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08.0 - MANAGING COST ESTIMATING & BUDGETING

08.1 - Module 08-1 - Introduction to Managing Cost Estimating & Budgeting

08.2 - Module 08-2 - Develop Cost Estimating & Budgeting Policies & Procedures Manual

08.3 - Module 08-3 - Define The Estimates Purpose And Scope Of Work (Owner)

08.4 - Module 08-4 - Creating the Owners Cost Estimate (Top Down)

08.5 - Module 08-5 - Define the Estimates Purpose and Interpret the Scope of Work (Contractor)

08.6 - MODULE 08-6 - DEVELOPING THE CONTRACTORS COST ESTIMATE (BOTTOM UP)

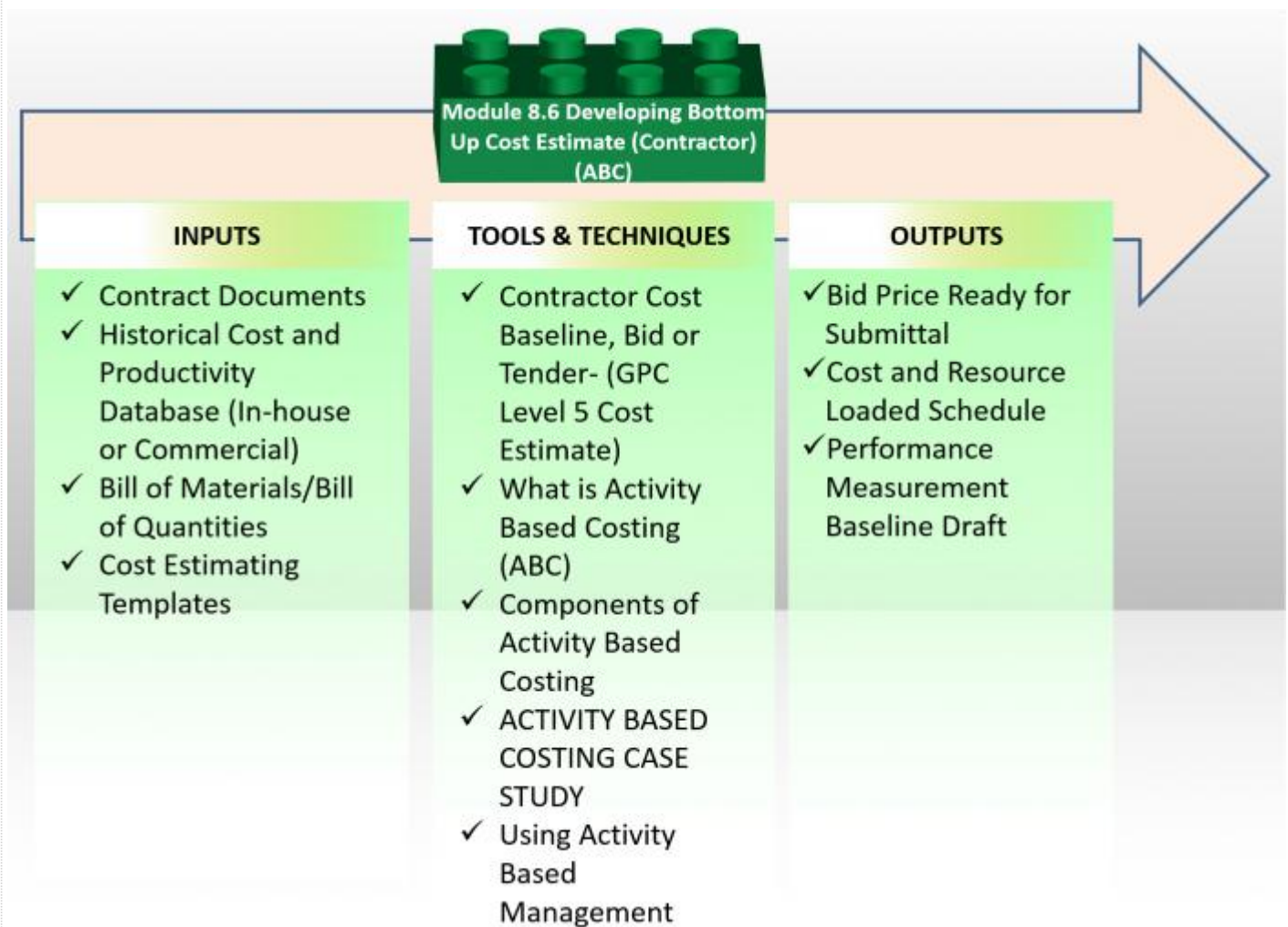


Figure 1 - Developing The Contractors Cost Estimate (Bottom Up) Process Map

Source: Guild of Project Controls

08.6.1 INTRODUCTION

Normally it is junior cost estimators who are tasked with producing what is called a "neat" or "clean" cost estimate. This may or may include doing the quantity take-offs either manually or using a computerized table.

This results in a preliminary estimate which is based on P50 estimates and contains no markups for project overhead, home office

overheads, contingency or profit margin (contractors only). That responsibility normally belongs to senior cost estimators working in conjunction with their top project managers and/ or senior management. Another subject matter expert who should be included in the development and refinement of cost estimates is the forensic claims assessor. Knowing what elements in contracts and/or execution which have historically proven to problematic will help the project team identify the appropriate risk mitigation strategies and tactics and include those in the costing/pricing calculations.

While this "rule of thumb" applies to both owners and contractors, because for contractors the project is a profit center and given contractors historically make single digit EBIT margins, this process takes on significant importance for contractors, especially when bidding on firm fixed price and the various incentive contracts, as adding too much contingency will result in the contractor not winning any bids, while not correctly or appropriately adding contingency can result in a contractor going bankrupt. So this final step is taken very seriously primarily by contractors. (See **Module 5 - Managing Contracts** for more on this topic)

While "bottom up" cost estimates are normally done by contractors as a "core competency" or "business as usual" procedure, there are instances where quantity surveyors or cost consultants may produce a "bottom up" cost estimate as the basis for the owner either as a "check" or "owner's estimate" against which to validate the accuracy, reliability and precision of the bids being submitted by the contractors or as what is known as an "Independent Cost Estimates" (ICE). Unlike the "Check" or "Owners" cost estimates which are designed to be used as a baseline against which to check the contractors bids, Independent Cost Estimates are designed to validate the accuracy, reliability and precision of the OWNER's cost estimates. This is normally done towards Phase 3 and Phase 4, prior to the owner submitting the cost estimate for final approval and funding prior to actually commencing work on the project.

08.6.2 INPUTS

Contract Documents

Historical Cost And Productivity Database (In-House Or Commercial)

Bill Of Materials / Bill Of Quantities

Cost Estimating Templates

08.6.3 TOOLS & TECHNIQUES

08.6.3.1 Bill of Quantities / Bill of Materials

The "Bill of Materials" (BoM) or "Bill of Quantities" (BoQ) is literally a list of materials or quantities which go into any project.

There are three ways either an owner or contractor can create or produce a BoQ or BoM:

Owner can hire a QUANTITY SURVEYOR who will take the plans and specifications and using manual or digitized estimating boards, create a BoQ/BoM

Contractor can hire their own in house Quantity Surveyors/Cost Estimators who take the plans and specifications and using manual or digitized estimating boards, create a BoQ/BoM. There are many contractors who do their own quantity take offs looking for discrepancies or mistakes in the quantities provided by the owner. The contractor uses this to UNBALANCE THE BID by quoting a LOWER unit in place price of items they think the owner has OVER ESTIMATED and a HIGHER unit in place price of items they think the owner has UNDERESTIMATED the quantities. This is covered in more detail in Module 5- Contracts

Building Information Modelling (BIM) As Building Information Modelling seems to be gaining traction, the days of performing manual or even digitized quantity take offs is probably coming to a close, except for the smallest of projects. With BIM, as the design is created, the BoM/BoQ is automatically created. As with any computer program, the old maxim "garbage in/garbage out" applies and it still behoves the contractor to perform their own due diligence by random sampling some of the major components just to see how reliable, accurate and precise the BoM/BoQ are.

08.6.3.2 Contractor Cost Baseline, Bid or Tender - (GPC Level 5 Cost Estimate)

This is a "bottom up" estimate almost always done by contractors only, as this type of effort takes considerable effort and time, and it may not result in the contractor actually being awarded the contract, either as low bidder or through negotiations. For this type of cost estimate, some form of "Activity Based Costing" (ABC) is used to develop the estimate.

While **Activity Based Costing** is most often used by contractors, for owners considering doing their own work or for any owners activities on an Integrated Master Schedule (IMS) the owner would be prudent to also cost load his/her activities as well.

While the Guild of Project Controls is not endorsing any particular software or system, R.S. Means has given the Guild permission to use their well-known and highly respected cost estimating databases to illustrate not only what fields a well-constructed project

controls database should contain but how both planner/schedulers and cost estimators as part of the project controls team need to be able to use this information separately or together to produce cost and resource loaded schedule.

