PERT/COST AND THE VISIONREADER PROJECT[1]

Photios G. Ioannou, Ph.D., Dipl.Eng., F.ASCE
Civil and Environmental Engineering Department
University of Michigan
November 27, 2023

On Thursday, June 15, 1967, eight weeks after the start of the VisionReader project, Mr. Frank Johnson, the project manager, was preparing for a visit from the government engineering officer responsible for the VisionReader. The visitor was to arrive the following Monday to review the first two months of progress on the project as well as ClarityTech LLC's general effectiveness in managing the development effort.

Mr. Johnson had recently received the initial PERT/Cost reports on the VisionReader (see Exhibits 7 and 8) and he wished to analyze these to determine what action he should take prior to the visit. Two decisions were needed:

- The choice of a course of action that would ensure completion of the project within the scheduled time.
- A decision regarding the future of PERT/Cost, i.e., whether to improve, discontinue, or continue its use on the project.

The use of PERT/Cost had met with resistance within ClarityTech, and several sources indicated that the government was taking a closer look at PERT/Cost application on contracts, particularly on projects such as the VisionReader for which costs were charged directly to the contract. Because of these reasons and the possibility that the overall costs of the project would exceed estimates, Mr. Johnson wished to review his decision to use PERT/Cost to manage the project and to develop a clear understanding of its advantages and disadvantages. Issues of particular concern to him were:

- PERT/Cost's value in this project versus its cost of approximately $30,000.
- The distinction between:
  - PERT/Cost's value in planning and in the early stages of project development.
  - PERT/Cost's use as a reporting and management control tool.
    - * The limitations of the probabilities developed by PERT.
    - * The difficulties that might be imposed by ClarityTech's cost-collecting system.

He thought that the best way to focus on these issues was to use the available PERT/Cost data to help decide how best to ensure its usefulness in this decision vi-a-vis its cost and the costs of other project management systems.

VisionReader Contract

Late in April 1967, ClarityTech LLC had been awarded a cost-plus-fixed-fee (CPFF) contract from the government to develop and deliver an electronic OCR reader (VisionReader).

---

[1] Partly based on a case prepared by William Abernathy as part of the requirement of the Doctoral Program at the Harvard Graduate School of Business Administration. It is intended as a basis for class discussion rather than to indicate effective or ineffective handling of administrative situations.

The estimated cost under the contract was $592,920. This included labor, materials, overhead, and $41,370 general and administrative expenses. The negotiated fee was an additional $35,580. Delivery of the hardware was called for in 47 weeks with a demonstration in 44 weeks after the start of the contract. The contract included liquated damages of $3,000 per week for each week the demonstration was delayed past 44 weeks.

The function of the VisionReader was to hold and scan certain printed forms, convert the information on the printed forms into electrical impulses, and store the impulses on a magnetic tape. The VisionReader development contract was the first of a series of electronic readers and assorted equipment procurements planned by the government. ClarityTech's marketing organization reported that the company was in excellent position to win subsequent contracts if performance under the present contract was good and if ClarityTech's technological lead was not lost because of delays by the government in the dates of planned procurement. ClarityTech's management was relying heavily upon such subsequent contracts to maintain company sales.

Organization

Under ClarityTech's program management concept, a separate program management organization was formed for each system development contract received, with a program manager and staff assigned for the duration of the program. The technical personnel required to perform particular tasks were transferred into and out of a particular program group at the program manager's discretion. Most of these personnel were charged directly to the contract involved. This charge included an additional amount for engineering overhead, equal to 175% of the direct labor cost. Manufacturing tasks were performed by a separate manufacturing organization at the direction of the program manager.

The VisionReader project was organized in the customary manner with an assigned management group which included an administrator, a systems engineer, a PERT planner, a contract administrator, and clerical personnel. This group would be kept intact for the duration of the contract. Mr. Johnson had not been able to obtain the contract administrator until the second week, and the PERT planner was not added until the fourth week.

Since his assignment to the program the planner had been actively engaged in such tasks as setting up the PERT/Cost system, familiarizing himself with the program, and breaking estimated costs into packages consistent with work tasks.

