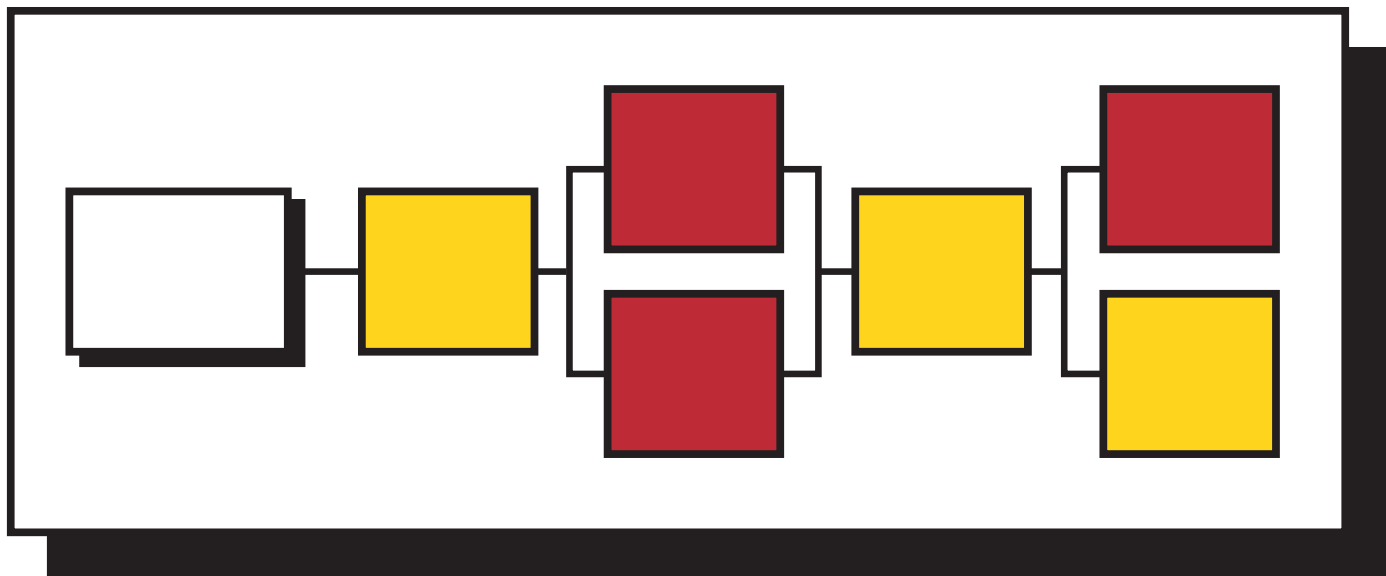




Determining the Impact of Process Change on the EPC Process



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A Model to Quantify Time and Cost Improvements

Prepared by

Construction Industry Institute

Information Management Impacts Research Team

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Chapter 1:

Introduction

What's the Value?

The business world is now interconnected electronically: communication is instantaneous and the need to access vital information is often immediate. In order to maintain global competitiveness and to benefit from the sweeping changes taking place in the business world, the construction industry must develop a proactive approach to these developments. Because many aspects of the design and construction process are “information-intensive,” the industry must be able to implement various information management strategies and technologies effectively. Doing so will contribute toward two key competitiveness goals: reducing overall project costs, and reducing the time required to design and deliver construction projects.

A common practice in the industry is to identify specific project activities that can be eliminated or reduced. Many such activities require the exchange of information both within an organization and between various entities. Expediting or eliminating such activities will likely lead to project cost and time savings. Implementing other information management strategies may also reduce project costs and time.

Unfortunately, too much effort has been placed on information technologies or upon certain activities assumed to be critical to schedule and cost objectives. This may be due to the fact that, to date, no methodology has been developed to examine the contribution of information management in reducing overall project schedule and cost. The inability of the industry to quantify the process improvements resulting from information management strategies is a key barrier to their full implementation.

Information management project strategies are only one of many concepts in the broad issue of improving cost and schedule. Each new management technique, contract execution strategy, or electronic technology has some impact on the time and cost required to design and construct a facility. These impacts must be predicted and quantified. If they are not, owners, contractors and others can only speculate. Given that implementation of these process improvement strategies is often costly, it is important to utilize tools designed for quantifying process impacts.

Objective

The CII Information Management Research Team was formed to measure the potential impacts of information-intensive tasks on the industry's ability to meet or exceed project performance criteria for schedule and cost. The goal was to examine the design and construction processes holistically, since improving one activity of the project delivery system may have little effect on the overall process. Determining the extent to which information management and data exchange activities actually affect overall project schedule and cost is in itself a major undertaking. The team exceeded this by providing the implementation tools described in this publication.

The key objectives for this publication include:

- identifying the principal activities that commonly occur in engineer-procure-construct (EPC) projects in an hierarchically structured format.
- documenting the duration (time) and resource (cost) requirements for each activity.
- presenting a network logic of how these activities are commonly related.

- presenting an interactive computer simulation model that enables quantification of time and cost performance.
- providing a methodology for predicting the impact of proposed process changes on project schedule and cost using flow diagramming and a simulation modeling approach.
- providing generic logic diagrams (with associated time and cost data) that illustrate the decomposition of many critical activities of the EPC process into a finer level of detail for process improvement analysis.

