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Better Proposals Using Basis of Estimates (BOE)

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Kevin A. Mussmacher, PE

1. Introduction

A major cause of cost and schedule overruns in projects is the poor accuracy and quality of the technical and cost proposals submitted in an attempt to win a contract. Typically proposals are part time efforts by teams of busy technical personnel, who barely have time to finish and submit the proposal. The basis for the time and material estimates included in the proposal are usually vague recollections or wild guesses. Since the proposal tasks are also often ill defined, things get left out and the scope of the job falls short, leading to cost overruns and late programs. Conversely sometimes the efforts are overestimated leading to a high price and a losing bid. The solution to this dilemma is to focus on previous performance, similar programs and accurate grass root estimates. The tool to utilize in this effort is called the Basis of Estimate.

2. Basis of Estimate Definition

From Businessdictionary.com

Basis of Estimate – "A document that details the premise, or basis, from which critical aspects of a project cost estimate were developed including cost and labor estimates, material availability, any assumptions or deviations, any studies or analysis used as a reference and any other details which impacted the cost estimates."
In plain English, it represents answers to the following questions:

- What did you bid?
- How did you come up with the estimate?
- How do you know it is right?

3. What is the Purpose of the BOE?

The purpose of a BOE is threefold. 1) It tells you what tasks you are supposed to bid in accordance with Request for Proposal (RFP) or specification guidelines; 2) It tells you how much you actually bid for these tasks and why; 3) To note any special conditions, circumstances or assumptions made that would affect the bid.

In order to fulfill these purposes, the BOE should start with a brief, but excellent description of the overall program and any special conditions or considerations. It should also explain the type of contract (new design, existing design, or modified design).

A typical BOE spreadsheet is shown below along with a sample description of contents. BOE sheets can be in many different formats, but similar essential items of interest should be included. For example, the table below list indirect costs where later in the course we have substituted Outside Direct Costs as something more relevant to the bid. These sheets can be tailored to your specific needs. The template below mentions WBS and cost methodology. These topics are covered later in paragraph 5.

Basis of Estimate Template: From projectmanagementdocs.com

Basis of Estimate								
Project:						**Date:**		
WBS Element:								
Category	**Material**	**Labor**	**Indirect Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
This should describe what phase of the project the line item belongs to.	This is the cost of material for this line item.	This is the labor cost associated with this line item.	This is any indirect cost that falls under this line item.	This is the total of the material, labor and indirect costs.	This column includes any reserve cost designated for the line item.	This is the sum of all costs for the line item.	This should describe the source of funding for this portion of the project.	This should describe what method was used to derive the cost estimate.
WBS Description: This section should include the text from the WBS Dictionary for this WBS item. This ensures that the scope of the line item is captured and related to the cost estimate.								
Cost Description: This section should describe the specific details of how costs were calculated. If costs were derived from vendor quotes, wage rates or other means this is where the details should be described.								

You can see the level of detail this format allows the project team to provide. The columns list the costs, funding source(s), and methodology for the WBS item. The text fields below allow the project team to communicate the scope of the WBS item based on the WBS Dictionary description as well as to describe in detail how the various costs were estimated.

4. Reasons to use BOEs

To Remember What You Bid

One of the best reasons to do a Basis of Estimate is to have a record of tasks descriptions and budget amounts bid on a particular opportunity. If the bid is successful and becomes a contract, then the BOE is an excellent beginning for a Project Budget and Program Plan. A typical problem that occurs during the transition from successful proposal to a funded project is change in personnel. The people that bid the job may or may not be on the Program Team. This is important because time goes by and assumptions made during the proposal are forgotten and usually not shared with the Program Team.

Too many times, there is no resemblance between what was bid and what gets planned. With a BOE, there is a decent chance of continuity and consistency between the proposal and actual program implementation. The BOE package lists all the tasks required for the Program as well as listing any assumptions made during the proposal phase. It serves as an excellent foundation for the Program Plan typically generated at the start of a contract to lay down the rules and requirements of a project. This greatly increases the probability of correlation between the proposal price quoted and the project costs incurred. At least you are not off on some tangent or scope deviation on day one of the program.

To Discover Future Variances

The BOE, when used as a basis for a program budget, provides a baseline for both scope and cost of tasks bid on the original proposal. When costs start to overrun, as they will, the BOE task descriptions and costs serve as a trail to discover any overruns or scope creep. It is important to discover and analyze variances early so they are not compounded and amplified later in the program.

To Allow Sanity Checks against Previous Efforts

Another use of Basis of Estimates is as a sanity check. By comparing BOE's from similar bids or actual programs, one can lend credence to a bid or draw a bid into question. Similar tasks should have consistent costs and schedules. If there are significant differences, either the new bid is wrong or there was an error in the previous bid. In either case, lessons are learned or errors avoided. Also, be aware that underbidding errors can cause future overruns, but overbids can endanger the probability of a proposal win due to price.

If something sounds crazy to the experienced estimator, it usually is. An experienced reviewer can look at a task and at least have a feel for order of magnitude of effort. If it doesn't smell or feel right, it deserves a second look. It may be that the task is misinterpreted, special circumstances exist or typically, somebody just made a mistake. Finding these innocent, but costly goof ups is reason alone for using the Basis of Estimates and sanity checks. Typically somebody got the quantity wrong, entered duplicate estimates or put the wrong WBS number on the BOE sheet. Some small amount of these errors may still make it through, but if they pass the sanity check, their impact should be negligible.

To Justify Proposed Efforts during Price Negotiations

Basis of Estimates are a valuable tool for justifying bids during contract negotiations. It is easier to sell estimates that are backed up by thoughtful documented task descriptions and costs than vague guesses.

