Cost Engineering and Scope of Work

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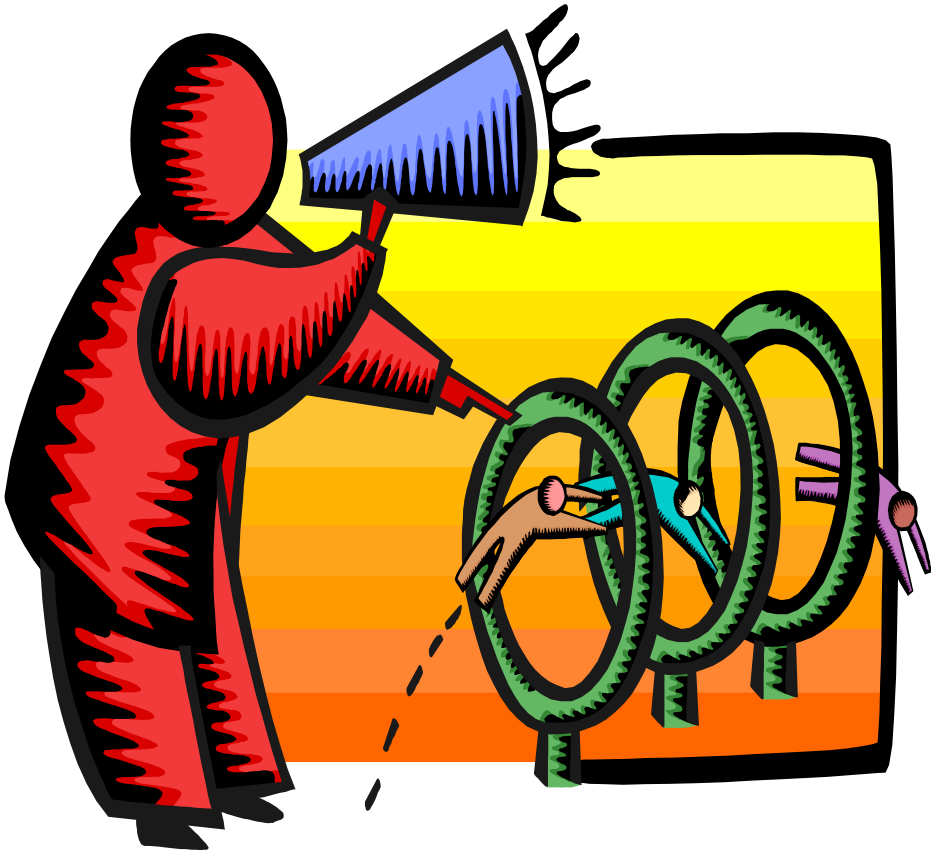
Project Scope of Work and Management's Perspective

- Management has preconceived numbers in mind even before the project scope of work is established
- Project completion dates are established without any project scope of work
- Management misuses old estimates to force fit new conditions with total disregard to new project scope of work

Is Scope of Work Necessary?



- Management wants a Class II estimate with no written Scope of Work. Do you think that we can provide them with meaningful numbers?

Definition of Cost Engineering

- AACE International defines Cost Engineering as: "That area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problems of cost estimating, cost control and profitability".

Function of Cost Engineering

- To provide independent, objective, accurate, and reliable capital and operating cost assessments usable for investment funding and project control decisions.

(Source: Cost Engineering Vol. 43 No. 12 December 2001, Page 41)

Cost Engineering Includes

- Estimates of capital costs
- Estimates of operating & manufacturing costs
- Risk assessment and analysis
- Trending of scope and cost changes
- Financial analysis (Like net present value, rate of return etc..)
- Decision analysis
- Project cost control
- Appraisals of existing assets
- Project analysis, databases, and benchmarking

(Source: Cost Engineering Vol. 43 No. 12 December 2001, Page 41)

Cost Engineering can be divided into three major components:-

- Cost Estimating
- Cost Control
- Cost Methodology

Cost Engineering

- Cost Engineering helps in making sound business decisions regarding projects
- All projects are primarily based on economics:
  - like what is the return on investment
  - what product is produced - quantity followed by when and where
  - answers to these questions require economic studies which in turn require Cost Estimates

Cost Estimate
(First component of cost engineering)

- In general Cost Estimate is "An evaluation of all costs of the elements of a project or effort as defined by an agreed-upon scope".

