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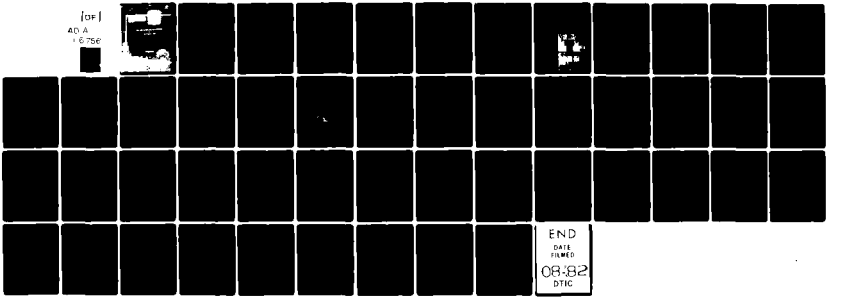

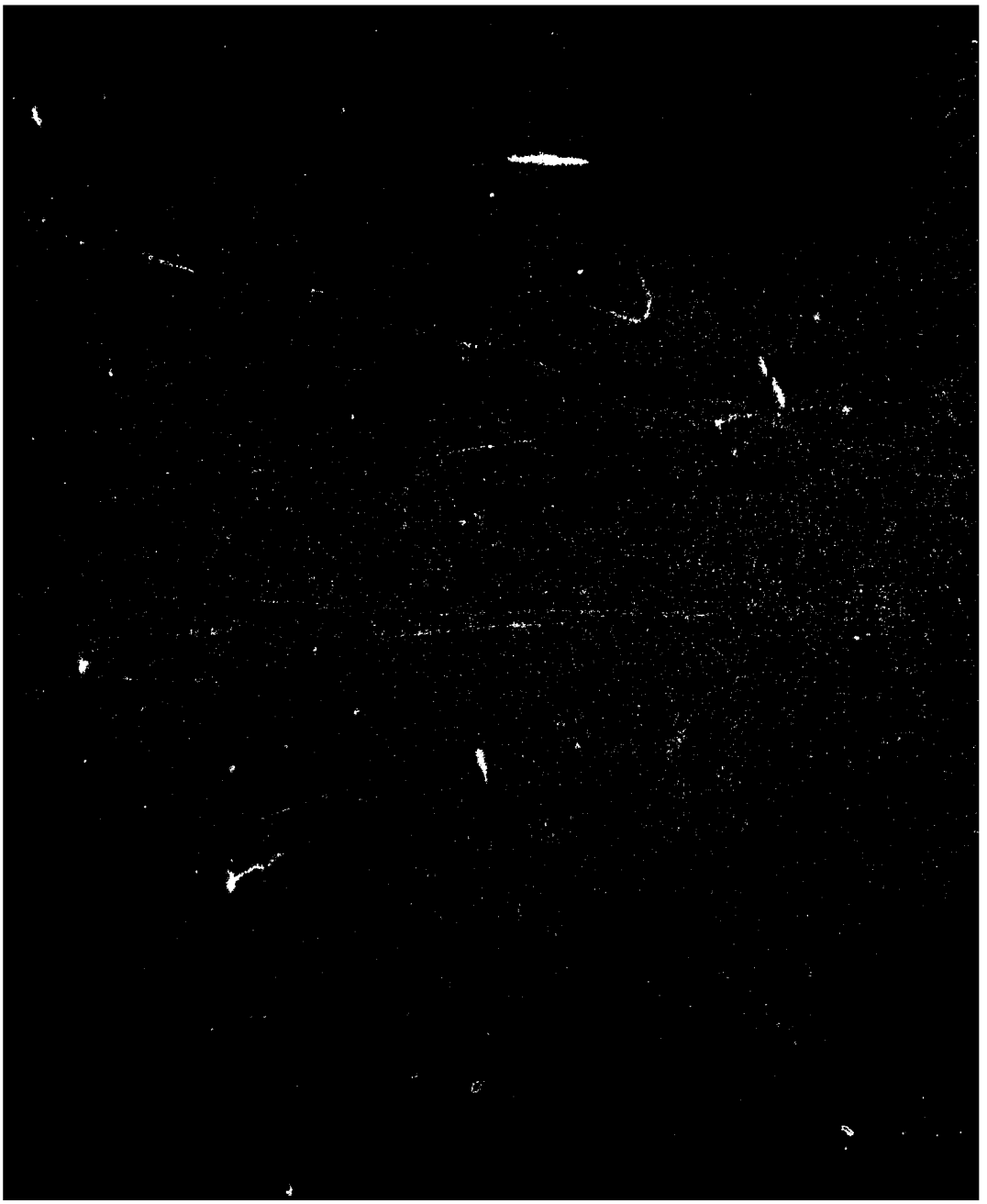

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Examines the use of Program Review Evaluation Technique (PERT) as a possible management tool that could be used by Reserve Component (RC) Commanders to assist them in accomplishing their mobilization tasks. Examines what PERT is and its evolvement as a management tool for RC commanders in transitioning units at home station from a peacetime to wartime status. Examines the advantages of using this management technique. Identifies problems and pitfalls associated with

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its use as a management tool. Analyzes the tasks to be accomplished at home station and presents a sample PERT network to demonstrate the process.

