ARAB REPUBLIC OF EGYPT

THE INSTITUTE OF NATIONAL PLANNING

Memo No. 1456

PERT / CPM Techniques in Planning and Monitoring Some Agricultural Projects

By

Dr. Abdalla El-Daoushy

March 1988

CAIRO
SALAH SALEM St-NASR CTTY

Abstract :

This paper aims at providing the reader with the applications of Network Analysis Techniques to planning in general and to the Agricultural sector in particular.

It also aims to treat the lack of essential details (which are very useful details to trainees in agricultural planning) and not explored in the reference listed below .

It discusses how the process of project planning and management is performed in some agricultural projects and how PERT/CPM can be effectively used . This well be done through three case studies . These case studies are quoted (but modified here --- see later ---) from :

Maurizio Garzia ,
Project planning and monitoring using Network Analysis Techniques ,
Development policy studies and training services (ESPT) , 1982 .

The three case studies are :

1. Wailing lift irrigation projects ,

2. Terai-construction of a sawmill , and

3. Integrated area development programme .

While the first two case studies focus on the application of Network Analysis Techniques to specific sectoral projects , the third case study aims at illustrating how the same techniques could be applied to the planning of an integrated programme comprising several projects from different sectors .

The precedence relationships between the project activities were specified by using the approach named : *
An Activity-On-Arrow representation (or An Arrow Network) .

* The next paper will present a modified version named :

An Activity-On-Node representation (or A Node Network) .

Introduction :

In agricultural planning , the PROJECT may be defined as a major undertaking made up of many tasks or ACTIVITIES.

The activities are interrelated through PRECEDENCE relationships in a way such that certain activities cannot be STARTed until others are COMPLETEd. If activity A must precede activity B, we say that A is a Predecessor of B and B is a Successor of A . If no other activity comes so that B can start immediately upon COMPLETION of A , we use the term immediate Predecessor and so immediate Successor.

Network Analysis Techniques , specially the CPM (Critical Path Method) and the PERT (Program Evaluation and Review Technique) are very useful techniques for planning , scheduling , and controlling and evaluating the cost and time aspects of large complex projects. The construction of buildings or bridges , the development of new products or systems and many complex agricultural projects are typical applications of these techniques .

Usually , there are three factors influencing Project management decisions :

i, Time ,

ii, Available resources , and

iii, Cost .

i, If we have only one limited supply resource (named TIME) and sufficient other production resources (such as materials , equipment , personnel , . . . etc) available at any time to proceed with any activities whose Predecessors have all been completed , we may ask :

1. What is the Expected project COMPLETION time ?
2. What is the Scheduled START time and COMPLETION time for each activity ?
3. Which activities are CRITICAL , in the sense that if they are not completed on time , the entire project will be delayed ?
4. For each nonCRITICAL activity , how much SLACK or FLOAT time is there : i.e., how long can the activity be held up (or kept back) without delaying the project ?

The time duration of each activity may be assumed to be either precisely known (the deterministic case) or specified in terms of the following three estimates :

. An optimistic time (or shortest possible time) ,

. A pessimistic time (or longest possible time) , and

. A most likely time .

ii, Project Managers must also determine how many resources , such as People and equipment , are available for the project and how they should be allocated among the various activities . Improper management of resources can significantly delay many projects .

iii, The cost of the project must be controlled . Managers seek ways in which cost can be minimized . This is closely related to the allocation of resources through the project .

PERT was developed with an objective of being able to handle uncertainties in activity completion times .
On the other hand , CPM was developed for scheduling and controlling projects when the task or activity times were considered well known . However , CPM offered the option of reducing activity times by adding more workers and/or resources , usually at an increased cost . A distinguishing feature of the CPM was that it enabled time and cost tradeoffs for the various activities in the project .

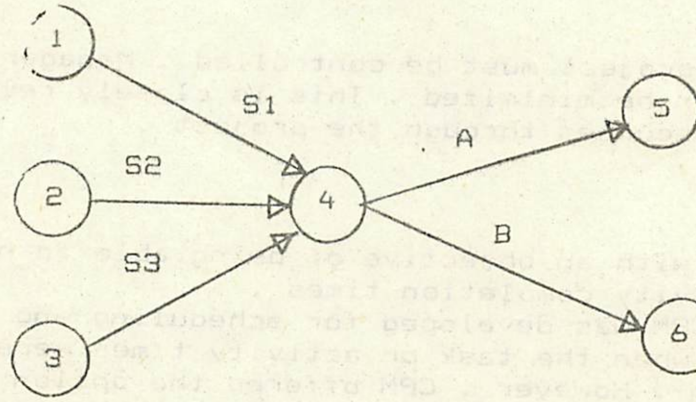
In today's usage , the distinction between PERT and CPM as two separate techniques have largely disappeared . Computerized versions of the PERT/CPM approach often contain options for considering uncertainty in activity times as well as activity time-cost tradeoffs .

