DOCUMENT RESUME

ED 030 967 EA 002 382

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The Application of PERT to Large-Scale Educational Research and Evaluation Studies.

Educational Testing Service, Princeton, N.J.
Report No-RM-69-14
Pub Date 8 Feb 69
Note-16p.; Paper presented at the Annual Meeting of the Amer. Educ. Res. Assn. (Los Angeles, Calif., Feb. 8, 1969).
EDRS Price MF-$0.25 HC-$0.90
Descriptors-*Critical Path Method, Educational Researchers, Manpower Utilization, Networks, *Objectives, Program Coordination, *Program Evaluation, *Program Planning, *Research Projects, Resource Allocations, Task Analysis, Work Simplification
Identifiers-PERT, *Program Evaluation and Review Technique

The application of a PERT system to a large-scale project will increase the probability of accomplishing project objectives by providing greater visibility of (1) the project objectives, (2) the relationships among the parts of the projects, and (3) the relationships of those component parts to the project objectives. Consequently, educational researchers should find that a PERT system will increase their collective ability to coordinate planning and evaluation efforts. A review of a PERT system applied to a study of disadvantaged school children indicates that in order to achieve optimal utility, the system should be implemented well ahead of the project starting time, and must be responsive to program developments through continued updating procedures. (JH)

RESEARCH MEMORANDUM

RM-69-14

THE APPLICATION OF PERT TO LARGE-SCALE EDUCATIONAL RESEARCH AND EVALUATION STUDIES

C. Marston Case

Paper presented at the meetings of the American Educational Research Association, Los Angeles, California, February 8, 1969.

Educational Testing Service
Princeton, New Jersey
May 1969

THE APPLICATION OF PERT TO LARGE-SCALE EDUCATIONAL RESEARCH AND EVALUATION STUDIES

This morning I would like to cover four points related to the management of large scale studies. First, I will discuss the need for what I call "project visibility." Second, I will note some basic features of a PERT chart using the example in the handout. As some of you already know, PERT is an acronym standing for Project Evaluation and Review Technique. Third, I will use a very simple application as a basis for making some recommendations about implementing PERT. Finally, I will describe an application of PERT to a large scale project at Educational Testing Service. In this last item I will refer to the reports in the handout, which come from one of IBM's PERT-like computer packages.

The success of any project depends on whether the participants actually contribute to its accomplishment. This may seem obvious, but one often finds that the participants in a large-scale project, including the manager, are vague about how their efforts are related to the project objectives. Such projects often fail to meet their objectives; sometimes the objectives have to be changed so that they conform with what the people on the project have been doing. But we try to avoid that. Usually when one finds that the efforts of the people working on the project are not well related to the project objectives one will also find there is a lack of project visibility. I feel that this visibility can easily determine the difference between a highly successful project and a not so successful or an abandoned one. Three things need to be made visible: (1) the project objectives themselves, (2) the relationships among the parts of the project, and (3) the relationships of those component parts to the project objectives.

Figure 1 in your handout is an example of how we can go about improving project visibility. It looks rather like a flow chart, but strictly speaking it is not one. It is a work item network. Each box represents an item of work. The leader of a certain part of a project estimated that this set of 23 work items was necessary to the completion of his part of the project. In a work item network, a key relationship among the work items is made visible. This key relationship is precedence. The arrows in the network mean that the work item following the arrow cannot begin until the work item preceding the arrow is finished. Thus one sees from a work item network how the work items are related to each other in terms of their succession in time. Our objective is the completion of all of the work items, but since the precedence relations all flow into the last work item, we may as well say that our objective is the completion of that last work item.

Thus far we have defined precedence relations among the work items. Now let us make this network into a resource allocation scheme where the resource to be allocated is time. We can do that by assigning time durations to the work items. The number at the lower right corner of each work item box is the expected number of days needed to do the given work item.

Now let us see how PERT fits into the picture. We have in the network diagram of Figure 1 all the information contained in any PERT chart.

1. It has work items (the boxes).
2. It shows the precedence relations among the work items (the lines and arrows).
3. It shows expected time durations of work items (the numbers in the lower right corners).

