water |
| 5. Light gas oil | 19. Sour water |
| 6. Natural Gas | 20. Stripped sour water |
| 7. Flash gas | 21. Sour gas(H_2S , NH_3) |
| 8. Rich MEA | |
| 10. Lean MEA | |
| 12. Acid Gas (H_2S) | |
| 13. Tail Gas | |
| 14. SCOT Recycle Gas | |

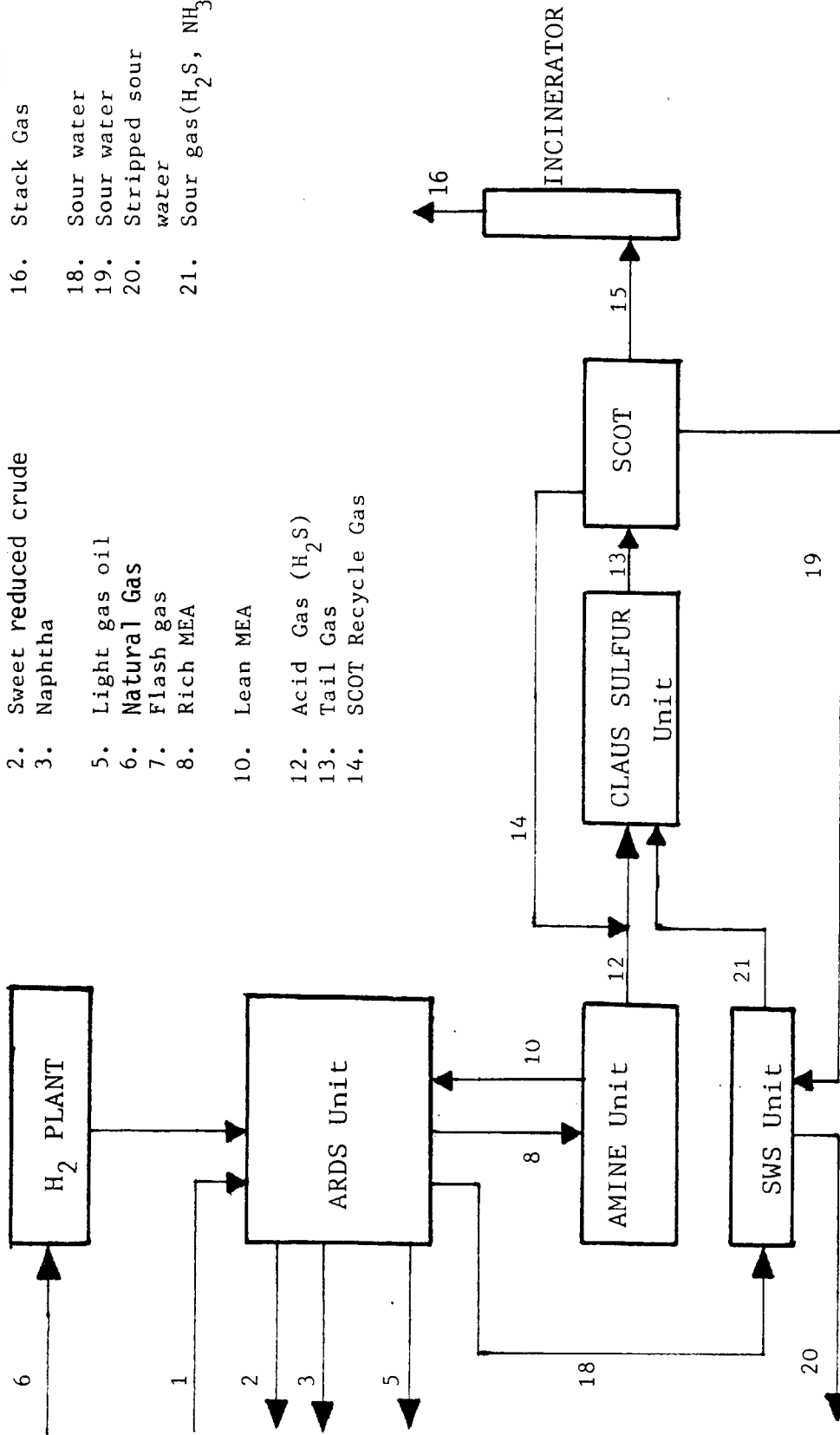


Figure 11. Block Flow Diagram of Refinery-Modernization Project.

in addition to various fractions of sulfur-free hydrocarbons, sulfurous water (sour water) and hydrogen sulfide which constitute environmental hazards. Hydrogen Sulfide (H_2S) from ARDS is absorbed in some amine solution. It is then stripped by the Amine Regeneration unit and delivered to the Sulfur plant (CLAUS) for recovery of elemental sulfur. The Tail Gas (SCOT) unit serves to enhance the sulfur recovery efficiency of the sulfur plant. Output sulfur compounds and free sulfur are converted to H_2S over a cobalt/molybdenum catalyst in the presence of hydrogen [10:139]. Water vapor in the process gas is condensed, the condensate sent to the Sour Water Stripper, and the converted H_2S is recycled to the sulfur plant. Remnant traces of H_2S are burned in the incinerator.

The sweet (low-sulfur) outputs of the ARDS unit--naphtha, distillate, and residue--are submitted to existing units of the refinery for further processing and/or treatment by some of the processes described previously.

So far, the report has addressed the organizational and technological bases of the internship project. The following chapter will relate the author's specific work assignments during the internship. As previously mentioned, the internship position was that of a Cost and Scheduling engineer, responsible for various cost-control activities as well as monitoring and reporting work schedule changes on the hydrogen plant. For each assignment, an attempt will be made to cover its objectives, the task description, related activities, implementation approach, sources of information, and results accomplished.

CHAPTER IV

WORK ASSIGNMENTS AND CONTRIBUTIONS

The internship activities can be described under three major categories: Cost engineering, Scheduling engineering, and miscellaneous tasks. Appendix D contains a comprehensive listing of these activities as presented on the monthly progress reports sent to the author's advisory committee over the duration of the internship. The purpose of this chapter is to indentify each primary task, point out its objectives and scope, describe the implementation approach and accruing results, and identify the various sources of pertinent information.

COST ENGINEERING

Included under this category are those tasks that pertain to the project cost control aspect of the department's function. In general, the tasks involve estimating, analyzing, and reporting cost data to project management; and this is precisely where cost engineering differs from traditional finance/accounting functions. The latter involve securing needed funds and analyzing the overall profitability of the project (finance), and monitoring and reporting cash commitments and expenditures (accounting). Cost engineering, on the other hand, projects the needed funds through cost estimating techniques, analyzes and justifies changes in the cost projections, and reports on the status of the projected cost picture throughout the life of the project. The following tasks constitute the author's contribution to this cost engineering effort.

Client Cost Summary Report

This is a client-requested report that summarizes the total project cost on a monthly basis. In essence the report shows a breakdown of the total project cost into direct field costs (DFC), indirect field and other costs, and proratable costs; it also shows the distribution of direct costs between the physical facilities comprising Fluor's scope of the project. All cost categories are further divided-up into labor, material and subcontract costs.

