


It costs WHAT?

E.F.C. LaBerge

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Week 1 1-1



I'm going to **price** my project

- What do I need to know?
 - How many hours?
 - Who does the work?
 - What do I contract out & how much does it cost?
 - What parts do I need?
 - What travel or "other direct costs"?
- I'll use an example assuming "government" work,...
- ... because government accounting standards require somewhat more visibility.

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Week 1 1-2

Let's start with you

- **Zero experience engineer (Cat Z)** \$62,400 / yr
- **There are 52, 40 hour weeks, so that's 2080 hours**
 $Z_0 = \$62,400 / 2080 \text{ hr} = \$30 / \text{hr}$
- **Wait a second. Holidays? Vacations? Sick time?**
 - **Assume 10 days for each (80 hours each), that means only $2080 - 240 = 1840$ hrs available for work**
 - **And assume 4 hours/wk is tied up in staff meetings, mandatory training, etc, that's another 184 hours** $Z = \$62,400 / (1840 - 184) = \37.68
- **Health care? Life Insurance? Social Security, Medicare, Retirement plan? 401(k)? Stock Plan?**
Easily \$15/hour, $Z = \$37.68 + \$15 = \$52.68 / \text{hr}$
- **Office? Lab? Desk? Computer? Phone? Boss? Director? VP? HR?** \$15 / hr isn't unreasonable (believe me!)

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Week 1 1-3

- **So now** $Z = \$52.58 + \$15 = \$67.68 / \text{hr}$
- **We call the ratio**

$$\frac{Z - Z_0}{Z_0} \triangleq \text{burden rate} \quad \frac{\$37.68}{\$30.00} = 125\% (!!)$$
- **The labor **cost** is** $L = (1 + B)Z_0 = 225\%$ of your "salary"
- **And there are different categories of labor**
 - **Z (new kids on the block)**
 - **Y (young)** $Z \times 1.66$
 - **X (extinguished)** $X = Z \times 2.5$

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Week 1 1-4

How much time?

- To estimate the time, you need at least a short description of what will be done
- We call this a Statement of Work, (SoW) or, ...
- ...in outline form, a Work Breakdown Structure
- **Heuristic It doesn't exist if it isn't written down**
- ...and you need to break that task down further
- Experience helps: young (new) engineers are invariably *optimistic*...
- ...meaning they estimate too few hours over too short a time
- **Software estimation is notoriously inaccurate...**
- ...although some parametric models (REVIC) may work well when properly calibrated

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Week 1 1-5

Task 1: System Engineering. The system engineering task will ensure that all operational scenarios are identified when the program is kicked off. The [redacted] team will develop a system plan that includes the the key approach and strategy for the WANN architecture. It will cover approaches to baseband processing, RF processing, broadband antennas, and networking features that optimize the best WANN performance leading to a \$500 target. Any other relevant trades will be performed and presented at CDR. As part of this task, the [redacted] Team will publish an open network API specification for review by potential developers.

Task 2: Generate Radio Specifications. A detailed radio node specification will be developed based upon the requirements flow-down. The [redacted] team will breakdown each section according to the architecture elements. The predicted performance based on these specifications will be simulated and analyzed for feasibility.

Task 3: WANN design. The WANN design will include predicted radio performance for the filter design, the antenna design, RF baseband processing approach and strategy as well as support for network adaptation. A detailed plan will be laid out to mitigate long-lead component delivery and that will identify and reduce the risk leading to a long-term approach through R4. The designs for each subsection will include a comprehensive risk mitigation plan to identify and alleviate performance versus cost issues. Phases R2-R4 improvements will be planned as part of the WANN design to include an evolution toward advancements in lower cost technologies. Pre-planned, low-cost improvements include technology insertion options from other DARPA programs, including but not limited to ASP, MNM, XG, CN, and DTN.

Task 4: Critical Design Review. The [redacted] team will document the WANN architecture and present the system approach at the CDR. Complete designs and approaches for the subsystems, including performance objectives and predictions will be presented. The WANN architecture that is presented at CDR aside from pre-planned product improvements (P³I) will remain constant throughout the remaining phases, only the implementation will be

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Week 1 1-6

OK, at least I know what the parts cost

- Really?
- Do you have a detailed parts list?
- Do you know the quantity and time phasing?
- Do you have special requirements?
 - Special environment?
 - Special screening?
 - Catalog or special order?
 - Expedited shipping?
- OK, so they cost more than I expected
- They sure do!
- Oh, by the way, the Parts Department charges you 15% just for placing and tracking the order

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Week 1 1-7

Cost estimate sheet (high level)

	\$168.75	\$112.00	\$67.50			
Task	X	Y	Z	Total Hrs	MLB	Task Total
Prepare Operational Scenarios	100	100	40	240	\$ 30,775.00	\$ 197,700.00
Prepare System Plan	80	80		160	\$ 22,460.00	
Prepare processing tradeoffs	40	80	120	240	\$ 23,810.00	
Prepare \$500 production cost estimate	100	150	80	330	\$ 39,075.00	
Develop open API	80	200	300	580	\$ 56,150.00	
Publish open API	40	40	40	120	\$ 13,930.00	
				0.15		
Parts	10000				\$ 11,500.00	

