PERFORMANCE BOND - a bond that guarantees the work will be completed in accordance with the contract documents. The bond also assures the owner that the contractor will fulfill all contractual and financial obligations. (11/90)

PERFORMANCE MEASUREMENT BASELINE - the time-phased budget plan against which contract performance is measured. It is formed by the budgets assigned to scheduled work elements and the applicable indirect budgets. For future effort not planned in detail, the performance measurement baseline also includes budgets assigned to higher level CWBS elements and undistributed budget. It will reconcile to the contract budget base. It equals the total allocated budget less management reserve. (11/90)

PERT - an acronym for Project Evaluation Review Technique which is a probabilistic technique, used mostly by government agencies, for calculating the "most likely" durations for network activities. Most recently, however, the term PERT has been used as a synonym for CPM. (11/90)

PESSIMISTIC TIME ESTIMATE - the maximum time required for an activity under adverse conditions. It is generally held that an activity would have no more than one chance in a hundred of exceeding this amount of time. (11/90)

PHASED CONSTRUCTION - as most commonly used today, implies that construction of a facility or system or subsystem commences before final design is complete. Phased construction is used in order to achieve beneficial use at an advanced date. (11/90)

PHYSICAL PROGRESS - the status of a task, activity, or discipline based on preestablished guidelines related to the amount or extent of work completed. (11/90)

PLAN - a predetermined course of action over a specified period of time which represents a projected response to an anticipated environment in order to accomplish a specific set of adaptive objectives. (11/90)

PLANNED COST - the approved estimated cost for a work package or summary item. This cost when totaled with the estimated costs for all other work packages results in the total cost estimate committed under the contract for the program or project. (11/90)

PLANNING - the determination of a project's objectives with identification of the activities to be performed, methods and resources to be used for accomplishing the tasks, assignment of responsibility and accountability, and establishment of an integrated plan to achieve completion as required. (11/90)

PLANNING BILL (of Material) - an artificial grouping of items, in bill of material format, used to facilitate master scheduling and/or material planning. (11/90)

PLANNING HORIZON - in an MRP system, the span of time from the current to some future date for which material plans are generated. This must cover at least the cumulative purchasing and manufacturing lead time and is usually substantially longer to facilitate MRP II. (11/90)

PLANNING PACKAGE - a logical aggregation of work within a cost account, normally the far term effort that can be identified and budgeted in early baseline planning, but which will be further defined into work packages, LOE, or apportioned effort. (11/90)

PLANT OVERHEAD - those costs in a plant that are not directly attributable to any one production or processing unit and are allocated on some arbitrary basis believed to be equitable. Includes plant management salaries, payroll department, local purchasing and accounting, etc. Syn.: FACTORY EXPENSE. (11/90)

PLUG DATE - a date assigned externally to an activity that establishes the earliest or latest date when the activity is scheduled to start or finish. Syn.: CONSTRAINT DATE. (11/90)

POPULATION - all conceivable or hypothetically possible instances or observations of the selected phenomenon. (11/90)

PRECEDENCE DIAGRAM METHOD (PDM) - a method of constructing a logic network using nodes to represent the activities and connecting them by lines that show logic relationships. (11/90)

PRECEDING EVENT - see BEGINNING EVENT. (11/90)

PRECONSTRUCTION CPM - a plan and schedule of the construction work developed during the design phase preceding the award of contract. (11/90)

PREDECESSOR - An activity that immediately precedes another activity. (3/04)

PREDECESSOR ACTIVITY - any activity that exists on a common path with the activity in question and occurs before the activity in question. (11/90)

PREDECESSOR EVENT - see BEGINNING EVENT. (11/90)

PREFERENTIAL LOGIC - the contractor's approach to sequencing of the work over and above those sequences indicated in or required by the contract documents. Examples include equipment restraints, crew movements, form reuse, special logic (lead/lag) restraints, etc factored into the progress schedule instead of disclosing the associated float times. (11/90)

PRELIMINARY CPM PLAN - CPM analysis of the construction phase made before the award of contracts to determine a reasonable construction period. See PRECONSTRUCTION CPM. (11/90)

PRELIMINARY ENGINEERING - includes all design-related services during the evaluation and definition phases of a project. (11/90)

PRESENT VALUE - the value of a benefit or cost found by discounting future cash flows to the base time. Also, the system of comparing proposed investments, which involves discounting at a known interest rate (representing a cost of capital or a minimum acceptable rate of return) in order to choose the alternative having the highest present value per unit of investment. This technique eliminates the occasional difficulty with profitability index of multiple solutions, but has the troublesome problem of choosing or calculating a "cost of capital" or minimum rate of return. Also called Net Present Value. Syn.: PRESENT WORTH. [B] (11/90)

PRESENT VALUE FACTOR - (1) the discount factor used to convert future values (benefits and costs) to present values; (2) a mathematical expression also known as the present value of an annuity of one; (3) one of a set of mathematical formulas used to facilitate calculation of present worth in economic analysis involving compound interest. Syn.: PRESENT WORTH FACTOR. [B] (11/90)

PRESENT WORTH - see PRESENT VALUE. [A] (11/90)

PRESENT WORTH FACTOR - see PRESENT VALUE FACTOR. [A] (11/90)

PREVENTION - quality activities employed to avoid deviations; includes such activities as quality systems development, quality program development, feasibility studies, quality system audits, contractor/subcontractor evaluation, vendors/suppliers of information/materials evaluation, quality orientation activities, and certification/qualification. (11/90)

PRICE - the amount of money asked or given for a product (eg, exchange value). The chief function of price is rationing the existing supply among prospective buyers. (11/90)

PRICE INDEX - the representation of price changes, which is usually derived by dividing the current price for a specific good by some base period price. See COST INDEX. (11/90)

PRICE RELATIVES - the ratio of the commodity price in a given period to its price in the base period. (11/90)

PRICING - In estimating practice, after costing an item or activity, the determination of the amount of money asked in exchange for the item, activity, or project. Pricing determination considers business and other interests (e.g., profit, marketing, etc.) in addition to inherent costs. The price may be greater or less than the cost depending on the business or other objectives. In the cost estimating process, pricing follows costing and precedes budgeting. In accounting practice, the observation and recording (collecting) of prices. (1/03)

PRICING, FORWARD - an estimation of the cost of work prior to actual performance. It is also known as Prospective Pricing. Pricing forward is generally used relative to the pricing of proposed change orders. (11/90)

PRICING, RETROSPECTIVE - the pricing of work after it has been accomplished. (11/90)

PRIMARY CLASSIFICATION - the classification of commodities by "commodity type." (11/90)

PROBABILITY - a value depicting the likelihood of an expected or occurred event. (11/90)

PROBABILITY DISTRIBUTION - a distribution giving the probability of a value x as a function of x; or more generally, the probability of joint occurrence of a set of variates $x_1 \ldots x_p$ as a function of those quantities.

It is customary, but not the universal practice, to use "probability distribution" to denote the probability of values up to and including the argument x. From a frequency viewpoint the distinction is the same as between Frequency Function and "distribution function". (11/90)

PROCUREMENT - the acquisition (and directly related matters) of equipment, material, and nonpersonal services (including construction) by such means as purchasing, renting, leasing (including real property), contracting, or bartering, but not by seizure, condemnation, or donation. Includes preparation of inquiry packages, requisitions, and bid evaluations; purchase order award and documentation; plus expediting, in-plant inspection, reporting, and evaluation of vendor performance. (11/90)

PRODUCTION PLAN - the agreed upon strategy that comes from the production planning function. (See *PRODUCTION PLANNING.*) (11/90)

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PRODUCTION PLANNING - the function of setting the overall level of manufacturing or construction output. Its prime purpose is to establish production rates that will achieve management's objective, while usually attempting to keep the production force relatively stable. (11/90)

PRODUCTION RATE - the amount of work, which may be accomplished in a given unit of time. (4/04)

PRODUCTION SCHEDULE - a plan which authorizes the factory to manufacture a certain quantity of a specific item. Usually initiated by the production planning department. (11/90)

PRODUCTIVITY - In general terms, labor productivity can be defined as the ratio of the value that labor produces to the value invested in labor. It is an absolute measure of work process efficiency, i.e., a measure of the extent to which labor resources are minimized and wasted effort is eliminated from the work process.

In earned value project control practice, productivity is a relative measure of labor efficiency, either good or bad, when compared to an established base or norm as determined from an area of great experience. Alternatively, productivity is defined as the reciprocal of the labor factor. (1/04)

PROFIT–

(1) Gross Profit - earnings from an on-going business after direct costs of goods sold have been deducted from sales revenue for a given period.

(2) Net Profit - earnings or income after subtracting miscellaneous income and expenses (patent royalties, interest, capital gains) and federal income tax from operating profit.

(3) Operating Profit - earnings or income after all expenses (selling, administrative, depreciation) have been deducted from gross profit. (11/90)

PROFIT MARGIN - see NET PROFIT, PERCENT OF SALES. (11/90)

PROFITABILITY - a measure of the excess income over expenditure during a given period of time. (11/90)

PROFITABILITY ANALYSIS - the evaluation of the economics of a project, manufactured product, or service within a specific time frame. (11/90)

PROFITABILITY INDEX (PI) - the rate of compound interest at which the company's outstanding investment is repaid by proceeds for the project. All proceeds from the project, beyond that required for interest, are credited, by the method of solution, toward repayment of investment by this calculation. Also called discounted cash flow, interest rate of return, investor's method, internal rate of return. Although frequently requiring more time to calculate than other valid yardsticks, PI reflects in a single number both the dollar and the time values of all money involved in a project. In some very special cases, such as multiple changes of sign in cumulative cash position, false and multiple solutions can be obtained by this technique. (11/90)

PROGRAM - an endeavor of considerable scope and enduring in nature as opposed to a project; usually representing some definable portion of the basic agency mission and defined as a line item in the agency budget. (11/90)

PROGRAM MANAGER - *an official in the program* division who has been assigned responsibility for accomplishing a specific set of program objectives. This involves planning, directing and controlling one or more projects of a new or continuing nature, initiation of any acquisition processes necessary to get project work under way, monitoring of contractor performance and the like. (11/90)

PROGRESS - development to a more advanced stage. Progress relates to a progression of development and, therefore, shows relationships between current conditions and past conditions. In networking, progress indicates activities have started or completed, or are in progress. See STATUS. (11/90)

PROGRESS TREND - an indication of whether the progress rate of an activity or of a project is increasing, decreasing, or remaining the same (steady) over a period of time. (11/90)

PROJECT - an endeavor with a specific objective to be met within the prescribed time and dollar limitations and which has been assigned for definition or execution. (11/90)

PROJECT CONTROL - project control is a process for controlling the investment of resources in an asset where investments are made through the execution of a project. Project control includes the general steps of; 1) project planning including establishing project cost and schedule control baselines; 2) measuring project performance; 3) comparing measurements against the project plans, and; 4) taking corrective, mitigating, or improvement action as may be determined through forecasting and further planning activity. (1/02)

PROJECT DURATION - the elapsed duration from project start date through project finish date. (11/90)

PROJECTED FINISH DATE - the current estimate of the calendar date when an activity will be *completed.* (11/90)

PROJECTED START DATE - the current estimate of the calendar date when an activity will begin. (11/90)

PROJECTED UNDERRUN (OVERRUN) - the planned costs minus the latest revised estimate for a work package or summary item. When planned cost exceeds the latest revised estimate, a projected underrun condition exists. When the latest revised estimate exceeds the planned cost, a projected overrun condition exists. (11/90)

PROJECT FINISH DATE (SCHEDULE) - the latest scheduled calendar finish date of all activities on the project. (11/90)

PROJECTION - an extension of a series, or any set of values, beyond the range of the observed data. (11/90)

PROJECT LIFE - see ECONOMIC LIFE. [A] (11/90)

PROJECT MANAGEMENT - the utilization of skills and knowledge in coordinating the organizing, planning, scheduling, directing, controlling, monitoring and evaluating of prescribed activities to ensure that the stated objectives of a project, manufactured product, or service, are achieved. (11/90)

PROJECT MANAGER - an individual who has been assigned responsibility and authority for accomplishing a specifically designated unit of work effort or group of closely related efforts established to achieve stated or anticipated objectives, defined tasks, or other units of related effort on a schedule for performing the stated work funded as a part of the project. The project manager is responsible for the planning, controlling, and reporting of the project. [P] (11/90)

PROJECT NETWORK ANALYSIS (PNA) - a group of techniques based on the network project representation to assist managers in planning, scheduling, and controlling a project. (11/90)

PROJECT OFFICE - the organization responsible for administration of the project management system, maintenance of project files and documents, and staff support for officials throughout the project life cycle. (11/90)

PROJECT PHASES - the major phases of a project, which include preplanning, design, procurement, construction, start-up, operation, and final disposition. (11/90)

PROJECT PLAN - the primary document for project activities. It covers the project from initiation through completion. (11/90)

PROJECT START DATE (SCHEDULE) - the earliest calendar start date among all activities in the network. (11/90)

PROJECT SUMMARY WORK BREAKDOWN STRUCTURE (PSWBS) - a summary WBS tailored by project management to the specific project, and identifying the elements unique to the project. (11/90)

PROJECT TIME - the time dimension in which the project is being planned. (11/90)

PROPOSAL SCHEDULE - the first schedule issued on a project; accompanies either the client's request or the contractor's proposal. (11/90)

PROPOSED BASE CONTRACT PRICE - the sum total of the individual total price amounts for items of work designated as base bid items listed on the schedule of prices on the bid form (excluding alternates, if any). (11/90)

PROPOSED COMBINED CONTRACT PRICE - the sum total of bidder's proposed base contract price and all of the individual total price amounts for items of work designated as alternate bid items listed on the schedule of prices for alternate bid items on the bid form (excluding all additional alternates, if any). (11/90)

PROPOSED CHANGE ORDER - the form furnished by the owner or the engineer which is to be used (1) by the owner, when signed by the owner, as a directive authorizing addition to, deletion from, or revision in the work, or an adjustment in contract price or contract time, or any combination thereof; (2) by the owner, when unsigned, to require that the contractor figure the potential effect on contract price or contract time of a proposed change, if the proposed change is ordered upon signing by the owner; (3) by the contractor, to notify the owner that in the opinion of the contractor, a change is required as provided in the applicable provisions of the contract documents. When signed by the owner, a proposed change order may or may not fully adjust contract price or contract time, but is evidence that the change directed by the proposed change order will be incorporated in a subsequently issued change order following negotiations as to its effect, if any, on contract price or contract time. When countersigned by the contractor, a proposed change order is evidence of the contractor's acceptance of the basis for contract adjustments provided, except as otherwise specifically noted. (11/90)

PRUDENT INVESTMENT - that amount invested in the acquisition of the property of an enterprise when all expenditures were made in a careful, businesslike, and competent manner. (11/90)

PUNCHLIST - a list generated by the owner, architect, engineer, or contractor of items yet to be completed by the contractor. Sometimes called a "but" list ("but" for these items the work is complete). (11/90)

PURE PRICE CHANGE - change in the price of a particular commodity which is not attributable to change in its quality or quantity. (11/90)

QUALIFICATION SUBMITTALS - data pertaining to a bidder's qualifications which shall be submitted as set forth in the instructions to bidders. (11/90)

QUALITY - conformance to established requirements (not a degree of goodness). (11/90)

QUALITY ACCEPTANCE CRITERIA - specified limits placed on characteristics of a product, process, or service defined by codes, standards, or other requirement documents. (11/90)

QUALITY ACTIVITIES - those activities directly associated with appraisal, training, and prevention. (11/90)

QUALITY APPRAISAL - quality activities employed to determine whether a product, process, or service conforms to established requirements, including: design review, specification review, other documentation review, constructability review, materials inspection/tests, personnel testing, quality status documentation, and post project reviews. (11/90)

QUALITY ASSURANCE - all those planned or systematic actions necessary to provide adequate confidence that a product, process, or service will conform to established requirements. (11/90)

QUALITY AUDIT - a formal, independent examination with intent to verify conformance with the acceptance criteria. An audit does not include surveillance or inspection for the purpose of process control or product acceptance. (11/90)

QUALITY CONFORMANCE - quality management activities associated with appraisal, training, and prevention adapted to achieve zero deviations from the established requirements. (11/90)

QUALITY CONTROL - inspection, test, evaluation or other necessary action to verify that a product, process, or service conforms to established requirements and specifications. (11/90)

QUALITY CORRECTIVE ACTION - measures taken to rectify conditions adverse to quality and, where necessary, to preclude repetition. Corrective action includes rework and remedial action for nonconformance deviations. (11/90)

QUALITY MANAGEMENT - concerns the optimization of the quality activities involved in producing a quality product, process or service. As such, it includes appraisal, training, and prevention activities. (11/90)

QUALITY MANAGEMENT COSTS - the sum of those costs associated with appraisal, training, and prevention activities. (11/90)

QUALITY NONCONFORMANCE - a deviation that occurs with a severity sufficient to consider rejection of the product, process, or service. In some situations the product, process, or service may be accepted as is; in other situations, it will require corrective action. It also may involve the provision of deliverables that are more than required. (11/90)

QUALITY PERFORMANCE TRACKING SYSTEM - a management tool providing data for the quantitative analysis of certain quality-related aspects of projects by systematically collecting and classifying costs of quality. (11/90)

QUANTIFICATION - In estimating practice, an activity to translate project scope information into resource quantities suitable for costing. In the engineering and construction industry, a take-off is a specific type of quantification that is a measurement and listing of quantities of materials from drawings. Syn.: TAKE-OFF. (1/03)

QUANTITY RATIO - a ratio which measures, for a given commodity, its quantitative shift between alternative baskets. (11/90)

QUANTITY SURVEY - using standard methods measuring all labor and material required for a specific building or structure and itemizing these detailed quantities in a book or bill of quantities. (11/90)

QUANTITY SURVEYOR - In the United Kingdom, contractors bidding a job receive a document called a bill of quantities, in addition to plans and specifications, which is prepared by a quantity surveyor, according to well-established rules. To learn these rules the quantity surveyor has to undergo five years of technical training and must pass a series of professional examinations. In the United Kingdom a quantity surveyor establishes the quantities for all bidders, and is professionally licensed to do so. (11/90)