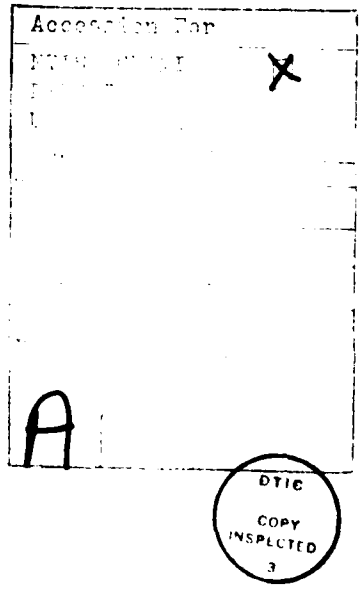
US ARMY WAR COLLEGE

INDIVIDUAL RESEARCH BASED ESSAY

PERT - WHAT POSSIBLE VALUE FOR MOBILIZATION

BY

LTC LEONARD D. HARDY



16 APRIL 1982

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CHAPTER 1

INTRODUCTION

"Git thar fustest with the mostest."[1]
General Nathan Bedford Forrest

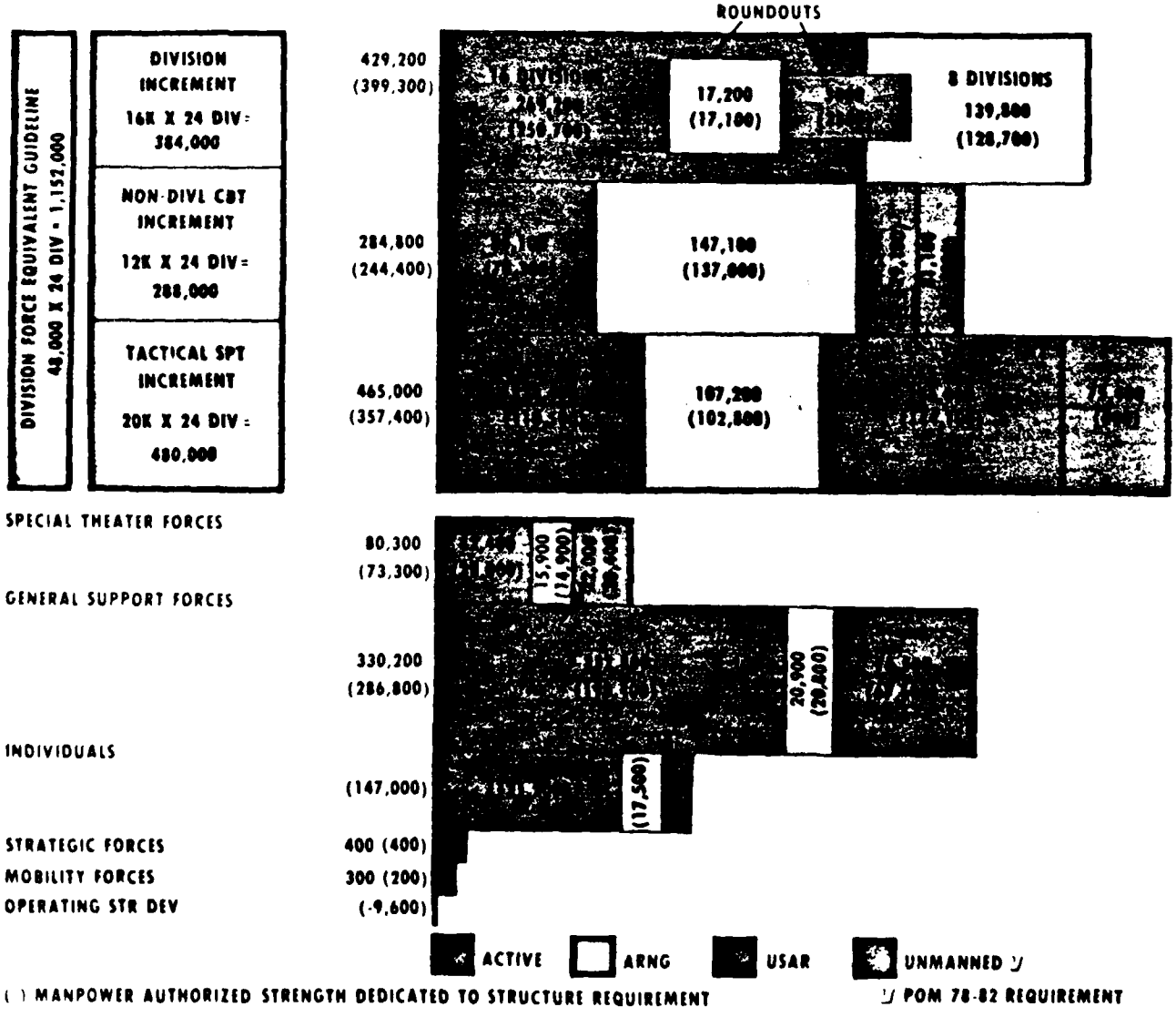
General

Late one afternoon, the phone rang in South Carolina's Office of Military Affairs. It was the National Guard Bureau from Washington on the line with the word that it was time — the National Guard was being activated. South Carolina's Adjutant General alerted the State Area Command (STARC) and mobilization plans were placed into action. The units being called to active duty followed previously established mobilization procedures that included alert, mobilization at home station, preparation for movement to mobilization stations where active duty operational control would be established, and preparation for movement to ports of embarkation for eventual deployment to the designated war zone.[2]

This portrayed scenario would be one repeated many times throughout the United States in the event of an actual call-up of Reserve and National Guard units in a national emergency. While our citizen-soldier concept is certainly not new to the nation, the 1973 introduction of the total-force concept has fostered a much greater dependence on the Reserve Components than we have ever faced in the past.[3]

One needs only to superficially examine our total force structure to discover exactly the important part that Reserve and National Guard units play in the current total-force policy. In the 1979 Army Greenbook, Major General William Berkman, Chief of the Army Reserve graphically pointed out their significance to the Army (See Figure 1 for updated data for FY82). The bottom line of a quick inspection of the figure is that the Army cannot perform its wartime mission without the complete and proper integration into the active force of its Reserve Components.

FIGURE 1 TOTAL ARMY WARTIME STRUCTURE FY 82 [4]



Today we find that the National Guard provides 46 percent of the Army's combat units. When one considers the 24 divisions that comprise the total Army, one discovers that seven of them are Active divisions; eight are National Guard divisions; and nine are composed of Reserve, National Guard and Active units. In otherwords, 71 percent of the total Army's divisions are either National Guard or require a roundout of Reserve Component units to enable them to go to war.[5]

The very magnitude of our reliance on these forces requires that a smooth and orderly transition from a peacetime to a wartime posture occurs for our Reserve and National Guard units. The turbulence and confusion that will exist during mobilization must be held to a minimum so that Reserve Component units can be rapidly integrated into the active Army and deployed to the war zone. The use of sound planning and sound management practices will be the only way that Reserve or National Guard commanders will be able to cope and insure their units are effectively and efficiently brought onto active duty.

Purpose

The general purpose of this paper is to examine the use of PERT (Program Review Evaluation Technique) as a possible management tool that could be used by Reserve Component commanders to assist them in their mobilization tasks. More specifically, however, this paper will:

- examine what PERT is and its evolvement as a contemporary management technique;
- examine its potential as a management tool to be used by a Reserve Component commander in transitioning his unit at home station from a peacetime to a wartime status;
- discuss the advantages associated with using this

management technique;

- determine any problems or pitfalls associated with its use as a management tool;
- analyze the tasks that might be accomplished at a reserve unit's home station and develop a sample PERT network to demonstrate the process.

CHAPTER 2

THE PERT APPROACH

General

In the late 1950's and early 1960's, the United States government and American industry discovered that conventional management techniques pioneered by men such as Henri Fayol were being overwhelmed by the complexities and uncertainties introduced by the technological revolution. To meet the challenges in the managerial areas of planning and controlling, new techniques were sought to ease the burden imposed on management by the complex development programs in which they had become involved. One such technique developed to assist contemporary management in dealing with the problems facing them was PERT.

Definition

While many people may be familiar with and understand PERT, I would like to offer a definition of the technique that will be used throughout this paper. Rue and Byars, in their book, Management: Theory and Application, have defined PERT as "A planning and control technique that graphically depicts the relationships between various activities that compose a project. PERT is used when the durations of the project activities are not accurately known."[6]

We find that PERT employs the networking technique as its analytical device. Use of this technique permits a graphical representation of

what is required to complete a project. This pictorial depiction of what is to be accomplished and the sequence in which it is to be accomplished enables a project manager or unit commander:

> . . . to evaluate progress toward the attainment of project goals, focus attention on potential and actual problems in projects, provide management with frequent, accurate status reports, predict likelihood of reaching project objectives, and determine the shortest time in which a project can be completed.[7]

Background

The requirement to plan and schedule thousands of individual and separate work activities in order to complete large-scale projects forged the basis for development of network analysis. Two closely associated techniques were developed almost simultaneously yet independently in the late 1950's to assist in the planning and controlling of massive projects. These two methods of network analysis were the Critical Path Method (CPM) and PERT.[8]

CPM was developed as a result of a joint study between E. I. Dupont Company and Remington Rand Univac on how to best schedule plant construction, maintenance and overhaul. Basically, CPM is the civilian counterpart of PERT. PERT resulted from the requirement to coordinate the development, scheduling and production of the Polaris missile system and was developed by the Navy in conjunction with Lockheed Aircraft Corporation and the management consulting firm of Booze, Allen and Hamilton.[9]

While there are distinctions between CPM and PERT, these two techniques over the years have borrowed from each other to the point that their differences, for all practical purposes, are purely academic. What is important, however, is that the planner has available to him a

management tool that assists him in a disciplined manner to develop and connect the sequence of interrelated events that will carry a project through to completion.[10] In this paper, no distinction will be drawn between CPM and PERT in order to simplify the discussion.

