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Quantitative Analysis of Nuclear Power Plant Licensing Reform

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QUANTITATIVE ANALYSIS OF NUCLEAR POWER PLANT LICENSING REFORM

by

Robert H. Drake, Myron L. Stein, Carolyn A. Mangeng, and Gary R. Thayer

ABSTRACT

A model is presented that analyzes the licensing and construction process for commercial nuclear power plants. A regulatory reform package being proposed by DOE is analyzed and found to reduce average nuclear construction time from 12.7 to 7.5 years and to reduce capital costs from $1342/kW to $964/kW (1981$).

I. INTRODUCTION

The purpose of this project is to model the licensing and construction process for commercial nuclear power plants, to gather appropriate time and cost data for this process, and to analyze the quantitative effects of proposed nuclear regulatory reforms. A model is a theory that simplifies and abstracts from the real world. Our model cannot be an exact duplicate of reality because it would become too complicated to use. We have constructed a model that neglects irrelevant and unimportant questions, but the major factors seriously affecting licensing and construction phenomena are included. The purpose of the model is to make predictions about the real world, and we are confident that the level of detail included is sufficient to accomplish this reliably.

The model we created uses computer network simulation techniques to analyze project evaluation and review technique (PERT) charts. The computer code identifies milestone data, activity durations, and critical path information. The model uses probabilistic data and operates in Monte Carlo fashion. The Monte Carlo technique repeats the same calculation many times using different values selected from probability distributions for those variables whose true value is not an exact number.

The code computes total capital construction costs including interest, nuclear plant cost escalation, and inflation. It distinguishes between overhead and direct costs so that cost corrections are automatically made when times vary with each Monte Carlo pass. It also spreads normalized cash flow curves for different phases of construction to fit each activity duration time for particular Monte Carlo passes.

Basic data were gathered from the Nuclear Regulatory Commission (NRC), Department of Energy (DOE), Electric Power Research Institute (EPRI), Atomic Industrial Forum (AIF), Edison Electric Institute (EEI), Oak Ridge National Laboratory (ORNL), private utilities, and others. These data were processed into appropriate statistical form to be used with our computer code. They are representative of current nuclear industry conditions and identify changes that occur with different regulatory structures.

We have specifically analyzed a package of nuclear regulatory reforms that is being proposed by DOE.* Although our analysis is specific to these particular reforms, the reader can easily recognize that the reform proposals of the other major reform task forces at NRC and AIF are fundamentally similar to the DOE package.[1-2] Therefore, the relative importance of the various "standardization," "site banking," "one-step licensing" and other variations of generic reform can be evaluated reasonably well simply by reference to our quantitative results.

The total DOE reform package reduces average project time from 12.7 to 7.5 years and saves about 28% of today's nuclear plant capital cost. A summary of individual reform cost and time savings is shown in Table XIII in Sec. IV. The sections that follow provide details about the methods we used to generate our results, how to interpret these results, and their underlying significance.

This research was limited to the evaluation of quantitative cost and time savings attributable to proposed licensing reform. We recognize that other major factors may be largely responsible for the rising nuclear plant capital costs and construction delays currently receiving such wide

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*Stephen H. Greenleigh, "Report of DOE Task Force on Nuclear Licensing and Regulatory Reform," DOE internal document, April 1982. Also, "Nuclear Licensing and Regulatory Reform Act of 1982," draft legislation.

attention. We have not tried to evaluate the causes of, remedies for, or potential savings from dealing with the nonregulatory problems. Delays resulting from reduced rates of electricity demand growth, utility financing problems, environmental concerns, the public furor over nuclear power safety, and other sources of industry problems are not evaluated in this report. We have measured the gains that can reasonably be expected from specific nuclear power plant licensing reforms. These benefits are substantial and represent a positive contribution to efficiency of the nuclear construction process that is needed in conjunction with the resolution of the nonregulatory problems.

II. DESCRIPTION OF MODEL

The model developed to calculate nuclear plant capital costs is structured around PERT charts of the licensing and construction process. A PERT chart displays individual project activities showing their sequence and interrelationships. They are a particularly suitable base from which to model the nuclear regulatory reform process, which produces modifications in the basic system of constructing nuclear plants. It involves potential changes in the activities that will be performed and in their sequence. These fundamental changes are easily modeled by modifying PERT charts. The important quantification of time and cost savings can be accomplished by a model designed to analyze PERT charts.

A simplified schematic concept of our model is shown in Fig. II-1. The basic PERT chart is at the core of each calculation. Other basic information for each case includes the individual activity times and the direct construction costs. These basic data are processed by the model, and standard parameters for interest rates, nuclear construction escalation, and inflation are applied to produce bottom-line time and capital cost outputs. The model is necessarily probabilistic in order for it to deal realistically with the effects of licensing reform. Actual nuclear construction and licensing activities are subject to wide ranges in duration times that are not adequately represented by mean values. This means that the same activities will not always be on the critical

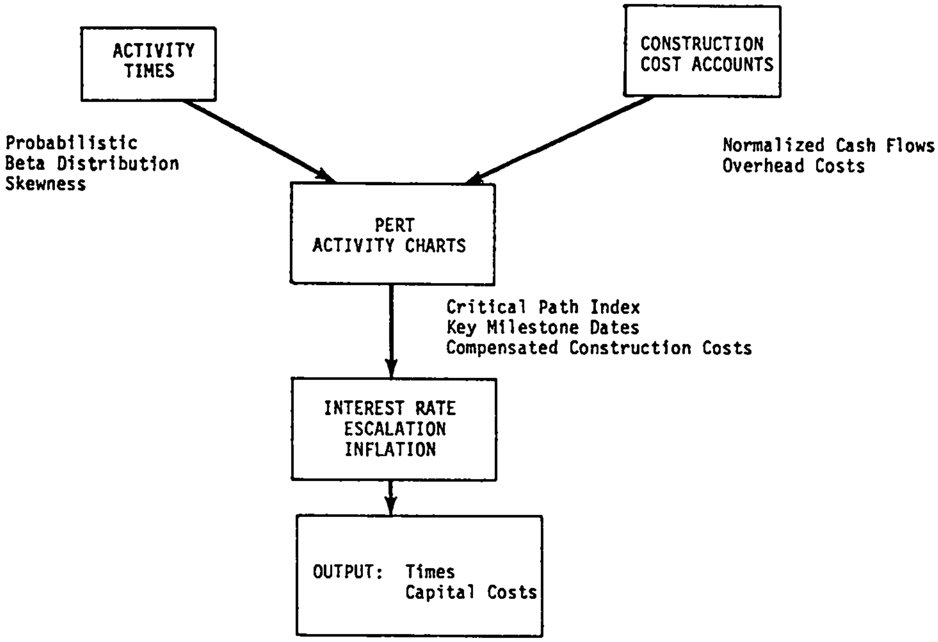


Fig. II-1. Monte Carlo modeling of nuclear licensing and construction process.

path.* It also means that overhead costs associated only with the passing of time will vary for each activity and for the process as a whole. The probabilistic nature of this process is handled by running the model in Monte Carlo fashion for each case analyzed. By repeatedly analyzing each case while picking different sets of data from the input probability distributions, much more realistic final time and cost figures are calculated.

The starting point for analyzing each nuclear reform case is to create a PERT chart of the process. Actual charts are presented in Secs. III.B.1-12. The next step is to select activity duration time input data for each activity on the chart. This is the step where probabalistic data are entered into the model. It is the nature of many activities that their time distributions are highly skewed. Normal expected times are likely to have a range that does not allow much saving, but a few occurrences may cause a much longer duration time. Examples would be public hearings that typically take three months,

*Critical activities are those whose delay will cause an equal delay in the completion of the project. That path through the network that consists of all such activities is the "critical path."

rarely less time, and sometimes take as much as a year when strong intervention occurs; or construction work that may be speeded or slowed by weather but is always slowed by labor strikes. This property of skewness makes it unsuitable to simply try to use average times to model regulatory reform. Our model uses an approximation to a beta distribution for all input time data. A beta distribution is appropriate because it allows for skewed data, and it has finite beginning and ending points. Figure II-2 shows a typical beta distribution for an input time activity duration, construction permit environmental (C.P. Environmental). The beta distribution is the most correct theoretical distribution for activity duration times and is well accepted as the standard way to handle probabilistic data in PERT models.[3-4] For computational purposes in Monte Carlo PERT models, the beta distribution is generally approximated by a triangular distribution. We use a triangular distribution for economy of calculation, and because for our size model with 10 000 Monte Carlo passes, the final results are not significantly affected.[5]

In our computer model the input times for each activity are presented in the form of three point estimates: shortest, most likely, and longest. The computer automatically fits these point inputs to a probability distribution for use in the Monte Carlo runs. Tables of actual input data are shown in Secs. III.B.1-12. The tables contain the beginning and ending node numbers (as shown on the PERT chart) for each activity, the three point estimates of the time distribution, and the activity name (Table I-a). Some of the activities, labeled "dummy," are simply activities required by the PERT computer algorithm

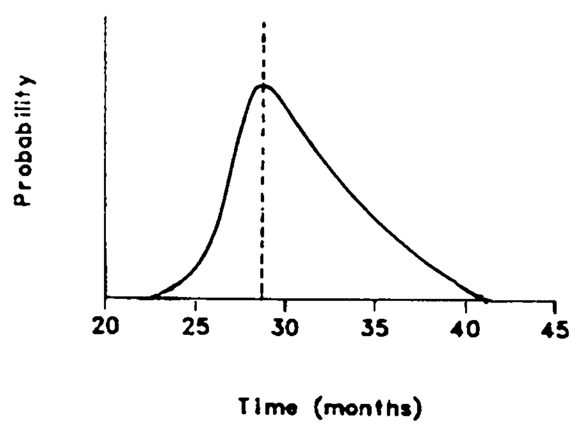


Fig. II-2. "C.P. Environmental" activity duration time for the base case.

in cases where we would otherwise have two or more parallel activities directly connected between identical nodes without any intervening nodes for either activity path.

The first computational step in the computer model is to process the input time data to identify duration time totals and specific milestone dates throughout the PERT chart (Fig. III-1). (A cost computation using time information follows immediately and will be described in detail later.) The PERT charts shown in Figs. III.1-12 result from this calculation as are the output tables in Sec. III. The times and dates actually printed are based on averages. In reality the computation is repeated Monte Carlo fashion (usually 10 000 times for each case), and for each individual run the times differ somewhat from those printed on the charts and tables. The individual activity durations listed on the output tables are averages and, if summed along the critical path, will not generally add up to the Monte Carlo time (Table I-b). The Monte Carlo time is the true average computed value of total project duration and correctly captures the effects of skewness in activity times.

The standard deviation computed for time is not the result of a statistical inference process, but rather indicates typical variations in project times for normal licensing and construction projects and applies to an entire population of hypothetical future nuclear plants. It highlights inherent uncertainties and shows that concentrating only on average outcomes ignores important information about real variances in even typical construction programs. This same concept shows up in the "criticality index" on the far right of the output tables. This index shows the fraction of cases in which a particular activity is on the critical path. For example, in the base case, Table I-b, C.P. Environmental is on the critical path 67% of the time, but C.P. Safety replaces it on the critical path 33% of the time. This is important information gained from Monte Carlo modeling, which avoids the trap of having to define a single critical path found in most nuclear reform analyses. (The dotted line critical path on the PERT chart printout is the most frequently occurring combination of critical path activities.)

The key milestone times computed in the PERT chart analysis are used in computing capital costs. The starting input data for computing costs are the standard direct construction cost accounts taken from Refs. 6-7. The costs are all based on a pressurized water reactor (PWR) design of 1139 MW(e).

The cost and timing of the cash flow for reactor construction were obtained from two sources. The base costs are from United Engineers and Constructors (UE&C) estimates of reactor costs for the Energy Economic Data Base Program, and the timing of the cash flow is from "Power Plant Capital Investment Cost Estimates: Current Trends and Sensitivity to Economic Parameters," an Oak Ridge National Laboratory report that is based on the UE&C data.

Because Oak Ridge determined that an additional "owners' cost" was not included in the UE&C data, we included such an extra cost item in our report. The overhead portion of the total cost was derived from the detailed accounts provided by the UE&C report. UE&C separated the reactor capital costs into 10 accounts, including the additional account added for owners' costs. The timing of the expenditures in each account, given in the Oak Ridge report, was used in our calculations. First, an overhead fraction was determined for each of the 10 accounts. Then, to give a weighted overhead fraction for the total cost, each fraction was multiplied by the fraction of the total cost represented by the particular account. This calculation was done for both the preconstruction permit phase and the construction phase. The sum of the individual weighted overhead fractions was used as the overhead factor in the model.

The construction cost accounts include all payments to vendors, contractors, employees, and managers in constant 1981$. They do not include interest, escalation, or inflation. The costs are translated into normalized cash flow curves such as shown in Fig. II-3. The timing of direct cash flow is needed for subsequent interest, escalation, and inflation calculations. These direct, normalized cash flow curves are split into four different time periods between key milestone dates encompassing the entire project. They are then renormalized so that cash flow can be modified according to delays at specific stages of the construction process, as shown for two different time periods in Fig. II-4.

The first computation on each Monte Carlo pass takes the renormalized cash flow curves and modifies them in two ways: (1) the curves are fitted to actual key dates--they are stretched horizontally to fit the actual duration time, and (2) the amount of total cash outlay is changed to reflect increased overhead cost of longer times or decreased costs of shorter times--the curves are individually stretched vertically. The information on overhead costs is taken from the detailed cost accounts and stored for use in modifying total

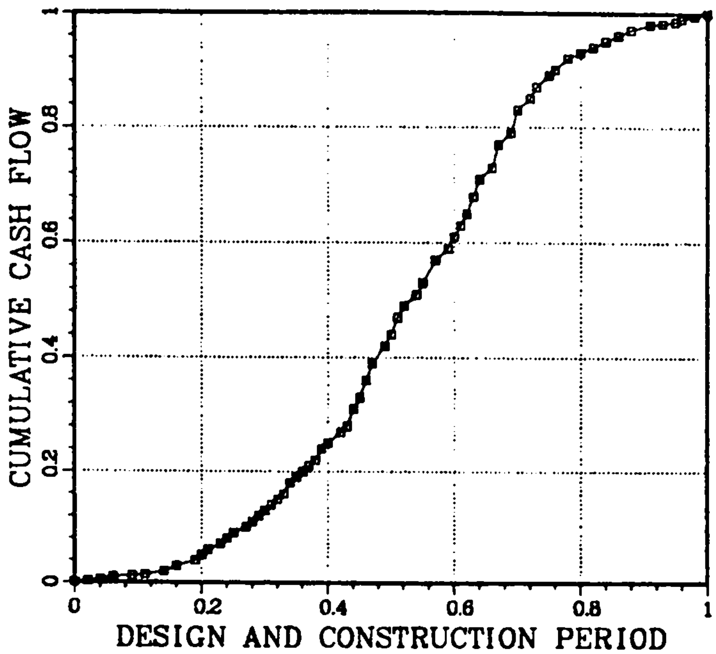
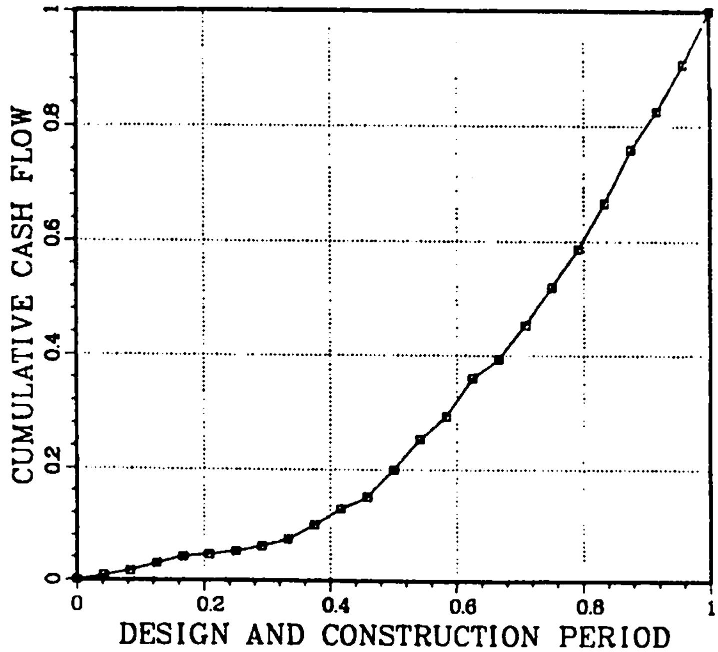


Fig. II-3. Normalized cash flow curve for nuclear plants.

