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SEMINAR

"SCHEDULING FOR DOLLARS"

Ralph J. Stephenson, P.E.

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SEPTEMBER 20, 1978

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THINKING PATTERNS:

Why plan?..... to evaluate!

Why translate?..... to communicate!

Why control?..... to achieve!

Why correct?..... to maintain!

Why learn?..... to improve!

APPROACH PATTERNS:

1. Improve capabilities
2. Gain control
3. Create - Don't adapt
4. Experiment
5. Expand conceptual grasp
6. Don't deadhead - Keep learning
7. Solve problems
8. Define objectives

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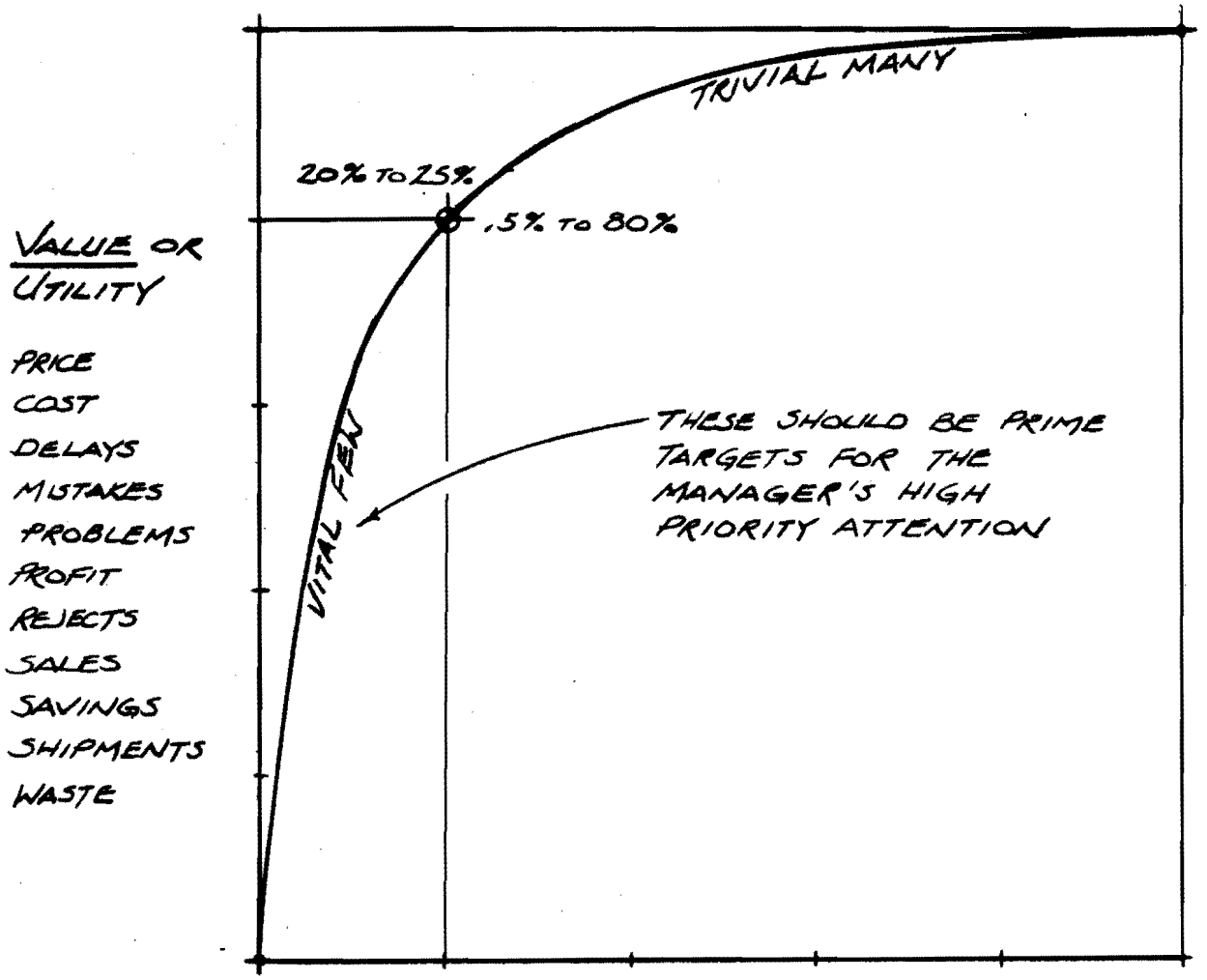
PARETOS LAW - IN AN OBJECT/VALUE SITUATION ONLY A FEW OF THE OBJECTS ACCOUNT FOR THE GREATEST PART OF THE VALUE.



VALUE OR UTILITY

PRICE
COST
DELAYS
MISTAKES
PROBLEMS
PROFIT
REJECTS
SALES
SAVINGS
SHIPMENTS
WASTE

OBJECTS OR RESOURCES

ACTIVITIES
CAUSES
OCCURANCES
PROBLEMS
RESOURCES
PRODUCTS
DECISIONS
FACILITIES
MATERIALS
METHODS
PRODUCTS
SALES CALLS
SERVICES
STAFF

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GLOSSARY OF TERMS USED IN

PROJECT PLANNING AND MANAGEMENT

Administrative

Usually considered to be supportive of ex'e-cutive operations in an organization. Very simply, administrative costs may be considered the cost of management.

Authority

The leverage, either vested or earned, that allows an individual in an organization to effectively carry out his responsibilities.

Business model

A graphic depiction of the elements which make up a business entity. The model usually identifies premises, objectives and implementation. It recognizes basic business functions, business activities and manager activities.

Control

Maintaining firm, fair, competent managerial direction of any given situation. Controlling leads to achievement. It is usually accomplished by the invisible use of leverage.

Critical path method

A mathematical modeling technique which allows the user to establish ranges within which resources can or must be used.

Decision table

A tabular display of information regarding a defined situation which permits alternative courses of action to be evaluated by yes or no answers to explicit questions.

Decision - to - action time span

The amount of time required from the point at which a decision is made to the point where the decision is implemented. In a management structure it is important to insure that the full span of time from decision to action is covered from shortest to longest.

Decision tree

A graphic device showing alternate courses of action from a given situation point. The decision tree is used to graphically show the impact of various possible decisions at any given point in the decision process. It can be quantified or unquantified.

Dysfunction - organizational

An organizational problem that hinders or prevents achieving objectives - may be temporary or permanent.

Early finish (EF)

The earliest possible time a task can finish in a network model if all of the tasks preceding it have been completed by their early finish dates.

Early start (ES)

The earliest possible time at which a task can begin in a network model if all tasks preceding it start at their earliest possible starting times.

Education

The teaching and learning process by which principles of doing things are conveyed to the learner.

Effective

Of a nature that accomplishes identifiable end objectives in accordance with an action plan, and achieves worthwhile peripheral goals resulting from intermediate accomplishments.

Elapsed duration

The estimated or actual amount of calendar or clock time an activity requires to accomplish considering all directly and indirectly related influences upon the task activity. This includes temporary work delays and stoppages due to influencing actions on the task.

Ex'e-cutive

The executing arm of the organization. This is the group and activities that are closest to the flow of expense and income in achieving the organization's prime objectives. It is closely related to line operations.

Fabrication facilities

Usually considered to be the physical location where materials and equipment are prepared and assembled ready for use.

Goals

Similar to objectives but quite often applied to individual effort rather than group or company effort.

Goals - dependent

Targets to be achieved, but affected by major influences beyond the manager's control. (Note: dependent goals, while beyond a manager's control, may be well within his company's ability to achieve. Lack of correlation between company and individual effort in achieving a manager's dependent goals may cause severe organizational dysfunctions.)

Goals - direct control

Targets achieved by managing conditions well within the direct influence of the manager.

Histogram

A graphic depiction of quantity plotted against various elements such as item function, item name or time.

Hygiene

The elements in a given situation that are acceptable to an individual but do not necessarily motivate him. These same factors, if unacceptable, act as negative influences upon the individual.

Interfaces

Points at which different but related activities exert direct influences upon each other. Interfaces are often the influence points where direct control goal activities contact dependent goal activities. Poor management of interface situations usually causes problems.

Late finish (LF)

The latest allowable time in a network model that a task can be completed without forcing those tasks that follow it past their latest allowable starting dates.

Late start (LS)

The latest allowable time at which a task in a network model can start without forcing the tasks that follow it past their latest allowable starting dates.

Leverage

The effective use of vested and earned authority to solve problems and achieve objectives.

Life cycle cost

The total cost of a system over its entire defined life.

Line activities

Those organizational activities that are most closely identified with the flow of basic expense and income related to the prime objectives of the organization.

Line of action

A sequential statement of the activities necessary to conceive, design, build and operate an environment.

Manage

To define, assemble and direct the application of resources.

Management by exception (MX)

A measuring and monitoring system that sounds an alarm to the manager when problems have or are about to arise, and remains silent when there are no problems. The system explicitly identifies the problem area, thus permitting the effective manager to manage the exception while leaving smoothly running operations to continue running smoothly.

Managerial grid

A numerical grid which positions a manager in a matrix by defining his concern for people as compared to his concern for production. This grid has been highly developed by Blake & Mouton and is useful in establishing managerial systems that are both desirable and needed.

Money flow

The flow of income and expense plotted in amounts of money against time.

Monitoring

Measurement of current project conditions and position against the standard of performance.

Motivation

The elements of a given situation that encourage and make effective, successful and meaningful the activities of those engaged.

Network plan

A graphic statement of the action standard of performance expected to be used in achieving project objectives.

Network planning

A graphic technique of showing the necessary and desired actions needed to achieve end, intermediate and peripheral objectives.

Objectives - end

Those objectives that are realized from and upon total completion of the project work.

Objectives - intermediate

Those objectives achieved at specific and identifiable stages of the project, i.e. partial occupancy of a building, or turn-over of a mechanical system for temporary heat.

Objectives - long range

Usually applied to organizational objectives to be achieved within a 5 to 10 year period. Sometimes called strategic objectives.

Objectives - medium range

Organizational objectives to be achieved within a 1 to 5 year period. Sometimes called tactical objectives.

Objectives - peripheral

Those objectives realized on an ongoing basis through the life of the project and achieved as an indirect result of project activities. Peripheral objectives may be personal, professional, technical, financial or social. Examples of peripheral objectives might include staff promotion, profitable subcontractor operations or specialized experience.

Objectives - short range

Organizational goals to be achieved between now and 1 year. Sometimes called operational or short term tactical objectives.

Ongoing organization

The arrangement and interrelationships of people charged with maintaining supportive actions provided by the ongoing elements of a company. Examples of functions contained in the ongoing organization are estimating, administration, legal, sales and purchasing.

Organization

The arrangement of resources (talent, skill, money, time, space, people, et al) that has evolved or been selected to accomplish the functions, activities, manager activities and goals of a business or institution.

Planning

Establishing and arranging the necessary and desired actions leading to end, intermediate and peripheral objectives.

Problem

A deviation from an accepted standard of performance.

Profiling

A selective, flexible, dynamic operable system of screening projects, people, activities and other elements of a project to achieve optimum results, as defined by established plans and objectives.

Profit - education

Company and project fulfillment of learning goals held by individuals or groups involved.

Profit - financial

Fundamentally, the difference between organizational cash income and organizational cash expense. Further definitions of financial profit are complex and often unique to an organization or project.

Profit - self actualization

Personal fulfillment realized after basic needs of shelter, safety, protection, love and freedom from hunger are achieved.

Profit - socio-economic

Company, group or individual achievement of social objectives within a financially profitable situation.
(Note: very difficult to explicitly define.)

Profit - value system

Company and project fulfillment of personal, professional, technical, social and financial values held important by individuals and groups.

Project

A set of work actions having identifiable end objectives.

Project Manager

That individual responsible for full implementation of a project through the authority and resources given him by his organization. Usually the project manager is most concerned with supportive action which brings resources to the point of effective use.

Project organization

The arrangement and interrelationships of people charged with implementing the end, intermediate and peripheral objectives of the project.

Project stages

A sequential definition of the action steps to be taken in successfully carrying out a project.

Project superintendent

The individual, usually in a construction program, who is most directly responsible for the expenditure of funds to carry out the project. The project superintendent is responsible for ex'e-cutive actions.

Question - direct

One asked with strong indications as to specifically who should reply.

Question - overhead

One asked of a group without indication as to who is to reply.

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Question - relay

One passed along to someone else other than the party originally asked.

Question - reverse

One returned to the questioner by rephrasing or rewording the original question.

Relations - formal functional

Project relationships that concern distribution and use of data, information and decisions that flow along formally defined transmission lines. Formal functional communications are usually written and are normally one to many or many to one in nature. Formal relations are precisely defined and most day to day business is accomplished within the formal relation framework.

Relations - informal functional

The natural channels along which organizationally related material is most easily, comfortably and quickly transmitted. The informal relation usually exists by consent and is stimulated to maximum effectiveness by a mutual profit gained from the relation. There is little, if any, authority normally expressed in informal relations. Communication is usually oral and one to one. Often informal relations define the hidden organizational structure.

Relations - occasional or temporary

Those created when extraordinary or unusual management demands arise. The temporary relationship is, by its nature, unstable and should seldom be adopted as a permanent active arrangement. Extensive use of informal functional relationships creates business dysfunctions, breaks down morale and causes internal tensions difficult to resolve.

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Relations - reporting

The official channels through which each individual conveys or is given raises, appraisals and evaluations; is fired, assigned, reassigned, and is provided professional, vocational and personal identity. Usually is a one to one communication. The true organizational superior of an employee is usually that individual with whom he maintains a reporting relation.

Relations - staff

Those business relations through which a person or group provides advisory services necessary to accomplish goals. Staff personnel usually act in a consulting capacity with little or no authority relative to those outside the staff group.

Resources

The tools of the supportive and ex'e-cutive manager. Resources can include manpower, talent, tools, equipment, time, money, experience, space, materials, as well as intangibles such as enthusiasm, morale and leverage.

Responsibility

The assignment, spoken or understood, that a person in an organization has as his part in maintaining the organization's health and continued vitality.

Schedule

A graphic or written tabulation of project activities showing where they are to start and finish. The schedule is derived from the plan of action and the network model by locking the tasks and the resources they require into a specific time position.

Span of control

The number of organizationally related individuals a manager directly controls. Span of control is signified by the number of one to one relations a manager maintains.

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Staff

A supportive unit of any organization in which the basic function is usually advisory in nature. Staff functions are occasionally defined as overhead or non-production. They are considered to be the opposite of line activities.

Standard of performance

A well defined, explicitly stated, approved and accepted statement of the measurement object to be used as a gage of performance and goal achievement.

Structured organization

An arrangement of business elements that tends toward highly defined, formal functional definition. The structured organization, depending upon degree, can work exceptionally well or not at all. It tends to lead toward high overhead, excessive management layering and quite often, particularly in subsidized sectors, management paralysis. It is beneficial in that when well used, it tends to eliminate confusion and misconceptions regarding the role of the individual in the organization.

Talent

A capacity for achieving identifiable success. Usually talent is considered one of the abstract resources.

Time

The clock or calendar position assigned to activities. Usually in network systems time is measured in elapsed working days.

Total float (TF)

The amount of discretionary time available to a task in a network model. The total float is the difference between the early and late starts and finishes. It is one of the most important elements in the use of network systems.

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Training

The teaching and learning processes by which specific, explicit methods and systems of doing something are conveyed to the learner.