As was indicated earlier, the complex project that was responsible for the development of PERT was The Polaris Missle System Progam initiated by the Navy in 1957. In this program hundreds of millions of dollars, over three thousand different yet interrelated activities and hundreds of contractors were involved in the planning, developing and manufacturing of this weapon system. The success experienced by the Polaris program demonstrated PERT's value to industry and the United States government.[11]

Another success story for the use of PERT was the Apollo project that landed the first men on the moon. NASA used the PERT system at every stage of planning and development of the program. The magnitude of the control and coordination of the project was mind-boggling since over 20,000 firms worked on the project, 150,000 engineers and scientists were employed and 100,000 separate operations required planning and coordination.[12]

Probably the most complete use of PERT occurred on the development of the C-141 cargo plane. Lockheed used the networking techniques employed in PERT from program initiation through the deployment of the first operational squadron. This application of PERT to the planning and controlling functions of the C-141 program proved to be extremely successful.[13]

These projects are only three examples that demonstrate that the use of the PERT system has contributed significantly as well as successfully to the planning and controlling of very large, very complex

projects. Without PERT there is some question as to how successful they would have been since their size and complexity would have overwhelmed conventional management techniques.

While the size and complexity of the problem of mobilizing a Reserve Component battalion does not approach that faced by the Navy or Lockheed, the managerial technique of using PERT to plan and control the process offers an attractive proposition to the unit commander. Here is a proven process that may materially assist a commander in solving the mobilization problem of company-size units spread out over many miles that are all attempting to accomplish the same objective.

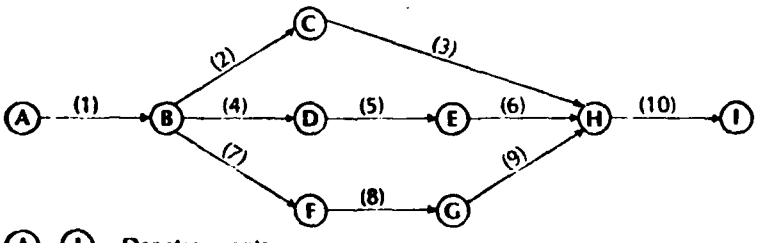
CHAPTER 3

THE ESSENCE OF PERT

If PERT is to be used by a unit commander as a management technique, it is important for him to understand the tools used to portray the PERT network. To develop in the commander an understanding of the process involved, I have elected to use a fictional illustrative example from the space industry.

PERT's main strength lies in the planning and controlling of one-time complex projects that have a great deal of uncertainty associated with the estimation of the time required to complete the project. Figure 2 is a small sample network that pictorially depicts the basic design for a fictional project of construction of a space-landing vehicle. In actuality this project's pictorial depiction would consist of a much more complicated and detailed network than that shown. However, for our purposes of examining what PERT is and what goes into constructing a PERT network, this simplified network will serve adequately.

FIGURE 2 Basic PERT Network for Space-landing Vehicle Project [14]



As can be seen from examining the sample network, its two basic components are events and activities. In the example, events are represented by lettered circles and are defined as either the start or completion of a specific task. For this reason an event is a specific point in time and does not have an elapsed time associated with it. In order for an event to be completed, all activities that lead to that event must be accomplished.[15] Figure 3 tabulates all the various events that fictional project manager has listed as starting or ending tasks to be accomplished in construction of the space-landing vehicle.

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FIGURE 3 EVENTS FOR SPACE-LANDING VEHICLE PROJECT

A. Receive Specifications
B. Begin Project
C. Begin Recruiting
D. Begin Power System Construction
E. Begin Power System Test
F. Begin Frame Construction
G. Begin Frame Test
H. Assemble Frame and Power System
I. Deliver Vehicle

The second basic component of our project network is an activity. The activity is represented by an arrow and is defined as the work required to accomplish a given event. Elapsed time is associated with an activity, and it is expressed as a standard measurement of time (days, weeks, months, etc.). One thing that must be made clear is that an activity usually cannot commence until all preceeding activities that lead to the identified activity have been completed.[17] Figure 4 lists the activities or work identified as required to complete the sample project.

FIGURE 4 Activity Time Estimates [18]

Activities	Optimistic (a)	Most Likely (m)	Pessimistic (c)	Activity Time Estimate (t_e)
1. Approve Specifications	2	2.5	6	3
2. Develop Recruiting Plans	1	3	5	3
3. Hire Work Force	3	4.5	9	5
4. Design Power System	4	5.5	10	6
5. Build Power System	8	11	14	11
6. Test Power System	4	6	8	6
7. Design Frame	3	4.5	9	5
8. Build Frame	9	9.5	13	10
9. Test Frame	1	3	5	3
10. Assemble and Test Vehicle	4	6	8	6

It is the responsibility of the PERT planner to gather time estimates on how long it will take to do the various activities determined as necessary to complete the project. More than likely these will be assembled from the engineers, contractors, and line managers who are responsible for accomplishing the actual work.[19] As can be seen from Figure 4, three time estimates are obtained from these personnel: the pessimistic time estimate, optimistic time estimate, and most likely time estimate. The pessimistic time is the longest time that would be required if things go wrong. The optimistic time is the shortest possible time that would be required if no problems are encountered. The most likely time is the normal time that would be required to complete the activity.[20]

In order to obtain the expected time of occurrence which is a weighted time estimate for the activity, the following formula is used:

$$t_e = \frac{a + 4m + b}{6}$$

The derivation of this formula is predicated on the assumption that the

actual performance times follow a theoretical probability distribution known as the beta distribution. The outer boundaries for this distribution of activity times are the most pessimistic time estimate and the most optimistic time estimate. The expected occurrence time (t_e) is determined by assuming that the beta distribution adequately represents this distribution of actual performance time. Additionally, this distribution of actual performance time has a standard deviation of 1/6 of its range.[21] Figure 5 graphically portrays the theoretical distribution of the actual performance times and shows that they are bounded by the most optimistic time and the most pessimistic time.

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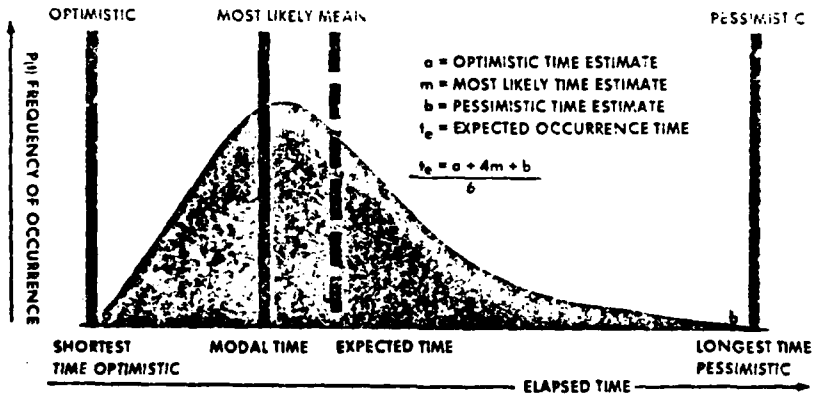
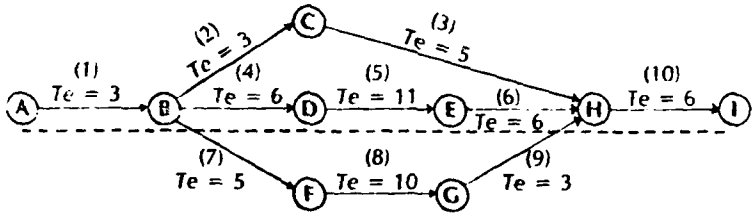
FIGURE 5 Beta Distribution

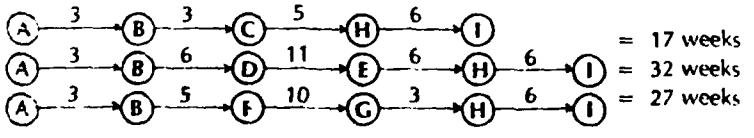


The next step that a commander/project director will undertake is to determine the critical path for the project network. The identification of the critical path is most beneficial to the commander/project director since it provides him with some powerful tools to assist him in the management process. The longest path in the network is the critical path. Once this is determined, and assuming that our time estimates are accurate, the commander/manager can see graphically the critical control points that must be managed closely in order to keep a project on track timewise. This gives the unit commander an invaluable tool in his task of management by exception.[23] Figure 6 demonstrates the determination of the critical path for our fictional project.