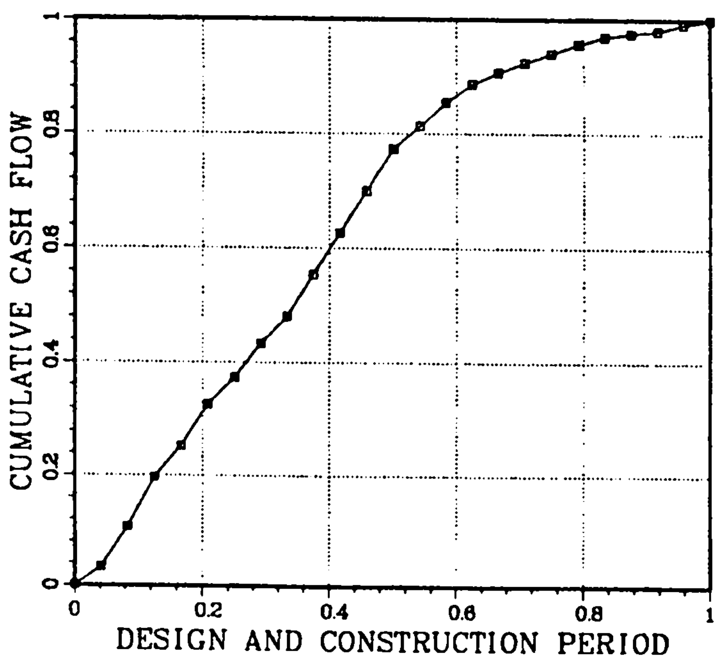
standard costs as time changes with each Monte Carlo pass. (The percentage of overhead costs is different in each of the four sets of renormalized cash flow curves.) This is another place where the skewness of the time distribution has important bottom-line effects. Cost effects of delays caused by regulatory proceedings are accurately measured by the model's close control of actual cash outlay times and by its distinction between time-dependent overhead and other direct costs.

Direct cash outlays are computed for each of 72 time intervals in the model, which provides more than adequate precision in both timing and level of outlays. Using this information, we add and compound interest, escalation, and inflation computations to produce the final capital cost figures shown in the output tables. As with the time results, the standard deviation of capital costs represents a measure of the normal variability to be expected even for typical plants and shows the spread of the total population of plants.

The times shown on output tables are measured from the time of initially deciding to build a plant until the start of commercial operation (from "Decision to Build" to "Commercial Operation Started"). This entire period requires accurate modeling to compute correctly the total capital cost.



(a) Time period 0.0 - 0.4.



(b) Time period 0.4 - 1.0.

Fig. II-4. Renormalized cash flow curves.

However, the times shown are more comprehensive and therefore longer than the more commonly given measures of time described in discussions of nuclear construction or of regulatory reform. The latter times usually consider only the time from the construction permit application until operating license granting ("C.P. Application" to "O.L. Granting"). We have included the more common measure of time in our summary of results although our cost information continues to be based on the more comprehensive time period for a more accurate modeling of total capital costs. To compute capital costs and either measure of project length, we used Monte Carlo times to capture correctly uncertainty and skewness effects.

III. APPLICATION OF MODEL

A. Data Development

The computational power of our model requires detailed time and cost input data. The choice of data sources is critical to the quality and proper applications of our results. In selecting input data, we were careful to keep in mind the overall purpose of the applications and the use for our quantitative results. Because the results will be used to evaluate changes in the current and future nuclear power plant licensing process, outdated historical data are unsuitable to use. Even current data that are unrepresentative of present normal conditions are inappropriate to use as part of the process of designing new legislation or other rules to be applied in the future.

Our basic philosophy is to screen data sources to the point of including only what should represent normal times and costs (including normal variations) for the current licensing and construction process. Our normal cost data come from Refs. 6-7. Cost data are intended to cover a typical new nuclear plant including current contingency costs resulting from typical construction and licensing problems. Our PERT chart information and most time duration data come from current NRC licensing and construction status books[8-12] and other sources as applicable.[13-24]

How we implemented our data processing philosophy is shown by the development of our base case construction time durations. Using the December 1981 "Nuclear Power Plants Construction Status Report" (Ref. 8), we computed duration times for 61 plants currently under construction. These plants include some with unusual problems, such as Diablo Canyon (major seismic and quality assurance holdups), or Washington Nuclear (major holdups for reevaluation of cost and need for power). Also, some plants are included that have been under construction long enough to have escaped some of today's typical delays.

Several methods of screening out clearly atypical plants from this data set were considered. Although the most satisfactory possibility would be to use direct information about each plant to eliminate those with major problems, such as deliberate delays because of financing or lack of demand, the information publicly reported by utilities is inadequate to make judgments. Often the information is simply not reported. When it is reported, it may not be fully accurate because of utility perceptions about where to place the responsibility for actual schedule slippages.

To avoid subjective bias in data interpretation and to adhere to a philosophy of obtaining representative data for a normal new plant today, we eliminated the atypical outliers in the data by mathematical means. We examined statistics for the entire data set and subsets of the data. The central tendency of the data was not significantly changed by various mechanically selected screenings of plants although the spread of all possible construction times was smaller as more plants were excluded.

Our technique resulted in our not using the data from plants with the 15 longest and 15 shortest construction times, which still left a group of 31 projects from which to derive a data distribution. Construction activity duration times for these 31 plants were statistically smoothed to fit a beta distribution using a nonlinear curve-fitting program developed at Los Alamos. The distribution parameters were then checked with a second curve-fitting algorithm designed specifically for beta distributions.[25] The fitted curves were converted to our three-point triangular distribution input format for computer use. The shortest, most likely, and longest points in the distribution that resulted were 79, 109, and 143 months.

By using mathematical screening in deciding how to eliminate outliers, we avoided subjective manipulation of the data, yet by reviewing several such alternative mechanical screening processes, we retained some judgement in trying to keep our data genuinely representative. We believe that the statistics actually used in our time and cost savings calculations are the most representative set for normal, contemporary plants. Of course, our actual goal was to derive a hypothetical distribution that represents current and likely foreseeable future conditions. For this purpose we can use only the publicly available data as a guide to deriving the distributions needed to evaluate future changes in the construction and licensing process.

In Appendix A we present bottom-line licensing reform results using alternative data-screening processes. We include both the results using all of the 61 plants currently reported as under construction as well as the group of central 45 plants. The appendix clearly shows that the relative importance of different licensing reforms is not affected by the particular set or subset of data used for calculations.

The philosophy of trying to use only currently applicable data and screening to eliminate nonrepresentative plants was consistently applied to all input data. This process should be borne in mind when interpreting our results. The results are intended to apply only to a fairly normal plant of the present and future; they are not applicable to the past, and they do not apply to plants involved in extraordinary circumstances.

The reported standard deviations show the variation expected throughout the entire population of nuclear plants. They do not reflect uncertainties surrounding a particular set of reforms as they apply to an individual plant.

B. Analysis of DOE Reform Proposals

We used our model to analyze specific nuclear power plant licensing regulatory reform proposals as described in the DOE task force report and draft legislation (see footnote on p. 2). We called together a committee to discuss how to interpret each reform, what data were to be used, and how to perform the necessary calculations. The committee members were an economist, a nuclear engineer, a computer scientist, and a political scientist. Other supporting personnel were requested to provide input as needed.

A critical program review of our methodology and results was held on April 9, 1982 at Los Alamos. About 20 technical and management personnel attended the review. Included were the Associate Director for Energy Programs, Deputy Associate Director for International Affairs and Energy Policy, Deputy Associate Director for Nuclear Programs, Program Manager for Reactor Safety Applications, Deputy Division Leader of the Analysis and Assessment Division, Economics Group Leader, Energy Technologies Deputy Group Leader, and technical staff members from a variety of groups.

A second review was held with DOE personnel including members of the task force on nuclear licensing and regulatory reform on May 21, 1982 at Washington, D.C.

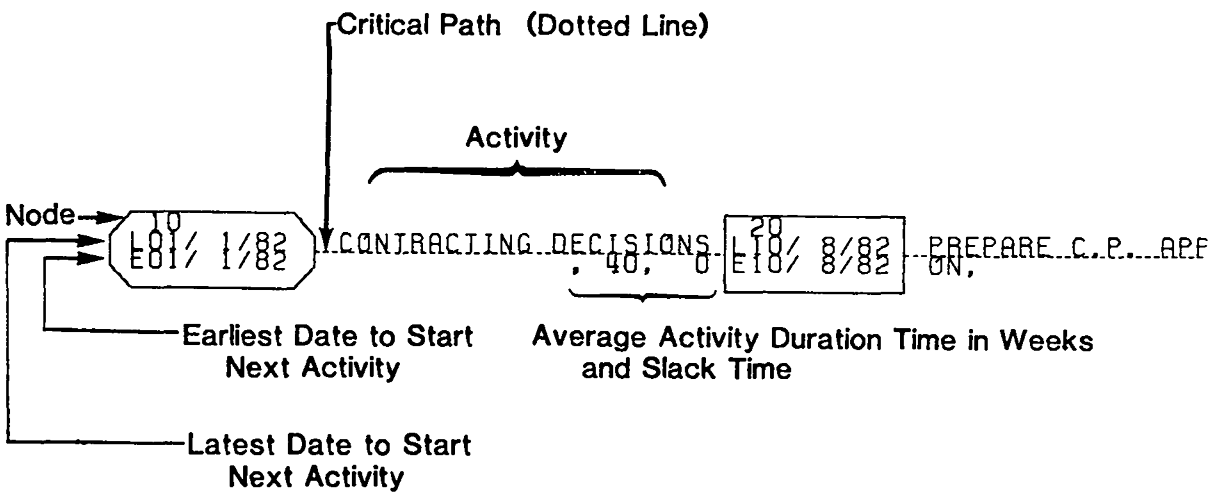
A third review was conducted by a staff member from Argonne National Laboratory, a staff member from Brookhaven National Laboratory, and a DOE staff member. They reviewed the work before the meetings and discussions held at Los Alamos June 8-9, 1982.

The critical comments from all of the reviews were constructive and have been incorporated into the work presented here, including Appendixes A and B.

In the sections that follow, a short narrative describes the major changes that we incorporated into each reform calculation. For each case, an input data table, a PERT chart, and an output data table are shown.

In each input data table, node numbers mark the milestones that also appear on each PERT chart. Times are in months in these tables although they are in weeks in the PERT charts. The input data tables show three point estimates that are used by the computer to generate a probability distribution. The three times are respectively the shortest, most likely, and longest.

The following display shows how to read the PERT chart information:



In each output data table the same node numbers and activities are listed as appear on the corresponding input data table and PERT chart. The early start time shows the earliest time each activity can start without changing the normal shortest critical path. The late finish time shows the latest time each activity can be completed without changing the normal shortest critical path.

The tabulated duration and standard deviation for each activity are simple statistics based on the input probability distribution for each activity. They are not based on Monte Carlo times and will not generally add along the critical path to the computed Monte Carlo time.

The criticality index shows the fraction of times each activity is on the critical path when all activities are modeled in Monte Carlo fashion.

The bottom-line costs are shown in current dollars (nominal dollars summed over the entire project starting from Jan. 1, 1982 until completion at a 7% inflation rate). Costs are also shown in constant 1981 dollars for more meaningful comparisons and analysis.

1. Base Case: Current Licensing and Construction Process. The base case cost and time calculations are generated from a consistent set of current data as previously described (Sec. III.A and Appendix A). The reforms to the current licensing and construction process that follow are analyzed using the same basic data sources. However, because hard data cannot be found for procedures and processes that do not yet exist, we have modified existing cost and time data as necessary to reflect predictable changes that will result from reforms.

The computed costs and savings are intended to account only for utility capital costs. They do not include any additional charges or savings that might accrue to the NRC, state agencies, or other parties to the nuclear construction process.

TABLE I-a

INPUT DATA FOR CURRENT LICENSING AND CONSTRUCTION PROCESS
(Base Case)

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	30	36	48	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	54	O.L. ENVIRONMENTAL
90	110	48	54	64	O.L. SAFETY
90	120	79	109	143	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

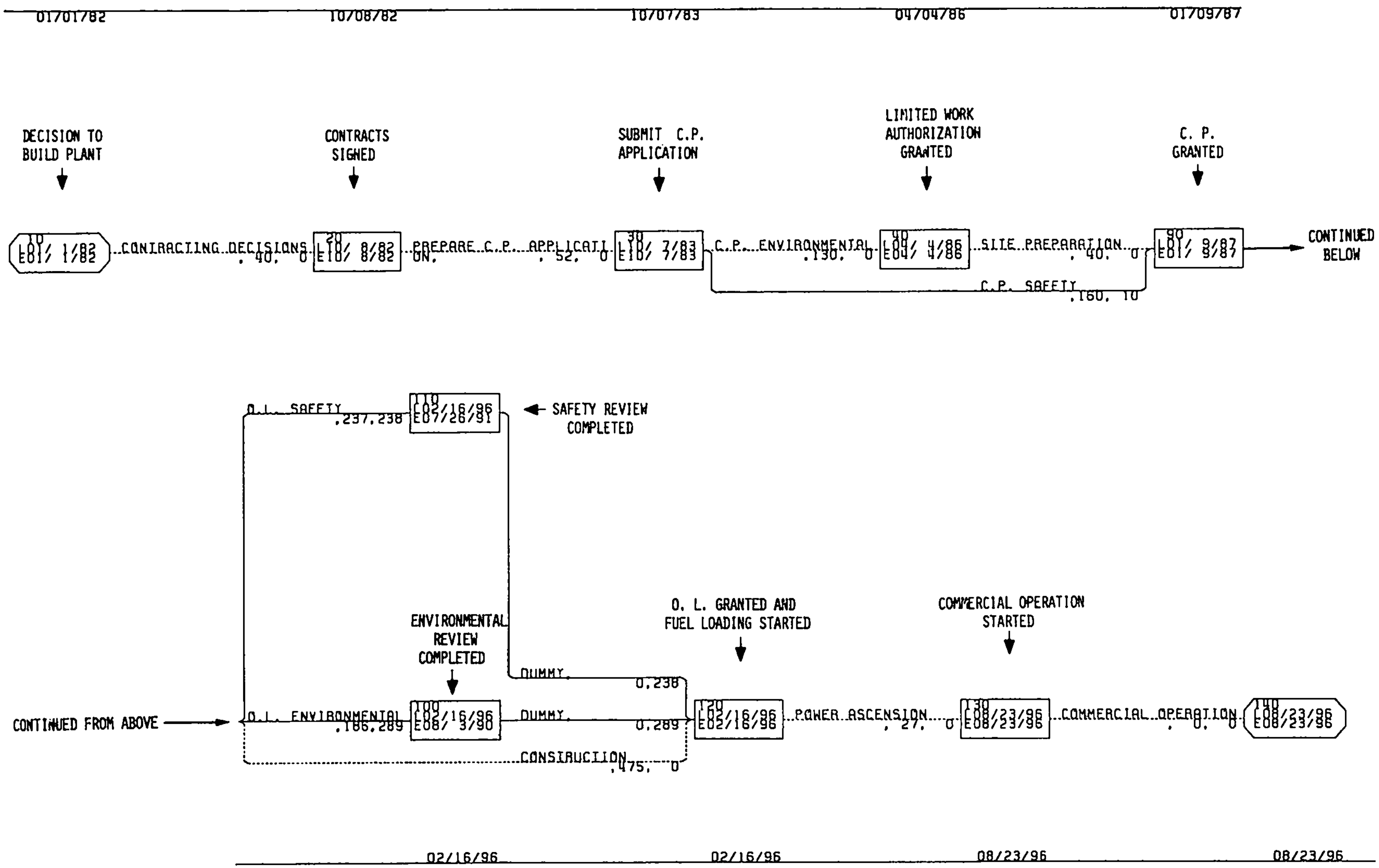


Fig. III-1. Current licensing and construction process (base case).