PERT is a method of showing proposed resource allocations; in using it one develops a time allocation scheme, and perhaps a scheme for allocating other resources, such as cost or manpower. It has been successfully employed in managing large-scale projects in the construction industry and in the Department of Defense. It was first used in the development of the Navy's Polaris missile.

Now a full-blown PERT treatment of a project involves the use of a computer to analyze the network before the project starts, and then periodically during the execution of the project. In small projects, however, worthwhile benefits can be gained with the use of a PERT-like diagram, without getting into more sophisticated analyses. I will give you an example. Recently my wife agreed to the use of a PERT chart for cleaning the house and getting ready for guests later in the day. We drafted a network diagram which gave a clear view of the day's tasks and the precedence relations among them. Rooms had to be put in order before they were dusted and then dusted before they were vacuumed. Operations in the various rooms could run along roughly parallel except in our little boy's room, which was done last, so he could play there while we were busy elsewhere. The dishes could not be washed until all the cooking was done. The roast was to go in the oven at a certain time, and so on.

The chart worked quite well. It not only kept us at relevant tasks in their proper order, but it became an unobtrusive rallying point; we worked in reference to the chart, with no need to ask or tell the other what to do. Now, this unobtrusiveness is an important point in coordinating research projects, because most people, especially researchers, do not like to be told what they are to do, in any direct way. This is one reason I think

that educational researchers will find that a PERT chart makes it easier to coordinate efforts with others on large-scale projects.

We have been noticing the fact that the PERT chart, a detailed and explicit document, is a help in maintaining momentum toward project goals and that project morale is benefited by such momentum. However, the PERT chart can be a product of management alone, with little representation of the desires of those who are to follow its dictates. On the other hand, a PERT chart can be the product of the joint efforts of project management and the other participants. If it is a joint product there will be a spirit of coordination and cooperation; done in this spirit, PERT helps to avoid that obtrusiveness sometimes ascribed to management.

Now, people are usually able to clean house without the benefit of a PERT chart. However, these sorts of simple applications of PERT are invaluable in giving one a sense of how PERT works. I recommend that prospective PERT users make a few such simple applications before they attempt the use of PERT in a large-scale project.

A PERT system provides a method to make plans before a project begins and then to review and revise the plans while the project is being carried out. In the house cleaning, for example, we jointly prepared the PERT chart and then referred to it when each work item was done in order to choose the next thing to do. During the process of doing these tasks we noted down the times each work item was started and finished and compared them with our planning estimates to see whether we would have to work harder or would have time to spare before the guests arrived.

This reviewing and revising while the project is going on is crucial in keeping the project on schedule, largely because it keeps the relationship of

everyone's efforts to project objectives visible to all concerned. This process, known as updating, should be a regularly-scheduled event during the lifetime of the project. I think updating is the most demanding part of keeping a large PERT system going, because the people whose work is represented on the charts often have to be reminded of the need for information about their progress. You can use various devices to prod the participants for this information; you can set up a reporting schedule and provide progress report forms; you can write memos, make phone calls, and visit the project participants. Such special efforts are frustratingly inefficient but it will not be necessary to resort to them so often if the project is well planned early enough and with all the people in the project participating in the planning.

Now let us turn to an example of the application of PERT to a large project. A group of people at ETS have embarked on a large-scale longitudinal study of disadvantaged preschool children. Another person and I were attached to the project as advisors and implementers of a PERT approach to the coordinating of the project. We came into this role more because of our ability to bring a computer to bear on the problem than because of management skill or experience. We have used an IBM PERT-type computer package called Project Control System, or PCS, which runs on the IBM 360 computers.

At the outset, the project had seven component parts called task forces, with a task force leader designated for each. Each task force was to provide a way to assess a different aspect of the preschool child or his environment. The main objective of the project is to identify the components of early

education in preschool and primary grades that are associated with children's cognitive, perceptual and personal-social development. We first worked with the task force leaders in setting up work item networks. Figure 1 is one of the early task force work item networks. In the initial seven task force networks there were about 220 work items. About a month was required to gather this information and get it into the computer.