FIGURE 6 PERT Network for Space-landing Vehicle Project Showing Estimated Activity Times and Critical Path [24]

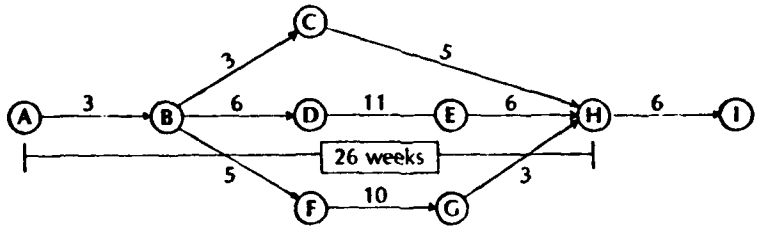


Path Times ------ Critical Path



On the critical path there is no slack time or leeway since this is the shortest time in which the project can be completed given the resources allocated. However, on the other paths of our project we will find that there is slack time available. This knowledge is essential for the commander/manager since it identifies where resources are available for diversion to the critical path should the need arise to keep the project on course from a time point of view. These are only potential sources for diversion to other areas of the project since the skills and expertise of the soldiers/workers and materials available may not be compatible to what is required in the activity experiencing difficulty. However, if a commander is forearmed with such knowledge, he can rapidly make the necessary decisions to reallocate resources and manpower to keep the project on track.[25] Figure 7 demonstrates how slack time is determined for our fictional project.

FIGURE 7 Slack Time Computation for Space-landing Vehicle Project [26]



Event C: Latest Allowable Time, 26 - 5 = 21 weeks
Earliest Possible Time, 3 + 3 = 6 weeks
Event G: Latest Allowable Time, 26 - 3 = 23 weeks
Earliest Possible Time, 3 + 5 + 10 = 18 weeks
Event F: Latest Allowable Time, 26 - 3 -10 = 13 weeks
Earliest Possible Time, 3 + 5 = 8 weeks

To this point the fictional project that we have been dealing with has been overly simplified in order for this paper to deal with the basics of PERT. The projects that overwhelmed conventional management practices were not simple but were of a very complex nature involving literally thousands of activities and hundreds of separate contractors. All these require interfacing in order to complete the projects. The application of PERT to computer processing routines has enabled project managers and military commanders to interface the multitude of activities that confront them and provide them a means of rapidly revising the schedules should the need arise. In essence computerization provided managers a mechanism to assist them in planning and controlling very complex projects.[27] However, the use of computers is not essential for good commanders/managers to use the techniques discussed in managing the tasks a unit might be required to perform.

CHAPTER 4

PERT APPLICATION TO MOBILIZATION TASKS

General

The mobilization requirements phasing for a Reserve Component unit can be roughly divided into three broad phases. Phase I is composed of those tasks that a unit must accomplish at home station prior to movement to its designated mobilization station. Phase II consists of those tasks that must be accomplished before a unit commences movement to the port of embarkation for deployment to the war zone. Phase III tasks are those that a unit must complete prior to being ordered to perform its primary mission in the combat zone. For each Reserve Component unit these tasks will differ and could conceiveably be moved from one phase to another depending on the unit's capability and status during mobilization.[28]

The complexity of attempting to analyze all the tasks that a Reserve Component unit might be required to perform from the time of its initial alert until it is required to perform its primary mission in combat goes far beyond the scope of this paper. However, I do propose to analyze those tasks a unit might be required to complete at home station and to develop a sample PERT network to demonstrate the feasibility and utility of using this contemporary management technique.

As was demonstrated in the last chapter, the analysis of the

activities to be performed is critical to success. This analysis will determine all the tasks that a unit must perform during the various stages/phases of the mobilization process so that the mobilization will progress smoothly. Once the required tasks have been identified, we can determine the events (start or completion of a task) and the time required to accomplish the various tasks necessary to insure the unit is fully prepared to move to the next phase of the mobilization process. As was stressed early, it is critical that we correctly and completely identify all the tasks to be performed so that we can properly develop our PERT network. Herein lies the key to success and where a commander should spend the majority of his time if he desires to properly use this management technique.

Task Identification

My discussions with Brigadier General Sajer, USAR, identified a problem area that needs to be addressed at higher headquarters in order to assist a Reserve Component battalion transition from a peacetime organization to a mobilized operational unit. This problem is that there needs to be more definitive guidance issued to battalion commanders as to exactly what is to be accomplished during the various phases of the mobilization process.[29] However, even though such guidance may be lacking, a Reserve Component battalion commander in conjunction with his staff can develop a listing of the tasks/activities that the unit must accomplish during its mobilization. I would suggest that the commander should develop this list based on a close examination of the functional areas that his staff is responsible for — Personnel, Intelligence, Operations and Training, and Logistics. Once this has been completed, the commander can then determine exactly which phase of

the mobilization process would most appropriately and efficiently accommodate the activity. Sequencing the accomplishment of those tasks in his PERT network for mobilization becomes a simple matter once the activities have been identified.

As was stated earlier, this identification of the tasks to be done is perhaps the most important part of planning the mobilization of the battalion. If the mobilization of a unit is to proceed in a smooth and uninterrupted manner, it is this job that must be done well by a commander and his staff. Based upon my own personal experience as a battalion commander and the work contained in Fort Carson and 4th Infantry Division Regulation 220-10 (Deployment Operations), I have attempted to identify typical tasks that a Reserve Component unit could best accomplish at home station during what has been identified as Phase I of the mobilization process. A warning must be issued here to the reader that by no means should this list be taken as being all inclusive since each Reserve Component battalion will have different capabilities and/or limitations depending upon its location, status, and mobilization priority. However, it does serve to show the thought process necessary to develop a listing of the tasks a unit must accomplish and could well be used as the starting point for any commander who elected to use the PERT techniques to plan and control the mobilization of his unit.

The list of tasks that I have developed are organized by functional area to demonstrate the importance of examining what must be accomplished in a logical manner as well as getting one's staff to participate in the process. These typical activities are shown in Figure 8.