The author's task was to develop a format of the report for computer reproduction. The objective was to facilitate easy and quick generation of the hitherto manually made report, since all the basic cost data was already stored in computer files within Fluor's Project Cost Reporting System (PCRS). A computerization of the Client Summary report was desirable for two main reasons. First, a direct access to the database by the computer would be achieved, thus saving the 24 hours of manual labor that went into first pulling detailed cost listings from PCRS and then preparing the report from these every month. Second, the need for training new personnel in the preparation of this report would be eliminated, since it would now take merely filling out standard report-generator forms whenever the report was desired.

The initial steps in the approach to executing this task entailed clarifying all cost category definitions, identifying corresponding files and cost codes under which the cost items were stored, and developing a viable format that best highlighted the critical information. In some cases, more than one cost item were contained in a cost code; in such

cases, the proper components were identified and a reasonable basis applied to prorate the costs. In other cases, cost data under different cost codes were combined to arrive at the appropriate cost figures for the report. Having completed the above steps, the information was transmitted to a computer programmer for modeling. The final steps in executing this task involved testing the program to verify that the desired format was generated.

All of the pertinent information for accomplishing the task was available in the Cost/Scheduling department. The only outside contact was with the Computer Science department as noted above. The result of the task has been fully implemented. The author was not aware of any problems in the monthly task of generating the report, as of the end of his internship. However, minor problems related to errors in the output cost-figures might not be unexpected, as such errors could originate from human-error in inputting the data to PCRS in the first place.

Preliminary Trending

This task involved preliminary work covering the collection of data for the preparation of a very important cost document, the "trend". Trends are routine documents which report, and provide justification for, changes in the work content of the project. Their very close counterparts, "change orders," report and provide justification for changes in the project scope, as defined by the initial contractual agreement. Cost figures reported in change orders have a direct impact

on the budget--which is a client cost document--while trend figures only impact the inhouse cost projection which is primarily used for internal cost-control by Fluor management. Often, a trend becomes a change order if and when the change involved is proven to be a change in scope-of-work. Some examples of non-scope changes are: a change in estimated manhours to perform a given task, an escalation in price of some material or equipment, or a change in approach which results in manhour and/or dollar changes in the project.

The objective in preliminary trending is usually to accurately identify the cost and manhour impacts of changes in the project. This is the key to effective monitoring of project cost. Errors in this area could adversely affect an accurate projection of the project's profitability for internal control purposes. In fact, of all cost-engineering activities on the task-force, trending perhaps receives the most attention of project management.

The approach to trending is fairly standard and routine. The department initiating a change files an initial document with cost-engineering, defining the change and its scope. Based on this document, the cost engineer identifies the cost and/or manhour impact using standard basic manhour estimates for work units, material prices, labor rates and adjustment factors for contingencies. Once this preliminary work is completed, the rest of the trending activity is merely writing-up the document on standard forms. The author's task covered only the preliminary work.

Information for trending comes from both the line-engineering disciplines on the task force and the cost-engineering files. Usually, much verbal interaction occurs between the cost-engineer preparing a trend and the initiating line-engineer to clarify proposed changes. This is where the necessity arises to have, at least, a basic familiarity with the process, mechanical, and instrumentation aspects of the project, since many of the changes usually originate from these disciplines. Interpersonal relations hence play a very significant role in effective trending activity, even though all involved parties are officially expected to cooperate in working toward the common goal of successful project-completion. Good interpersonal relations could enhance the collection and clarification of information while poor relations could considerably extend the lead time on a trend.

Monitoring Budget and ITC

The budget is the client-approved and controlled cost figure that portrays the total financial scope of the project. The Indicated Total Cost (ITC) is a Fluor-controlled figure that represents the total estimated cost of the project at any juncture during the life of the project. Both of these cost figures are initially based on the initial estimates developed by the cost/scheduling department, but change at different rates over the duration of the project. As previously stated, change orders modify the budget while trends modify the ITC.

The task here was to develop and maintain plots of the monthly values of both the budget and the ITC which reflect periodic changes in these figures; to explain any large changes by identifying specific

trends and change orders that provide detailed justification for such changes; and to keep control team management informed of such changes.

The primary purpose of this task was to maintain a capsulized documentation of fluctuations in the budget and the ITC, with proper indication of significant changes.

The task of developing and maintaining budget/ITC plots is a rather simple and clerical task requiring only reference to monthly progress reports which furnish the relevant figures. Application of the results is also purely internal being solely for the information of the manager of cost and scheduling to use as he pleased. However, the opportunity resulting from this task to observe, at a glance, the changes in the total cost picture since the start of a project could be useful even to the Project Director.

Forecast of Operations/MADAP

The Manpower Distribution Analysis Program (MADAP) is a computer package for forecasting expected progress, manning, and cash requirements over the duration of a project. Specific areas of application include:

1. Finding the manpower required to sustain a given job progress.
2. Finding the progress rate associated with a given manpower plan.
3. Generating preliminary job progress curves and manpower loading curves from stored standard progress curves.
4. Finding the expected performance, and manhour and dollar expenditures associated with a given manpower loading or progress plan.

5. Finding the effects of weather, saturation, supervision, and lost time on job progress and productivity.
6. Forecasting the expected cash flow for a job.
7. Converting United States Gulf Coast manhours to jobsite manhours adjusted for factors affecting local performance.

The author had the responsibility for running MADAP for the duration of the internship; however, only applications 1, 2, 4, and 6 above were covered during that period of time. The Forecast of Operations is a quarterly report, based on basic information generated by MADAP, which summarizes the expected monthly consumption of manhours and dollars during the remaining life of a project. Divisional top management uses it on all projects, together with the forecasts of cash flow, to forecast the expected performance of the Division, and hence its profit outlook, on a quarterly basis. Accuracy is therefore critical in generating basic information for these reports.

The task of using MADAP to generate information for the above quarterly report often involves interaction with other engineering disciplines on the task force. Each discipline develops its progress and manpower plans, which serve as inputs to MADAP. Using these plans, both the total manhour and dollar allocations to each discipline are spread by MADAP, on a monthly basis, and the discipline figures totalled to arrive at overall job dollar/manhours utilization plans. This MADAP output becomes an input to both the quarterly and the cash flow reports. It also serves as a basis for measuring the performance of various disciplines on the task force.

Manual of Cost Reports

The purpose of the Manual of Cost reports was to consolidate in a single volume the procedures for developing major cost-engineering reports such as the quarterly and cash flow reports mentioned in the previous section. This was especially desirable for easy training of new personnel that may be assigned the responsibility of preparing any of these reports. As at the beginning of the internship, no written procedures for generating those reports were available. Only computer-generated PCRS reports had procedure manuals.

The planned implementation approach was to identify all manually-prepared cost-engineering reports, become familiar with the procedures for preparing them by talking to and observing cost engineers who were then responsible for the reports, develop a standard format for presentation of the procedures in the manual, write the procedures, review each procedure with the cost-engineer in charge, and make final corrections. All but the last three steps in the approach had been completed before the decision was made to discontinue work on the manual, after discussions with the intern supervisor.

The decision to discontinue the task of writing a cost-reports manual was made for a number of reasons. First, responsibilities for the intern were changed from cost-engineering to scheduling engineering assignments. Second, with experience in the operation of the task-force organization, it became obvious that the proposed manual may not be as useful as had been hoped. For one thing, each project has its own cost-reporting needs which often differ from those of others. Different

project managers also define their own format for their reports. Thus the manual may turn out to be no more applicable than to the one project on which it would be based.