Once we had this initial version in the computer, we were able to provide schedules and graphs corresponding to each task force's proposed plans. Page 2 of your handout shows an example of a schedule report corresponding to the network in Figure 1. This tabulates the work items and the earliest and latest they can start and finish. It also indicates the float or slack associated with such scheduling; this is the amount of leeway one has in doing the given work item providing everything else goes according to schedule. Notice that in some cases this is a negative number, which indicates inconsistencies in the proposed plan. Page 3 shows a graph of some of the same information. We do not need to examine all the details of these reports here although you may want to study them later.

In this project we are estimating manpower requirements for each work item. We are doing this in order to avoid excessive manpower demands in peak demand periods which would be costly or impossible to meet. The IBM program prepares reports showing manpower requirements versus time. Pages 4 and 5 of the handout are examples of these. Page 4, for instance, shows a tabulation of manpower requirements of various work items by days, with the total requirement of the project for each day at the bottom. On page 5 the resource utilization report shows, with asterisks, the total requirement for each week and, with C's, the cumulative requirements of the project over the term of the entire project.

There are three problems we have encountered in this implementation of PERT which seem to be of sufficient importance to mention here. First, we did not have the initial version of the project (the planning version) on the computer and ready to go at the time the project started. This meant that people were working by plans, some of which were later shown to be inconsistent. That is, they could not use as much time as they were alloting themselves and still meet certain deadlines. This is a perennial problem: the problem of gaining time enough before the project starts to prepare a plan which is at once consistent and acceptable to all concerned.

The second problem we have encountered to some extent derives from the first; at least it is aggravated by the presence of the first. This is the problem I mentioned earlier, keeping the PERT system up to date. As soon as the project is started, updating should begin. This means that periodically, say every week or two, the network should be reviewed and revised estimates of resource requirements should be provided. If any work items have been started or finished since the last updating, they should be reported. When update information is put into the computer system, work status reports such as the one shown on page 6 of the handout can be provided. This report tabulates information on the work items which have not been completed. It includes the original estimate of time required and the present estimate of remaining time needed to finish the work item, plus other information. In our project updating has been somewhat thwarted by the fact that other things received priority over the updating activities.

The third problem, which is not independent of the first two, is that the PERT materials are not sufficiently used as a basis for reviewing

and revising project plans. Now this is the one key use for which PERT was designed. The main reason PERT has not been used in reviewing and revising plans (aside from the problems of a late start and weak updating) is that the project staff has had to contend with a variety of unexpected events. These required major revisions in project plans, such as personnel changes and changes in the subjects to be studied. As a result the staff has often, in critical times, fallen back on ad hoc measures to revise project plans.

In this project we are continuing to work on bringing the status of the plans up to date. We expect the PERT system to be of more benefit as the project progresses, plans crystalize, and the PERT system catches up with the plans.

I believe that a PERT system, implemented well ahead of project start and kept responsive to project developments, provides a certain visibility of the structure of the project not available by other means. Several benefits derive from such visibility. Basically these stem from the fact that everyone concerned sees how the pieces of the project fit together in support of the project objectives. With this readily available grand view of the project, ramifications of any changes are quickly assessed and massive changes are more easily handled. The visibility aids in maintaining communication up and down and across project organizational lines, with a PERT network acting as an impersonal entity to represent the wills of all project participants. My conclusion is that such visibility, in an otherwise well-conceived project, will make it more likely that the project objectives will be accomplished.

ANDOUT

THE APPLICATION OF PERT

TO LARGE-SCALE EDUCATIONAL RESEARCH AND EVALUATION STUDIES

C. Marston Case, Educational Testing Service

Part of the Symposium:

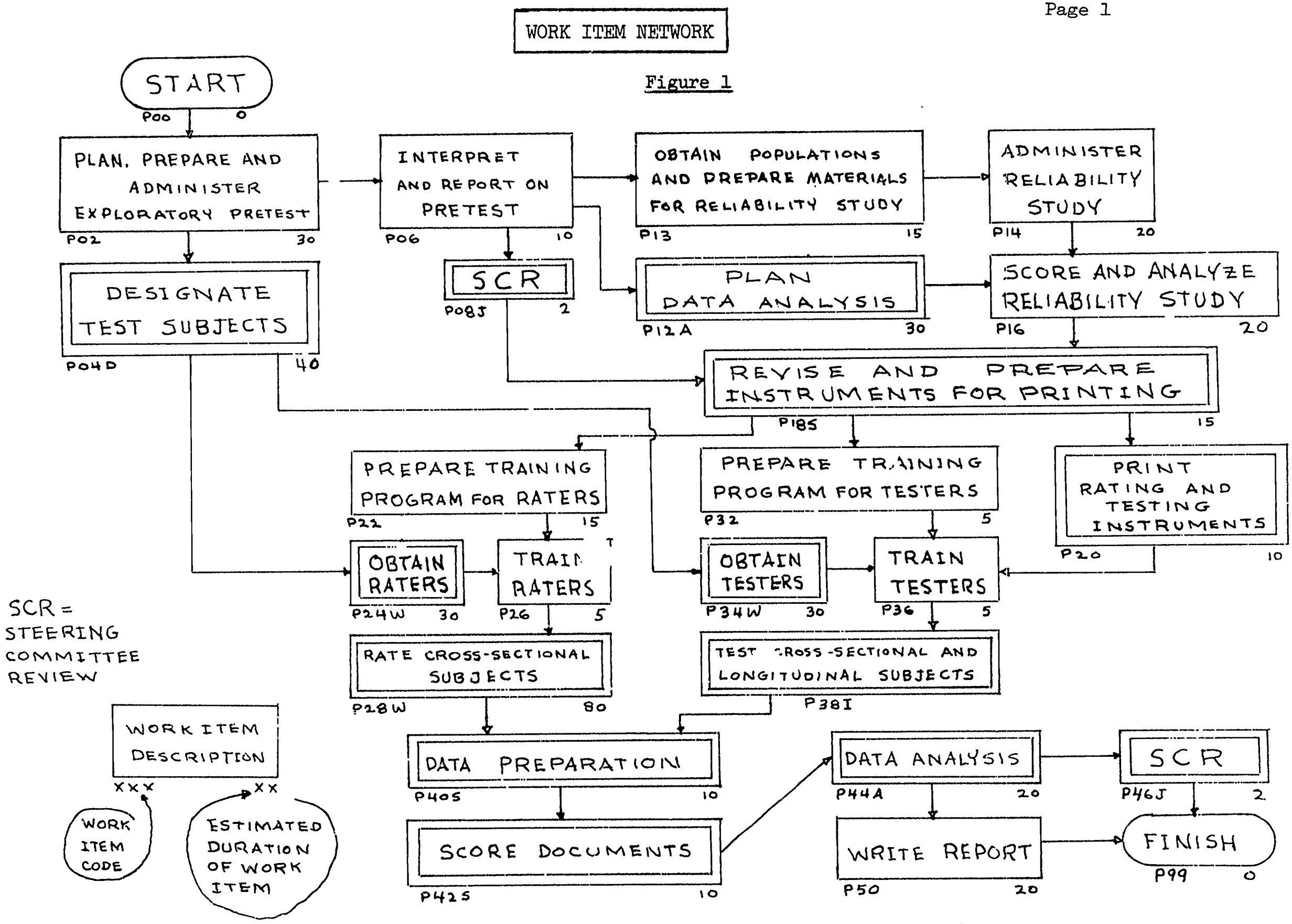
Management Problems in Conducting Large-Scale Research and Evaluation Studies