Exhibit 1 shows the PERT/Cost network resulting from his efforts. The arrows in this network represent the activities. Next to each arrow is the activity name along with the three time estimates in parentheses that were assessed for the duration of that activity (a = optimistic duration, M = most likely duration, b = pessimistic duration). The mean (expected value) and the variance of each activity duration given by the standard PERT formulas are shown separated by a dash below the three duration estimates.

In Exhibit 1, each circle with a number in it represents an event. On top of each circle are two numbers separated by a dash that represent the early and late event times for that event. The number on the left is the earliest time in weeks from the start of the network by which that event may be completed. The number on the right is the latest time by which the event must be completed. All times are shown in weeks and are based upon most likely activity duration estimates.

Exhibit 2 shows a table that lists the activities for the project, the numbers (*i*,*j*) for their preceding (*i*) and succeeding (*j*) events, and the three time estimates (a, M, b) for the duration of each activity in weeks. This table also shows the mean (expected value), the standard deviation, and the variance of each activity duration that were calculated by the standard PERT formulas shown at the bottom of the table.

In setting up the PERT/Cost system the planner reassigned some accounting charge numbers. This was necessary to match the PERT/Cost network, and to minimize the difficulty caused by individuals who signed their timecards by job title rather than job task. The last digit in the charge number was intended to represent the job function performed, but as a result of current practices it often represented an individual's title. Exhibit 3 provides a list of cost packages and corresponding activities.

Development Task Breakdown in the PERT/Cost Network

The VisionReader consists of seven components, each specified as a separate deliverable item in the contract:

1. Camera. This includes an easel and housing for holding documents, optics, image orthicon tube, and an electronic package. (An image orthicon is a television camera tube having a sensitivity and spectral response approaching that of the human eye.)

2. Video amplifier. (This amplifies impulses produced by the camera.)

3. Signal comparator. (This amplifies impulses from the camera into characters.)

4. Signal converter. (This converts signals into a form compatible with other electronic data processing (EDP) equipment.)

5. Magnetic tape recorder.

6. Power supply. (This supplies special power requirements to all other units.)

7. Console. (This contains wiring, controls, and housing for all other units.)

The development of each of the seven items requires different types of technical effort and each different type of effort is described in the PERT/Cost network by a separate activity. As an example, for any one item the initial engineering, compatibility testing, and rework (i.e., reengineering after testing) are separate activities. The following were described by Mr. Johnson as the major activities immediately facing the project organization:

Video Amplifier, Magnetic Tape Recorder, Power Supply Unit.

The magnetic tape recorder (events 2-37-38) and power supply unit (events 2-8) were commercially available as “off-the-shelf items” and only had to be mounted by ClarityTech. The video amplifier (events 2-34) and many of the subassemblies of other units were commercially available but had to be manufactured to ClarityTech’s specification or modified upon receipt by ClarityTech. The delivery of these units was relatively certain and was backed up by guarantees from the manufacturers involved.

Camera.

The camera was the heart of the system. It included three major subassemblies — optics; easel and housing unit (E&H unit); and electronics package. The optics included a lens, image orthicon tube, frame, and lighting system. The optics projected the image of the document to be scanned upon the orthicon tube.

The lens (events 2-32-33-39) was particularly critical since no more than 0.005 degree of curvature in the projected image was permissible. Management was relying heavily upon the artisan skill of an expert optics group to produce the lens to the required high tolerance. Since a trial-and-error approach was involved in the manufacture, the exact date of delivery was uncertain. Mr. Johnson expressed relief that this item was not on the “critical path”.

The camera electronics package included: a scan generator (events 2-5-12-13-14) which generated varying voltages to control the scanning action of the orthicon tube; a blanking amplifier (events 2-4-10-12-13-14) which shuts off the tube during scan retrace; and a sync. generator (events 2-3-9-12-13-14) which synchronizes the scan generator and blanking amplifier. Although these three units were commercially available, considerable engineering was required to modify them to perform in the system. To expedite development, separate groups were to perform the modification and reengineering of these units. They would, however, be manufactured as one unit. Although design of the camera electronics was complicated, there was not great uncertainty in the schedule of completion. If more funds were allocated to their development, some of the tasks could even be completed ahead of time.