5. Work Breakdown Structures (WBS)

In order to organize a bid properly and not miss estimating any elements bids estimates are generated in response to Tasks Descriptions generated during the initial phase of a proposal. These task descriptions originate from the Work Breakdown Structure (WBS). A WBS provides an organizational chart of the proposed tasks, showing relationships and hierarchy for all the material and labor on a program. An excellent explanation of Work Breakdown Structures and their use from Upland Software Inc. (http://glossary.tenrox.com/Work-Breakdown-Structure.htm) is quoted below:

"*Work breakdown structure, WBS, is a project management technique initially developed by the US Defense Establishment, which deconstructs a project with the intent to identify the deliverables required to complete the project. The project management work breakdown*

structure, WBS, is utilized at the beginning of the project to define the scope, estimate costs and organize Gantt schedules.

Work breakdown structure, WBS, captures all the elements of a project in an organized fashion. Breaking down large, complex projects into smaller project pieces provides a better framework for organizing and managing the project. WBS can facilitate resource allocation, task assignment, responsibilities, measurement and control of the project.

The project management work breakdown structure, WBS, is utilized at the beginning of the project to define the scope, estimate costs and organize Gantt schedules. In the project management WBS it is important that the project is not broken down into too much detail as that can lead to micro management. Conversely, too little detail can result in tasks that are too large to manage effectively. Work breakdown structure, WBS, can be presented in a tabular list, an indented task list as part of a Gantt chart or in a hierarchical tree. More often the work breakdown structure, WBS is listed in a hierarchical tree that captures deliverables and tasks needed to achieve project completion.

There are multiple ways that a project can be broken down so it is possible to have more than one project management WBS. For example, the project might be broken down by phase, function or discipline."

"The work breakdown structure, WBS, can be used to make a listing of activities in the projects, which can then be used as a foundation to add other information in the other steps of the project management model."

6. Task Descriptions

Task Descriptions define efforts required to achieve completion of a particular task. They should be in enough detail to enable unambiguous estimates of the work to be performed. They should be numbered to track with assigned areas of the WBS. They should also list deliverable items or documents to prove successful completion of the task. For instance, if the task is acceptance testing of a piece of hardware, the deliverable might be a copy of the fully filled out and signed acceptance test procedure document. An excellent example of a Task Description is provided below courtesy of Catalyst Group, Inc. (See references for link).

SAMPLE TASK DESCRIPTION

Task ID 9999
Task Name Design Fromboneski Circuit
Task Owner Tom Tomorrow
Last Revision 7/4/2015 8:45:00 PM

Task Description:
A text description of the task that describes what is known about the work. Describe what is to be done and the deliverables that will be produced. Provide any information known about related activities. Anything created may need a review or test task. Everything reviewed should have a rework task. Remember to describe any documentation, testing, or training that will occur as part of this task. For example:

"The purpose of this task is to create a detailed design of the Fromboneski Alarm Circuit from a customer approved sketch. The circuit will monitor eight signals that will be present on eight twisted pairs of wires in the control room. All current levels will be TTL. Each alarm should have a distinct audible and visual component."

Resources Required:
Describe people, facilities, materials, and equipment known to be required to do the work. Be specific about the skills needed, even if you are not sure who will do the work, for example:

- **senior engineer capable of reviewing TTL wiring schematics and making corrections and recommendations (someone with Mary Smith's skills)**
- **engineer capable of designing TTL circuits from the attached alarm specification with minimal assistance using the EasyCircuit software package (someone like Lisa Brown or Fred Robinson)**
- **Workstation with the EasyCircuit package loaded**

Deliverables:
List the product(s) that this task will produce. Consider adding a sample of what you want if you have one or a reference to a sample. Be as specific as possible, for instance:

"This task will produce an electrical and mechanical design for the Frombonesky Alarm Circuit. The design will be submitted in both hard copy form and on a diskette in EasyCurcuit format."

Completion Criteria:
What conditions must be satisfied to complete this task? Be clear and unambiguous. Describe the completion of a task so that it interlocks with its successors. For example, if this task builds a document and a review task will follow, completion criteria might be:

"Task is complete when copies of the paper design document and CDs containing the design document have been delivered to the reviewer and the Project Manager."
"It is assumed that the Fromboneski alarm design will be a minor modification to the Shlabotnick Alarm we have installed at the Paris site. The time allocated to the design has therefore been reduced by one half since hard copy of that design is available which can be entered 'as is' to establish a baseline."

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SAMPLE TASK DESCRIPTION (Cont'd)

Estimates:

Identify the effort (number of person hours by skill) and approximate duration (number of work-days) required to complete the task. It is prudent to count a full time person as 5-6 person hours per day. A half time person counts as 2-3 person hours per day. Be specific about your assumptions regarding people availability. For example:

"Alarm for first of 8 pairs expected to require 24 hours of design effort (4 hrs senior engineer & 20 junior), others pairs should be knock offs of the first and require no senior time (4 hrs each)

4 hrs senior engineering time (Mary or equivalent)

- **48 hours (20+(4x7)) of junior engineer time (Tom or equivalent)**

If Mary is available on day 1 and 2 and Tom is full time, should be an 8 day task."

Identify costs associated with the task and the estimates associated with the costs:

Category	Notes	Cost
People (Labor)	52 hours @ $100 each	$5,200
Equipment	N/A	
Facilities	N/A	
Materials	N/A	
Other Costs	Reproduction costs for paper designs (24"x36") 50 pages	$600
Total		**$5.800**

Assumptions

It is critical that any assumptions about the task be documented. This includes assumptions about the size and complexity of the task and what those assumptions are based upon, assumptions about the skill levels of people working on the task, the number of review cycles that will be needed etc. We are documenting these assumptions as notes to the ultimate doer of the task and to facilitate later review to improve our estimation process.