Translation

Recasting standard of performance information and data into graphic, narrative, mental, oral or other form to insure optimum use by all involved.

Unstructured organization

An arrangement that encourages interrelations tending toward informal operations, minimal paper work, loosely defined reporting relations and high dependence upon individual initiative. It should be noted that the informal nature of this kind of organization demands continued challenge and excitement infused from the outside to maintain economic strength without being subsidized. Usually subsidization of the unstructured activity brings it to an end.

Value engineering

A simulation technique that encourages identification of the best function for the least cost (not only financial) in a given technical decision situation.

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WHAT FACTORS INFLUENCE PROFIT?

Business Volume
Field Efficiency (Effectiveness)
Office Efficiency (Effectiveness)
Executive Competence
Executive Interest
Diversity of Operation (Hedging)
Types of Contracts
Quality of Estimating
Unit Costs
Area Work Volume
Season of Year
Local Economy
National Economy
Governmental Policies
Caliber of Participating Contractors
Caliber of Competing Contractors
Caliber of Suppliers
Delivery Dates
Amount of Warranty Work
Caliber of Owner or Client
Type of Project

Size of Project
Quality of Dwgs & Specs
Location
Labor Relations
Caliber of Field Managers
Expediting Effectiveness
Project Planning
Project Scheduling
Withheld Amounts
Availability of Labor
Billing Procedures
Inventory Practices
Internal Education
Internal Training
Type of Business
Experience
Reputation
Staff Honesty
Caliber of Purchasing Skills
Profiling Procedures
Organizational Plans

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DB 2/4/72

LINE OF ACTION

ELEMENTS OF THE LINE OF ACTION

The line of action is a simple statement of the range of tasks necessary to conceive, design, build and operate an environment. The line begins at a point referred to as the recognition of need with these actions following:

- Conceive
- Program
- Articulate
- Approve
- Design
- Construct
- Turnover
- Operate
- Maintain

These all culminate at an end point called discharge of environmental design and construction responsibility. A brief description of each step is appropriate in understanding their importance to the total design and build concept.

Recognition of need is the point at which a requirement for a new environment is first felt. The good design build operation tries to become involved in this creative stage. There is a danger of getting in too early and giving away so much of the early work that the job may be lost through over-exposure at a later date. However, recognition of needs is the starting point and the sales activity starts here. Taking the points in order -

Conceive - During the conceptual period the need which may be for increased facilities, larger dollar volume, more efficient handling systems or a variety of other demands is visualized and put down in some rough form. It may be a pencil sketch or may remain an idea in someone's mind. Here the project sees its origin and it is this early idea that often carries through the entire project. A good conceptual grasp is essential if the project is to be successfully completed.

Program - During the programming phase, the needs of the concept are put into easily understood tabular form so many square feet for storage, so many square feet for office, so much height for shipping facilities, etc. The actual physical demands of the environment are set forth in the project program or project bible.

Articulate - Now the concept and program are combined into preliminary construction language. Floor plans are drawn in accordance with requirements. The functional arrangement is shown in accordance with the project bible. Materials are called out in terms of the demands of the concept.

Approve - This is a critical point in the line of action. By now sufficient work has taken place so the manager can understand the project and say: "I like this or I don't; change this, revise this; let's increase that a bit; let's cut down here." Finally saying: "OK, I'm satisfied with this set of ideas showing the concept and the program - let's move on!" Approval unlocks the design and construction period.

Design - In the design phase, products of the previous four steps are utilized concurrently to prepare a set of working drawings and specifications that translate concept into steel, concrete and space.

Construct - Next, the actual environment is built. Construction is the first point where something major and tangible happens as a result of the concept.

Turnover - When the project has been built, it is turned over with the appropriate operating manuals to the owner or tenant. Turnover is an important step since if done properly it insures that a valuable commodity, the completed environment, is properly given to those who must use it.

Neglect of good turnover procedures is often the cause of serious callback problems. We certainly wouldn't turn a complex piece of machinery over to

Turnover - (Continued)

an amateur operator and expect he would make it perform 100% right from the start. Neither should we assume that an owner can take a new environment that has just been built for him and immediately operate it at full efficiency. Time should be spent during turnover to explain how this environment is to function.

Operate - The environment is now run-in and begins to achieve its full purpose. Operation can be an important responsibility although the design/build contractor should furnish his operational functions in connection with a new environment only on a paid contract arrangement and provided he is competent to operate the facility.

Maintain - Maintenance of the physical environment is the door opener for future projects. It also assures that the environment that has been nursed through the previous eight stages will be maintained correctly so as to work at its best for those who must use it. The maintenance contract is perhaps one of the least explored areas in the more sophisticated approaches to environmental design and construction.

The end of the line of action is when the designer and builder of environments has discharged his responsibilities. In a continuing trustworthy relationship, the line of action will have no end since before it is finished, a competent professional will be re-involved in another program at its beginning.

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PARTICIPANTS IN DESIGNING AND BUILDING ENVIRONMENTS

There are four basic participants in the process of designing and building environments. These are the

- Conceivers, - Translators, - Constructors, - Operators

Conceivers - Those who conceive the idea and provide the wherewithall to bring the environmental program to a successful conclusion. The conceiver may be the owner but it may also be a governmental agency, a financial source, an architect, a contractor, a vendor or even a tenant looking for space. We identify the conceiver since he usually is the key person driving the project on to completion.

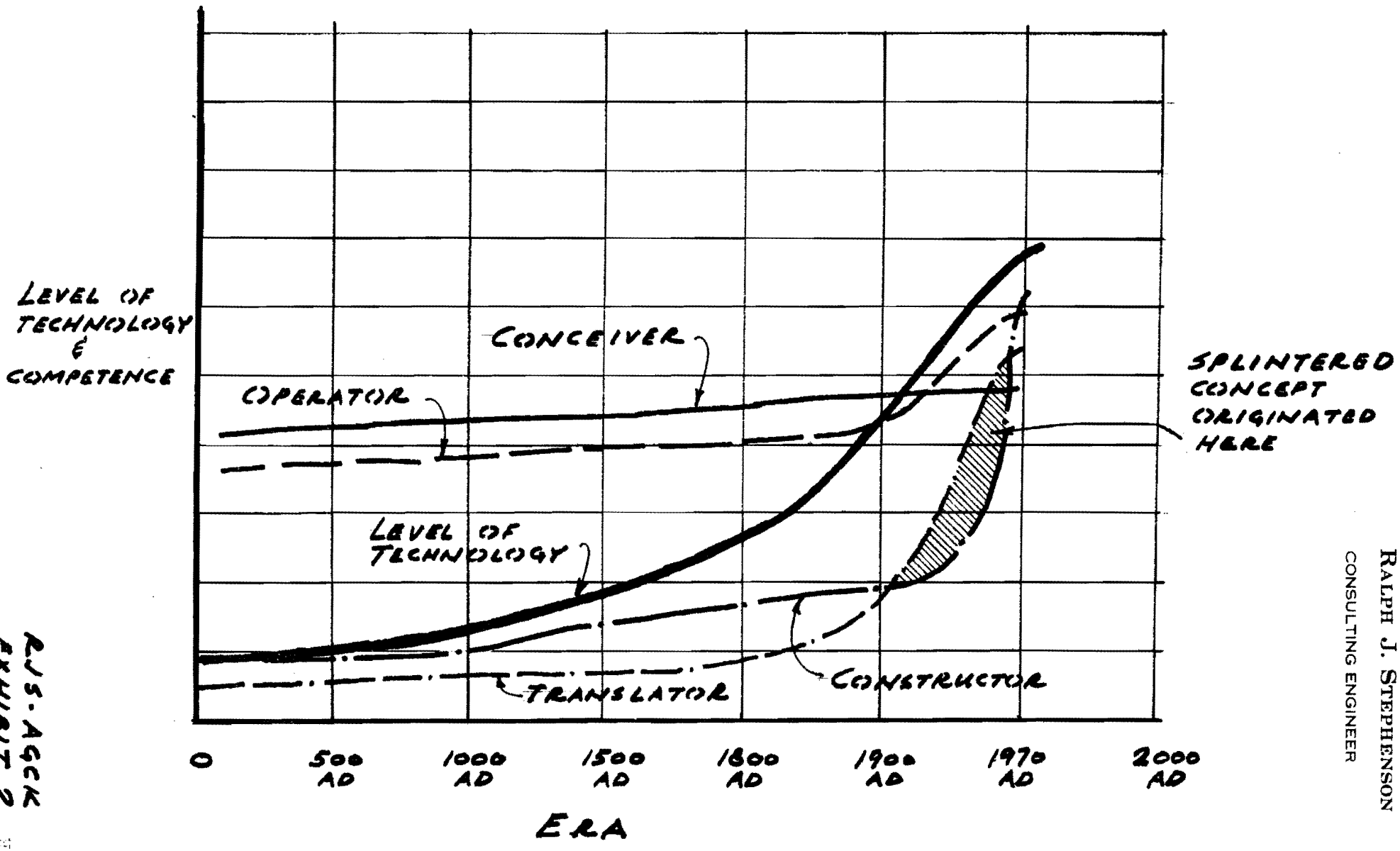
Translators - Those who translate the concept into construction language. Traditionally, we think of the architect/engineer as the translator. However, careful thought on this matter will show that there are many others who translate the conceiver's fundamental idea into some kind of understandable, workable construction language. Sub contractors, suppliers, vendors, manufacturers, contractors, the conceiver, himself, may all play a role in translating.

Constructors - Those who interpret the construction language and convert it into an actual physical environment. Occupying this role are the general contractor, sub contractors, vendors, suppliers, manufacturers and others who actually put the materials into place in the field.

Operators - Those who take over the completed physical environment and make it function on a continuing basis. Usually, the party responsible for this is an owner or tenant working through a plant engineer or building supervisor. In some instances the design/build contractor can become involved on a maintenance and operational basis, particularly if he has designed and built under a gross lease contract.

Identification of the parties to a project is important because it assists in defining the most important individuals in a given project situation. By accurate identification of the individuals concerned, their functional authority and responsibility can be established and optimum use made of their assistance.

LEVEL OF TECHNOLOGY



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RJS. AGCK EXHIBIT 2

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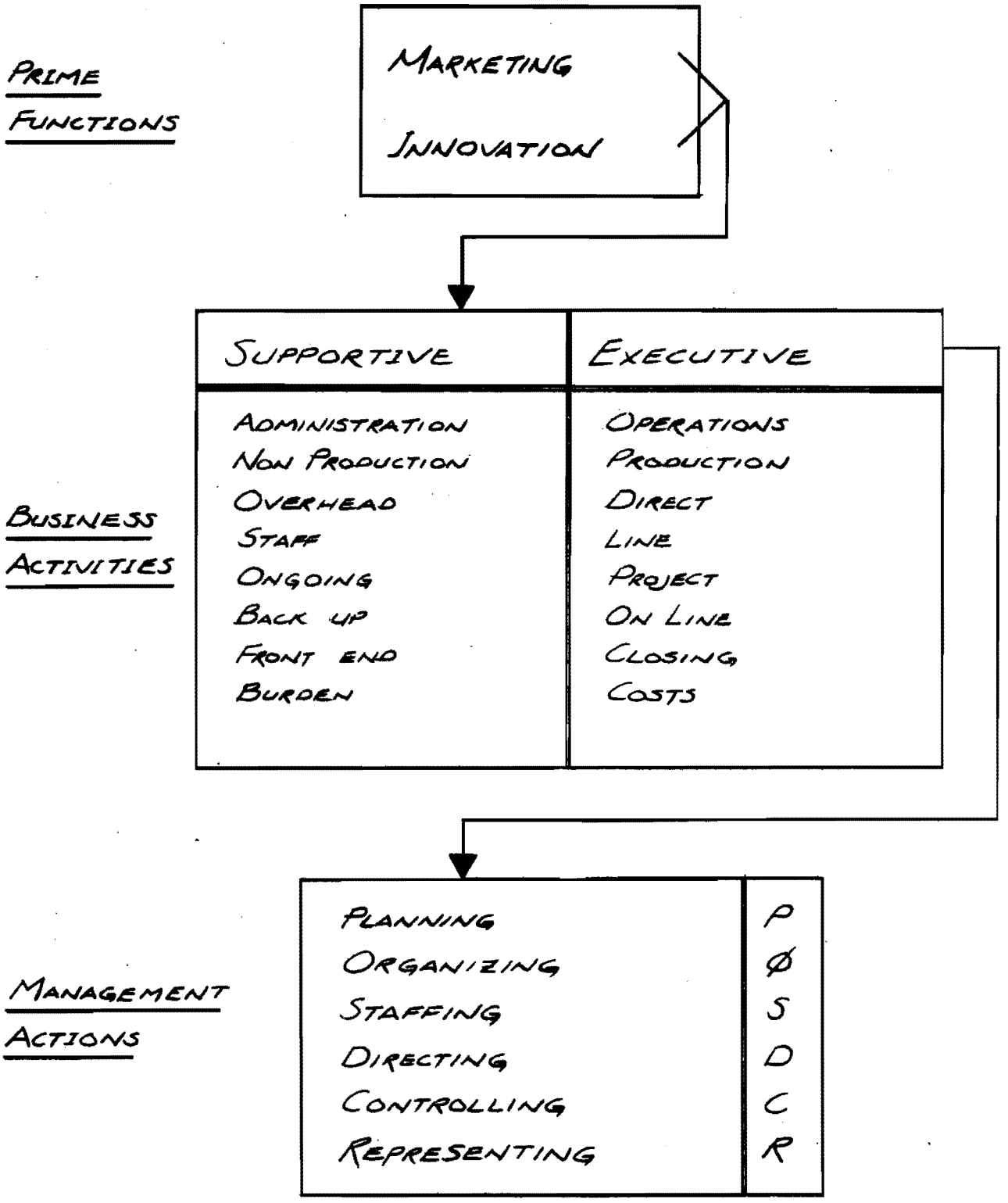
ELEMENTS OF BUSINESS & MANAGEMENT