Moreover, the project would have less than half of its planned duration remaining by the time the manual would be completed. Thus the overall usefulness of the manual was questionable and the time to spend on it could not be justified. These considerations were presented to the intern supervisor who consented to discontinuing the task. However, the preliminary work on the manual served well to acquaint the intern with all cost-reports on the task force and how to prepare them. It also helped to familiarize the intern with the various sources of cost-engineering information on the task force.

SCHEDULING ENGINEERING

In general, scheduling engineering is responsible for developing, maintaining, and reporting various levels of work schedule for project management and the client. Three forms of schedules are commonly generated by the section; bar charts, critical path method (CPM) diagrams, and progress curves. Bar charts provide an initial and general layout of the sequence and time frame for major blocks of engineering, procurement, and construction activities pertaining to the project. They constitute the basis for initial project planning activities including such important functions as identification of major milestones on the project and indication of manpower needs over the life of the project.

As the project progresses into the preliminary engineering phase, detailed information on the logic of detailed activities in engineering, procurement and construction becomes available and CPM networks are developed. Working in cooperation with other sections of the task force, scheduling engineers identify detailed work steps comprising the engineering, procurement and construction activities; assign a time estimate to each work step; and tie the various work steps by their proper logic of operation. CPM networks are developed for each unit of the project, units being physical divisions of the plant, and documented in the Fluor Analytical Scheduling Technique (FAST) system -- a computerized CPM-based program which facilitates analysis of schedule data, update of the data-base as required, and generation of scheduling reports. The CPM schedule represents the greatest level of detail in the project plan and it provides a basis for day-to-day control of work by project management.

The third form of schedule developed by the scheduling engineer consists of progress curves comprising bell-shaped manpower curves and S-plots showing the projected cumulative expenditure of manhours over the life of the project and the projected progress--measured by percent complete--of physical work on the project. These progress curves are sometimes generated by FAST from the scheduling data-base in the system.

The author's scheduling responsibilities in the above areas covered only the scope of the work pertaining to the hydrogen plant. To these were added a bi-weekly progress reporting responsibility covering the entire project.

Routine Scheduling Tasks

Once the initial development of the CPM network has been completed and the networks input to FAST, scheduling responsibility over the hydrogen plant involved maintenance activities aimed at assuring that the data-base constituted accurate and complete information and that the generated monthly reports reflected the actual state of affairs on the project. Thus the CPM data base was updated on a monthly basis. This usually involved reviewing manhour and duration estimates with the disciplines directly involved with particular activities. Also, scheduled milestones were periodically reviewed with line-disciplines to ensure that they reflected the actual work plans of the disciplines. This is particularly crucial during the construction phase of the project. Field construction schedules were periodically sent to the home-office where the scheduling engineer reconciled both the home office and field schedules. Such reconciliation was necessary to assure uniformity of reported information on the job progress, especially since construction was being performed by another subsidiary of Fluor Corporation. Much scheduling attention was directed toward internal coordination between the home-office activities and those of the field.

Another routine scheduling task on the hydrogen plant, as on other units of the projects, was status and progress reporting. Each month, critical and alert activities lists were generated, analyzed for accuracy and issued to project management and to the client. Here again, there was considerable interaction between the intern and the area project manager in charge of the hydrogen plant to clarify and/or justify the reported information. The amount of float reported on detailed CPM

reports was particularly crucial; considerable effort therefore went into float analysis to assure accuracy. Overstatements in float could convey to the line disciplines that work slippages would be accommodated and thus encourage slackness in their effort to get the job done on schedule; understatements in float, on the other hand, could cause project management to place undue pressure on line disciplines to work harder. Moreover, inaccurate floats could give the client wrong impressions on the progress of the job.

Bi-weekly Progress Report

The bi-weekly progress report is a client summary report that identifies and reports the status of critical areas of the project twice in the month. Included in the report are shipping information on major equipments, percent completion of both home office engineering and field construction, total actual manhours spent to date and manhours remaining, and the status of piping drawings. The report covers both the cost and scheduling aspects of critical items; for example the total purchase commitments on equipments and bulk commodity items are included.

The intern's responsibility in this area included collecting the information from the various sources ranging from the field construction group to home-office project administration and, of course, cost/scheduling files; and compiling the report.

MISCELLANEOUS TASKS

In addition to the routine tasks described in the previous sections, special tasks were performed for the control team manager on a need basis. Often, the special tasks required an integrated application of both cost and scheduling engineering skills. The purpose of this section is to briefly discuss each of these tasks in the same format as that of the routine tasks.

CPRS Manual Review

The Construction Progress Reporting System (CPRS) is a computer package used by the Cost/Scheduling Department in monitoring the progress of field construction activities. It helps in the objective of providing management with accurate and timely monthly reports of construction activities by comparing planned performance to actual progress. Using material requirements, basic manhour estimates, and productivity and complexity factors input by the user or transferred automatically from other computer files, the system generates manhour plans for specific work units such as pipelines or instrumentation loops.

The intern's task was to review the CPRS user-manual from a user's perspective and to recommend changes that could enhance the readability and usability of the manual. Applying such basic criteria as simplicity, conciseness and proper organization to highlight the information most needed by a potential user in order to access the system, the manual was read a number of times by both the intern and a technician; and based on their reactions, recommendations were made covering primarily the language and organization of the manual.

While simple in content, the task of reviewing the CPRS manual provided familiarity with the system which would have been otherwise impossible. Moreover, the task provided an opportunity to interact with the department's Analysis and Development (A & D) group in the main office which had developed the manual. Following the completion of the task, modifications were made in the manual but the intern was not aware of what exact changes were made. The internship was completed before the modified issue was released.

Performance Studies

Performance studies involve the measurement of actual manhours spent on a particular work area over some period against planned manhours. Two measures of performance were used on the internship project: productivity and equivalent-men, defined as

$$\text{Productivity} = \frac{\text{Earned manhours}}{\text{actual manhours}}$$

$$\text{Equivalent men} = \frac{\text{Earned/Actual manhours}}{\text{Available manhours per period}}$$

Both productivity and equivalent-men measure past performance. However, equivalent-men can be either actual--based on actual manhours --or earned, based on earned manhours. Earned-manhours is a function of the percent progress toward job completion in the particular discipline of interest while actual manhours refer to the total hours spent on the job over the period of interest. Earned equivalent men, when

compared to actual equivalent-men, provides an indication of the manpower utilization over the period of interest. Thus while productivity measures manhour utilization equivalent-men measures manpower utilization. Available manhours is a function of the period under consideration, number of hours-per-week normally worked in the particular discipline, and the number of weeks in the period. For example, in one month there could be a minimum of 160 available hours based on a 40-hour week and a 4-week month; or up to a maximum of 225 hours, based on a 45-hour week and a 5-week month. Periods are usually defined in accordance with Fluor's fiscal calendar.

The intern had the responsibility for monitoring the performance of the design engineering disciplines in the home-office as defined by their productivity and equivalent-men. Using historical data and man-hour plans available from cost/scheduling files, the relevant numbers were generated and presented as productivity and equivalent-men curves which were then analyzed and reported to management. It was often necessary to discuss the curves with the design group coordinator to clarify or justify any absurdities before presentation to management.