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Week 1 1-8

So we're done, right? \$197,700 for task 1

- **No!**
- **That's just the "burdened cost"**
- **The company also has to do things**
 - **Pay debt service**
 - **Perform R&D**
 - **Market Products**
 - **Maintain Customer Support Centers**
 - **Pay the Grand Pooh-Bahs (CFO, CEO, Chairman)**
- **This adds another 25-40% (-ish)...**
- **...and this factor is call "General and Administrative Costs" or G/A** $\$197,700 \times 140\% = \$276,780$

So we're done, right? \$276,780 for task 1

- **Well, no, not yet.**
- **The company has to pay the stockholders – the profit!**
- **The DoD – believe it or not – tends to hold this profit down to about 8% of the cost so far...**
- **...so, in effect, DoD pays for B and G/A**
- **The commercial sector makes the profit much larger, but the gross profit includes what we have called B and G/A**
- **Anyway a typical DoD profit is about 8%**

$$\$276,780 \times 108\% = \$298,922$$
- **The gross profit (which is what the commercial sector uses) is price – cost**

$$\$298,922 - \$197,700 = \$101,222 \approx 35\% \text{ of the total price}$$

So, back to the original question:

▪ What do I cost?

Base	\$30.00	\$30.00	Z engineer @ \$62,400
Burden	125%	\$37.50	\$67.50 cost to company
G/A	40%	\$27.00	
Profit	8%	\$7.56	
Sell Price		\$102.06	

▪ X cost

Base	\$75.00	\$75.00	X engineer @ \$156,000
Burden	125%	\$93.75	\$168.75 cost to company
G/A	40%	\$67.50	
Profit	8%	\$18.90	
Sell Price		\$255.15	

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Week 1 1-11

You (or the company) needs to control this

- We won the job...
- ...gulp! Now we have to do it
- How does your boss know that you're going to get done in the available time...
- ...and spend no more than the available budget?
- That's the art form of engineering management!
- But there is a (growing) trend to using *earned value techniques*.
- Our focus group wants new engineers to know about earned value...
- ...so here's a crash course.
- First thing to remember: It's **not** rocket science!
- In fact, it's **not science** at all, just some useful rules of thumb that require only basic arithmetic

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Week 1 1-12

Earned value basics

- We need a cost & deliverable schedule
- From which we compute the “budgeted cost of work scheduled” or BCWS

Prepare Operational Scenarios							
		Jan	Feb	Mar	April	Total Hrs	Total MLB
X	\$187.50	20	40	40		100	\$18,750.00
Y	\$125.00		40	60		100	\$12,500.00
Z	\$75.00		40			40	\$3,000.00
						240	\$ 34,250.00
Deliverable	Status Rept	Prelim Scenarios	Final Scenarios				
BCWS	interval	\$ 3,750.00	\$ 15,500.00	\$ 15,000.00	\$		
BCWS	cum.	\$ 3,750.00	\$ 19,250.00	\$ 34,250.00	\$ 34,250.00		

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Week 1 1-13

Now, as the work is done...

- I keep track of the time actually worked on this task
- ...and compare the *deliverables completed* to the *deliverables scheduled*...
- ...taking credit for “partial completion”
- And compute the “budgeted cost of work performed” (BCWP...
- And the “actual cost of work performed” (ACWP)

Charges							
		Jan	Feb	Mar	April	Total Hrs	Total MLB
X	\$187.50	10	30	30	50	120	\$22,500.00
Y	\$125.00		20	20	40	80	\$10,000.00
Z	\$75.00		30	20	20	70	\$5,250.00
	Status		Prelim	Final		270	\$ 37,750.00
BCWP this int		3750	7750	12700	10050		\$ 34,250.00
BCWP		3750	11500	24200	34250		
ACWP this int		1875	10375	9625	15875		\$ 37,750.00
ACWP		1875	12250	21875	37750		

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Using the BCWS, BCWP, ACWP

- We now use these quantities to put a dollar value (which is all the finance guys care about) on our progress

- ...they're really just useful metrics of how things are going
 $SV = BCWP - BCWS$ (+ is good, - is bad) Schedule variance

$$CV = BCWP - ACWP, \text{ (+ is good, - is bad) Cost variance}$$

$$SPI = \frac{BCWP}{BCWS} \text{ (>1 good, <1 bad, <0.5 really bad) Sched. Perf. Index}$$

$$CPI = \frac{BCWP}{ACWP} \text{ (>1 good, <1 bad, <0.5 really bad) Cost Perf. Index}$$

BCWS	cum.	\$ 3,750.00	\$ 19,250.00	\$ 34,250.00	\$ 34,250.00
BCWP		\$ 3,750.00	\$ 11,500.00	\$ 24,200.00	\$ 34,250.00
ACWP		\$ 1,875.00	\$ 12,250.00	\$ 21,875.00	\$ 37,750.00
Schedule Variance		\$ -	\$ (7,750.00)	\$ (10,050.00)	\$ -
Cost Variance		\$ 1,875.00	\$ (750.00)	\$ 2,325.00	\$ (3,500.00)
Schedule Perf Index		100%	60%	71%	100%
Cost Perf Index		200%	94%	111%	91%

A few words of wisdom

- Understand what you cost
- Help get the costs right!
 - If the company bids too high, and you lose, that's bad
 - If the company bids too low, and you win, that's also bad
- Don't whine about the time reporting or earned value reporting
 - It doesn't take very long
 - It doesn't need 3 digit precision to be useful
 - It keeps them happy
 - It really is **not rocket** science, although mgmt and finance treats it as revealed truth
- Keep your own records, it will help you later
- **It doesn't exist if it isn't written down**