TABLE I-b

OUTPUT DATA FOR CURRENT LICENSING AND CONSTRUCTION PROCESS (Base Case)

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.095 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	21.33	12.00	1.00	1.000
C.P. ENVIRONME	30	40	21.33	51.33	30.00	3.00	0.674
C.P. SAFETY	30	90	21.33	60.50	37.00	3.00	0.326
SITE PREPARATI	40	90	51.33	60.50	9.17	0.83	0.674
O.L. ENVIRONME	90	100	60.50	170.17	43.00	3.00	0.000
O.L. SAFETY	90	110	60.50	170.17	54.67	2.67	0.000
CONSTRUCTION	90	120	60.50	170.17	109.67	10.67	1.000
DUMMY	100	120	103.50	170.17	0.00	0.00	0.000
DUMMY	110	120	115.17	170.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	170.17	176.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	176.50	176.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 180.232 (MONTHS)
CP STANDARD DEVIATION = 13.751

TOTAL COST = 4.389 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.540

TOTAL COST = 1.528 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.066

2. Early Site Permit Reform. We interpret this reform to mean that an approved site is available before the plant-specific licensing process begins. The PERT chart (Fig. III-2) is modified by eliminating environmental reviews at both construction permit and operating license stages. We assume that the optional public hearings could be held concurrently with the safety hearings already included in C.P. Safety and so they do not appear individually on the chart. Additional time savings of two months would be realized during the construction permit application preparation activity while parallel safety work continues as at present. Direct cost reductions of $13 million occur because of eliminated environmental impact statement (EIS) expense and slightly lower overhead costs from time savings.

Total project cost savings from the base case are $35 million (1981$)--only 2% of current costs. The savings are small because the elimination of environmental reviews in the absence of any change in the parallel safety reviews does little to change the overall process time.

In evaluating this reform, as with all others, we are considering only utility costs. We have made the strong assumption that the preapproved site was approved through the use of something like a pool of industry funds or state funds. (These are some of the proposals mentioned in the industry press.) If, instead, the utility must pay directly for the site certification, we would have to add the direct cost that was taken out in our calculation. Also, because the expenditures would occur before the usual licensing process (up to 10 years earlier), there would be additional interest charges. These charges would cancel the project cost savings if site certification occurs any earlier than four years before the construction permit application is made.

Clearly, there would be a negligible effect on total project costs. This reform becomes significant only when combined with preapproval of design.

TABLE II-a

INPUT DATA FOR EARLY SITE PERMIT REFORM

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	7	10	13	PREPARE C.P. APPLICATION
30	40	0	0	0	DUMMY
30	90	30	36	48	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	0	0	0	DUMMY
90	110	48	54	64	O.L. SAFETY
90	120	79	109	143	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

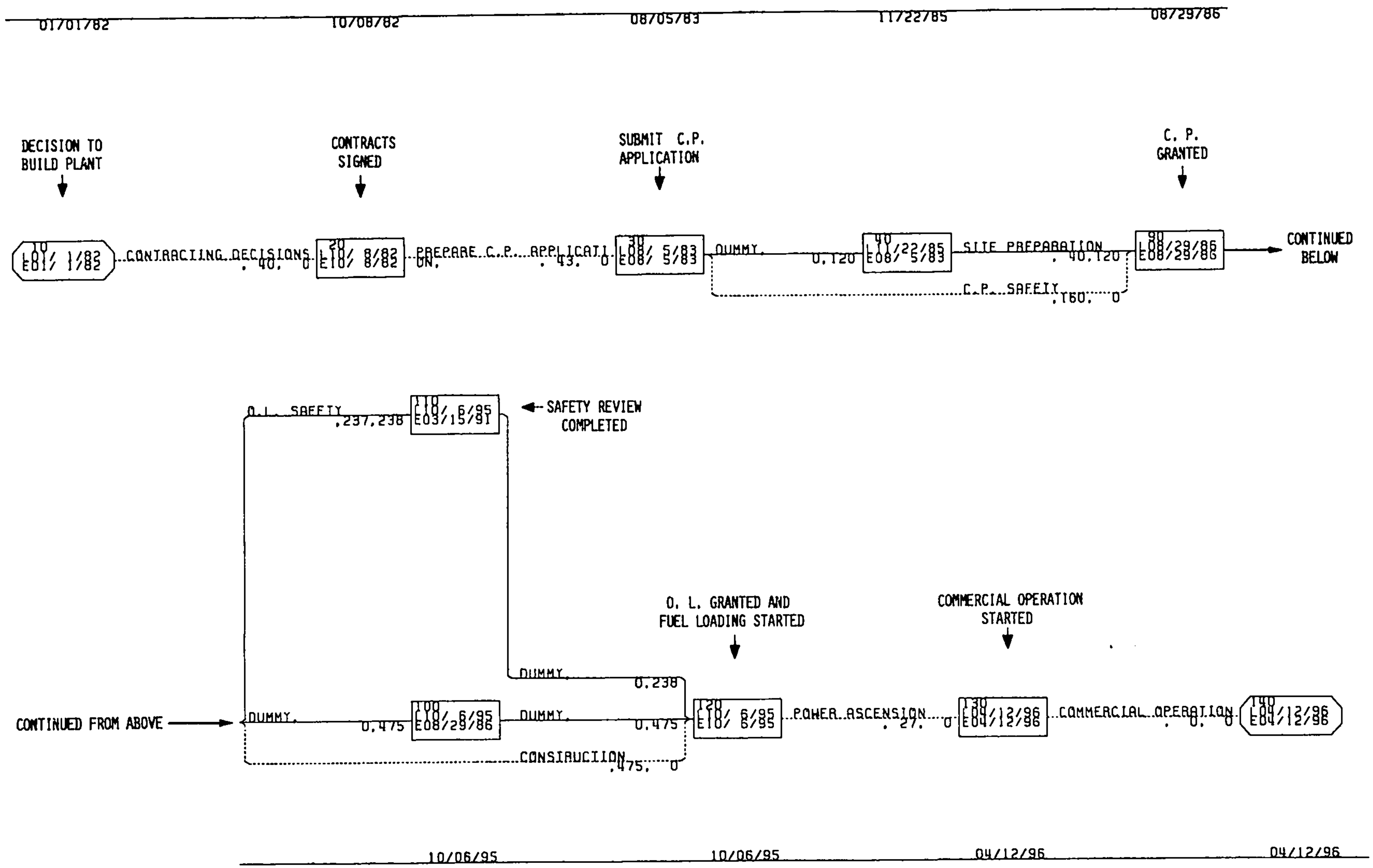


Fig. III-2. Early site permit reform.

TABLE II-b

OUTPUT DATA FOR EARLY SITE PERMIT REFORM

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.082 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	19.33	10.00	1.00	1.000
DUMMY	30	40	19.33	47.17	0.00	0.00	0.000
C.P. SAFETY	30	90	19.33	56.33	37.00	3.00	1.000
SITE PREPARATI	40	90	19.33	56.33	9.17	0.83	0.000
DUMMY	90	100	56.33	166.00	0.00	0.00	0.000
O.L. SAFETY	90	110	56 33	166.00	54.67	2.67	0.000
CONSTRUCTION	90	120	56.33	166.00	109.67	10.67	1.000
DUMMY	100	120	56.33	166.00	0.00	0.00	0.000
DUMMY	110	120	111.00	166.00	0.00	0.00	0.000
POWER ASCENSIO	120	130	166.00	172.33	6.33	1.33	1.000
COMMERCIAL OPE	130	140	172.33	172.33	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 174.649 (MONTHS)
CP STANDARD DEVIATION = 13.858

TOTAL COST = 4.152 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.517

TOTAL COST = 1.493 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.066

3. Preapproval-of-Design Reform. We interpret this reform to mean that a nuclear steam supply system (NSSS) vendor will have had a standard design certified before any contracting with the utility takes place. The PERT chart is changed by adding the optional public hearing to the beginning of the process. The hearings occur at the very start of activities because they would be the responsibility of the NSSS vendor, and detailed contracting would not start until the design had passed this stage. The contracting time is reduced by three months because of the preselection of the NSSS vendor and his role in the public hearing. The preparation time for the construction permit application is reduced by only two months because the parallel environmental activities must still take place. The construction permit and operating license safety reviews are eliminated, but have little effect on overall project time savings because of the continuing requirements for parallel environmental reviews. The construction period itself is reduced by five months as a result of "learning by doing" efficiencies resulting from vendors using the same design for several plants and from fewer supply delays. The direct construction costs are reduced by $53 million in saved engineering and other costs because they are spread over more plants of the same design and by an additional $7 million in utility overhead costs owing to a shorter construction time.

This reform saves a total of $108 million (1981$) in project capital costs. The total time savings is only 8.4 months. Only when this reform is combined with the early site permit reform do much larger time savings occur (42.1 months) and, consequently, even larger cost savings.

TABLE III-a

INPUT DATA FOR PREAPPROVAL-OF-DESIGN REFORM

Nodes		Times			Activities
10	11	0	3	6	PUBLIC HEARINGS
11	20	5	6	9	CONTRACTING DECISIONS
20	30	7	10	13	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	0	0	0	DUMMY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	54	O.L. ENVIRONMENTAL
90	110	0	0	0	DUMMY
90	120	74	104	138	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

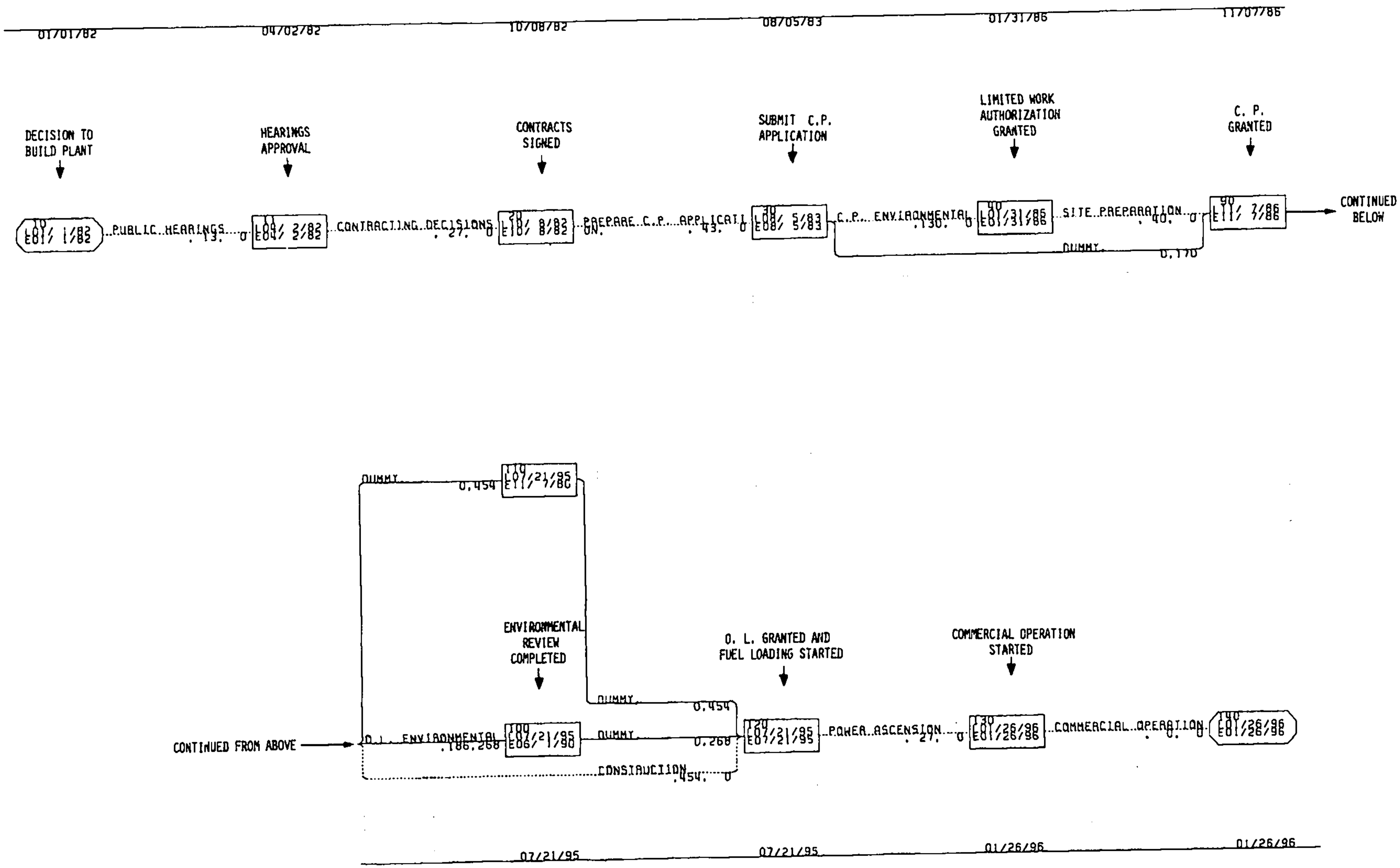


Fig. III-3. Preapproval-of-design reform.