END

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7. Methods of Estimating

There are three (3) types of methods for determining the basis of an estimate. These are listed below.

a. Grass Roots (or "Bottom Up") Estimate
b. Similarity
c. Actuals

Explanations of each method are included in the following paragraphs.

Grass Roots Estimate

A Grass Root or "bottom up" estimate is used when there are no comparable tasks previously performed on which to base your estimate. You look at the requirements of the task and estimate labor hours based on your experience. It is rare that this estimate is totally devoid of past similar efforts but when this direct experience only yields a fraction of the task, an educated guess must take over. This is the least preferred estimating method, but will frequently show up in new designs.

Similarity

Bidding by similarity is one the best bid techniques to use when exact duplication of effort (actuals) is not available. This technique may use actuals but the efforts are usually "factored" for complexity level. For example if you have actual hours and material expended to generate Circuit Card XYZ, these values may be multiplied by a factor to equal the required design. If the board is twice as big but not as complex, the material may increase by a factor of 1.2 but the design time may only be .8 of the actuals. Similarly, if there are fewer parts than the XYZ card, the assembly time may be less. This method can be remarkably accurate if the experience of the estimator is relevant.

Actuals

Actuals are great if you are doing exactly the same thing you did before. Well maybe. An "Actual" is a past record of how long a task took to perform and how much material cost or other costs were associated with it. If you designed an assembly for the first time and assembled and tested three of them, there are things for which to account. These are listed below:

- Did the design go well? You don't want to include iterative design hours due to screw ups, re-do's or other factors outside of the normal efficient design process. You don't want idealistic bids either. It should reflect the "should" cost.
- The first unit took a longer time to build and test than the other two. You have assembly and test times for the three units. Take an average to get a safe but not excessive number.

For material estimates the three choices are 1) Purchasing History 2) recent Vendor Quotes and as a last resort 3) Engineering estimates.

It is also important to reference the program and task that you are using as a basis for bidding each task. You should list any assumptions, factoring and justifications for your bid. This will help the reviewer evaluate your bid and also refresh your memory in the future. This is all very important and urgent when you are doing it, but wait two weeks and "estimate amnesia" will set in leaving you clueless as to why you did anything. There can never be too much information on a BOE sheet. Make as many notes as you deem necessary. I suggest using complete sentences to make your notes as short hand notations can be misinterpreted if not clearly spelled out.

8. Evaluating & Mitigating Risk (Schedule/Technical/Cost)

There are three (3) types of risk that one must identify and mitigate when generating and submitting a proposal and cost bid; 1) Schedule, 2) Technical and 3) Cost Risk.

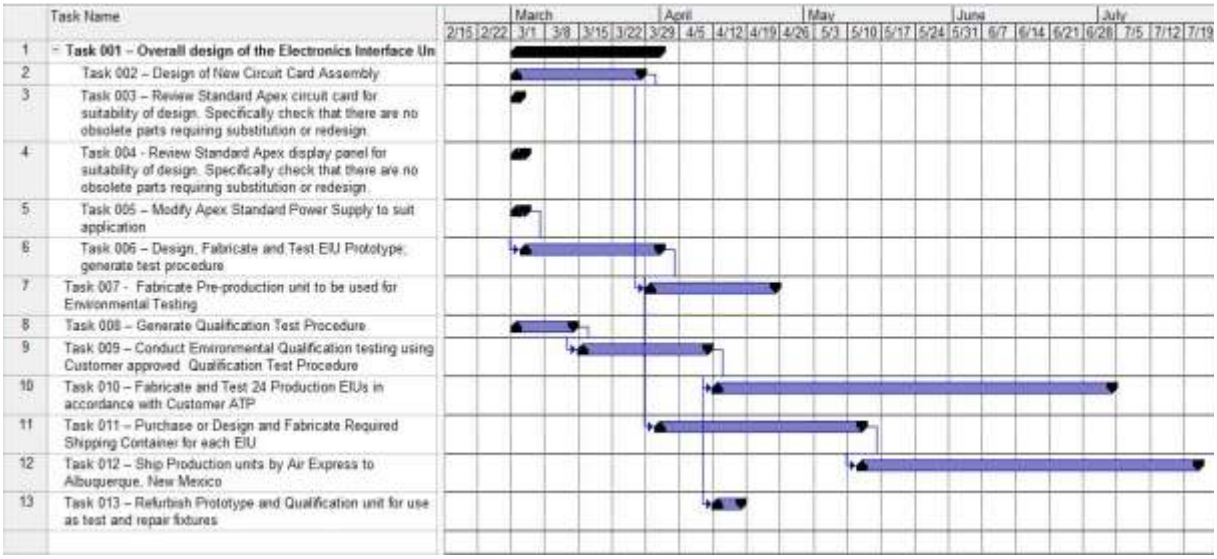
Schedule Risk

This is anything that can make you late such as testing problems, material delays, technical problems or late data items. Most of these issues can be mitigated by good planning and flawless execution. This is difficult to achieve with certainty. So you can either reserve resources (personnel) or money for expediting fees. Both of these affect the price and the profit.

Typically, efforts like this are scheduled using Microsoft Project or a similar scheduling program. The most commonly used schedule type is the Gantt chart. This pictorially depicts tasks in a time phased interdependent fashion. MS Project is usually used to give a quick look at the program schedule and all the dependencies between tasks. Risk items can be identified with slack time included if desired. This would depend on the desired Customer schedule. Depending on design and fabrication time, you may or may not have extra time to allocate to risk items. If you are pressed for time from the start, the schedule risk increases.