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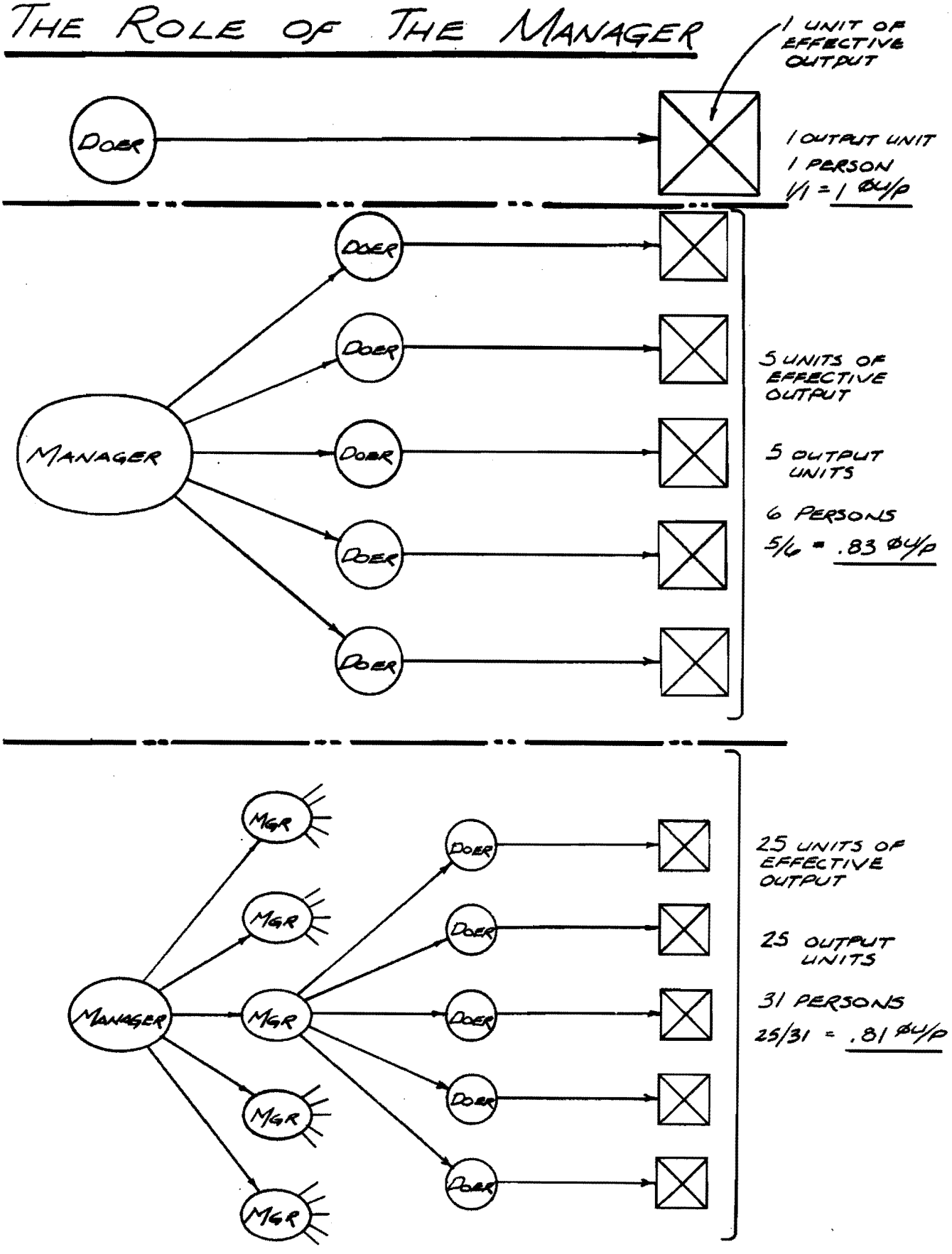
THE ROLE OF THE MANAGER



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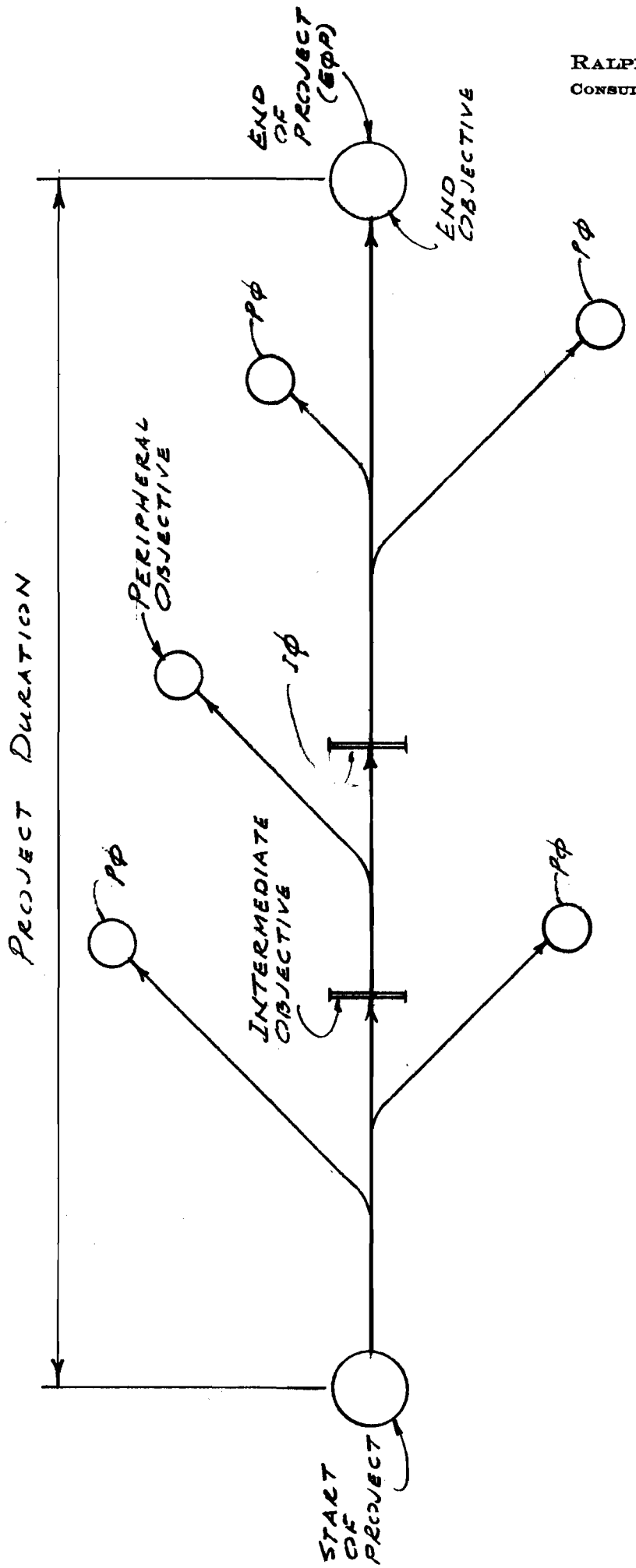
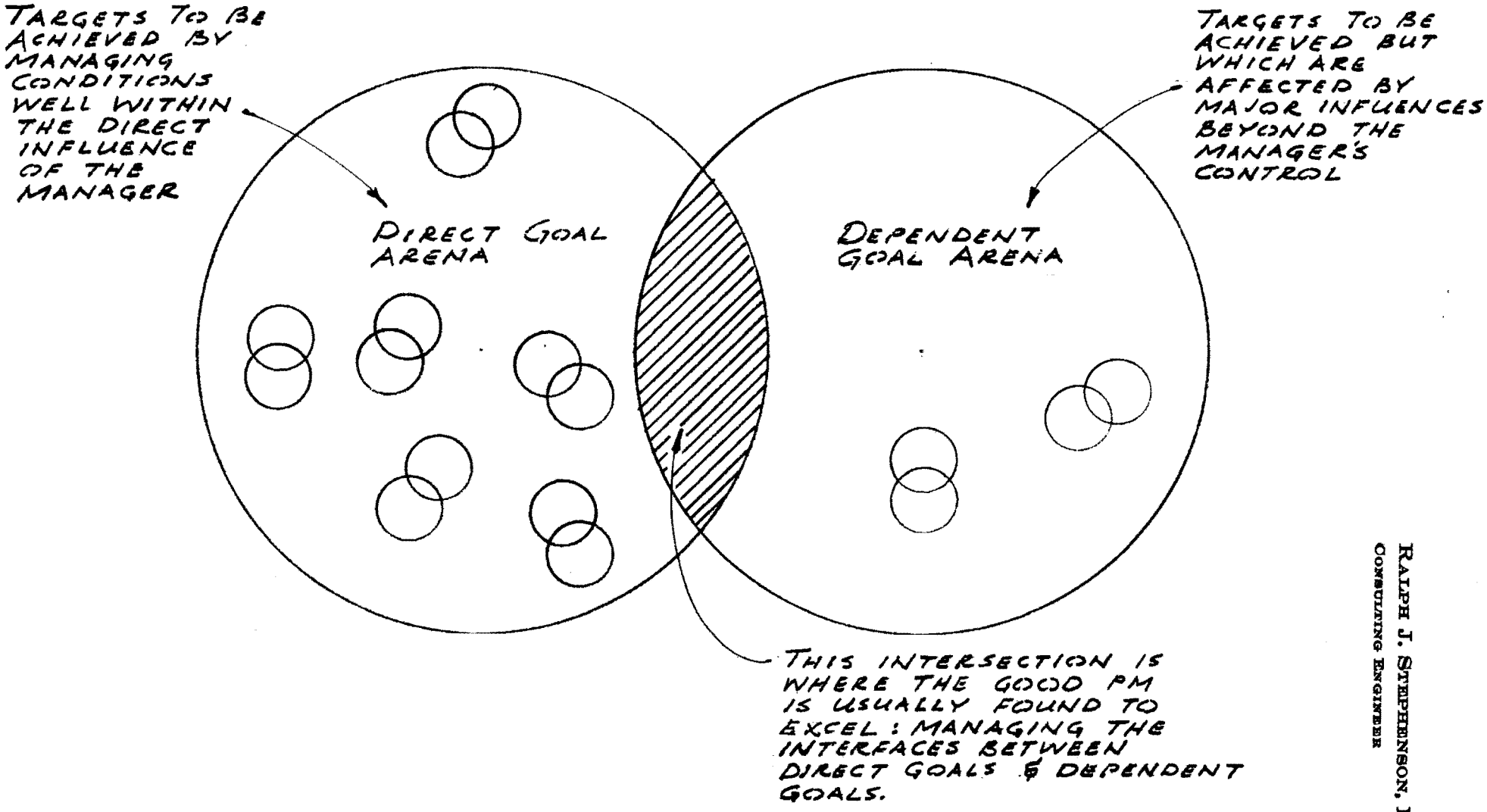


END, INTERMEDIATE & PERIPHERAL OBJECTIVES



THE DIG/DEG INTERSECTION

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H/O 137

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PICTURE OF A PROJECT

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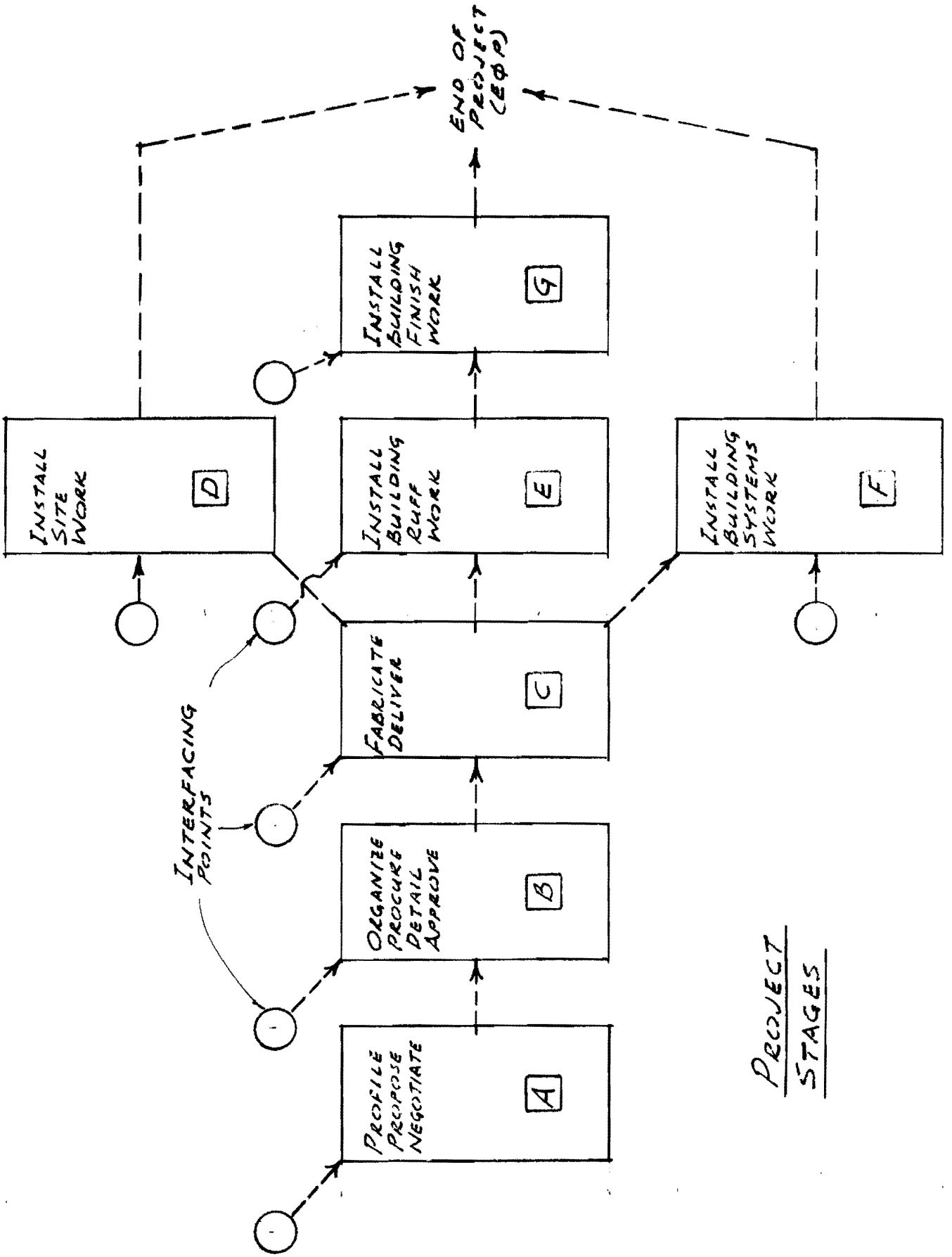

PROJECT STAGES

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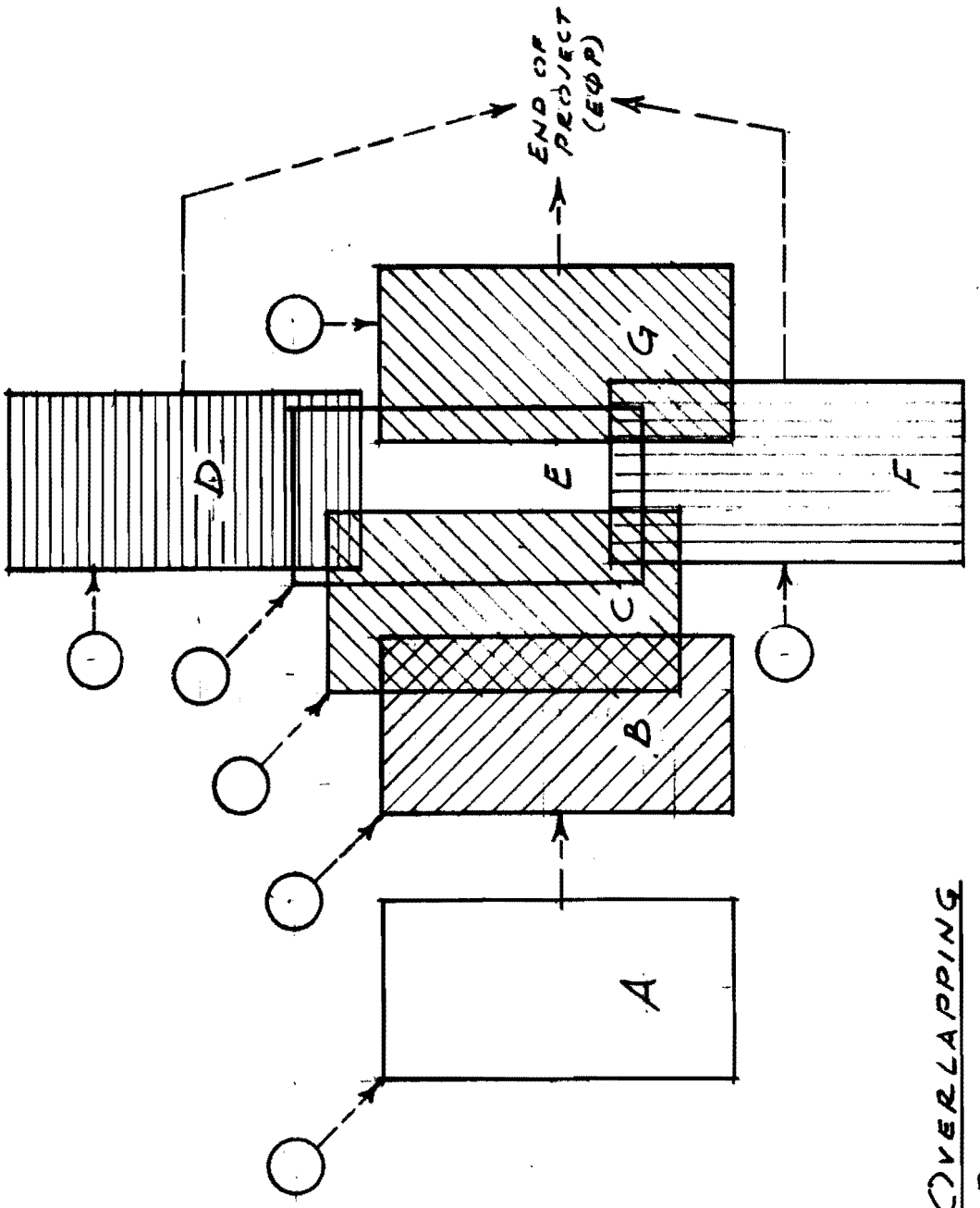

OVERLAPPING PROJECT STAGES

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PROJECT MANAGEMENT

AN EXPLORATORY LOOK

Definition:

Project - A set of work actions having identifiable objectives.