TABLE III-b

OUTPUT DATA FOR PREAPPROVAL-OF-DESIGN REFORM

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.035 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
PUBLIC HEARING	10	11	0.00	3.00	3.00	1.00	1.000
CONTRACTING DE	11	20	3.00	9.33	6.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	19.33	10.00	1.00	1.000
C.P. ENVIRONME	30	40	19.33	49.33	30.00	3.00	1.000
DUMMY	30	90	19.33	58.50	0.00	0.00	0.000
SITE PREPARATI	40	90	49.33	58.50	9.17	0.83	1.000
O. L. ENVIRONM	90	100	58.50	163.17	43.00	3.00	0.000
DUMMY	90	110	58.50	163.17	0.00	0.00	0.000
CONSTRUCTION	90	120	58.50	163.17	104.67	10.67	1.000
DUMMY	100	120	101.50	163.17	0.00	0.00	0.000
DUMMY	110	120	58.50	163.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	163.17	169.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	169.50	169.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 171.805 (MONTHS)
CP STANDARD DEVIATION = 13.706

TOTAL COST = 3.882 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.480

TOTAL COST = 1.420 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.063

4. Combined Early Site Permit and Preapproval-of-Design Reforms. As previously discussed, a combination of reforms can be much more time and cost effective than individual reforms considered separately. In the case of early site permitting combined with preapproval of design, the construction permit preparation time is reduced by six months. Other changes are shown on the PERT chart.

The combined savings in engineering, EIS, Safety Analysis Report (SAR), and other licensing costs is $73 million. Added to this direct cost reduction is $56 million in overhead cost savings resulting from the large drop in overall project duration. It should be noted that this reform implicitly incorporates a one-step licensing reform as well because no significant operating license proceedings remain. However, this is a much simpler licensing procedure than the one described in the "One-Step Licensing Reform," which still requires full reviews of both safety and environmental issues for a custom-designed plant at the preconstruction licensing stage. In fact, the six-month construction permit license preparation time for reform #4 really just includes documenting the site and design approvals so that construction may immediately proceed. There is basically no further licensing review--only conformance inspections.

Individually, these reforms respectively save only 5.6 months/$35 million and 8.4 months/$108 million, but in combination they save 42.1 months/$268 million. This represents 62% of the savings calculated for the total reform package (#12).

TABLE IV-a

INPUT DATA FOR COMBINED EARLY SITE PERMIT AND PREAPPROVAL-OF-DESIGN REFORMS

Nodes		Times			Activities
10	11	0	3	6	PUBLIC HEARINGS
11	20	5	6	9	CONTRACTING DECISIONS
20	30	5	6	11	PREPARE C.P. APPLICATION
30	40	0	0	0	DUMMY
30	90	0	0	0	DUMMY
40	90	7	9	12	SITE PREPARATION
90	100	0	0	0	DUMMY
90	110	0	0	0	DUMMY
90	120	74	104	138	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

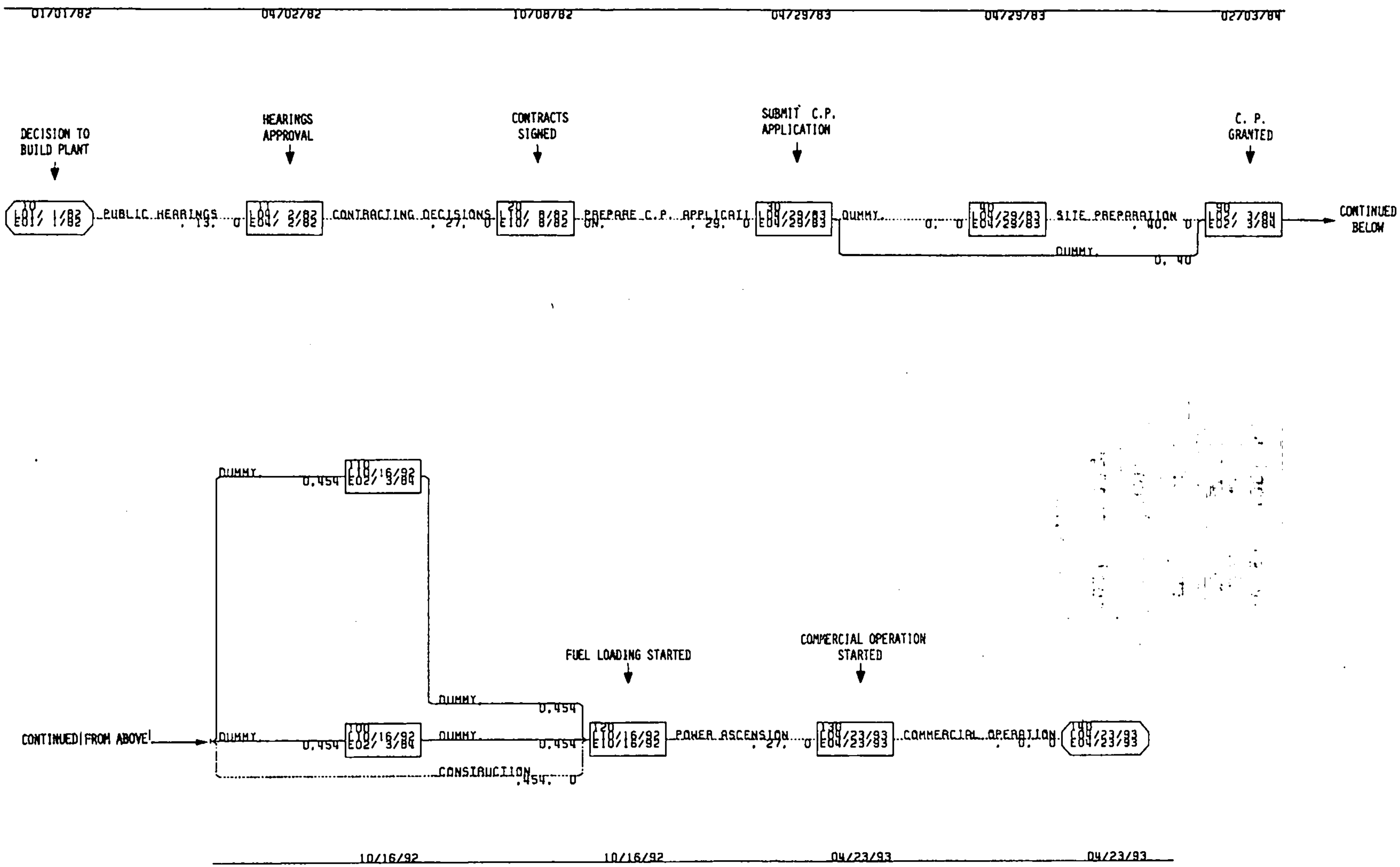


Fig. III-4. Combined early site permit and preapproval-of-design reforms.

TABLE IV-b

OUTPUT DATA FOR COMBINED EARLY SITE PERMIT AND PREAPPROVAL-OF-DESIGN REFORMS

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 0.966 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
PUBLIC HEARING	10	11	0.00	3.00	3.00	1.00	1.000
CONTRACTING DE	11	20	3.00	9.33	6.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	16.00	6.67	1.00	1.000
DUMMY	30	40	16.00	16.00	0.00	0.00	1.000
DUMMY	30	90	16.00	25.17	0.00	0.00	0.000
SITE PREPARATI	40	90	16.00	25.17	9.17	0.83	1.000
DUMMY	90	100	25.17	129.83	0.00	0.00	0.000
DUMMY	90	110	25.17	129.83	0.00	0.00	0.000
CONSTRUCTION	90	120	25.17	129.83	104.67	10.67	1.000
DUMMY	100	120	25.17	129.83	0.00	0.00	0.000
DUMMY	110	120	25.17	129.83	0.00	0.00	0.000
POWER ASCENSIO	120	130	129.83	136.17	6.33	1.33	1.000
COMMERCIAL OPE	130	140	136.17	136.17	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 138.127 (MONTHS)
CP STANDARD DEVIATION = 13.235

TOTAL COST = 2.833 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.341

TOTAL COST = 1.260 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.055

5. <u>One-Step Licensing Reform</u>. The one-step licensing procedure applies only to a custom-designed plant as typically exists at present. There are no plant standard designs or early site permits assumed so that all of the licensing approval work currently required before a construction license and an operating license are issued must still be performed.

This reform combines normal operating license licensing with construction permit licensing for final regulatory licensing approval before construction begins. On the PERT chart this eliminates the operating license safety and environmental reviews. Special hearings are offered as an option after construction starts, but have no effect on the critical path or project duration.

Construction time is reduced by five months because of fewer delays for engineering changes, amendments, and variances during the operating license stage. However, the requirement to perform all licensing reviews at the construction permit stage lengthens that process to the amount of time that is currently required at the operating license stage (about 50% more time than construction permit reviews). We assume that the limited work authorization could still be obtained after the same amount of construction permit environmental review, but that additional environmental review would follow and be required to meet all old operating license requirements.

The net effect of the time changes is to lengthen the project by 8.7 months. Some direct costs, $10 million, are saved by eliminating the separate operating license process, but the increase in total project time adds $18 million in new overhead costs so that direct cash flow is worsened by a net $8 million. The final effect on total project cost of time and cost additions is to add $25 million (1981$).

This reform is a net detriment to capital costs. It is commonly advocated in the industry press as a good thing. We do not denigrate it altogether because it results in positive savings when combined with other reforms by eliminating cost, time, and uncertainty during actual construction. But standing alone, the need to add licensing review time at the construction permit stage cancels its beneficial effects.

TABLE V-a

INPUT DATA FOR ONE-STEP LICENSING REFORM

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	48	54	64	C.P. SAFETY
40	50	7	10	13	ENVIRONMENTAL REVIEW
50	90	0	0	0	DUMMY
40	90	7	9	12	SITE PREPARATION
90	100	0	3	6	SPECIAL HEARINGS
90	110	0	0	0	DUMMY
90	120	74	104	138	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

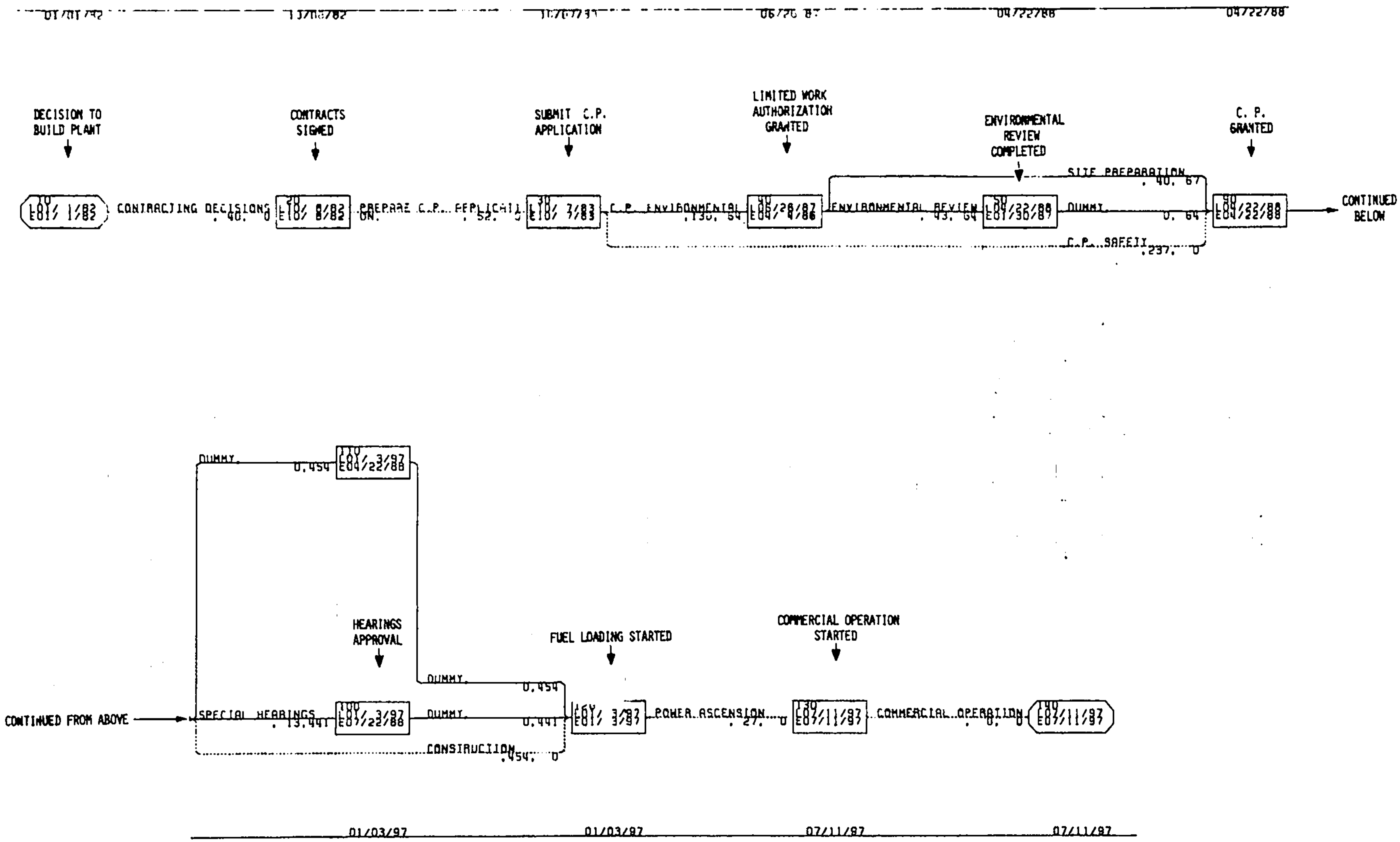


Fig. III-5. One-step licensing reform.

TABLE V-b

OUTPUT DATA FOR ONE-STEP LICENSING REFORM

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.103 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	21.33	12.00	1.00	1.000
C.P. ENVIRONME	30	40	21.33	66.00	30.00	3.00	0.001
C.P. SAFETY	30	90	21.33	76.00	54.67	2.67	0.999
ENVIRONMENTAL	40	50	51.33	76.00	10.00	1.00	0.001
DUMMY	50	90	61.33	76.00	0.00	0.00	0.001
SITE PREPARATI	40	90	0.00	76.00	9.17	0.83	0.000
SPECIAL HEARIN	90	100	76.00	180.67	3.00	1.00	0.000
DUMMY	90	110	76.00	180.67	0.00	0.00	0.000
CONSTRUCTION	90	120	76.00	180.67	104.67	10.67	1.000
DUMMY	100	120	79.00	180.67	0.00	0.00	0.000
DUMMY	110	120	76.00	180.67	0.00	0.00	0.000
POWER ASCENSIO	120	130	180.67	187.00	6.33	1.33	1.000
COMMERCIAL OPE	130	140	187.00	187.00	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 188.973 (MONTHS)
CP STANDARD DEVIATION = 13.612

TOTAL COST = 4.691 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.574

TOTAL COST = 1.553 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.067

6. Amendments and Variances Reform--Part 1. This reform does not change any of the basic activities on the PERT chart. The entire savings results from a decrease of five months in likely construction time and amounts to a fairly small $25 million savings in total capital costs. The time reduction is based on data in Refs. 13 and 15. We interpret this reform to cover fairly small types of regulatory mandated design changes such as minor changes in control panel layouts or new specifications for cable tray hanger fasteners. Part 1 changes are below the threshold of what is generally considered to be major backfitting. We analyze major backfitting as a separate reform that is more uncertain and harder to obtain reliable data for than in the case of the smaller "backfits." These major items are considered separately as Part 2 in reform #7.