Strategies for Process Change

It is critical to examine proposed process changes as corporate strategies rather than as isolated technologies that may be implemented for selected areas within an organization. Given the rapidly evolving nature of technology, particularly information technology, and the potential benefit of non-technological process modifications, companies should avoid perceiving process change as equivalent to the automation of an activity or process task.

New technologies are constantly under development. A technology may even become outdated before a complete implementation plan is developed. What is needed is a methodology that permits planning, analysis, and (re)design of a process independent of the execution platform or the technologies that enable it. It is important for owners and contractors to identify corporate strategies for process improvement and understand in doing so that the solution to implement the strategy may be evolutionary.

Many technologies are dependent on the use and proper functioning of complimentary technologies. For example, the potential of an expert system is limited by the breadth and accuracy of the database from which it draws information. To attempt to quantify the time and cost benefits of

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one technology, in isolation from all others, would be a misleading exercise. This underscores the need to examine proposed process changes as intermediate steps toward the fulfillment of a well conceived corporate improvement strategy.

Process Modeling Approach

For the purpose of this publication, a process is defined as “a set of interrelated activities necessary for the performance of a specific business mission.” It is imperative that processes be examined at a broad, comprehensive level. This often means that the process, when fully defined, will cross many functional boundaries. These boundaries may be internal or external to an organization. Yet, if a process is to be fully understood, and process impacts are to correctly quantified, then the process model should be defined without limitation to organizational structure or functional responsibility.

For these reasons, the process modeling approach is comprehensive in nature. The EPC process is defined as one set of interrelated activities that span from the owner’s earliest involvement with pre-project planning responsibilities to the completion of plant start-up. Activities included in the model may be performed by owners, contractors, sub-contractors, suppliers, and others. No differentiation is made regarding responsibility or reference to organizational structure. This methodology is crucial. To examine the EPC process otherwise creates the opportunity to be greatly mislead regarding the likely benefit of proposed process improvements. For example, it may be possible to substantially improve one portion of the process, significantly speeding the performance of certain activities. However, this process change may not result in any improvement to the overall project schedule.

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The objective here is to model the EPC process comprehensively, and in sufficient detail, so that suboptimization of the process is avoided. The goal is to facilitate finding process improvements that measurably reduce project schedule and cost. Improvements to the EPC process in only one area may or may not yield the desired overall effect. Thus, with the proposed methodology, it is possible to prioritize corporate improvement strategies to maximize the return on capital investment and to ensure that project performance measures are improved.

ABC-SIM Software

Activity Based Costing–Simulation (ABC-SIM) is a software package specifically designed to support the type of process modeling methodology undertaken by the CII Information Management Impacts Research Team. The EPC process is modeled as a node and link network. The nodes represent the required activities and process resources, while the links provide the control mechanism to ensure that the prescribed precedence logic is maintained during simulation. ABC-SIM network logic is similar to the “activity on node” or precedence networks commonly used in schedule planning (CPM or PERT) or cyclical process analysis (e.g., CYCLONE Simulation).

The ABC-SIM tool is designed to provide a means of evaluating the time and cost impacts to highly variable processes, such as the EPC process, common to many CII member companies. The simulation process yields output measures for the:

- total *activity time* required to execute all activities defined in the process.
- total *activity cost* required to execute all activities defined in the process.

-
- total *elapsed time* (calendar time) required to fully execute the process with the defined precedence logic.

By quantifying the degree of change in these three performance measures while process improvements are modeled and experimentally applied, it is possible to predict the impact to project schedule and cost. Although the predicted outcomes will not precisely reflect the real world, they can provide strong indications of potential project impacts.

The ABC-SIM software provided is user friendly, Windows-based, and can be used to model many types of business processes. “Before” and “after” process conditions can be modeled, simulated, and then analyzed to determine the time and cost impacts of proposed process changes required to fulfill corporate strategic initiatives.

Practical Application of Process Modeling

To illustrate the effectiveness of the methodology described above, the CII Information Management Impacts Research Team identified three information management strategies that are being implemented:

- Document Management
- Data Management
- Information Access

The highest payback for the implementation of these strategies is the processes relating to the finalization of the project scope, the development of the detailed project design, and various aspects of the materials management process. The time and savings resulting from information management can be significant. For example, CII members have already demonstrated savings of approximately two percent in the overall duration of the total EPC process, and the use of recommended strategies may save

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an additional six to seven percent. The savings to the expenditure of professional, technical, and other labor activities is also notable. For example, by using the suggested information strategies in the materials management activities, two- to three-percent savings can be achieved in labor costs associated with the process.

An analysis such as this can easily be performed by using the EPC models and ABC-SIM software included in this publication. Process changes can be analyzed to determine their impacts on project schedule and cost. By having tools available for quantifying the impacts to these project performance measures, owners and contractors alike can focus process improvement initiatives on the portions of the EPC process most likely to yield maximum benefit.

Chapter 2:

Understanding the EPC Macro Model

The EPC Macro Model consists of two elements, an activity list and a logic diagram. The activity list is simply a listing of activities commonly executed in an EPC project; the logic diagram, which identifies the relationships between these activities, is a schematic representation of a typical project process sequenced from start to finish. It also serves as a baseline against which impacts resulting from process changes are compared and measured. Each element of the EPC Macro Model is described below in greater detail.

