



NASA Cost Symposium 2013



The Strange Case of Dr. Cost and Mr. Schedule – The Split Personality of the BOE

*Excerpts Taken from The Strange Case of Dr. Jekyll and Mr. Hyde
by Robert Louis Stevenson*

*A Follow-on to the 2012 NASA Cost Symposium Presentation,
“What should come first: Cost (Chicken) or Schedule (Egg) BOE?”*

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Agenda



- The Facts about Cost and Schedule
- BOEs...What are these?
- The Introductions – Meet Dr. Cost and Mr. Schedule
- BOE Questions to Address
- BOEs Require...*Documentation, Communication, Transparency*
- The BOE Pathway
- Revisiting Dr. Cost and Mr. Schedule - Guidance for Successful BOEs
- Moving Forward with the Schedule BOE
- The Questions You *Should* Ask
- Why BOEs are Important
- Do You Trust *YOUR* Project Schedule?
- Q&A



The Facts about Cost and Schedule



- Previous studies/presentations (PM Challenge, NASA Cost Symposium, etc.) show how estimates for facilities, space crafts, and other programs routinely exceeded budget and schedule
 - It's a consistent issue across a variety of programs and projects
- Over the last 20 years, NASA has spent in excess of \$21B on canceled programs



BOEs...What are these?



- BOEs are the quintessential foundation by which Programs/Projects are defined
- BOEs are intended to be developed within the parameters of requirements, not idealistic hopes (ex: budget and launch date)
- BOEs have two sides...

Meet Dr. Cost and Mr. Schedule!



Our Old Friend, Dr. Cost



- Cost analysts have been developing BOEs for decades, using spreadsheet programs and eventually very specific, well-developed software tools to run models that calculate cost estimates
- Newer tools lead the analyst “through carefully planned equations, hierarchical listings of elements, standard calculations, checklists of project elements, and other methods”¹ to determine the total cost of the project
- Cost estimating relationships (CERs) have been developed based on established relationships, which serve as a “basis” for portions of or even entire cost estimates

1. Courtesy of Wikipedia, “Basis of Estimate,” 28 May 2013.



The Evil, Mr. Schedule



- Unfortunately, while tools to determine “schedule estimates” might exist in theory – some tools claim to “estimate the schedule” – they are not widely known about or used; scheduling tools, such as MS Project or Oracle’s Primavera are scheduling tools, not “schedule estimating” tools
- Schedule estimating relationships (SERs) are new; in fact, they are considered a “nontraditional approach to estimating schedule duration.”²

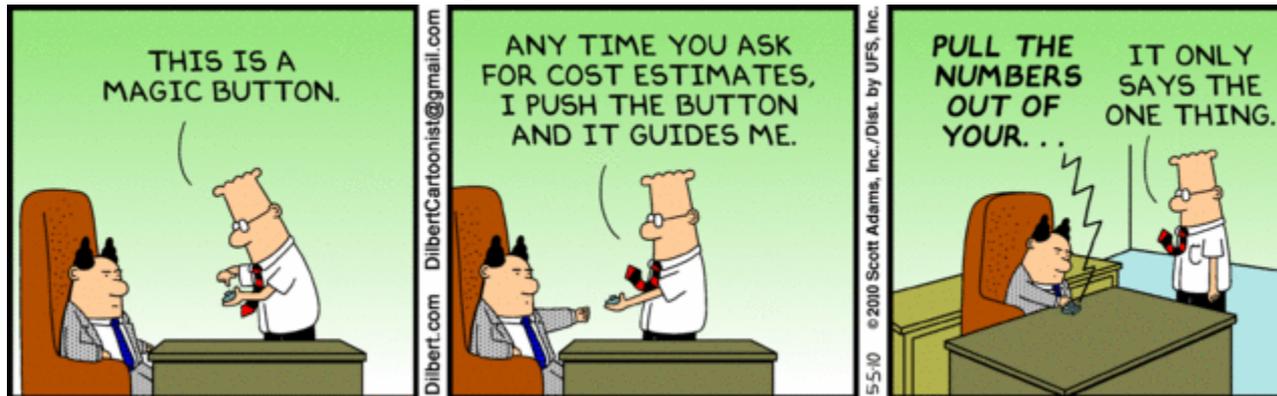
2. Boyd, D. Scott and Brian D. Mundt, “Schedule Estimating Relationships for the Engineering and Manufacturing Development of Bomber, Transport, Tanker, and Surveillance Aircraft Systems.” The Journal of Cost Analysis. Volume 12, Issue 1. Page 131. 1995. Published online, <http://www.tandfonline.com/>, 04 January 2012. Accessed 28 May 2013.



Why are Cost BOEs so much easier than Schedule BOEs?