1969 American Educational Research Association Meetings

February 8, 1969, Los Angeles

WORK ITEM NETWORK

Figure 1



IBM PROJECT CONTROL SYSTEM

RUN DATE 15 AUG 68 * * S C H E D U L E R E P O R T * * DATA DATE 01 AUG 68

RUN SEQUENCE 1 NETWORK ID 1 ETS HEADSTART LONGITUDINAL STUDY 588-07 FROM 01 JUL 68 TO 10 OCT 69

SEQUENCE ORG LEV 1, W I ORG CODE... P

WI	DESCRIPTION	TOT DURAT	CAL	START EARLY.		START LATE	START FLOAT	FINISH EARLY		FINISH LATE	FIN FLOAT
P00	START PERSONAL-SOCIAL TASK FORCE	0.0	51	1JUL68	A	1JUL68	0.0	2JUL68	A	2JUL68	0.0
P02	PLAN,PREPARE,ADMIN EXPLORATORY PRETEST	30.0	51	8JUL68	A	8JUL68	0.0	16AUG68	S3	16AUG68	0.0
P04D	DESIGNATION OF MAIN 1969 TEST SUBJECTS	40.0	51	27AUG68		20CT68	25.0	220CT68		26NOV68	25.0
P06	INTERPRET AND REPORT ON SUMMER PRETEST	10.0	51	19AUG68		19AUG68	0.0	30AUG68	S3	30AUG68	0.0
P08J	SCR	2.0	51	3SEP68		6NOV68	46.0	4SEP68		7NOV68	46.0
P12A	DATA ANALYSIS PLANNING	30.0	51	3SEP68		29AUG68	-2.0	140CT68		100CT68	-2.0
P13	OBTAIN POPS AND MATERIALS FOR RELIABILITY SY	15.0	51	3SEP68		22AUG68	-7.0	23SEP68		12SEP68	-7.0
P14	ADMINISTER RELIABILITY STUDY	20.0	51	24SEP68		13SEP68	-7.0	210CT68		100CT68	-7.0
P16	SCORE AND ANALYZE RELIABILITY STUDY	20.0	51	220CT68		110CT68	-7.0	18NOV68		7NOV68	-7.0
P18S	REVISE AND PREPARE INSTRUMENTS FOR PRINTING	15.0	51	19NOV68		8NOV68	-7.0	10DEC68		29NOV68	-7.0
P20	PRINTING OF RATING AND TESTING INSTRUMENT	10.0	51	11DEC68		2DEC68	-7.0	15DEC68	S3	15DEC68	0.0
P22	PREPARE TRAINING PROGRAM FOR RATERS	15.0	51	11DEC68		19DEC68	6.0	6JAN69		14JAN69	6.0
P24W	OBTAIN RATERS	30.0	51	230CT68		27NOV68	25.0	4DEC68		14JAN69	25.0
P26	TRAIN RATERS	5.0	51	7JAN69		15JAN69	6.0	13JAN69		21JAN69	6.0
P28W	RATE CROSS-SECTIONAL SUBJECTS, 3 HRS PER DAY	80.0	51	14JAN69		22JAN69	6.0	6MAY69		14MAY69	6.0
P32	PREPARE TRAINING PROGRAM FOR TESTERS	5.0	51	11DEC68		6MAR69	56.0	17DEC68		12MAR69	56.0
P34W	OBTAIN TESTERS	30.0	51	230CT68		29JAN69	65.0	4DEC68		12MAR69	65.0
P44A	DATA ANALYSIS	20.0	51	12JUN69		18AUG69	47.0	9JUL69		12SEP69	47.0
P46J	SCR	2.0	51	10JUL69		90CT69	65.0	11JUL69		100CT69	65.0
P50	WRITE REPORT	20.0	51	10JUL69		15SEP69	47.0	6AUG69		100CT69	47.0
P99	FINIS	0.0	51	6AUG69		100CT69	47.0	6AUG69		100CT69	47.0

PROJECT BASE DATE 1 JUL 68 PROJECT DURATION 467.0 PROJECT COMPLETION DATE 10 OCT 69

IBM PROJECT CONTROL SYSTEM

RUN DATE 15 AUG 68 * * B A R G R A P H * * DATA DATE 01 AUG 68

RUN SEQUENCE 1 NETWORK ID 1 ETS HEADSTART LONGITUDINAL STUDY 588-07 FROM 01 AUG 68 TO 10 OCT 69

SEQUENCE ORG LEV 1, W I ORGANIZATION P PAGE 1 PART 2

* DURATION, X CRITICAL DURATION, - FLOAT, N NEGATIVE FLOAT

WORK ITEM	MTWTFSS 23SEP68	MTWTFSS 07OCT68	MTWTFSS 21OCT68	MTWTFSS 04NOV68	MTWTFSS 18NOV68	MTWTFSS 02DEC68	MTWTFSS 16DEC68	MTWTFSS 30DEC68
P02	I I I I I I I I I I I I I I I I							
P04D	***** ***** ***** ***** **--- ----- ----- ----- ----- -- I I I I I I							
P06	I I I I I I I I I I I I I I I I							
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P32	I I I I I I I I I I I I I I I *** **--- ----- ----- I							
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P38I	I I I I I I I I I I I I I I I I							
P40S	I I I I I I I I I I I I I I I I							
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P46J	I I I I I I I I I I I I I I I I							
P50	I I I I I I I I I I I I I I I I							
P99	I I I I I I I I I I I I I I I I							