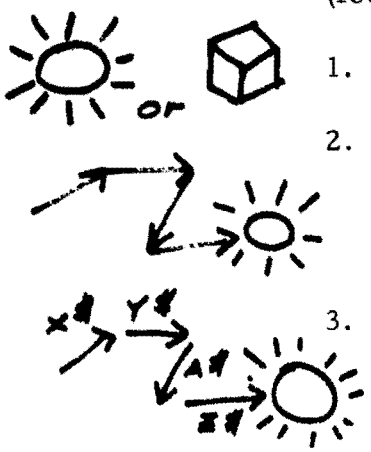
Effective - Of a nature that accomplishes identifiable objectives in accordance with the action plan, and achieves specified peripheral goals resulting from intermediate actions.

Manage - To direct the application of available resources.

Question?: What is different about project organization as compared to the ongoing parent organization?

1. Project organization is usually temporary (relatively).
2. Project organization may be on a different base than the ongoing parent organization.
3. Project authority positions tend to be vested first and earned later.

What is it?: A project seems to have the following characteristics (features) and requirements.



1. Its objectives must be clearly defined.
2. The desired course of action from start to finish is (and if it isn't, should be) explicitly stated as a standard of performance (if you can't plan it, you can't do it!)
3. The resources required to do each action from beginning to end are identified and made countable.

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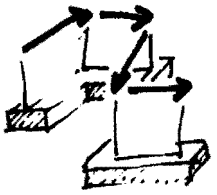
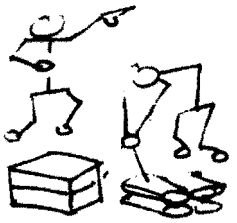
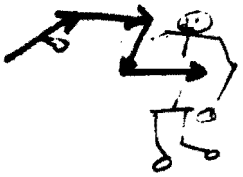


4. An organization structure should be (or is best) built under (not over) the resource framework to give the resource frame quality, continuity and monitorbility.

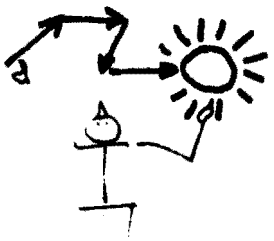


5. The resources needed to do the project can be assembled and put to work.



6. A method of isolating, identifying and correcting deviations from the standards of expected performance has to be devised and applied.

7. The performance should be measured to reward competence, and correct and improve lesser efforts as the project proceeds and upon its completion.



8. Outside management (ongoing management) usually sets both the starting and ending of the project.

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How CPM cuts construction time and money

Newest thing to hit the construction management industry is a tool called CPM (critical path method) or network planning. Used intelligently, it can cut total project costs up to 25%, slash total time by 10 to 30% and free management from 90% of routine decision-making

BENEFITS OF NETWORK PLANNING

- Makes you think about a project in more detail, tending to prevent omission of tasks.
- Tells you accurately how long a project will take and what jobs must be kept on time to meet the schedule.
- Simplifies advance work assignments and helps improve communications between those responsible for a project.
- Assists you in evaluating and forecasting the outcome of alternate plans of action.
- Focuses attention on potentially troublesome tasks and allows you to pinpoint corrective action.
- Fixes responsibility and provides a permanent record of assignments.
- Insures continuity of action, even with changes in personnel.
- Encourages personnel at all management levels to contribute to effective job planning.
- Simplifies periodic re-evaluation and rescheduling.
- Provides a uniform system of planning, scheduling and reporting.
- Measures proposed changes against time, money and manpower yardsticks.
- Shows proper relationships between all tasks.
- Provides a graphic picture of the work that encourages making accurate and prompt field decisions where needed.
- Shows what to expedite.
- Encourages accurate and continuous control of buying operations and subcontractor performance.
- Separates planning of the task sequence from assignment of time values to each task, making project scheduling less susceptible to time distortions.

By RALPH J. STEPHENSON
Consulting Engineer
Detroit, Michigan

MANAGEMENT decisions — how do you make them? By instinct? By objective analysis? Or by a dash of emotion, mixed with large doses of technical knowledge and experience?

Whatever method you use, decisions are almost always based upon a complex combination of all of these. Oddly enough, the major job facing the competent manager today is not how to make the decision, but how to justify it to himself and others, how to communicate with the staff or company that is to carry out the program, and how to sharpen the implementation process.

Management Breakthrough

A relatively new technique of expression called network planning (NP), or critical path method (CPM), has entered the building industry picture, and shows great promise for those who use it intelligently as an aid to their managerial abilities. The NP concept is simple. *A network plan is the graphic charting of a series of end-to-end tasks, none of which can start until those preceding have been completed.* A sequence of these tasks makes up a complete project.

Networks vary in complexity. To

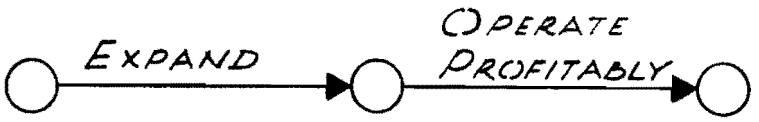


Figure 1

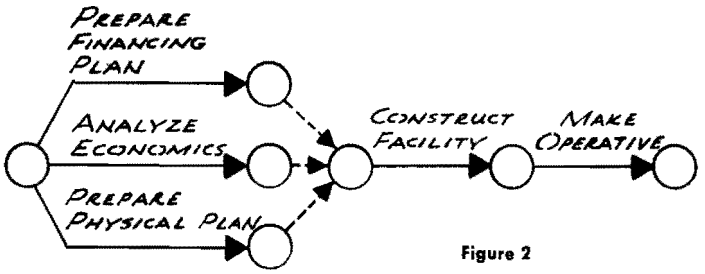


Figure 2

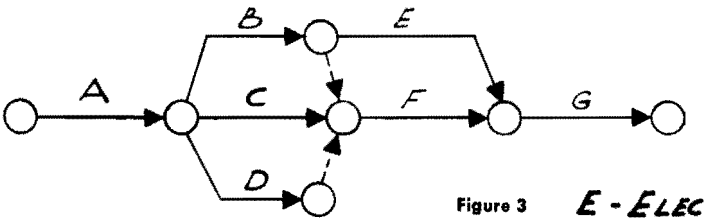


Figure 3

E - ELECTRICIAN
P - PIPEFITTER

TASK	CREW SIZE	TOTAL MAN DAYS REQD	DURATION IN WORKING DAYS
A	1 E 2 P	6	2
B	2 E 1 P	9	3
C	3 E 0 P	3	2
D	4 E 4 P	32	4
E	3 E 2 P	10	2
F	2 E 1 P	6	2
G	1 E 1 P	2	1

Figure 4

illustrate, let's examine a typical set of action levels in a corporate expansion program. At the top is the plan of action for the president. (Figure 1).

The vice president in charge of operations receives his assignment by an even more definite network plan (Figure 2).

From this operational network, the architect, the engineer, the contractor, and the comptroller prepare their work plans. These plans require detailed networks because they actually allocate large quantities of manpower and resources. In fact, it is not uncommon for a contractor's plan of action to be expressed by a network of several hundred individual tasks such as the one superimposed on these two pages. In turn each of these tasks may be broken down into smaller units of action. Let's look at one of these smaller sub networks and see what it is and how it's used.

Figure 3 is a detailed network plan of one of the tasks shown in the contractor's network. Requirements for the project action plan diagrammed in Figure 3 are that:

A must be done first

B, C, and D cannot start until A is complete

E follows B directly

F cannot start until B, C, and D are complete

G must follow E and F

Each letter in the net represents a specific task.

Ground Rules for Graphics

To depict this set of actions graphically we follow a set of rules:

1) Each solid arrow must represent a single activity or task.

2) Where a relation exists between tasks, but no activity connects them, a dotted line called a dummy or restraint is used to show the relationship.

3) Arrow junctions, indicated by circles, or nodes, are momentary points in time and signify the start or completion of a task.

4) No two arrows may have the same starting and finishing nodes.

5) Tasks originating from a node cannot be started until all tasks terminating at that node have been completed.

6) The logic of the action plan must be explicitly stated. Constant reference to rule five will help prevent errors in logic statement.

Imagine you are the person responsible for executing the plan in Figure 3. You naturally want to know how long it will take to do the job. Notice, this is the first mention of time as a factor. Until now, our concern has been to produce a workable action plan. In fact, one of the major advantages of the network technique is that it does separate project planning from time assignments and thus minimizes plan distortions caused by concurrent worries about time requirements.

Time Assignments

There are several methods of assigning times but let's use one that gives us flexibility for future adjustment of the network. In our example assume the work shown requires two trades, electricians (E), and pipefitters (P). Assignment of manpower is shown in Figure 4.

The estimated durations (d) from the table are entered on the corresponding arrows in the network plan. (Figure 5) Dummy arrows are assigned zero duration.

By a series of simple computations the earliest start (ES) and latest finish (LF) time limitations are determined for each task. ES's are the earliest possible times a task can start from each node as-

(continued on next page)

MAKE MONEY

Network planning can be used in the office, and in the field; it can help plan a financing and leasing program, or chart a public relations campaign; it can show a new secretary how to process a change order, or an experienced manager how to construct a multi-million-dollar high rise office building

suming all previous tasks are completed on time. ES times are figured from the beginning to the end of the network with the earliest start at the last node being the duration of the project. LF's are the latest allowable times a task can finish at each node without affecting the completion time of the entire project. LF times are computed by figuring back to the beginning along each path in the network.

In our example, the longest time sequence of tasks is through A, D, F, and G, a path which takes nine working days to traverse. The other paths (ABEG, ABFG, and ACFG) must then have spare time available since none take as long as ADFG. This spare time is called float.

Total float (TF) is the amount of time that any task can be delayed without delaying the entire project. It is computed by subtracting the duration of a task from the total time available to accomplish it. For instance, task B can start as early as 3 (ES), takes three days to complete, but doesn't have to be finished until 7 (LF). Thus there are 7–3=4 days available to do the three-day task. Task B then has one day float that can be used as job conditions dictate.

Similarly, task E is found to have 9–6=3 days available, but the task only takes two days. Therefore task E also has one day total float. Observe though, it is the same day that is available for task B or E and it can be used for one or the other, but not for both.

The Bottleneck Route

The path (or paths) through the network which takes the longest time to complete is the critical path. As a working definition, we say that the tasks within a project that have minimum total float time available (usually zero) are on the critical path. So, the critical path is the longest path through the project, but is the shortest time in which the project can be completed.

At this point, we know this about our job from the network:

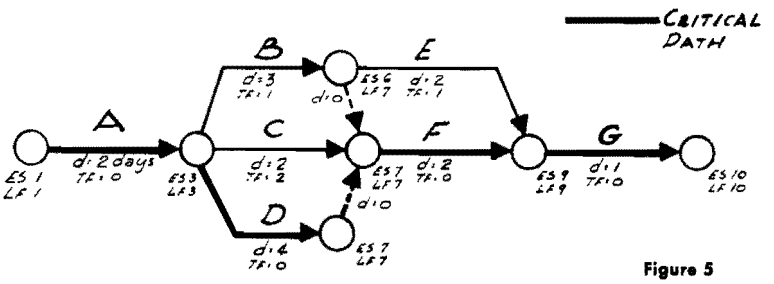


Figure 5

Method of Computation

Early start times (ES) are computed by adding the task duration to the ES time at the beginning node of the task. Where two or more arrow heads enter a node the ES time at that node is the latest of the computed early start times.

Latest finish times (LF) are computed by subtracting the task duration from the LF time at the end node of the task. Where two or more arrow tails leave a node the LF time at that node is the earliest of the computed latest finish times.

1) Everybody on the project is familiar with the work sequence and how many working days are allocated to their tasks.

2) Management knows how long the project will take and when it can expect each task to start and finish if the job is to be on time.

3) Management has an advance look at where trouble might develop by analyzing the critical path tasks.

4) Purchasing can be scheduled at times when buying conditions are best.

5) The effect of changes upon completion dates can be seen easily.

6) Replanning of the project (for example because of anticipated strikes or material shortages) can be accomplished with full knowledge of the impact of the change in plan upon the rest of the work.

Better Use of Manpower

If we went no further than preparing the plan and assigning times, NP would be of great benefit. But there are other uses for the network. By our data table in Figure 4 we can inject the concept of scheduling and resource allocation into the program. Look at Figure 5. Only four of the tasks, A, D, F, and G are actually scheduled with definite starting and completion dates. These are critical tasks which have no float time available. The other three tasks, B, C, and E have some leeway.

The question is — when are the best times to start and complete the noncritical tasks?

To determine these times we should first define our objectives. Assume that management wants to complete the project in minimum time and keep a crew size of about six electricians and five pipefitters.