TABLE VI-a

INPUT DATA FOR AMENDMENTS AND VARIANCES REFORM--PART 1

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	30	36	48	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	54	O.L. ENVIRONMENTAL
90	110	48	54	64	O.L. SAFETY
90	120	74	104	138	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

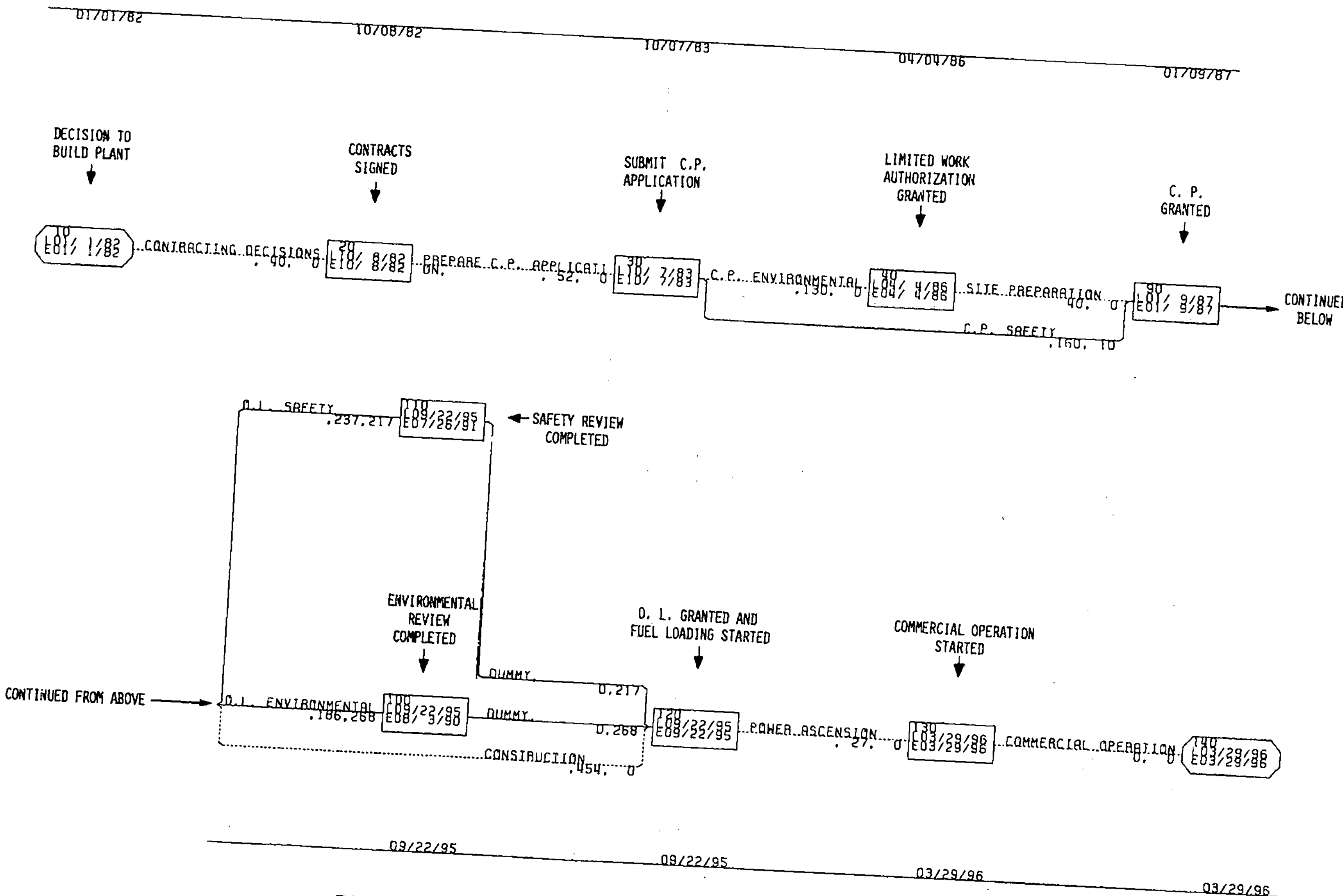


Fig. III-6. Amendments and variances reform--Part 1.

TABLE VI-b

OUTPUT DATA FOR AMENDMENTS AND VARIANCES REFORM--PART 1

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.088 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	21.33	12.00	1.00	1.000
C.P. ENVIRONME	30	40	21.33	51.33	30.00	3.00	0.674
C.P. SAFETY	30	90	21.33	60.50	37.00	3.00	0.326
SITE PREPARATI	40	90	51.33	60.50	9.17	0.83	0.674
O.L. ENVIRONME	90	100	60.50	165.17	43.00	3.00	0.000
O.L. SAFETY	90	110	60.50	165.17	54.67	2.67	0.000
CONSTRUCTION	90	120	60.50	165.17	104.67	10.67	1.000
DUMMY	100	120	103.50	165.17	0.00	0.00	0.000
DUMMY	110	120	115.17	165.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	165.17	171.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	171.50	171.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 175.232 (MONTHS)
CP STANDARD DEVIATION = 13.751

TOTAL COST = 4.196 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.520

TOTAL COST = 1.505 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.067

7. Major Backfitting Reform (Amendments and Variances--Part 2). This reform does not change any of the basic activities on the basic PERT chart. We have interpreted "major backfitting" to mean a whole series of actions that result in major changes in basic plant design. Examples of this are the NRC-mandated changes that followed the Brown's Ferry fire, or the Three Mile Island incident. These are changes that far exceed the normal scope of NRC amendments as analyzed under the amendments and variances reform. Major backfitting reform depends on the regulatory structure of amendments and variances procedures, so Part 2 reform is a separate analysis of #6, the amendments and variances reform.

Hard, consistent data have not been compiled on what the costs of major backfitting have been, and there is not close agreement among industry experts on how to measure these costs. However, it is generally agreed that these costs are very large and make a major contribution to uncertainty in nuclear planning.

We have obtained cost estimates from managers at three plants presently under construction as well as from EPRI and AIF personnel. These estimates range from $100 to $500 million in direct costs for current plants with a general concensus that $200 million is a reasonable estimate for major backfitting in general at present.

Also, it was agreed that with moderate regulatory reform, well-defined safety goals, and sensible contingency planning by utilities, construction time losses could be cut by about two years on current plants. The data input that we used was a construction time reduced by two years (saving $35 million in overhead costs) and a direct backfitting engineering and construction cost reduced by $100 million. The rationale for using the $100 million backfitting cost savings was to take the estimated $200 million total backfitting cost figure and assume that only one-half of all backfits would be eliminated under the proposed reform.

This is a major reform that results in a total project cost savings of $246 million.

TABLE VII-a

INPUT DATA FOR MAJOR BACKFITTING REFORM (AMENDMENTS AND VARIANCES--PART 2)

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	30	36	48	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	54	O.L. ENVIRONMENTAL
90	110	48	54	64	O.L. SAFETY
90	120	68	85	106	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

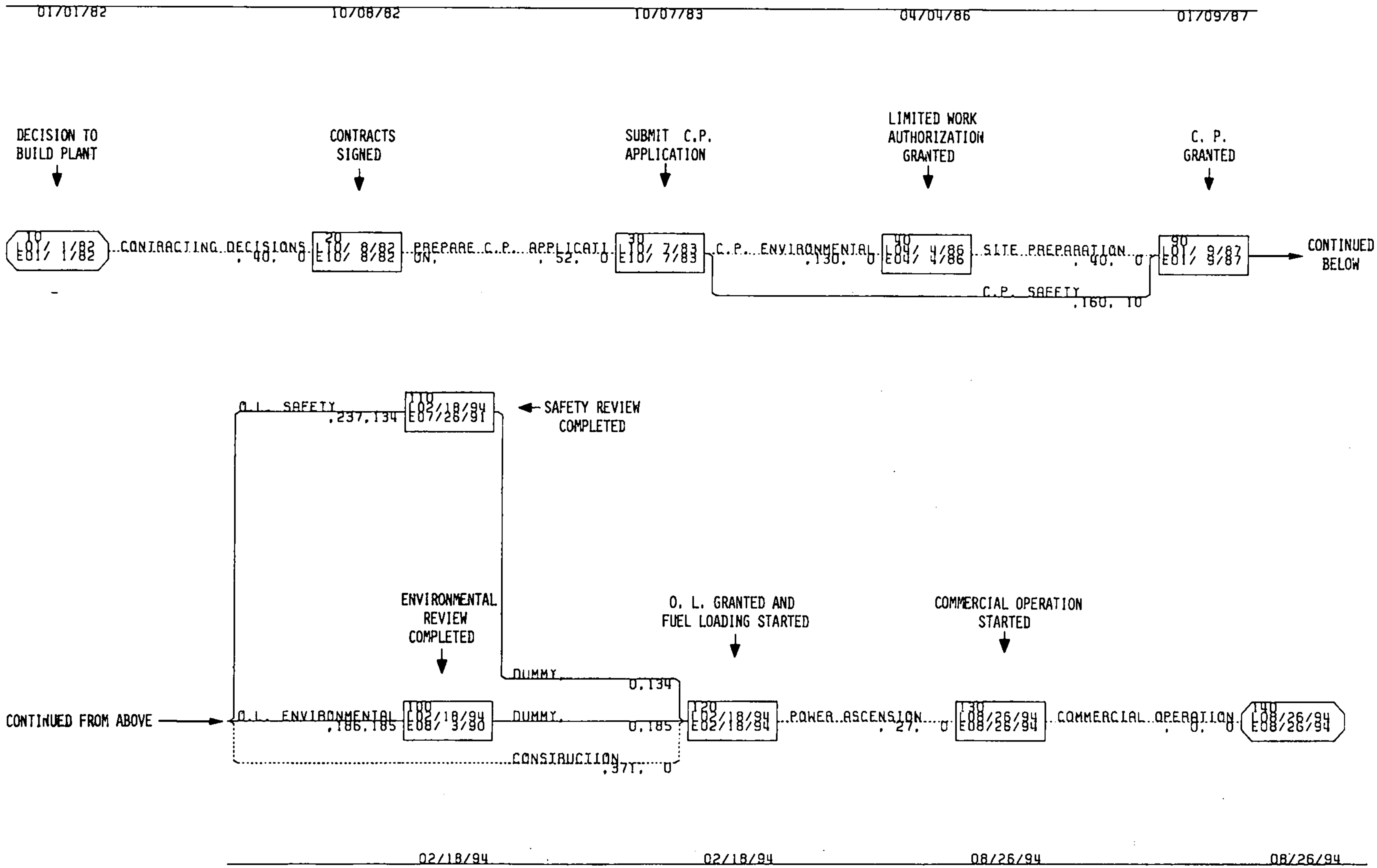


Fig. III-7. Major backfitting reform (amendments and variances--Part 2).

TABLE VII-b

OUTPUT DATA FOR MAJOR BACKFITTING REFORM (AMENDMENTS AND VARIANCES--PART 2)

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 0.960 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	21.33	12.00	1.00	1.000
C.P. ENVIRONME	30	40	21.33	51.33	30.00	3.00	0.674
C.P. SAFETY	30	90	21.33	60.50	37.00	3.00	0.326
SITE PREPARATI	40	90	51.33	60.50	9.17	0.83	0.674
O.L. ENVIRONME	90	100	60.50	146.17	43.00	3.00	0.000
O.L. SAFETY	90	110	60.50	146.17	54.67	2.67	0.000
CONSTRUCTION	90	120	60.50	146.17	85.67	6.33	1.000
DUMMY	100	120	103.50	146.17	0.00	0.00	0.000
DUMMY	110	120	115.17	146.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	146.17	152.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	152.50	152.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 156.221 (MONTHS)
CP STANDARD DEVIATION = 8.820

TOTAL COST = 3.184 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.259

TOTAL COST = 1.282 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.039

8. Combined Preapproval-of-Design and Major Backfitting Reforms. We believe that it is appropriate to analyze a combination of the two major reforms that cover most of the proposed design safety reforms. The PERT chart is basically the same as for the preapproval of design reforms. The only additional change is to reduce the construction time by two years in accordance with the major backfitting reform.

The total direct cost savings are $150 million for engineering and backfitting expenses, plus an additional $43 million in overhead expenses because of the shorter project deviation. The resultant total project cost savings is $343 million, which is 80% of the possible savings from the total reform package.

TABLE VIII-a

INPUT DATA FOR COMBINED PREAPPROVAL-OF-DESIGN AND MAJOR BACKFITTING REFORMS

Nodes		Times			Activities
10	11	0	3	6	PUBLIC HEARINGS
11	20	5	6	9	CONTRACTING DECISIONS
20	30	7	10	13	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	0	0	0	DUMMY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	54	O.L. ENVIRONMENTAL
90	110	0	0	0	DUMMY
90	120	63	80	101	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

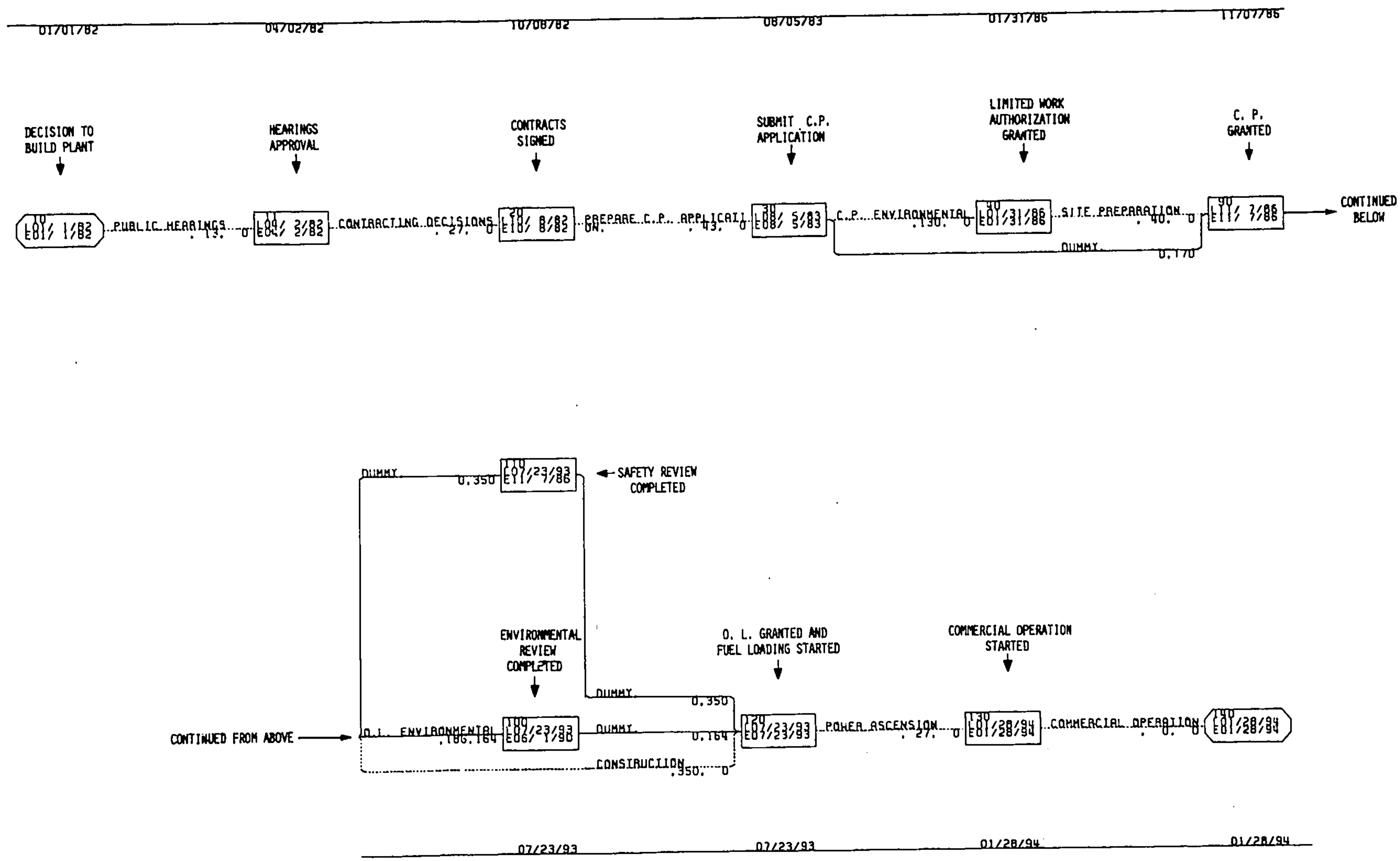


Fig. III-8. Combined preapproval-of-design and major backfitting reforms.