FIGURE 8 ACTIVITIES FOR PHASE I (MOBILIZATION)

Functional Area	Activity
Personnel	1. Alert Notification. 2. Execution of Wills. 3. Execution of Power of Attorney. 4. Resolution of Civil Litigation. 5. Immunizations. 6. Medical Examinations. 7. Dental Examinations. 8. Issue of Individual Medical Supplies. 9. Inventory of Individual Equipment. 10. Establishment of Financial Support. 11. Updating Pinpoint Distribution Account. 12. Cross-leveling of Critical Personnel Skills. 13. Disposition of Unit Records and Files. 14. Disposition of Unit Historical Property. 15. Family Member Counselling and Assistance. 16. Disposition of Unit Personnel Personal Property. 17. Requisition of Unit Personnel Shortages.
Intelligence	18. Update Security Clearances. 19. Review of Security Procedures with Unit Personnel. 20. Establishment of Physical Security of Unit Installation(s). 21. Inventory and Reordering of Basic Load of Maps. 22. Threat Briefing for Unit Personnel. 23. Briefing of Personnel on Essential Elements of Friendly Information (EEFI).
Operations and Training	24. Conduct of Individual Refresher Training. 25. Weapons Familiarization/ Qualification. 26. Unit NBC Refresher Training. 27. Preparation of Equipment for Movement Refresher Training. 28. Loading of Equipment Refresher

Training.
29. Update Unit Load Plans.
30. Review of Unit SOP's.
31. Operational Security Training.
32. Status of Forces Briefing.
33. Activate Emergency Operation Center/Home Station.
34. Key Personnel Assemble at Home Station.
35. Update Training Estimate for Mobilization Station.
36. Move to Mobilization Station.

Logistics

37. Maintenance of Individual Equipment.
38. Maintenance of Individual and Crew-Served Weapons.
39. Maintenance of Section Equipment.
40. Requisition of Individual Equipment Shortages.
41. Requisition of Unit Equipment Shortages.
42. Establishment of Unit Messing Capability.
43. Establishment of Unit Billeting Capability.
44. Procurement of Unit Movement Material.
45. Coordination of Unit Maintenance Requirements.
46. Dispatch of Quartering and Advance Parties to the Mobilization Station.
47. Coordinaion of Unit Transportation Requirements.
48. Conduct Inventories of Section Equipment.
49. Issue Section Equipment.
50. Prepare Vehicles for Movement.
51. Obtain Convoy Clearances for Movement.

As you can readily see from a cursory examination of the activities listed in Figure 8, these actions are by no means all inclusive. However, they do provide a flavor of the type tasks a mobilizing unit must perform. By careful consideration of the functional areas the staff supervises, any commander can develop a detailed list of what needs to be done by his unit. Once the unit has developed this list, it can easily complete a list of events that are necessary to accurately

portray the activities list. It is important at this stage for the PERT planner to remember that an event is a specific point in time and does not have an elapsed time associated with it. In otherwords, an event is either the start or completion of a specific task or activity. Figure 9 depicts the events for the activities we have determined to be essential and have displayed in Figure 8.

FIGURE 9 EVENTS FOR PHASE I (MOBILIZATION)

Functional Area	Activity
Personnel	A. Initiate Alert Notification. B. Complete Alert Notification/ Assembly. C. Determine Personal Wills Requirements. D. Complete Preparation of Wills. E. Determine Power of Attorney Requirements. F. Complete Preparation of Powers of Attorney. G. Determine Personnel Involved in Civil Litigation. H. Complete Actions to Fulfill Responsiblities in Civil Litigation. I. Initiate Immunizations. J. Complete Immunizations. K. Initiate Medical Exams. L. Complete Medical Exams. M. Initiate Dental Exams. N. Complete Dental Exams. O. Begin Issue of Individual Medical Supplies. P. Complete Issue of Individual Medical Supplies. Q. Begin Inventory of Personal Equipment. R. Complete Inventory of Personal Equipment. S. Begin Financial Support Processing. T. Complete Financial Support Processing. U. Review Pinpoint Distribution Account. V. Update Pinpoint Distribution

	Account. W. Determine Requirement for Cross-leveling of Personnel. X. Complete Cross-leveling of Personnel. Y. Review Disposition of Unit Records and Files. Z. Complete Disposition of Unit Records and Files. A1. Begin Disposition of Unit Historical Property. B1. Complete Disposition of Unit Historical Property. C1. Begin Family Member Counselling and Assistance. D1. Complete Family Member Counselling and Assistance. E1. Begin Disposition of Unit Personnel Personal Property. F1. Complete Disposition of Unit Personnel Personal Property. G1. Determine Unit Personnel Shortages. H1. Requisition Unit Personnel Shortages.
Intelligence	I1. Initiate Update of Security Clearances. J1. Complete Update of Security Clearances. K1. Initiate Security Procedures Instruction. L1. Complete Instruction on Security Procedures. M1. Establish Physical Security of Facilities at Home Station. N1. Terminate Physical Security of Facilities. O1. Initiate Inventory of Maps. P1. Complete Inventory and Reorder Maps. Q1. Initiate Threat Briefing. R1. Complete Threat Briefing. S1. Initiate EEFI Briefing. T1. Complete EEFI Briefing.
Operations and Training	U1. Initiate Individual Refresher V1. Complete Individual Refresher Training. W1. Initiate Weapons Familiarization/ Qualiflication. X1. Complete Weapons Familiarization/ Qualification. Y1. Initiate Unit NBC Training. Z1. Complete Unit NBC Training.

A2. Commence Preparation of Equipment for Movement Training.
B2. Complete Preparation of Equipment for Movement Training.
C2. Begin Equipment Loading Refresher Training.
D2. Complete Equipment Loading Refresher Training.
E2. Initiate Update of Unit Load Plans.
F2. Complete Update of Unit Load Plans.
G2. Initiate Review of Unit SOP's.
H2. Complete Review of Unit SOP's.
I2. Initiate OPSEC Training.
J2. Complete OPSEC Training.
K2. Initiate Status of Forces Briefing.
L2. Complete Status of Forces Briefing.
M2. Activate EOC/Home Station.
N2. Close EOC/Home Station.
O2. Alert Key Personnel.
P2. Assemble Key Personnel.
Q2. Review Training Status of Unit.
R2. Update Training Status of Unit for Mobilization Station.
S2. Begin Movement to Mob Station.
T2. Complete Movement to Mob Station.

Logistics

U2. Begin Maintenance of Individual Equipment.
V2. Complete Maintenance of Individual Equipment.
W2. Begin Maintenance of Weapons.
X2. Complete Maintenance of Weapons.
Y2. Begin Maintenance of Section Equipment.
Z2. Complete Maintenance of Section Equipment.
A3. Identify Individual Equipment Shortages.
B3. Requisition Individual Equipment Shortages.
C3. Identify Unit Equipment Shortages.
D3. Requisition Unit Equipment Shortages.
E3. Activate Unit Messing Capability.
F3. Terminate Unit Messing Capability.
G3. Activate Unit billeting

Facilities.
H3. Terminate Unit billting Facilities.
I3. Identify Unit Movement Material.
J3. Procure Unit Movement Material.
K3. Identify Unit Maintenance Requirements.
L3. Coordinate Unit Maintenance Requirements.
M3. Dispatch Quartering and Advance Parties to Mob Station.
N3. Arrival at Mob Station of Quartering and Advance Parties.
O3. Determine Unit Transportation Requirements.
P3. Requisition Unit Transportation Needs.
Q3. Commence Inventory of Section Equipment.
R3. Complete Inventory of Section Equipment.
S3. Begin Issue of Section Equipment.
T3. Complete Issue of Section Equipment.
U3. Begin Preparation of Vehicles for Movement.
V3. Complete Preparation of Vehiches for Movement.
W3. Initiate Request for Convoy Clearance.
X3. Obtain Convoy Clearance.