QUEUING THEORY - the theory involving the use of mathematical models, theorems and algorithms in the analysis of systems in which some service is to be performed under conditions of randomly varying demand, and where waiting lines or queues may form due to lack of control over either the demand for service or the amount of service required, or both. Utilization of the theory extends to process, operation and work studies. (11/90)

RANDOM PROCESS - in a general sense the term is synonymous with the more usual and preferable "stochastic" process. It is sometimes employed to denote a process in which the movement from one state to the next is determined by a variate which is independent of the initial and final state. (11/90)

RANDOM WALK - the path traversed by a particle which moves in steps, each step being determined by chance either in regard to direction or in regard to magnitude or both. Cases most frequently considered are those in which the particle moves on a lattice of points in one or more dimensions, and at each step is equally likely to move to any of the nearest neighboring points. The theory of random walks has many applications, eg, to the migration of insects, sequential sampling and, in the limit, to diffusion processes. (11/90)

RATE OF RETURN - the interest rate earned by an investment. See RETURN ON AVERAGE INVESTMENT, RETURN ON ORIGINAL INVESTMENT, PROFITABILITY INDEX, INTERNAL RATE OF RETURN, DISCOUNTED CASH FLOW. (11/91)

REAL DISCOUNT RATE - the rate of interest reflecting that portion of the time value of money related to the real earning power of money over time. This is the discount rate used in discount formulas or in selecting discount factors when future benefits and costs are expressed in constant dollars. [A] (11/90)

REAL DOLLARS - see CONSTANT DOLLARS. [A] (11/90)

REAL ESTATE - this refers to the physical land and appurtenances, including structures affixed thereto. In some states, by statute, this term is synonymous with real property. (11/90)

REAL PROPERTY - refers to the interests, benefits, and rights inherent in the ownership of physical real estate. It is the bundle of rights with which the ownership of real estate is endowed. (11/90)

REASONABLENESS STANDARD - costs that do not exceed the amount incurred by a prudent contractor or those costs which are generally accepted. Some factors on which reasonableness is based are recognition of the costs as ordinary and necessary and restraints imposed by law, contract terms, or sound business practices. (11/90)

REBASING - conversion of a price index from one time base to another. (11/90)

REGRESSION - a functional relationship between two or more correlated variables often empirically determined from data and used to predict values of one variable when given values of the others. (11/90)

REMAINING AVAILABLE RESOURCES - the difference between the resource availability pool and the level schedule resource requirements. Its computed from the resource allocation process. (11/90)

REMAINING DURATION - the estimated work units needed to complete an activity as of the data date. (11/90)

REMAINING FLOAT (RF) - the difference between the early finish and the late finish. (11/90)

RENTAL (LEASED) EQUIPMENT COST - the amount which the owner of the equipment (lessor) charges to a lessee for use of the equipment. The best evidence of such costs are rental invoices that indicate the amount paid for leasing such equipment. (11/90)

REPLACEMENT - a facility proposed to take the place of an existing facility, without increasing its capacity, caused either by obsolescence or physical deterioration. (11/90)

REPLACEMENT COST - (1) the cost of replacing the productive capacity of existing property by another property of any type, to achieve the most economical service, at prices as of the date specified; (2) facility component replacement and related costs, included in the capital budget, that are expected to be incurred during the study period. [B] (11/90)

REPLACEMENT VALUE - that value of an item determined by repricing the item on the basis of replacing it, in new condition, with another item that gives the same ability to serve, or the same productive capacity, but which applies current economic design, adjusted for the existing property's physical deterioration. (11/90)

REPRODUCTION COST - the cost of reproducing substantially the identical item or facility at a price level as of the date specified. (11/90)

REPROGRAMMING - a comprehensive replanning of the efforts remaining in the contract resulting in a revised total allocated budget which exceeds the contract budget base. (11/90)

REPUDIATION - see ANTICIPATORY BREACH. (11/90)

REQUIRED COMPLETION DATE - the required date of completion assigned to a specific activity or project. (11/90)

REQUIRED RETURN - the minimum return or profit necessary to justify an investment. It is often termed *interest, expected return or profit*, or charge for the use of capital. (11/90)

REQUIREMENT - an established requisite characteristic of a product, process, or service. A characteristic is a physical or chemical property, a dimension, a temperature, a pressure, or any other specification used to define the nature of a product, process, or service. (11/90)

RESALE VALUE - the monetary sum expected from the disposal of an asset at the end of its economic life, its useful life, or at the end of the study period. [A] (11/90)

RESCHEDULE -(1) in construction, the process of changing the duration and/or dates of an existing schedule in response to externally imposed conditions or progress. (2) in manufacturing, the process of changing order or operation due dates, usually as a result of their being out of phase with when they are needed. (11/90)

RESEARCH EXPENSE - those continuing expenses required to provide and maintain the facilities to develop new products and improve present products. (11/90)

RESERVE STOCK - see SAFETY STOCK. (11/90)

RESIDENT ENGINEER - the authorized representative of the *engineer* who is assigned to the site or any part thereof whose duties are ordinarily set forth in the contract documents and/or the engineer's agreement with the owner. (11/90)

RESOURCE - *in planning and scheduling*, a resource is any consumable, except time, required to accomplish an activity. From a total cost and asset management perspective, resources may include any real or potential investment in strategic assets including time, monetary, human, and physical. A resource becomes a cost when it is invested or consumed in an activity or project. (1/02)

RESOURCE ALLOCATION PROCESS (RAP) - the scheduling of activities in a network with the knowledge of certain resource constraints and requirements. This process adjusts activity level start and finish dates to conform to resource availability and use. (11/90)

RESOURCE AVAILABILITY DATE - the calendar date when a resource level becomes available to be allocated to project activity. (11/90)

RESOURCE AVAILABILITY POOL - the amount of resource availability for any given allocation period. (11/90)

RESOURCE CODE - the code for a particular labor skill, material, equipment type; the code used to identify a given resource. (11/90)

RESOURCE DESCRIPTION - the actual name or identification associated with a resource code. (11/90)

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RESOURCE HISTOGRAM - a graphic display of the amount of resource required as a function of time on a graph. Individual, summary, incremental, and cumulative resource curve levels can be shown. Syn.: RESOURCE PLOT. (11/90)

RESOURCE LIMITED SCHEDULING - a schedule of activities so that a preimposed resource availability level (constant or variable) is not exceeded in any given project time unit. (11/90)

RESOURCE PLOT - see RESOURCE HISTOGRAM. (11/90)

RESOURCE REQUIREMENTS PLANNING - the process of converting the production plan and/or the master production schedule into the impact on key resources, such as labor, machine hours, storage, standard cost dollars, shipping dollars, inventory levels, etc. (11/90)

RESPONSIBLE ORGANIZATION - the organization responsible for management of a work package. (11/90)

RESPONSIBILITY - originates when one accepts the assignment to perform assigned duties and activities. The acceptance creates a liability for which the assignee is held answerable for and to the assignor. It constitutes an obligation or accountability for performance. (11/90)

RESTRAINT - see CONSTRAINT. (11/90)

RETENTION - usually refers to a percent of contract value (usually 5 or 10 percent) retained by the purchaser until work is finished and testing of equipment is satisfactorily completed. (11/90)

RETIREMENT OF DEBT - the termination of a debt obligation by appropriate settlement with the lender. It is understood to be in full amount unless partial settlement is specified. (11/90)

RETURN ON AVERAGE INVESTMENT - the ratio of annual profits to the average book value of fixed capital, with or without working capital. This method has some advantages over the return-on-original-investment method. Depreciation is always considered; terminal recoveries are accounted for. However, the method does not account for the timing of cash flow and yields answers that are considerably higher than those obtained by the return-on-original-investment and profitability index methods. Results may be deceiving when compared, say, against the company's cost of capital. (11/90)

RETURN ON ORIGINAL INVESTMENT - the ratio of expected average annual after tax profit (during the earning life) to total investment (working capital included). It is similar in usefulness and limitations to payoff period. (11/90)

RETURN ON RATE BASE - for a public utility, that monetary sum established by the proper regulatory authority as a basis for determining the charges to customers and the "fair return" to the owners of the utility. (11/90)

REVISION - in the context of scheduling, a change in the network logic, activity duration, resources availability or resources demand which requires network recalculation and drawing correction(s). (11/90)

RIPPLE EFFECT - the multiplying effect of change(s) and/or productivity impacts to upstream work that may have an adverse impact on the subsequent work to be performed. (4/04)

RISK - the degree of dispersion or variability around the expected or "best" value which is estimated to exist for the economic variable in question, eg, a quantitative measure of the upper and lower limits which are considered reasonable for the factor being estimated. (11/90)

ROLLING WAVE PLANNING - Concept of planning where near-term work is planned in more detail than work in the future that is usually planned in summary. As the project progresses, summary activities are broken into more detail for near term execution. (3/04)

ROYALTIES - payments a company receives to allow others to use a design or concept the company has researched and developed to commercialization. Generally, one of two types: (1) paid-up royalties where a lump sum payment is made, and (2) running royalties where continuous payments are made, usually based on actual production or revenues. (11/90)

SAFETY STOCK - the average amount of stock on hand when a replenishment quantity is received. Its purpose is to protect against the uncertainty in demand and in the length of the replenishment lead time. Safety stock and cycle stock are the two main components of any inventory. Syn.: RESERVE STOCK. (11/90)

SAFETY TIME - in a time series planning system, material is frequently ordered to arrive ahead of the forecast requirement date to protect against forecast error. The difference between the forecast requirement date and the planned in-stock date is safety time. (11/90)

SALES - orders booked by customers. (11/90)

SALES ANALYSIS (or RESEARCH) - a systematic study and comparison of sales for consumption data along the lines of market areas, organizational units, products or product groups, customers or customer groups, or such other units as may be useful. See MARKET RESEARCH. Typical analyses would include:

1. Promotion Evaluation

2. Quota Assignment

3. Territory Assignment (11/90)

SALES FORECAST - a prediction or estimate of sales, in dollars or physical units, for a specified future period under a proposed marketing plan or program and under an assumed set of economic and other forces outside the unit for which the forecast is made. The forecast may be for a specified item of merchandise or for an entire line. (11/90)

SALES PROFILE - the growth or decline of historical or forecast sales volume, by years. (11/90)

SALES PRICE - the revenue received for a unit of a product. Gross sales price is the total amount paid. Net sales are gross sales less returns, discounts, freight and allowances. Plant netbacks are net sales less selling, administrative and research expenses. Syn.: SELLING PRICE. (11/90)

SALES REVENUE - revenue received as a result of sales, but not necessarily during the same time period. (11/90)

SALVAGE VALUE - (1) the cost recovered or which could be recovered from a used property when removed, sold, or scrapped; (2) the market value of a machine or facility at any point in time (normally an estimate of an asset's net market value at the end of its estimated life); (3) the value of an asset, assigned for tax computation purposes, that is expected to remain at the end of the depreciation period. (11/90)

SAMPLE - a part, or subset, of a population. (11/90)

SAVINGS-TO-INVESTMENT RATIO (SIR) - either the ratio of present value savings to present value investment costs, or the ratio of annual value savings to annual value investment costs. [A] (11/90)

SCHEDULE - the plan for completion of a project based on a logical arrangement of activities, resources available, imposed dates or funding budgets. (11/90)

SCHEDULED COMPLETION DATE - a date assigned for completion of activity or accomplishment of an event for purposes of meeting specified schedule requirements. (11/90)

SCHEDULED DATE - see CONTRACT DATE. (11/90)

SCHEDULED EVENT TIME - in PERT, an arbitrary schedule time that can be introduced at any event but is usually only used at a certain milestone or the last event. (11/90)

SCHEDULE VARIANCE - the difference between BCWP and BCWS. At any point in time it represents the difference between the dollar value of work actually performed (accomplished) and that scheduled to be accomplished. (11/90)

SCHEDULING - the assignment of desired start and finish times to each activity in the project within the overall time cycle required for completion according to plan. (11/90)

SCHEDULING RULES - basic rules that are spelled out ahead of time so that they can be used consistently in a scheduling system. (11/90)

SCHEDULING VARIANCE - the difference between projected start and finish dates and actual or revised start and finish dates. (11/90)

SCOPE - The sum of all that is to be or has been invested in and delivered by the performance of an activity or project. In project planning, the scope is usually documented (i.e, the scope document), but it may be verbally or otherwise communicated and relied upon. Generally limited to that which is agreed to by the stakeholders in an activity or project (i.e., if not agreed to, it is "out of scope"). In contracting and procurement practice, includes all that an enterprise is contractually committed to perform or deliver. Syn.: PROJECT SCOPE. (1/03)

SCOPE CHANGE - a deviation from the project scope originally agreed to in the contract. A scope change can consist of an activity either added to or deleted from the original scope. A contract change order is needed to alter the project scope. (11/90)

SEASONAL COMMODITIES - commodities which are normally available in the market-place only in a given season of the year. (11/90)

SEASONAL VARIATION - that movement in many economics series which tends to repeat itself within periods of a year. (11/90)

SECONDARY FLOAT (SF) - is the same as the Total Float, except that it is calculated from a schedule date set upon an intermediate event. (11/90)

SECULAR TREND - the smooth or regular movement of a long-term time series trend over a fairly long period of time. (11/90)

SELLING EXPENSE - the total expense involved in marketing the products in question. This normally includes direct selling costs, advertising, and customer service. (11/90)

SELLING PRICE - see SALES PRICE. (11/90)

SENSITIVITY - the relative magnitude of the change in one or more elements of an engineering economy problem that will reverse a decision among alternatives. (11/90)

SENSITIVITY ANALYSIS - a test of the outcome of an analysis by altering one or more parameters from an initially assumed value(s). [A] (11/90)

SENTIMENTAL VALUE - a value associated with an individual's personal desire, usually related to a prior personal relationship. (11/90)

SEQUENTIAL ANALYSIS - a process by which statistical data are analyzed continuously as the sample accumulates. After each additional item is obtained, and on the basis of a certain calculation, a decision is made whether to accept the hypothesis H_1, under test, or to accept an alternative hypothesis H_2 or to suspend judgement until more data are examined. The decision is based on the probability ratio of the sample under alternative hypotheses where the probabilities of the two types of erroneous conclusions are assigned in advance. Frequently fewer observations are required than under any other known method for the same degree of reliability and discrimination. It is very simple to apply and it requires the analyst to state his problem precisely and determine the alternative answers in advance with the attendant probabilities of erroneous conclusion. The calculations involved are the computations of the ratio of the probability of the observations if H_1 is true to the probability of the observations under the hypothesis H_2. If this ratio exceeds (I-B)/A, the hypothesis H_1 is accepted, whereas if it is less than B/(I-A), the hypothesis H_2 is accepted; if it is between these two ratios, judgement is suspended. A is the maximum acceptable probability of erroneously rejecting the hypothesis H_2, and B is the maximum acceptable probability of erroneously accepting the hypothesis H_2. (11/90)

SERVICEABILITY - a measure of the degree to which servicing of an item will be accomplished within a given time under specified conditions. (11/90)

SERVICING - the replenishment of consumables needed to keep an item in operating condition, but not including any other preventive maintenance or any corrective maintenance. (11/90)

SERVICE WORTH VALUE - earning value, assuming the rates and/or prices charged are just equal to the reasonable worth to customers of the services and/or commodities sold. (11/90)

SHIFTING BASE - changing the point of reference of an index number series from one time reference period to another. (11/90)

SHOP DRAWINGS - all drawings, diagrams, illustrations, schedules and other data which are specifically prepared by or for the contractor to illustrate some portion of the work and all illustrations, brochures, standard schedules, performance charts, instructions, diagrams and other information prepared by a

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supplier and submitted by the contractor to illustrate material or equipment for some portion of the work. (11/90)

SHOP ORDER NUMBER - see ACCOUNT NUMBER. (11/90)

SHOP PLANNING - the coordination of material handling, material availability, the setup and tooling availability so that a job can be done on a particular machine. (11/90)

SHORT-TERM ACTIVITIES - see MONTHLY GUIDE SCHEDULE. (11/90)

SHUTDOWN POINT - the production level at which it becomes less expensive to close the plant and pay remaining fixed expenses out-of-pocket rather than continue operations; that is, the plant cannot meet its variable expense. See BREAKDOWN POINT. (11/90)

SIC CODE - the Standard Industrial Classification of the Office of Management and Budget, which provides the framework for the industry-sector index classification scheme. Product indexes are aggregated to five-digit product classes and four-digit industries. Industry indexes can be aggregated to three- and two-digit levels as well. (11/90)

SIGNIFICANT VARIANCES - those differences between planned and actual performance which exceed established thresholds and which require further review, analysis and action. (11/90)

SIMPLE INTEREST - (1) interest that is not compounded -- is not added to the income-producing investment or loan; (2) the interest charges under the condition that interest in any time period is only charged on the principal. (11/90)

SIMPLE PAYBACK PERIOD (SPB) - the time required for the cumulative benefits from an investment to pay back the investment cost and other accrued costs, not considering the time value of money. [A] (11/90)

SIMULATION - (1) the technique of utilizing representative or artificial operating and demand data to reproduce, under test, various conditions that are likely to occur in the actual performance of a system. Simulation is frequently used to test the accuracy of a theoretical model or to examine the behavior of a system under different operating policies; (2) the design and operation of a model of a system. (11/90)

SINKING FUND - (1) a fund accumulated by periodic deposits and reserved exclusively for a specific purpose, such as retirement of a debt or replacement of a property; (2) a fund created by making periodic deposits (usually equal) at compound interest in order to accumulate a given sum at a given future time for some specific purpose. (11/90)

SITE PREPARATION - an act involving grading, landscaping, installation of roads and siding, of an area of ground upon which anything previously located had been cleared so as to make the area free of obstructions, entanglements or possible collisions with the positioning or placing of anything new or planned. (11/90)

SKEWNESS - an expression for nonsymmetrical "tailing" of a distribution. (11/90)

SLACK - see FLOAT. (11/90)

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SLACK PATHS - the sequences of activities and events that do not lie on the critical path or paths. (11/90)

SLACK TIME - the difference in calendar time between the scheduled due date for a job and the estimated completion date. If a job is to be completed ahead of schedule, it is said to have slack time; if it is likely to be completed behind schedule, it is said to have negative slack time. Slack time can be used to calculate job priorities using methods such as the critical ratio. In the critical path method, total slack is the amount of time a job may be delayed in starting without necessarily delaying the project completion time. Free slack is the amount of time a job may be delayed in starting without delaying the start of any other job in the project. (11/90)

SPECIFICATION, DESIGN (PRESCRIPTIVE) - a design specification providing a detailed written and/or graphic presentation of the required properties of a product, material, or piece of equipment, and prescribing the procedure for its fabrication, erection, and installation. (11/90)

SPECIFICATION, PERFORMANCE - a statement of required results, verifiable as meeting stipulated criteria, and generally free of instruction as to the method of accomplishment. (11/90)

SPECIFICATIONS - written directions regarding the quality of materials and the nature of the workmanship for a job. Specifications may be written directly on the drawings, or presented in a separate document. (11/90)

SPLICING TECHNIQUE - one of the procedures used for maintaining the continuity of a price index series in the case of substituted items (and/or replaced outlets). The basic assumption underlying the technique is that, at a given point in time, the relative difference in prices between the replaced and replacing items (and/or outlets) reflects the difference in respective qualities. In effect, the splicing technique is analogous to, and may be considered a particular case of, the linking procedure. (11/90)

SPOT MARKET PRICE INDEX - daily index used as a measure of price movements of 22 sensitive basic commodities whose markets are to be presumed to be among the first to be influenced by changes in economic conditions. It serves as one early indicator of impending changes in business activity. (11/90)

STAGE OF PROCESSING - a commodity's intermediate position in the value-added channel of production. (11/90)

STANDARD DEVIATION - the most widely used measure of dispersion of a frequency distribution. It is calculated by summing squared deviations from the mean, dividing by the number of items in the group and taking the square root of the quotient. (11/90)

STANDARD ERROR OF THE MEAN - the standard deviation of the distribution, divided by the square root of the number of cases. (11/90)

STANDARD ERROR OF ESTIMATE - an expression for the standard deviation of the observed values about a regression line, i.e., an estimate of the variance likely to be encountered in making predictions from the regression equation. (11/90)

STANDARD INDUSTRIAL CLASSIFICATION (SIC CODE) - a classification system of the Office of Management and Budget which provides the framework for the industry-sector index classification scheme. Product indexes are aggregated to five-digit product classes and four-digit industries. Industry indexes can be aggregated to three- and two-digit levels as well.