The E&H unit (events 2-16-19-20-21) was a document holding frame incorporating a servomechanism to move the document being scanned in proper synchronism with the scanning action of the camera. The E&H unit was well within the “state of the art”, but some uncertainty was involved in the estimated schedule because of compatibility requirements between this and other units.

Comparator and Signal Converter

The logic portion of the comparator (events 2-24-25-28) represented the most complex electronics design task. The engineer responsible for its design was confident that the technical problems could be solved but the complexity of the unit made it difficult to estimate completion times with confidence. The comparator logic received the output of the camera after it had been amplified by the video amplifier. It reassembled each scanned segment into character blocks and compared these with permanently stored signals for character identification.

The output of the comparator went to the signal converter (events 2-23-24-25-27). The signal converter changed the order of electrical impulses so that they would be compatible with electronic data-processing equipment. The design of the converter was very similar to that of the comparator logic, although it was a much less complicated task.

The comparator also contained a separate unit which functioned as a master time for the entire system (events 2-19-20-22-28). This unit was composed largely of a very stable oscillator that acted as a clock. The uncertainty of the engineering effort required to develop the timer stemmed from possible difficulty in achieving stability. This could be overcome, however, by purchasing more expensive components.

Console

The task of designing the console (events 2-45-47) was largely that of mechanical layout and planning the internal wiring (integration) within the console so that all other units would be properly connected. The major uncertainty involved in the design of this unit was the timely receipt of data concerning the other units in the system.

In discussing the project, Mr. Johnson stated that the definition of work packages might be somewhat deceptive to an outsider. Breaking the development of each unit of equipment into tasks described as engineering, testing, and rework, gave the impression that each package was relatively independent, whereas in fact the rework or engineering to be done after compatibility testing was strongly dependent upon the amount and quality of prior engineering. For this reason, what might appear to be a cost overrun in an early work package might be due to a superior design effort which would reduce the time and dollars required for the entire effort. He pointed out that this situation might well exist in the VisionReader project. Whereas early work packages might seem expensive, his engineers assured him that they could bring costs into line.

In addition, some activities may be expedited if additional funds are committed to those activities. Exhibit 4 identifies the activities that can be accelerated and the cost per week of accomplishing the acceleration along with the minimum duration each activity can have. For example, activity 4-10, the engineering effort on the blanking amplifier, can be accelerated at a cost of $7,124 per week gained. Since the maximum acceleration that may be accomplished is from a most likely duration of 5 weeks to a most likely duration of 4.5 weeks, the cost of the greatest acceleration possible (0.5 weeks) is $3,562.

Current Status of the VisionReader Project

The first VisionReader PERT/Cost report that Mr. Johnson received was a slack order report (Exhibit 5). This report surprised all concerned because it showed half a week more slack than was projected by straight addition of the most likely activity durations leading to that event. The times used in determining slack in Exhibit 5 are not the scheduled completion times shown next to the events in Exhibit 1 (which were based on most likely activity duration estimates). Rather, an estimate of each activity's "mean duration" was computed as a weighted average of optimistic, most likely, and pessimistic times (using the standard PERT formulas) and these "mean durations" were used to compute event times.

The Pr. = 0.70 (probability of completing on or ahead of the target date) was also better than had been expected. To determine methods of further improving the probability of timely completion, another slack order report was prepared. The second slack order report (Exhibit 6) was a trial computation to reflect the project situation if the existing critical path were eliminated. In Exhibit 6 resources were hypothetically allocated, so that the sub-path 2-5-12-13-14-35 was no longer the most critical. Mr. Johnson and the PERT planner were both puzzled with this report and wondered if they should attach any significance to either the first or the second slack order report because the probability of completion listed on the second report (Pr. = 0.61) was poorer than the first. This anomaly was attributed in some manner to the uncertainty of lens design and delivery.