If used fully, MS Project can tie in WBS numbering, budget and resource allocations and manpower loading. It would be great to enter all the information in the proposal phase but time is usually at a premium. It can show the critical paths for the project and could be used for material planning. Great tool, no time.

Just be aware that it is there if you have the luxury of taking advantage of all the features. A typical schedule applicable to the given example is shown below.



Program Schedule – Electronic Interface Unit

The above schedule shows the elapsed time for each task, which task must be completed in order to start others and the overall program length.

Technical Risk

If you don't meet all the specs, it will affect cost big time. Technical compliance reviews should mitigate this risk if they are done correctly. If not, you may have to beg for spec relief or a waiver or pay for this relief. An effective technical compliance review ties each task description back to the Specification, Statement of Work or Requirements document. It shows that every requirement is addressed, by what task and the rationale for the bid. The other thing to watch out for is "technical arrogance" or designing a Rolls Royce for a Chevy customer. Stick to the minimum acceptable requirements stated and resist the temptation to design what your technical team thinks the Customer needs rather than what they asked for.

Cost Risk

One of the main reasons for a Basis of Estimate is to reduce Cost Risk on a proposal. There are two main types of risk when it comes to money: Funded and Unfunded

Funded risk is something that is likely but not certain to happen. For example, if you think that there will be retesting associated with Environmental Qualification Testing, you may include some additional money in the bid for retest. This is where it gets "risky". Some pun intended. Do you want to be safe and include two entire re-do's of testing or do you want to have a price that might win the program? The answer usually comes from previous experience and how much risk your management is prepared to accept. The cost of any risk experienced only has two places to cover cost: the program budget or the program profit. If you only want to include 25% risk funding based on your previous test experience, your basis of estimate should back it up with extra hours needed on previous programs factored for current circumstances. Then you have to sell it to management.

Unfunded Risk is for events that are possible but not probable. You are willing to take a hit (usually moderate) to the bottom line if the gods are against you and the improbable occurs. This technique does keep the bid price of the proposal more competitive and increases the probability of a win.

9. Management Reserve

After all is said and done, sometimes Management is just not comfortable with your bid. This is where the "Management Reserve" comes in. Even the most detailed estimates cannot cover every contingency or "imponderable" on a program. In these instances, the risks on the program are evaluated and money set aside and included in the bid.

This "Management Reserve" can be allocated as Program Management deems fit once the bid becomes a program. If the risk is realized, the cost is covered in the budget. If the risk item does not occur, the management reserve goes to the bottom line as profit or could be used to cover any other overages. Sometimes they just think you bid too low, without any particular

rationale, and stick some money in the bid reserved for use at their discretion if you win the program.

Sometimes Management thinks that you bid too high and remove money from the bid and issue a "Management Challenge". In other words, they shrink your budget and challenge you to do the tasks quicker and cheaper. This usually happens during the proposal phase but don't be surprised if they do it again once you win the program. Very challenging!

10. Detailed Example of Using BOEs in a Proposal

This section provides a simplified but detailed example of the use of Basis of Estimates in preparing and validating a bid and proposal. It will demonstrate the process used in preparing and reviewing a typical bid. It will also show examples of typical issues that might negatively impact the results and have these how these issues can be detected and corrected.

Example Requirement

Apex Manufacturing has just received an RFP (Request for Proposal) for an Electronics Interface Unit (EIU). It is a new design utilizing one standard product Apex circuit card assembly and one new circuit card design and a display panel identical to a previous Apex unit display. The power supply to be used can be a modified Apex standard power supply design. The unit needs to prototyped and after successful electrical test, a pre-production unit must be subjected to environmental qualification testing. After successful Qualification Testing, 24 production units are to be fabricated and tested in accordance with a customer provided production test procedure. The production units are to be shipped at Apex's expense from their Florida plant to Albuquerque, New Mexico via express air in a special humidity and shock resistant crate. The prototype and Qualification Units are to be retained by Apex as fixtures for future repairs.

Procedure

The first step is to select a Proposal Manager and generate a Work Breakdown Structure (WBS). A Proposal Outline is generated to organize the writing effort to make sure the RFP is completely responsive and in full compliance. The WBS is the structure used to ensure bid and price compliance. The Requirements are presented to the various departments for labor and material bid inputs. Meetings are then held to ensure compliance with relevant documents such as the Technical Specifications and Statement of Work (SOW). Final "scrub" meetings are held after the bid inputs are received to reduce redundant, unnecessary or "padded" labor or material bids. This helps to ensure that the bid is competitive with other company's bids.

The process for pricing the proposal is listed in bullet list form below. Detailed explanations of each step are presented in the paragraphs following the bullet list.

- RFP/RFQ Review to generate Requirements
- Communicate Requirements
    - Proposal Outline
    - WBS generation
    - Task Description generation
    - Compliance matrix consisting of
        - Tech vs spec
        - Schedule vs RFP
        - Cost vs expectations and the competition
- Generate Labor Bids and Price Bill of Materials (BOM)
- Bid scrub consisting of
    - reality / sanity checks and
    - basis of estimates
- Management Review

RFP/RFQ Review to Generate Requirements

When a Request for Proposal (RFP) or Request for Quote (RFQ) is received by your company, a person is assigned as Proposal Manager. This person usually is from Business Development or Program Management and has total responsibility for interpreting the requirements and communicating them to the people who must generate the labor and material estimates to get the program successfully completed.

Communicate Requirements

Once the Requirements have been reviewed, they must be communicated to the troops to allow them to bid. Several documents (listed below) are generated to accomplish this transfer of information.