The next step in compiling the data needed to construct our PERT Network for the Phase I mobilization process for our unit is to gather the time estimates required to complete each activity. These estimates would be solicited from the section sergeants and staff officers responsible for managing completion of the various tasks. Estimates would be obtained in the manner described in Chapter 3 of this paper. Listed in Figure 10 are typical expected occurrence times (t_e) for each activity described in Figure 8.

FIGURE 10 ACTIVITY TIME ESTIMATES

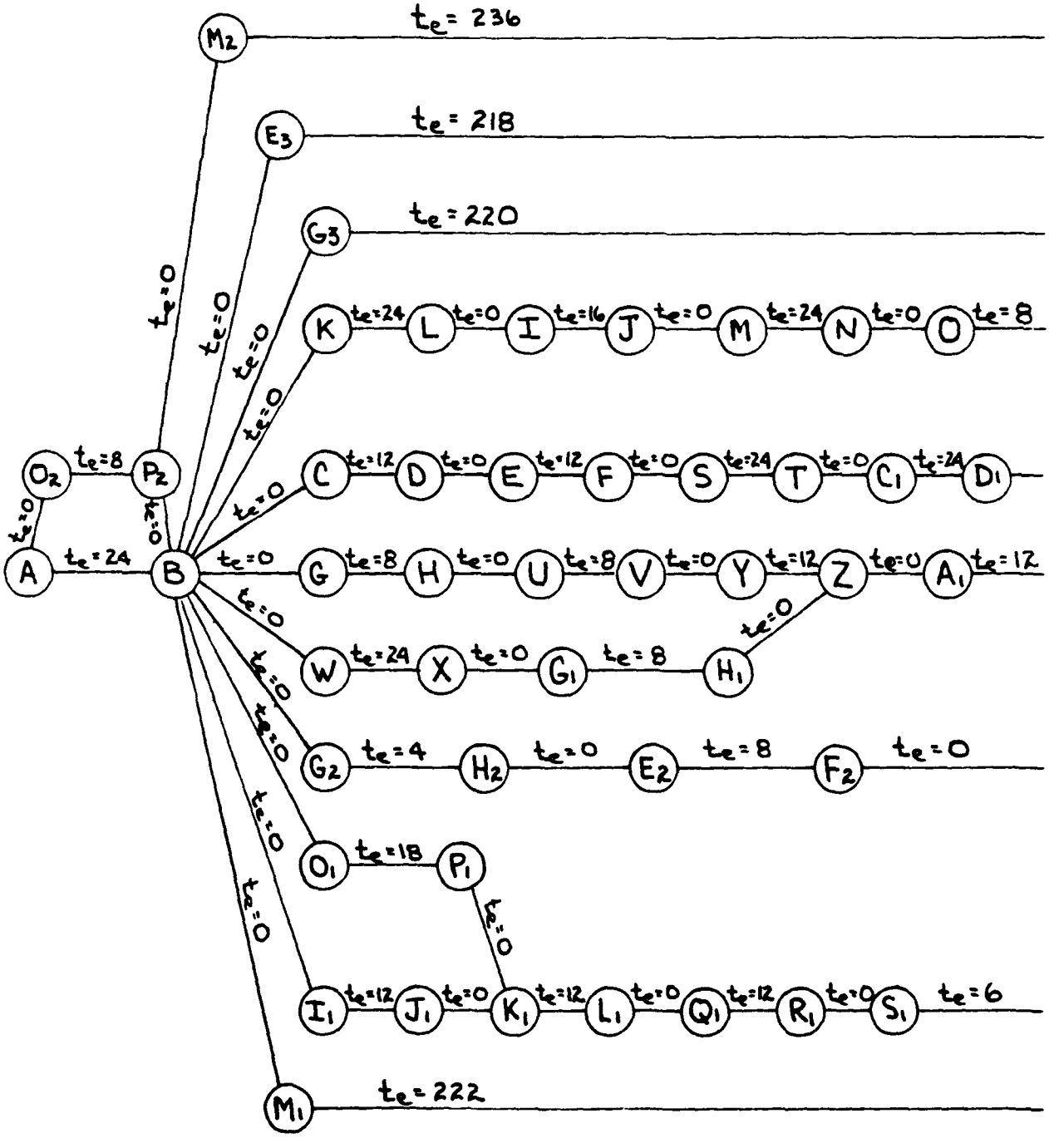
Activity	Time Estimate (t_e) (hours)
1	24
2	12
3	12
4	8
5	16
6	24
7	24
8	8
9	12
10	24
11	8
12	24
13	12
14	12
15	24
16	18
17	8
18	12
19	12
20	222
21	18
22	12
23	6
24	48
25	24
26	8
27	8
28	6
29	8
30	4
31	12
32	6
33	236
34	8
35	8
36	6
37	8
38	8
39	18
40	8
41	8
42	218
43	220
44	24
45	12
46	4
47	12
48	12
49	4
50	36
51	8

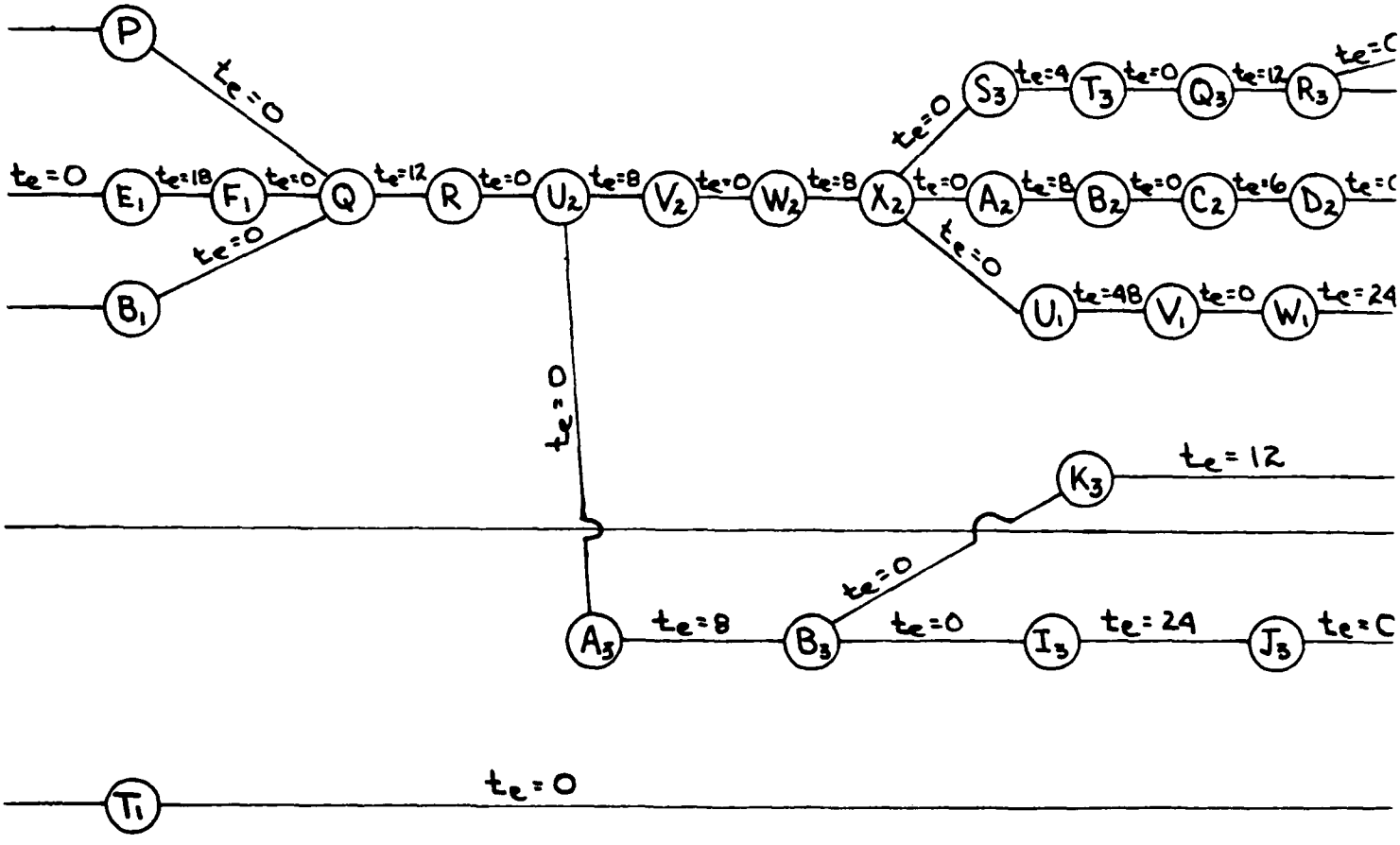
At this point the commander has collected all the data necessary for him to construct his PERT Network to pictorially depict his Phase I of the mobilization process. Figure 11 is an example of one way to interrelate all the actions a unit must accomplish in order to prepare itself at home station for departure for its mobilization station. One will notice that there are activities that are interrelated but have no time expenditure required to complete the relationship between the two events. These events are connected with a dummy activity (an activity whose expected occurrence time t_e is zero).