The most current reports available to Mr. Johnson on Thursday, June 15, 1967, were the PERT/Cost Status Report (Exhibit 7) and the Charge Number Cost Summaries (Exhibit 8), both dated June 2, 1967. This was because there was a two-week delay in collecting, summarizing, and reporting the costs incurred. As soon as he received these reports, he held a meeting with project personnel to discuss the significance of the reported data. The first part of the meeting was devoted to discussing technical progress. The engineers responsible for individual work packages reported on the status of their effort. The report on the comparator (events 2-24) indicated it was ahead of schedule. The engineers responsible for the camera electronics package (scan generator, sync. generator, and blanking amplifier, events 2-5-12) had also been encouraging in their report, stating that the decision to start the scan generator early had been wise. Although the major components for the scan generator would be a few days late, enough time had been gained by spending a few extra dollars to maintain the present schedule.

The scientist responsible for the optics (events 2-32-33) did not attend the meeting. He had, however, informed Mr. Johnson that he accepted responsibility for the lens and there was nothing to be done to improve the present status, which remained the same as initially reported. The optics work was nevertheless discussed by those present at the meeting. It was noted that, although the optics effort could not be speeded up in the conventional sense, one alternative was to use a different method to design the lens. This method would involve a higher cost but offered a more certain delivery. For example, if at the time of the meeting, a more scientific approach to the design of the lens was taken, delivery would be firm at the end of the 25th week, versus the present date of the 24th week. The cost, however, would be $6,000 higher.

After a review of technical progress, the meeting turned to an open discussion of the use of PERT/Cost on the project. Several engineers made critical comments concerning its continued use. They pointed out that in the planning stages of a project, while it was still easy to make major changes in the development effort, PERT was an excellent tool. After hardware design was decided upon, PERT/Cost was of little value because each engineer knew his responsibilities and how much money and time he was allowed. All that remained to be done was to get the job completed in the least time and at the least cost. They went on to say that if Mr. Johnson wished to decrease the extent of a cost overrun on the project, the PERT planner should be dropped from the project. A portion of the dollars saved in this manner could be applied to expedite technical effort on the critical path. In any event, they felt that their time could be best spent on solving engineering problems rather than updating PERT/Cost reports.

The program administrator agreed that it might appear possible, in the short run, to save funds by dropping the PERT planner, but he emphasized that resource allocation decisions were required throughout the program and that the only way such decisions could be made intelligently was via the PERT/Cost reports. He cited as an example the initial contention that the lens (events 2-32-33-39) would be the critical element in the project. PERT/Cost showed that this was not the critical path at all. The current need to expedite the project was also noted as an excellent example of the continuing need for PERT/Cost on the project.

The administrator then stated that the only difficulty with the use of PERT/Cost at the present time was that it had not been updated to include current time estimates, and periodic "cost-to-complete" estimates were not submitted for activities in progress. He told Mr. Johnson in confidence that the trouble was that the engineers did not want to be controlled as tightly as PERT/Cost permitted. He recommended that project status be improved by having the engineers re-estimate the tasks without including the extra allowances they normally used. The meeting closed with no agreement on either a method for expediting the project, or on the future of PERT/Cost on the project.

As Mr. Johnson reviewed the comments made in the meeting, the PERT/Cost reports, and other information available to him, he knew that he had to make two decisions:

- The first was what action to take to improve the chances that the VisionReader project would be a success. He could clearly allocate additional money to certain work packages to expedite them, but he wasn't sure which allocation, if any, would represent the most fruitful use of funds.
- The second decision concerned the future role of PERT/Cost in the project.

EXHIBIT 1 VisionReader — ClarityTech LLC
PERT/Cost Network for VisionReader Project