The resulting curves were used for internal control by the control team manager and the project director and were never released to the client.

Risk Analysis

One of the primary responsibilities of the cost engineering group on the task force is to develop project cost estimates at different points in the project. At least three estimates are usually

prepared: the factor estimate at the beginning of the project; the detailed estimate within the first few months of the project; and the check-estimate during the construction phase. In order to test how 'good' an estimate is, a risk analysis is performed which provides measures of the probabilities of under-run and over-run of the estimate.

The risk analysis model used on the internship project is based on the triangular distribution. The usual approach is to generate Monte Carlo estimates using the original estimate to determine an appropriate sample size at a specified confidence level. The simulation is done by a computer, usually run by an engineer in the Analysis and Development group at the main office. The intern's responsibility was to generate the original data on which the computer simulation was based. Such data included detailed components of the overall estimate broken down to material cost, labor cost, and subcontract cost; with their corresponding triangular distribution parameters (high, low, and most likely) and the associated levels of confidence. These data were then transmitted to the A & D group for computer analysis.

This concludes the discussion of the intern's major assignments over the course of the internship. Minor activities such as field visits for construction progress monitoring and computer-cost reporting have been omitted because they involved very little time to carry out.

Much of the intern's daily tasks involved interaction with project engineers and managers; as such, observation of project management approaches was a major preoccupation during the internship. The following chapter is therefore devoted to a discussion of project management principles and practice. Some of the material presented in the chapter

is a result of direct interviews with the project director and the control team manager, and observation of managers in meetings and in their daily work activities.

CHAPTER V

PROJECT MANAGEMENT

The responsibility of managing projects, while much like other management areas in its basic functions of planning, coordinating, staffing, directing, organizing and controlling, is unique in many respects. First, projects usually involve people from different functional departments working together, often with others from more than one company. Second, projects are typically temporary assignments with durations ranging from a few months to a few years. Management, organization and information systems are developed anew for each project with a very limited learning curve for those involved. Furthermore, the project environment is dynamic, with work emphasis usually shifting between phases at different times in the project cycle; work relationships and authority patterns are also rendered flexible by the very nature of the project organization. Finally the matrix set-up of project organizations complicates authority relationships.

These special characteristics of projects make project management unique in its repertoire. Specialized information systems, skills in the techniques of project planning and the ability to direct the efforts of people from many different professions, backgrounds, trades, departments, and companies to achieve the common objective are but a small component of this repertoire.

In this chapter, the role of project management on the task force, its relationship with cost/scheduling engineering, what it takes to make a successful project manager, and the problems of project management

will be considered. Much can be found on the subject in the literature but for the purpose of this report the discussion will be limited to aspects that are relevant to the internship experience and much of the material will be drawn from interviews and observations of the project managers made during the internship.

ROLE ON THE TASK FORCE

Project management oversees the day-to-day operations on the task force, along with sectional heads who supervise the technical aspects of work. As was previously pointed out in the discussion of the project organization, project management is headed by the project director. He is supported by a deputy project director and a number of area project managers and project-engineers. Overall responsibility for the successful execution of the project lies with the project director; he represents and reports to Fluor's top management on all matters related to the particular project and has functional authority over cost and schedules on the project. Technical authority remains with functional department heads who usually assign discipline personnel to the task force as needed to perform the necessary discipline tasks.

Collectively, the function of project management on the task force boils down to integration of efforts by different branches of the project organization toward the attainment of the common goal of successful project completion. Such integration usually involves management of three interfaces: personal, organizational, and system interfaces. Personal interfaces are the inter-relationships between people on the task force. Management of personal interfaces entails resolution of

interpersonal problems and conflicts. These require the attention of the project director especially when sectional heads of task-force units are involved. Organizational interfaces cover interactions between various organizational units involved in the project including clients, vendors, subcontractors, and other contractors on the same project. System interfaces are non-people interfaces dealing with changes in the project phase. For example, in changing from the design phase to the construction phase project management must assure timely client approval of drawings for front-end construction as well as see to it that required materials are delivered to the field on schedule. Of course, much of such responsibilities are not executed directly by the project director; area project managers are usually directly responsible for some of them.

In general, it is the responsibility of project management to develop plans for integration which assure that participants in a project understand their roles and responsibilities; to develop integrated work-breakdown structure, schedule and budget; to continually review and update project plans; to assure project control and adherence to project plans; to resolve conflict situations; to remove roadblocks; to set priorities for the utilization of personnel, equipment and facilities; to make administrative and technical decisions across interfaces; to solve customer or client problems; to assure that project transfer takes place; and to maintain communication links across interfaces [9:145].

RELATIONSHIP WITH COST/SCHEDULING

Cost/Scheduling engineers on the task force, under the leadership of the control team manager, are responsible for the details of some of the project management responsibilities listed above. Perhaps in this respect, cost/scheduling engineers operate as technicians for project management. In particular, the project management responsibilities of developing integrated work-breakdown structure, schedule and budget, and continual review and update of the project plans define the preponderance of cost/scheduling responsibility on the task force.

WHAT IT TAKES

With greater experience in the task force approach it became obvious that the responsibility of project management was no simple task. As such, the question of requisite skills for successful performance as a project manager was top on the list of items for discussion during the interviews. Interestingly, all three managers interviewed gave similar responses in this regard. In summary, mentioned among important skills for successful performance are:

- 1) proper experience in engineering and project control techniques,
- 2) good human relations,
- 3) good communication skills,
- 4) ability to motivate others,

- 5) management/business mentality,
- 6) enjoying decision-making rather than involvement with technical details, and
- 7) sense of direction/goal orientation.

Experience

Proper experience in engineering provides the basic understanding of technical aspects of the project to facilitate communications with engineers on the task force. This requirement will be even more important with greater technological advances which would lead to increasing complexity and sophistication in engineering projects. Experience in project control techniques is also crucial as they constitute the tool for developing project plans, schedules and budgets. Such experience should also help the project manager develop quick schemes for ascertaining the reliability of project control information, and to interpret such data properly.

Human Relations

Human relations skills cannot be overemphasized in view of the complexity of the matrix project-organization and the limited authority that the project manager has to effect his or her obligations. In the absence of formal influence via functional authority over heads of functional departments who must often make technical decisions affecting the project, a project manager must rely on good human relations skills to manage these interfaces. Also, the project manager must have good human relation skills to perform his or her duty of conflict resolution between individuals on the task force.

Communication

Good communication skills come-in handy in the project manager's task of managing both the personal and organizational interfaces on the project. Proper breakdown of work responsibilities and coordination efforts with the various organizational units require good communication skills. Most project managers find that they spend at least half of their time talking to people--getting information, clarifying directives, and resolving conflict and misunderstanding [9:150].

Motivating Others

It is only natural in a multi-disciplinary organizational set-up that component units tend to hold different views of the critical objectives of a project, in addition to personal goals that individual members of the task force are prone to pursue. The project manager must therefore add to his/her communication skills the ability to motivate others to action along official project objectives. There are several ways of motivating project personnel, including giving assignments that provide challenges; clearly defining performance expectations; giving proper criticisms as well as credit; giving honest appraisals; providing a good working atmosphere; developing a team attitude; and providing proper direction [6:172]. The timely and skillful application of these and other techniques is a must for successful project management.