Activity List

The activity list identifies items encountered in a typical EPC project execution approach. No relationship is shown between the activities in the list since it is not intended to be indicative of process flow. The list is a consolidation of ideas, comments, and suggestions from practitioners representing more than 40 CII member companies. The complete activity list is included in Appendix A.

Since the input was obtained from experienced personnel of both contractor and owner companies representing a wide range of facility types, the activity list is not expected to summarize any one company's process explicitly, nor be inclusive of all possible activities for every unique EPC project undertaken. Rather, the list includes only those activities most commonly executed by a significant portion of the industry to complete a conventional project.

Three levels of detail are in the activity list. *Level one* consists of the five primary phases of project execution in an EPC process:

- Pre-Project Planning (PPP)
- Design (D)
- Materials Management (MM)

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- Construction (C)
 - Start-Up (SU)

Level two of the activity list defines broad subdivisions or categories of the work performed in each of the five primary phases. For example, when performing pre-project planning, the following level two activities would be common in an EPC process:

- Development of a detailed business plan (PPP.BP)
- Development of a product technical plan (PPP.TP)
- Facility scope planning (PPP.SD)
- Development of a project execution plan (PPP.PP)
- Definition of the project's contract strategy (PPP.CS)

Level three is a further refinement of the hierarchical activity listing and defines specific project activities that commonly occur in an EPC project execution strategy. There are 164 level three activities.

The EPC Logic Diagram presented herein is constructed at level three detail. Each of the level three activities is associated, by coding convention, to levels one and two. To illustrate how a level two category of work is decomposed into level three activities, the activities for “Development of Business Plan” (PPP.BP) are presented below. Note the coding scheme is designed to enable easy reference of the activities and comprehension of the hierarchical structure of the model. As noted, the entire activity list is presented in Appendix A. Additionally, a Definition of Terms is provided in Appendix B, which provides discussion for each of the activities in the model. Figure 1 illustrates the hierarchical organization of the EPC Activity List.

Pre-Project Planning (PPP)	Level 1
Business Plan (PPP.BP)	Level 2
Define Business Objectives (PPP.BP.1)	Level 3
• Define Facility Objectives/Determine Capacity Demands (PPP.BP.2) • Conduct Market Research (PPP.BP.3) • Establish Image and Public Relations (PPP.BP.4) • Finalize Site Selection (PPP.BP.5) • Address Regulatory Issues (PPP.BP.7) • Raw Material Sourcing (PPP.BP.8) • Develop Labor Plan and Address Human Resource Issues (PPP.BP.9) • Define Start-up Requirements (PPP.BP.10)	

Figure 1. Hierarchical Structure of Activity List

Logic Diagram — Depicting Activity Precedence

The EPC Logic Diagram consists of all level three activities linked together in a precedence relationship. All 164 activities were incorporated along with 16 process milestones. The entire EPC Logic Diagram is presented in Appendix C. The EPC Logic Diagram represents the process, or order, in which activities typically may be executed in an EPC project. This logic diagram represents the consensus view of numerous CII member companies who participated in the model's development, but as will be discussed in Chapter 5, this process logic may easily be modified by the user to become more company specific.

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The specific level three activities are shown in the diagram as boxes with the activity title and code. Milestones are identified by the larger, shadowed boxes and include their associated milestone codes. The only other elements in the diagrams are the arrows indicating activity relationship and direction of process flow. Each arrow directed out of an activity or milestone leads to one or more successor activities. Each arrow directed into an activity or milestone is coming from one or more predecessor activities. If an activity has only one successor, the arrow leads directly from the activity to its successor as shown in Figure 2a. For example, Finalize Site Selection (PPP.BP.5) leads directly into Develop Funding Plan (PPP.BP.7). In this instance, PPP.BP.7 can only execute after its predecessor, PPP.BP.5, has been completed. Relationships diagrammed in this manner indicate that the successor activity will not execute until the predecessor activity has been completed.

If an activity has more than one successor, the lead arrow branches into the number of successor activities as shown in Figure 2b. For example, the milestone Process Start (PPP.M1) has two successors: Define Business Objectives (PPP.BP.1) and Conduct Market Research and Analysis (PPP.BP.3). The arrow leading from PPP.M1 branches into two arrows, one leading into PPP.BP.1 and one into PPP.BP.3. In this instance, neither PPP.BP.1 nor PPP.BP.3 may be executed until their predecessor, PPP.M1, has occurred. A relationship diagrammed in this way indicates that none of the successor activities may execute until the predecessor activity is completed. All successor activities would then begin simultaneously.