Cost Estimate Continued

- Cost Estimate involves
  - assumptions and unknowns
  - probabilities
  - given scope of work(contingency covers variability within the defined scope - not changes in scope)

Cost Estimate is used for:

- Quantifying capital costs of investment alternatives
- Costing design and execution alternatives for optimization
- Provide estimates for funding decisions and cost control

Cost Estimate is:

- A technical document that defines a value or a range of values of the most probable cost of a project based on
  - Present scope of work
  - To be completed at a defined location
  - Point of time in the future

Cost Control
(Second component of cost engineering)

- Analysis of trends, helps with management decisions
- Developing and recommending corrective action
- Implementing responsive cost feedback systems

Cost Control

- All projects are considered under control if these four elements are under control:
  - Schedules
  - Progress
  - Budgets
  - Incurred Cost

Cost Methodology
(Third component of cost engineering)

An effective cost methodology consists of a standard set of cost estimating practices, resources and tools applied consistently to all cost estimates. It helps:

- Establishing estimating methods and cost data base
- Development of cost controls tools and techniques
- Measurement of cost levels and trends

Generic Estimating Classification Matrix

(From AACE International RPS 17R-97)

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

Notes: a) if the range indice value of "1" represents +10/- 5%, then an indice value of 10 represents +100/- 50%
b) if the range indice value of "1" represents .005%, then an indice value of 100 represents 0.5%

Scope of Work

Scope of work is the only element that ties Cost Estimating, Cost Control and Cost Methodology together.

Scope of Work -

- Scope of work is also the only element that influences Project Cycle time (Total project duration, from concept to steady-state operation).

Scope of Work

Scope of work can be defined as the extent, type, and quality of activity and specified criteria required to achieve a certain outcome defined by an agreement between all parties involved in that activity

Scope of work and Executing a project

Scope of work for any project should be expressed in terms of the following four descriptive areas:

- **Functional Scope** - Capacity to be provided or Product to be made
- **Technical Scope** - Design philosophy, Design standards & specifications to be used and the process design to be followed

Scope of work and Executing a project - Continued

- **Physical Scope** - Like what is left standing when the project is complete for new units and for all existing units to be debottlenecked.
- **Activity Scope** - The division and extent of responsibility among all entities doing the work - an item like Hookup is included but commissioning is not included in the scope of work.

Scope Of Work and Basic Design Engineering Considerations

- **.Basic Development Engineering Package**
  - Process Design Basis & Design Specifications
  - Project Design Basis
    - Project Description
    - Project Goals
    - Detailed Scope of work
    - Division of responsibility
    - Specifications & Standards Requirements
  - Licenser Design Package (If Required)
  - Data Gathering
    - Existing Facility Documentation
    - Drawings
    - Operating Process Conditions
    - Operating Process Limits
    - Equipment Inspection Records
    - Equipment Maintenance Records

Scope Of Work and Basic Design Engineering Considerations Continued

- Plot Plan & Facility Layout
- Materials Of Construction & Metallurgy Selection
- Technical Specifications & Standards
  - Government Standards & Codes
  - Industry Standards & Codes
  - Engineering Design Data Specifications
  - Technical Specifications & Standards
- Site Conditions Evaluation
  - Site Survey
  - Geo-Technical Investigation
  - Environmental Survey
- Utilities Requirements
- Offsites Requirements
- Key Design Considerations

Scope Of Work and Basic Design Engineering Considerations Continued

- **.UTILITIES**
  - Typical Utilities
    - Nitrogen
    - Instrument Air
    - Natural Gas
    - Utility Air
    - Utility Water
    - Cooling Water Supply & Return
    - Firewater System
    - Steam Requirements
    - Flare & Vent Systems
    - Electric Power Supply
    - UPS
    - Sewers

Scope Of Work and Basic Design Engineering Considerations Continued

- **Other Items to be Included**
  - **Offsites**
  - **Plant Integration**
  - **Operations Requirements**
  - **Maintenance Requirements**
  - **Constructability Review Considerations**

Scope Of Work and Basic Construction Design Considerations

- **.Construction Planning**
  - Construction Scope Of Work
    - Work Breakdown Structure
    - Planning – Work Package
  - Division Of Responsibility
    - Responsibility Matrix
    - Work Flow Diagram
    - Contractor Interfaces
  - Construction Organization
    - EPC Staffing Plan – Project Team
    - Owner Staffing Plan & Project Team
    - Overall Roles & Responsibilities
    - Subcontractor Staffing Plan

Scope Of Work and Basic Construction Design Considerations Continued

- **Construction Planning**
  - Mobilization Plan
  - Temporary Construction Facilities
  - Construction Permits
  - Labor Agreements & Meetings
  - Area & Site Survey
  - Pre-Construction Activities
  - Construction Procedures
  - Establish Local Vendors & Suppliers
  - Materials Management
  - Laydown & Marshalling Areas
  - Heavy Lift Program