TABLE VIII-b

OUTPUT DATA FOR COMBINED PREAPPROVAL-OF-DESIGN AND MAJOR BACKFITTING REFORMS

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 0.902 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
PUBLIC HEARING	10	11	0.00	3.00	3.00	1.00	1.000
CONTRACTING DE	11	20	3.00	9.33	6.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	19.33	10.00	1.00	1.000
C.P. ENVIRONME	30	40	19.33	49.33	30.00	3.00	1.000
DUMMY	30	90	19.33	58.50	0.00	0.00	0.000
SITE PREPARATI	40	90	49.33	58.50	9.17	0.83	1.000
O. L. ENVIRONM	90	100	58.50	139.17	43.00	3.00	0.000
DUMMY	90	110	58.50	139.17	0.00	0.00	0.000
CONSTRUCTION	90	120	58.50	139.17	80.67	6.33	1.000
DUMMY	100	120	101.50	139.17	0.00	0.00	0.000
DUMMY	110	120	58.50	139.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	139.17	145.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	145.50	145.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 147.889 (MONTHS)
CP STANDARD DEVIATION = 8.934

TOTAL COST = 2.802 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.233

TOTAL COST = 1.185 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.038

9. Hearings Reform. We have not changed the basic PERT chart to analyze the hearings reform. In terms of input data, most efficiency improvements in hearings management will have little effect on actual utility costs. The data we did change were based on hearing duration times found in Refs. 9-12. Although the most likely hearing length of three months is unaffected, the setting of thresholds for contentions and reviews of procedures should reduce significantly the time skewness of possible long hearings. We reduced the worst case hearing and relitigation times by six months. The resultant project cost savings was $12 million.

TABLE IX-a

INPUT DATA FOR HEARINGS REFORM

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.P. APPLICATION
30	40	23	29	35	C.P. ENVIRONMENTAL
30	90	30	36	42	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	48	O.L. ENVIRONMENTAL
90	110	48	54	58	O.L. SAFETY
90	120	79	109	143	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

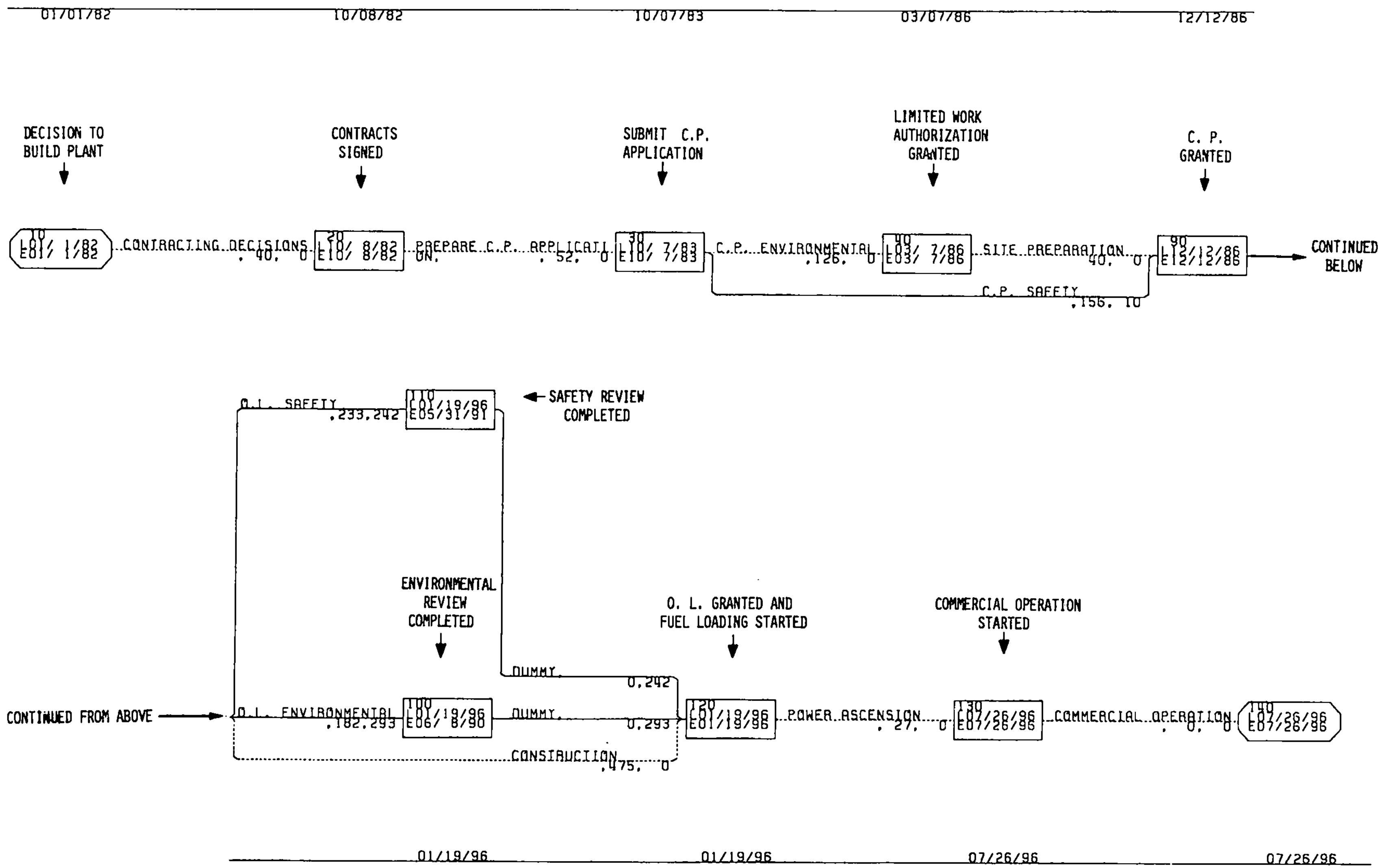


Fig. III-9. Hearings reform.

TABLE IX-b

OUTPUT DATA FOR HEARINGS REFORM

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.094 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	21.33	12.00	1.00	1.000
C.P. ENVIRONME	30	40	21.33	50.33	29.00	2.00	0.741
C.P. SAFETY	30	90	21.33	59.50	36.00	2.00	0.259
SITE PREPARATI	40	90	50.33	59.50	9.17	0.83	0.741
O.L. ENVIRONME	90	100	59.50	169.17	42.00	2.00	0.000
O.L. SAFETY	90	110	59.50	169.17	53.67	1.67	0.000
CONSTRUCTION	90	120	59.50	169.17	109.67	10.67	1.000
DUMMY	100	120	101.50	169.17	0.00	0.00	0.000
DUMMY	110	120	113.17	169.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	169.17	175.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	175.50	175.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 177.612 (MONTHS)
CP STANDARD DEVIATION = 13.490

TOTAL COST = 4.287 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.518

TOTAL COST = 1.516 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.064

10. Allocation-of-Resources Reform. This reform has little direct effect on utility costs. The actual implementation of some management reforms, such as delegating the need for power determination to the states, might reduce some of the licensing review process times. Others, such as establishing a new advisory committee, have the potential to add time. The only direct change that we could identify specifically as affecting utility costs in this reform was the implementation of a discretionary Advisory Committee on Reactor Safeguards (ACRS) review. This would eliminate three months from the construction permit and operating license safety review process, and we made only this change in the basic PERT chart. Because these reviews are on the critical path only a small percentage of the time, the resultant savings to the total project are less than one month, and the cost savings are only $4 million.

TABLE X-a

INPUT DATA FOR ALLOCATION-OF-RESOURCES REFORM

Nodes		Times			Activities
10	20	8	9	12	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.P. APPLICATION
30	40	23	29	41	C.P. ENVIRONMENTAL
30	90	27	33	45	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	36	42	54	O.L. ENVIRONMENTAL
90	110	45	51	61	O.L. SAFETY
90	120	79	109	143	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

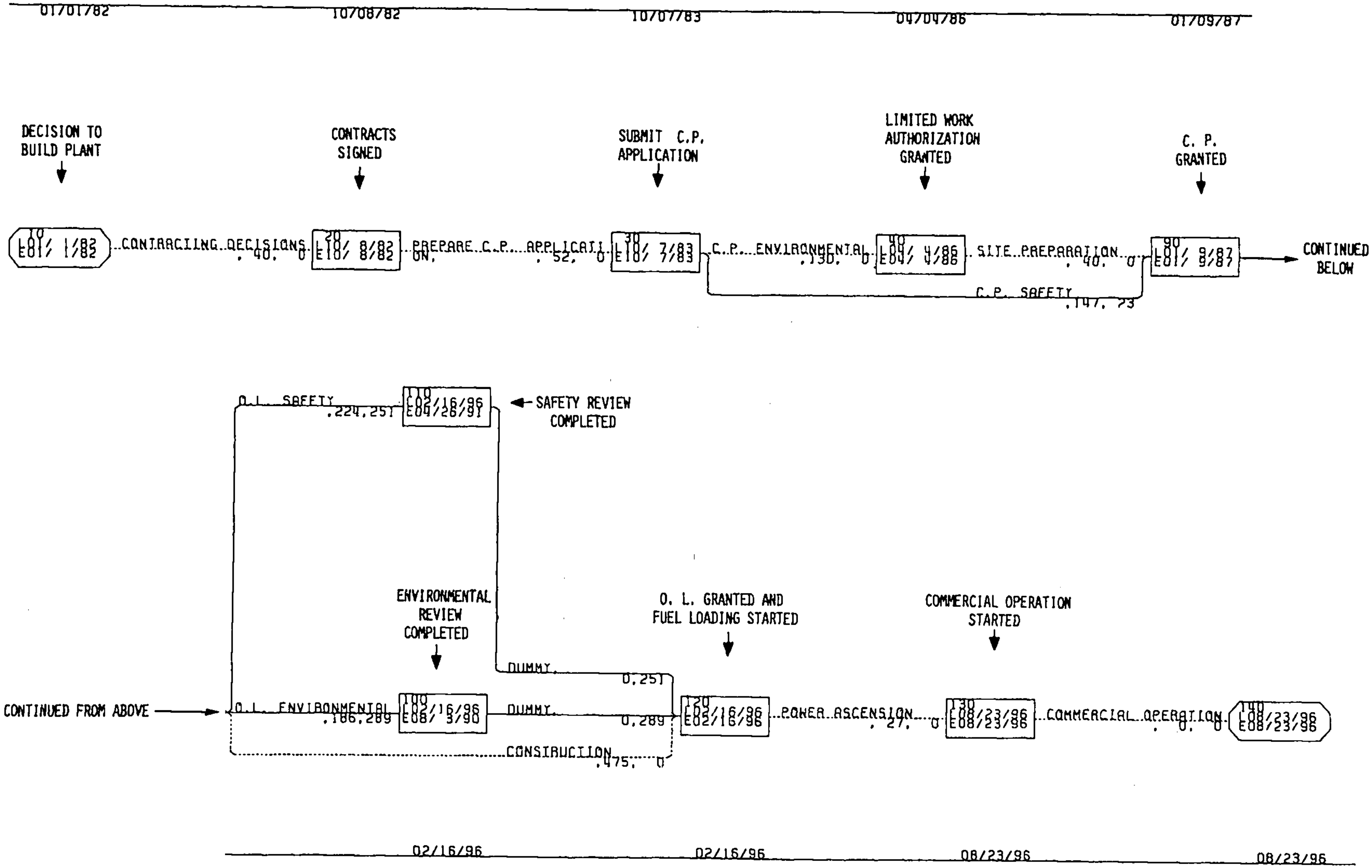


Fig. III-10. Allocation-of-resources reform.

TABLE X-b

OUTPUT DATA FOR ALLOCATION-OF-RESOURCES REFORM

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 1.095 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	9.33	9.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	21.33	12.00	1.00	1.000
C.P. ENVIRONME	30	40	21.33	51.33	30.00	3.00	0.837
C.P. SAFETY	30	90	21.33	60.50	34.00	3.00	0.163
SITE PREPARATI	40	90	51.33	60.50	9.17	0.83	0.837
O.L. ENVIRONME	90	100	60.50	170.17	43.00	3.00	0.000
O.L. SAFETY	90	110	60.50	170.17	51.67	2.67	0.000
CONSTRUCTION	90	120	60.50	170.17	109.67	10.67	1.000
DUMMY	100	120	103.50	170.17	0.00	0.00	0.000
DUMMY	110	120	112.17	170.17	0.00	0.00	0.000
POWER ASCENSIO	120	130	170.17	176.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	176.50	176.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 179.511 (MONTHS)
CP STANDARD DEVIATION = 13.783

TOTAL COST = 4.360 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.539

TOTAL COST = 1.524 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.067

11. Combined Major Backfitting, Preapproval-of-Design, and Early Site Permit Reforms. In this reform we combine the three major reforms into a single package that captures virtually all of the time and cost savings to utilities resulting from the DOE reform proposals. The PERT chart is basically the same as for the combination of early site permit and preapproval-of-design proposals (Fig. III-4). Additional direct costs and time are saved because of the major backfitting reform, so construction time and total direct costs are reduced to the same levels as for the total reform package (Sec. III.B.12).

The only difference between the combined reforms and the total reform package is that the combined construction and operating license (C.O.L.) is not included. Thus, the optional public hearing still occurs first because the safety-of-design aspects are the responsibility of the NSSS vendor. (In the total reform package the public hearing is concerned with the marriage of site and design and occurs along with the C.O.L. activity.) The C.P. preparation time is shorter than for the total reform package, which requires the more comprehensive C.O.L.

The slight timing differences occur very early in the project process and result in a slightly shorter overall time period than for the total reform package. The final capital cost figures are virtually identical to the total reform package and verify that these three major reforms are of prime importance to the utilities and their customers.