If an activity has more than one predecessor, the arrows of all predecessors are consolidated into one arrow leading into the activity as shown in Figure 2d. For example, Finalize Site Selection (PPP.BP.5) has six preceding activities. Arrows leading out of all six activities are consolidated

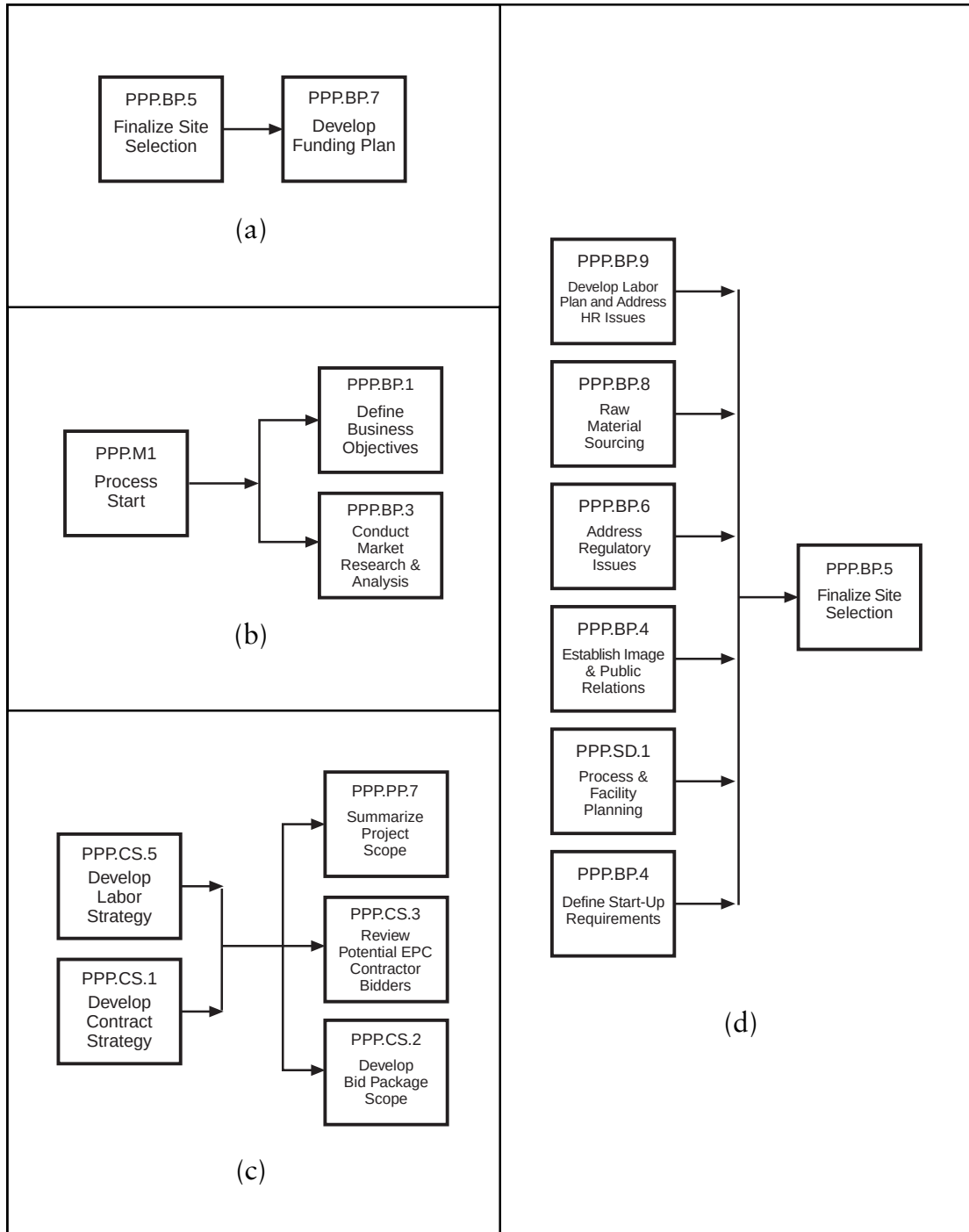


Figure 2. Process Modeling Diagram Logic

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into the one leading into PPP.BP.5. In this instance, PPP.BP.5 will not execute until all predecessor activities have been completed. Not all predecessors need to, nor likely will they, be completed at the same time.

The only other type of relationship shown in the diagram is more than one activity leading into several successor activities. This is simply a combination of the two previous conditions. In this case, all arrows from the preceding activities are consolidated into one and then branch out again into the appropriate number of successor arrows as shown in Figure 2c. For example, the arrows leading from PPP.CS.5 and PPP.CS.1 are consolidated. The consolidated arrow then branches into three arrows, one leading to PPP.PP.7, one to PPP.CS.3, and one to PPP.CS.2. None of the three successor activities will begin until both PPP.CS.5 and PPP.CS.1 are completed. This diagrammed relationship indicates that none of the successor activities may execute until all predecessors have been completed. Each of the successor activities, then, will begin simultaneously.

As stated, the logic diagram depicts the typical execution process for EPC projects. However, many of the activities shown sequentially on the logic diagram may often be shown in actual project schedules as occurring concurrently. An example is described by the model's precedence relationship between activities Finalize Drawings and Construction Specifications (D.DD.2) and Distribute Documents (D.DD.11). In a standard project schedule, these activities might be shown as generally concurrent if all project drawings and specifications are considered. Lead and Lag may be specified by the scheduler to add a higher level of detail or clarity to their precedence relationship. However, for any one drawing, specification, or package of documents, the element must be complete before it is distributed. Therefore, in the EPC Logic Diagram, these two activities would be shown as sequential. In other words, for each pass

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through the network logic, the finalization of documents must precede their distribution. This action would occur many times over the life of a project. It is modeled as a repetitive, sequential event.