03 30 Cast in Place Concrete 1										
03 30 53 Miscellaneous Cast in Place Concrete 2										
03 30 53.40 Concrete in Place 3 7 8 9 10 11 12 13 14 15										
0.0010	Including Forms (4 uses), reinforcing steel, concrete placement and finishing, unless otherwise indicated.	Crew Type	Daily Output per Unit	Labor Hours per Unit	Unit of Measure	Material Costs	Labor Costs	Equip- ment Costs	Total Costs per Unit	Total Price/Unit Including OH&P
0.0020										
0.0050										
0.0300	Beams- 5 kip per lineal foot, 10' long spans 5	C14-A	15.62	12.8	Cubic Yard (CY)	\$315.00	\$490.00	\$48.50	\$853.50	\$1,225.00
0.0350	Beams- 5 kip per lineal foot, 25' long spans 6	"	16 18.55	17 10.78	CY	18 \$325.00	19 \$415.00	20 \$40.50	21 \$780.50	22 \$1,100.00

Figure 2 - Case Study Using Commercial Database Information

Source: Giammalvo, Paul D (2015) Course Materials. Adapted from R.S. Means 2008 Facility Cost Estimating Database Crew C-14A. Contributed Under [Creative Commons License BY v 4.0](https://creativecommons.org/licenses/by/4.0/)

In the example above:

(1) 03 30 Cast In Place Concrete is CSI Masterformat/Omniclass Table 22 2nd Level WBS Structure. (Level 1 is 03 is Concrete and Level 2 is 03 30 is Cast in Place Concrete)

(2) 03 30 53 Misc Cast in Place Concrete is CSI Masterformat/Omniclass Table 22 3rd Level WBS (Level 1, 03 is Concrete, Level 2, 03 30 is Cast in Place Concrete)

(3) 03 30 53.40- Concrete in Place is CSI Masterformat/Omniclass Table 22 Level 4 WBS, which from this level down becomes not only a WBS but a Cost Breakdown Structure (CBS) and Productivity Breakdown Structure (PBS) as well. One coding structure serving three purposes. Worth noting is Level 3 of the WBS is the MINIMUM level of detail that an owner should be providing to a contractor, assuming the owner wants to minimize claims and disputes while at the same time, obtaining highly competitive bids.

(4) 03 30 53.40.0010, 03 30 53.40.0020 and 03 30 53.40.0050 is an ACTIVITY consisting of Forming (0.0010); Installing Rebar (0.0020) and Placing and Finishing Concrete (0.0050)

(5) There are two types of Activity "03 30 53.40.0300 is based on 10' (foot) long spans" and Activity "03 30 53.40.0350 is based on 25' (foot) long spans". Depending on the number of scenarios, you could create other cost and productivity calculations for as many different combinations as you are likely to use.

(6) For the remaining example we will be using Activity 03 30 53.40.0350 to form, reinforce, place concrete and strip 25' long, 5 kip (5,000 lbs) beams. Notice that the only piece of information MISSING from this is the Quantity Take Off or Bill of Materials? When we start to use Building Information Modelling (BIM) this information will be coming to us, using these coding structures. If we do not use BIM, then we have to do it the old fashioned way- doing quantity take offs using manual methods.

(7) This is where we know the composition of the crew that was used to calculate the productivity and costs. For this example, we will use Crew C-14A. See below for a more detailed look at what Crew C-14A is made of.

(8) Is simply the daily output that Crew C-14A can produce ON AVERAGE. (P50) value. It is not adjusted for any risks. This is one of the most important pieces of information that the Planner/Scheduler needs as this is how we calculate the DURATION and the Cost Estimator needs to know and understand to estimate the COSTS

(9) Is the number of Crew Labor Hours per Cubic Yard (CY) of beam concrete. This too is another useful piece of information for all project control professionals but especially planners/schedulers, as many projects are not tracked based on money but on man-hours expended or earned vs planned man hours. This will be covered in Module 9- Managing Progress.

(10) This is the Unit of Measure. In this case, it is Cubic Yards (CY) but it could have been Cubic Meters (M3) or any other fast and reliable way to measure physical progress.

(11) This is the Field where we enter Material Costs. As material costs tend to be location specific, the professional cost

estimate needs to keep this updated and adjust these values for different locations.

(12) Labor Costs- As with Material costs, labor costs are highly variable and need to be checked and validated by the cost estimator/project controller for each location and for each trade.

(13) Equipment Costs- Tend to be less variable than material or labor costs, but also need to be updated at least semi-annually and preferably quarterly. Equipment productivity tends to be relatively stable and predictable.

(14) Total Costs is the sum of 11, 12 and 13

(15) Marked Up Costs (Contractors Selling Price) is shown in this column and as we can see, ranges from about 44% to 47% to cover Project Overhead, Home Office Overhead and all the other items shown above in **Figure ??** R.S. Means 2008 Facility Cost Estimating Database Back Cover Showing Labor Rate Markups

(16) Crew C-14A can produce on average, 18.55 Cubic Yards (CY) per day for this particular activity. Different activities will have different productivity rates.

(17) On average, it takes 10.782 labor hours per Cubic Yard (CY) in place for this particular activity. Different activities will have different productivity rates.

(18) The Material Costs for this activity is \$315.00 per Cubic Yard of Concrete in place

(19) The Labor Costs for this activity is \$415.00 per Cubic Yard of Concrete in place

(20) The Equipment Costs for this activity is \$40.50 per Cubic Yard of Concrete in place

(21) The Total Costs per Cubic Yard of Concrete in Place is \$780.50

(22) The Fair Market Value or Contractors Selling Price for each Cubic Yard of Concrete in Place is \$1,100, including a markup for OH&P of ~47% (16% Home Office Overhead + 16% for Project Overhead + 15% for Contractors Gross Profit = 47%)

For the example below the Unit of Measure will be Cubic Yards (CY)

This same data is required by both the planner/scheduler and the cost estimator and ideally both should be working of the same database. Failure to create an integrated database will result in conflicts between what the scheduler calculates for costs based on the hourly or daily rate and the marked up costs which include overhead and profit margin.

Important for Owner's cost estimators especially is for you to use the COSTS if you are trying to decide whether an activity is cheaper for you do to in house with your own team or outsource it. Failure to back out the contractors OH&P will always make it look like you can do it cheaper, when in fact, you may not be able to.

And again using the above referenced R.S. Means database this is what the aforementioned "**Crew C-14A**" consists of. You will notice that the "crew" is further broken down into its constituent parts:

#	Crew C-14A 1	Contractors Bare Costs		Including Subcontractors OH & P		Contractors Cost Per Labor Hour	
		Hourly	Daily	Hourly	Daily	Bare Costs	Billing Rate Including OH & P
1	Carpenter Foreman	\$40.10	\$320.80	\$66.40	\$531.20	\$38.36	\$63.65
16	Carpenters	\$38.10	\$304.80	\$63.10	\$504.80		
4	Rodmen	\$43.00	\$344.00	\$73.55	\$588.40		
2	Laborers	\$30.25	\$242.00	\$50.10	\$400.80		
1	Cement Finisher	\$37.00	\$296.00	\$58.00	\$464.00		
1	Equipment Operator	\$39.85	\$318.80	\$62.90	\$503.20		
1	Gas Engine Vibrator		\$24.80		\$27.28		
1	Concrete Pump (Small)		\$728.20		\$810.02	\$3.77	\$4.14
200	Total Daily Labor Hours 2	3	\$8,425.40	4	\$13,558.70	5 \$42.13	6 \$67.79

Figure 3 - Case Study Demonstrating Crew Composition Details

Source: Giammalvo, Paul D (2015) Course Materials. Adapted from R.S. Means 2008 Facility Cost Estimating Database Crew C-14A. Contributed Under [Creative Commons License BY v 4.0](https://creativecommons.org/licenses/by/4.0/)

(1) Crew C-14A consists of the 8 Labor and Equipment items; 1 carpenter foreman plus 16 carpenters, 4, rodmen, 2 laborers and 1

equipment operator.

(2) This crew of 25 people equals 25 man days of labour and assuming they are working an 8 hour day = 200 man hours of labour per crew working day.

(3) The bare COST of this crew is \$8,425.40 per day (bare costs are wages and fringe benefits for the labor and the depreciated costs of the equipment)

(4) This is what the PRIME CONTRACTOR has to CHARGE for this crew to work one day

(5) This is the additional amount the PRIME CONTRACTOR has to add to cover his/her Overhead and Profit on his Foreman and the Concrete pump the prime contractor provided. Thus the PRIME CONTRACTOR would have to take the \$13,558.70 and ADD the OH&P of \$67.79 for his Foreman and Pump for a total of \$13,626.79 per 8 hour working day.

What we are MOSTLY looking for as cost estimators are the Crew, the daily output, the labour hours and the unit of measure and the total costs if we are a contractor and the . (See Figure XX above)

Having established and kept current a PROJECT CONTROLS DATABASE when we have created a schedule then we have to draw from this database to create our RESOURCE POOL or RESOURCE ASSIGNMENTS or RESOURCE DICTIONARY.

08.6.3.3 What is Activity Based Costing

Activity-based, detailed or unit cost estimates are typically the most definitive of the estimating techniques and use information down to the lowest level of detail available. They are also the most commonly understood and utilized estimating techniques.

The accuracy of activity-based detailed or unit cost techniques depends on the accuracy of available information, resources spent to develop the cost estimate and the validity of the bases of the estimate.