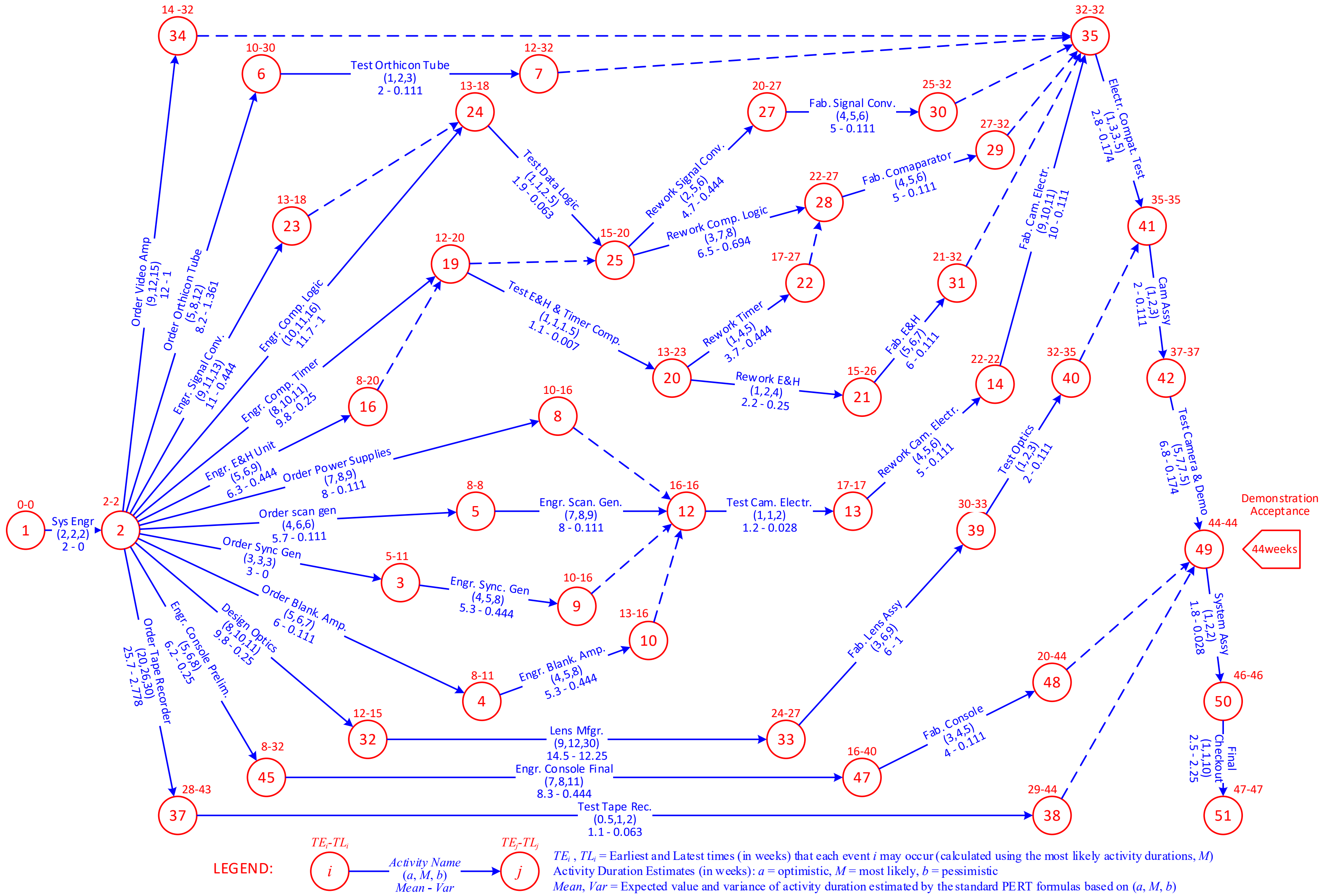

EXHIBIT 2
VISIONREADER — CLARITYTECH LLC

LIST OF ACTIVITIES IN VISIONREADER DEVELOPMENT PROJECT
AS LISTED ON PERT/COST NETWORK, EXHIBIT 1

i	*j*	Activity Description	a	M	b	Mean	Var	SD
1	2	Contract award and systems engr.	2	2	2	2.0	—	—
2	3	Receive sync. generator	3	3	3	3.0	—	—
2	4	Order blanking amp	5	6	7	6.0	0.111	0.333
2	5	Order scan gen	4	6	6	5.7	0.111	0.333
2	6	Order orthicon tube	5	8	12	8.2	1.361	1.167
2	8	Order power supplies	7	8	9	8.0	0.111	0.333
2	16	Design E&H	5	6	9	6.3	0.444	0.667
2	19	Engr. comparator timer	8	10	11	9.8	0.250	0.500
2	23	Engr. signal converter	9	11	13	11.0	0.444	0.667
2	24	Engr. comparator logic	10	11	16	11.7	1.000	1.000
2	32	Design optics	8	10	11	9.8	0.250	0.500
2	34	Procure video amp	9	12	15	12.0	1.000	1.000
2	37	Procure tape recorder	20	26	30	25.7	2.778	1.667
2	45	Eng. console prelim.	5	6	8	6.2	0.250	0.500
3	9	Eng. sync. generator	4	5	8	5.3	0.444	0.667
4	10	Engr. blanking amp.	4	5	8	5.3	0.444	0.667
5	12	Engr. scan. gen.	7	8	9	8.0	0.111	0.333
6	7	Test orthicon tube	1	2	3	2.0	0.111	0.333
7	35	Dummy	0	0	0	0.0	—	—
8	12	Dummy	0	0	0	0.0	—	—
9	12	Dummy	0	0	0	0.0	—	—
10	12	Dummy	0	0	0	0.0	—	—
12	13	Test camera elect.	1	1	2	1.2	0.028	0.167
13	14	Rework camera elect. package	4	5	6	5.0	0.111	0.333
14	35	Camera electronics fabrication	9	10	11	10.0	0.111	0.333
16	19	Dummy	0	0	0	0.0	—	—
19	20	Test E&H & timer compatibility	1	1	1.5	1.1	0.007	0.083
19	25	Dummy	0	0	0	0.0	—	—
20	21	E&H rework	1	2	4	2.2	0.250	0.500
20	22	Timer rework	1	4	5	3.7	0.444	0.667