- Proposal Outline – if a written description is required to accompany the cost proposal, an outline is generated and writing assignments made.
- WBS – The Work Breakdown Structure is an organizational chart which is used to collect costs from the Task Descriptions.
- Task Descriptions – these are detailed explanations of the tasks required to achieve the requirements of a program. These are derived from the requirements documents from the customer.
- Compliance matrix - this is a matrix that compares individual aspects of the Requirements to specific task descriptions to ensure that all requirements and specifications are addressed to prevent disqualification by the potential

Customer for non-compliance. Three (3) areas of concern are included in this compliance review.

- Technical tasks to meet specification requirements
- Program Schedule vs RFP required need date(s)
- Cost vs customer budget expectations and the competition bid history

This course does not address writing the proposal, but the same principles apply to making sure the proposal matches the requirements and reflects what is bid.

Generate and Collect Labor Bids and Priced Bill of Materials (BOM) per WBS numbers

Once all the requirements and task descriptions are issued, it's time to estimate the labor and materials. Each task description is reviewed and if possible similar or identical tasks are used to generate the bid. If totally new, a grass roots (original) estimate is generated based on experience. Each task description or sometimes groups of tasks descriptions are collected under the relevant WBS number. Basis of Estimate (BOE) sheets are filled out to justify and specify the activities to be performed. The BOE identifies the rationale for the bid and cites similar tasks performed in the past, their relative complexity and applicability.

As important or perhaps more so is the Bill of Materials (BOM). Material costs are subject to change due price increases over time, quantity price differences and decreased availability. Part obsolescence is a key problem in producing products for extended periods of time. Care must be taken to ensure that parts are still available and supported for future programs or that some new technology make it sensible to upgrade to the next new thing. Even one part going obsolescent with no direct replacement can trigger a board redesign or even box redesign resulting in increased cost. Find out now rather than later when the boards or boxes are already built waiting for a part you can't get.

Once all the bids are collected, they are totaled and scrubbed for final Management review.

Scrubbing the Bid

A typical scrub meeting makes extensive use of the Basis of Estimate Sheets to validate the bid inputs. Each bid input is justified by comparison to a known previous program task. If tasks are not identical, similarities and differences from known actuals are identified and appropriate multiplying factors are assigned.

Sanity checks are performed on these bids, as well as on original grass roots bids, to be sure that both the task description and bid inputs make sense. A strong meeting leader can look the bidder in the eye and get him or her to admit that something is overbid or raise task elements that have not been addressed.

Corrections or adjustments to bid inputs can be either up or down. The goal is not to get the lowest bid, but it is to get the lowest accurate bid. Notes of corrections or adjustment are made to the BOE sheets as a record of reasons or rationales for changing bid inputs.

This effort is to produce a valid estimate by removing "padding", interpretation errors or rounding accumulation from the bid. Find someone to lead this effort that the group producing the estimate respects and fears.

Usually this effort lowers the answer, but sometimes it discovers omissions which will cost you later because it was never budgeted. For this example, during the scrub meeting, it was pointed out that the last time Qualification units were used for test fixturing, they had to be refurbished to return them to a clean and usable condition. This effort was added to the WBS, a task description written and an estimate prepared. This omission of a necessary task would have caused a loss on day one of the program, as well as, causing a potential schedule slip.

One risk of detailing the estimate for every task in a program is the accumulation of rounding errors leading to an excessively high bid. This reduces the competitiveness of the price bid and jeopardizes the probability of winning the contract. This rounding is caused by making tasks too small. When you estimate a task that takes 3-5 hours it invariably shows up as 8 hours in the bid. If this happens multiple times, a 40 hour group of tasks gets estimated at 64 to 80 hours. Sure you have a margin to perform the job, but you may not get the opportunity because you lost on price.

Management Review

Once the bid is scrubbed and proposal (if required) is complete, it's time for the final review of the package by company management before submission. Management hopefully consists of executives with extensive experience in preparing and submitting similar proposals. There should be a Technical, Financial and Business expert to provide efficient advice and consent.

The Technical representative will make sure specifications are addressed and that the tech team is not over reaching and taking on too much risk.

The Financial representative will check for price reasonableness and low financial risk.

Finally the Business representative knows how the company works, whether it bids optimistically or pessimistically and if the bid is competitive with the other companies submitting bids.

The result of this meeting could be establishing a management reserve, issuing a management challenge or requiring a relook at some areas or even the whole effort. These guys and gals are on the line for the success of the bid so they feel their responsibility to lend their wisdom.

The Management Team also determines what loading factors to apply to the cost estimate generated. These include Manufacturing and Engineering overhead factors, material handling factors, G&A rates and profit. The estimates provided here were direct inputs without this loading. Many times standard rates for these items have been established and are only modified by the Management Review for special circumstances.

Task Descriptions

The paragraph below is a copy of the Requirements for the Example. I have reviewed it and highlighted anything that looks like a task. Since this is the only requirement presented for the example, it should represent a fairly complete list of tasking. In more complex bids, all documents should be reviewed to determine full tasking.