Example: industry code - 3443 - fabricated platework
product code - 80201 carbon steel tanks and vessels (11/90)

STANDARD NETWORK DIAGRAM - a predefined network intended to be used more than one time in any given project. (11/90)

STARTING EVENT - see BEGINNING EVENT. (11/90)

STARTUP - that period after the date of initial operation, during which the unit is brought up to acceptable production capacity and quality within estimated production costs. Startup is the activity that commences on the date of initial activity that has significant duration on most projects, but is often confused (used interchangeably) with date of initial operation. (11/90)

STARTUP COSTS - extra operating costs to bring the plant on stream incurred between the completion of construction and beginning of normal operations. In addition to the difference between actual operating costs during that period and normal costs, it also includes employee training, equipment tests, process adjustments, salaries and travel expense of temporary labor, staff and consultants, report writing, post-startup monitoring and associated overhead. Additional capital required to correct plant problems may be included. Startup costs are sometimes capitalized. (11/90)

STATUS - the condition of the project at a specified point in time relative to its plan. An instantaneous snapshot of the then current conditions. See PROGRESS. [P] (11/90)

STATUS LINE - a vertical line on a time-scaled schedule indicating the point in time (date) on which the status of the project is reported. Often referred to as the time now line. See DATA DATE. (11/90)

STATUSING - indicating on the schedule the most current project status. See UPDATE. (11/90)

STOCHASTIC - the adjective "stochastic" implies the presence of a random variable. (11/90)

STOCK AND BOND VALUE - a special form of market value for enterprises, which can be owned through possession of their securities. Stock and bond value is the sum of (1) the par values in dollars of the different issues of bonds multiplied by the corresponding ratios of the market price to the par value, and (2) the number of shares of each issue of stock multiplied by the corresponding market price in dollars per share. (11/90)

STOP WORK ORDER - see SUSPENSION OF WORK, DIRECTED. (11/90)

STRAIGHT-LINE DEPRECIATION - method of depreciation whereby the amount to be recovered (written off) is spread uniformly over the estimated life of the asset in terms of time periods or units of output. (11/90)

STRATEGIC ASSET - any unique physical or intellectual property that is of long term or ongoing value to the enterprise. As used in total cost management, it most commonly includes capital or fixed assets, but may include intangible assets. Excludes cash and purely financial assets. Strategic assets are created by the investment of resources through projects. (1/02)

STUDY PERIOD - the length of time over which an investment is analyzed. Syn.: LIFE CYCLE; TIME HORIZON. [A] (11/90)

SUBCONTRACT - any agreement or arrangement between a contractor and any person (in which the parties do not stand in the relationship of an employer and an employee) and where neither party is the owner. (11/90)

SUBCONTRACTOR - an individual, partnership, corporation, joint venture or other combination thereof having a direct contract with the contractor or with any other subcontractor for the performance of a part of the work at the site. (11/90)

SUBINDEX - a price index for a subaggregate of a given basket of commodities. (11/90)

SUBNET - the subdivision of a network into segments usually representing some form of subproject; a portion of a larger network generally for a unique area of a project. See also FRAG NET. [P] (11/90)

SUBSTANTIAL COMPLETION - work (or a specified part thereof) which has progressed to the point where in the opinion of the engineer, as evidenced by the engineer's definitive certificate of substantial completion, it is sufficiently complete, in accordance with the contract documents, so that the work (or specified part) can be utilized for the purposes for which it is intended; or if there be no such certificate issued, when final payment is due in accordance with the general conditions. Substantial completion of the work, or specified part thereof, may be achieved either upon completion of pre-operational testing or startup testing, depending upon the requirements of the contract documents. The terms Substantially Complete and Substantially Completed as applied to any work refer to substantial completion thereof. (11/90)

SUBSYSTEM - an aggregation of component items (hardware and software) performing some distinguishable portion of the function of the total system of which it is a part. Normally, a subsystem could be considered a system in itself if it were not an integral part of the larger system. (11/90)

SUCCESSOR - An activity that immediately succeeds another activity. (3/04)

SUCCESSOR ACTIVITY - any activity that exists on a common path with the activity in question and occurs after the activity in question. (11/90)

SUCCESSOR EVENT - the event that signifies the completion of an activity. (11/90)

SUMMARY ITEM - an item appearing in the work breakdown structure. (11/90)

SUMMARY NETWORK - a summarization of the CPM network for presentation purposes. This network is not computed. (11/90)

SUMMARY NUMBER - a number that identifies an item in the work breakdown structure. (11/90)

SUMMARY SCHEDULE - see MASTER PROJECT SCHEDULE. (11/90)

SUM-OF-DIGITS METHOD - A method of computing depreciation in which the amount for any year is based on the ratio: (years of remaining life)/(1+2+3+...+n), n being the total anticipated life. Also known as sum-of-the-years-digits method. (11/90)

SUNK COST - a cost that has already been incurred and which should not be considered in making a new investment decision. [B] (11/90)

SUPERIOR KNOWLEDGE - see MISREPRESENTATION. (11/90)

SUPPLEMENTARY CONDITIONS - the part of the contract documents which amends or supplements the general conditions. (11/90)

SUPPLIER - a manufacturer, fabricator, distributor or vendor. (11/90)

SURETY - a bonding company licensed to conduct business which guarantees the owner that the contract will be completed (Performance Bond) and that subcontractors and suppliers will be paid (Payment Bond). (11/90)

SUSPENSION OF WORK, CONSTRUCTIVE - an act or failure to act by the owner, or the owner's representative, which is not a directed suspension of work or work stoppage, but which has the effect of delaying, interrupting, or suspending all or a portion of the work. (11/90)

SUSPENSION OF WORK, DIRECTED - actions resulting from an order of the owner to delay, interrupt, or suspend any or all portions of the work for a given period of time, for the convenience of the owner. (11/90)

SYSTEM - a collection of hardware (equipment and facilities) and related software (procedures, etc) designated to perform a unique and useful function. A system contains everything necessary (except personnel and materials or supplies) to perform its defined function. (11/90)

SYSTEMS STUDIES - the development and application of methods and techniques for analyzing and assessing programs, activities and projects to review and assess efforts to date and to determine future courses and directions. These studies include cost/ benefit analysis, environmental impact analysis, assessment of the likelihood of technical success, forecasts of possible futures resulting from specific actions, and guidance for energy program planning and implementation. (11/90)

TAKE-OFF - a take-off is a specific type of quantification that is a measurement and listing of quantities of materials from drawings in order to support the estimate costing process and/or to support the material procurement process. Syn.: QUANTIFICATION. (1/03)

TANGIBLES - things that can be quantitatively measured or valued, such as items of cost and physical assets. (11/90)

TARGET DATE - the date an activity is desired to be started or completed; either externally imposed on the system by project management or client, or accepted as the date generated by the initial CPM schedule operation. (11/90)

TARGET REPORTING - a method of reporting the current schedule against some established base line schedule and the computations of variances between them. (11/90)

TARGET START DATE - see EXPECTED BEGIN DATE. (11/90)

TASK - Smallest unit of work planned. It must have an identifiable start and finish, and usually produces some recognizable results. (3/04)

TASK MONITOR - the individual assigned the monitoring responsibility for a major effort within the program. (11/90)

TAXES PAYABLE - tax accruals due within a year. (11/90)

TEMPORARY CONSTRUCTION COST - includes costs of erecting, operating, and dismantling impermanent facilities, such as offices, workshops, etc, and providing associated services such as utilities. (11/90)

TERMINATION - actions by the owner, in accordance with contract clauses, to end, in whole or in part, the services of the contractor. Termination may be for the convenience of the owner or for default by the contractor. (11/90)

TERMS OF PAYMENT - defines a specific time schedule for payment of goods and services and usually forms the basis for any contract price adjustments on those contracts that are subject to escalation. (11/90)

THIRD PARTY CLAIM - a claim against either or both the owner or the contractor by members of the public, or other parties, usually for property damage or personal injury. (11/90)

TIED ACTIVITY - an activity that must start within a specified time or immediately after its predecessor's completion or start. (11/90)

TIME EXTENSION - an increase in the contract time by modification to complete an item of work. Time extension may be granted under the corresponding provisions in the general conditions. An excusable delay generally entitles a contractor to a *time extension*. (11/90)

TIME HORIZON - see STUDY PERIOD. [A] (11/90)

TIME-LIMITED SCHEDULING - the scheduling of activities so predetermined resource availability pools are not exceeded unless the further delay will cause the project finish to be delayed. Activities can be delayed only until their late start date. However, activities will begin when the late start date is reached, even if resource limits are exceeded. Networks with negative total float time cannot be processed by time-limited scheduling. (11/90)

TIME NOW LINE - the point in time that the network analysis is based upon. May or may not be the data date. See STATUS LINE. (11/90)

TIME OF THE ESSENCE - a contract requirement that completion of the work within the time limits in the contract is essential. Failure to do so is a *breach for which the injured party is entitled to damages*. (11/90)

TIME-SCALED CPM - a plotted or drawn representation of a CPM network where the length of the activities indicates the duration of the activity as drawn to a calendar scale. Float is usually shown with a dashed line as are dummy activities. (11/90)

TIME UNIT - see CALENDAR UNIT. (11/90)

TIME VALUE OF MONEY - (1) the *time-dependent value of money stemming both from changes in the* purchasing power of money (that is, inflation or deflation), and from the real earning potential of alternative investments over time. (2) the cumulative effect of elapsed time on the money value of an event, based on the earning power of equivalent invested funds. See FUTURE WORTH and PRESENT WORTH; (3) the expected interest rate that capital should or will earn. [B] (11/90)

TOTAL COST BIDDING - a method of establishing the purchase price of movable equipment; the buyer is guaranteed that maintenance will not exceed a set maximum amount during a fixed period and that the equipment will be repurchased at a set minimum price when the period ends. (11/90)

TOTAL COST MANAGEMENT - the effective application of professional and technical expertise to plan and control resources, costs, profitability and risks. Simply stated, it is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product, or service. This is accomplished through the application of cost engineering and cost management principles, proven methodologies and the latest technology in support of the management process. Can also be considered the sum of the practices and processes that an enterprise uses to manage the total life cycle cost investment in its portfolio of strategic assets. (1/02)

TOTAL FLOAT (TF) - the amount of time (in work units) that an activity may be delayed from its early start without delaying the project finish date. Total float is equal to the late finish minus the early finish or the late start minus the early start of the activity. (11/90)

TOTAL QUALITY MANAGEMENT - the consistent integrated orchestration of the total complex of an organization's work processes and activities to achieve continuous improvement in the organization's processes and products. (11/90)

TRACKING - a form of monitoring applied to projects. The measurements are expected to change according to the planned progress. [P] (11/90)

TRANSFER PRICE - a term used in economic analysis in the mineral processing industries; used to assign a value to raw materials when the same company does the mining and processing; usually equal to the fair market value. (11/90)

TRANSPORTATION PROBLEM - a homogeneous product is to be shipped in the amounts $a_1, a_2,...,a_m$ respectively from each of m shipping origins and received in amounts $b_1, b_2,...,b_n$ respectively by each of n shipping destinations. The cost of shipping a unit amount from the i^{th} origin to the j^{th} destination is c_{ij} and is known for all combinations (i,j). The problem is to determine the amounts x_{ij} to be shipped over all routes (i,j) so as to minimize the total cost of transportation. (11/90)

TRANSSHIPMENT PROBLEM - a generalized transportation problem in which transshipment through intermediate nodes between source and destination is allowed. (11/90)

TURNOVER RATIO - the ratio of annual sales to investment. Inclusion of working capital is preferable, but not always done. Turnover ratio is considered by some to be reasonable basis for a guesstimate of facilities cost, for new products similar to existing products. It ranges around 1.0 for many chemical plants. The product of turnover ratio and profit margin on sales gives a return-on-investment measure. (11/90)

UNBALANCING - A technique used in the pricing process to allocate estimated costs to accounts whose definitions do not fully reflect the nature of the cost being allocated. The purpose of unbalancing is to achieve a desired business result such as improved cash flow. For example, a disproportionate amount of overhead costs may be allocated in a contract bid to early project activities so that early income is maximized. (1/03)

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UNCERTAINTY - unknown future events which cannot be predicted quantitatively within useful limits, eg, accidents which destroy invested facilities, a major strike, a competitor's innovation which makes the new product obsolete. (11/90)

UNDERGROUND FACILITIES - all pipelines, conduits, ducts, cables, wires, utility accessways, vaults, tanks, tunnels or other such facilities or attachments, and any encasements containing such facilities which have been installed underground to furnish any of the following services or materials: electricity, gases, steam, liquid petroleum products, telephone or other communications, cable television, sewage and drainage removal, traffic or other control systems or water. (11/90)

UNIT COST - dollar per unit of production. It is usually total cost divided by units of production, but a major cost divided by units of production is frequently referred to as a unit cost; for example, the total unit cost is frequently subdivided into the unit costs for labor, chemicals, etc. (11/90)

UNJUST ENRICHMENT DOCTRINE - the belief in law that one person should not be allowed to profit or enrich himself or herself unfairly at the expense of another person. (11/90)

UNUSUALLY SEVERE WEATHER - adverse weather which, at the time of year in which it occurred, is unusual for the place of contract performance. No matter how severe or destructive, if the weather is not unusual for the particular time and place, the contractor is not entitled to relief. Unusual or normal weather does not mean ideal weather or the best weather that can be expected; rather it means the normal weather pattern, both good and bad, that could be reasonably anticipated in a particular area. The normal weather pattern is generally that based on the record of the prior ten years unless the contract documents provide for a different period. (11/90)

UPDATING - the regular review, analysis, evaluation, and reporting of progress of the project, including recomputation of an estimate or schedule. See STATUSING. (11/90)

UNION - a group of workers who organize together for the purpose of negotiating wage rates, working conditions and fringe benefits. (11/90)

USEFUL LIFE - the period of time over which an investment is considered to meet its original objective. [A] (11/90)

USE VALUE - see FUNCTIONAL WORTH. (11/90)

VALUATION OR APPRAISAL - the art of estimating the fair-exchange value of specific properties. (11/90)

VALUE, ACTIVITY - that portion of the contract price which represents a fair value for the part of the work identified by that activity. (11/90)

VALUE ADDED BY DISTRIBUTION - the portion of the value of a product or service to the consumer or user which results from distribution activities. This value includes such components as time utility and place utility. (11/90)

VALUE ADDED BY MARKETING - that portion of the value of a product or service to the consumer or user which results from marketing activities. This value includes such components as price reduction through economies of scale and buyer awareness of more desirable innovations in products or services. (11/90)

VALUE OF WORK PERFORMED TO DATE - the planned cost for completed work. (11/90)

VALUE EFFECTIVE - generally used to describe decisions which have a cost impact; value-effective decisions tend to optimize the value received for the decision made and to maximize return on investments. (11/90)

VALUE ENGINEERING - a practice function targeted at the design itself, which has as its objective the development of design of a facility or item that will yield least life-cycle costs or provide greatest value while satisfying all performance and other criteria established for it. (11/90)

VALUE ENGINEERING COST AVOIDANCE - a decrease in the estimated overall cost for accomplishing a function. (11/90)

VALUE ENGINEERING COST REDUCTION - a decrease in the committed and/or established overall cost for accomplishing a function. (11/90)

VALUE ENGINEERING JOB PLAN - an aid to problem recognition, definition, and solution. It is a formal, step-by-step procedure followed in carrying out a value engineering study. (11/90)

VARIABLE COSTS - those costs that are a function of production, eg, raw materials costs, by-product credits, and those processing costs that vary with plant output (such as utilities, catalysts and chemical, packaging, and labor for batch operations). (11/90)

VARIANCE - in cost control, the difference between actual cost or forecast budget cost. (11/90)

VARIATION IN ESTIMATED QUANTITY - the difference between the quantity estimated in the bid schedule and the quantity actually required to complete the bid item. Negotiation or adjustment for variations are generally called for when an increase or decrease exceeds 15 percent. (11/90)

VENTURE LIFE - the total time span during which expenditures and/or reimbursements related to the venture occur. Venture life may include the research and development, construction, production and liquidation periods. See FINANCIAL LIFE. (11/90)

VENTURE WORTH - present worth of cash flows above an acceptable minimum rate, discounted at the average rate of earnings. (11/90)

VERTICAL EVENT NUMBERING - assigning event numbers in vertical order. (11/90)

WAGE RATE - the hourly, daily or weekly cost of a person who works for wages, e.g., mechanics, laborers, steamfitters. (11/90)

WEIGHTS - numerical modifiers used to infer importance of commodities in an aggregative index. (11/90)

WORK - any and all obligations, duties, responsibilities, labor, materials, equipment, temporary facilities, and incidentals, and the furnishing thereof necessary to complete the construction which are assigned to, or undertaken by the contractor, pursuant to the contract documents. Also, the entire completed construction or the various separately identifiable parts thereof required to be furnished under the contract documents. Work is the result of performing services, furnishing labor, and furnishing and incorporating materials and equipment into the construction, all as required by the contract documents. (11/90)

WORK BREAKDOWN STRUCTURE (WBS) - a product-oriented family tree division of hardware, software, facilities and other items which organizes, defines and displays all of the work to be performed in accomplishing the project objectives.