Business Mentality

Business mentality refers to the general consciousness for schedules and budget limitations. Since a project is a temporary

assignment, slippages in schedule and/or budget overruns tend to be cumulative. It is therefore necessary that the project manager carry out plans within schedule and budget, and the consciousness for such constraints is a necessary first step.

Decision Making

This requirement is particularly important in the technical project setting where all project managers are engineers by training. The engineer-project manager must overcome problems caused by the lack of compatibility between the purely technical role of the engineer and the non-technical requirements of the managerial role. He/she must be careful to avoid getting involved with technical details of the project. Attention should rather be given to managing people, money and materials which usually involves tasks requiring a much broader, creative approach and ability to diverge and search for alternative solutions to a problem and then to choose the solution applicable at that particular time. Management requires a non-mechanistic approach to problem solving and a bias toward efficient resource utilization and more people orientation.

Goal Orientation

Finally, a project manager must be constantly aware of the relevant objectives of his/her responsibilities. While not unique to project management, the special characteristics of the matrix organization render goal orientation very critical. Not only must goals be met, but they must be met within budget and on schedule; and proper goal orienta-

tion helps the project manager to apply his/her time to only the most important and critical management tasks and delegate others to capable people on the task force.

PROBLEMS OF PROJECT MANAGEMENT

Problems encountered by project management in performing its responsibilities are generally in connection with the three interfaces discussed in the previous sections; namely personal interfaces, organizational interfaces, and system interfaces. Classified otherwise, the project manager's problems are either 'people' problems or technical problems. When asked what problem areas surface in their day-to-day management duties, the managers interviewed pointed out the following:

- 1) personnel motivation
- 2) communication
- 3) interpersonal conflicts
- 4) interactions with the client
- 5) vendor slippages
- 6) support of department-functional managers

Each of these problem areas clearly falls under one of the three project interfaces already discussed and they are all perhaps people problems. Technical problems are quite easily settled, usually, without much project management involvement except as the need arises to assure proper definition of priorities and allocation of resources. People

problems, on the other hand, demand much attention of the project manager, and nearly all the project management skills described in the previous section help to address this problem area. The specific approaches to solving these problems depend on the leadership style of a particular project manager. Two styles are generally recognized, the human relations approach and the formal authority approach, and these in turn correspond with the so called theory Y and theory X management philosophies respectively [4:290].

At Fluor, supervisory skills training programs are carried out periodically to teach problem solving approaches within the project environment. It is the objective of these programs to prepare supervisory personnel in the menu of problem solving and conflict resolution approaches. The exact applications and outcomes, of course, depend on the personal style of the project manager.

CHAPTER VI

SUMMARY AND CONCLUSION

The author's internship which lasted twelve months was served in the Houston Division of Fluor Engineers & Constructors, Inc., a subsidiary of Fluor Corporation, as a cost/scheduling engineer on a refinery modernization project.

In his role as a cost engineer, the author's responsibilities covered various project cost control functions including cash flow forecasting, risk analysis and computerized cost control, analysis and reporting. As a scheduling engineer, the author developed, analyzed, maintained and reported CPM schedules on the hydrogen production plant, the second largest physical facility of the refinery project. In addition, manpower utilization and productivity studies were performed on design related activities of project engineering. Furthermore, an individual study of the process basis for the entire project was undertaken to gain overall familiarity with the primary engineering aspect of the project. Also undertaken on an individual basis was a study of the organizational atmosphere within the project environment through direct involvements with, and observation of activities in, other disciplines on the task force.

These various involvements contributed greatly to the author's understanding of the problem solving approach at Fluor, and they were

all made possible because of the author's being in the cost/scheduling group, rather than any other section of the project organization. The strategic position of the cost/scheduling group on the organization chart vis-a-vis the project management group made possible observation of, and in many cases direct involvement with, the total picture rather than a minute segment of the project. Such broad exposure to different aspects of the project in turn facilitated the accomplishment of the program objectives for Doctor of Engineering internships.

In conclusion, the author strongly believes that both the program and his personal objectives for the internship were met. In addition, useful experience in the operation of project control systems and the art of managing a large project was gained, the latter through observation. The intern supervisor's letter--copy attached in Appendix E--bears out both of these conclusions.

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APPENDICES

APPENDIX A

COST ENGINEER

The Cost Engineer is involved in all stages of an engineering or construction project. During the proposal phase, the Cost Engineer handles the development of economic feasibility studies and the preparation of a competitive bid. After a contract is awarded, a budget is prepared for the project. The Cost Engineer compares actual project costs to this budget and proposes cost control measures when required. Throughout the life of a project, the Cost Engineer uses computerized estimating, cost control and forecasting systems. At a project's conclusion, the Cost Engineer performs a detailed cost analysis and suggests improvements in estimating and cost control methods.

SCHEDULING ENGINEER

Planning is an essential element required for profitable project execution. The Scheduling Engineer translates broadly stated project plans into definitive schedules. These schedules provide a means for the optimum allocation of engineering and construction manpower, as well as furnishing standards for project performance measurement. To prepare and analyze schedules, Fluor has developed a sophisticated, computerized "critical path method" of scheduling and project performance analysis known as FAST (Fluor Analytical Scheduling Technique). By comparing actual performance against the original plan, the Scheduling Engineer identifies potential schedule problems and develops alternative solutions.

APPENDIX B

1-3
9/9

FLUOR

JOHN E. WENDT

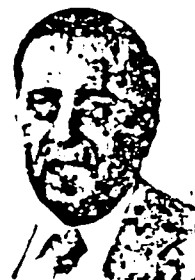
GENERAL MANAGER, COST AND SCHEDULING ENGINEERING

DATE AND PLACE OF BIRTH:

December 2, 1931, Denver, Colorado

EDUCATION:

B.S. in Electrical Engineering,
University of Colorado
Courses in Engineering & Mathematics - Evening
Division, University of California,
Los Angeles

SUMMARY OF EXPERIENCE:

General Manager, Cost and Scheduling Engineering responsible for the technical and administrative supervision of all personnel in the Houston Cost and Scheduling Engineering Department.

General Manager, Design Engineering responsible for the technical and administrative supervision of all personnel in the Houston Design Engineering Department.

Manager, Design Engineering responsible for the technical and administrative supervision of all personnel in the Houston Design Engineering Department.

Manager, Electrical Engineering responsible for the technical and administrative supervision of all personnel in the Houston Electrical Section.

Principal Electrical Engineer supervising lead electrical engineers on various refinery and chemical projects including a grass roots refinery, alkylation revamp, and complete fertilizer plant.

Lead electrical engineer on a variety of project assignments including a major refinery expansion. Electrical Engineer on a grass roots refinery; an alkylation plant; a crude unit, hydrotreater, catalytic reformer, saturate gas plant, and hydrogen and hydrocracker units for a refinery expansion.

During employment with a large manufacturer of electrical products, performed electrical engineering and instrumentation on low voltage motor control centers, high voltage motor starters, and switchgear.

2-3
9/9

RESUME. JOHN E. WINDT

TECHNICAL SOCIETIES:

Institute of Electrical & Electronics Engineers (IEEE)

LICENSES: (Professional Engineer)

Texas No. 36000

FLUOR - HOUSTON (1971 to Present)GENERAL MANAGER, COST AND SCHEDULING ENGINEERING:

Responsible for the technical and administrative supervision of all personnel in the Cost and Scheduling Engineering Department.