Scope Of Work and Basic Construction Design Considerations Continued

- **Construction Controls**
  - Cost Control
    - Cost Control Procedures
    - Construction Cost Report
    - Subcontractors Cost Report
    - Subcontractor Backcharge Report
    - Cost Related to Change Orders
  - Schedule Control (EPC Contractor & Subcontractors)
    - Formal Schedule Reviews & Meetings
    - Tie-In Schedules
    - Progress Schedule
    - Subcontract Schedule Status Report
    - Turnaround Schedules
    - 4 Week Rolling Look ahead Schedules

Scope Of Work and Basic Construction Design Considerations Continued

- **Construction Execution**
  - Develop Construction Packages
    - Project Related & Technical Documents
    - Bid Related & Contract Documents
    - Review & Approval Process
  - Contractor Selection Process
    - Contractor Qualifications
    - Competitive Bidding Process
    - Evaluation & Selection Criteria
    - Contract Negotiation & Execution Process

Scope Of Work and Basic Construction Design Considerations Continued

- **Facility Construction (By Crafts or Subcontractor)**
  - Site Preparation
  - Survey
  - Geo-technical Investigation
  - Demolition
  - Excavation & Backfill
  - Under Ground Piping & Electrical
  - Foundations
  - Area Paving
  - Structural Steel
  - Set Equipment
  - Tankage
  - Piping/ Instrumentation/Electrical Etc..

Scope Of Work and Basic Construction Design Considerations Continued

- **Mechanical Completion Process**
  - Punchlists
  - Tightness Testing
  - Flushing & Cleaning
  - Hydrotest/Pneumatic Testing Equipment
  - Hi-Pot/Megger/Continuity Checks
  - Radiography/UT
  - Mechanical Completion / Turnover
  - Exception List
  - Final Acceptance

Scope Of Work and Basic Construction Design Considerations Continued

- Demobilization
- Construction close-out
  - As-built Drawings
  - Close-out Meetings
  - Disposition Of Materials on site

Scope of Work and Project Management

Project Management should ensure that

- A realistic reference (Scope, Cost, Time) is set up for further control and is in line with the objectives
- Appropriate management tools are set up to help the team control the project
- Create a cost-minded atmosphere within the team
- make decisions on what should be done in case of variance
- The project objectives remain in line with business needs

(Source: Cost Engineering Vol.. 43 No. 12 December 2001, Page 41)

Basis of Estimate Document

- Purpose of estimate
- General description of project
- Scope description by project breakdown structure
- Assumptions and allowances
- Estimate exclusions or exceptions
- Execution strategy
- Pricing
- Contingency
- Benchmarking
- Reference Documents

Comparison of Estimate Classifications

INCREASING PROJECT DEFINITION

AACE Intl Recommended Practice	ANSI Standard Z94.2-1989	AACE Pre-1972	Association of Cost Engineeers UK-ACE	Norweigan Project Mgmt Assoc NFP (NACPE)	American Society of Professional Estimators (ASPE)
				Concession Estimate	Level 1
Class 5	Order of Magnitude Estimate -30 / +50	Order of Magnitude Estimate	Order of Magnitude Estimate -30 / +30	Exploration Estimate	
				Feasability Estimate	
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

Indirect Costs

- **Items considered Indirect for a project**
  - Civil and Site Work
  - Earthmoving Equipment Usage
  - Site Surveying
  - Temporary Paving
  - Temporary Construction Facilities
  - Project mobilization / demobilization
  - Small Tools
  - Home Office Costs
  - Procurement staffing
  - Safety and other training programs

Direct Costs

- **Items considered as Direct for a project**
  - Concrete & Masonry
  - Formwork
  - Steel
  - Permanent access and support
  - Mechanical & Major equipment
  - Piping
  - Freight, Import/Export fee
  - Misc. Consumables

Field Indirects & Overheads

- Field Indirects & Overheads refer to contractor's construction costs necessary to support direct work.
- **Temporary Construction and Consumables** Material, Labor and Subcontract costs associated with establishing and operating a temporary infrastructure to support construction work.
  - Like Temporary Facilities
  - Scaffolding materials & labor
  - site clean-up
  - temporary utility costs
  - protective clothing etc..

Field Indirects & Overheads Continued

- **Field Supervision/Field Office Costs**
  Material, Labor and subcontract costs associated with supervising the construction work. Items like:
  - Wages
  - Salaries and benefits
  - Travel Expenses
  - Field office expenses etc..

Field Indirects & Overheads Continued

- **Construction Equipment/Tools**
  Material, labor and subcontract costs necessary for providing tools and machines to support the construction work. Items like:
  - **Cranes**
  - **Trucks**
  - **Welding machine**
  - **small tools etc..**

Field Indirects & Overheads Continued

- **Payroll Burdens**
  Insurance and benefits related to the construction workers payroll. Items like
  - **Workman's Compensation insurance**
  - **vacation/sick time**
  - **unemployment insurance**
  - **safety incentive pay etc..**