A work statement and set of drawings or specifications may be used to identify activities that make up the project. Non-traditional estimates may use the WBS, team input and the work statement to identify the activities that make up the work. Each activity is further decomposed into detailed items so that labor hours, material costs, equipment costs, and subcontract costs are itemized and quantified. Good estimating practice is to use a verb as the first word in an activity description. Use of verbs provides a definitive description and clear communication of the work that is to be accomplished. Subtotalled, the detailed items comprise the direct costs. Indirect costs, overhead costs, contingencies and escalation are then added as necessary. The estimate may be revised as known details are refined. The activity-based detailed or unit cost estimating techniques are used mostly for Class 4 and Class 5 estimates, and they should always be used for proposal or execution estimates. Activity-based detailed cost estimates imply that activities, tasks, work packages, or planning packages are well-defined, quantifiable, and are to be monitored, so that performance can be reported accurately. Quantities should be objective, discrete, and measurable. These quantities provide the basis for an earned value measurement of the work within the activities and the WBS.

Advantages in using activity-based detailed or unit cost estimating methods include:

a greater level of confidence in the accuracy, reliability and precision of the cost estimate;
more detail that can be used for better monitoring, change control and claims analysis;
enhanced scope and individual activity definition making tracking/reporting easier;
detailed quantities to establish more accurate earned value metrics;
better ability to match the cost budget to the CPM schedule;

Disadvantages include:

more time needed to develop the estimate
more costly to develop the estimate

08.6.3.4 Components of Activity Based Costing

To explain activity based costing, let's first explore the component parts to see what goes into activity based costing and then we can explore how to create a cost and resource loaded activity.

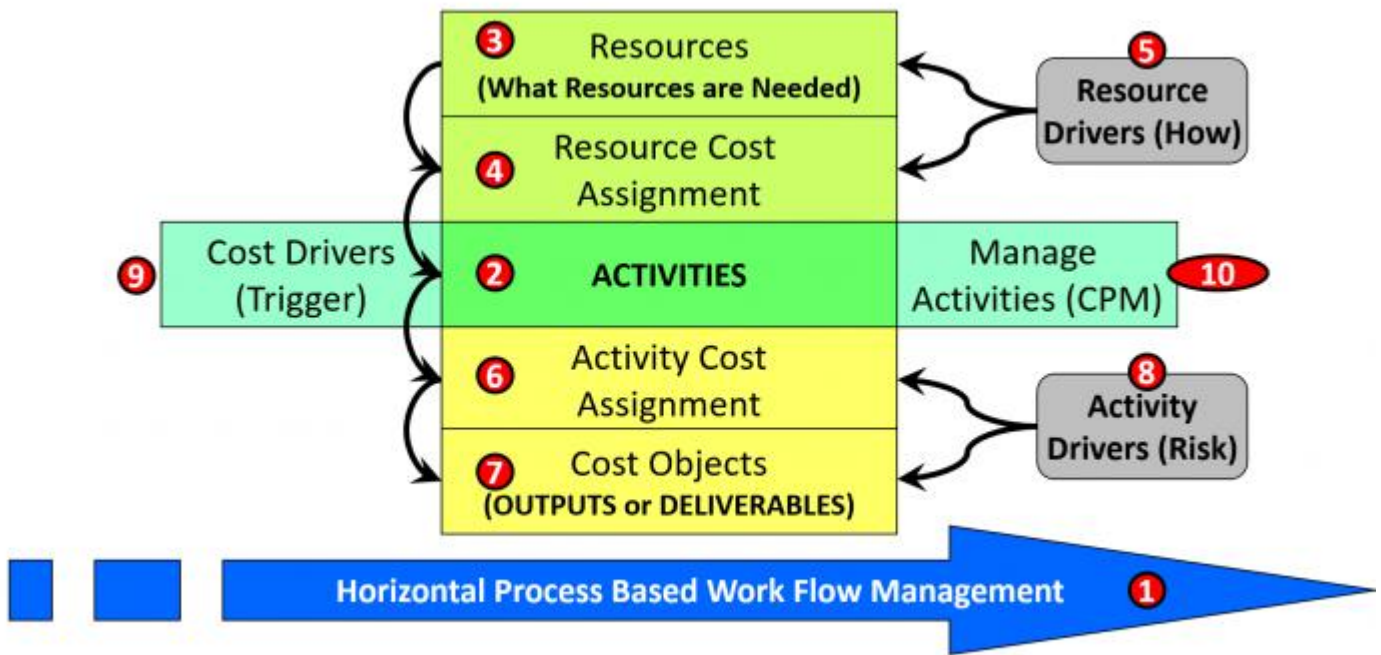


Figure 4 - Listing of the Components Comprising Activity Based Costing

Source: Cokins, Gary (2006) Implementing Activity-Based Costing

In the graphic above, he defines the elements which go into "Activity Based Costing" and is the initial reference we have adopted as the "best tested and proven practice" in **Activity Based costing (ABC)** and **Activity Based Management (ABM)** is "Implementing Activity-Based Costing" (2006) written by Gary Cokins for the Institute of Management Accountants (IMA)

- (1) Activity Based Costing (ABC) and Activity Based Management (ABM) is based on the horizontal work flow, which makes it ideally suited to use with CPM schedules.
- (2) It starts out with ACTIVITIES, which produce or create a DELIVERABLE.
- (3) To produce anything it takes RESOURCES. These can be PEOPLE, MACHINES or MATERIALS and are most often measured or expressed in terms of monetary value. RESOURCES come from a RESOURCE POOL and are assigned from the pool to individual activities.
- (4) In addition to identifying our RESOURCES, we have to put a cost to each resource.
- (5) The RESOURCES and the COST of those resources are known as the RESOURCE DRIVERS and are the ENABLERS which indicate how we (either owner or contractor) are going to execute that activity. As can be appreciated, within limits defined by the Law of Diminishing Returns, adding more resources shortens the activity duration while reducing the number of resources results in a longer duration. Implicit in this is there is an OPTIMUM or IDEAL number of resources for any given activity.
- (6) The Activity Cost Assignment is the total cost of that activity. There are two "costs" which have to be considered. The first is the CONTRACTORS cost and the second is the CONTRACTORS SELLING PRICE, which becomes the OWNERS cost when completed and billed by the contractor.
- (7) Cost Object is the COST of the Activity Divided by the UNITS OF OUTPUT from that activity. Explained more simply, it is the Unit Cost of whatever it was that the activity created or produced.
- (8) It is here, in the Activity Cost Assignment where we build in CONTINGENCY. Contingency can be in the form of money or time or both. Remember that CONTINGENCY is designed to cover "known-unknown" risks and is owned or controlled by the individual or entity who created the contingency. For more on the types of contingency, see Module XX- Managing Project Risks. This is known as the ACTIVITY DRIVERS and is used to offset or mitigate known risks.
- (9) Cost Drivers are the preceding activities, which if they are either early or late may have an impact on the costs

(10) The concept behind Activity Based Costing and Activity Based Management is IF you have a realistic and achievable plan to start with and you manage it activity by activity then the “big picture” will take care of itself.

IMPORTANT CONCEPT- “God (or the devil if you prefer) lies in the details”

It is generally accepted that we CANNOT effectively manage a project at Level 3 of a schedule. You can track and report at that level but to effectively MANAGE a project you must be down at Level 4 minimum and Level 5 practically speaking. One of the reasons so many projects are late and/or over budget is we are trying to manage projects at too high a level. Or worse yet, we are trying to manage a project by controlling the money, which is the worst approach. To manage projects effectively, manage the work, which is represented by the activities. Manage the work effectively and the money will follow.

While Activity Based Costing is most often used by contractors, for owners considering doing their own work or for any owners activities on an Integrated Master Schedule (IMS) the owner would be prudent to also cost load his/her activities as well, the reason being that additional research by Gary Cokins indicates that for owners especially, when they allocate overheads on a pro-rata or straight line basis (as a % of cost of the project) that their on-going operations is actually SUBSIDIZING the cost of managing your projects.