IBM PROJECT CONTROL SYSTEM

RUN DATE 15 AUG 68 * * **RESOURCE ASSIGNMENT** * * DATA DATE 1 AUG 68

RUN SEQUENCE 1 NETWORK ID 1 ETS HEADSTART LONGITUDINAL STUDY 588-07 FROM 1 AUG 68 TO 10 OCT 69

SEQUENCE RES- WI PRNCTN PROFESNL 1100 PAGE 1 PART 1

WI	WI DESCRIPTION	START FLOAT	RESOURCE DAILY RATE									
			29JUL68 MON	TUE	WED	THU	FRI	SAT	SUN	5AUG68 MON	TUE	
E04	SURVEY SCHOOL LITERATURE	213.0				0.4	0.4			0.4	0.4	
E06	IDENTIFY SCHOOL VARIABLES	213.0										
E08	DEVISE SCHOOL ITEMS	213.0										
E10	IDENTIFY SCHOOL DATA SOURCES	213.0										
E12J	STEERING REVIEW OF SCHOOL PLANS	213.0										
E14I	COORDINATE SCHOOL ITEMS WITH FIELD ADMIN	213.0										
E16	PLAN PRETEST OF PRINCIPAL'S ITEMS	213.0										
E20T	INTEGRATE SCHOOL ITEMS WITH TEACHER TF	221.0										
E34	SURVEY COMMUNITY LITERATURE	231.0				0.5	0.5					
E36	IDENTIFY COMMUNITY VARIABLES	231.0								2.0		
E38	DEVISE COMMUNITY ITEMS	231.0										0.5
E40	IDENTIFY COMMUNITY DATA SOURCES	231.0										
E42J	STEERING REVIEW OF COMMUNITY PLANS	231.0										
E46F	INTEGRATE COMM ITEMS WITH FAMILY TASK FORCE	231.0										
E48	PLAN SEARCH FOR CENSUS DATA	232.0										
E50	CONDUCT SEARCH FOR CENSUS DATA	232.0										
			29JUL68							5AUG68		
P12A	DATA ANALYSIS PLANNING	-2.0										
P13	OBTAIN POPS AND MATERIALS FOR RELIABILITY SY	-7.0										
	TOTAL FOR RESOURCE		0.5	0.5	0.5	1.4				2.9		1.4