Before starting the case studies , let us discuss the algorithm and solve at least one example :

The Activity-On-Arrow Approach :

With An Activity-On-Arrow approach , the project is drown as a network in which the arrows represent activities and the nodes are the events or time points at which the last of the incoming activities ends and the outgoing activities can begin . For example ,

If activities A and B can both begin only after all of three activities S1 , S2 , and S3 are complete , the Activity-On-Arrow (or the Arrow Network) can be represented as follows :



Node 4 represents the event that all of the activities S1 , S2 , and S3 have been completed ; and the activities A nd B can start .

The solution ALGORITHM :

1. In Case of Deterministic Activity Times :

The basic problem concerns of finding :

- The ES (Earliest Start) and EF (Earliest Finish) time possible for each activity ,
- The LS (Latest Start) and LF (Latest Finish) times for each activity that would not delay the project as a whole are also generated .
- The critical activities ,
- the slack times , and
- The minimum duration of the project .

2. In Case of Probabilistic Activity Times :

With probabilistic activity times , the mean and variance for each activity are obtained as follows :

If :

a_i : represents the estimate of the optimistic duration of activity i ,

m_i : represents the estimate of the most likely duration of activity i , and

b_i : represents the estimate of the pessimistic duration of activity i .

then , the mean (t_i) and the standard deviation (d_i) are computed as follows :

$$t_i = \frac{a_i + 4\,m_i + b_i}{6}$$

&

$$d_i = (b_i - a_i) \;/\; 3.2$$

Hint :

This is a technical issue involving the precise probabilistic meaning of a " pessimistic " or " optimistic " estimate , and it is also an attempt to compensate in part for a tendency of the algorithm to underestimate the variance of the project duration .

The probabilistic critical path calculation is now performed using the mean time for each activity , and the project mean and variance are estimated as the sums of means and variances of critical activities .

Project duration is assumed to be normally distributed with these parameters .

Sample Problem 1 :

The following table represents the activities , with their required precedence and the estimated times (in weeks) that each activity will take , of one project (each of these activities is itself a more or less complex project , but as a first pass -- management wishes to evaluate the undertaking without further refinement) .

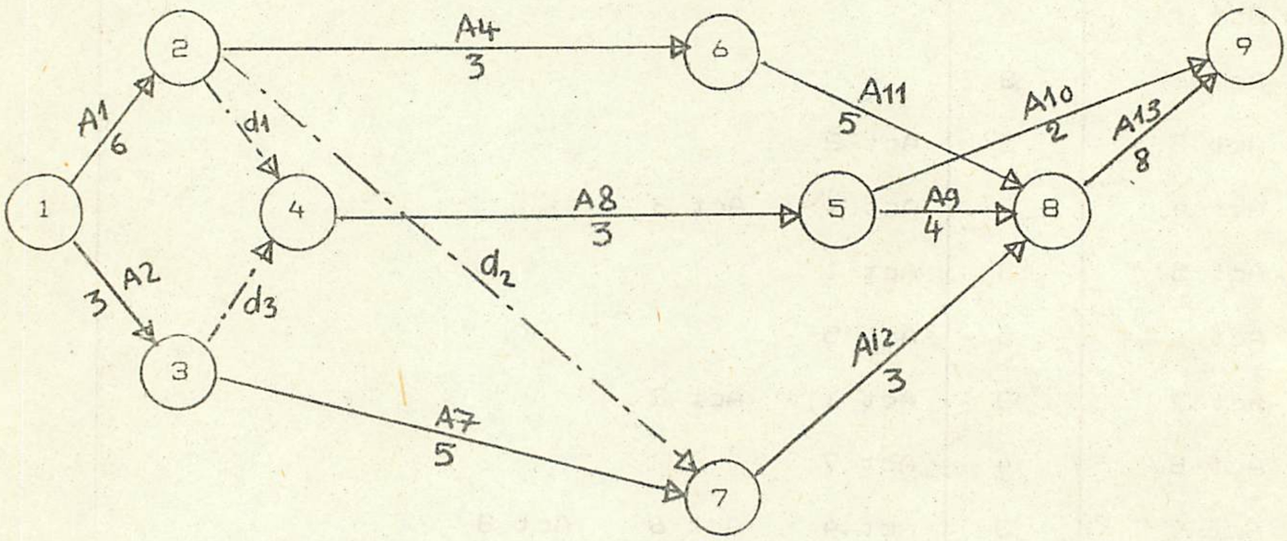
Act. code	Time	Predecessors				
		pred 1	pred 2	pred 3	pred 4	. . .
Act 1	6					
Act 2	3					
Act 3	5	Act 2				
Act 4	3	Act 1	Act 3			
Act 5	3	Act 1				
Act 6	5	Act 5				
Act 7	3	Act 1	Act 2			
Act 8	4	Act 7				
Act 9	3	Act 4	Act 6	Act 8		
Act10	2	Act 7				

a: NPROB_01.DAT

The Activity-On-Arrow Approach :