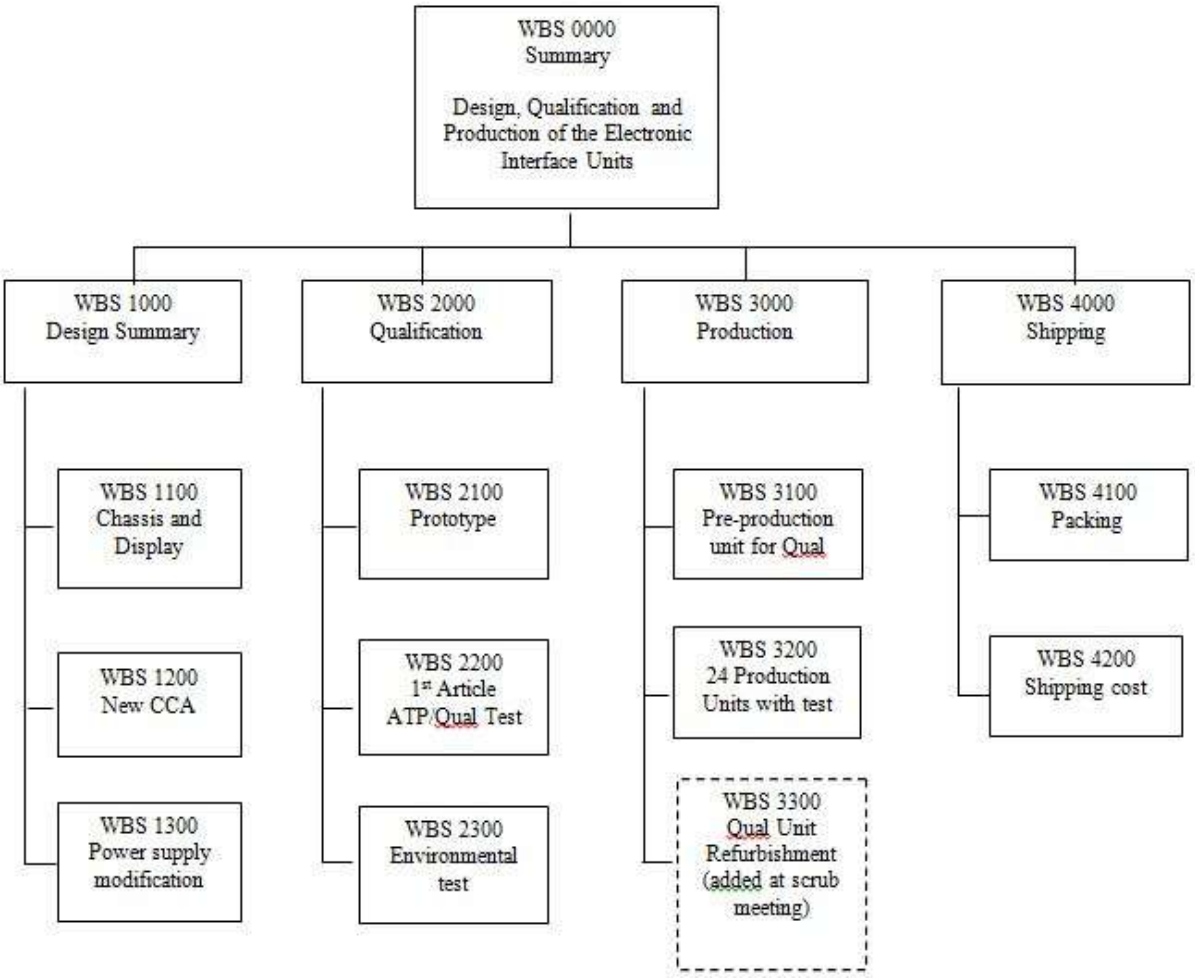
"Apex Manufacturing has just received an RFP (Request for Proposal) for an Electronics Interface Unit (EIU). It is a new design utilizing one standard product Apex circuit card assembly and one new circuit card design and a display panel identical to a previous Apex unit display. The power supply to be used can be a modified Apex standard power supply design. The unit needs to prototyped and after successful electrical test, a pre-production unit must be subjected to environmental qualification testing. After successful Qualification Testing, 24 production units are to be fabricated and tested in accordance with a customer provided production test procedure. The production units are to be shipped at Apex's expense from their Florida plant to Albuquerque, New Mexico via express air in a special humidity and shock resistant crate. The prototype and Qualification Units are to be retained by Apex as fixtures for future repairs."

The following Tasks are generated from the highlighted areas. This represents a greatly simplified sampling of tasking in response to a requirement. A Task Description for each of these efforts would be generated describing the work to be performed in sufficient detail to avoid any confusion or ambiguity in scope. For a real project, this listing can range into the hundreds of individual Task Descriptions.

Task 001 – Overall design of the Electronics Interface Unit
Task 002 – Design of New Circuit Card Assembly
Task 003 – Review Standard Apex circuit card for suitability of design. Specifically check that there are no obsolete parts requiring substitution or redesign.
Task 004 - Review Standard Apex display panel for suitability of design. Specifically check that there are no obsolete parts requiring substitution or redesign.
Task 005 – Modify Apex Standard Power Supply to suit application
Task 006 – Design, Fabricate and Test EIU Prototype; generate test procedure
Task 007 - Fabricate Pre-production unit to be used for Environmental Testing
Task 008 – Generate Qualification Test Procedure
Task 009 – Conduct Environmental Qualification testing using Customer approved Qualification Test Procedure
Task 010 – Fabricate and Test 24 Production EIUs in accordance with Customer ATP
Task 011 – Purchase or Design and Fabricate Required Shipping Container for each EIU
Task 012 – Ship Production units by Air Express to Albuquerque, New Mexico
Task 013 – Refurbish Prototype and Qualification unit for use as test and repair fixtures

Example Work Breakdown Structure

The following Work Breakdown Structure is constructed from typical efforts involved in a contract as well as specifics that might be detailed in the Requirements.