TABLE XI-a

INPUT DATA FOR COMBINED MAJOR BACKFITTING, PREAPPROVAL-OF-DESIGN, AND EARLY SITE PERMIT REFORMS

Nodes		Times			Activities
10	11	0	3	6	PUBLIC HEARINGS
11	20	5	6	9	CONTRACTING DECISIONS
20	30	5	6	11	PREPARE C.P. APPLICATION
30	40	0	0	0	C.P. ENVIRONMENTAL
30	90	0	0	0	C.P. SAFETY
40	90	7	9	12	SITE PREPARATION
90	100	0	0	0	O.L. ENVIRONMENTAL
90	110	0	0	0	O.L. SAFETY
90	120	63	80	101	CONSTRUCTION
100	120	0	0	0	DUMMY
110	120	0	0	0	DUMMY
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

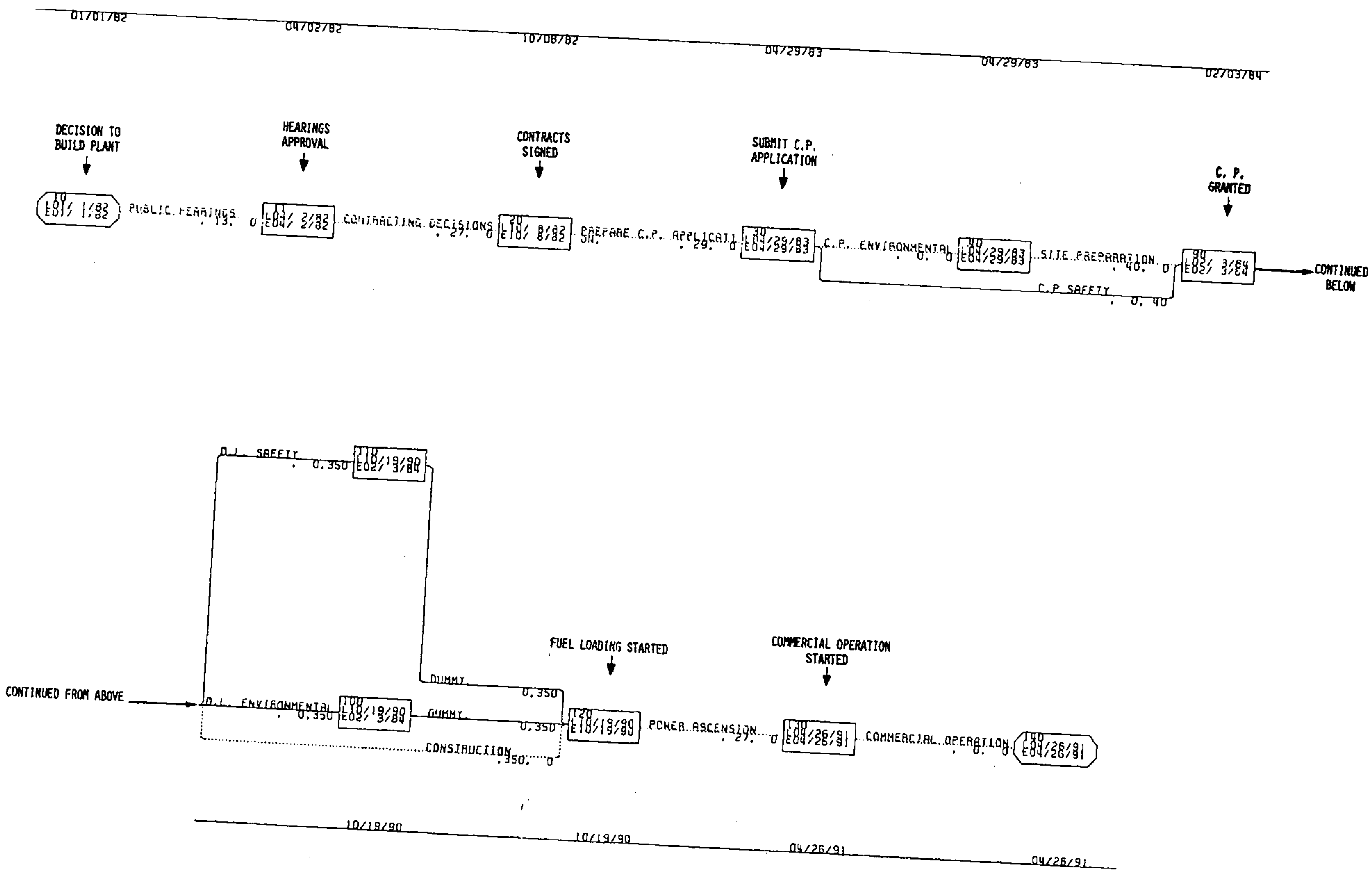


Fig. III-11. Combined major backfitting, preapproval-of-design, and early site permit reforms.

TABLE XI-b

OUTPUT DATA FOR COMBINED MAJOR BACKFITTING, PREAPPROVAL-OF-DESIGN, AND EARLY SITE PERMIT REFORMS

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 0.881 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
PUBLIC HEARING	10	11	0.00	3.00	3.00	1.00	1.000
CONTRACTING DE	11	20	3.00	9.33	6.33	0.67	1.000
PREPARE C.P. A	20	30	9.33	16.00	6.67	1.00	1.000
C.P. ENVIRONME	30	40	16.00	16.00	0.00	0.00	1.000
C.P. SAFETY	30	90	16.00	25.17	0.00	0.00	0.000
SITE PREPARATI	40	90	16.00	25.17	9.17	0.83	1.000
O.L. ENVIRONME	90	100	25.17	105.83	0.00	0.00	0.000
O.L. SAFETY	90	110	25.17	105.83	0.00	0.00	0.000
CONSTRUCTION	90	120	25.17	105.83	80.67	6.33	1.000
DUMMY	100	120	25.17	105.83	0.00	0.00	0.000
DUMMY	110	120	25.17	105.83	0.00	0.00	0.000
POWER ASCENSIO	120	130	105.83	112.17	6.33	1.33	1.000
COMMERCIAL OPE	130	140	112.17	112.17	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 114.211 (MONTHS)
CP STANDARD DEVIATION = 8.173

TOTAL COST = 2.141 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.167

TOTAL COST = 1.100 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.034

12. Total Reform Package. In this reform we have combined all of the reforms previously independently analyzed into a single package. The remaining activities on the PERT chart are easily understood. Contracting decisions still take place. Time is still required before construction to prepare the certification documents for a combined C.O.L. Optional public hearings take place as part of the activity of preparing the combined license. The hearings deal with the marriage of site and design, so they take place only after both are selected.

The construction time is reduced through the advantages of preapproved design, major backfitting reform, and amendments reform, as previously described. The time between applying for the construction permit until the operating license is granted is reduced from 12.7 years to 7.5 years. The total length of the project from the decision to build the plant until commercial operation starts is reduced by 64.3 months.

The direct cash flow outlays are reduced by a total of $214 million owing to engineering, major backfitting, licensing, and overhead cost savings, as described under the individual reforms. The capital cost per kilowatt is reduced from $1342/kW to $964/kW. The computed total project savings are $430 million, which is about 28% of today's unreformed capital cost.

The combined package of reforms would clearly be of great value to consumers of nuclear-produced electricity.

TABLE XII-a

INPUT DATA FOR TOTAL REFORM PACKAGE

Nodes		Times			Activities
10	20	5	6	9	CONTRACTING DECISIONS
20	30	9	12	15	PREPARE C.O.L.
30	40	0	0	0	DUMMY
40	90	7	9	12	SITE PREPARATION
90	120	63	80	101	CONSTRUCTION
120	130	3	6	11	POWER ASCENSION
130	140	0	0	0	COMMERCIAL OPERATION

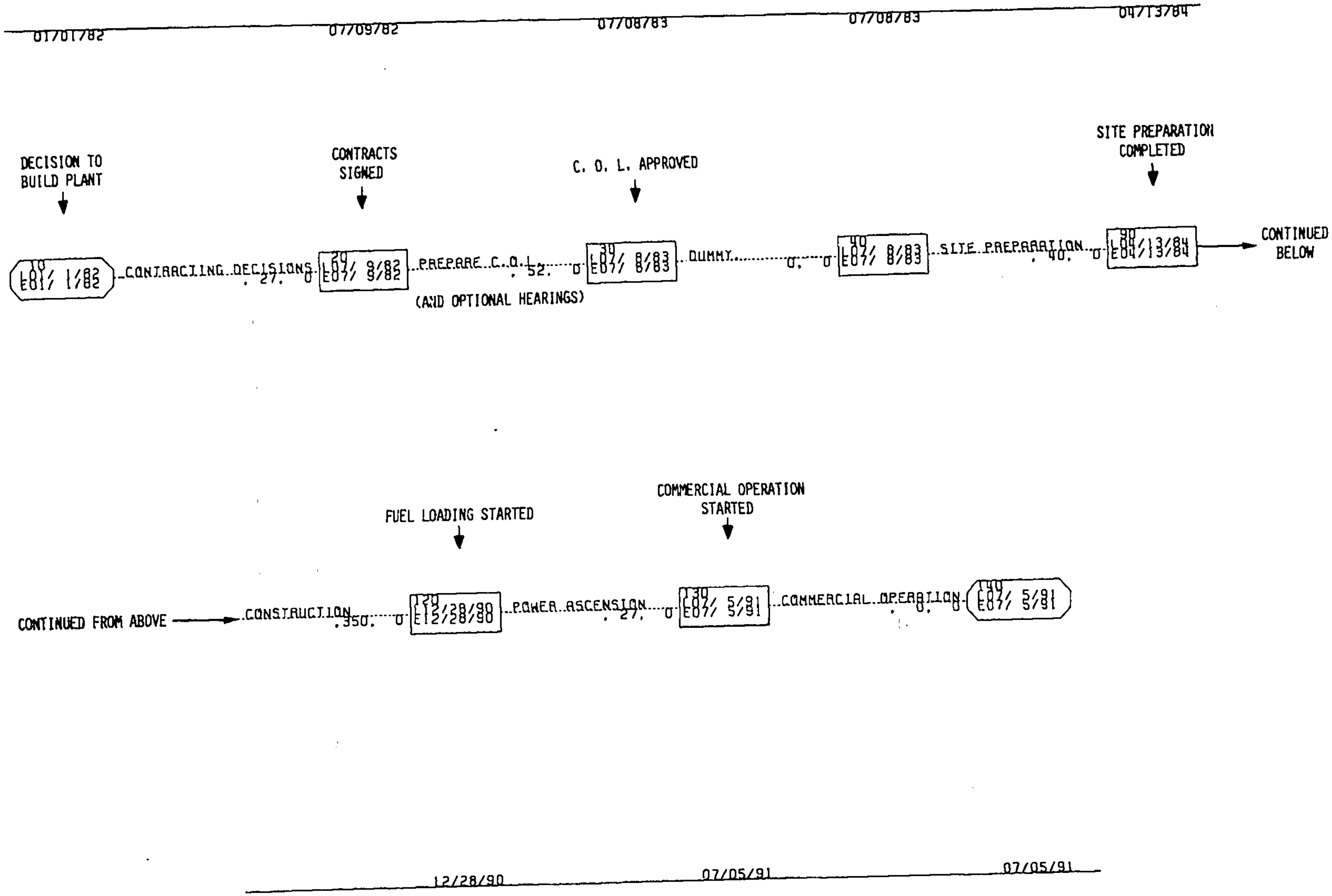


Fig. III-12. Total reform package.

TABLE XII-b

OUTPUT DATA FOR TOTAL REFORM PACKAGE

NO. OF MONTE CARLO PASSES ... 10000

INTEREST 0.094
ESCALATION 0.090
INFLATION 0.070
DIRECT CONSTRUCTION COST .... 0.881 BILLION

ACTIVITY	START NODE	END NODE	EARLY START	LATE FINISH	DURATION	STD DEV	CRITICALITY INDEX
CONTRACTING DE	10	20	0.00	6.33	6.33	0.67	1.000
PREPARE C.O.L.	20	30	6.33	18.33	12.00	1.00	1.000
DUMMY	30	40	18.33	18.33	0.00	0.00	1.000
SITE PREPARATI	40	90	18.33	27.50	9.17	0.83	1.000
CONSTRUCTION	90	120	27.50	108.17	80.67	6.33	1.000
POWER ASCENSIO	120	130	108.17	114.50	6.33	1.33	1.000
COMMERCIAL OPE	130	140	114.50	114.50	0.00	0.00	1.000

MONTE CARLO

CRITICAL PATH LENGTH = 115.955 (MONTHS)
CP STANDARD DEVIATION = 8.122

TOTAL COST = 2.161 (BILLION NOMINAL DOLLARS)
STANDARD DEVIATION = 0.166

TOTAL COST = 1.099 (BILLION CONSTANT 1981 DOLLARS)
STANDARD DEVIATION = 0.033

IV. SUMMARY OF RESULTS AND DISCUSSION

A summary of the results of the quantitative analysis of the proposed reforms is presented in Tables XIII and XIV. The reforms with the largest potential benefits are those combining early site permit, preapproval of design, and major backfitting. The total integrated reform package reduces the construction permit application to operating license granting average times from 12.7 to 7.5 years and capital costs from $1342/kW to $964/kW. The standard deviations are indications of normal expected variability in times and costs for the population of all plants. The summary of results and numbers speak for themselves in terms of the specific potential economic benefits of regulatory reform.

Investigators using different data bases for input cost and time information would find different numerical results. However, we believe that our data are among the best and most reasonable available. Although a change in the levels of costs or base case times would change the absolute size of capital costs, the relative importance and approximate percentage savings attributable to each of the analyzed reforms would not be greatly affected by different data bases (see Appendix A).

We have tried two different data sets and found less than a 1% change in every reform cost savings. Because we applied both data and methodology in a consistent manner, our quantitative results are unlikely to be affected by anything other than a complete change in approach to the reform process itself.

Additionally, we have investigated the same reforms with different sets of parameters for interest, escalation, and inflation. The relative importance of the reforms is affected only in minor ways by changes in these parameters. We used the 9.4% tax-adjusted interest rate (13.7% equivalent weighted-average market rate), 9.0% escalation, and 7.0% inflation that are recommended in an unpublished DOE report* for nuclear plant analysis so that standards exist for comparability across all DOE studies. Our quantitative results of reform significance are not changed in relative importance by variations in these parameters.

Finally, it is important to note that changes in economic parameters have a significant effect on nuclear construction costs. Table XV shows how

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*Publication information is not available at present.

TABLE XIII

LOS ALAMOS ANALYSIS OF DOE TASK FORCE PROPOSED NUCLEAR LICENSING REFORMS

	Time from Decision to Build to Commercial Operation (months)	Average Cost in Millions of		Plant Capital Cost
		Current $	1981$	(1981$/kW ± std dev)
Base Case Power Plant LWR 1139 MW(e)	180.2 ± 13.8	4389	1528	1342 ± 58
	Time Savings (months)	Average Cost Savings in Millions of		Plant Capital Cost
		Current $	1981$	(1981$/kW ± std dev)
Early Site Permit	5.6	237	35	1311 ± 58
Preapproval of Design	8.4	508	108	1247 ± 55
Early Site Permit + Preapproval of Design	42.1	1556	268	1106 ± 49
One-Step Licensing	-8.7	-302	-25	1363 ± 59
Amendments and Variances--Part 1	5.0	193	23	1321 ± 58
Major Backfitting (Amendments and Variances--Part 2)	24.0	1205	246	1126 ± 34
Major Backfitting + Preapproval of Design	32.4	1587	343	1040 ± 33
Hearings	2.6	102	12	1331 ± 57
Allocation of Resources	0.7	29	4	1338 ± 58
Major Backfitting + Preapproval of Design + Early Site Permit	66.0	2248	428	966 ± 30
Total Reform Package	64.3	2228	430	964 ± 29

*Although the time period commonly cited for nuclear construction time is from construction permit application to operating license granting (see Table XIV), time from decision to build to commercial operation describes the entire process more completely.