- Scheduling tools don't ask the right questions or lay the groundwork for documenting a BOE like cost tools; they don't come with *Magic* buttons":

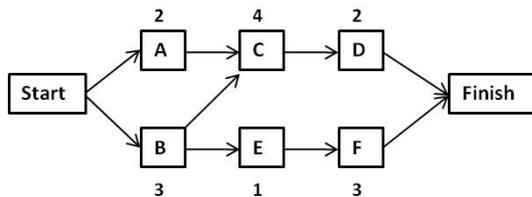




Where are the Schedule Cartoons?



- Ever wonder why there are no cartoons about schedule estimates?
 - Is it because Cost is just more fun than Schedule?
 - Ex: Websites like “How Much Would it Cost to Build the Death Star?” actually exist. At 2012 steel prices, it would cost about \$852,000,000,000,000,000. That’s roughly 13,000 times the world's GDP. No one really cares how long it would take to build.
 - Ex: 12 Days of Christmas costs are reported in the NY Times and other well-known publications each year. \$107,300 in 2012.
 - Is it because logic network diagrams take up more space than dollar signs?



VS. \$

- ***Or perhaps because no one knows what a Schedule BOE is!! (For the remainder of the presentation, we will focus primarily on Schedule BOEs.)***

3. <http://www.centives.net/S/2012/how-much-would-it-cost-to-build-the-death-star/>

4. http://www.nytimes.com/2012/12/22/business/cost-of-12-days-of-christmas-totals-107300.html?_r=0



BOE Questions to Address



- When it comes to BOEs, are we focusing on the solution or the problem?
- Will developing BOEs solve these problems?
- Do we need separate BOE “products” or do we simply need to do a better job communicating and documenting with respect to our current program and project management products?



BOEs Require Documentation



- NASA NPR 7120.5E calls for an assessment of the “adequacy of the *integrated cost and schedule estimates* and funding strategy” at each Life Cycle Review
- NASA NPR 7120.5E BoE Definition:
 - “The documentation of the ground rules, assumptions, and drivers used in developing the *cost and schedule estimates*, including applicable model inputs, rationale or justification for analogies, and details supporting cost and schedule estimates.”
- NASA NPR 7120.5E Requirement Statement, Paragraph 2.4.2:
 - “All programs and projects develop cost estimates and planned schedules for the work to be performed in the current and following life-cycle phases (see Appendix I tables). As part of developing these estimates, the program or project shall *document the basis of estimate (BOE)* in retrievable program or project records.”



BOEs Require Documentation



- “NASA leaders must temper the Agency's culture of optimism by requiring realistic cost **and** *schedule estimates*, well-defined and stable requirements, and mature technologies early in project development.”
 - NASA’s Challenge to meeting Cost, Schedule, and Performance Goals, NASA Office of Inspector General, September 2012.

"With every day, and from both sides of my intelligence, the moral and the intellectual, I thus drew steadily nearer to the truth, by whose partial discovery I have been doomed to such a dreadful shipwreck: that BOE is not truly one, but truly two."



Schedule BOEs Require Documentation... But How?



- Limited best practice resources exist for schedule BOEs in comparison to cost BOEs

"Some day...after I am dead, you may perhaps come to learn the right and wrong of this. I cannot tell you."



Schedule BOEs Require Communication



- Schedulers work closely with the project manager and project element leads to determine work sequences and activity durations.
- Unfortunately, schedulers do not always document the basis for durations, uncertainties, risks, or even activity logic flow.
- Schedulers cannot document what they do not have.

“total failure!!!”



Schedule BOEs Require Transparency...

Where are the Missing Pieces?



"There is something wrong with his appearance; something displeasing, something downright detestable."

- Oftentimes, we find that project schedules are not directly tied to other management products/tools
 - Is the schedule reflective of the work being done? Was it developed using decomposition of the WBS?
 - Are project constraints, assumptions, and dependencies taken into account, and are they identified in the schedule?
 - Is the schedule resource- or cost-loaded, and does the mapping support the budget?
 - Do the EVM metrics reflect the work completed as per the schedule?
 - Are the risks mapped to the schedule? Does the risk list provide quantified impacts should the risks occur? Are the mitigations developed enough to understand the associated time needed to perform them?
- In many cases, the answer to these questions is “No”



The BOE Pathway

- Development of BOEs is a process in which functional areas overlap
- In our framework, we are focused on developing separate products called a Cost BOE and a Schedule BOE; in theory, the Cost and Schedule BOE should be an integrated product
- The Schedule BOE will directly affect the development of the Cost BOE in terms of resource allocation mixture, fiscal year funding, management reserve requirement, PM Office Support, etc.
- Unfortunately, we have less to go on the part that comes first – the schedule
- We need to continue to progress with making documentation a priority for both cost and schedule estimates

“I let my brother go to the devil in his own way.”