GENERAL MANAGER, DESIGN ENGINEERING (1975 to 1978):

Responsible for the technical and administrative supervision of all personnel in the Design Engineering Department.

MANAGER, DESIGN ENGINEERING (1974 to 1975):

Responsible for the technical and administrative supervision of all personnel in the Design Engineering Department.

MANAGER, ELECTRICAL ENGINEERING (1971 to 1974):

Responsible for the technical and administrative supervision of personnel in the Electrical Section.

FLUOR - LOS ANGELES (1964 to 1971)PRINCIPAL ELECTRICAL ENGINEER:Urea Plant, 1,000 T/D
(600 T/D Ammonia)Dawood Hercules Chemicals
Lahore, West PakistanComplete Grass Roots Refinery
30,000 B/DUnion Pacific Railroad Company
Wilmington, California

Hydrogen Peroxide Plant

FMC Corporation
South Charleston, West Va.Alkylation Unit Expansion
Butane Storage FacilityUnion Oil Company
Wilmington, California

Nuclear Fuel Reprocessing Plant

General Electric Company
Morris, Illinois

FCC Unit

Mobil Oil Company
Beaumont, Texas

3-3
9/9

RESUME: JOHN E. WENT

FLUOR - LOS ANGELES (Continued)

LEAD ELECTRICAL ENGINEER:

Major Refinery Expansion 150,000 B/D	Standard Oil Company of Ohio Lima, Ohio
Complete Grass Roots Refinery 95,000 B/D	Kuwait National Petroleum Co. Shuaiba, Kuwait
Alkylation Unit 10,500 B/D	Tidewater Oil Company Avon, California

ELECTRICAL ENGINEER:

Major Refinery Expansion	Shell Oil Company Martinez, California
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WESTINGHOUSE ELECTRIC CORPORATION (1958 to 1964)

ELECTRICAL ENGINEER:

Responsible for electrical and instrumentation at the hydroballistics laboratory, Naval Ordnance Test Station, Pasadena, California.

Engineering on low voltage motor control centers, high voltage motor starters and building-type switchgear at manufacturing and repair plant, Compton, California.

Graduate Student Training Program, Pittsburgh, Pennsylvania.

1-3
9/0

FLUOR

Resumé

EARLE E. A. JANSEN

PROJECT PLANNING AND CONTROL MANAGEMENT

DATE AND PLACE OF BIRTH:

February 29, 1932, Colombo, Ceylon

EDUCATION:

Diploma in Mechanical Engineering
University of Ceylon, Technical College, 1955

Industrial Administration
University of Manchester, 1958

Evening School toward Masters Degree
University of Houston



SUMMARY OF EXPERIENCE:

Twenty-two years experience in engineering and construction of major petrochemical plants with emphasis on project planning and control. Current assignment is Control Team Manager for a \$360 MM refinery modernization. Responsible for preparation of engineering and construction cost estimates, project schedules, cost reporting and analysis, construction progress reporting and analysis, cost and schedule trending, corrective action recommendation for cost or schedule anomalies. Other projects include refinery expansion in Louisiana, national gas processing plant in Saudi Arabia, petrochemical plant in Virgin Islands, substitute natural gas plant in Pennsylvania, and a gas conservation plant in Canada.

Prior to Fluor, was Project Engineer for a large nylon polymer plant expansion and a pharmaceutical plant project; Senior Construction Planning Engineer for naphtha and gas reforming plants; Senior Mechanical Engineer for polyethylene plant and magnesia plant projects in United Kingdom; Field Office Engineer with responsibility for "hand-over" of completed systems to client.

LANGUAGES:

Ceylonese (Singhalese)
Indian (Tamil)

READ

Well

SPEAK

Well
Moderately

TECHNICAL SOCIETIES:

Member, Institute of Mechanical Engineers - United Kingdom

RESUME: EARLE E. A. JANSEN

LICENSE:

Chartered Engineer - United Kingdom

FLUOR - HOUSTON DIVISION (1970 to Present)CONTROL TEAM MANAGER:Borger Refinery Modernization
ARDS Plant AdditionPhillips Petroleum Company
TexasCONTROL TEAM LEADER:FCCU Addition
Refinery ExpansionMarathon Oil Company
LouisianaFIELD COST/SCHEDULING MANAGER:Ju'aymah Fractionation Center
Natural Gas Processing PlantArabian American Oil Company
Saudi ArabiaFIELD COST/SCHEDULING MANAGER:Paraxylene Plant
Grass Roots Chemical ProjectSt. Crois Paraxylene Corp.
(Hercules-Hess)
U.S. Virgin IslandsCONTROL TEAM LEADER:Crude Oil Gasification Plant
Synthetic Natural Gas ProcessingTransco Energy Co.
PennsylvaniaLEAD SCHEDULING ENGINEER:Gas Conservation Plant
Turbo-Expander ProjectImperial Oil Co.
CanadaBECHTEL CORPORATION (1966 - 1970)PROJECT ENGINEER:

Project duties included management of engineering task force for a number of construction projects.

RESUME: EARLE E. A. JANSEN

HUMPHREYS & GLASGOW, LTD. (UNITED KINGDOM) (1965 - 1966)SENIOR CONSTRUCTION PLANNING ENGINEER:

Duties included planning construction activities (manpower requirements, cost controls, and trend forecasting) for naphtha and gas reforming plants located in England.

GEORGE WIMPEY & COMPANY, LTD. (UNITED KINGDOM) (1960 - 1965)SENIOR MECHANICAL ENGINEER:

Project Engineer on oil refinery expansion, polyethylene plant and magnesia plant. Other duties included design engineer on piping, vessels, heat exchangers, and bulk conveyor systems for various projects located throughout the United Kingdom. Worked as field office engineer and was responsible for coordinating design changes, planning, scheduling, cost and material control, punch listing, and hand-over of completed system to Clients.

DESIGNERS SUPPLY COMPANY (UNITED KINGDOM) (1957 - 1960)DESIGNER:

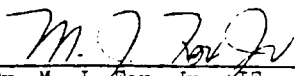
Duties included mechanical design and engineering on chemical plant projects.


APPENDIX C

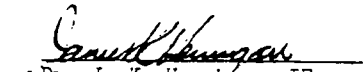
INTERNSHIP OBJECTIVES

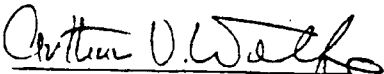
1. Become familiar with the Process Industry technology.
2. Take responsibility for cost engineering on one aspect of a project.
3. Develop a manual of major cost reports.
4. Learn the essence of scheduling engineering.
5. Observe management practices at the project level.

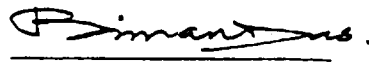
Approved by:

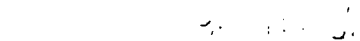

 Dr. M. J. Fox, Jr., IE
 Committee Chairman



 Mr. J. E. Wendt, P.E., Fluor
 Intern Supervisor

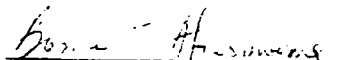

 Dr. J. K. Hennigan, IE
 Committee Member


 Dr. A. V. Wolfe, Mgmt
 Committee Member


 Dr. Biman Das, IE
 Committee Member


 Dr. C. B. Parnell, Jr., AgE
 College of Engineering Rep.