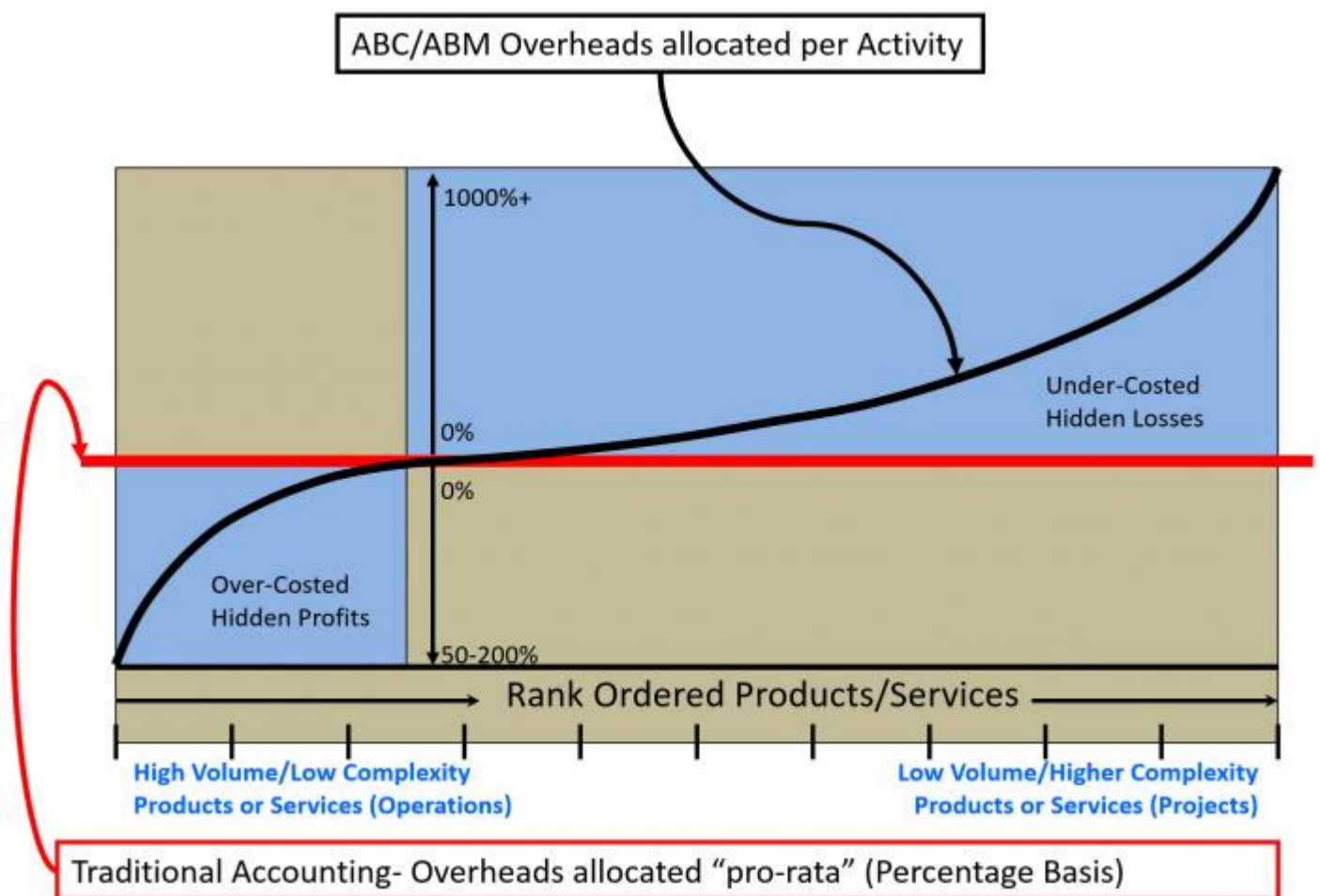


Figure 5 - Showing Allocation of Overhead Costs by Owners using Actual Level of Effort vs % of Costs Basis

Cokins, Gary (2006) Implementing Activity-Based Costing

As we can see in **Figure 5** above, when owners allocate overhead costs on projects using an average %, what you are doing is in effect, subsidizing the real costs of projects in your organization at the expense of operations. In other words, operations is actually more profitable than you are showing while managing your projects is actually more expensive than you think it is. Why is this? By applying the standard management concept of “managing by exception” it means that relatively expensive top management time as well as many other home office and site overhead services (i.e. QA/QC, Safety, Health and Environment etc.) are generally consumed more by projects than they are by on-going operations.

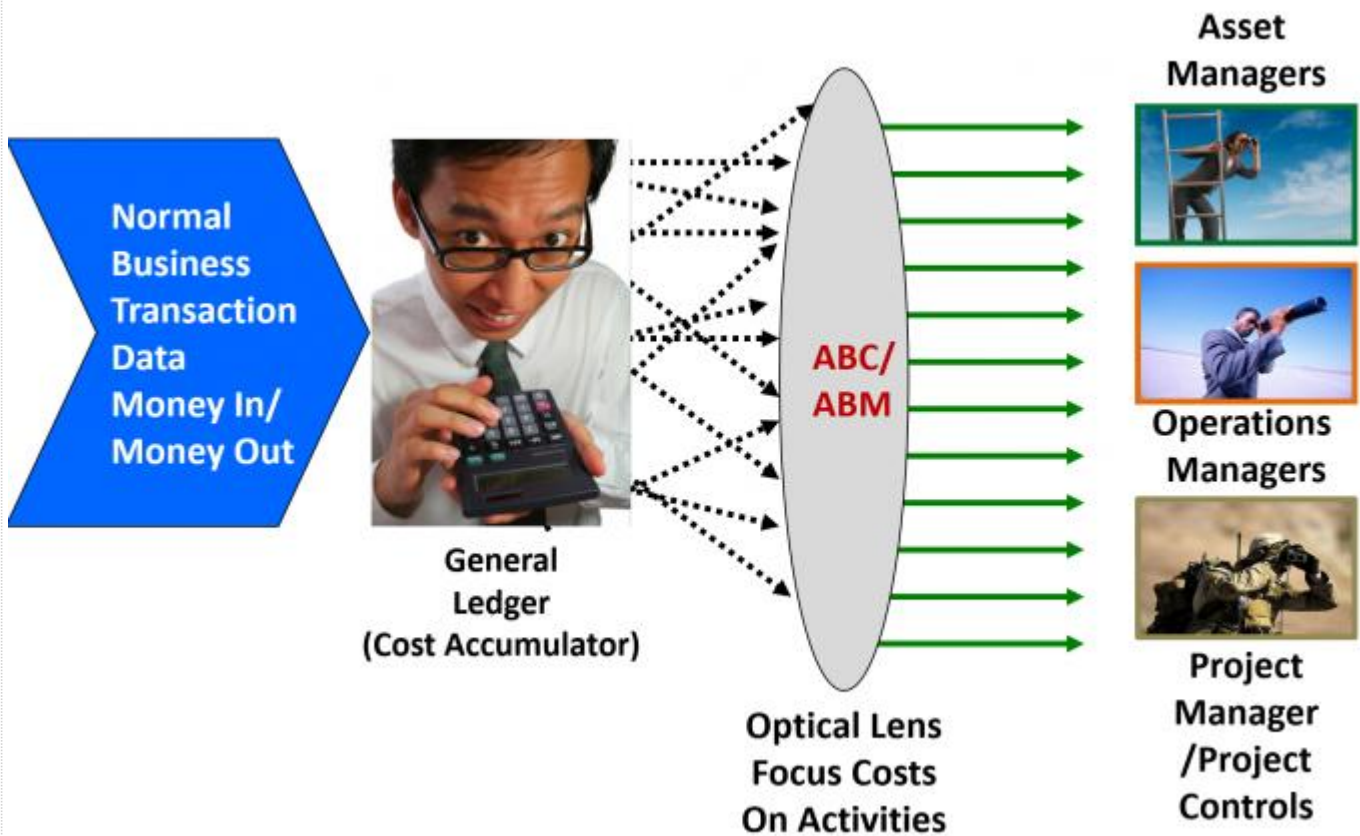


Figure 6 - Showing How ABC / ABM Works

Cokins, Gary (2006) Implementing Activity-Based Costing

Activity Based Management is NOT a different or unique accounting system. ABC/ABM is simply a different way to sort cost information based not on what the Financial Accountants need or want to see but on what the key decision makers in project management need to see in order to make both strategic and tactical decisions on the project. This includes the Asset Managers, (CAPEX funded project) Operations Managers (OPEX funded projects) who, in their role as PROJECT SPONSORS need to make strategic decisions, but also Project Managers, who are responsible to make TACTICAL decisions on the project. Project Controls plays a key role in collecting, analysing and making recommendations to these stakeholders based on the cost information coming to us from Accounting/Finance.

As it is highly likely you will see a question on activity based costing and activity based management, you should not only know and understand the concept and terminology, but also understand how to apply it.

For the Proficient level Practitioner and above, it is highly likely you will be required to prepare an Activity Based Cost Estimate.

08.6.3.5 Activity Based Costing Case Study

The example above provides us with the information contained in most commercial databases. This example comes to us from R.S. Means 2008 Facilities Construction Cost Data. For those who are setting up your own databases, as R.S. Means has been around for 100+ years, the template they are using has been tested and proven and you would be prudent to use their template as the basis for your own in house cost and productivity database.

In the figure below, you can see the detailed composition of Crew C-14A, which is the crew we will be using for the case study we will be doing later on in this module.

#	Crew C-14A ①	Contractors Bare Costs		Including Subcontractors OH & P		Contractors Cost Per Labor Hour	
		Hourly	Daily	Hourly	Daily	Bare Costs	Billing Rate Including OH & P
1	Carpenter Foreman	\$40.10	\$320.80	\$66.40	\$531.20	\$38.36	\$63.65
16	Carpenters	\$38.10	\$304.80	\$63.10	\$504.80		
4	Rodmen	\$43.00	\$344.00	\$73.55	\$588.40		
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1	Equipment Operator	\$39.85	\$318.80	\$62.90	\$503.20		
1	Gas Engine Vibrator		\$24.80		\$27.28		
1	Concrete Pump (Small)		\$728.20		\$810.02	\$3.77	\$4.14
200	Total Daily Labor Hours ②		③ \$8,425.40		④ \$13,558.70	⑤ \$42.13	⑥ \$67.79

Figure 7 - Crew C-14A Composition and Costs

Source: Giammalvo, Paul D (2015) Course Materials. Adapted from R.S. Means 2008 Facility Cost Estimating Database Crew C-14A. Contributed Under [Creative Commons License BY v 4.0](#)

In the R.S. Means Cost Databases there are some 200+ standardized crew compositions for every trade from welding to site work to HVAC. What is important to know and understand is that in order to be able to generate consistent, reliable cost, productivity and duration data, not only do the cost coding structures need to be standardized but also the crew sizes and compositions. We will cover this in more detail when we get into Module 11- Managing Project Databases, but for now suffice it to say that unless we are willing to standardize, then benchmarking cost, productivity or durations will result in considerable variability.