1. Contract Work Breakdown Structure (CWBS) - the complete WBS for a contract developed and used by a contractor in accordance with the contract work statement. It extends the PSWBS to the lowest level appropriate to the definition of the contract work.

2. Project Summary Work Breakdown Structure (PSWBS) - a summary WBS tailored by project management to the specific project with the addition of the elements unique to the project. (11/90)

WORK BREAKDOWN STRUCTURE ELEMENT - any one of the individual items or entries in the WBS hierarchy, regardless of level. (11/90)

WORK DIRECTIVE CHANGE - a written directive to the contractor, issued on or after the effective date of the agreement and signed by the owner and recommended by the engineer ordering an addition, deletion or revision in the work, or responding to differing or unforeseen physical conditions or emergencies under which the work is to be performed as provided in the general conditions. A work directive change may not change the contract price or the contract time, but is evidence that the parties expect that the change directed or documented by a work directive change will be incorporated in a subsequently issued change order following negotiations by the parties as to its effect, if any, on the contract price or contract time. (11/90)

WORKHOUR - an analysis of planned versus actual staffing of the project used to determine work progress, productivity rates, staffing of the project, etc. (11/90)

WORK-IN-PROCESS - product in various stages of completion throughout the factory, including raw material that has been released for initial processing and completely processed material awaiting final inspection and acceptance as finished product or shipment to a customer. Many accounting systems also include semifinished stock and components in this category. Syn: IN-PROCESS INVENTORY. (11/90)

WORK ITEM - the precedence notation equivalent of an activity. See ACTIVITY. (11/90)

WORK PACKAGE - a segment of effort required to complete a specific job such as a research or technological study or report, experiment or test, design specification, piece of hardware, element of software, process, construction drawing, site survey, construction phase element, procurement phase element, or service, which is within the responsibility of a single unit within the performing organization. The work package is usually a functional division of an element of the lowest level of the WBS. (11/90)

WORK POWER LEVELING - see LOAD LEVELING. (11/90)

WORK SAMPLING - A direct method of measuring and monitoring labor productivity so that labor resources can be minimized and wasted effort eliminated from work processes. Work sampling provides information about the work process (i.e., how work is done) in a way that supports statistical assessment of such processes in order to optimize productivity. (1/04)

WORK SITE - The area designated in the contract where the facility is to be constructed. (11/90)

WORK UNIT - a unit of time used to estimate the duration of activities. (11/90)

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WORTH - the worth of an item or groups of items, as in a complete facility, is determined by the return on investment compared to the amount invested. The worth of an item is dependent upon the analysis of feasibility of the entire item or group or items under discussion (or examination). (11/90)

WRITTEN AMENDMENT - A written amendment of the contract documents, signed by the owner and the contractor on or after the effective date of the agreement and normally dealing with the non-engineering or non-technical rather than strictly work-related aspects of the contract documents. (11/90)

YEAR-TO-YEAR PRICE INDEX - a price index for a given year with the preceding year as the base period. (11/90)

YIELD - the ratio of return or profit over the associated investment, expressed as a percentage or decimal usually on an annual basis. See RATE OF RETURN. (11/90) aace International

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COST ESTIMATE CLASSIFICATION SYSTEM

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Cost Estimate Classification System

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PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to asset project cost estimates. Asset project cost estimates typically involve estimates for capital investment, and exclude operating and life-cycle evaluations. The Cost Estimate Classification System maps the phases and stages of asset cost estimating together with a generic maturity and quality matrix that can be applied across a wide variety of industries.

This guideline and its addenda have been developed in a way that:

- provides common understanding of the concepts involved with classifying project cost estimates, regardless of the type of enterprise or industry the estimates relate to;
- fully defines and correlates the major characteristics used in classifying cost estimates so that enterprises may unambiguously determine how their practices compare to the guidelines;
- uses degree of project definition as the primary characteristic to categorize estimate classes; and
- reflects generally-accepted practices in the cost engineering profession.

An intent of the guidelines is to improve communication among all of the stakeholders involved with preparing, evaluating, and using project cost estimates. The various parties that use project cost estimates often misinterpret the quality and value of the information available to prepare cost estimates, the various methods employed during the estimating process, the accuracy level expected from estimates, and the level of risk associated with estimates.

This classification guideline is intended to help those involved with project estimates to avoid misinterpretation of the various classes of cost estimates and to avoid their misapplication and misrepresentation. Improving communications about estimate classifications reduces business costs and project cycle times by avoiding inappropriate business and financial decisions, actions, delays, or disputes caused by misunderstandings of cost estimates and what they are expected to represent.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally-acceptable classification system that can be used as a basis to compare against. If an enterprise or organization has not yet formally documented its own estimate classification scheme, then this guideline may provide an acceptable starting point.

INTRODUCTION

An AACE International guideline for cost estimate classification for the process industries was developed in the late 1960s or early 1970s, and a simplified version was adopted as an ANSI Standard Z94.0 in 1972. Those guidelines and standards enjoy reasonably broad acceptance within the engineering and construction communities and within the process industries. This recommended practice guide and its addenda improves upon these standards by:

1. providing a classification method applicable across all industries; and
2. unambiguously identifying, cross-referencing, benchmarking, and empirically evaluating the multiple characteristics related to the class of cost estimate.

This guideline is intended to provide a generic methodology for the classification of project cost estimates in any industry, and will be supplemented with addenda that will provide extensions and additional detail for specific industries.

CLASSIFICATION METHODOLOGY

There are numerous characteristics that can be used to categorize cost estimate types. The most significant of these are degree of project definition, end usage of the estimate, estimating methodology, and the effort and time needed to prepare the estimate. The "primary" characteristic used in this guideline to define the classification category is the degree of project definition. The other characteristics are "secondary."

Categorizing cost estimates by degree of project definition is in keeping with the AACE International philosophy of Total Cost Management, which is a quality-driven process applied during the entire project life cycle. The discrete levels of project definition used for classifying estimates correspond to the typical phases and gates of evaluation, authorization, and execution often used by project stakeholders during a project life cycle.

Five cost estimate classes have been established. While the level of project definition is a continuous spectrum, it was determined from benchmarking industry practices that three to five discrete categories are commonly used. Five categories are established in this guideline as it is easier to simplify by combining categories than it is to arbitrarily split a standard.

The estimate class designations are labeled Class 1, 2, 3, 4, and 5. A Class 5 estimate is based upon the lowest level of project definition, and a Class 1 estimate is closest to full project definition and maturity. This arbitrary "countdown" approach considers that estimating is a process whereby successive estimates are prepared until a final estimate closes the process.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical +/- range relative to best index of 1 [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Screening or Feasibility	Stochastic or Judgment	4 to 20	1
Class 4	1% to 15%	Concept Study or Feasibility	Primarily Stochastic	3 to 12	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Mixed, but Primarily Stochastic	2 to 6	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Primarily Deterministic	1 to 3	5 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Deterministic	1	10 to 100

Notes: [a] If the range index value of "1" represents +10/-5%, then an index value of 10 represents +100/-50%.
[b] If the cost index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%.

Figure 1 – Generic Cost Estimate Classification Matrix

DEFINITIONS OF COST ESTIMATE CHARACTERISTICS

The following are brief discussions of the various estimate characteristics used in the estimate classification matrix. For the secondary characteristics, the overall trend of how each characteristic varies with the degree of project definition (the primary characteristic) is provided.

Level of Project Definition (Primary Characteristic)

This characteristic is based upon percent complete of project definition (roughly corresponding to percent complete of engineering). The level of project definition defines maturity or the extent and types of input information available to the estimating process. Such inputs include project scope definition, requirements documents, specifications, project plans, drawings, calculations, learnings from past projects, reconnaissance data, and other information that must be developed to define the project. Each industry will have a typical set of deliverables that are used to support the type of estimates used in that industry. The set of deliverables becomes more definitive and complete as the level of project definition (*i.e., project engineering*) progresses.

End Usage (Secondary Characteristic)

The various classes (or phases) of cost estimates prepared for a project typically have different end uses or purposes. As the level of project definition increases, the end usage of an estimate typically progresses from strategic evaluation and feasibility studies to funding authorization and budgets to project control purposes.

Estimating Methodology (Secondary Characteristic)

Estimating methodologies fall into two broad categories: stochastic and deterministic. In stochastic methods, the independent variable(s) used in the cost estimating algorithms are generally something other than a direct measure of the units of the item being estimated. The cost estimating relationships used in stochastic methods often are somewhat subject to conjecture. With deterministic methods, the independent variable(s) are more or less a definitive measure of the item being estimated. A deterministic methodology is not subject to significant conjecture. As the level of project definition increases, the estimating methodology tends to progress from stochastic to deterministic methods.

Expected Accuracy Range (Secondary Characteristic)

Estimate accuracy range is in indication of the degree to which the final cost outcome for a given project will vary from the estimated cost. Accuracy is traditionally expressed as a +/- percentage range around the point estimate after application of contingency, with a stated level of confidence that the actual cost outcome would fall within this range (+/- measures are a useful simplification, given that actual cost outcomes have different frequency distributions for different types of projects). As the level of project definition increases, the expected accuracy of the estimate tends to improve, as indicated by a tighter +/- range.

Note that in figure 1, the values in the accuracy range column do not represent + or - percentages, but instead represent an index value relative to a best range index value of 1. If, for a particular industry, a Class 1 estimate has an accuracy range of +10/-5 percent, then a Class 5 estimate in that same industry may have an accuracy range of +100/-50 percent.

Effort to Prepare Estimate (Secondary Characteristic)

The level of effort needed to prepare a given estimate is an indication of the cost, time, and resources required. The cost measure of that effort is typically expressed as a percentage of the total project costs for a given project size. As the level of project definition increases, the amount of effort to prepare an estimate increases, as does its cost relative to the total project cost. The effort to develop the project deliverables is not included in the effort metrics; they only cover the cost to prepare the cost estimate itself.

RELATIONSHIPS AND VARIATIONS OF CHARACTERISTICS

There are a myriad of complex relationships that may be exhibited among the *estimate characteristics* within the estimate classifications. The overall trend of how the secondary characteristics vary with the level of project definition was provided above. This section explores those trends in more detail. Typically, there are commonalties in the secondary characteristics between one estimate and the next, but in any given situation there may be wide variations in usage, methodology, accuracy, and effort.

The level of project definition is the "driver" of the other characteristics. Typically, all of the secondary characteristics have the level of project definition as a primary determinant. While the other characteristics are important to categorization, they lack complete consensus. For example, one estimator's "bid" might be another's "budget." Characteristics such as "accuracy" and "methodology" can vary markedly from one industry to another, and even from estimator to estimator within a given industry.

Level of Project Definition

Each project (or industry grouping) will have a typical set of deliverables that are used to support a given class of estimate. The availability of these deliverables is directly related to the level of project definition achieved. The variations in the deliverables required for an estimate are too broad to cover in detail here; however, it is important to understand what drives the variations. Each industry group tends to focus on a defining project element that "drives" the estimate maturity level. For instance, chemical industry projects are "process equipment-centric"—i.e., the level of project definition and subsequent estimate maturity level is significantly determined by how well the equipment is defined. Architectural projects tend to be "structure-centric," software projects tend to be "function-centric," and so on. Understanding these drivers puts the differences that may appear in the more detailed industry addenda into perspective.

End Usage

While there are common end usages of an estimate among different stakeholders, usage is often relative to the stakeholder's identity. For instance, an owner company may use a given class of estimate to support project funding, while a contractor may use the same class of estimate to support a contract bid or tender. It is not at all uncommon to find stakeholders categorizing their estimates by usage-related headings such as "budget," "study," or "bid." Depending on the stakeholder's perspective and needs, it is important to understand that these may actually be all the same class of estimate (based on the primary characteristic of level of project definition achieved).

Estimating Methodology

As stated previously, estimating methodologies fall into two broad categories: stochastic and deterministic. These broad categories encompass scores of individual methodologies. Stochastic methods often involve simple or complex modeling based on inferred or statistical relationships between costs and programmatic and/or technical parameters. Deterministic methods tend to be straightforward counts or measures of units of items multiplied by known unit costs or factors. It is important to realize that any combination of methods may be found in any given class of estimate. For example, if a stochastic method is known to be suitably accurate, it may be used in place of a deterministic method even when there is sufficient input information based on the level of project definition to support a deterministic method. This may be due to the lower level of effort required to prepare an estimate using stochastic methods.

Expected Accuracy Range

The accuracy range of an estimate is dependent upon a number of characteristics of the estimate input information and the estimating process. The extent and the maturity of the input information as measured by percentage completion (and related to level of project definition) is a highly-important determinant of accuracy. However, there are factors besides the available input information that also greatly affect estimate accuracy measures. Primary among these are the state of technology in the project and the quality of reference cost estimating data.

State of technology—technology varies considerably between industries, and thus affects estimate accuracy. The state of technology used here refers primarily to the programmatic or technical uniqueness and complexity of the project. Procedurally, having "full extent and maturity" in the estimate basis deliverables is deceptive if the deliverables are based upon assumptions regarding uncertain technology. For a "first-of-a-kind" project there is a lower level of confidence that the execution of the project will be successful *(all else being equal)*. There is generally a higher confidence for projects that repeat past practices. Projects for which research and development are still under way at the time that the estimate is prepared are particularly subject to low accuracy expectations. The state of technology may have an order of magnitude (10 to 1) effect on the accuracy range.

Quality of reference cost estimating data—accuracy is also dependent on the quality of reference cost data and history. It is possible to have a project with "common practice" in technology, but with little cost history available concerning projects using that technology. In addition, the estimating process typically employs a number of factors to adjust for market conditions, project location, environmental considerations, and other estimate-specific conditions that are often uncertain and difficult to assess. The accuracy of the estimate will be better when verified empirical data and statistics are employed as a basis for the estimating process, rather than assumptions.

In summary, estimate accuracy will generally be correlated with estimate classification (and therefore the level of project definition), *all else being equal*. However, specific accuracy ranges will typically vary by industry. Also, the accuracy of any given estimate is not fixed or determined by its classification category. Significant variations in accuracy from estimate to estimate are possible if any of the determinants of accuracy, such as technology, quality of reference cost data, quality of the estimating process, and skill and knowledge of the estimator vary. Accuracy is also not necessarily determined by the methodology used or the effort expended. Estimate accuracy must be evaluated on an estimate-by-estimate basis, usually in conjunction with some form of risk analysis process.

Effort to Prepare Estimate

The effort to prepare an estimate is usually determined by the extent of the input information available. The effort will normally increase as the number and complexity of the project definition deliverables that are produced and assessed increase. However, with an efficient estimating methodology on repetitive projects, this relationship may be less defined. For instance, there are combination design/estimating tools in the process industries that can often automate much of the design and estimating process. These tools can often generate Class 3 deliverables and estimates from the most basic input parameters for repetitive-type projects. There may be similar tools in other industry groupings.

It also should be noted that the estimate preparation costs as a percentage of total project costs will vary inversely with project size in a nonlinear fashion. For a given class of estimate, the preparation cost percentage will decrease as the total project costs increase. Also, at each class of estimate, the preparation costs in different industries will vary markedly. Metrics of estimate preparation costs normally exclude the effort to prepare the defining project deliverables.

ESTIMATE CLASSIFICATION MATRIX

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed above.

This generic matrix and guideline provide a high-level estimate classification system that is nonindustry specific. Refer to subsequent addenda for further guidelines that will provide more detailed information for application in specific industries. These will provide additional information, such as input deliverable checklists, to allow meaningful categorization in that industry.

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering.**

aace International

AACE International Recommended Practice No. 18R-97

COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

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COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

February 2, 2005

PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with a generic maturity and quality matrix, which can be applied across a wide variety of industries.

This addendum to the generic recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice (17R-97) by providing:

- a section that further defines classification concepts as they apply to the process industries;
- charts that compare existing estimate classification practices in the process industry; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic standard, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. It is hoped that this addendum will allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the level of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in nonprocess industries such as commercial building construction, environmental remediation, transportation infrastructure, "dry" processes such as assembly and manufacturing, "soft asset" production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the

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significant building construction that may be a part of process plants. Building construction will be covered in a separate addendum.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed by the AACE International Cost Estimating Committee. The practices were found to have significant commonalities that are conveyed in this addendum.

COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed in the generic standard. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline provide an estimate classification system that is specific to the process industries. Refer to the generic standard for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will typically provide additional information, such as input deliverable checklists to allow meaningful categorization in those particular industries.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** *Expressed as % of complete definition*	**END USAGE** Typical purpose of *estimate*	**METHODOLOGY** Typical estimating *method*	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	*Semi-Detailed Unit* Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

see page 5

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

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Figure 1. – Cost Estimate Classification Matrix for Process Industries
CHARACTERISTICS OF THE ESTIMATE CLASSES

The following charts (figures 2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each chart, the following information is provided:

- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the level of project definition.
- **Level of Project Definition Required:** expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage:** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methods Used:** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range:** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.
- **Effort to Prepare:** this section provides a typical level of effort (in hours) to produce a complete estimate for a US$20,000,000 plant. Estimate preparation effort is highly dependent on project size, project complexity, estimator skills and knowledge, and on the availability of appropriate estimating cost data and tools.
- **ANSI Standard Reference (1989) Name:** this is a reference to the equivalent estimate class in the existing ANSI standards.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. *These alternate names are* not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in the chart.

CLASS 5 ESTIMATE	
Description: Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation. ***Level of Project Definition Required:*** 0% to 2% of full project definition. **End Usage:** Class 5 estimates are prepared for any number of strategic *business planning purposes, such as but not limited to* market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.	**Estimating Methods Used:** Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 5 estimates are - 20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Order of magnitude estimate (typically -30% to +50%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, *prospect estimate*, concession license estimate, guesstimate, rule-of-thumb.

Figure 2a. – Class 5 Estimate

CLASS 4 ESTIMATE	
Description: Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists. **Level of Project Definition Required:** 1% to 15% of full project definition. **End Usage:** Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage.	**Estimating Methods Used:** Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. **Expected Accuracy Range:** Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Screening, top-down, feasibility, authorization, factored, pre-design, pre-study.

Figure 2b. – Class 4 Estimate

CLASS 3 ESTIMATE	
Description: Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists. **Level of Project Definition Required:** 10% to 40% of full project definition. **End Usage:** Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase "control estimates" against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control.	**Estimating Methods Used:** Class 3 estimates usually involve more deterministic estimating methods than stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project. **Expected Accuracy Range:** Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 150 hours or less to perhaps more than 1,500 hours, depending on the project and the estimating methodology used. **ANSI Standard Reference Z94.2-1989 Name:** Budget estimate (typically -15% to + 30%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate.

Figure 2c. – Class 3 Estimate

CLASS 2 ESTIMATE	
Description: Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc. **Level of Project Definition Required:** 30% to 70% of full project definition. **End Usage:** Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program.	**Estimating Methods Used:** Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods. **Expected Accuracy Range:** Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Typically, as little as 300 hours or less to perhaps more than 3,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2-1989 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate.

Figure 2d. – Class 2 Estimate

CLASS 1 ESTIMATE	
Description: Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans. **Level of Project Definition Required:** 50% to 100% of full project definition. **End Usage:** Class 1 estimates are typically prepared to form a current control estimate to be used as the final control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution.	**Estimating Methods Used:** Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities. **Expected Accuracy Range:** Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. **Effort to Prepare (for US$20MM project):** Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes. **ANSI Standard Reference Z94.2 Name:** Definitive estimate (typically -5% to + 15%). **Alternate Estimate Names, Terms, Expressions, Synonyms:** Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate.

Figure 2e. – Class 1 Estimate

COMPARISON OF CLASSIFICATION PRACTICES

Figures 3a through 3c provide a comparison of the estimate classification practices of various firms, organizations, and published sources against one another and against the guideline classifications. These tables permits users to benchmark their own classification practices.

INCREASING PROJECT DEFINITION

AACE Classification Standard	ANSI Standard Z94.0	AACE Pre-1972	Association of Cost Engineers (UK) ACostE	Norwegian Project Management Association (NFP)	American Society of Professional Estimators (ASPE)
Class 5	Order of Magnitude Estimate -30/+50	Order of Magnitude Estimate	Order of Magnitude Estimate Class IV -30/+30	Concession Estimate Exploration Estimate Feasibility Estimate	Level 1
Class 4	Budget Estimate -15/+30	Study Estimate	Study Estimate Class III -20/+20	Authorization Estimate	Level 2
Class 3		Preliminary Estimate	Budget Estimate Class II -10/+10	Master Control Estimate	Level 3
Class 2	Definitive Estimate -5/+15	Definitive Estimate	Definitive Estimate Class I -5/+5	Current Control Estimate	Level 4
Class 1		Detailed Estimate			Level 5 Level 6

Figure 3a. – Comparison of Classification Practices

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INCREASING PROJECT DEFINITION

AACE Classification Standard	Major Consumer Products Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)	Major Oil Company (Confidential)
Class 5	Class S Strategic Estimate	Class V Order of Magnitude Estimate	Class A Prospect Estimate Class B Evaluation Estimate	Class V
Class 4	Class 1 Conceptual Estimate	Class IV Screening Estimate	Class C Feasibility Estimate Class D Development Estimate	Class IV
Class 3	Class 2 Semi-Detailed Estimate	Class III Primary Control Estimate	Class E Preliminary Estimate	Class III
Class 2	Class 3 Detailed Estimate	Class II Master Control Estimate	Class F Master Control Estimate	Class II
Class 1		Class I Current Control Estimate	Current Control Estimate	Class I

Figure 3b. – Comparison of Classification Practices

INCREASING PROJECT DEFINITION

AACE Classification Standard	J.R. Heizelman, 1988 AACE *Transactions* [1]	K.T. Yeo, The Cost Engineer, *1989* [2]	Stevens & Davis, 1988 AACE *Transactions* [3]	P. Behrenbruck, Journal of Petroleum Technology, 1993 [4]
Class 5	Class V	Class V Order of Magnitude	Class III*	Order of Magnitude
Class 4	Class IV	Class IV *Factor Estimate*	Class II	*Study Estimate*
Class 3	Class III	Class III Office Estimate		
Class 2	Class II	Class II Definitive Estimate		*Budget Estimate*
Class 1	Class I	Class I Final Estimate	Class I	Control Estimate

[1] John R. Heizelman, ARCO Oil & Gas Co., 1988 AACE Transactions, Paper V3.7
[2] K.T. Yeo, The Cost Engineer, Vol. 27, No. 6, 1989
[3] Stevens & Davis, BP International Ltd., 1988 AACE Transactions, Paper B4.1 (* Class III is inferred)
[4] *Peter Behrenbruck, BHP Petroleum Pty., Ltd., article in Petroleum Technology, August 1993*

Figure 3c. – Comparison of Classification Practices

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ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Figure 4 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the degree of completion of the deliverable. The degree of completion is indicated by the following letters.

- None (blank): development of the deliverable has not begun.
- Started (S): work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- Preliminary (P): work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- Complete (C): the deliverable has been reviewed and approved as appropriate.

	ESTIMATE CLASSIFICATION				
General Project Data:	**CLASS 5**	**CLASS 4**	**CLASS 3**	**CLASS 2**	**CLASS 1**
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Drawings		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control System Discipline Drawings			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Figure 4. – Estimate Input Checklist and Maturity Matrix

REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering.**
AACE International Recommended Practice No.17R-97, **Cost Estimate Classification System.**

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(3)

CSC.14

Construction Cost Contingency Tracking System

Mr. John F. Rowe, PE

The author will present an objective, forward-looking cost contingency tracking system (CTS) that uses readily available cost information and a simple spreadsheet format. Using the CTS, project managers can assign contingency to construction contracts, track its consumption and manage a reserve for upcoming work. The paper will discuss the development of rules, using the perceived risk of each construction contract, to assign an initial contingency value to each construction contract. The author will then describe setting up the CTS using this initially assigned contingency value, basic cost information and cost trends from field staff. Once in place, project managers can use the CTS to assess a project's overall budget health and focus on contracts that require special attention. The CTS can also be used to calculate the estimated cost at completion for each contract to provide early warning of overruns. It has been successfully tested on a $1.4 billion rail and highway improvement program.

CONTINGENCY

The Association for Advancement of Cost Engineering defines contingency as, "An amount added to the estimate to allow for changes that experience shows will likely be required"[5]. The value of possible changes, and thus contingency, is proportional to the risk present in a project and this risk drops as the design advances, construction contracts are awarded, and construction is completed. Figure 1 shows a downward sloping channel that represents total project contingency over the life cycle of a project. Typically, the baseline project budget is set at some point in the project life cycle and project managers must live within that contingency budget. Ideally, the baseline budget should not be set until the project manager has a good handle on the remaining project risk and can determine a sufficient value of contingency to include in the budget to cover that risk [1,2]. Although beyond the scope of this paper, much has been written about techniques to initially set the contingency budget including expert opinion, Monte Carlo analysis, and other statistical methods [3,4]. *This paper will focus on managing that contingency* budget once it has been set, specifically during the construction phase of a capital project. This is accomplished by solving the twin problems of how to assign cost contingency to each construction contract and how to accurately forecast the final cost of these contracts at any given time.

The construction phase is where the rubber meets the road in managing capital projects. The pace quickens, spending accelerates, and an unprepared project team can be left in the dust. During the construction phase, the estimate at completion (EAC) of the contract packages changes more quickly than at any other phase of the project. A project manager must be able to detect potential project contingency shortfalls in order to down-scope or otherwise rebuild contingency. Conversely, if it becomes apparent that excess contingency will remain at the end of the project, project managers should re-deploy that capital to a more productive use as soon as possible.

ASSIGNING CONTINGENCY TO CONSTRUCTION CONTRACTS

By the start of the construction phase, final design should be complete and most, if not all, risk associated with each contract should result from change order growth occurring after contract award. Since the engineer's estimate for a construction contract is only intended to predict the bid price of the contract, contingency must be included in the contract budget to account for change order growth.

Project managers should establish guidelines governing the amount of change order contingency to be assigned to each contract. A survey of past experience with change order growth on completed contracts can provide a good basis for setting these guidelines. Typically, since different types of contracts contain different levels of change order risk, initial contingency guidelines should take the contract type into account. Table 1 shows an example set of guidelines by contract type—the details will vary by project. Using established guidelines, the project team can quickly determine the desired contingency value to assign to each contract as its design is completed. The same guidelines will be used to reset the contingency based on the original contract value once bids are received on each contract. This initial contingency value (C_I) is a key numerical input to the CTS.

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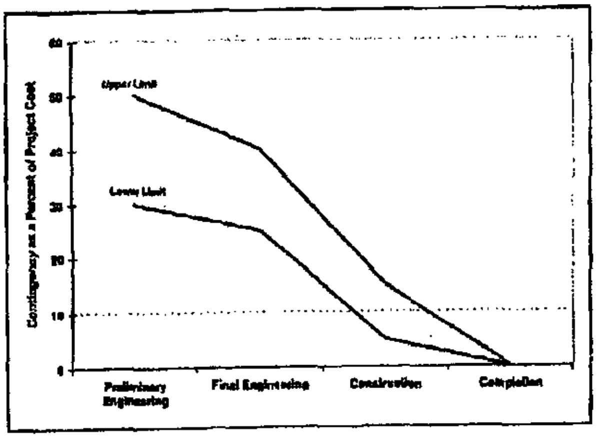

Figure 1—Project Contingency Should Decrease Over the Life of a Project.

Table 1—Example Guidelines for Initial Contingency Assignment.

Contract Type	Initial Change Order Contingency (as a % of Contract Cost)
Procurement Only	5%
Typical Construction	10%
Special Construction:	
Tunnels	15%
Very Small Contracts	20%

ACCURATE CONSTRUCTION CONTRACT FORECASTING

Once construction contracts have been awarded, accurate forecasts are needed to track contingency consumption. The people most able to provide accurate forecast information for each construction contract are those closest to the action. These are typically the resident engineers, project controls engineers, or contract administrators with direct responsibility for day-to-day construction management. Using either spreadsheets or specialized construction management software, the field team should maintain the most thorough contract forecast possible, given the other demands on their time. This forecast should include the original contract amount, approved change orders, pending change orders, and all identified cost issues. A well maintained forecast will change from day to day as issues are identified, negotiations are completed, and costs are agreed upon. This field-generated contract forecast (F) is another important numerical input to the CTS.

From experience we know that even the best field team will not be able to forecast all the change issues and associated costs until very close to the end of construction. For this reason, to develop an accurate value for the estimate at completion (EAC), we must keep some retained contingency (C_R) in addition to the field-generated Contract Forecast (F). This can be expressed as follows:

$$EAC = F + C_R$$

(equation 1)

Intuitively, the value of retained contingency (C_R) should be based on the initial contingency (C_I) value assigned at contract award and should drop as the contract is completed and risk drops.

AN EMPIRICAL FORMULA FOR RETAINED CONTINGENCY

For simplicity, one could assign retained contingency (C_R) based on the assumption that risk drops linearly as a contract is completed and is inversely related to the percent complete. As an example, at 80 percent complete 20 percent of initial contingency (C_I) would be retained to account for changes that have not yet been identified. Intuitively, this linear assumption seems conservative, as we would expect that more than half of the change issues should have been identified at the 50 percent completion point. In order to test the straight-line assumption and modify it if necessary, the author collected some real world data. Actual cost (A) and contract forecast (F) data were collected over four years, on a monthly basis, for 15 of the largest construction contracts on a light rail expansion program managed by the Valley Transportation Authority in San Jose, California. The contracts studied had a combined value of $257 million and covered a wide array of work including heavy civil and track, tunnel, elevated structure, station finish and overhead contact system construction contracts.

For each monthly Contract Forecast (F) reading, the Value of Changes Forecast (Δ_t) at that time was calculated by subtracting the Original Contract Amount (C_0).

$$\Delta_t = F - C_0$$

(equation 2)

Once each contract is complete, the final contract amount (CF) is known and the final value of changes (Δ_F) can be calculated as follows:

$$\Delta_F = C_F - C_0$$

(equation 3)

The proportion of final changes forecast ($\Delta_{t/F}$) at each point in time can be readily calculated using the final value of changes (DF) as follows:

$$\Delta_{t/F} = \Delta_t / \Delta_F$$

(equation 4)

Figure 2 shows a scatter diagram with a total of 282 monthly coordinates for the proportion of final changes forecast ($\Delta_{t/F}$) on the y-axis (expressed as a percent) and percent complete (P) on the x-

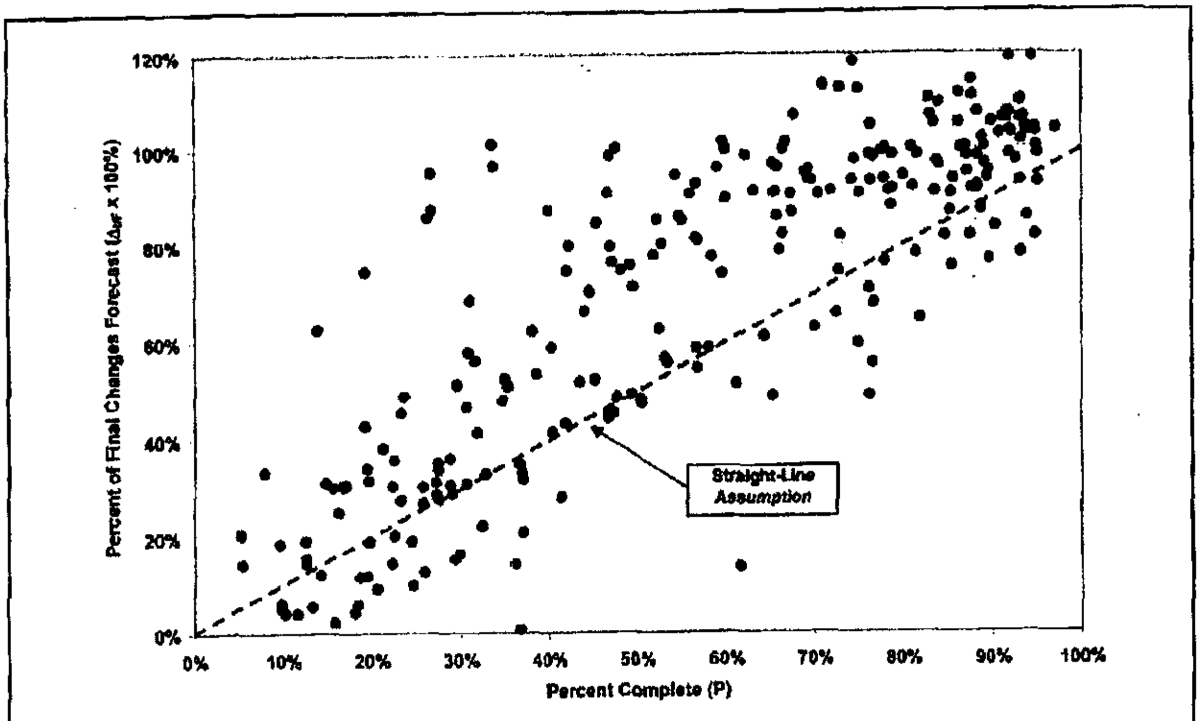

Figure 2—Scatter Diagram of Data with Straight-Line Assumption Superimposed.