Mapping Task Descriptions into the Work Breakdown Structure

Presumably the WBS was generated from the Requirements document. It should therefore mirror the tasks generated from the same requirement. The Tasks must be mapped to particular WBS numbers to ensure estimate inputs are collected under the right efforts. The correlation is usually obvious resulting in the following List of tasks and WBS numbers:

Task Number	Description	WBS number	WBS Description
001	Overall design of the Electronics Interface Unit	1100	Chassis and Display
002	Design of New Circuit Card Assembly	1200	New CCA
003	Review Standard Apex circuit card for suitability of design. Specifically check that there are no obsolete parts requiring substitution or redesign.	1100	Chassis and Display
004	Review Standard Apex display panel for suitability of design. Specifically check that there are no obsolete parts requiring substitution or redesign.	1100	Chassis and Display
005	Modify Apex Standard Power Supply to suit application	1300	Power Supply Modification
006	Design, Fabricate and Test EIU Prototype; generate test procedure	2100	Prototype
007	Fabricate Pre-production unit to be used for Environmental Testing	3100	Pre-production Unit for Qual
008	Generate Qualification Test Procedure	2200	1st Article ATP/Qual Test
009	Conduct Environmental Qualification testing using Customer approved Qualification Test Procedure	2300	Environmental Test
010	Fabricate and Test 24 Production EIUs in accordance with Customer ATP	3200	24 Production units with Test
011	Purchase or Design and Fabricate Required Shipping Container for each EIU	4100	Packing
012	Ship Production units by Air Express to Albuquerque, New Mexico	4200	Shipping cost
013	Refurbish Prototype and Qualification unit for use as test and repair fixtures	3300	Qual Unit Refurbishment
There are certainly more tasks involved in this project, but this sampling of tasks demonstrates the process.			

Basis of Estimate Sheet Package for the Given Example

The following pages contain examples of Basis of Estimate (BOE) sheets that might be produced from this bid. They include one sheet for every box on the WBS. Level 1 is the top summary for the job and consists of the summary of all the Level 2 WBS boxes. Level 2 boxes are the summary of relevant Level 3 WBS Boxes and tasks. There may be additional efforts included in Level 2 boxes if not covered by any of the Level 3 tasks. For this example the following labor rates apply:

Labor Code	Description	Rate/Hr
ENG	Engineering	45.00
ASSY	Production Assembly	12.00
CAD	Design & Drafting	28.00
TEST	Test technician	25.00

Each BOE sheet contains the WBS element being addressed, the bidder's name, a brief description of the task being bid and the detailed hours of labor and dollars of material used. It also gives the rationale for the bid and cites ant similar efforts or assemblies that might have been used for comparison.

Basis of Estimate Sheet								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 0000 Top Project Summary							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 1	$96,570	387 hrs Eng 712 hrs Test 244 hrs CAD 488 hrs Assy	$9,410	$200,201	None	$200,201	Contract Budget	See individual BOEs
This WBS element is a summary box for all of the WBS elements on the Bid. It represents the total design, production and qualification Test effort as well as packing and shipping of the 24 EIUs.								
The cost of the project was reviewed in a Scrub meeting by Engineering, Production and Program Management. A task was added to refurbish the Qual and Pre-production units for use as Text fixtures. Other design tasks associated with bard and power supply modifications were reduced to remove rounding accumulation. Management deemed the bid 5% too high based on competition bid history and issued both Production Material and Labor challenges of 8% (included in total)..								

Basis of Estimate Sheet								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 1000 Design Summary							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 2	$3,900	193 hrs Eng 244 hrs CAD 32 hrs Assy 56 hrs Test	$3,350	$24,551	-	$24,551	Contract Budget	Various
See Level 3 sheets								
Se Level 3 Sheets								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 1100 Chassis and Display							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$2,350	65 hrs Eng 80 hrs CAD	$850 Machine shop	$8,365	None	$8365	Contract Budget	Grass roots Similarity Actuals
This WBS element includes design labor and material expended to integrate the CCAs, power supplies and display to complete the EIU design.								
No design time is included for identical assemblies previously manufactured. It does include original chassis design work and material need to prototype the chassis parts where required.								

Basis of Estimate Sheet								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 1200 New CCA							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
3rd Level	$1,450	120 hrs Eng 160 hrs CAD 32 hrs Assy 40 hrs Tech	$2500	$15,214	None	$15,214	Contract Budget	Grass roots
This WBS element represents all the design and test labor used to produce the new board design. It also includes all the material required for prototyping and bread boarding to prove the design. ODC is for outside PCB fab per quote.								
Material cost is from quotes of items on preliminary new parts list plus 50% shrinkage for prototyping. Production material cost is collected under production units and has a reduced shrinkage of 10% applied.								