Both sets of numbers are important for both owners and contractors to know and understand. For an owner, this data will help them decide if it is better to do some activities with their own people. For example, if an owner has their own maintenance crews, they may well be able to do the work at or less than the \$8,425.40 shown in the "Bare Costs" column.

For the contractor, knowing that R.S. Means is a P50 value, it enables the contractor to be able to judge if his or her crew sizes are optimized. In other words, IF a contractor is to be competitive in performing this task, his or her costs cannot be any higher than \$13,558.70, otherwise he runs the risk of not being competitive in the marketplace.

03 30 Cast in Place Concrete										
03 30 53 Miscellaneous Cast in Place Concrete										
03 30 53.40 Concrete in Place										
0.0010	Including Forms (4 uses), reinforcing steel, concrete placement and finishing, unless otherwise indicated.	Crew Type	Daily Output per Unit	Labor Hours per Unit	Unit of Measure	Material Costs	Labor Costs	Equipment Costs	Total Costs per Unit	Total Price/Unit Including OH&P
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0.0300	Beams- 5 kip per lineal foot, 10' long spans	C14-A	15.62	12.8	Cubic Yard	\$315.00	\$490.00	\$48.50	\$853.50	\$1,225.00
0.0350	Beams- 5 kip per lineal foot, 25' long spans	"	18.55	10.78	CY	\$325.00	\$415.00	\$40.50	\$780.50	\$1,100.00

Figure 8 - Example Showing Where the Input Data for Activity Based Costing Comes From

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When using Activity Based Costing this is the process we follow:

- (1) Step 1- Start with an activity, in the example above, it is "Form, Pour & Strip 25' long, 5 kip Beams". The Activity Coding Structure would be CSI Masterformat 03310-240-0350-Activity ID#.
- (2) Step 2- Assign the RESOURCES. In the example above, it is Crew C-14A, which we can see has a daily COST of \$8,425.40 and a daily BILLING RATE of \$13,558.70, which we round to \$8.425 and \$13,559 respectively.
- (3) The Output Per Unit for Crew C-14A is 18.55 CY per 8 hour working day
- (4) The Man-Hours Per Unit in Place is 10.782 MH per Cubic Yard (CY)

(5) The Unit of Measure is Cubic Yards (CY)

(6) The Material Costs is \$325.00 per CY

(7) The Labor Costs are \$415.00 per CY

(8) The Equipment Costs are \$40.50 per CY

(9) The Total Costs are \$780.50 per CY

(10) The "Marked Up" or "Selling Price" quoted by the Contractor to the Owner is \$1,100 per CY

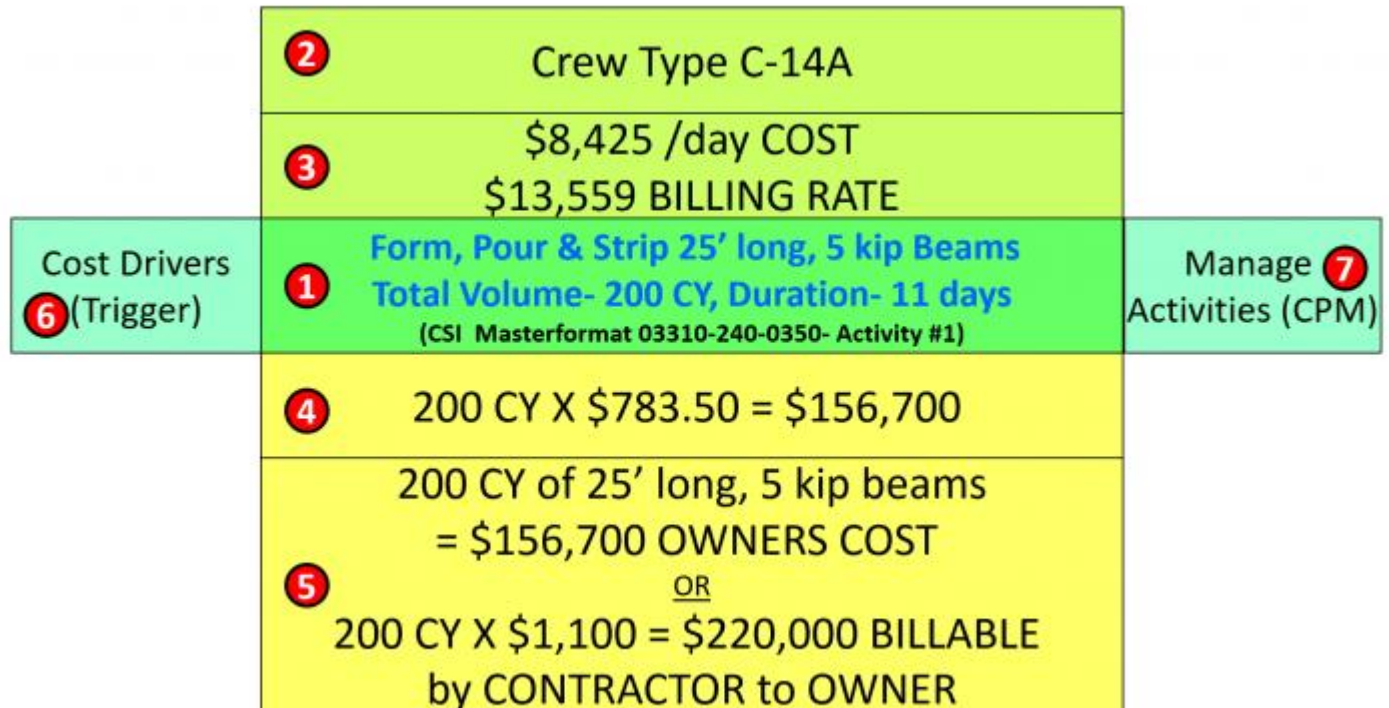


Figure 9 - Setting Up Activity Based Costing Using the Cost Estimating Database

Source: Giammalvo, Paul D (2015) Course Materials. Contributed Under [Creative Commons License BY v 4.0](#)

(1) Activity Name- Start with an activity, in the example above, it is "**Form, Pour & Strip 25' long, 5 kip Beams**". The Activity Coding Structure would be CSI Masterformat 03310-240-0350-Activity ID#. We then look to the Bill of Materials (BoM) or Bill of Quantities (BoQ) and find that the Total Volume- 200 CY. Applying the DAILY OUTPUT of 18.55 Cubic Yards per day for Crew C-14A, we divide 200 CY/18.55 and we arrive at a duration of 10.78 days so we enter in our CPM schedule for this activity, the Duration- 11 days. Bear in mind this is a P50 value which means at this point, we do NOT have any risk contingency built in.

(2) Resource Assignment- The Crew Type is C-14A which if we look above at Figure XX Crew C-14A Composition and Costs, we can see exactly what the composition of that crew is.

(3) Resource Cost- Looking again at Figure XX Crew C-14A Composition and Costs, we see that the COST for this crew is \$8,425/8 hour work day and that the BILLING RATE is \$13,559 per 8 hour work day. Thus the RESOURCE COST ASSIGNMENT = Cost \$8,425 and Billing \$13,559. What this means is for the CONTRACTOR's cost estimate he would use the figure of \$8,425 cost per day, but when calculating the SELLING PRICE to the owner, he would use the \$13,55 per day value. This is really important to understand that when the owner asks the contractor for a "Cost and Resource Loaded Schedule" is it NOT the contractors COSTS which are loaded on the activities but the Contractor's SELLING PRICE which is the OWNER's costs, not the Contractor's costs.

(4) Activity Cost- Knowing the how many cubic yards the activity represents, we can now calculate the value of the activity:

- a. 200 cy X \$783.50 (9) Contractors Bare Costs = \$156,700
- b. 200 cy X \$1,100.00 (10) Contractors Marked Up Selling Price = \$220,000 Billable for this activity

What this means is if the OWNER is using the cost estimate to determine whether or not they should do it with their own in-house maintenance teams OR whether they should outsource it this is the number they need to be comparing their costs against the contractors costs. If they compare their costs against the contractors SELLING PRICE, it will always look like the owner can do it

cheaper. Likewise, the contractor too can use the cost the same way. If he can “buy out” the activity by finding a subcontractor who can do it for less money than he can do it with his own workforce, then the contractor is also better off to sub-contract this activity.

(5) The “Cost Object” is either the COST of the Activity (important to the contractor) and/or the VALUE of the activity which is the “cost” from the contractor to the owner, and thus is important to the owner. As above, knowing the Volume of Concrete is 200 Cubic Yards (CY) and multiplying the quantity (200) X the cost (\$783.50) we know the COST of this activity should be \$156,700 and multiplying the 200 CY X Unit in Place SELLING PRICE of \$1,100 = a “fair market value” of \$220,000. For owner’s checking the price quoted to you by the contractor for each activity as part of your “Due Diligence” is important as it is the only way you can validate whether the contractor is “unbalancing the bid” by putting more overhead and profit on the early activities in the schedule and cutting the overhead and profit margin on the activities towards the end of the schedule.

(6) Item 6 are the PREDECESSOR activities which DRIVE the activity and it is the responsibility of the person or entity for those preceding activities to MANAGE them, including risk. (Hence, Activity Based Management (ABM) which we will pick up in the following module.