Other differences exist between the generic EPC Logic Diagram and project specific CPM schedules. Project-specific schedules address unique material requirements, site impacts, organizational structure, project location, and many other project influences. Such project-specific factors are not reflected in the generalized EPC Logic Diagram. The diagram also does not differentiate between industry sectors such as forest products, power, or petrochemical. Since the EPC Logic Diagram does not represent a CPM schedule that incorporates lead/lag and project specific considerations, the elapsed time output generated by the simulation does not explicitly represent the actual duration of a project.

Time and Cost Data for the EPC Logic Diagram

Time and activity cost data are loaded against each level three activity (164 total activities) in the EPC Logic Diagram. To account for the variation in time and cost associated with the variety of facility types and locations included in the data collection at the “macro level,” the data are represented as low, most likely, and high values (a triangular probability distribution). Each one of the values in the triangular distribution is expressed as a percentage. The percentage should be thought of as the contribution of each activity toward the total project cost or project time requirements.

These values are based on data derived from 20 EPC projects volunteered by CII member companies. Specific project time and cost data were normalized (converted to percentages) to permit inclusion into a common database of values. Project data were supplied by experienced company

personnel from a wide range of disciplines. Participants in the data collection were personally familiar with the project from which the data originated.

Companies may wish to modify the time and cost parameters for each of the activities. It may be desirable for the time and cost distributions to be company-specific or restricted to a particular project type. To assist in such an effort, an example of a suggested data collection form is provided below in Figure 3.

Activity ID	Activity Description	% Total Project Cost			% Total Activity Time		
		Low	Most Likely	High	Low	Most Likely	High
D	Design						
D.DD	Design Schedule						
D.DD.1	Detailed Design Schedule						
D.DD.2	Detailed Materials Management Schedule						
D.DD.3	Detailed Construction Schedule						
D.DD.4	Detailed Start-Up Schedule						

Figure 3. Suggested Macro Model Data Collection Form

The section for “% Total Cost” can be used to record each activity’s contribution to total project labor cost. The cost should include only that associated with labor hours dedicated to activity completion. Material and equipment costs should not be included. This restriction is necessary to compare projects of varying size and facility type. That is, certain facility types have higher equipment and materials costs simply because of the nature of the production process within that facility. Similarly, facilities of the same type with different magnitudes or capacities for production may have significantly different material and equipment costs, although the effort required to perform individual activities is relatively

constant. Additionally, material and equipment cost is often unaffected by process changes during project execution. Therefore the costs simply adds significant variability to the data and makes it difficult to measure process impacts resulting from strategic change.

It is important to express cost values as a percentage of total dollars expended (for labor) rather than listing the values as a percentage of labor hours. This is because labor hours may have different wage rates applied. Some labor hours in the design phase, for example, have a much different wage rate than labor hours expended in other parts of the EPC process. As a result, the percentage contribution to total cost for a given activity is a function of the wage rates that have been applied throughout the process. As assumptions or actual wage rates change, the cost percentages will change. If the user is not using actual historical data, it may be desirable to identify the types of labor required to perform each of the activities in the model. Labor categories should be very simple. For example, it may be sufficient to identify the labor categories as clerical, professional/technical, or managerial, and then assume a range of wage rates for each.

The section on the data collection form labeled “% Total Activity Time” can be used to record each activity’s contribution of total time. Activity time is defined as the amount of effort in calendar time spent throughout the life of the project for each activity. While the activity *cost* is associated with the actual labor hours physically spent to complete an activity, activity *time* is associated with the total time that passes from the time an activity starts to the time it completes. Activity time should include work time as well as time spent waiting or in an idle state.

For example, to process an invoice may physically take someone one hour. However, the person may not spend that hour on the invoice until it has been on a desk for four hours. The activity *cost* in this example would be based upon one hour of work. The activity *time* would be based on five

hours, four hours spent waiting for processing and one spent actually being processed. As another example, consider an activity to install a piece of equipment. Five workers may take one hour together for installation after that piece had been on site for five days. The activity cost in this example would be five hours, one for each worker. The activity time would be approximately five days or 40 hours. All values for the individual activities should be expressed as percentages of the total expended on the project. As before, the inherent variability in the EPC process will undoubtedly dictate that the values be expressed as a range of possibilities defined by a probability distribution. ABC-SIM can easily accommodate multiple types of probability distributions that may be used in modeling time and cost parameters for the individual activities in the EPC Logic Diagram.

Chapter 3:

ABC-SIM User's Guide — Using the CII Software

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ABC-SIM is specifically designed to apply the principals of activity based costing to construction engineering processes. It permits the user to assign both time and cost values to activities within a prescribed process. These values can be either deterministic (e.g., the average value) or stochastic (meaning variable or probabilistic). Cost values may be independent variables or they may be described as rates (e.g., crew rates or wage rates) that are a function of the time required to perform a given activity.