21	31	E&H fabrication	5	6	7	6.0	0.111	0.333
22	28	Dummy	0	0	0	0.0	—	—
23	24	Dummy	0	0	0	0.0	—	—
24	25	Test data logic	1	2	2.5	1.9	0.063	0.250
25	27	Rework signal converter rework	2	5	6	4.7	0.444	0.667
25	28	Rework comparator logic	3	7	8	6.5	0.694	0.833
27	30	Fab signal converter	4	5	6	5.0	0.111	0.333

i	*j*	Activity Description	a	M	b	Mean	Var	SD
28	29	Fab comparator	4	5	6	5.0	0.111	0.333
29	35	Dummy	0	0	0	0.0	—	—
30	35	Dummy	0	0	0	0.0	—	—
31	35	Dummy	0	0	0	0.0	—	—
32	33	Lens mfg.	9	12	30	14.5	12.250	3.500
33	39	Fab lens assembly	3	6	9	6.0	1.000	1.000
34	35	Dummy	0	0	0	0.0	—	—
35	41	Elect. compatibility test	1	3	3.5	2.8	0.174	0.417
37	38	Test tape recorder	0.5	1	2	1.1	0.063	0.250
38	49	Dummy	0	0	0	0.0	—	—
39	40	Test optics	1	2	3	2.0	0.111	0.333
40	41	Dummy	0	0	0	0.0	—	—
41	42	Camera assembly	1	2	3	2.0	0.111	0.333
42	49	Test camera and demo [end critical path]	5	7	7.5	6.8	0.174	0.417
45	47	Eng. console final	7	8	11	8.3	0.444	0.667
47	48	Fab console	3	4	5	4.0	0.111	0.333
48	49	Dummy	0	0	0	0.0	—	—
49	50	System assembly	1	2	2	1.8	0.028	0.167
50	51	Final checkout and end project	1	1	10	2.5	2.250	1.500

The above three time estimates for activity durations (a, M, b) were assessed subjectively based on the expert judgment of ClarityTech engineers (in units of weeks) as follows:

- a = optimistic activity duration—the shortest duration the activity could have.
- M= most likely activity duration—the most probable duration for the activity.
- b = pessimistic activity duration—the longest duration the activity could have.