Once the commander has graphically portrayed his plan by way of the PERT network, he would make a forward pass through the system to determine the critical path of the network (the path that permits the completion of the project in the shortest time possible given current resources). This is the path that the commander must manage closely if he is to successfully mobilize his unit in the shortest time possible. In our unit the critical path requires 254 hours to mobilize the battalion at home station, and the critical path is described by Events A-B-C-D-E-F-S-T-C1-D1-E1-F1-Q-R-U2-V2-W2-X2-U1-V1-W1-X1-Y1-Z1-I2-J2-K2-L2-Q2-R2-S2-T2.

The commander now has at his fingertips a graphical portrayal of what his unit must accomplish in order to complete its transition from a peacetime reserve unit to a fully operational unit during Phase I of the mobilization process. The PERT network has provided the commander an extremely valuable management tool to use to plan and control his unit during mobilization.

FIGURE 11 PERT NETWORK, PHASE I (MOBILIZATION)

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E1
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F1
te=0
Q
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R
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U2
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V2
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W2
te=8
X2
te=0
A2
te=8
B2
te=0
C2
te=6
D2
te=0
B1
te=0
te=0
S3
te=4
T3
te=0
Q3
te=12
R3
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te=0
U1
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V1
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W1
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te=0
K3
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A3
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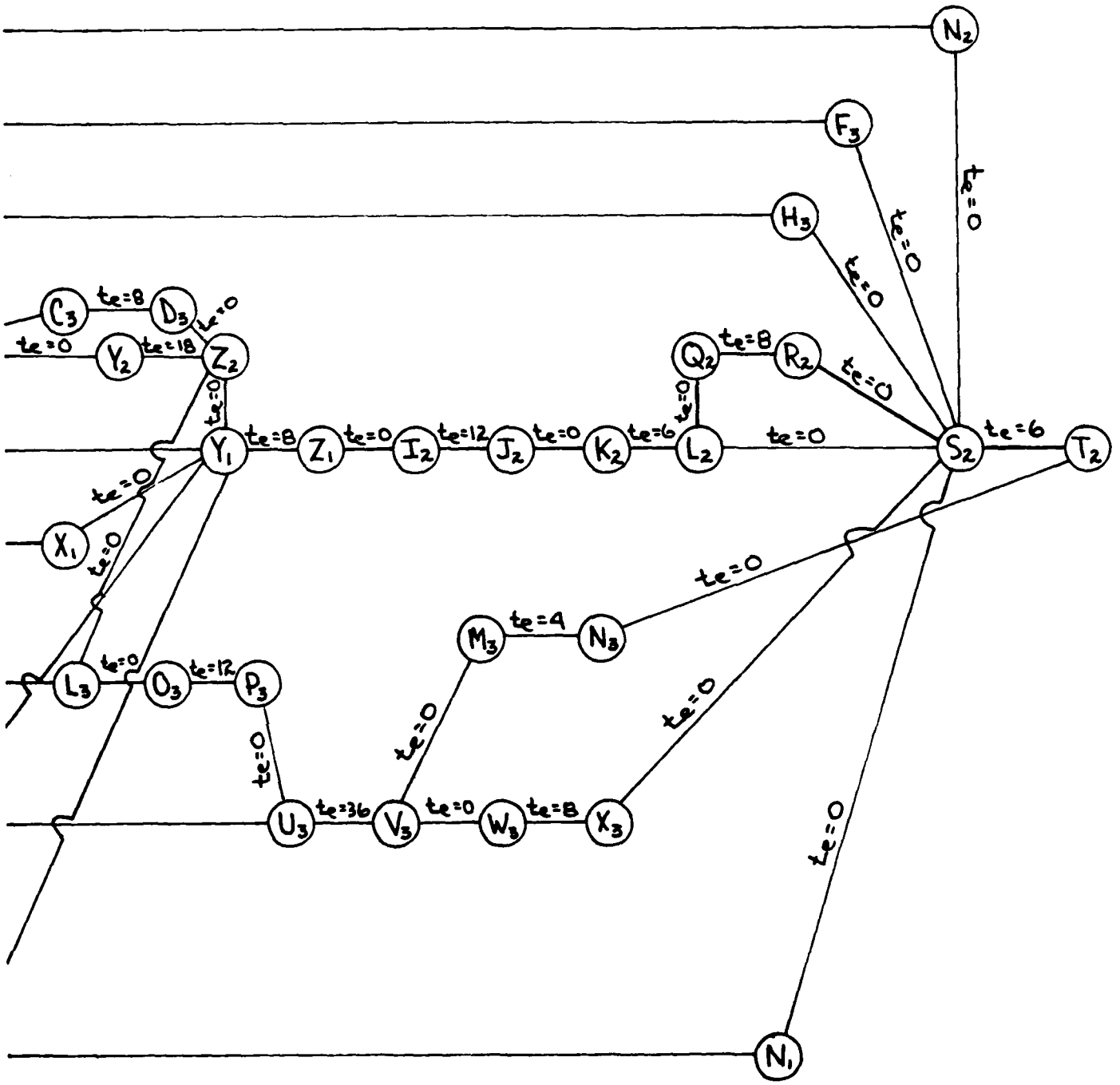
B3
te=0
I3
te=24
J3
te=0
T1
te=0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F3
H3
te=0
te=0
te=0
C3
te=8
D3
te=0
te=0
Y2
te=18
Z2
te=0
Q2
te=8
R2
te=0
te=0
Y1
te=8
Z1
te=0
I2
te=12
J2
te=0
K2
te=6
L2
te=0
S2
te=6
T2
te=0
te=0
X1
te=0
te=0
M3
te=4
N3
L3
te=0
O3
te=12
P3
te=0
te=0
te=0
U3
te=36
V3
te=0
W3
te=8
X3
te=0
N1

CHAPTER 5

BENEFITS AND PITFALLS

Value to Management

PERT is an invaluable tool when used for nonrepetitive, nonroutine projects such as research and development projects.[30] Furthermore, there is little doubt that it is an improvement in management techniques that is ideally suited for use by managers or commanders in the uncertain environment. Its application to management decision problems enables those responsible in the organization to plan, control and direct operations as well as assist them in the alloction and reallocation of resources.[31]