(7) Item 7 are the SUCCESSOR activities which are driven by this activity.

8.6.3.6 Producing the “S-Curve”

Plotting the cumulative summation from cost loading each and every activity results in an “S” shaped curve. To accomplish that, we first have to determine what the COST PROFILE is going to be for each activity. While the default for most software programs (i.e. Primavera, MS Project etc) is “flat” or “straight line” or “pro-rata” we have the options of selecting the way we distribute costs on each activity.

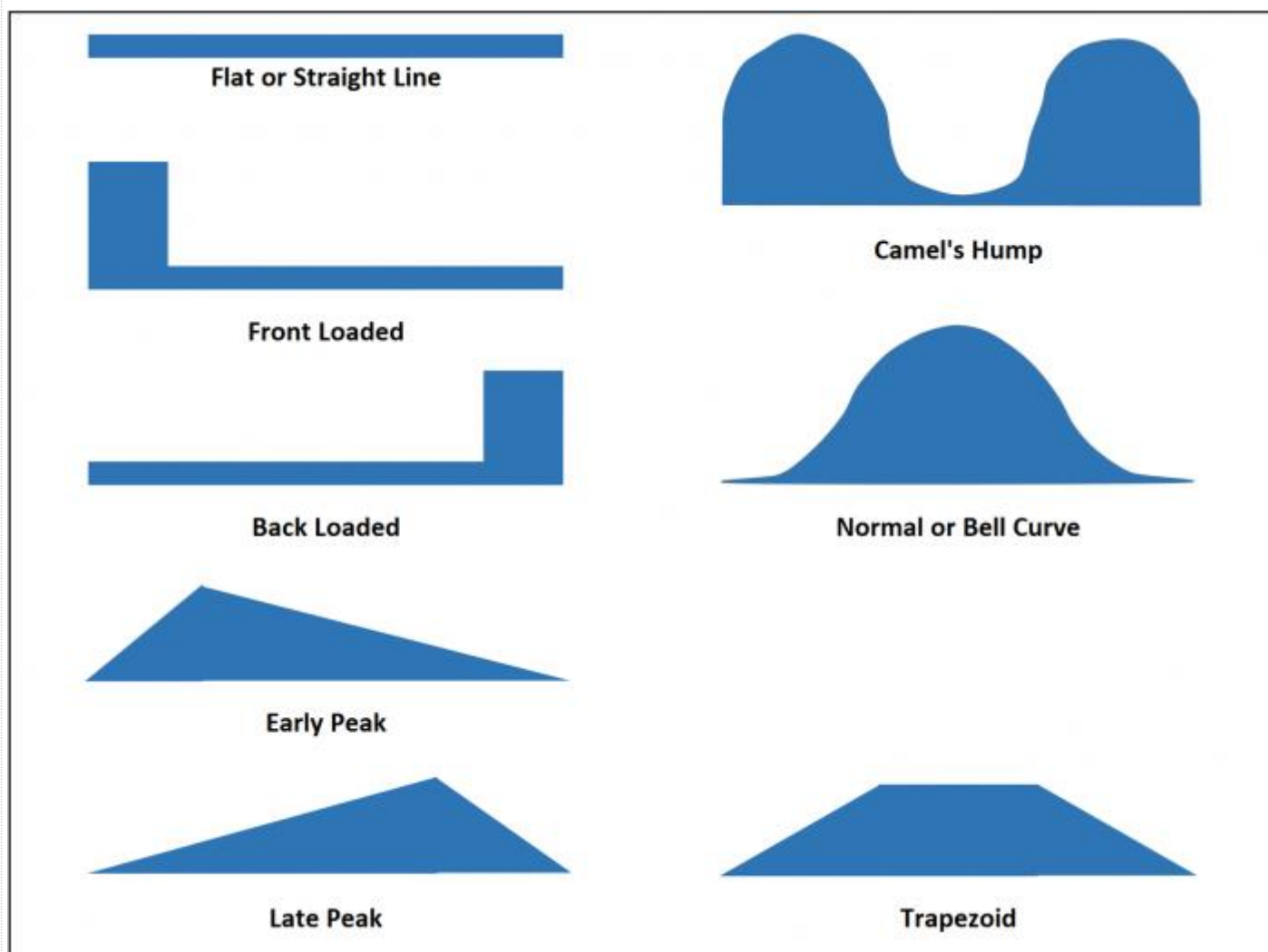


Figure 10 - Showing the Possible “Cost Profiles” Available in most CPM Scheduling Software Packages

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The names shown above are coming from MS Project but most other software packages offer the same or similar distributions, even though they may call them by a different name.

As a caution to owners, as part of your "due diligence" when reviewing schedules submitted by contractors, you need to randomly check all major activities to ensure that the contractors have selected a "cost profile" which is appropriate to the activity's work flow. In most cases, "flat" or "straight line" or trapezoid distributions are acceptable. What you want to be cautious about are any activities which are "front loaded". Contractors will often create activities called "Deliver and Install XYZ equipment" and then proceed to FRONT LOAD the activity to cover the value of delivering the equipment or materials. What you as an owner's project controller wants to do is insist the contractor break the activity into two separate activities-

(1) "DELIVER XYZ piece of equipment" and **(2) "INSTALL XYZ piece of equipment"**. This way you can negate the argument by the contractor for the need to front load the costs. The Deliver activity will have the fair market value of the equipment delivered FoB site and the Install activity will have the fair market value of the installation.

In the example below, we have 3 Activities:

Activity A has a fair market value of \$840 and is 3 work periods long. Using "straight line" or "flat" cost profile, by dividing $\$840/3$ periods we get a value of \$280 per period.

Activity B has a fair market value of \$1,000 and is 5 work periods long. Using "straight line" or "flat" cost profile, by dividing $\$1,000/5$ periods we get a value of \$200 per period.

Activity C has a fair market value of \$960 and is 6 work periods long. Using "straight line" or "flat" cost profile, by dividing $\$960/6$ periods we get a value of \$160 per period.

As this cost loaded schedule is being submitted to the owner by the contractor, we need to keep in mind that what is being loaded on the activities is not the CONTRACTORS COSTS but the CONTRACTORS SELLING PRICE, which includes the CONTRACTORS:

(1) Direct Costs (Labor, Materials, Equipment)

(2) Project Indirect Costs (i.e. Project Management, CSI Division 1 General Conditions costs, trailers, toilets, temporary power etc)

(3) Contingency - Price Contingency and Risk Contingency

These top 3 cost categories are what are known as "Cost of Goods Sold" or "above the line" costs and the resulting profit is called GROSS PROFIT. These costs are what the on-site project/construction manager have control over and thus are held responsible for and are provided with appropriate authority to make the kinds of decisions to manage those costs effectively.

(4) Home Office Indirect Costs (CEO's salary, home office rental, cost estimating and bidding departments, accounting/finance and cost of money, taxes and insurance.) These are what are known as "General, Sales and Administrative (GS&A) costs" or "below the line" costs. These are the costs of doing business whether the organization has zero projects or 1,000.....

(5) Deducting the "below the line" costs from the GROSS PROFIT gives us NET PROFIT, which is often referred to as "EBIT" - "Earnings before Interest and Taxes". It is this margin which for most contractors is a single digit- i.e. <10% and helps to explain why contracting is such a risky business and why so many contractors end up going out of business.

As noted previously, we could have used any of the 8 different cost profiles shown above (as well as user customizable profiles in some software packages) but for the sake of simplicity, we have chosen "flat" or "straight line" or "pro-rata". This is the default for most software programs and unless there are compelling reasons or other extenuating circumstances to justify the use of another profile, flat should be acceptable to both owner and contractor.

As we want to generate BOTH an **Early Date Budgeted Cost of Work Scheduled (BCWS)** or **Planned Value (PV)** as well as a **Late Date Budgeted Cost of Work Scheduled (BCWS)** or **Planned Value (PV)** there are two sets of activities shown- all activities constrained to start "As Early as Possible" and the second set constrained to start "As Late as Possible". For OWNER's, in addition to the "cost" loaded activities provided to you by the contractor, you have to ADD your own cost loaded activities which cover:

(1) Owner's Project Overhead Costs (i.e. Project Manager, Project Controls Department, QA/QC, Safety etc)

(2) Owner supplied Equipment (i.e. long lead specialty equipment such as pumps, heat exchangers or vessels)

(3) Owner supplied Materials (i.e. Bulk materials such as pipe or fittings)

(4) Owner supplied Professional Services (i.e. Architect, Engineer, Quantity Surveyors etc)

(5) Owner's Home Office Overhead

Thus the OWNER's S Curve will ALWAYS be larger than that of the Contractor and if the owner wants to be able to capture the real or true costs of the projects for the purposes of amortization and depreciation, they will track their own costs as diligently and as closely as the contractor will be tracking his, understanding that unless the contract is an "open book" or "cost reimbursable" type contract, the contractor is NOT obligated to disclose his/her costs to the owner and most likely would not unless required to do so because of arbitration or litigation processes.