IBM PROJECT CONTROL SYSTEM

RUN DATE 9 AUG 68 ** RESOURCE UTILIZATION ** DATA DATE 1 AUG 68

RUN SEQUENCE 1 NETWORK ID 1 FROM 1 JUL 68 TO 10 OCT 69

SEQUENCE RES- ES PRNCTN PROFESNL 1100 PAGE 1

PERIOD STARTNG	PERIOD AMOUNT	PERIOD (*) AND CUMULATIVE (C) REQUIREMENTS WHOLE UNITS	CUMULATIVE AMOUNT	PERIOD STARTNG
PERIOD SCALE		10 20 30 40 50 60 70 80	PITCH	1
CUMULATIVE SCALE		50 100 150 200 250 300 350 400	PITCH	5
1JUL68	0.0		0.0	1JUL68
8JUL68	0.0		0.0	8JUL68
15JUL68	0.0		0.0	15JUL68
22JUL68	0.0		0.0	22JUL68
29JUL68	2.9	C*	2.9	29JUL68
5AUG68	9.7	C *	12.6	5AUG68
12AUG68	18.1	C *	30.6	12AUG68
19AUG68	10.0	C*	40.6	19AUG68
26AUG68	8.2	*C	48.8	26AUG68
2SEP68	3.3	* C	52.0	2SEP68
9SEP68	3.0	* C	55.0	9SEP68
16SEP68	5.4	* C	60.4	16SEP68
23SEP68	7.5	* C	67.8	23SEP68
30SEP68	6.5	* C	74.2	30SEP68
7OCT68	5.4	* C	79.6	7OCT68
14OCT68	5.2	* C	84.8	14OCT68
21OCT68	5.2	* C	89.9	21OCT68
28OCT68	5.1	* C	95.0	28OCT68
4NOV68	5.3	* C	100.3	4NOV68
11NOV68	6.2	* C	106.4	11NOV68
18NOV68	7.0	* C	113.3	18NOV68
25NOV68	5.6	* C	118.9	25NOV68
2DEC68	8.0	* C	126.9	2DEC68
9DEC68	6.4	* C	133.2	9DEC68
16DEC68	7.2	* C	140.4	16DEC68
23DEC68	2.6	* C	142.9	23DEC68
30DEC68	5.1	* C	148.0	30DEC68
6JAN69	5.7	* C	153.6	6JAN69
13JAN69	4.0	* C	157.6	13JAN69
20JAN69	2.6	* C	160.1	20JAN69
27JAN69	2.6	* C	162.7	27JAN69
3FEB69	3.2	* C	165.9	3FEB69
10FEB69	5.6	* C	171.5	10FEB69
17FEB69	4.5	* C	176.0	17FEB69
24FEB69	4.9	* C	180.8	24FEB69
3MAR69	1.5	* C	182.3	3MAR69
10MAR69	1.5	* C	183.8	10MAR69
17MAR69	1.4	* C	185.1	17MAR69

IBM PROJECT CONTROL SYSTEM

RUN DATE 15 AUG 68 | ** W O R K S T A T U S A N D P R O G R E S S ** | DATA DATE 1 AUG 68

RUN SEQUENCE 1 NETWORK ID 1 TITLE ETS HEADSTART LONGITUDINAL STUDY 588-07 FROM 1 JUL 68 TO 10 OCT 69

SEQUENCE ORG1- WI P PAGE 1

WI	DESCRIPTION	ORIGL DURAT	UNIT	CAL	REMAI DURAT	PERCNT COMPLT		EXPECTED START DATE	LATEST FINISH DATE
P02	PLAN,PREPARE,ADMIN EXPLORATORY PRETEST	30.0	DAY	51	12.0	0.6000	A	8 JUL 68	16 AUG 68
	PWI P00 DATE A 2 JUL 68								
P04D	DESIGNATION OF MAIN 1969 TEST SUBJECTS	40.0	DAY	51	40.0	0.0		27 AUG 68	26 NOV 68
	PWI P02 DATE 16 AUG 68								
P06	INTERPRET AND REPORT ON SUMMER PRETEST	10.0	DAY	51	10.0	0.0		19 AUG 68	30 AUG 68
	PWI P02 DATE 16 AUG 68								
P08J	SCR	2.0	DAY	51	2.0	0.0		3 SEP 68	7 NOV 68
	PWI P06 DATE 30 AUG 68								
P12A	DATA ANALYSIS PLANNING	30.0	DAY	51	30.0	0.0		3 SEP 68	10 OCT 68
	PWI P06 DATE 30 AUG 68								
P13	OBTAIN POPS AND MATERIALS FOR RELIABILITY SY	15.0	DAY	51	15.0	0.0		3 SEP 68	12 SEP 68
	PWI P06 DATE 30 AUG 68								
P14	ADMINISTER RELIABILITY STUDY	20.0	DAY	51	20.0	0.0		24 SEP 68	10 OCT 68
	PWI P13 DATE 12 SEP 68								
P16	SCORE AND ANALYZE RELIABILITY STUDY	20.0	DAY	51	20.0	0.0		22 OCT 68	7 NOV 68
	PWI P12A DATE 10 OCT 68 PWI P14 DATE 10 OCT 68								
P18S	REVISE AND PREPARE INSTRUMENTS FOR PRINTING	15.0	DAY	51	15.0	0.0		19 NOV 68	29 NOV 68
	PWI P16 DATE 7 NOV 68 PWI P08J DATE 7 NOV 68								
P20	PRINTING OF RATING AND TESTING INSTRUMENT	10.0	DAY	51	10.0	0.0		11 DEC 68	15 DEC 68
	PWI P18S DATE 29 NOV 68								