Several approaches can be used, but I suggest that first, a simple bar chart be drawn showing each task starting at the earliest possible starting time, and continuing for its assigned duration. (Figure 6) The daily crew work force should also be shown on the chart based upon Figure 4 data. This method of scheduling the project by starting each task at the ES time, gives a variation in manpower assignments ranging from a maximum of eight electricians and six pipefitters down to one of each trade. Further,

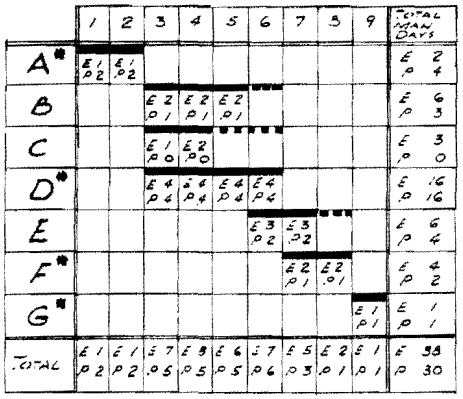


Figure 6

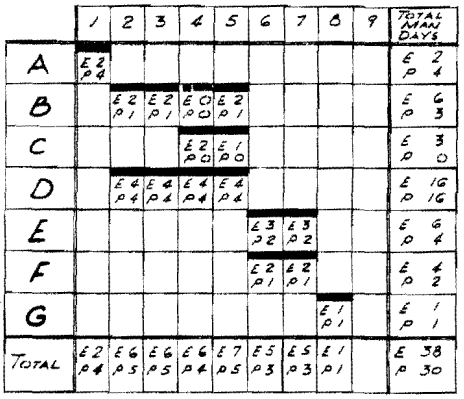


Figure 8

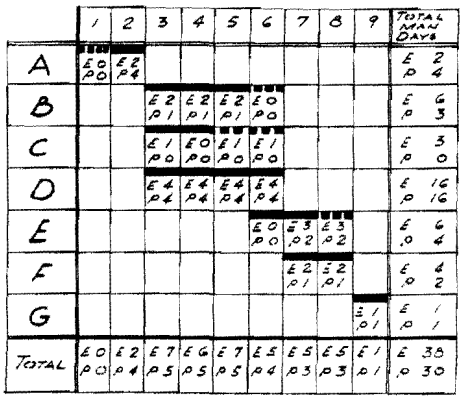


Figure 7

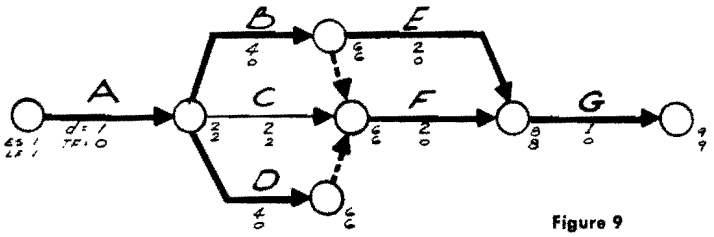


Figure 9

the fluctuation over the nine day period shows poor work continuity, and the project completion time hasn't been shortened.

Therefore a second reassignment is made using some of the float time from noncritical tasks (Figure 7).

Carrying out the project in this manner gives better manpower leveling characteristics by reducing the maximum required number of electricians from eight to seven, and the maximum required number of pipefitters from six to five. We have also cut the time of the project by one day by assigning additional available manpower to Task A. (In many cases doubling the crew size doesn't cut the required time in half, although for this small task we have assumed it does).

Analyzing our second schedule, we can still see additional modifications which will further smooth out the work assignments to give the final schedule and manpower allocation shown in Figure 8. By two visual adjustments to the original network and schedule we have now prepared a work assignment pattern that better fulfills the management objectives of cutting project time and minimizing crew size.

The last check made is a re-examination of the network to see if the schedule changes have necessitated a revision of the work plan (Figure 9). Inspection of the adjusted network shows there are no major changes except a reduction in the total length of the project by one day. Notice, when the new durations were assigned, elapsed times were used (such as for Task B where there is a one day interruption in the work).

Computered CPM

Our example has been a simple one, and the analysis quite easy. But visualize how complex the scheduling and resource allocation could become for many concurrent projects containing several hundred individual tasks. In such cases we usually resort to an electronic computer to furnish the multitude of arithmetical and logical conclusions needed to make decisions. For networks between 100 and 200 tasks, however, and where the only data required is the ES, LF, and total float information, hand computations by a good estimator will prove adequate, though slow.

In summary, we have discussed four application levels of NP:

1) The plan of action.

2) The arithmetical computation of ES, LF, and total float for each task.

3) The project schedule derived *from* the network.

4) The allocation of resources. #

Mr. Stephenson is a consulting engineer with a diversified background in land planning, facilities location and building design and construction. He has been associated with such firms as Smith, Hinchman and Grylls, Victor Gruen Associates and the H. F. Campbell Company. With the latter two organizations, Mr. Stephenson occupied executive positions as vice president. He has taught courses on the use of the critical path method in the construction industry, and since 1953, has been actively involved at a management level with the planning, programming, design and construction of millions of dollars worth of industrial, commercial and public facilities in all parts of the U.S. This broad experience has given Mr. Stephenson an understanding of both large and small management, and for the need to solve problems through a creative, systematic and knowledgeable approach.

RALPH J. STEPHENSON, P.E.
CONSULTING ENGINEER

NETWORK PLANNING MINITEXT

Symbols

1. Arrow or task ⟶

   A single definable action (or a single grouping of a number of definable actions) requiring resources.

2. Circle or node ◯

   The starting or ending point of a task .... a momentary point in time.

3. Dotted or dummy arrow ----→

   A symbol representing the existence of a relationship between tasks. Dummies have no resources allocated.

   Note: 95% of time a dummy goes from end of one task to start of another.

KEEP SYMBOLS SIMPLE !

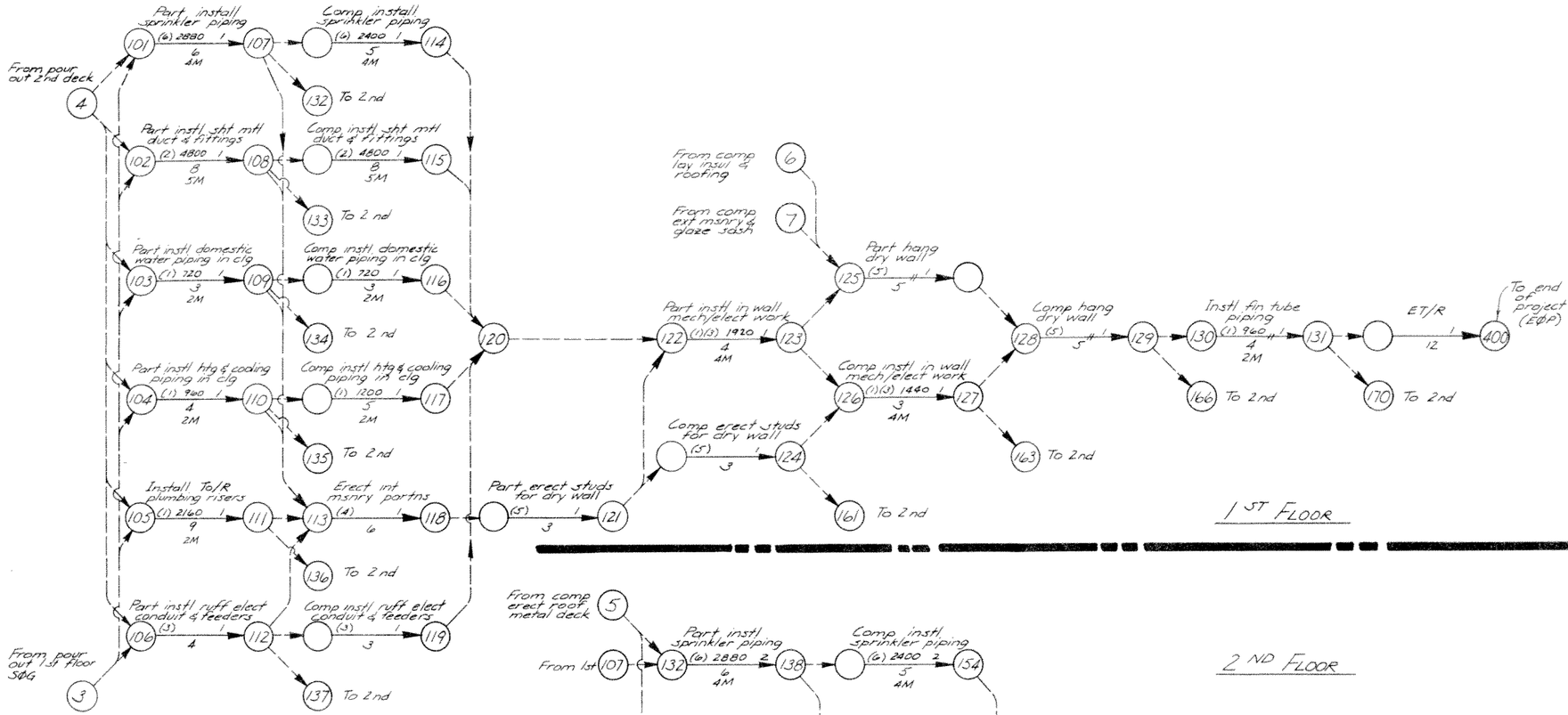
Rules of Job Planning

1. All tasks preceding any single task must be complete before that single task can start.

2. The logic plan represented by a series of single tasks, nodes and dummies must be explicit.

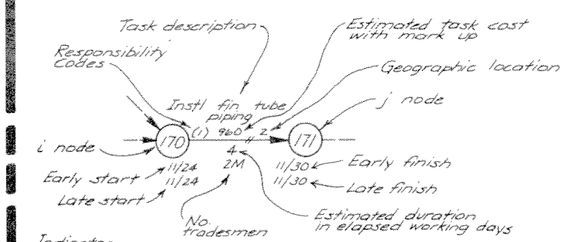
Steps in Network Planning

1. Define scope of work.
2. Draw logic plan.
3. Approve logic plan.
4. Assign durations.
5. Compute ES, LF and TF
6. Analyze and recompute, if necessary. (May make additional resource allocation)
7. Issue.



Responsibility Codes

1. Victoria Mechanical Co.
2. HVAC contractor
3. Electrical contractor
4. Masonry contractor
5. Dry wall contractor
6. Sprinkler contractor



ARROW KEY PLAN

Special Abbreviations

T/R	Time restraint
3M	3 mech tradesmen
SOG	Slab on grade
To/R	Toilet room
ET/R	End time restraint
EOP	End of project
R	Roof

MONITORING RECORD				ISSUE RECORD	
DATE	DATE	DATE		ISSUE No.	DATE
				PI	APR 6
				1	APR 26

Reserved Node Nos.

141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 172 thru 199

LN 1
HN 171
EOP 400

76:10

NETWORK MODEL FOR NEW OFFICE FACILITY

HIGHLAND & MORAN INC.

KEITH, IOWA

VICTORIA MECHANICAL CO.

RALPH J. STEPHENSON, P.E.
15064 WARWICK ROAD
DETROIT, MICHIGAN 48223
CONSULTANT PH 273-5026

3
JDM

MULTI-COLOR 480 3-75 MC 3000

RALPH J. STEPHENSON, P.E.
CONSULTING ENGINEER

Rules for Numbering Nodes

1. It is recommended the numbering sequence move down and to the right.

2. Normally, twenty numbers per hundred should be reserved for future use, and noted on diagram.

3. A node, having two or more arrows entering, or two or more arrows leaving, is numbered.

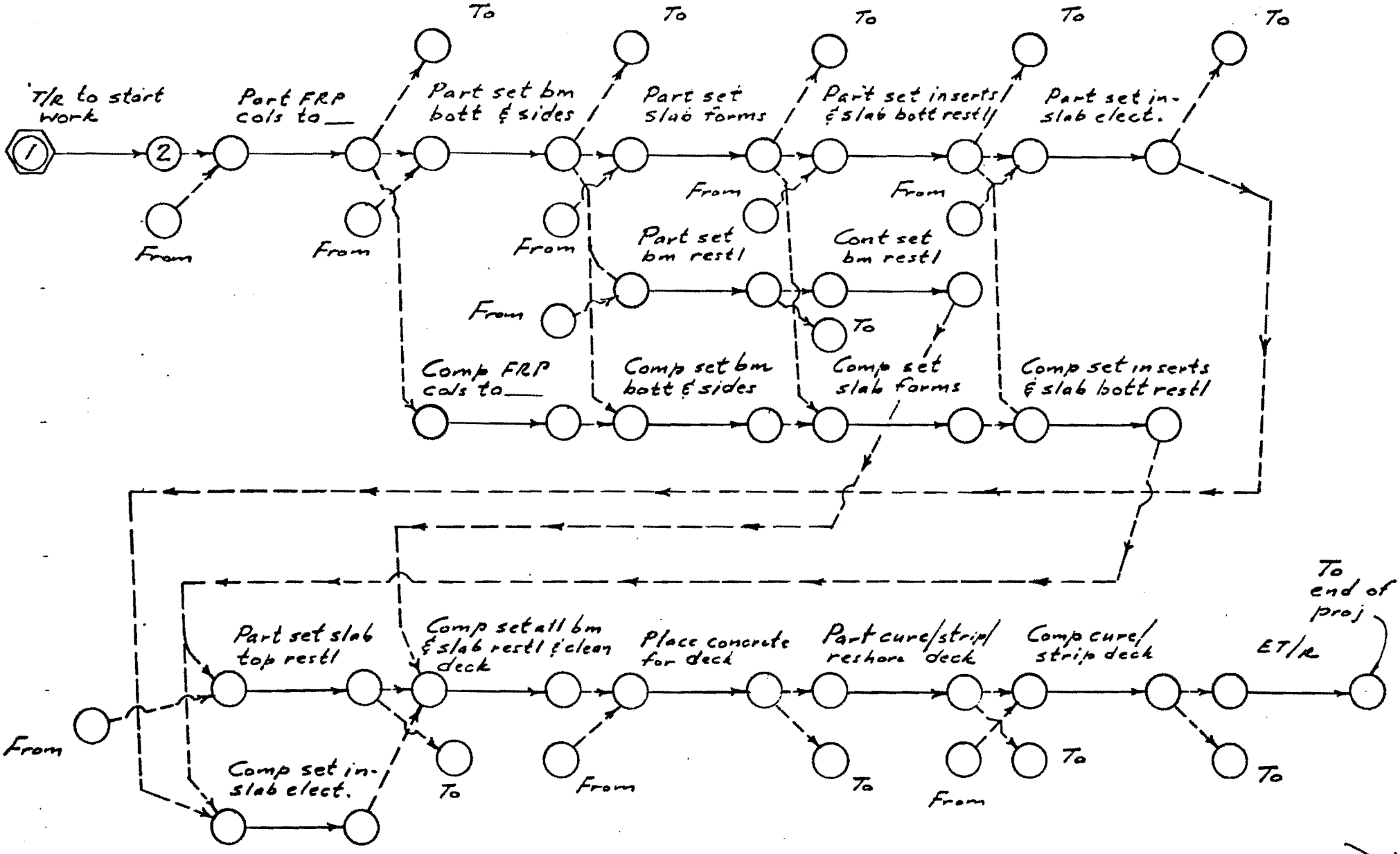
4. A node, having a single arrow entering, and a single arrow leaving, does not have to be numbered unless required by rule 5.

5. No more than one node in a sequence should be without a number.

Note: Node numbers are used to identify tasks. The final measure of whether node numbers are assigned correctly is whether any task in the network can be identified uniquely (the only one in the network) by its pair of node numbers.

i is the initial node number designation.