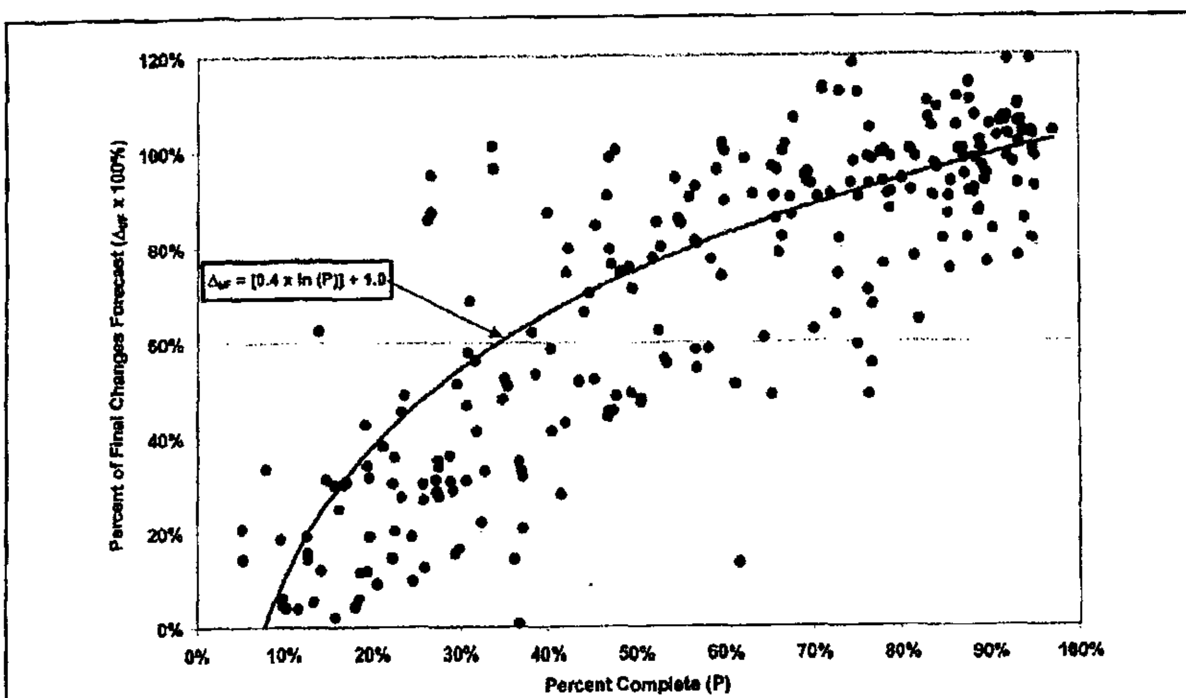

Figure 3—Scatter Diagram from Figure 2 With the Best-Fit Curve and Equation.

axis. (Values for P<5% and P>95% were excluded for clarity.) The dashed line on the graph shows the straight-line assumption we are testing.

Although the data points in our sample don't trace out a perfect curve, it is clear that the straight-line assumption is not accurate and is probably too conservative. In order to find a better solution, the author employed the spreadsheet program's curve-fitting feature. The best-fit curve (R^2=0.46), shown in figure 3, is a natural logarithmic function (ln = $\log_e$) described as follows:

$$\Delta_{I/F} = 0.4\ln(P) + 1.0$$

(equation 5)

This equation provides a value for the proportion of final changes Forecast ($\Delta_{I/F}$) expected to be included in the contract forecast (F) as a function of percent complete (P). It should be noted that, for values of percent complete (P) less than approximately 25percent, the best-fit curve does not fit the data very well. For this reason, and due to the fact that forecast data can be highly variable in the early stages of contract execution, estimate at complete (EAC) values derived from this equation and the contingency Tracking system (CTS), to be described shortly, should be considered to be unreliable until at least 25 percent completion is reached. Natural log functions are readily calculated by spreadsheet programs, and table 2 shows the results of this equation for a range of percent complete (P) values. The numerical results generated by this empirical equation seem to be intuitively more accurate than the straight-line assumption, as the proportion of final changes forecast ($\Delta_{I/F}$) rises quickly in the first half of contract completion as cost issues are identified and negotiated, then levels out as completion is reached.

Table 2—Values of $\Delta_{I/F}$ Resulting from the Empirical Equation.

Percent Complete (P)	Percent of Final Changes Included in Contract Forecast ($\Delta_{I/F}$ x 100%)
10%	8%
20%	36%
30%	52%
40%	63%
50%	72%
60%	80%
70%	86%
80%	91%
90%	96%
100%	100%

As an example, for a contract that is 50 percent complete, table 2 shows that we can expect that a good contract forecast (F) figure has captured 72 percent of the final changes that will occur on the contract. To account for the 28 percent of changes that have not yet been forecast, we would simply retain 28 percent of the initial contingency (C_I) value in addition to the contract forecast (F) value. Since the value of $\Delta_{I/F}$ derived in our empirical equation is expressed as a decimal, we would subtract it from one to arrive at a value for retained contingency (C_R). Mathematically, retained contingency (C_R) is derived as follows:

$$C_R = (1 - \Delta_{I/F}) \times C_I$$

(equation 6)

Substituting in our empirical equation for $\Delta_{I/F}$:

$$C_R = [1 - (0.4\ln(P) + 1.0] \times C_I$$

(equation 7)

Simplifying the equation results in the following:

$$C_R = -0.4\ln(P) \times C_I$$

(equation 8)

Table 3—An Example CTS for a Simplified Light Rail Project.

Contract No.	Contract Description	Numerical Inputs B Current Budget	 F Current Forecast	 A Actual Costs	 C_I Initial Contingency	Calculated Values P = (A/F) as % Percent Complete	 C_R = - 0.4 ln(P) x C_I Retained Contingency	 EAC = F + C_R Estimate at Completion	 C_{SD} = B - EAC Contingency Surplus/(Deficit)
A100	Procure Rail, Ties and Special Trackw	525,000	525,000	525,000	25,000	100.0%	0	525,000	0
A999	Procurement Allocated Contingency	0	0	0	0	0.0%	0	0	0
	Subtotal Procurement	525,000	525,000	525,000	25,000	100.0%	0	525,000	0
C100	Civil, Track & Landscaping	11,000,000	11,325,000	7,630,000	1,000,000	67.4%	157,970	11,482,970	(482,970)
C200	Stations & Park and Ride Facilities	3,300,000	3,125,000	1,000,000	300,000	32.0%	136,732	3,261,732	38,268
C999	Civil Allocated Contingency	25,000	0	0	0	0.0%	0	0	25,000
	Subtotal Construction	14,325,000	14,450,000	8,630,000	1,300,000	59.7%	294,702	14,744,702	(419,702)
S100	Overhead Contact System	1,650,000	1,550,000	50,000	150,000	3.2%	206,039	1,756,039	(106,039)
S200	Combined Communications & Signals	2,300,000	2,000,000	0	300,000	0.0%	300,000	2,300,000	0
S999	Systems Allocated Contingency	25,000	0	0	0	0.0%	0	0	25,000
	Subtotal Systems	3,975,000	3,550,000	50,000	450,000	1.4%	506,039	4,056,039	(81,039)
Z999	Project (Unallocated) Contingency	1,500,000	0			0.0%	0	0	1,500,000
	Subtotal Project Contingency	1,500,000	0	0	0	0.0%	0	0	1,500,000
	TOTAL PROJECT	$20,325,000	$18,525,000	$9,205,000	$1,775,000	48.7%	$800,741	$19,325,741	$999,259

Table 4—Numerical Inputs to the CTS

Numerical Input	Designation	Contract Status / Type	Value to Use
Current Budget	B	Pre-Bid	Current Budget, which should include change order contingency that was developed using the contingency guidelines.
		Active	Current Budget, which was reset at award to equal the Original Contract Value + Initial Contingency (C_I).
		Contingency Line	Current Budget for the contingency line.
Current Forecast	F	Pre-Bid	Set equal to the Current Budget (B) less any change order contingency included in that number.
		Active	Original Contract Amount + Approved/Pending Change Orders + Identified Potential Changes. *(Note: This value should not include any allowance for changes that have not yet been identified.)*
		Contingency Line	Always zero.
Actual/Incurred Costs to Date	A	Pre-Bid	Always zero.
		Active	Use either Actual or Incurred Costs for the contract, depending on what's available from the cost system.
		Contingency Line	Always zero.
Initial Contingency	C_I	Pre-Bid	Change order contingency included in the Current Budget
		Active	Use the contingency guidelines, based on the contract risk type, to develop a percentage factor to apply to the Original Contract Amount.
		Contingency Line	Always zero.

Table 5—Calculated Values Used in the CTS

Calculated Value	Designation	Calculation	Description
Contract Percent Complete	P	A / F	Measure of progress toward contract completion expressed as a percentage.
Retained Contingency	C_R	$-0.4\ ln(P)\ x\ C_I$	This equation was derived empirically. C_R is an allowance for future changes that have not yet been identified. *(For P=0, $C_R = C_I$)*
Estimate at Completion	EAC	$F + C_R$	Contract estimated cost at completion that takes into account all approved/identified changes plus an allowance for future changes.
Contingency Surplus/Deficit	$C_{S/D}$	B - E	A contract's projected impact on project contingency. Negative values (deficit) represent consumption of project contingency while positive values (surplus) indicate contracts that will return contingency back to the project upon completion.

We now have all the prerequisites in place for a construction phase contingency tracking system (CTS).

THE CONTINGENCY TRACKING SYSTEM (CTS)

The contingency tracking system (CTS) was developed to provide an up-to-date snapshot of remaining cost contingency on a large rail and highway expansion program. The goal was to provide an objective measure of remaining contingency that takes into account the latest forecast cost for each component construction contract as well as an allowance for changes that will likely occur but have not yet been identified. The CTS had to be simple to understand so that it would be accepted by a number of project stakeholders, and easily maintained so as not to present a recurring burden to the project controls staff. The CTS focuses on the construction category of project costs since, during the construction phase, this is where the vast majority of risk remains.

Table 3 shows the CTS as applied to a simplified project, in this example a small light rail project. At first glance, it looks somewhat complex but as will be shown, it consists of readily available numerical inputs and values derived from these inputs with simple calculations.

The rows of the CTS represent construction contracts and contingency line items that are organized by contract type. In this example, an allocated contingency line is included in each construction category as well as a project contingency line at the bottom. The specifics of how contingency is deployed across the project categories are a matter of preference, but the CTS can be adapted to any scenario.

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The contracts in table 3 range in progress from pre-bid (S200), to active (C100, C200, and S100), to completed (A100) in order to demonstrate how the CTS treats each type. Totals for each column are shown by category and at the bottom line. The columns are organized into two groups: numerical inputs and calculated values.

NUMERICAL INPUTS TO THE CTS

The numerical inputs to the CTS should all be readily available information from either the project cost report or forecast reports maintained by field construction management staff. These numerical inputs are as follows and are summarized in table 4 for handy reference:

Current Budget (B)

Taken from the project cost report, it should include all budget transfers/changes that resulted from the evolution of contract scope up until contract award and, as discussed, should also include an amount to cover change orders. When bids are received and the contract is awarded, the budget should be re-set to equal the original contract amount plus an initial contingency (C_I) by transferring budget to/from allocated and/or project contingency. Ideally, this budget will not be changed again until the contract is completed and excess budget is returned to contingency.

Current Forecast (F)

Before a contract is bid, this will equal the current budget, less the amount included to cover change orders. After contract award, field construction management personnel typically maintain the current forecast as previously discussed. Note that the current forecast should not include any factors to predict the value of unidentified changes, as the CTS will account for these.

Actual Costs (A)

Taken from the project cost report. The value of all payments made on a given contract as of the date the CTS is being updated.

Initial Contingency (C_I)

Before a contract is bid, the initial contingency guidelines discussed earlier are typically employed to develop the Initial Contingency (C_I) value based on the engineer's estimate. When bids are received and the contract is awarded, C_I is recalculated using the same guidelines applied to the bid amount. Note that, while the other numerical inputs are updated on a regular basis, initial contingency is a static number that will not change once contract award is made.

CALCULATED VALUES USED IN THE CTS

The CTS takes the numerical inputs described above to derive calculated values that are ultimately used to arrive at the total contingency available after taking construction cost trends into account. These calculated values are as follows and are summarized in table 5 for handy reference:

Contract Percent Complete (P)

There are many ways to ascertain progress toward completion of construction contracts. For simplicity, the CTS relies on Actual Costs (A) and the Current Forecast (F) to generate this number as follows:

$$P = A / F$$

(equation 9)

Retained Contingency (C_R)

This calculation is at the heart of the CTS. It represents a forecast value of change orders that have not yet been identified by the construction management team but that we anticipate from experience will sooner or later be encountered. As derived earlier, this number is a natural log function, calculated as follows:

$$C_R = -0.4 \ln(P) \times C_I$$

(equation 8)

This formula provides invalid results for a zero value of percent complete (P). In this case, the value of initial contingency (C_I) should be used.

Estimate at Completion (EAC)

This number is simply the sum of the current forecast (F) provided by our field construction management staff and Retained Contingency (C_R). The estimate at completion (EAC) is calculated as equation 1 demonstrates.

The author has used this EAC value as an early warning of contracts that are trending toward exceeding agency contract authorization limits. It often provides a warning several months before an overrun becomes readily apparent, but tends to be unreliable until a contract is at least 25 percent complete, as discussed earlier.

Contingency Surplus/Deficit (CS/D)

By comparing the estimate at completion (EAC) to the current budget (B) we can determine whether a given contract is trending towards adding to or depleting project contingency. The contingency surplus/deficit ($C_{S/D}$) is calculated as follows:

$$C_{S/D} = B - F$$

(equation 10)

When the contingency surplus/deficit ($C_{S/D}$) is totaled across all construction contracts, allocated contingency lines and the project contingency line, the resulting value represents a good estimate of contingency available for non-construction project categories (e.g. right-of-way, design, and management).

The "punch line" of our CTS example is shown in the bottom right corner of table 3. This number represents the contingency available for other project risks after construction risks are covered. In the example, although the budgeted project contingency is \$1.5 million, the *CTS shows that only about \$1.0 million* in contingency is actually available for non-construction project risks. The CTS is forecasting that the construction contracts will consume \$0.5 million of project contingency to complete.

Note that, in the example project depicted in table 3, the total bottom-line value for retained contingency (C_R) is approximately \$0.8 million. Recall, that this is the amount the CTS is adding to the field-generated contract forecasts to account for unidentified changes. Therefore, a project manager who relied solely on the field-generated forecasts to calculate EAC's would think that \$1.8 million in contingency was available. If a scope addition valued at \$1.25 million was approved, *it might lead to a* nasty surprise, as construction contracts progressed and additional changes were identified, resulting in an overrun of the project budget.

ADVANTAGES AND LIMITATIONS OF THE CTS

The main advantage of the CTS is its simplicity. It does not require advanced mathematics, statistics, or computer programming abilities to set up and maintain. This simplicity makes it easier to explain to and achieve buy-in from project stakeholders for the results that it generates. The basis for the Retained Contingency (C_R) calculation at the heart of the CTS is a set of real-world data, and the results pass the reasonableness test. The simple spreadsheet format and readily available numerical inputs make maintenance quite easy, which is important because the CTS should be updated on a regular basis in order to spot trends early. Another advantage is that the CTS provides an objective reading of remaining contingency, generated in a consistent manner from month to month. The only subjective input to the CTS is the initial contingency (C_I) value for each contract, and even that results from the application of a pre-determined set of guidelines and is set just one time for the life of the contract. Individual judgment can be applied to the values that result from the CTS, but the objectivity and consistency of the calculation method is important given the high stakes involved in managing project contingency.

As discussed, the retained contingency (C_R) calculation at the heart of the CTS was derived empirically from real world data on a light rail project. That data did not conform perfectly to a smooth curve; hence there is bound to be some inaccuracy in the empirical equation that resulted from it. However, the results shown in table 2 seem to be intuitively more representative of reality than the simplified straight-line alternate assumption. The fact that the data used to derive the calculation came from light rail projects may limit its usefulness in other sectors, e.g. building construction. More study is needed here, with forecast data collection and analysis in other sectors of construction necessary to verify or modify the retained contingency (C_R) calculation as appropriate. Also, as mentioned earlier, the estimate at completion (EAC) calculation can produce inaccurate results on an individual contract basis prior to approximately 25 percent completion due to inconsistent forecast information and poor correlation of the model in the early stages of contract execution.

As with any mathematical system, the CTS is only as good as the data that goes into it. The most important and hardest numerical input to come by is an accurate current forecast (F) for each contract. If reliable current forecast numbers are not available, the CTS will be of limited value. Finally, although simple, the CTS does require that consumers of its output be educated on the assumptions and calculations that underpin it to the point that they can understand and trust its results. There is no purpose in setting up and maintaining the CTS if project stakeholders have no understanding of or faith in it and are unwilling to act on its results.

As stated at the beginning of this paper, contingency is defined as an amount added to the budget to account for changes that inevitably occur. Using pre-established guidelines, we can establish a percentage of the original bid to initially include in our contract budget to account for change order growth. We have seen that, to derive an accurate estimate at completion (EAC) for each construction contract, we must start with a thorough contract forecast and add a retained portion of the initially established change order contingency to account for changes that have not yet been identified. A formula for calculating the retained contingency value was then derived based on a sample of real-world data. By comparing EAC's calculated in this way with the current budget for each contract, we can determine the amount each contract will add to or subtract from project contingency. Finally, by summing these impacts over all contracts and contingency lines, a bottom-line value of project contingency available for non-construction uses can be obtained.

The contingency tracking system (CTS) combines all of these steps into a compact and easily maintainable spreadsheet table. Using the CTS, project managers have a guide to the expected final cost of each contract and the approximate value of project contingency left after accounting for construction risks. This ability to see into the future will serve project managers well as they navigate the many obstacles standing in the way of successful project delivery.

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CONSULTING LLC

INDUSTRIAL CONSTRUCTION & TURNAROUND CONSULTANT

Prepared for:

Burns & McDonnell Engineering

Area Labor Study
for
KCPL Iatan Unit 2 Project

February 13th, 2006

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CONSULTING LLC

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KCPL Iatan Unit 2 Project
Area Labor Study

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1.0 Overview

The period of 2006 through 2012 will see unprecedented amounts of new industrial construction and retrofits in the Midwest and gulf coast states. In addition, the rebuilding from hurricane damage will add to the strain on skilled manpower supply. It is reported that it will take 43,000 crafts to rebuild housing alone in the New Orleans area and predictions are for a 35% shortage of skilled workers overall in the gulf coast region.

The result of this high demand for skilled workers will be higher wages and incentive pay. The non union sector has not been successful in attracting and maintaining a skilled workforce in recent years. Existing skilled manpower is estimated to be 25,000 people in the gulf coast region.

Wages have been flat for 20 years, benefits are lagging other occupations, all resulting in a 75% drop in enrollment at NCCER, the ABC training center for construction crafts. The gulf coast private sector is very concerned about stability in the non union construction area regarding costs, schedules, and supply of workers.

Only recently, a non union welder on the gulf coast is paid $29 per hour in wages plus $3.50 per hour in fringes, $70 per day Per Diem, and up to $2.00 per hour in incentives. The standard work week is 5-10's.