This Approach requires that an Arrow Network to be prepared as a first step .

The following figure represents the Arrow Network for this example :



The Corresponding Activity-On-Arrow Table :

Act. Code	Act. Nodes i	Act. Nodes j	Time	
Act 1	1	2	6	
Act 2	1	3	3	
d1	2	4	0	<--- dummy activity
Act 4	2	6	3	
d2	2	7	0	<--- dummy activity
d3	3	4	0	<--- dummy activity
Act 7	3	7	5	
Act 8	4	5	3	
Act 9	5	8	4	
Act10	5	9	2	
Act11	6	8	5	
Act12	7	8	3	
Act13	8	9	3	

a: APROB_01.DAT

Notice that :

- You can see that it was necessary to add 3 dummy activities : d1 , d2 , and d3 .
- Having numbered the Nodes , we need only give the Start and End nodes of each activity to specify precedence .
- All activities must be entered including dummy activities which should be assigned zero time . Thus , the number of activities has been increased accordingly .
- The Events must be numbered " left-to-right " ; i.e., each activity's End node must have a larger number than its Start node . This is to assure the absence of loops in the network and avoids any need to check for loops .

The computer input data and output results will be shown in the following pages .

DETAILED PROBLEM DATA LISTING FOR
Prblem 01 Arrow Network

ROW LABEL		SYMBOL	MEAN TIME	START NODE	END NODE
ACT	1	A01	6.	1	2
ACT	2	A02	3.	1	3
ACT	3	A03	0.	2	4
ACT	4	A04	3.	2	6
ACT	5	A05	0.	2	7
ACT	6	A06	0.	3	4
ACT	7	A07	5.	3	7
ACT	8	A08	3.	4	5
ACT	9	A09	4.	5	8
ACT	10	A10	2.	5	9
ACT	11	A11	5.	6	8
ACT	12	A12	3.	7	8
ACT	13	A13	3.	8	9

Prblem 01 Arrow Network
ACTIVITY LIST REPORT

Activity Name	Symb	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack	
ACT 1	A01	0.00	6.00	0.00	6.00	0.00	c
ACT 2	A02	0.00	3.00	3.00	6.00	3.00	
ACT 3	A03	6.00	6.00	7.00	7.00	1.00	
ACT 4	A04	6.00	9.00	6.00	9.00	0.00	c
ACT 5	A05	6.00	6.00	11.00	11.00	5.00	
ACT 6	A06	3.00	3.00	7.00	7.00	4.00	
ACT 7	A07	3.00	8.00	6.00	11.00	3.00	
ACT 8	A08	6.00	9.00	7.00	10.00	1.00	
ACT 9	A09	9.00	13.00	10.00	14.00	1.00	
ACT 10	A10	9.00	11.00	15.00	17.00	6.00	
ACT 11	A11	9.00	14.00	9.00	14.00	0.00	c
ACT 12	A12	8.00	11.00	11.00	14.00	3.00	
ACT 13	A13	14.00	17.00	14.00	17.00	0.00	c

Earliest project completion time = 17.00000

```
Prblem 01 Arrow Network : Bar chart
ct.   0                                                                   17.00
------+------+------+------+------+------+------+------+------+------+------+--

01    |CCCCCCCCCCCCCCCCCCCCCCCCCC                                              |
04    |                         CCCCCCCCCCCCC                                 |
11    |                                     CCCCCCCCCCCCCCCCCCCCCC            |
13    |                                                           CCCCCCCCCCCC
02    |xxxxxxxxxxxxx.............                                             |
07    |            xxxxxxxxxxxxxxxxxxxxxx............                         |
06    |            x.................                                         |
08    |                         xxxxxxxxxxxxxx....                            |
03    |                         x....                                         |
05    |                         x....................                         |
12    |                                  xxxxxxxxxxxx.............            |
09    |                                     xxxxxxxxxxxxxxxxxx....            |
10    |                                     xxxxxxxxx........................
--------------------------------------------------------------------------------
```