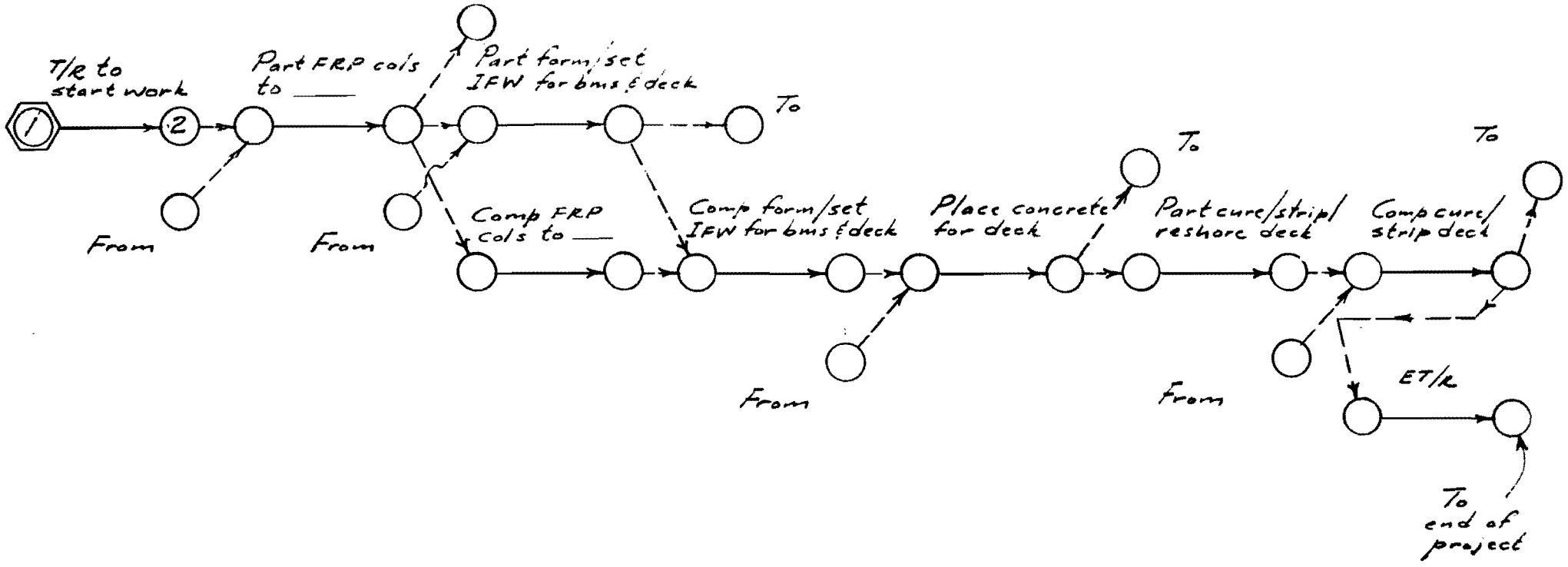
j is the end node number designation.



DETAILED NETWORK PLAN FOR ONE POUR

PCA 2/25/73

RALPH J. STEPHENSON, P.E.
CONSULTING ENGINEER



SUMMARY NETWORK PLAN FOR ONE POUR

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CONSULTING ENGINEER

PCA 2/25/73

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CONSULTING ENGINEER

CPM EXERCISE #1

Project starts with task A.
D can be concurrent with A.
B must follow A and precede F.
C follows A.
E cannot begin until both C & D are complete.
F precedes G & H.
G Cannot begin until E is complete.
H, G, & I must precede J.
I follows E and precedes L.
K follows D.
L cannot begin until K is complete.
J & L must be complete before M can start.
N cannot start until L is complete.
O follows N.
P is the last task and can start only when M & O are complete.

RALPH J. STEPHENSON, P.E.
CONSULTING ENGINEER

CPM EXERCISE #2

Z, T, & L are the first tasks and can be concurrent.
X must be complete before N can start.
Q follows H.
C must follow L and precede W.
S follows B & W and precedes D & V.
N must be complete before M can begin.
K & D must be complete before R & X can start.
A must follow Z.
G precedes Q and follows V.
H cannot begin until F & R are complete.
D must be complete before F can start.
U follows B and precedes K.
W cannot start until T is complete.
M is the last task & follows Q.
B cannot begin until A & T are complete.

Z2	C6	M4
T4	W1	R5
L1	S3	U2
X3	B1	A2
N4	D2	F3
Q2	V3	G4
H3	K1	

R J STEPHENSON, P.E. 15064 WARWICK DETROIT, MICH 48223 PH 313-273-5026

2-YR WORKING-DAY CALENDAR STARTING JAN. 3, 1978

DATE	W/D
JAN 1978	
03	1
04	2
05	3
06	4
09	5
10	6
11	7
12	8
13	9
16	10
17	11
18	12
19	13
20	14
23	15
24	16
25	17
26	18
27	19
30	20
31	21
FEB	
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28	41
MAR	
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02	43
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28	253
29	254

R J STEPHENSON, P.E. 15064 WARWICK DETROIT, MICH 48223 PH 313-273-5026

2-YR WORKING-DAY CALENDAR STARTING JAN. 3, 1978

DATE	W/D
JAN 1979	
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04	257
05	258
08	259
09	260
10	261
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12	263
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18	267
19	268
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30	275
31	276
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MAR	
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APR	
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27	380
28	381
29	382
JLY	
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03	448
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08	451
09	452
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19	460
22	461
23	462
24	463
25	464
26	465
29	466
30	467
31	468
NOV	
01	469
02	470
05	471
06	472
07	473
08	474
09	475
12	476
13	477
14	478
15	479
16	480
19	481
20	482
21	483
23	484
26	485
27	486
28	487
29	488
30	489
DEC	
03	490
04	491
05	492
06	493
07	494
10	495
11	496
12	497
13	498
14	499
17	500
18	501
19	502
20	503
21	504
24	505
26	506
27	507
28	508
31	509

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4-YR WORKING-DAY CALENDAR STARTING JAN. 3, 1978

DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D
JAN 1978		15	52	26	104	09	155	23	207	JAN 1979		14	306	25	358	08	409	22	461
03	1	16	53	30	105	10	156	24	208	02	255	15	307	29	359	09	410	23	462
04	2	17	54	31	106	11	157	25	209	03	256	16	308	30	360	10	411	24	463
05	3	20	55	JNE		14	158	26	210	04	257	19	309	31	361	13	412	25	464
06	4	21	56	01	107	15	159	27	211	05	258	20	310	JNE		14	413	26	465
09	5	22	57	02	108	16	160	30	212	08	259	21	311	01	362	15	414	29	466
10	6	23	58	05	109	17	161	31	213	09	260	22	312	04	363	16	415	30	467
11	7	24	59	06	110	18	162	NOV		10	261	23	313	05	364	17	416	31	468
12	8	27	60	07	111	21	163	01	214	11	262	26	314	06	365	20	417	NOV	
13	9	28	61	08	112	22	164	02	215	12	263	27	315	07	366	21	418	01	469
16	10	29	62	09	113	23	165	03	216	15	264	28	316	08	367	22	419	02	470
17	11	30	63	12	114	24	166	06	217	16	265	29	317	11	368	23	420	05	471
18	12	31	64	13	115	25	167	07	218	17	266	30	318	12	369	24	421	06	472
19	13	APR		14	116	28	168	08	219	18	267	APR		13	370	27	422	07	473
20	14	03	65	15	117	29	169	09	220	19	268	02	319	14	371	28	423	08	474
23	15	04	66	16	118	30	170	10	221	22	269	03	320	15	372	29	424	09	475
24	16	05	67	19	119	31	171	13	222	23	270	04	321	18	373	30	425	12	476
25	17	06	68	20	120	SEP		14	223	24	271	05	322	19	374	31	426	13	477
26	18	07	69	21	121	01	172	15	224	25	272	06	323	20	375	SEP		14	478
27	19	10	70	22	122	05	173	16	225	26	273	09	324	21	376	04	427	15	479
30	20	11	71	23	123	06	174	17	226	29	274	10	325	22	377	05	428	16	480
31	21	12	72	26	124	07	175	20	227	30	275	11	326	25	378	06	429	19	481
FEB		13	73	27	125	08	176	21	228	31	276	12	327	26	379	07	430	20	482
01	22	14	74	28	126	11	177	22	229	FEB		13	328	27	380	10	431	21	483
02	23	17	75	29	127	12	178	24	230	01	277	16	329	28	381	11	432	23	484
03	24	18	76	30	128	13	179	27	231	02	278	17	330	29	382	12	433	26	485
06	25	19	77	JLY		14	180	28	232	05	279	18	331	JLY		13	434	27	486
07	26	20	78	03	129	15	181	29	233	06	280	19	332	02	383	14	435	28	487
08	27	21	79	05	130	18	182	30	234	07	281	20	333	03	384	17	436	29	488
09	28	24	80	06	131	19	183	DEC		08	282	23	334	05	385	18	437	30	489
10	29	25	81	07	132	20	184	01	235	09	283	24	335	06	386	19	438	DEC	
13	30	26	82	10	133	21	185	04	236	12	284	25	336	09	387	20	439	03	490
14	31	27	83	11	134	22	186	05	237	13	285	26	337	10	388	21	440	04	491
15	32	28	84	12	135	25	187	06	238	14	286	27	338	11	389	24	441	05	492
16	33	MAY		13	136	26	188	07	239	15	287	30	339	12	390	25	442	06	493
17	34	01	85	14	137	27	189	08	240	16	288	MAY		13	391	26	443	07	494
20	35	02	86	17	138	28	190	11	241	19	289	01	340	16	392	27	444	10	495
21	36	03	87	18	139	29	191	12	242	20	290	02	341	17	393	28	445	11	496
22	37	04	88	19	140	OCT		13	243	21	291	03	342	18	394	OCT		12	497
23	38	05	89	20	141	02	192	14	244	22	292	04	343	19	395	01	446	13	498
24	39	08	90	21	142	03	193	15	245	23	293	07	344	20	396	02	447	14	499
27	40	09	91	24	143	04	194	18	246	26	294	08	345	23	397	03	448	17	500
28	41	10	92	25	144	05	195	19	247	27	295	09	346	24	398	04	449	18	501
MAR		11	93	26	145	06	196	20	248	28	296	10	347	25	399	05	450	19	502
01	42	12	94	27	146	09	197	21	249	MAR		11	348	26	400	08	451	20	503
02	43	15	95	28	147	10	198	22	250	01	297	14	349	27	401	09	452	21	504
03	44	16	96	31	148	11	199	26	251	02	298	15	350	30	402	10	453	24	505
06	45	17	97	AUG		12	200	27	252	05	299	16	351	31	403	11	454	26	506
07	46	18	98	01	149	13	201	28	253	06	300	17	352	AUG		12	455	27	507
08	47	19	99	02	150	16	202	29	254	07	301	18	353	01	404	15	456	28	508
09	48	22	100	03	151	17	203			08	302	21	354	02	405	16	457	31	509
10	49	23	101	04	152	18	204			09	303	22	355	03	406	17	458		
13	50	24	102	07	153	19	205			12	304	23	356	06	407	18	459		
14	51	25	103	08	154	20	206			13	305	24	357	07	408	19	460		

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4-YR WORKING-DAY CALENDAR STARTING JAN. 3, 1978

DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D	DATE	W/D
JAN 1980		13	561	27	613	07	664	21	716	JAN 1981		16	817	28	869	10	920	22	972
02	510	14	562	28	614	08	665	22	717	02	766	17	818	29	870	11	921	23	973
03	511	17	563	29	615	11	666	23	718	05	767	18	819	JNE		12	922	26	974
04	512	18	564	30	616	12	667	24	719	06	768	19	820	01	871	13	923	27	975
07	513	19	565	JNE		13	668	27	720	07	769	20	821	02	872	14	924	28	976
08	514	20	566	02	617	14	669	28	721	08	770	23	822	03	873	17	925	29	977
09	515	21	567	03	618	15	670	29	722	09	771	24	823	04	874	18	926	30	978
10	516	24	568	04	619	18	671	30	723	12	772	25	824	05	875	19	927	NOV	
11	517	25	569	05	620	19	672	31	724	13	773	26	825	08	876	20	928	02	979
14	518	26	570	06	621	20	673	NOV		14	774	27	826	09	877	21	929	03	980
15	519	27	571	09	622	21	674	03	725	15	775	30	827	10	878	24	930	04	981
16	520	28	572	10	623	22	675	04	726	16	776	31	828	11	879	25	931	05	982
17	521	31	573	11	624	25	676	05	727	19	777	APR		12	880	26	932	06	983
18	522	APR		12	625	26	677	06	728	20	778	01	829	15	881	27	933	09	984
21	523	01	574	13	626	27	678	07	729	21	779	02	830	16	882	28	934	10	985
22	524	02	575	16	627	28	679	10	730	22	780	03	831	17	883	31	935	11	986
23	525	03	576	17	628	29	680	11	731	23	781	06	832	18	884	SEP		12	987
24	526	04	577	18	629	SEP		12	732	26	782	07	833	19	885	01	936	13	988
25	527	07	578	19	630	02	681	13	733	27	783	08	834	22	886	02	937	16	989
28	528	08	579	20	631	03	682	14	734	28	784	09	835	23	887	03	938	17	990
29	529	09	580	23	632	04	683	17	735	29	785	10	836	24	888	04	939	18	991
30	530	10	581	24	633	05	684	18	736	30	786	13	837	25	889	08	940	19	992
31	531	11	582	25	634	08	685	19	737	FEB		14	838	26	890	09	941	20	993
FEB		14	583	26	635	09	686	20	738	02	787	15	839	29	891	10	942	23	994
01	532	15	584	27	636	10	687	21	739	03	788	16	840	30	892	11	943	24	995
04	533	16	585	30	637	11	688	24	740	04	789	17	841	JLY		14	944	25	996
05	534	17	586	JLY		12	689	25	741	05	790	20	842	01	893	15	945	27	997
06	535	18	587	01	638	15	690	26	742	06	791	21	843	02	894	16	946	30	998
07	536	21	588	02	639	16	691	28	743	09	792	22	844	06	895	17	947	DEC	
08	537	22	589	03	640	17	692	DEC		10	793	23	845	07	896	18	948	01	999
11	538	23	590	07	641	18	693	01	744	11	794	24	846	08	897	21	949	02	1000
12	539	24	591	08	642	19	694	02	745	12	795	27	847	09	898	22	950	03	1001
13	540	25	592	09	643	22	695	03	746	13	796	28	848	10	899	23	951	04	1002
14	541	28	593	10	644	23	696	04	747	16	797	29	849	13	900	24	952	07	1003
15	542	29	594	11	645	24	697	05	748	17	798	30	850	14	901	25	953	08	1004
18	543	30	595	14	646	25	698	08	749	18	799	MAY		15	902	28	954	09	1005
19	544	MAY		15	647	26	699	09	750	19	800	01	851	16	903	29	955	10	1006
20	545	01	596	16	648	29	700	10	751	20	801	04	852	17	904	30	956	11	1007
21	546	02	597	17	649	30	701	11	752	23	802	05	853	20	905	OCT		14	1008
22	547	05	598	18	650	OCT		12	753	24	803	06	854	21	906	01	957	15	1009
25	548	06	599	21	651	01	702	15	754	25	804	07	855	22	907	02	958	16	1010
26	549	07	600	22	652	02	703	16	755	26	805	08	856	23	908	05	959	17	1011
27	550	08	601	23	653	03	704	17	756	27	806	11	857	24	909	06	960	18	1012
28	551	09	602	24	654	06	705	18	757	MAR		12	858	27	910	07	961	21	1013
29	552	12	603	25	655	07	706	19	758	02	807	13	859	28	911	08	962	22	1014
MAR		13	604	28	656	08	707	22	759	03	808	14	860	29	912	09	963	23	1015
03	553	14	605	29	657	09	708	23	760	04	809	15	861	30	913	12	964	24	1016
04	554	15	606	30	658	10	709	24	761	05	810	18	862	31	914	13	965	28	1017
05	555	16	607	31	659	13	710	26	762	06	811	19	863	AUG		14	966	29	1018
06	556	19	608	AUG		14	711	29	763	09	812	20	864	03	915	15	967	30	1019
07	557	20	609	01	660	15	712	30	764	10	813	21	865	04	916	16	968	31	1020
10	558	21	610	04	661	16	713	31	765	11	814	22	866	05	917	19	969		
11	559	22	611	05	662	17	714			12	815	26	867	06	918	20	970		
12	560	23	612	06	663	20	715			13	816	27	868	07	919	21	971		

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Chicago Area Weather

Source: Jack Kolstadt

Week		Working Day	Total Working Days Worked	Loss in Working Days
Dec.	1	234	3½	1½
	2	239	3½	1½
	3	244	4	1
	4	249	3	2
Jan.	1	256	2-1/5	2-4/5
	2	261	2-1/5	2-4/5
	3	266	3½	1½
	4	271	3	2
Feb.	1	277	3	2
	2	282	3	2
	3	287	4	1
	4	292	3½	1½
Mar.	1	297	4½	½
	2	302	4½	½
	3	307	4	1
	4	312	3½	1½
Apr.	1	320	3½	1½
	2	325	4½	½
	3	330	4	1
	4	335		0

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SCOPE OF WORK CHECKLIST ITEMS

1. Conditions existing as of the defined start of project work.
(Permits, contracts, easements, obstructions, pre-ordered materials, agreements, etc.)