The oil refining work load requirements add pressure to the Pipefitter, Boilermaker, and Electrician manpower problems. In addition, the $100 Billion dollar Tar Sands Project in Canada will preclude the use of Canadian workers on US work.

The Iatan Project will have reasonable success in attracting tradesmen due to the union's high wage and fringe packages (see attachment 2). For example, the Pipefitter wage in Kansas City is $34.83 per hour plus $15.00 per hour in fringes, compared to the Pipefitter union wage in Houston and Tulsa of $23 per hour and $10 per hour in fringes. It is significant to note that now the union fringe benefits are accrued to the workers home local. In the past the fringes stayed in the local where the work was performed.

The Kansas City Building trades enjoy a good reputation with the contractors for productive work and jobsite harmony when compared to many other parts of the country.

The International unions are interested in keeping their existing clients such as KCPL and expanding market share. Progressive activities are ongoing with the national building trades, such as the establishment of the Mechanical Trades Alliance, headed up by UA General President Bill Hite. This alliance is focusing on shared resources for the training of workers, productivity enhancements, and seamless jurisdiction between the trades. Other initiatives involve competitive agreements for use in low density union areas.

I recommend the NMAPC (National Maintenance Agreement) for this project (See paragraph 1.4). This agreement is administered by equal numbers of international union representatives, contractors, and a very competent staff. The application of the agreement is consistent among all crafts. All trades are bound to the agreement including the carpenters and teamsters even though those particular crafts have disaffiliated themselves with the AFL/CIO.

My review for information herein included inquiries of the following;

- Kansas City Building Trades

- UA, BM, IW International Representatives
- Four National Contractors
- NACBE
- NMAPC
- UA, BM, & IW Kansas City Locals
- BM Locals in surrounding areas
- Director of Pride Inc. of St. Louis
- Burns & McDonnell Sales and Marketing information

1.1 BEST PRACTICES

Approximately 30% of this projects costs will be construction labor therefore productivity enhancement is a must.

The ability to attain good productivity results requires the following practices at a minimum;

1). The contractor must be committed to the zero injury culture and techniques.

2). Detailed planning and scheduling by the contractor. This must be a serious effort. The plan must run the job. The contractor must have these resources.

3). Timely delivery of materials and equipment.

4). Minimize engineering and fabrication changes.

5). Substance abuse testing, including random.

6). Timely delivery of engineering and technical information.

7). The contractors must provide ample tools and equipment.

8). The contractor must have experienced and competent staff and supervision.

9). The contractor must control the labor on site. Utilize and understand the labor agreement management article to its fullest extent.

10). Control work jurisdiction between the crafts.

11). Negotiate a crew mix within the crafts using apprentices.

12). Avoid saturated manning and high work density.

13). Avoid shift work and overtime.

14). Promote craft ownership in the project. This begins with the safety initiative.

15). Minimize worker turnover. A 10% increase in turnover results in a 2.5% increase in labor costs plus productivity and safety impacts.

1.2 SAFETY/WORKER COMPENSATION

Training and orientation should be centered around the Zero Injury Techniques. (RE: Zero Employee Injury, Nelson Consulting).

The top high impact techniques are:

- Pre project / Pre task planning.
- Safety orientation and training. The quality of the training is much more effective than the quantity of training.
- Safety incentive, recognition and rewards program.
- Substance abuse program.
- Staffing for safety.
- Accident investigation.
- Worker participation and empowerment.
- A demonstrated management commitment.

Safety excellence is top driven; the owner, construction manger, and contractor executives and staff must actively support its commitment to having a zero injury work site. I also believe that the union business manager must become an active participant. I have a concern that they are not totally involved today.

Substance abuse testing on union projects has been somewhat more difficult to accomplish because the NLRB has ruled random testing of an employee must be negotiated or included in the collective bargaining agreement. I believe this could be negotiated through the NMAPC and the International Unions. Another method for accomplishing random testing would be to have an owner's drug policy for all contractors on their site.

1.3 QUALITY

Welder quality is excellent for pipefitters and boilermakers, however it is recommended to test each welder prior to start of work.

The NMA agreement allows 4 hours of pay if the welder passes the test.

The contractor on the Council Bluffs Project expressed that he has never had to perform as much on site training for any one project in the company's history. In particular the skill level of the Ironworkers, Carpenters, and Certified Operators was a serious problem. Most had very little industrial experience.

1.4 LABOR AGREEMENT

Attached is a copy of the NMAPC agreement and a summary of the agreement.

It is recommended that this project be done under the NMAPC agreement.

All crafts will be under the same agreement, therefore application of the articles are consistent among all.

The management clause is strong but it requires the contractor to use it effectively.

All trades are signatory including the Carpenters and Teamsters.

Consistent application of the agreement will minimize grievances and other HR issues which tend to take management time away from execution of the work.

Likewise, it is important the contractors enforce the work rules and agreement from day one on the project.

On reimbursable work I would consider placing a portion of the contractors fee at risk and use the management of the agreement as an incentive.

There is a "book of decisions" covering interpretation resulting from past issues and grievances which were ruled upon by the policy committee.

Even though the agreement is defined as maintenance, there have been broad interpretations of the agreement to include new construction.

The agreement is a stand alone national program without local administration. The only part of a local agreement is wages, fringe benefit trusts, and referral rules.

One may conclude that voting on issues and grievances, with the makeup of the policy committee being 14 management and 14 international union representatives to be along party lines, but as a member of the committee for many years, I have never seen a close vote, which says a great deal about the NMA

The vehicle is the NMAPC program, a labor- management organization that can reduce labor costs by at least 16% over local agreements. Some of these advantages include:

*No strikes clause- including substantial penalties

*Mandated pre-job conferences

*Alternate dispute resolution to reduce workmen's compensation insurance costs

*All overtime @ 1 1/2x except for Sundays and holidays

*All crafts observe the same 7 unpaid holidays

*Flexibility in scheduling

*Commitment to drug free workplace

*Contractor determines crew size needed

*Welder certification cost control

*Only 1 foreman per craft on any shift is guaranteed 40 hours pay

*Provision to enable participants to respond to changing needs

The Facts: *Over 1.6 billion man-hours worked since 1971

The Committee: The NMAPC is the construction industry's first incorporated labor management committee. It's members are 14 national maintenance contractors and 14 representatives from the participating International Unions of Building and Construction Trades Department, AFL-CIO. The office of the Impartial Secretary administers the NMAPC Program with a full time staff located in Arlington, Virginia. The Committee is a proactive entity which meets regularly to administer the NMAPC Program and provide a national forum to promote labor management cooperative efforts in construction.

1.4 LABOR AGREEMENT (Cont.)

NMAPC, Inc.
1501 Lee Highway, Suite 202
Arlington, Virginia 22209-1109

Web:	www.nmapc.org
Email:	info@nea-nmapc.org
Phone:	703-841-9707
Fax:	703-524-3364
Founded:	1971

1.5 MANPOWER

The compiling of manpower only focuses on the critical crafts of Boilermakers, Pipefitters, Ironworkers, and Electricians.

Membership rosters are as follows:

- Pipefitters - 600 members
- Boilermakers - 500 Members (200 live in the Kansas City Metro area)
- Electricians - 1200 Members
- Ironworkers - 1200 Members (covers western Missouri and eastern Kansas)

Boilermakers:
It is quite evident that the Boilermaker union feels an overwhelming responsibility to service KCPL work.

Local 83 covers Kansas, Iowa, Nebraska, and Western Missouri. The Boilermaker work through 2007, 2008, and 2009 in the four state area will average 1100 men with estimated peaks at 1600 men. The St. Louis and Southern Illinois locals have approximately 200 men working in local 83 presently but due to their upcoming workload these locals will not be a source of workers.

Local 83, with its wage and fringe structure plus a 5-10's work week will be in a position to man the Iatan project. They have had up to 900 boilermaker travelers in the past on work around the Kansas City metro area.

In the event the manpower during the project becomes a critical issue, even more so than we know now, consideration should be made for paying subsistence rather than increasing overtime hours of work due to the inefficiency encountered with overtime.

Additional workload on power projects in Wisconsin, Minnesota, and Michigan are going to exceed manpower availability in those respective locals by 1000 to 1200 Boilermakers in the 2007 through 2009 period. (1400 members, 2600 required). Currently there are 500 Boilermakers working 6-10's on the Council Bluffs project.

Nationally the Boilermaker Union has 26,000 active construction members which in my view will likely be exceeded by 5000 during the 2008/2009 period.

We must keep in mind the labor contract expires 12/31/07 and could see wage increases at $2.00 to $3.00 per hour.

Pipefitters:
The Kansas City Local has Jurisdiction over the Iatan and Norborne projects. The peak loading will occur during 2009 at 800 men for the two projects when the schedules overlap. A fairly steady requirement of 200 to 250 Pipefitters will be required on other work during the same time period.

This totals approximately 1000 men required where the local availability is 600. Presently they have 150 men out of work.

Again with the high wage and fringe in local 533, plus 5-10's work schedules, additional manpower will be available from Texas, Oklahoma, Louisiana, and Arkansas. Presently the Council Bluffs project has 600 Pipefitter travelers.

The Pipefitter contract expires 5/31/08.

Ironworkers:
Local 10 covers western Missouri and eastern Kansas and has 1200 active members with about 600 available in the Kansas City Metro area. Presently they have full employment; however, the commercial workload will decline somewhat by mid 2007.

The Ironworkers fringe package is the highest of all the trades which includes a $5.35 per hour annuity. This is an attraction for out of town workers.

The ironworker's skill level is reasonably good for setting heavy and high steel.

Manning of Iatan does not appear to be a problem with a 5-10's schedule.

Electricians:
This local has approximately 1200 members and presently does not have full employment. Most members are employed on commercial work.

The IBEW has a major effort ongoing nationally in training and innovative labor contracts in the low density union areas. Ed Hill, IBEW General President, is one of the building trades most progressive leaders on issues such as hours worked for hours paid, quality, safety, and training.

Their labor contract expires on 9/2/07 and I would expect to see $2.00 to $3.00 per hour settlements.

1.6 Summary

Solely for skilled labor attraction it is recommended the Iatan project work 5-10's when the critical crafts of Boilermakers and Pipefitters are required. This is approximately mid 2007. Obviously the entire project must work the 5-10's, not just the critical crafts, to keep labor harmony.

The total cost calculation for the project to work 5-10's from the start of civil / site work to completion is $35,524,000. If started only when critical crafts are required in mid 2007 that cost would be reduced by $5,000,000. When considering overtime work I would never consider hours greater than 10 hours per day or 6 days per week. For Example, the inefficiency for 7-12's is in excess of 30% and the premium pay adds 40% to labor costs.

I would consider a worker subsistence / Per Diem before increasing overtime beyond the 5-10's schedule. 6-10's, for example, only yields 8.2 hours of work per day after applying an inefficiency factor.

Labor escalation is expected to be 8-10% per year. See Attachment 2 for contract expiration dates and existing wage and fringe packages.

The average cost rate (Wage, fringe, Insurance, and taxes) is $53.45 per hour. A crew mix with apprentices will lower the overall rate. The contractor must request apprentices and give them meaningful work on the site. It is reasonable to expect 25% of the crew on work of this type could be apprentices.

Employees should be expected to be "work ready" when they arrive at the site. This would include safety training, site orientation, substance abuse testing, and all certification to be completed prior to signing up for employment.

A serious "Zero Injury" safety program must be in place prior to the start of work. I recommend Emmitt Nelson of Nelson Consulting in Houston, Texas for this endeavor.

A substance abuse policy with pre-employment, for cause, and random testing is a must. The pre-employment failure rate at Council Bluffs was an average of 10%. A recent power project in Northern Iowa had a 35% failure rate.

The NMAPC labor agreement is an agreement the Kansas City Building trades are familiar with and is very cost effective. It does require the contractor to manage the agreement for good results. The expectations for the project must be made clear to the labor organizations early on. This will also minimize turnover. In addition to the direct costs of turnover there is a high correlation between productivity and turnover. A turnover rate of 30% could result in a productivity factor of 1.5.

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Attachment 1
Cost to Work 5-10's

- **Basis is Burns & McDonnell Manhour Summary** 3,864,327 Mhs
- Factors:
  - **Premium Time** 20% of manhours at half time
  - **Inefficiency** 8% of manhours at full rate
- **Cost Calculations:**

Premium time	3,864,327 Mhs
	X 20%
	772,865 Mhs
	X $22.00
	$17,000,000
Inefficiency	3,864,327 Mhs
	X 8%
	309,146 Mhs
	X $53.45
	$16,524,000

- **Total cost for 5-10's:**

Premium time	$17,000,000
Inefficiency	$16,524,000
Total	**$33,524,000**

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Attachment 2
Craft Labor Rates

Craft	% of Job	JM Wage	Through	JM Wage	Through	JM Wage	Through	Fringes**	Contract Expiration
Insulator	1.2	29.64	9/30/07	31.64	9/30/08			18.80	9/30/08
Boilermaker	20.2	29.85	9/1/07	30.55	12/31/07			17.26	12/31/07
Carpenter / MW	10.2	31.85	4/1/07	33.70	4/1/08	35.55	3/31/09	9.66	3/31/09
Cement Finisher	.7	26.23	4/1/07	28.23	4/1/08	29.83	3/31/09	10.87	3/31/09
Electrician	11.2	31.53	9/2/07					14.31	9/2/07
Operators	10.7	32.31	3/31/07					9.98	3/31/07
Ironworkers	8.7	26.95	4/1/07	28.80	4/1/08	30.65	3/31/09	16.65	3/31/09
Laborer	10.4	23.05	3/31/07					9.76	3/31/07
Pipefitter	24.3	34.83	6/1/07	36.93	5/31/08			15.00	5/31/08
Sheetmetal	.9	35.87	6/30/07					13.41	6/30/07
Teamster	1.5	26.55	3/31/07					8.86	3/31/07
Avg.	100	30.73						13.81	

** Some Fringes calculated on paid hours

Payroll taxes and Insurance:

• W/C	6.8 % @ EMR of 1
• General Liability	5.0 %
• FICA	7.65 %
• FUI	.8 %
• SUI	8.8 %
	29.05 % x Wages

Overtime:

- Time & ½ after 8 hours / day & Saturday
- Double Time Sunday & Holidays

Example:

Boilermaker Wage	$29.85
Fringes	$17.26
T & I (29.05%)	$ 8.67
Total Cost	$55.78 Per Hour

Average Cost Rate:	ST	T-1/2 Add	2T Add
Wage	$30.73	15.37	
Fringes	$13.81	4.00	
T & I	$ 8.91	2.65	
Total Cost	$53.45	$22.00	$44.00

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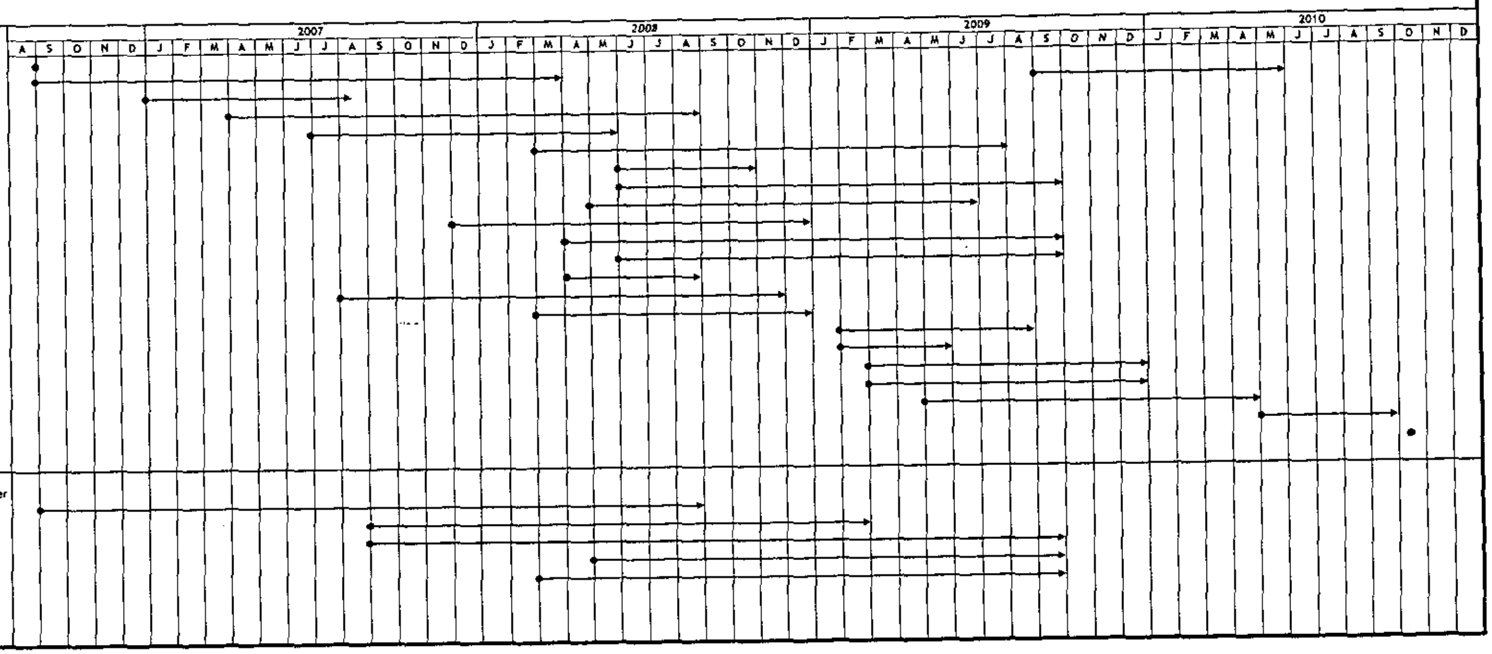
2.0
IATAN UNIT 2 PROJECT
PROJECT SCHEDULE AND MANPOWER



	Avg. Manpower	Peak Manpower
Civil (CA, LB, CF)	133	
IW	64	110
BM	160	300
PF	276	415
Elect	114	175