	W	W1	W2	W3	W4	W5	W6	W7	W8	W9
Act A Value \$840		\$280	\$280	\$280						
		Activity A (Early Dates)								
		0% physical % Complete								
Act B Value \$1000				\$280	\$280	\$280				
					Activity B (Late Dates)					
					0% Physically Complete					
Act C Value \$960			\$200	\$200	\$200	\$200	\$200			
					Activity B (Early Dates)					
					0% Physically Complete					
					\$200	\$200	\$200	\$200	\$200	
					Activity B (Late Dates)					
					0% Physically Complete					
				\$160	\$160	\$160	\$160	\$160	\$160	
					Activity C (Early Dates)					
					0% Physically Complete					
					\$160	\$160	\$160	\$160	\$160	\$160
				Activity C (Late Dates)						
				0% Physically Complete						
1	/PERIOD PLANNED	\$280	\$480	\$640	\$360	\$360	\$360	\$160	\$160	\$0
2	CUMULATIVE TOTAL PLANNED (BCWS or PV- Early Dates)	\$280	\$760	\$1,400	\$1,760	\$2,120	\$2,480	\$2,640	\$2,800	\$2,800
3	/PERIOD PLANNED	\$0	\$0	\$280	\$640	\$640	\$360	\$360	\$360	\$160
4	CUMULATIVE TOTAL PLANNED (BCWS or PV- Late Dates)	\$0	\$0	\$280	\$920	\$1,560	\$1,920	\$2,280	\$2,640	\$2,800
5	/PERIOD EARNED (BCWP or EV)									
6	CUMULATIVE EARNED (BCWP or EV)									
7	ACTUAL COSTS INCURRED TO DO THE WORK/PERIOD (ACWP)									
8	ACTUAL COSTS INCURRED TO DO THE WORK CUMULATIVE (ACWP)									



Figure 11 - The S-curve

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In the above example, we can see that in Row 1, we have added up each of the PER PERIOD planned values based on the EARLY START dates of each of the 3 activities, but in order to generate our S Curves, we plot the CUMULATIVE costs over time and not the per period. So in Row 2 above, you can see we have accumulated the costs over time and then plotted that curve in BLUE as the "Early Date BCWS or PV Curve".

Likewise, in Row 3, we have calculated the PER PERIOD planned values for the LATE DATES and then in Row 4 we have

accumulated those costs and plotted the values on the same graph in RED which represents the "Late Date BCWS or PV".

Why is showing BOTH the Early and Late Date curves considered to be a "best tested and proven practice"? Given that so many projects finish late, stands as prima facie evidence that we tend to be overly optimistic in the first place and given that we can tell so much about the project from analyzing where we are against where we planned to be not only in terms of float but also in terms of resource flexibility, in actuality, it is the late date curve which is far more important to us than the early date curve, which tends to be overly optimistic even under the best of circumstances.

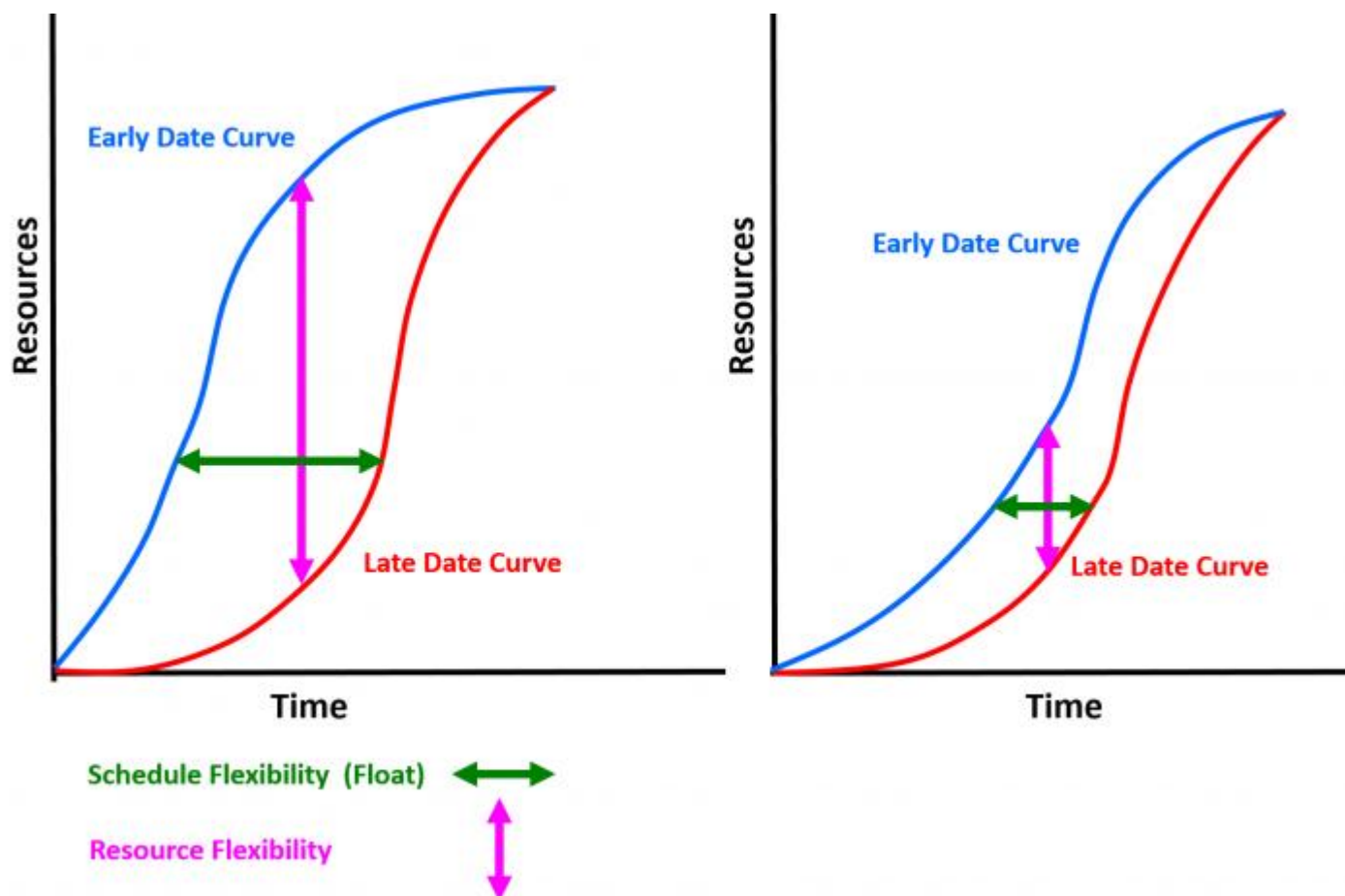


Figure 12 - Showing what the Early and Late Date Curves tell us about Time and Resource FLOAT

Source: Adapted from Humphrey's Gary (2015) *Project Management Using Earned Value*, 3rd Edition

As we can see from **Figure 12** drawing a perfectly HORIZONTAL line between any two points on the early date and late date curve shows us how much TOTAL FLOAT we have in the project, while drawing a perfectly VERTICAL line between any two points on the early date and late date curve shows us how much RESOURCE FLOAT (resource flexibility) we have in the project. Comparing Project A to Project B (above) we can see that in terms of both Total Float and Resource Float, Project B has much less of both, thus is the more risky of the two projects. Another very important piece of information we can see after we start capturing and recording BCWP (earned value) is how close we are coming to the Late Date curve, understanding that if our BCWP crosses and falls to the right of the Late Date curve, it means we have negative float in our project. It doesn't tell us WHERE the negative float is, just that we have some. This will all be explored in more detail in **Module 9 - Managing Project Progress**.

As noted in previous modules, the cost and resource loaded schedule, along with the early and late date S Curves is what the CONTRACTOR should be submitting to the OWNER prior to the owner issuing the Notice to Proceed (NTP) to the contractor. As this S curve forms the basis against which the contractor will be paid, it is critical that the owner perform his/her due diligence to ensure that:

(1) The value shown (contractors selling price/owners cost):

- a. represents "fair market value" for that activity;
- b. the Contractor has not "unbalanced the bid" items

(2) The cost profile or cost allocation has not been "front loaded" and actually represents as realistically as possible what the

contractors expenditure profile is likely to look like.

(3) The total amount shown in the cost loaded schedule submitted by the contractor to the owner contains EXACTLY the amount of the contract as signed.

Once submitted to and accepted by the owner, the owner issues the "Notice to Proceed" and this Cost and Resource Loaded CPM schedule becomes what is known as the "Performance Measurement Baseline" (PMB) or simply the "Baseline Schedule".

As this is a legal document, which may very well be submitted as evidence either to support or refute claims or counter claims by the parties to the contract, this document has significant value and should be treated as all other contract documents, with both hard and soft copies archived with other original contract documents, preferably in the home office of both owner and contractor. The originals of this CPM schedule should be sealed and not opened or used for purposes of updating or other "what if" analysis.

08.6.3.7 Level of Effort

Another type of estimate which is commonly used at all levels is known as the "Level of Effort" costs. At a level one cost estimate a type of "Level of Effort" cost estimate is we had a budget of 15 million dollars and we overran by 2 million dollars so this year let's budget 17 million dollars. At lower levels of cost estimating we often use them for activities such as project management or project controls, where we expect that the project will take a full year, therefore we allow 2,000 man hours (50 weeks x 40 hours per week) for the project manager and each project control professional assigned to the project.

Level of effort activities are discouraged as they are open to challenges, particularly by an owner if the contract is a cost reimbursable type. (i.e. why is the contractor proposing a project control team of 20 people, shouldn't 10 be enough?) Other complaints about LoE activities is they have few parameters or performance objectives or other criteria against which to determine their efficiency or effectiveness.