TABLE XIV

TOTAL PROJECT TIME FROM CONSTRUCTION PERMIT APPLICATION TO OPERATING LICENSE GRANTING

	Time (months ± std dev)
Base Case Power Plant LWR 1139 MW(e)	151.9 ± 13.6
Early Site Permit	148.4 ± 13.7
Preapproval of Design	145.5 ± 13.5
Early Site Permit + Preapproval of Design	114.5 ± 13.0
One-Step Licensing	160.7 ± 13.4
Amendments and Variances--Part 1	146.9 ± 13.6
Major Backfitting (Amendments and Variances--Part 2)	127.9 ± 8.5
Major Backfitting + Preapproval of Design	121.6 ± 8.6
Hearings	149.3 ± 13.3
Allocation of Resources	151.2 ± 13.6
Major Backfitting + Preapproval of Design + Early Site Permit	90.6 ± 7.9
Total Reform Package	90.6 ± 7.9

TABLE XV

EFFECTS OF CHANGES IN BASIC PARAMETERS

	Total Capital Cost in Millions of		
	Current $	1981$	Capital Cost (1981$/kW)
Base Case Power Plant LWR 1139 MW(e)	4389	1528	1342

	Change in Total Capital Cost in Millions of		
Change in Parameter	Current $	1981$	Change in Capital Cost (1981$/kW)
± 1% Escalation	±306	±106	±93
± 1% Market Interest Rate	±230	± 76	±67
± 1 Year Total Project Duration Time	±454	± 50	±44

capital costs are affected by changes in some basic parameters that are not necessarily an integral part of the reform process.

A 1% change in escalation is worth \$93/kW--almost as significant as one-fourth of the total reform package. Because a large part of today's excess of escalation over ordinary inflation (about 2% excess) may be due to regulatory-mandated increases in cost, escalation may be subject to improvement by regulatory reform. In particular, established safety goals and more consistent design standards may make it possible to reduce escalation to nearly the overall inflation level. Although this is speculative, the resultant savings would be another \$186/kW (about 14% of today's unreformed capital cost.)

A 1% change in market interest rates is worth \$67/kW in capital costs. The financial premiums associated with the riskiness of nuclear investments are not easy to determine, but again, if regulatory reform of safety goals can reduce uncertainty, then interest rates required by the financial markets would surely drop. To give some idea of the importance of this effect, we note that the spread between AAA-rated public utility bonds (the most secure rating) and BAA-rated bonds (usually about the least secure rating for marketing newly issued bonds to the public) is about 0.8% (Ref. 26). This would imply fairly small gains to nuclear capital costs savings owing to reduced uncertainty in the financial markets. However, if the interest penalty is higher (short-term construction loans often bear premiums of about 4% above nominal market rates), then the interest rate savings could be substantial. For example, at 4% premium, \$236/kW could be saved if all of the nuclear financial risk premium could be removed by regulatory reform. This, again, is highly speculative and not intended to reflect readily obtainable benefits from regulatory reform or to imply that risk premiums that high actually exist.

A calculation was made combining the total reform package and some reduction in uncertainty penalties resulting from more consistently defined safety goals. We lowered escalation to the same value as the inflation rate (eliminating any new increases in real nuclear construction costs) and lowered market interest rates by 1% (accounting for a minor reduction in financial risk). The resulting capital cost, including the total reform package, was \$861/kW. This is a 36% savings over current costs. (Recall that the total reform package alone results in 28% savings.) Clearly, further substantial savings are to be gained from the licensing reform process.

The point of discussing escalation and interest rate parameters in the context of possible changes resulting from regulatory reform is that much of the benefits to licensing reform may be obscured by the veil of uncertainty over the causes of today's high costs and long construction periods. We have confidently measured economic benefits resulting from concrete reform proposals and shown them to be substantial. However, we have also emphasized that the intangibles of uncertainty and risk resulting from the regulatory process may provide opportunities for ultimate additional quantitative cost benefits as large again as those we have already identified.

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APPENDIX A

SENSITIVITY OF RESULTS TO PLANTS USED IN CONSTRUCTION-TIME POPULATIONS

It is of particular interest in evaluating the robustness of our results to examine the effects of data screening. As discussed in Section III.A, the objective of input data selection is to get the most representative set of parameters to model the current and future conditions for a normal hypothetical nuclear construction process. This means it is not suitable to use historical data applying to conditions of the earlier, easier, licensing and construction process. Nor is it suitable to use data that are heavily influenced by current financing problems and deliberate construction stoppages resulting from unexpected lower electricity demand growth. So we mathematically selected a set of data to represent the current and future hypothetical nuclear industry.

The distribution of times for the critical construction time period that we used was derived from the central 31 plants of the total of 61 plants currently reported as being under construction.* Even with such a large percentage of plants excluded, the fitted beta distribution has a 6-1/2- to 12-year construction time range and a modal value of 9 years. (This period includes only construction, not site preparation, licensing, planning, or power ascension.) By including all 61 plants and fitting the data to a beta distribution, the modal value is shortened by only two months but the range of construction times is increased to 4-1/2 to 17-2/3 years. This range seems unreasonable for any normal hypothetical nuclear construction process. It arises because of so many atypical events occurring in the unscreened current data. This is why we screened the data. A selection of the central 45 plants leaves the modal value almost unchanged and gives a range of about 6 to 16 years. This range also seems unreasonable.

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*The 31 plants used in the data are Summer 1, Zimmer 1, Watts Bar 1 and 2, Shoreham, San Orofre 3, LaSalle 2, Washington Nuclear 1 and 2, Comanche Peak 1, Midland 1 and 2, Susquehanna 2, Catawba 1 and 2, Bellefonte 1 and 2, Byron 2, Harris 1, Braidwood 1 and 2, Palo Verde 3, Millstone 3, Seabrook 2, Nine Mile Point 2, Hope Creek 1, Marble Hill 1 and 2, Vogtle 1 and 2, and Yellow Creek 1.

We chose, therefore, to use the central 31 plants for our basic hypothetical population parameters and the results are reported in detail in the main body of this report. However, we actually repeated all of our calculations using unscreened and less highly screened data. Because the central tendency measures (mode, median, average) of all of these various data sets are fairly close, there are only very minor changes in bottom-line importance of licensing reform measures. The ranges of the data sets are quite different, however, so the ranges of times and costs are much wider for the less-screened data results. Of course, these ranges are not the product of a statistical inference procedure that would indicate uncertainty in parameter (time, cost) estimation. Rather, they just show the expected range of outputs among the entire population of hypothetical nuclear plants under various reform proposals. In comparing a reform to the base case, a plant with a shorter-than-average base process time owing to fewer-than-normal labor strikes, better-than-average management, or better weather would be expected to also have a shorter-than-average time under any given reform package because of the same basically fortuitous circumstances of labor, management, or weather.

Table A-I summarizes the results of bottom-line calculations made using three different data sets. The table shows that the percentage dollar savings attributable to the entire reform package changes by a negligible 0.2% or less for any of the data sets. The less-screened data have total average process times lengthened by over a year because many plants that currently have unique delays or outright work stoppages were included. This in turn raises average industry capital costs. But the percentage dollar savings available through licensing reform is unaffected. The variability (standard deviation) of construction times and costs is, of course, wider for the population of nuclear plants because less data are screened, but this does not affect the savings to each individual plant.

We have performed calculations for all data sets for all reform measures. In many cases there is no difference in percentage cost savings, and the largest difference is 0.2% for any specific reform package using different data sets. It is clear, therefore, that the screening techniques that we employed to bring reasonableness to our input information do not bias our resulting quantitative evaluation of licensing reform.

TABLE A-I

SENSITIVITY OF RESULTS TO PLANTS USED IN CONSTRUCTION-TIME POPULATIONS

Base Case	Time (months)	Average Cost in Millions of: Current $	1981$	Capital Cost (1981$/kW ± std dev)
31 plants	180.2 ± 13.8	4389	1528	1342 ± 58
45 plants	195.3 ± 24.0	5061	1590	1396 ± 104
61 plants	194.3 ± 33.1	5126	1589	1395 ± 144

Total Reform Package	Time Savings (months)	Average Cost Savings in Millions of: Current $	1981$	Capital Cost (1981$/kW ± std dev)
31 plants	64.3 (35.7%)	2228 (50.8%)	430 (28.1%)	964 ± 29
45 plants	64.4 (33.0%)	2573 (50.8%)	444 (27.9%)	1006 ± 67
61 plants	64.5 (33.2%)	2615 (51.0%)	444 (27.9%)	1005 ± 99

APPENDIX B

SENSITIVITY OF RESULTS TO ASSUMPTION OF COMMON STARTING DATE vs COMMON FINISHING DATE

This appendix addresses the assumption of project starting dates and their effect on our regulatory reform evaluations. In the report, we start each case January 1, 1982. With that starting date, our base case current licensing and construction process brings a plant into commercial operation on August 23, 1996 (using the most frequently occurring combination of critical path activities). All of the analyzed reforms bring a plant into operation at some other date as shown on the PERT charts.

An alternative assumption about schedule dates would be to have all plants come into operation on the same date rather than starting the licensing and construction process on a common date. A rationale for a common finishing date assumption is that the need for power is forecasted for a particular future time and any project would be timed to reach completion at that time.

If we adopt this assumption, then the reforms that save overall project time will result in later starting dates. Because the plants are started later, there will have been some nuclear plant real cost escalation. So the reforms, although otherwise identical to those in our report, will not save quite as much in constant 1981\$. We have used our computer program to recalculate the dollar savings of each reform using the common finishing date assumption and all of the same parameters used in previous calculations. The basic technique is to escalate the original direct construction cost (in 1981\$) by a 9% nuclear plant construction escalation rate to a new starting date as many months into the future as the reform time savings allow. Then we repeat the Monte Carlo calculations as before. The bottom-line cost figure is then deflated back to 1981\$ at a 7% inflation rate.

For the constant dollar comparisons, the calculation can be done simply by multiplying the bottom-line cost figure by the real cost escalation rate of 1.87%, compounded over the length of the time savings. For example, in the total reform package, 64.277 months are saved (5.356 years). So with the total bottom-line cost of 1.099 billion 1981\$, the total cost using the common finishing date assumption is:

$$1.099(1.0187)^{5.356} = 1.214 \text{ billion } 1981\$ \quad .$$

Table B-I lists the average cost savings attributable to each reform under the two different assumptions.

The common starting date assumption is a reasonable way to compare various reform outcomes. The common finishing date assumption may be reasonable for some purposes. However, because delaying construction results in real cost increases using our escalation assumptions, it is not clear that actual utility planning would ever follow such a simplistic course. A complex management decision considering cost escalation, power sales or purchases, wheeling charges, timing of need for power, uncertain demand forecasts, financing, and other variables would influence actual project starting dates. Thus, the straightforward assumption that projects being evaluated for regulatory reform impacts all start at the same time, regardless of the particular set of reforms, seems to be as fair and realistic as we can make it.

TABLE B-I

SENSITIVITY OF RESULTS TO ASSUMPTION OF COMMON STARTING DATE vs COMMON FINISHING DATE

Reform	Average Cost Savings with Common Starting Date Assumption (10^6 1981$)		Average Cost Savings with Common Finishing Date Assumption (10^6 1981$)	
Early Site Permit	35	(2.3%)	22	(1.4%)
Preapproval of Design	108	(7.1%)	89	(5.8%)
Early Site Permit + Preapproval of Design	268	(17.5%)	183	(12.0%)
One-Step Licensing	-25	(-1.6%)	-5	(-0.3%)
Amendments and Variances--Part 1	23	(1.5%)	11	(0.7%)
Major Backfitting (Amendments and Variances--Part 2)	246	(16.1%)	198	(13.0%)
Major Backfitting + Preapproval of Design	343	(22.4%)	282	(18.5%)
Hearings	12	(0.8%)	6	(0.4%)
Allocation of Resources	4	(0.3%)	2	(0.1%)
Major Backfitting + Preapproval of Design + Early Site Permit	428	(28.0%)	310	(20.3%)
Total Reform Package	430	(28.1%)	314	(20.5%)

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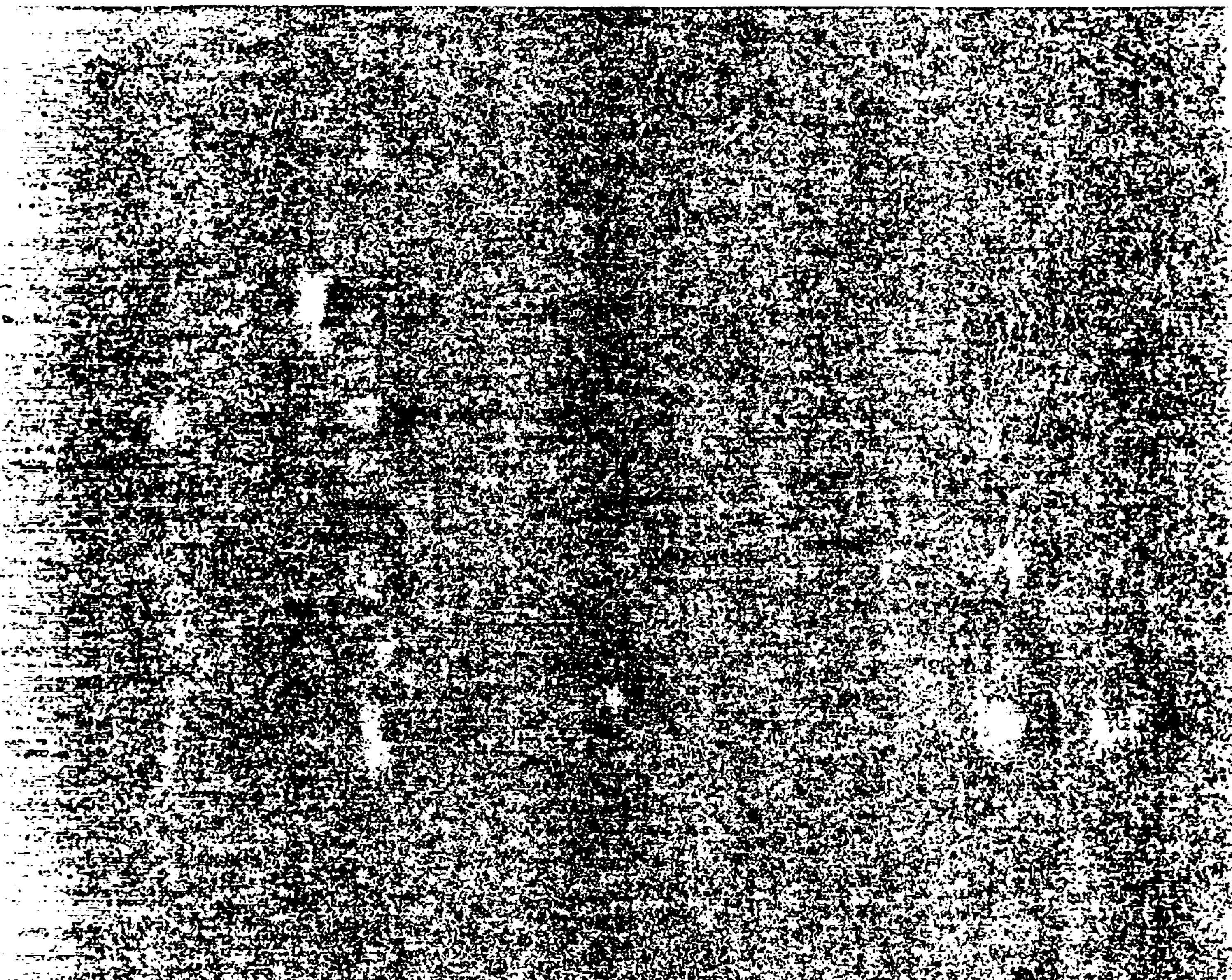

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