2. Front end work
(Work involving permits, contract documents, procurement, detailing, fabrication, deliveries, approvals and other non-construction project items)

3. Off-site work
(Work outside the project property line that has a direct influence and is of importance to achieving project goals)

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Scope of Work
Checklist Items
Page two

4. Site work
(Work outside the building line and within the property line or contract limits)

5. Substructure
(Footings, foundation walls, piling, caissons and all related work which transmits loads to the sub-soil)

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Scope of Work
Checklist Items
Page three

6. Superstructure
(All structural items which directly or indirectly transmit building loads back to the substructure)

7. Exterior skin
(All work to close the building to weather)

8. Interior rough work
(Interior work which can be totally or partially exposed to weather)

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9. Interior finish work
(Interior work which must be partially or totally protected from weather)

10. Systems work
(Work which collectively makes up a total operating unit and can be identified as a separate work project from other project elements)

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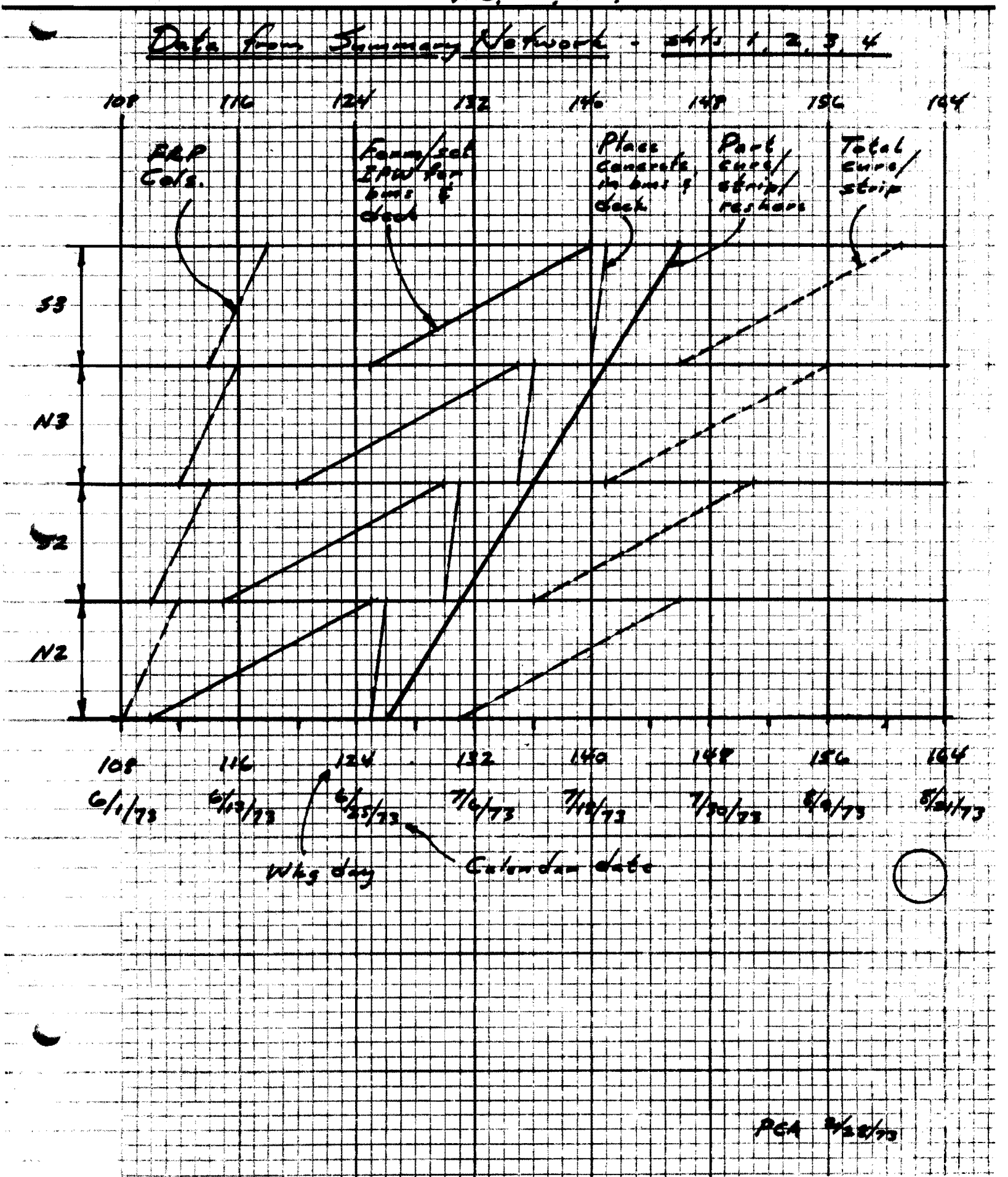
Subject Slant Chart - Floor Pours N2, S2, N3, S3 Date 3/1/73 Page (1)



Date May 10

Project: Lake City Community College

Page 1

Item	Code	Contractor or Vendor	Code	Lead Time Reqd.--wkg.dys.					Earliest		Latest		Best		Actual		Remarks
				Detail	Approve	Fabric	Deliver	Total	DTO	DOJ	DTO	DOJ	DTO	DOJ	DO	DOJ	
Struct Steel	5	Frey Erectors	4	10	4	10	2	26	5/23	6/29	5/23	6/29	5/23	6/29			
Alum sash	11	Bell Bros.	9	9	5	12	2	28	6/17	7/28	6/27	8/5	6/17	7/28			
Excavation	3	Mate Bros.	2	—	—	—	—	2	5/12	5/16	5/12	5/16	5/12	5/16			
Roofing	9	Cicotte Roofing	8	—	—	—	—	15	6/24	7/18	7/21	8/11	6/24	7/18			
Brick	10	Richardson Inc.	6	—	—	—	1	1	5/13	5/16	5/16	5/17	5/13	5/16			Sample wall
Plastering	16	Robert Plastering	15	—	—	—	—	10	7/11	7/25	8/4	8/18	7/14	7/28			

Abbreviations

Fabric = Fabricate

Wkg=Working

Dys = Days

Requird = Required

DTO = Date to order (calendar)

DOJ = Date on job (calendar)

DO = Date ordered (calendar)

Purchasing Schedule Example

Project ______________________ **Date** __________ RALPH J. STEPHENSON
Sht __________ CONSULTING ENGINEER

ITEM PROCESSING SCHEDULE

Item	Date shop dwgs to be submitted			Date of shop dwg approval			Date fabrication complete	Date item on job site
	Subm 1	Subm 2	Subm 3	Subm 1	Subm 2	Subm 3		

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FIRST LEVEL NETWORK - Summary Management Diagram

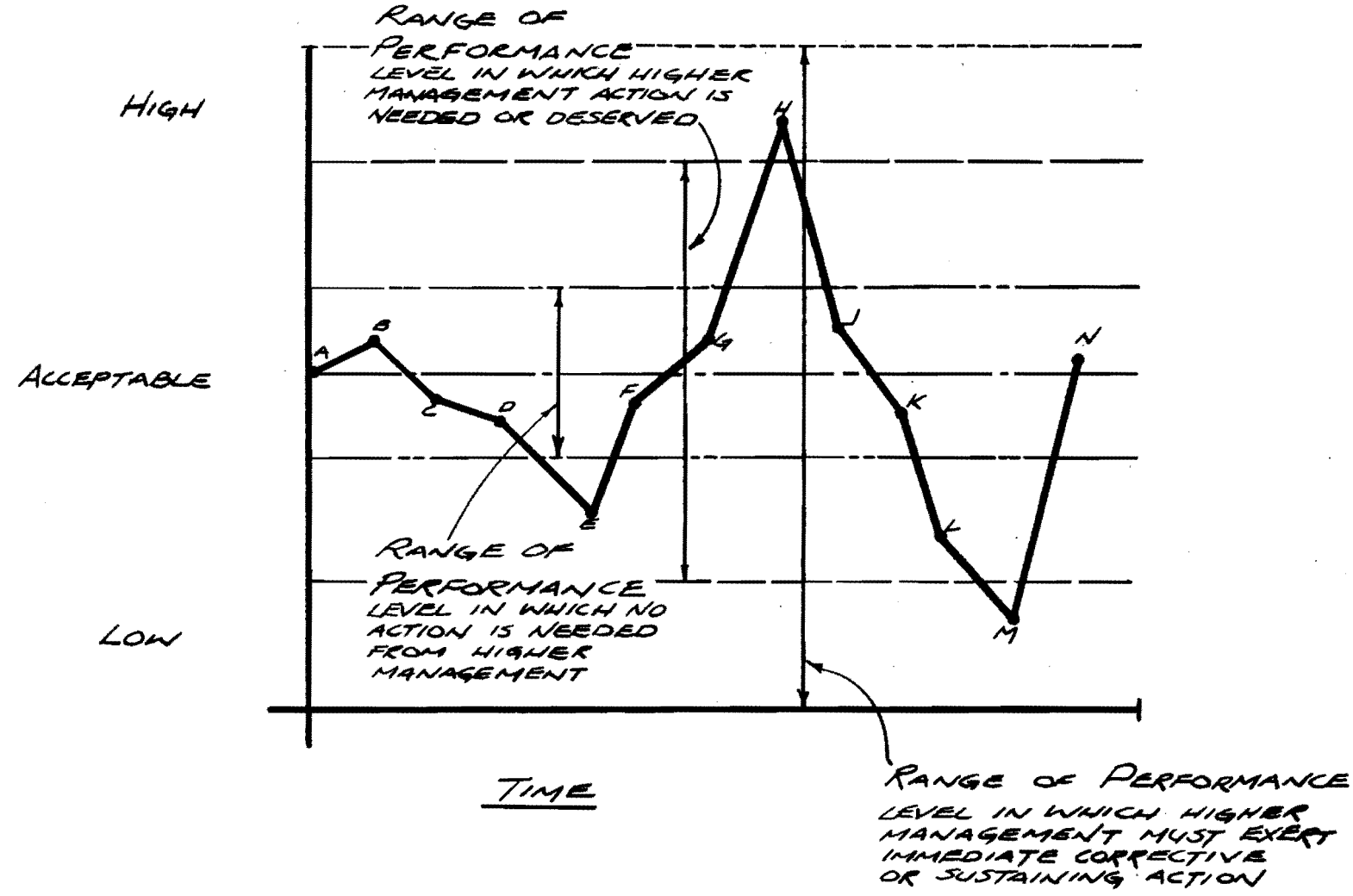
A diagram prepared very early in the project life. The summary network provides an overall look at the entire program, grouping major operations and containing tasks with durations from 10 to 50 working days. This network should normally contain 25 to 70 tasks exclusive of dummies.

SECOND LEVEL NETWORK - Working Diagram

A diagram prepared when most data about major tasks is available and the actual project work is about to begin or is underway. The working network should be sufficiently detailed so as to define key points or milestones at closely spaced intervals. It should contain tasks with durations of one to 10 working days. The second level network is the one most commonly used during project implementation.

THIRD LEVEL NETWORK - Key Operation Sub Diagram

A diagram prepared for the detailed planning of smaller operations within the second level network. Task durations usually range from one to five working days. Most often these networks are prepared by or for sub-contractors, vendors, suppliers, manufacturers and conform to established early start/late finish limits determined from the second level network.



MANAGEMENT BY EXCEPTION (MX) AND PERFORMANCE LEVEL ACTIONS

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H/O 150 3/77

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COLOR CODING

	1	2	3	4	5	6
IS TASK CURRENTLY PAST EF DATE?	N	N	Y	Y	Y	
IS TASK CURRENTLY PAST LF DATE?	N	N	N	N	Y	
WILL TASK MAKE LF DATE?	Y	N	Y	N	—	
COLOR CODE GREEN	X					
COLOR CODE ORANGE			X			
COLOR CODE BLUE		X		X		
COLOR CODE YELLOW					X	

Color coding is used to qualitatively evaluate project status. The status indicator colors described below are drawn on the solid task arrows, with the end of the color line shown at the approximate percentage of the task complete. The color line end is dated with the current calendar date.

Green

Task on time - currently not past early finish (EF) date.

Orange

Task on time - currently past early finish (EF) date.

Blue

Task behind - currently not past late finish (LF) date.

Yellow

Task behind - currently past late finish (LF) date.

Note that the evaluation is made on the basis of the current date. Changes in color are significant, indicating a deteriorating or improving sequence of work depending upon the progression. Color coding is primarily used to locate undesirable trends in work progress and to show job history.

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CONTROL SYSTEM TECHNIQUES

Color Coding

Color coding is used to qualitatively evaluate project status. The status indicator colors described below are drawn on the solid task arrows, with the end of the color line shown at the approximate percentage of the task complete. The color line end is dated with the current calendar date.

Green

Task on time - currently not past early finish (EF) date.

Orange

Task on time - currently past early finish (EF) date.

Blue

Task behind - currently not past late finish (LF) date.

Yellow

Task behind - currently past late finish (LF) date.

Note that the evaluation is made on the basis of the current date. Changes in color are significant, indicating a deteriorating or improving sequence of work depending upon the progression. Color coding is primarily used to locate undesirable trends in work progress and to show job history.

Description of Various Listings

The computer output is issued in five (5) major listings - by ascending order of node numbers (node sequence), by ascending order of early start dates (ES sequence), by ascending order of late start dates (LS sequence), by ascending order of late finish dates (LF sequence), and by ascending order of available float time (TF sequence).

Node Sequence

The node sequence is arranged in ascending order, first by i node number, then by j node number, where i node numbers are the same. This is the master list from which all revisions are made. It is also the listing used when referring from the arrow diagram into the computer printout for information.

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CONTROL SYSTEM TECHNIQUES
(Page 2)

Node Sequence (continued)

All dummy arrows are shown in this listing since subsequent changes to the network (updating) must be shown on the node sequence list to revise the computer input.

Early Start (ES) Sequence

The early start sequence lists all tasks in ascending order of their earliest possible starting dates. The ES listing is used most often by field management as a check list.