PERT formulas used to estimate the mean and standard deviation of activity durations:

- Mean = Expected value of activity duration = (a + 4M + b) / 6
- SD = Standard deviation of activity duration = (b – a) / 6
- Var = Variance of activity duration = SD^2

EXHIBIT 3
VISIONREADER — CLARITYTECH LLC

WORK PACKAGE COST ESTIMATES WITH CHARGE NUMBERS AND EVENTS

Charge Number	Work Package	Events	Estimated Costs ($)
931J-01A()	Systems engineering*	01-02	$8,520
931J-01B()	Engineer comparator logic*	02-24	$38,300
931J-01C()	Engineer comparator master timer*	02-19	$15,630
931J-01D()	Engineer scan. generator*	05-12	$27,880
931J-01E()	Engineer sync. generator*	03-09	$7,180
931J-01F()	Engineer blanking amplifier*	04-10	$12,210
931J-01G()	Design optics*	02-32	$10,900
931J-01H()	Engineer E&H unit*	02-16	$12,200
931J-01I()	Rework converter*	25-27	$8,560
931J-01J()	Rework comparator logic*	25-28	$11,500
931J-01K()	Rework comparator master timer*	20-22	$6,240
931J-01L()	Rework E&H unit*	20-21	$4,080
931J-01M()	Rework camera electr.* (scan amp, blank amp and sync gen)	13-14	$35,000
931J-01N()	Preliminary console engineering and design*	02-45	$15,800
931J-01O()	Final console engineering*	45-47	$15,760
931J-01P()	Assembly, camera*	41-42	$2,650
931J-01Q()	Assembly, total system into console*	49-50	$8,701
931J-01R()	Engineer signal converter*	02-23	$22,300
931J-01S()	Purchase video amplifier	02-34	$5,000
931J-01T()	Purchase tape recorder	02-37	$34,000
931J-01U()	Purchase orthicon image tube and power supply	02-06, 02-08	$11,300
931J-01V()	Program management. Program manager and staff*		$154,000
931J-01W()	General material and supplies (technical)		$13,250
931J-01X()	Test and check out*		$32,783
931J-01Y()	Manufacturing (labor and material)		$28,342
931J-01Z()	Handbooks		$10,000
	TOTAL		$552,086

All costs include labor and materials plus allocated overhead, but no G&A allocation.
*Work package cost estimates include labor and overhead only. Material is separately charged.

EXHIBIT 4
VISIONREADER — CLARITYTECH LLC

LIST OF ACTIVITIES THAT CAN BE ACCELERATED AND ACCELERATION COST PER WEEK

Activities	Cost per Week of Acceleration	Current “Most Likely Duration, M” (weeks)	Minimum possible “Most Likely Duration, M” with Acceleration (weeks)
02-16	$7,124	6	5
02-24	3,750	11	9
02-19	6,320	10	9
02-23	3,465	11	9
03-09	5,132	5	4
04-10	7,124	5	4.5
05-12	6,980	8	6.5
14-35	11,000	10	8
21-31	3,100	6	5.5
27-30	2,463	5	4.5
28-29	3,000	5	4.5
42-49	19,440	7	6
45-47	1,100	8	6
47-48	2,100	4	3

M = Mode = Most likely activity duration (see Exhibit 2)

EXHIBIT 5
VISIONREADER — CLARITYTECH LLC

EXTRACT FROM
SLACK ORDER REPORT FOR VISIONREADER*

PERT System - VisionReader **Slack Order Report** **Date: June 1, 1967**

Event	TE	TL	TL-TE	TS	PR
01	0.0	0.5	+0.5		
02	2.0	2.5	+0.5		
05	7.7	8.2	+0.5		
12	15.7	16.2	+0.5		
13	16.9	17.4	+0.5		
14	21.9	22.4	+0.5		
35	31.9	32.4	+0.5		
41	34.7	35.2	+0.5		
42	36.7	37.2	+0.5		
49	43.5	44.0	+0.5	44	0.70
32	11.8	12.7	+0.9		
33	26.3	27.2	+0.9		
39	32.3	33.2	+0.9		
40	34.3	35.2	+0.9		

* Partial list only. Remainder of figures purposely omitted.