ABC-SIM allows the user to establish a baseline condition of activity time, activity cost, and elapsed time for a given process. *Activity time* is the summation of all individual activity durations for one simulated pass through the entire process or logic diagram. Similarly, the *activity cost* is the summation of all associated costs accumulated during the simulation. *Elapsed time* represents the “calendar time” required to perform the entire process and is an indicator of project schedule. Elapsed time is always less than activity time because it accounts for the fact that many activities are actually performed concurrently within a process. Elapsed time is wholly dependent on the process “logic.” For each simulated run using ABC-SIM, a value for activity time, activity cost, and elapsed time is computed.

Having established a baseline condition for a prescribed process, ABC-SIM also enables the user to change or modify the process to determine the degree of impact on the measures of activity time, activity cost, and elapsed time. Proposed process changes may affect each of these process measures quite differently. For example, the elimination of a labor-intensive task may reduce process cost substantially, however, there may be no measurable improvement to elapsed time as a result. This would occur if other activities of equal or greater duration were being performed at the same time and constraining the start of a common successor activity.

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ABC-SIM therefore provides the user with a methodology to quantify the time and cost impacts of proposed process changes. Changes to the process logic or to the time and cost distributions for individual activities can both be modeled. Probabilistic network branching and backward looping (e.g., rework conditions) can also be modeled and experimentally changed as desired.

Typography Conventions

SMALL CAPS	Keys on the keyboard appear in small capitals: ESC or F1.
Menu Items	Selected menu items appear in italics with initial capitals: File Exit. This means select and click-on the Exit entry in the File Menu.
Buttons	Clicked-on buttons are also italicized with initial capitals: Edit Open File. This means click-on the Open File Button in the Edit Window.
Bold	Text to be typed in a textbox is in bold: To be typed . Bold is also used for emphasis.
FILE NAMES	File and directory names appear as all capital letters; for example, CIIIPC.DBF

Hardware and Software Requirements

The ABC-SIM software is written in Microsoft Visual Basic 3.0 and has been installed and operated under Windows 3.11, Windows 95, and Windows NT Workstation 3.51 or 4.0. ABC-SIM runs as a 16-bit Windows application. In standard installations, all of the necessary Windows DLLs (Direct Link Libraries) will be in the search path (e.g., C:\windows\system) and no problems will occur. If this is not the case, consult your systems staff. The following discussion assumes a standard 16-bit Windows installation.

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ABC-SIM requires five megabytes of free disk space to install correctly. Setup also assumes that ABC-SIM will be installed on the C: drive directory C:\ABC-SIM. Exceptions may cause problems when starting ABC-SIM from the icon in the ABC-SIM Program Group in the Program Manager.

Version 3.1 of ABC-SIM uses dBase IV file format. ABC-SIM assumes that a generic file directory, C:\ABC-SIM\DATA, exists when the file handlers are loaded. If this directory does not exist, the ODBC administrator may prompt for a data source name. Select the data source and proceed.

Since Visual Basic 3.0 is interpreted during execution, it runs more slowly than programs that have been compiled. Since the simulation module is “compute bound,” it runs much more slowly than compiled programs. Therefore, large models should be run on fast PCs with fast graphics. For example, a Pentium 90 with a PCI/2mb video card will process the CII EPC model in less than 30 seconds.

Installation Steps

The Setup procedure on Setup Disk #1 is a standard Microsoft Setup procedure used to install other Microsoft products. The installation program itself is a Visual Basic 3.0 program available from Microsoft and modified to install ABC-SIM specifically. The compress and decompress programs are also standard Microsoft products.

1. Insert the 3.5-inch diskette labeled ABC-SIM Disk #1 into the 3.5-inch floppy drive. (The A: drive is assumed for this discussion.)
2. From the Program Manager, select *File\Run*. A small window with a textbox will appear. Type: A:\SETUP in the textbox. (Alternatively, use the Browse Button to locate the setup program on the appropriate drive or use the File Manager to locate SETUP.EXE on the appropriate drive.) Click-on the OK key to begin the setup process.

3. The Setup Program loads the ABC-SIM Installation Program and all of the necessary setup information. Reply affirmatively when the Installation Program asks permission to create ABC-SIM as the installation directory. Failure to install to the C:\ABC-SIM directory will cause problems. If the directory already exists, the old directory is used automatically.
4. When prompted to do so, remove Disk #1 and insert Disk #2 to complete the ABC-SIM installation process.

Installation Results

After the Install Program has completed installing ABC-SIM, the following should have been accomplished:

1. The Program Manager should contain a Program Group labeled ABC-SIM 3.1. This group window should contain an ABC-SIM icon. Double-click on the icon to start ABC-SIM. If ABC-SIM does not start, the installation failed. Contact your System Manager for assistance.
2. The C: drive should contain a C:\ABC-SIM directory with a C:\ABC-SIM\Data sub-directory. ABCSIM3.EXE (the execute file) should reside in the ABC-SIM directory and the Data sub-directory should contain example Project Files (e.g., CIIIPC.DBF), a simulation Output File (e.g., CIIIPC.OUT), and a Spreadsheet Template File (e.g., CIIIPC.XLS). (note: CIIIPC is the project name.) STARTUP.DBF, the standard project start-up file, will also be installed.
3. A number of system related DLLs will be transferred from the Installation Disks to the C:\Windows\System directory. Most will begin with a "QE" or "VB" prefix and are part of the database drivers and system files included with ABC-SIM. These files should be in the system "look up" path.