 Dr. David W. David, EdCI
 Graduate College Rep.


 Boma T. Afiesimama, IE
 Intern

December 9, 1980

Memorandum

TO: Advisory Committee

FROM: Boma T. Afiesimana

SUBJECT: Preliminary Internship Objectives

Please find listed below my preliminary objectives for the Doctor of Engineering internship with Fluor Engineers and Constructors in Houston, Texas, which will begin January 5, 1981. A final set of objectives will be presented for your approval by March 5, 1981.

1. Observe the overall organization of the company and learn how the parts work together to produce results.
2. Explore the sources of important information and the effective lines of communication.
3. Study the Cost Engineering and Scheduling methods, as they are applied to individual projects.
4. Combine my technical background and the knowledge gained in the previous objectives to make an identifiable contribution to one or more projects.

approved by:

M. J. Fox, Jr.
Dr. M.J. Fox, Jr., IE
Committee Chairman

J. K. Hennigan
Dr. J.K. Hennigan, IE
Committee Member

B. Das
Dr. Biman Das, IE
Committee Member

D. W. David
Dr. D.W. David, EdCI
Graduate College Rep.

N. C. Ellis
Dr. N.C. Ellis, IE
Department Head

J. E. Wendt
Mr. J.E. Wendt, Fluor
Intern Supervisor

A. V. Wolfe
Dr. A.V. Wolfe, MGMT
Committee Member

C. B. Parnell, Jr.
Dr. C.B. Parnell, Jr., AgE
College of Engineering Rep.

B. T. Afiesimana
Boma T. Afiesimana, IE
Intern

APPENDIX D

MONTHLY PROGRESS REPORT #1
JANUARY 1981

Boma T. Afiesimama

Internship with Fluor Engrs & Constructors - Houston Division

Placement and Orientation:

Following initial deployment to the Cost/Scheduling department, I was assigned to a task force involved in a refinery modernization project as one of ten Cost engineers on the project. Cost and Scheduling engineers on the task force work as a team under a common manager. I am thus able to observe the full scope of the scheduling function even as a cost engineer.

Most of the month was spent in orientation - introduction to the project flow-path and the various control activities that comprise the cost and scheduling engineering functions. I was also introduced, along with other new employees, to the chief executives and managers of the Fluor Houston Division. Mr. A.W. Picone, Divisional Vice-President and General Manager, was pleased with the idea of D.E. internships at Fluor; thanks to the good efforts of Mr. J.E. Wendt, General Manager of Cost and Scheduling, himself a zealous proponent of the program.

Assignments/Observations:

Experience still being the best teacher, my job orientation entailed hands-on involvement, and close observation of management practices primarily related to the internal operations of the cost/scheduling team.

Specifically, my assignments during January included:

- A - Studying the manpower distribution analysis program (MADAP), a computer software package used in many cost/scheduling control activities of the department. The objective of the study was to explore the program's full potential as a cost control tool in the forecast of dollar/manhour expenditures. This assignment was completed during the month and immediate supervision advised on my findings.
- B - Assisting with the application of MADAP to the preparation of cash-flow reports.

- C - Development and analysis of budget curves which reflect the periodic fluctuations in the budget and the project cost estimate, with a view to finding ultramodest deviations from plan, and signaling to immediate supervision the change vector and possible causes. This is an on-going assignment that must be carried through the life of the project.
- D - Familiarization with sundry tools in the form of an overview of various procedure manuals and other computer software systems used in the cost/scheduling control activities. This is consistent with a personal goal to develop functional familiarity with all software packages used in the routine reporting systems of the department.
- E - Participation with management in weekly progress meetings which entail the review of each week's activities. Such meetings have proven useful in my observation of management practices at the team level.

Prospects:

Coming months promise greater involvement in activities that require interaction with other disciplines. My goal is to develop contacts and communications that will enhance my understanding of the total spectrum of functions that bring about project completion. Furthermore, opportunities will be sought and utilized to observe management practices outside cost/scheduling, especially at the project management level.

There is also some indication that opportunities for supervisory duties will develop in the near future, most probably during my second quarter of the internship.

MONTHLY PROGRESS REPORT #2
FEBRUARY 1981

AFIESIMAMA - Internship with Fluor E & C, Houston.

General:

The necessary introduction to the Fluor system having been acquired in January, February featured much exploration of my specific prospects vis-a-vis opportunities for attaining the internship objectives set down in the guidelines. Consultations were made with Mr. J. E. Wendt, General Manager of Cost & Scheduling, the manager of cost/scheduling on the task force, and the project manager to discuss specific areas of interest. As a result, a rough schedule has been developed to facilitate attainment of both my specific objectives and the general internship objectives.

Assignments:

Some of the assignments begun in January continued into February. These include the work on budget curves and application of MADAP. Assignments begun in February include:

- A - Preliminary work on piping trends. Trends are documents that signal changes in one or more aspects of the project that in turn cause changes in the project cost estimate. Some interaction with piping engineers and procurement personnel, as well as acquaintance with some piping terminology, was necessary in performing this assignment.
- B - Application of the project cost reporting system (PCRS) to a particular report. This entailed setting up a report format hitherto unavailable in PCRS for future production by the system in accordance with client requirements.

C - Forecast of Operations. Much of the work in this area prepared me to take responsibility in producing a computer generated cash flow report for the client.

Prospects:

Greater involvement with other disciplines is expected in subsequent months. Hands-on involvement in scheduling engineering activities is planned. In general, there are more solid hopes for exposure to a broader scope of the project.

MONTHLY PROGRESS REPORT #3

MARCH 1981

AFIESLMAMA - Internship with Fluor E & C, HoustonGeneral:

The planned transfer to the Scheduling Engineering section was made at the beginning of the second week of March. Cost engineering work begun in February was completed during the first week, and the rest of the month was spent on specific assignments in the scheduling area.

At this point in the life of the project, scheduling work consists, primarily, of update of various schedules - CPM schedules, material delivery schedules and progress curves, and the generation of various status reports. There is progressively more involvement with other disciplines in performing these activities.

Assignments:

A. Cost Engineering:

- completed set-up work on special client cost report for programming by the Computer Science department.
- completed computer documentation of Forecast of Operations.
- performed preparatory work on proposed Cost Reports Manual, defining the scope, content and layout.

B. Scheduling Engineering:

- studied and analyzed vendor progress and expediting reports to update material delivery and CPM schedules, and discuss critical items with Area Project management.
- reviewed a newly revised Construction Progress Reporting System (CPRS) manual and made recommendations for further revision.

Prospects:

Specific plans have been made to engage in all phases of the scheduling function. Work on the Cost Reports manual will continue. Involvement with an even wider scope of the project is expected.

MONTHLY PROGRESS REPORT #4
APRIL, 1981

AFIESIMAMA - Internship with Fluor E & C, Houston

General:

Activities in April covered both the cost and scheduling areas. Much attention was given to the cost/scheduling interface with a view to learning how the exchange of information between the two areas enhances project progress reporting. The insight gained in this area became very useful in my role as the coordinator of data generation for the April issue of the quarterly forecast of operations(FOOPS).