By the time this iterative process has been completed from Level 1 down to minimum Level 3 and preferably Level 4, the scope should be well enough defined to at least minimize the number of change orders and claims.

08.6.3.8 Using Activity Based Management

Now that we understand the fundamentals of Activity Based Costing how do we use the information generated to actually manage our activities and thus our projects?

Because we have adopted Activity Base Costing, we can produce a very accurate, reliable and precise COST ESTIMATING MODEL based on the Costs of a Unit in Place. This can be done either by owners or contractors. (This topic will be covered in more detail in **Module 11- Managing Databases**)

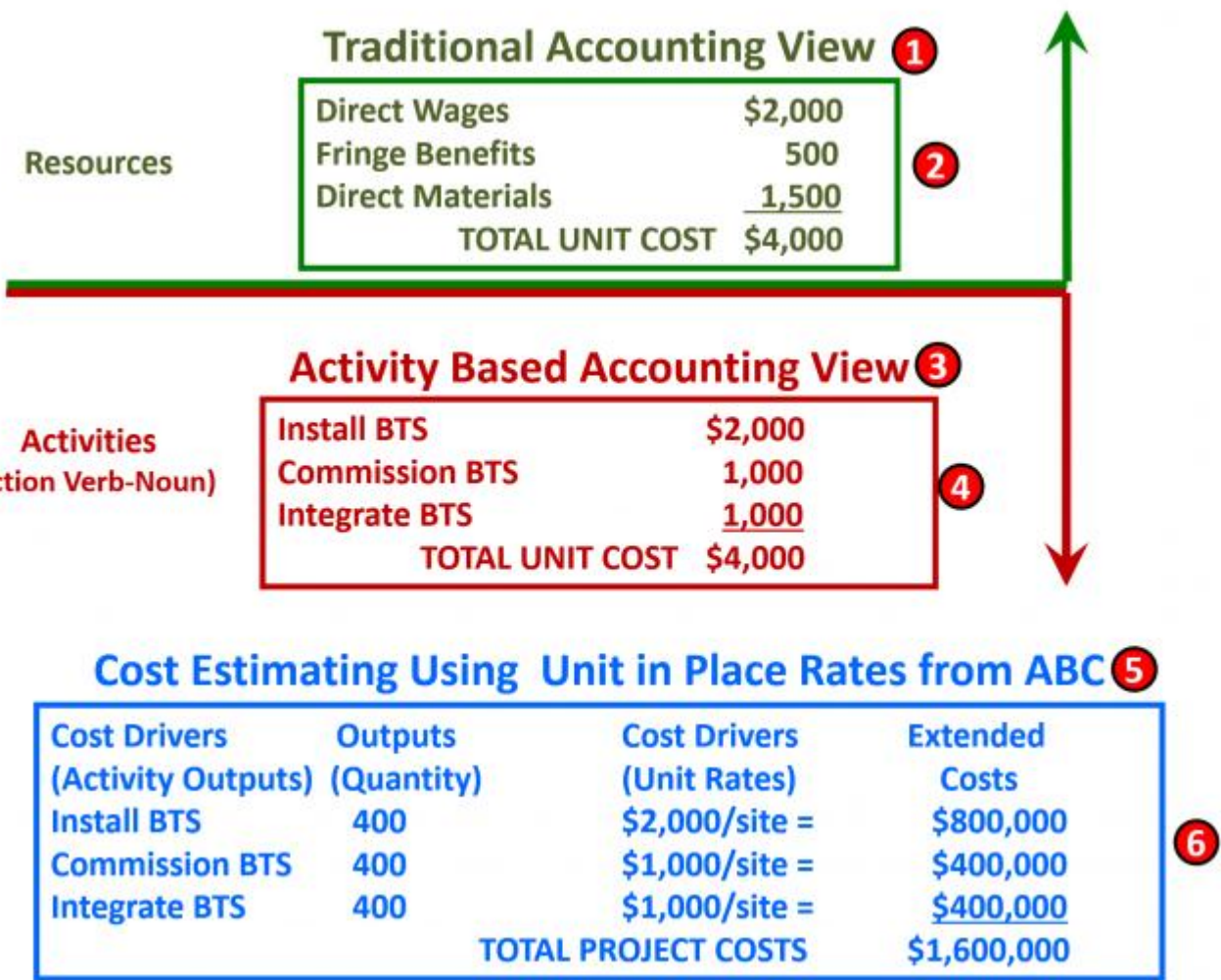


Figure 13 - Illustrating how we use Activity Based Costing to prepare the COST ESTIMATE

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(1) Here we see the traditional way accounts look at Unit Costs.

(2) They add together direct labor costs, fringe benefit costs and material costs and as you can see, **the total is \$4,000 per unit in place.**

(3) Now we take the same scenario but this time, instead of sorting the costs as the accountants see the numbers, being project control practitioners, **we want to see our costs sorted by ACTIVITY.**

(4) We have 3 Activities -

- a. Install the Base Transmitter Station (BTS)
- b. Commission the BTS
- c. Integrate the BTS

And as you can see, the total is exactly the same- \$4,000 per unit in place, meaning the only difference has been how we sorted the costs.

(5) Given that the project team or company install thousands of these units every year, they would build up a comprehensive COST ESTIMATING MODEL based on the UNIT COST IN PLACE.

(6) So now when they need to do a cost estimate, all they do is go to the COST ESTIMATING DATABASE, select the appropriate location and type of equipment (size and/or model number) and can quickly and easily put together a cost estimate with the only major variable being the actual quantity vs the estimated quantity. Thus a project, requiring the installation, testing and integration of 400 Base Transmitter Stations would cost \$1.6 million dollars (i.e. 400 x \$4,000).

08.6.3.9 Using the Cost Estimate and Actual Costs of Work Performed (Cost Variance or

CV)

From the General Ledger...

Chart of Accounts View			
Telecom Implementation			
COA CATEGORY	PLANNED	ACTUALS	VARIANCE
Salaries	\$18,000	\$24,000	\$(6,000)
Equipment	20,000	20,000	-0-
Travel Expense	2,000	4,400	(2,400)
Supplies	1,000	2,400	(1,400)
Rent	500	1,000	(500)
TOTAL	\$41,500	\$51,800	\$(10,300)

1

We know the bad news (we are bleeding to death financially) but what it doesn't tell us is WHERE we are bleeding...

... to the ABC Database Sort...

Activity Based View			
Telecom Implementation			
ACTIVITIES	PLANNED	ACTUALS	VARIANCE
Survey Site	\$5,000	\$4,800	\$200
Prepare Site Design	5,000	7,500	\$(2,500)
Deliver Equipment	2,000	3,500	(1,500)
Install Antennae	6,000	6,000	-0-
Install Feeder Lines	12,000	15,000	(3,000)
Test Antennae Line System	1,500	1,500	-0-
Install BTS Cabinet	2,000	2,000	-0-
Install Power System	2,000	2,000	-0-
Commission BTS	1,000	1,000	-0-
Connect Transmission	1,000	2,500	(1,500)
Integrate BTS	1,000	1,500	(500)
Produce Site Folder	2,000	2,000	-0-
Conduct Site Assessment	1,000	2,500	(1,500)
TOTAL	\$41,500	\$51,800	\$(10,300)

2

By moving to an ACTIVITY based Accounting System, we can identify sources of problems related to COST... (WHERE we are losing (or making) money)

Figure 14 - Case Study Showing General Ledger View of Cost Variance vs Activity Based View of Cost Variance

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(1) Using the traditional general ledger view, our accountants can tell us that our project is in deep trouble financially- that to date, we have spent \$10,300 MORE than what we had budgeted for this project.

While it clearly shows that we are in trouble, using the traditional accounting views don't help us find out WHERE the cost over-runs are occurring.

(2) In the second sort using Activity Based Management (ABM) view while we are still over budget by \$10,300, we are now able to see EXACTLY which activities are causing us to blow our budgets. Once we know where we are exceeding the budget, NOW as project control professionals, we can analyse each of these activities and make corrective or mitigating recommendations to the project team or other key decision makers.

08.6.4 OUTPUTS

Bid Price Ready For Submittal

Cost And Resource Loaded Schedule

Performance Measurement Baseline Draft

08.6.5 REFERENCES & TEMPLATES

The US Government Accountability Office (GAO) "Cost Estimating and Assessment Guide- Best Practices for Developing and Managing Capital Program Costs" (2009) GAO-09-3SP <http://www.gao.gov/new.items/d093sp.pdf>

US Dept of Energy (DoE) "DOE G 413.3-21, Cost Estimating Guide" <https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-21/view>

Gary Cokins and the Institute of Management Accounts (2006) "Implementing Activity Based Costing"

<http://www.garycokins.com/images/pdfs/Cokins%20IMA%20SMA%20Implementing%20ABC.pdf>

United States Department of the Interior National Park Service Class A Construction Cost Estimate BASIS OF ESTIMATE-

http://www.nps.gov/dscw/upload/classaconstcostestimatesample_1-26-11.pdf)

08.7 - Module 08-7 - Validate The Time & Cost Trade-Offs

08.8 - Module 08-8 - Validating Horizontal And Vertical Integration

08.9 - Module 08-9 - Conducting A Cost Risk Analysis

08.10 - Module 08-10 - Baselineing And Communicating The Cost Estimate/Cost Budget

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