Basis of Estimate Sheet								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 1300 Power Supply Modification							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 2	$100	8 hrs Eng 4 hrs CAD 16 hrs Tech	N/A	$972	None	$972	Contract Budget	Actuals
This WBS represents the design change and test of the modified power supply. It involved a simple resistor value change on the parts list without any change to the physical configuration or layout.								
Material cost is the same as the standard Power Supply unit as well as test time. CAD time is to change the Parts List; Eng time is to change the Parts List and modified the limits on the subassembly test procedure. Tech time is to prove out the unit and test procedure. Standard PS was most recently used on “White Cross” program.								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 2000 Qualification Summary							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 2	$7,500	130 hrs Eng 360 hrs Test 96 hrs Assy	$22,650	$48,670	25% for Env Test	$48,670	Contract Budget	Various
See Level 3 sheets								
See level 3 sheets								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 2100 Prototype							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$3,500	96 hr Assy 40 hrs Test	$650	$8,820	None	$8,820	Contract budget	Similarity Vendor Quotes
This WBS includes assembly and test time to build prototype unit and the material required.								
The Test and Assembly estimates are based on similar activities on the “STAR” program.								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 2200 1st Article test							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	-	160 hrs Test 40 hrs Eng	-	$5,800	None	$5,800	Contract budget	Similarity
This task includes writing the 1st Article/Qual Test Procedure and conducting electrical tests.								
1st article is similar to “STAR” project testing factored (x1.2) for complexity.								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 2300 Environmental Test							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$4,000	160 hrs Test 90 hrs Eng	$22,000	$34,050	25% include in estimate for possible retest	$34,050	Contract Budget	Similarity/ Vendor quote
This WBS includes conducting the Environmental qualification Test on the Electrical Interface Unit at an external test lab.								
This quote assumes conducting testing at a local test lab eliminating the need for travel and lodging expenses. ODC charges are from actual lab quotes for this specific effort.								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 3000 Production Summary							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 2	$83,250	64 hrs Eng 320 hrs Assy 296 hrs Test	-	$103,530	None	$103,530	Contract Budget	Various
See level 3 sheets								
See level 3 sheets								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 3100 Pre-Production Unit for Qual							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$6,200	320 hrs Assy 40 hrs Eng 24 hrs Test	-	$16,600	-	$16,600	Contract Budget	Similarity/ Vendor quotes
This WBS includes the labor and materials to build and test the EIU pre-production units.								
The estimates for labor are based on the “STAR” program which is roughly the same complexity in build techniques and test procedure. The material is from vendor quotes.								

Basis of Estimate								
Project: Electronics Interface Unit						**Date: 1/20/2015**		
WBS Element: 3200 Production Units (24)						By: KAM		
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$76,800	192 hrs Test 24 hrs Eng	-	$82,680	-	$82,680	Contract Budget	Similarity/ Vendor Quotes
This WBS includes the material for the 24 EIU build and includes 10% shrinkage. It also includes the Assy labor required to build the units and the Tech labor to test the 24 units.								
All labor is factor of the “STAR” program adjusted for quantity. The unit test and build complexity is roughly the same as the “STAR” program.								

Basis of Estimate								
Project: Electronics Interface Unit						**Date: 1/20/2015**		
WBS Element: 3300 Refurbish Qual Units for use as Test Fixtures						By: KAM		
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$250	80 hrs Tech	-	$4,250	_	$4,250	Contract budget	Grass Roots/Eng estimate
This WBS includes the effort to refurbish the Qual and pre-production units to use as Test Fixtures fir any warranty and repair work on the 24 EIUs.								
The material is an Engineering estimate. The labor is a grass roots estimate for repairing qualification Test damage from the “START” program.								

Basis of Estimate								
Project: Electronics Interface Unit						**Date: 1/20/2015**		
WBS Element: 4000 Shipping Summary						By: KAM		
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 2	$19,200	40 hrs Assy	$ 3,800	$23,480	None	23,480	Contract Budget	Similarity and Actual Quotes
This WBS is the summary of Tasks to pack and ship 24 EIUs to Albuquerque, NM via air freight in special humidity and shock resistant containers.								
The similarity for Assy labor is from the “Star” program for similar tasks adjusted for quantity.								

Basis of Estimate								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 4100 Packing							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	$19,200	40 hrs Assy	-	$19,680	None	$19,680	Contract budget	Actual Vendor quote
This WBS contains the material and labor cost to pack 24 EIUs in the special shipping containers								
The material cost is the actual quote for the standard humidity and shock resistant containers.								

Basis of Estimate Sheet								
Project: Electronics Interface Unit							**Date: 1/20/2015**	
WBS Element: 4200 Shipping Cost							By: KAM	
Category	**Material**	**Labor**	**Outside Direct Costs**	**Base Cost**	**Reserve**	**Total Cost**	**Funding Source**	**Cost Methodology**
Level 3	-	-	$3800	$3800	None	$3800	Contract Budget	Actual quote
This Task contains the cost of purchasing standard shock and humidity resistant shipping containers for each EIU.								
ODC cost is for air freight shipping cost quote for 24 units.								

11. Conclusions from Example

The following is a partial list of benefits achieved by the use of BOEs and related reviews.

- Built confidence in bid by using identical or similar bids as a comparison basis.
- More careful justified grass roots estimate inputs.
- Removed padding and rounding accumulation from bid by "scrubbing" BOE inputs.
- Discovered missing tasks such as Qualification Unit refurbishment for test fixture use.
- Identified any Risk on the Program
- Formed baseline for Program Plan.
- Made the bid more competitive.
- Ensured compliant bid.
- Documented Record of Bid.

12. Overall Conclusion from Course

Although, this course concentrated on the benefits of using Basis of Estimates (BOEs) in optimizing and validating cost proposals, I hope it also demonstrated a typical overall procedure for producing cost estimates. It demonstrated steps that can be taken to ensure technical and schedule compliance, realistic looks at Tasks and providing what the customer wants rather than something else that your Technical staff may like. The goal is to produce a responsive, compliant and competitive proposal that gives the custom exactly what they asked for at the lowest price. It's good for the Customer and good for your company.

13. References and Resources

a. Preparing a Basis of Estimate, EST 10 - 2005 AACE International Transactions Mr. Todd Pickett, CCC, Conquest Consulting Group, E-mail: tpickett@ccg-estimating.com
b. Definition of Basis of Estimate - Businessdictionary.com
c. Work Breakdown Structure (WBS) definition and description from Upland Software Inc... Work Breakdown Structure (WBS) in Project Management Definition & Resources
d. Sample Task Description v5.0; Catalysis Group, Inc. 2013 task-description-template sample