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4. The database drivers will be pointing at the C:\ABC-SIM\DATA sub-directory if the installation is complete. If this is a non-standard installation of Windows, use the ODBC Icon in the Control Panel to complete the process. ABC-SIM requires the Q&E dBase IV drivers to correctly access the Project Files.

Getting Started

The ABC-SIM Process

It is important to recognize that simulation is a process with a number of sequential steps. The ABC-SIM process itself consists of five distinct steps that must be completed in the following order:

1. Design and develop a baseline logic diagram. Failure to complete this step will usually bring about unsatisfactory results. The diagram should reflect the “business rules” being evaluated. This step entails the definition of specific process activities, their relationships, and their associated time and cost parameters. This step has already been completed for the baseline EPC process and has been described in detail in the *Logic Diagram-Depicting Activity Precedence* section of this publication. The EPC Logic Diagram is provided in Appendix C.
2. Translate the logic diagram into a simulation network. This involves creating a new project file and inputting the proper node property information into ABC-SIM. The EPC Logic Diagram has been provided as an ABC-SIM project file (CIIEPC.DBF) and is included on diskette in Appendix E.
3. Check the project file for network coding errors and correct any errors that may exist. This may require changes to the logic diagram. This step has been completed for the EPC Logic Diagram, however it is an

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important process step for new diagrams that may be developed by the software user.

4. Run the simulation and capture the results. The results are written into a text formatted output file for later use in a spreadsheet.
5. Import the output file into MS Excel (or other spreadsheet) for display and analysis. This step is described in detail later in Chapter 4 of this publication.

Starting ABC-SIM

ABC-SIM may be started in a number of ways. Assuming that the ABC-SIM Program Group has been created during the install process, double-click on the ABC-SIM Icon in the ABC-SIM Program Group. Alternatively, the File Manager may be used to locate ABCSIM3.EXE in the C:\ABC-SIM Directory. Double-click on the execute file entry.

When ABC-SIM begins, the Welcome Window remains on the screen as long as the load process is active. As soon as the loading process has been successfully completed, the main window becomes visible in the upper left-hand corner of the screen (recognized from the title bar, “ABC-SIM Main”) (see Figure 4).

The *Main|File* Menu is used to create a new project file; open an existing project file; perform a page setup; format and print the project file; or exit to Windows.

The *Main|View* Menu is used to access the other ABC-SIM windows. (This menu is visible only when a project file is open.) The other windows provide functionality while Main simply serves as a link between them. The other windows are: the Edit Window, the Grid Window, the Display Window, and the Simulation Window.

The *Main|Help* Menu selection provides access to the About Window. There is no Help File for this version of ABC-SIM. Help is provided through prompts appearing in the panel at the bottom of the Edit Window.

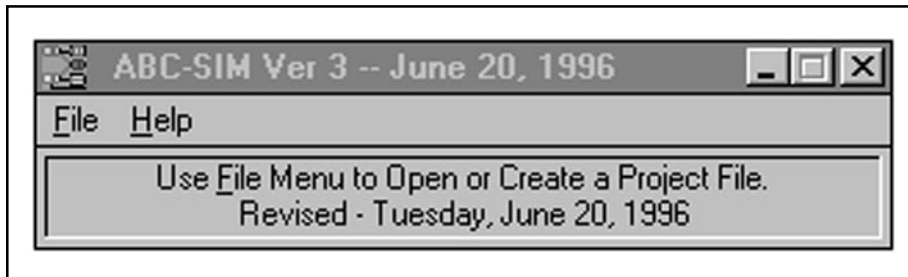


Figure 4. Example Main Window

Creating and Editing Project Files

Creating a New Project File

Select the *Main|File|New* menu item on the Main Form as shown in Figure 5. Click-on *New* and a standard Windows dialogue window will appear. This window enables the creation of a new project file in the directory of your choice. Select the correct directory path and type the file name in the file box. Click on *OK* and a new project file will be created in the selected directory. Once the new project file has been created, it can be edited using the Edit Window. The new project file has one “starter” record or node that must be edited to conform to the new project node properties.

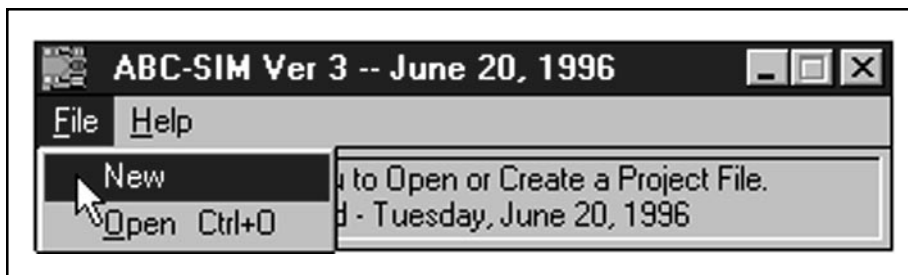


Figure 5. Example *Main|File|New*

.....

Alternatively, select any existing project file and edit it to create a new project file. This will alter the contents of the original project file. If an existing project file is to be used to create a new project, the best way is to copy that file to another directory, change its name, and then move it back to the original directory. This new file may then be edited without fear of altering the original project file contents. This is by far the easiest method to create alternative simulations that may be similar in nature, for example, the same network logic with different cost properties.