Late Start (LS) Sequence

The LS sequence lists tasks in ascending order of their latest allowable starting dates. This is a monitoring document and is used by first drawing a line under the current date in the LS column, and next evaluating tasks that have not started and are above that line. These tasks will be those that have not met their latest allowable starting dates.

As a suggestion, all tasks that are in-work can be indicated as such by circling their late start date. When tasks are complete, a check mark can be placed in front of their late start dates or the task can be crossed off. Thus, a quick inspection will show which tasks above the current date have not yet started or been completed.

Late Finish (LF) Sequence

The LF sequence lists all tasks in ascending order of their latest allowable finish dates. This list is used the same as the late start list but by applying the procedure to the late finish column.

Total Float (TF) Sequence

The TF list shows all tasks arranged in ascending order of the amount of float time available to the task. Those tasks indicated by a CP in the total float column are critical.

This list gives a good picture of (1) the relative criticalness of all tasks, and (2) what tasks become critical as a project begins to lag behind late finish dates. For instance, if a project has lost five (5) working days and it is still essential to maintain current anticipated end dates, then all tasks yet to be done and having float time to and including five, are now critical.

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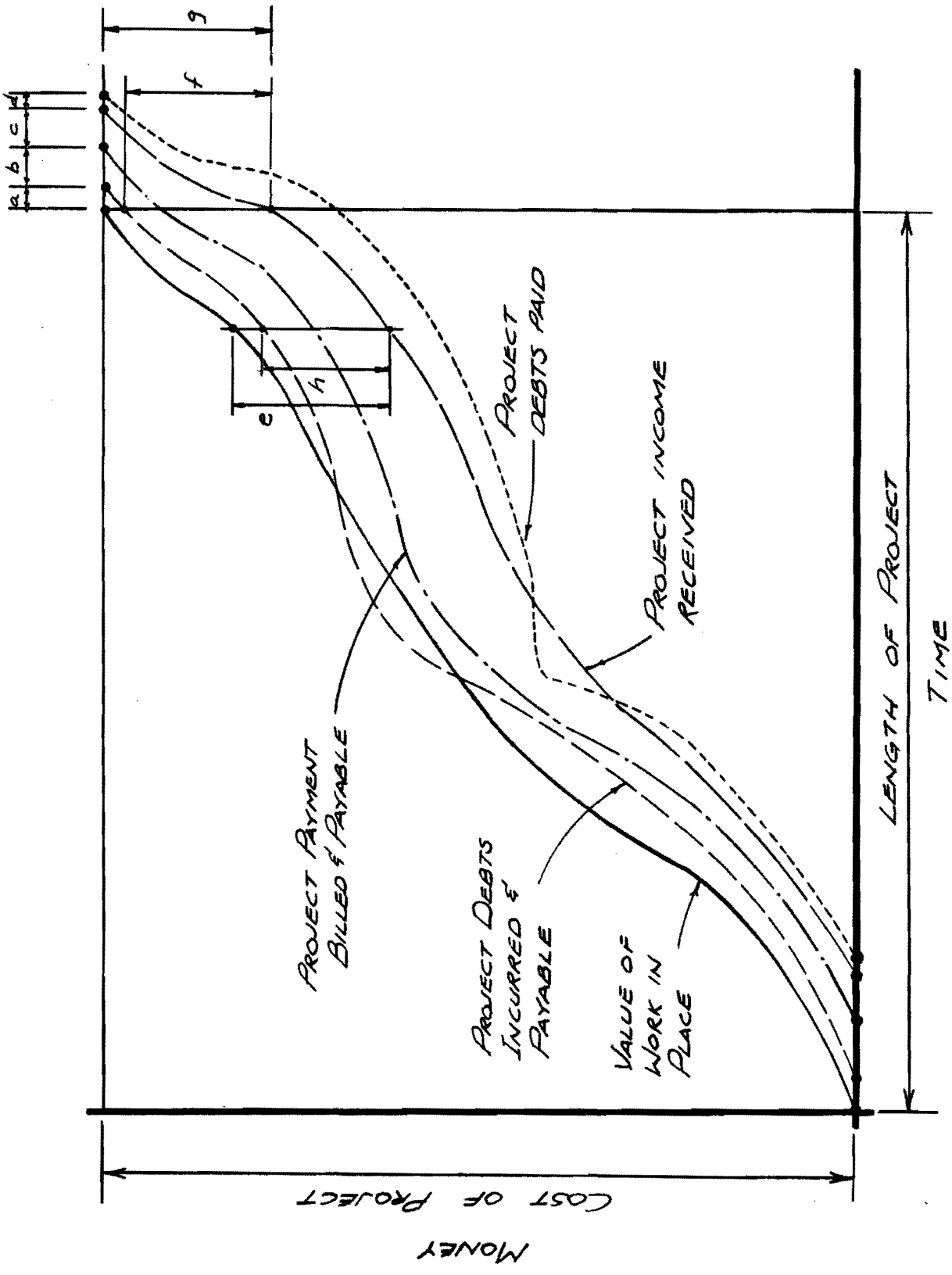

PROJECT MONEY FLOW

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November 1,

Subject: Monitoring Report #1

New Office Facility

Highland and Moran, Keith, Iowa

Victoria Mechanical Company

Project: 76:10

Monitored from Issue #1 dated April 26,

Date of Monitoring: September 24, (working day 188)

Target Completion Date: November 30, evening (working day 234) for fin tube piping

Actions taken:

- Inspected project
- Reviewed job progress with superintendent
- Evaluated job progress
- Color coded networks

General Summary

As of September 24, (working day 188) the project is basically in healthy condition. An evaluation of the job against late starts and late finishes shows that all major tasks are currently meeting or bettering late starts and late finishes.

Accurate information on exterior masonry and glazing status was not available from the general contractor. This work should be watched carefully since it affects hanging board upon which installation of our fin tube piping depends.

Projecting directly from late start/late finish sequences, it appears activities over the next two weeks should include:

- continuing installation of all major riser and overhead mechanical and electrical work
- installation of interior masonry partitions
- installation of insulation and roofing
- erection of exterior masonry and glazing

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It is anticipated that on September 29, according to the current early start schedule, studs for drywall are due to start at the first floor. However, looking at installation progress of toilet room plumbing risers, it appears these are lagging early start/early finish targets. Therefore, interior masonry which restrains installation of studs will probably be late and may delay installation of in-wall work past the current desired early target of October 4, (working day 194).

In a conference with the drywall contractor on September 24 (working day 188) he said he would prefer to erect studs and install one side of the board. We told him that this was not a desirable procedure and asked him if he would leave both sides exposed. He agreed, providing we would be liable for any damage to his studs by our work. We agreed.

In summary, the project is moving fairly well. The superintendent is on top of the job and our projections for work over the next week indicate the job should stay healthy.

Ralph J. Stephenson, P.E.

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Claim Prone Job Characteristics

During the profiling, proposing and negotiating period, it is often possible to gain a good insight into the expected nature of a job if one is fortunate (or unfortunate) enough to be the successful proposer. The problem job is becoming increasingly serious in our business and professional lives and it should be identified early. The problem job generally results in increased costs during the construction period and quite often requires arbitration or litigation to achieve resolution of costs and damages.

Thus, it is good policy for the perceptive owner, architect/engineer and contractor to become familiar with those characteristics that early identify a job as having potential for being a trouble project.

This list of characteristics is by no means complete, nor is it meant to imply that a job having these features will necessarily be claim prone. It is, on the other hand, an honest effort to state certain unique job features that have been identified in projects that have ended up in litigation or arbitration. The list is at random with no attempt to classify or characterize the features.

Claim prone job characteristics may include:

a. A wide spread in proposal prices.

b. Issuance of a large number of pre-bid addenda and instructions.

c. For subcontractors, a poor general contractor reputation if the project is being built by one prime.

d. For projects with separate primes, poor other prime contractor reputations.

e. More than four to six prime contractors involved(applicable on normal building work only).

f. Poor reputation of architect/engineer preparing contract documents.

g. Excessive how-to-do-it emphasis in contract drawings and specifications.

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Claim Prone Job Characteristics
(continued)

h. Non-liable party involvement in responsible positions, i.e. non-liable construction manager.

i. Large numbers of allowance items.

j. Zero (or excessively small) tolerance specifications.

k. Poorly defined authority and responsibility patterns in the offices of the architect/engineer, the owner, the general contractor or other prime contractors.

l. Inexperienced specialty contractors.

m. Excessive number of pre-selected suppliers for key material and equipment.

n. Large dollar amount or numbers of owner purchased equipment.

o. Location in strike prone areas.

p. Location in jurisdictionally sensitive areas.

q. Heavy use specified for untried products and equipment.

r. Non-liable party involvement in establishing delivery commitments, i.e. construction manager, architect/engineer, owner representative.

s. Involvement of politically accountable owners, architect/engineers or other contractors.

t. Multi responsibility payment structures.

u. Excessively long time periods to award contracts after a proposal.

(Note: This often occurs in public work where many non-project approvals and agencies are involved.)

v. Poor owner reputation.

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PROFIT POTENTIAL LEVELS

In construction the concept of profit is complex and often misunderstood. There are many kinds of profit - financial, socio-economic, value system, self-actualization, education, enjoyment, technical and probably as many more equally important but less obvious.

If we view the various kinds of returns on investments relative to project management, it appears there are three major levels of profit potential available, that achieved by being certain to consider and include all elements of the project, that achieved by arranging these elements in an effective action sequence and the profit achieved by making effective use of discretionary or float time. These are identified as levels A, B and C respectively.

A brief discussion of each is given below.

Level A Profit Potential

The basic profit potential is realized when the manager and his project team have made certain to include all project elements in the estimating, planning and control process; when they have made certain that everything is counted and there are no missing pieces. Every element missed erodes the profit picture just as a missing piece of a jigsaw puzzle spoils the pleasure of assembling it.

Level B Profit Potential

Once project elements are accounted for, they must be properly arranged in a logic pattern to produce the most effective plan of action. In any plan there are identified desired and necessary relationships. The proper expression of desired relations is a major factor in realizing level B profit potential. Here is where the true skill of the project manager begins to impact upon the job. The experienced, intelligent, knowledgeable manager will explore, simulate and select the most effective ways of assembling the job under his control. The level B profit potential is highest when the best ways have been selected.

Level C Profit Potential

This profit is highest when the job is scheduled well and a selection made as to where each task should be done in relationship to the discretionary time available to it. Often discretionary time is identified as float time. Where the good manager schedules the task when he has resource options (time, money, manpower, equipment, etc.) will largely determine how profitable the level C management work has been.

In a nutshall, level A profit potential deals with identifying all the elements involved. Level B profit potential is concerned with arranging these elements in a logical and effective action plan. The C level profit potential is engaged when the project is managed well by proper scheduling within allowable resource limits.

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SUGGESTED BIBLIOGRAPHY OF MANAGEMENT RELATED BOOKS

Managing Yourself Creatively — Ted Pollock

Hawthorn Books, Inc.
260 Madison Avenue
New York, New York (paperback)

The Nine Master Keys of Management — Lester R. Bittel

McGraw-Hill Book Company
330 West 42nd Street
New York, New York 10036

It All Depends — Harvey Sherman

University of Alabama Press
University, Alabama

Management - Tasks, Responsibilities, Practices — Peter F. Drucker

Harper & Row, Publishers, Inc.
10 East 53rd Street
New York, New York 10022

The Managerial Grid — Blake & Mouton

Gulf Publishing Company
Houston, Texas 77001

The Rational Manager — Kepner & Tregoe

McGraw-Hill Book Company
330 West 42nd Street
New York, New York 10036

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Top Management Planning — George R. Steiner

The Macmillan Company
866 Third Avenue
New York, New York 10022

Management By Exception — Lester R. Bittel

McGraw-Hill Book Company
330 West 42nd Street
New York, New York 10036

Critical Path Method — Radcliff, Kawal, Stephenson

Cahners Publishing Company, Inc.
Boston, Mass. 02116

Effective Psychology for Managers — Mortimer R. Feinberg

Prentice Hall, Inc.
Englewood Cliffs, New Jersey

The Time Trap — R. Alec MacKenzie

Amacom
135 W. 50th Street
New York, New York 10020

Management - Theory & Practice — Ernest Dale

McGraw-Hill Book Company
330 West 42nd Street
New York, New York 10036

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Pointers for Reading, Analyzing and Solving Case Studies

We will be using miniature case studies occasionally to point up various features of project planning and control systems. The suggestions below are to help you gain the most from the case study work.

Pointer 1

Read the case study carefully and try to get an overall managerial feeling for the situation and problems. The first scanning should be rapid with brief returns to specific problems. Underline and highlight key points as you go through the case study the first time.

Pointer 2

Where problems seem to exist in the description, isolate these even though they appear minor, and give them a mental priority ranking as you read through the study the first or second time. Identify problems to be solved and actions to be taken by asterisks or some other identifying mark.

Pointer 3

Clearly identify your position in the case study. What is it you are supposed to be, and how are you supposed to act? This activity is called internal role playing and is a good simulation technique for solving problems from your standpoint.

Pointer 4

Always ask yourself the basic questions about any situation - who?, what?, why?, when?, where? Without the answers to these five fundamental one word questions, an analysis may be incomplete and faulty.

Pointer 5

Be certain to answer the problem questions as fully as time permits. Normally the minutes allocated to a case study will be few and it is important to focus quickly upon the essential elements of the problems presented.

Pointer 6

When the case study is discussed, don't hesitate to bring out points you feel are important. Also learn from other's solutions. Remember there are usually many ways to solve problems and resolve difficulties.

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Case Study #4

The Wasted Treatment Plant

The project is a 26 million dollar waste treatment plant. You are the project manager and superintendent. Your involvement has been especially heavy for the past three weeks right after the job was obtained. It is apparent to you that the contract documents are poor, the owner is painfully indifferent to all influence except political pressures and the job is definitely claim prone.

What steps do you take now (within the first two months of this 2½ year job) to protect your company's interest?

Consider these questions:

1) How would a summary network diagram be of use?

2) What special activities should you be certain to include in the early summary diagram?

3) Who should be invited to the initial network planning session?

4) With whom should you discuss the problems that you see on the horizon?

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Case Study #5

The Sneaky Boiler Contractor

You have just completed and activated a sizable boiler house addition. The contract for boiler installation was a separate agreement with the owner, Carlton State College, with all other contracts direct with your firm, the Shoenite Construction Company, general contractors. As the job is being closed out, Jerry Biel, the physical plant director for the college comes to you confidentially and says the boiler contractor, Laguna, is claiming extra costs because Shoenite Construction interferred with his erection procedure by not providing a slab on grade from which to erect the tube systems and the boiler walls.

Actually Laguna, because of their separate contract with the owner, paid little or no attention to your requests as project manager to keep the area clear and early filled the slab on grade sector with material and equipment before you could possibly have built the slab.

Early in the job you prepared a detailed critical path diagram of all elements of the project including the boiler work. The boiler diagram was prepared in consultation with Laguna, and approved by their superintendent. The network clearly showed the slab on grade being built prior to loading the area with boiler equipment.

Consider these questions:

1) What potential problems exist here for you and Shoenite Construction Company?

2) What steps should you take immediately?

3) What is your own position in this matter? Why?

4) Describe the problem the owner has and how Shoenite Construction and you might help him resolve it.

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Reserved Node Nos.
21 24
22 25
23 26

SOLUTION TO EXERCISE #1
ARROW DIAGRAM

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Subject Bulletin of Change Order Date 11/26/77

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