The development of a PERT network provides a pictorial representation of all the activities required to complete a project. This graphical portrayal enables a project manager/commander to measure exactly all accomplishments to date against the agreed upon planning and objectives schedule. Should the project be falling behind or exceeding the program goals, a commander would then be able to quickly adjust goals or reschedule activities to compensate for what is occurring in the project. The PERT network also provides an excellent tool by which management is able to periodically review and evaluate its plans.[32]

Another value PERT has for management is that it fixes responsibility for the various phases and activities of a project. This

valuable aspect enables the top levels of management to be knowledgeable as to the exact division of effort in the organization. Additionally it enables them to contact the personnel responsible for the various areas of a project should difficulties develop and assists them to evaluate their subordinates' performance in the activities under their control. The use of PERT in project control goes a long way toward insuring a high degree of continuity in project effort even though the organization may undergo personnel turbulence and turnover.[33]

From the initiation of a project, PERT will aid a commander in the avoidance of omitting important or vital tasks. This is possible since PERT provides a logical and disciplined approach to viewing a program in its entirety. Moreover, it provides a vehicle by which the commander can determine potential problem areas in sufficient time for remedial action to be taken so that there is a minimal effect on the project. This remedial action can take the form of a tradeoff on manpower, performance, and time between critical and noncritical activities as means of redressing schedule performance.[34]

Also of excellent value is that PERT uses management by exception in the business of reporting progress to the top levels of management in the organization. Since our network is graphically depicted on charts, they are fully able to follow the progress being achieved on the project. The lower levels of management are then able to proceed with directing and controlling the day-to-day activities without being overburdened by progress reports. The only time the upper echelons of management need to become involved is when there is a problem that requires a reallocation of resources that must be made because of difficulties experienced at one phase of the project. This management by exception fosters a sense of well-being in the control aspect of a

project.[35]

For large, complex, one time projects, we find that PERT's use of a network system makes it possible to evaluate and forecast outcomes of the primary and alternate plans before implementaion through the use of computer simulation techniques. This provides management with a valuable tool in deciding just how to attack the problem at hand. Additionally, its use permits measuring the effect through computer simulation that proposed changes will have on the planned schedule, thus giving management the information it needs to make intelligent decisions.[36] While use of computers is not a requirement in developing our PERT network, their use can certainly facilitate the wargaming of our mobilization plans.

Advantages

Perhaps the greatest advantage of the use of PERT is that it imposes discipline in the preplanning stage of an operation. The commander and his staff are forced to thoroughly consider the various parts of a program and the effort required to achieve the overall results. The staff must examine the desired objectives and the interrelationship that exists between the various activities that must be accomplished in order to complete the project. This thorough preplanning goes a long way toward insuring that no critical tasks are overlooked. [37]

The use of PERT undoubtedly assists management in refining their thinking process about the project. It increases the awareness of the user of the PERT network to the problem areas that may be encountered and points out their relative importance when considering the overall operation. What might be considered a major stumbling block in one portion of the project when it is considered in relationship to the

other activities that are ongoing might become only a minor irritant that can easily be remedied.[38]

The generation of the PERT network provides an easy and effective means of communicating plans to subordinates. Laid out before the submanager is what he is required to accomplish and the milestones he is required to meet in order to keep the project on track. Since he more than likely has had input to the design of the project, he may well feel more responsible to insure his milestones are met which will assist in keeping the project on schedule. Additionally, he has before him, in the form of the PERT network, visible proof that a planning job has been accomplished for the project.[39]

Trouble spots are identified, often in advance, which enables management to focus its attention in these areas rather than on operations that are progressing without difficulty. This ability to manage by exception insures that the upper echelons of management can concentrate their efforts where they are needed and not become involved in areas that do not require attention. Progress reporting from lower levels of management can proceed without undue concern that their activities will be meddled with unless a problem area develops.[40]

Finally, it provides a vehicle by which the upper echelons of management are able to assess progress of the project and forecast any problems that may arise in the project's ability to meet its planned schedule. The visual display of the PERT network enables management to shade in those portions of the project that have been completed and have an accurate status report of progress readily available so that resource programming or reprogramming decisions can be made as needed.[41]

There is a psychological value to the use of PERT networks for

project control that goes beyond the fact that plans, charts and schedules contribute to a more efficient way of running an operation. Subordinates have been given the goal that they are expected to achieve. Once the standard has been established in terms of a time schedule for completion of an activity, one may well find that the workers will attempt to beat the standard and bring the activity to completion prior to its scheduled time. This may well result in an overall time savings to the project as well as free up resources for employment elsewhere as trouble spots develop.[42]

Limitations

A significant problem with PERT is the difficulty in motivating an organization to do the detailed planning necessary to implement the control system. There is a natural resistance to the introduction of any new management technique in any organization. This resistance can appear at any level from upper echelon to the soldier assigned to a program. However, even if an organization has a relatively successful record in planning and controlling projects, there is ample evidence from the RAND and Harvard Studies on program performance that industry as a whole has major management problems in this area.[43]

Another limitation is the cost involved with introducing PERT as a management control system. PERT will cost more than conventional planning techniques because of the indepth planning that is required to establish the PERT network. It has been estimated that PERT will cost as much as twice that of conventional planning techniques.[44]

Perhaps the greatest limitation of PERT is the introduction of errors into the planning process. The most common error in PERT concerns the estimation of the time required to complete individual activi-

ties. Studies conducted by K. R. MacCrimmon and C. A. Rayavec discovered that activity time estimates were off in some cases by as much as 30 percent. Errors were attributed to three causes: (1) human error in estimating the optimistic, pessimistic and most likely times used to determine the expected time occurrence for the activity, (2) the assumption that the expected time will follow the beta distribution, (3) the assumption that one activity must be completed before a related activity later in the network can commence. In actual practice it was determined that it was possible to start later activities before completion of earlier related scheduled activities.[45]

CHAPTER 6

CONCLUSIONS

The development of PERT in the late 1950's was a major breakthrough in providing a valuable tool for planning and controlling large, complex projects for the contemporary manager. Its major strength lay in its value as a management technique for use in large-scale nonrepetitive projects such as research and development programs and construction of large industrial plant complexes.

PERT's use by management provided them a number of advantages that were difficult to achieve using conventional management techniques. These include:

- the imposition of a disciplined manner to approach the preplanning stage of an operation;
- increasing the awareness of management to problem areas that might crop up and pointing out their relative importance in the overall operation;
- the provision of an effective means of communication with subordinate managers;
- the identification of trouble spots beforehand so that management could reprogram resources as required;
- the use of management by exception to control the complex operations of the project; and

- the provision of a means by which upper management could assess the progress of the project and the performance of its submanagers.

PERT's main limitations revolves around the costs in time to introduce it as a management planning and control system and the errors that can occur in time estimations that will impact on the planning and scheduling processes of the project at hand.

Even though its limitations impact heavily on a Reserve Component commander, the benefits that can be derived by the thought processes and procedures used by a commander and his staff to determine his particular PERT network are worth the effort. A commander will readily have available to him a graphical picture by which he can manage the activities of his organization during what would appear to be turbulent and confusing period as his unit prepares to switch from a peacetime to an operational status. Without the use of such a management tool, a commander could well find his unit seriously deficient in its operational capability as it transitions. Since, the United States Army is so dependent upon its Reserve Component forces during a national emergency, all commanders must strive to insure mobilization goes as smoothly as possible. It is essential then that the Army uses all the good management techniques it has available to insure our forces will be ready when they are needed.

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