TE	Earliest time in weeks from start of project by which event may be completed.
TL	Latest time from start of project by which event may be completed if project is to be completed on time.
TL-TE	"Event slack time". Represents time that may be used at the discretion of management in scheduling resources. Positive (+) slack is favorable, negative slack time (-) represents slippage already occurred.
TS	The time of the scheduled demonstration as required by the VisionReader contract. It effectively represents the end of the critical path.
PR	The probability of "completing the sequence of events ending in the event adjacent to the PR", on or before the scheduled completion time for that event (TS). It is computed from variances of the activities in the sequence.

EXHIBIT 6
VISIONREADER — CLARITYTECH LLC

EXTRACT FROM
SLACK ORDER REPORT FOR VISIONREADER

(From trial run in which sub-path 2-5-12-13-14-35 is accelerated and is no longer critical.)

Date June 1, 1967 **Weeks elapsed since project start: 6**

Event	TE	TL	TL-TE	TS	PR
01	0.0	0.9	+0.9		
02	2.0	2.9	+0.9		
32	11.8	12.7	+0.9		
33	26.3	27.2	+0.9		
39	32.3	33.2	+0.9		
40	34.3	35.2	+0.9		
41	34.3	35.2	+0.9		
42	36.3	37.2	+0.9		
49	43.1	44.0	+0.9	44	0.61

TE Earliest time in weeks from start of project by which event may be completed.
TL Latest time from start of project by which event may be completed if project is to be completed on time.
TL-TE "Event slack time". Represents time that may be used at the discretion of management in scheduling resources. Positive (+) slack is favorable, negative slack time (-) represents slippage already occurred.
TS The time of the scheduled demonstration as required by the VisionReader contract. It effectively represents the end of the critical path.
PR The probability of "completing the sequence of events ending in the event adjacent to the PR", on or before the scheduled completion time for that event (TS). It is computed from variances of the activities in the sequence.

EXHIBIT 7
VISIONREADER — CLARITYTECH LLC

VISIONREADER PROJECT STATUS REPORT

VisionReader **Date June 2, 1967** **Weeks elapsed since project start: 6**

Charge No.	Event		Date Com-pleted	Scheduled Completion Date		Slack	Actual Cost to Date*	Estimate	Revised Estimate	(Overrun) (Underrun)
	Begin	End		Earliest	Latest					
931J-01A	1	2	2	2	2	0	$9,642	$8,520		($1,122)
931J-01R	2	23		13	18	5		22,300		
931J-01D	2	11		16	16	0	3,658	27,880		
931J-01F	2	10		13	16	3	743	12,210		
931J-01B	2	17		13	18	5	22,646	38,300		
931J-01E	2	9		10	16	6	2,870	7,180		
931J-01G	2	32		12	15	3	5,940	10,900		
931J-01H	2	16		8	20	12	4,150	12,200		
931J-01C	2	18		12	20	8	1,100	15,630		

*Taken from charge number cost summaries (Exhibit 8).
All times shown in weeks.

EXHIBIT 8
VISIONREADER — CLARITYTECH LLC

CHARGE NUMBER COST SUMMARIES FOR VISIONREADER

Date June 2, 1967 **Sample Cost Summaries** **Charge No. 931J-01()**

Charge No.	Cost Previous Reporting Periods	Cost This Period	Total Costs To Date	
931J-01A-1	$2,132.26		$2,132.26	Engineering
931J-01A-2	486.23		486.23	Design
931J-01A-3	410.20		410.20	Drafting
931J-01A-8	111.31		111.31	Quality control
931J-01A-9	1,000.00		1,000.00	(94328 Consultant fee)
overhead	5,502.00		5,502.00	
Total	$9,642.00		$9,642.00	
931J-01D-1	$57.21	$1,121.78	$1,178.99	
931J-D1D-3		151.23	151.23	
overhead	$100.12	2,227.77	2,327.89	
Total	$157.33	$3,500.78	$3,658.11	
931J-01F-1		$271.12	$271.12	
overhead		471.92	471.92	
Total		$743.04	$743.04	
931J-01V-1	$5,455.01	$1,420.11	$6,875.12	
overhead	9,546.27	2,485.19	12,031.46	
Total	$15,001.28	$3,905.30	$18,906.58	