Assignments:

A. Cost Engineering:

- coordinated the FOOPS data generation effort
- processed and analyzed FOOPS using the manpower distribution analysis program(MADAP).
- investigated discrepancies between forecast and actual cash flows since the beginning of the project.
- developed computer cost curves.
- updated budget curves and manhour progress curves.
- trained some cost engineers and technicians in the use of MADAP.

B. Scheduling Engineering:

- assisted another engineer in performing all scheduling functions on the largest process unit of the refinery. Such functions include updating the CPM data base, general logic cleanups, and progress reporting.

Prospects:

Greater responsibilities in the scheduling area are expected during the months ahead.

MONTHLY PROGRESS REPORT #5
MAY 1981

AFIESIMAMA - Internship with Fluor E & C, Houston

General:

All scheduling operations on a section of the project, the hydrogen production unit, became my sole responsibility during the month. This carries a monthly responsibility for reviewing the CPM logic and plots, maintaining the CPM data base, updating all schedules, reconciling field and home office CPM's, performing float analysis on construction, engineering and procurement activities, and generating associated reports. There is, ofcourse, constant interaction with area project managers and lead engineers in the various disciplines on the task force.

Assignments:

In addition to the above tasks for the month, the following assignments were carried out:

- generation of data for risk analysis on project cost estimates.
- generation of special cost reports.
- miscellaneous fire drills.

MONTHLY PROGRESS REPORT #6
SEPTEMBER 1981

AFIESIMAMA - Internship with Fluor E & C, Houston

General:

A majority of my time was engaged in scheduling engineering activities. Beyond the usual meetings which have become occasions for observing management mentality, I seized an opportunity to participate in a performance review. A little time was also spent in cost engineering work.

Assignments:

- Reviewing CPM logic and plots and updating the data base.
- Performing float analysis on construction, engineering, and procurement activities; and writing associated reports.
- Generating prestatus reports for all units of operation.
- Reconciling field and home office schedules.
- Developing and inputting schedule for erection of steam reformer Furnace.
- Applying MADAP to forecast the spread of home office costs.

Prospects:

Arrangements are underway to give me exposure to the field organization and the construction activities at the job-site through a number of visits.

MONTHLY PROGRESS REPORT #7
OCTOBER 1981

AFIESIMAMA - Internship with Fluor E & C. Houston

Activities:

All effort went into performing the regular monthly scheduling activities which include updating the CPM data base and all schedules, reconciling field and home office CPM's, performing float analysis on procurement, engineering and construction activities, and writing associated reports.

I was able to visit the job-site to examine the progress of construction operations. This was a well-seized opportunity to observe work practices and interactions within the field organization. A written report was made to my control team manager on the visit. More visits are expected during the remainder of my internship.

Finally, I also sat-in to observe a management-level team of auditors in their interviews with task force lead engineers and managers on the project.

MONTHLY PROGRESS REPORT #8
NOVEMBER 1981

AFIESIMAMA - Internship with Fluor E&C, Houston

Activities:

Collection of information needed for the final Internship report was begun during the month. I held interviews with Mr. Earle Jansen, the Control team manager, and Mr. Jack Wendt, the general manager of the Cost & Scheduling department, to obtain their opinions of Fluor's management philosophy.

The usual scheduling function of performing analysis of computer-generated reports on construction, procurement and engineering activities, reconciling field and home-office CPM logic, reviewing and updating the project data-base, and updating various control curves was carried out.

MONTHLY PROGRESS REPORT #9
DECEMBER 1981

AFIESIMAMA - Internship with Fluor E&C, Houston

General:

Many members of the control team left on vacation all through the month. As a result, some extra responsibility was added to mine as necessary. I left on my vacation during the last week of the month. December was thus a short month on the job. A good part of the month was also spent in completing data collection for my final internship report, and getting proper permission for the use of certain materials.

Assignments:

- A visit to the jobsite was made to acquire latest status information and perform construction schedule revisions as required.
- An interview was held with the Project Director on project management philosophy, the task force concept, management - client and management-vendor interactions, and other relevant issues.
- Analysis of computer-generated reports on detailed project activities, reconciliation of field and home-office CPM logics, review and update of project data-base, and update and review of various control curves.
- Preparation of remaining manpower/manhour reforecast using MADAP.

APPENDIX E

FLUOR ENGINEERS AND CONSTRUCTORS, INC.

4820 NORTH BRAESWOOD
HOUSTON, TEXAS 77096
TELEPHONE: (713) 662-3000

March 24, 1982

Dr. M. J. Fox, Jr.
Industrial Engineering Department
Texas A & M University
College Station, Texas 77843

Dear Dr. Fox:

Boma Afiesimama completed his 12-month internship at Fluor on January 7, 1982. His internship was a success and in my opinion he achieved his internship objectives.

He was assigned to a task force set up to engineer, procure, and construct an oil refinery modernization. For your information, a task force within Fluor is a group of professionals dedicated to a specific project. As such, there is a lot of intermingling of various aspects and types of tasks required to achieve a common goal, none the least being management.

His role on the task force was that of an engineer having primary responsibility for controlling the cost and schedule for a segment of the project. In his primary responsibility his work involved interface with process engineers, mechanical engineers, design engineers, construction management and project management, which basically covers the whole gamut of the project task force concept. This responsibility gave him a clear insight on how all task force operations work and are managed. The experience gained will serve him well.

In addition to his primary responsibility, Boma also worked directly under my supervision on special studies, such as productivity in the office and in the field, risk analysis of project costs, estimating and forecasting job cost. Some of these studies necessitated handling problems for which there were no standard text book type approaches. This meant that he had to decide on his own problem solving approach to produce the desired results. These special studies challenged Boma's abilities to solve unique problems on the job and he did an outstanding job in this regard.

Boma demonstrated a strong ability to communicate his work plan and methods concisely and precisely to management. In all cases he met his deadlines on various assignments and displayed a consciousness for proper planning and efficient use of time, which is very important in our business.

FLUOR

Dr. M. J. Fox, Jr.

March 24, 1982
2

In summary, I have no hesitation in stating that Boma met his internship objectives. I also believe that he has demonstrated the technical ability required from a practicing engineer as well as a good awareness of the multitude of variables that bear on project management.

I appreciate the opportunity to serve on Boma's internship committee and look forward to meeting you again at his final examination.

Sincerely,



Earle Jansen

EEJ/cr

VITA

Boma Thompson Afiesimama
222 Niger Street
Port Harcourt, Nigeria

Birthplace: Ogoloma, Rivers State, Nigeria

Birthdate: November 28, 1952

Parents: Simon Itelima and Ruth Ibikiri Afiesimama

Family: Married, with one son

Education: B.S.E., Industrial and Operations Engineering
The University of Michigan, Ann Arbor, Michigan (1978)

M. Eng. Industrial Engineering
Texas A&M University, College Station, Texas (1980)

Experience: May 1982 - Present
Associate Engineer
Fluor Engineers & Constructors, Inc., Houston, Texas.

January - May, 1982 and January 1979 - December 1980
Graduate Assistant (Teaching)
Industrial Engineering Department
Texas A&M University, College Station, Texas

January 1981 - January 1982
Associate Engineer (Doctor of Engineering Internship)
Fluor Engineers & Constructors, Inc., Houston, Texas

The typist for this report was Elsa Cardenas