Editing A Project File

After the user selects the *File|Open* menu item from the Main Window, a dialogue window will appear. Select a project file from the list provided. If the desired project file is in the indicated file list, click on the desired list entry and the file name will appear in the file text-box at the top of the file list. Once the correct name is in the file text-box, click on *OK* and the Edit Window will automatically appear. Alternatively, double-click on the desired file name and the Edit Window will appear with the file ready to edit.

If the desired file is not in the indicated file list, then use the directory list to select the proper path to the directory containing the required project file. Then, select the project file from the list and the name should appear in the file text-box immediately above the suggested list. Once the correct name is in the file text-box, click on *OK* and the Edit Window will automatically appear.

The Edit Window

Once the Edit Window appears (see Figure 6), the Data Entry (or Data Edit) process is ready to begin. The title bar of the Edit Window contains the word *EDIT* followed by the name of the active project file inside a pair of brackets. The Menu Bar is at the top of the window just under the title

bar. The Status Bar is at the very bottom of the window. The far right panel of the Status Bar displays the number of the current node record. Prompt messages appear in the left panel of the Status Bar.

The Edit Window has six major groups of controls. The Project Properties group contains simulation project information such as the project title, the number of runs in the sample, and the maximum clock time. The File Operations group, containing the edit options, is on the right side. The left side contains the Network Precedents Structure input fields. The bottom three groups contain the Queue Node Properties, the Time Properties, and the Cost Properties.

The screenshot shows the 'Edit - [ciipec.dbf]' window with a menu bar (File, Node, Project, Help). The interface is divided into several sections:

- Project Properties:**
 - Project Name: CII EPC Macro Model Baseline
 - Runs: 500
 - Time: 99999.
- Network Precedence Structure:**
 - Back Nodes: 1
 - Node Number: 2
 - Node Type: ACT or QUE (selected: ACT)
 - Ahead Nodes / %: 210
 - Node Description: PPP.BP.1 - Define Business Objectives
- File Operations:**
 - Add New Node
 - Update Node
 - Delete Node
 - Check-Out File
 - Close DataBase
- Time Properties:**
 - Type: TRI
 - Low: 0.00
 - Most Likely: 0.00
 - High: 0.75
- Cost Properties:**
 - Type: TRI
 - Low: 0.001
 - Most Likely: 0.006
 - High: 0.265
- Status Bar:**
 - Node Number: unique integer between 1 and 500
 - 2

Figure 6. Example ABC-SIM Edit Window

The Data Entry Process

Project File editing (i.e., data entry) is best approached as a systematic process.

First, enter the Project Properties. The properties themselves are explained in the Running the Simulation section of this guide. The most straightforward method for entering these data is through use of the *Edit\Project* Menu. Then enter the node information.

Next, enter the node records. The buttons in the File Operations control group are used to control node-record edits. Click on the *Add New Node* button to add a new node. All of the input fields will appear blank and are ready for new node information. As soon as the data entry process for each node is complete, click on the *Update Node* button to save the new node in the Project File. If existing node information is changed and is to be saved, click on *Update Node* to save the information; otherwise it will be lost whenever another node is scrolled into view.

The delete button has been disabled in order to prevent inadvertent deletions of records. The delete function should be triggered through the *Edit\Record\Delete* Menu.

The simulation network logic and time and cost properties should be entered in the following order.

1. Create the node by entering the node number in the Node Number field. Valid numbers run from 1 to 999 with no duplicates. Then enter the Node Type as ACT or QUE depending upon whether it is an Activity or Control node. Finally enter the node description using 40 characters or less in the Node Description field.
2. Once the node has been established, the connections to the predecessor nodes should be entered in the Back (or predecessor) Nodes field. Once the back nodes have been established, the Ahead (successor) Nodes

should be entered. The order of the successor nodes is important in queuing and capture logic since ABC-SIM will “interpret” the input. Possible interpretations include the execution of all successor activities, execution of the highest priority activity, or execution of one successor based on probabilistic selection. Both QUE and ACT nodes may have a successor activity selected by inputting relative probabilities of occurrence in the % (percent) column. The sum of the weights must total one hundred percent. If an ACT node has more than one successor and the % column is left blank, all listed successor activities are selected for execution. If a queue node has more than one successor activity and the % column is left blank, the successor activity of highest priority (i.e., listed first) is selected for execution.

3. The Resource, Time, and Cost Properties are entered through the three input field groups that appear at the bottom of the Edit Window. Each of the three groups has a Type field as the first entry field. The labels corresponding to the three following entry fields change, depending upon the type of parameter involved. For example, when the time parameter is UNI, for uniform distribution, the proper fields in which to type the range-minimum and range-maximum appear next to the proper entry field. This is true for any of the various parameter types.

Finally, click on the *Check Out File* button to scan the project file for logic and data entry errors. The details of the Check Out process are described in a following section.

Click on the *Close Database* button to close the active project file. (Whenever there is no active Project File, the title of the button will read “Open Database.”) Records actually appear in the Project File in the order in which they were created. If they appear “out of sort” in the Edit Window, closing and then opening the project file will put the nodes in ascending sort order.