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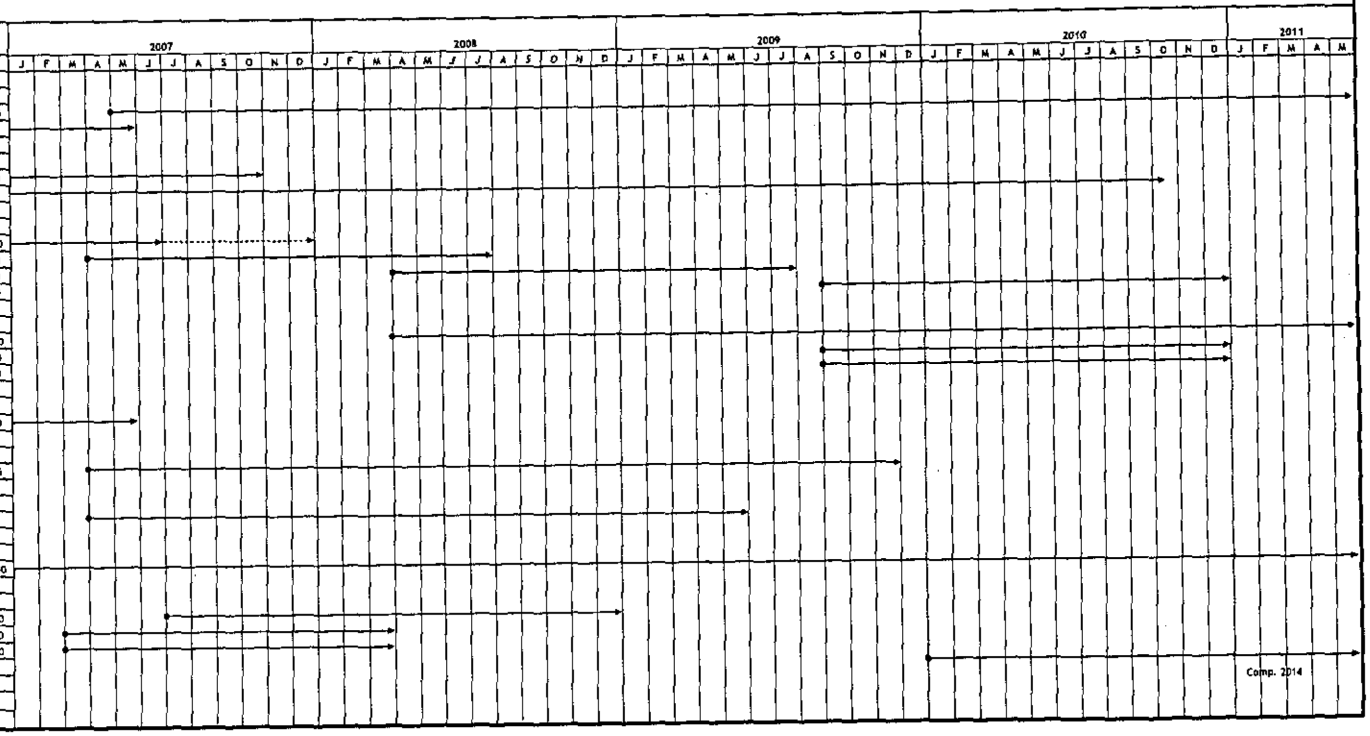
3.0
IATAN UNIT 2 PROJECT
CURRENT AND FUTURE AREA WORKLOAD

Project	Location	Critical Crafts Avg. Manpower BM	PF	IW	EL
Associated Electric					
Norborne Station - New 600 MW CFB	Norborne, MO	160	270	64	114
Thomas Hill - New SCR		120	40		20
KCPL					
LaCygne Station - New SCR	LaCygne, KS	120	40		20
Iatan Unit 2 - New CFB	Iatan, MO				
MidAmerica Energy					
Council Bluffs - New 790 MW CFB	Council Bluffs, IA	600	600		200
Council Bluffs - Unit 3 SCR	Council Bluffs, IA	120	40		20
Muscatine - New SCR / Scrubber	Muscatine, IA	120	40		20
Neal - New SCR / Scrubber		120	40		20
Alliant Energy					
Southerland - New 300-500 MW CFB		160	250	60	100
Ottumwa - New SCR / Scrubber - (1) 600 MW	*Ottumwa, IA*	120	40		20
Burlington - New SCR / Scrubber - (2) 300 M	Burlington, IA	120	40		20
Empire Electric					
Asbury Station - New SCR	Asbury, MO	100	30		20
City of Springfield, MO Utilities					
New 350 MW CFB	Springfield, MO	120	180	45	75
City of Hastings, NE Utilities					
New 225 MW CFB	Hastings, NE	Non-Union			
TriState / Sunflower Energy					
(2) New 700 MW CFB	Holcomb, KS	400	500	120	200
Westar Energy					
Simple Cycle	*Kansas*	40	40		40
Jeffrey Station - (3) 800 MW FGD	Kansas	120	40		20
Lawrence Station - Scrubber & Baghouse	Lawrence, KS	120	40		20
New CFB	Kansas				



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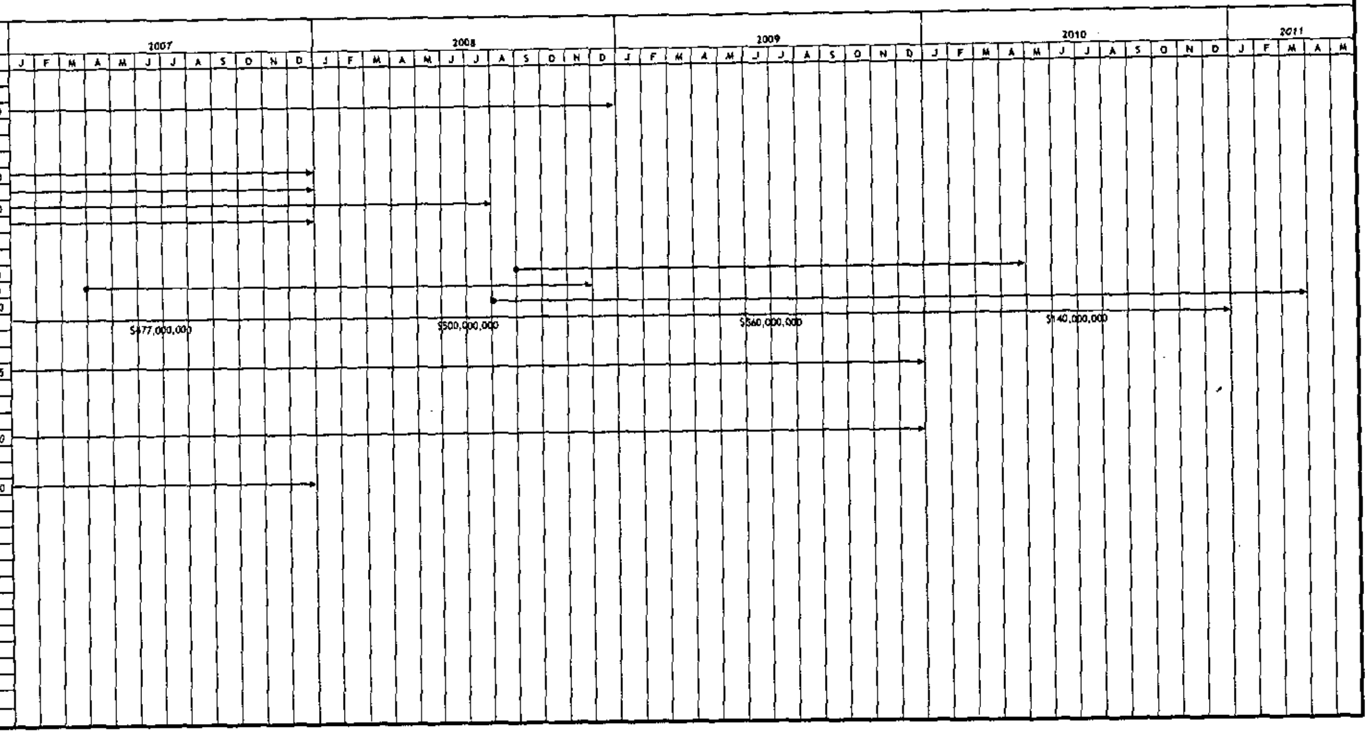
4.0
IATAN UNIT 2 PROJECT
OTHER WORKLOAD

Project	Location	Critical Crafts Avg. Manpower BM	PF	IW	EL
KC Commercial Work					
Auto, Hospital, Light Industrial	Kansas City, MO	0	200	300	400
$3.3 Billion Construction					
Petrochemical					
Coffeyville Refinery - Maint & T/A	Coffeyville, KS	55	165		100
McPherson Refinery - Maint. & T/A	McPherson, KS	50	150		80
ConocoPhillips - New Coker	Wood River, IL	120	400		250
Kansas, TX, OK, LA Turnarounds		2,650,000 Manhours			
Ameren					
Sioux Unit 1 & 2 SCR	Eastern MO	260	80		40
Sioux Unit 1 & 2 Scrubber	Eastern MO	240	100		40
Rush Island - New 750 MW CFB	Eastern MO	180	300		120
Upgrades & Outages	Eastern MO				
Peabody Energy					
Prairie States Energy	Marissa, IL	400	550	130	225
Greenfield 1500 MW plant					
Southern Illinois					
Misc Scrubbers, SCR's, and Baghouses		600	200		200
Holcim					
New Cement Plant	St. Genevieve, MO	400	150		150



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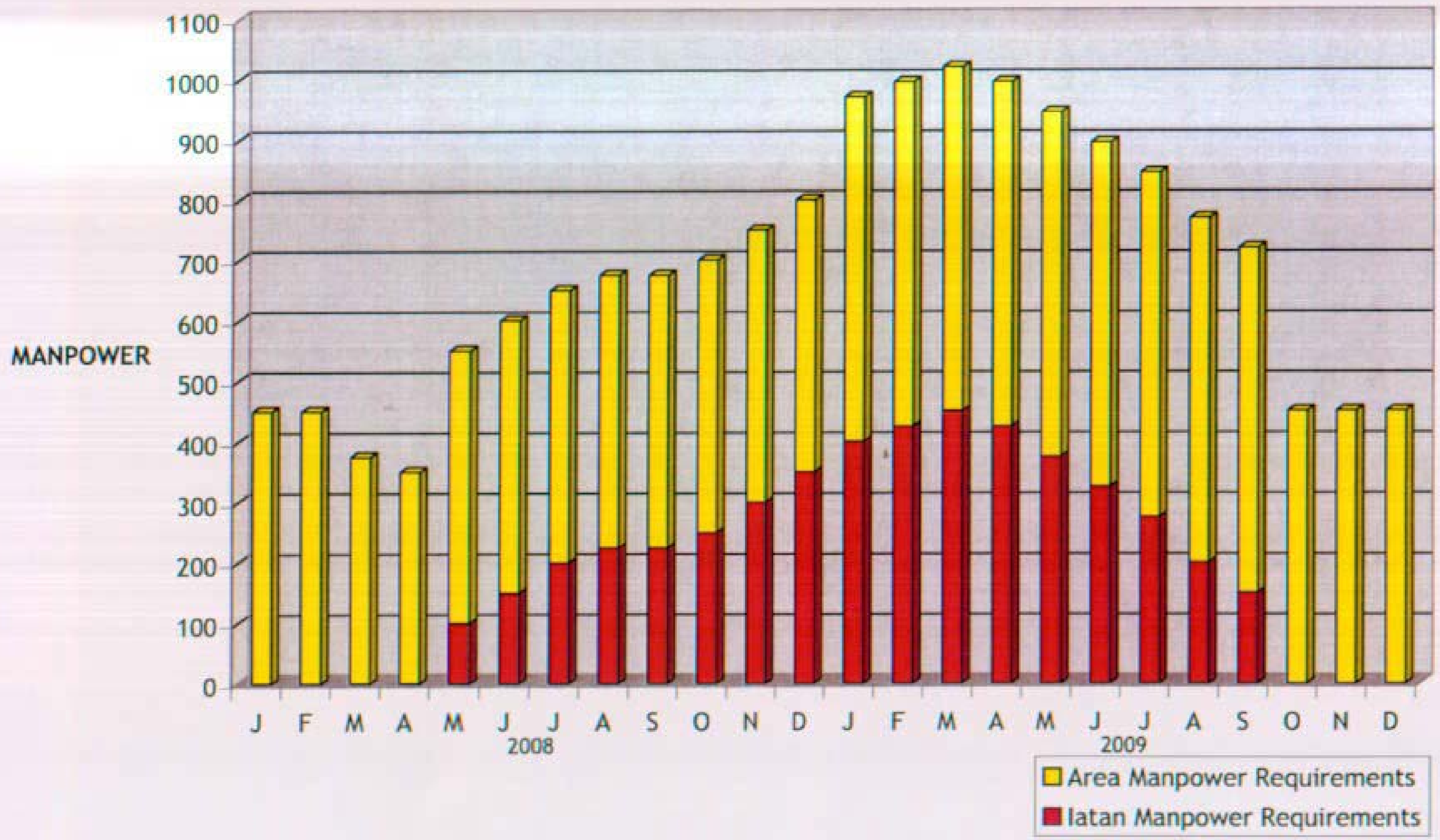
PIPEFITTERS L533

600 Active members available w/o travelers



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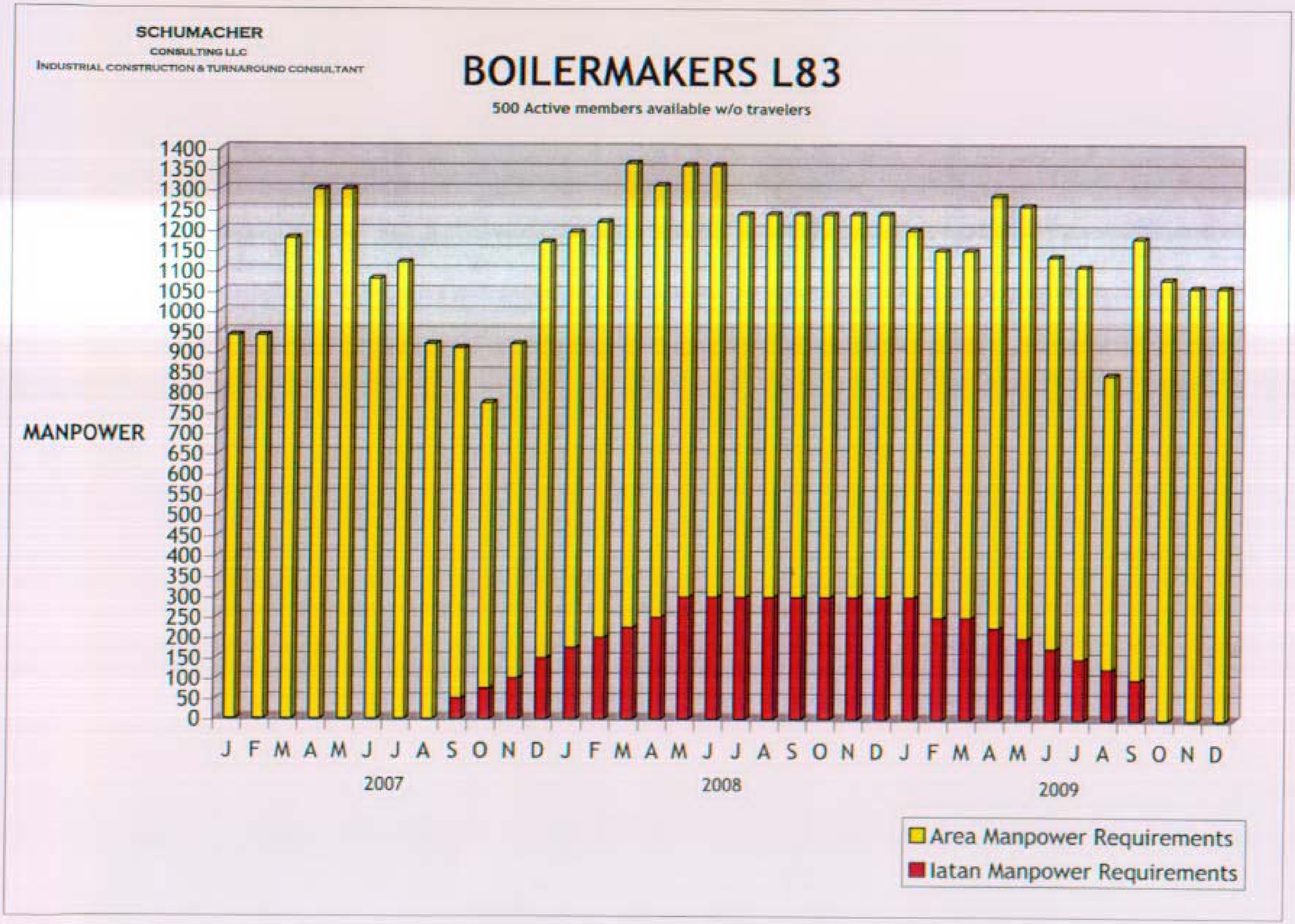

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PIPEFITTERS

	2008												2009											
Date	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Area Manpower	450	450	375	350	450	450	450	450	450	450	450	450	570	570	570	570	570	570	570	570	570	450	450	450
Iatan Manpower	0	0	0	0	100	150	200	225	225	250	300	350	400	425	450	425	375	325	275	200	150	0	0	0

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BOILERMAKERS

Date (2007)	J	F	M	A	M	J	J	A	S	O	N	D
Area Manpower	940	940	1180	1300	1300	1080	1120	920	860	700	820	1020
Iatan Manpower	0	0	0	0	0	0	0	0	50	75	100	150

Date (2008)	J	F	M	A	M	J	J	A	S	O	N	D
Area Manpower	1020	1020	1140	1060	1060	1060	940	940	940	940	940	940
Iatan Manpower	175	200	225	250	300	300	300	300	300	300	300	300

Date (2009)	J	F	M	A	M	J	J	A	S	O	N	D
Area Manpower	900	900	900	1060	1060	960	960	720	1080	1080	1060	1060
Iatan Manpower	300	250	250	225	200	175	150	125	100	0	0	0

SCHEDULE DFM2010-6

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