Let's Revisit Dr. Cost & Mr. Schedule



- What guidance currently exists on creating BOEs?
 - For our old friend Dr. Cost, it's the GAO Cost Estimating and Assessment Guide
 - For evil Mr. Schedule, it's the GAO Schedule Assessment Guide (notice that the word "estimating" is missing)
- Fortunately, the NASA Schedule Management Handbook and GAO does provide some guidance on how to create a reliable schedule, which may help us understand and better communicate the "basis" for our schedule



Guidance for Successful BOEs



- A reliable schedule is one that the project team can feel confident in...that can be relied on to provide information needed for informed decision-making⁵



Guidance for Successful BOEs



Implementing Schedule Reliability

Characteristic	Best Practice
Comprehensive	Capturing all activities
	Assigning resources to all activities
	Establishing the durations of all activities
Well-Constructed	Sequencing all activities
	Confirming that the critical path is valid
	Ensuring reasonable total float
Credible	Verifying that the schedule is traceable vertically and horizontally
	Conducting a schedule risk analysis
Controlled	Updating the schedule with actual progress and logic
	Maintaining a schedule baseline



Moving Forward with the Schedule BOE

- So how do we move forward with the Schedule BOE?
 - *Per the NASA Schedule Management Handbook:* “It is recommended for program schedulers to always seek valid sources and processes to assist in deriving the **most accurate task durations** possible for schedule development. It is also recommended that the basis of estimate for **task durations within the IMS be documented**. This practice will help to ensure schedule credibility is maintained and also provide a critical source for schedule rationale during later project reviews.”



Establishing the Schedule BOE



- We suggest that programs and projects also make certain that the basis for any data that ties to the IMS also have a sound basis of estimate. This includes not only having a basis for schedule task duration estimates, but also for the products that directly affect the IMS:
 - WBS and WBS dictionary entries
 - Uncertainty surrounding those task duration estimates
 - Risk and Opportunity ratings (quantified likelihoods and 3-point consequence estimates)
 - Schedule reserves
 - Cost reserves



The Questions You *Should* Ask – Example



Schedule Durations and Uncertainty

Example criteria questions for other “pieces” of the BOE (WBS, schedule reserve, cost reserve, risk/opportunity) can be found in the backup slides.

- Well-documented:
 - Are the overall project schedule and key milestones identified?
 - What assumptions were made with respect to the duration estimates?
 - Who was involved in creating the duration estimates, and were they the most qualified individuals to do so? / What is the source of the data? / What method was used for determining the duration estimates?
 - Are changes in the schedule durations from the original baseline documented and justified?
 - Is the schedule documentation verifiable? / Is the schedule configuration controlled?
- Comprehensive:
 - Is all work accounted for in the schedule? Is any work double counted in the schedule?
 - What assumptions are there with respect to the schedule durations?
- Accurate:
 - Does the overall project schedule accurately reflect the work to be done? (Is the Critical Path reasonable?)
 - Have any reviews of the schedule durations taken place (especially with respect to EVM/schedule trends)?
- Credible:
 - Are the estimating methodologies used for schedule durations appropriate for the application (analogy/heritage/new technology/bottoms-up/SERs, as well as cost/risk/resource-informed)?
 - Have appropriate project and key resource calendars been applied to the schedule?
 - Have major assumptions with respect to schedule duration uncertainty been varied and other outcomes recomputed to recomputed to determine their sensitivity to changes in assumptions?
 - Has a schedule uncertainty analysis been performed to determine the level of uncertainty associated with the IMS as a whole?



Just One More Reason Why BOEs are Important – Independent Assessments



- Independent assessors (at any level) need to have the appropriate information and data available to be able to judge whether an estimate is realistic.

*“The less I understood of this farrago,
the less I was in a position to judge of
its importance.”*

- It’s important to make sure that independent assessors have access to any information available, which will help them to understand your estimates.



Finally...Do You Trust *YOUR* Project Schedule?



- Developing a **well-documented, comprehensive, credible, and accurate** BOE is the best way to ensure that the stakeholders all have the same level of trust in the project's schedule
 - Project Managers need to be able to use the schedule to manage the project
 - Project teams need to be able to use and update the schedule at the working level
 - The schedule should reflect the work the team is performing
 - As people come and go on the project, new team members need to understand the assumptions and constraints
 - Independent reviewers need to have the appropriate insight into project estimates, including all the pieces that make up those estimates



A Schedule BOE Might Look Like...



- A HIGH-QUALITY, RELIABLE SCHEDULE!

Is the entire plan captured and does it map to the WBS?

What method was used for determining the duration estimates?

Have opportunities/risks been identified and are they tied to the schedule, as defined tasks or as a series of mitigations to resolve the risk?

WBS	Task Name	Minimum Duration	Min Rationale	Duration	M/L Rationale	Maximum Duration	Max Rationale	Cost	Prede	Succe	Resource Names	Risks	BOE
1.0	Imaginary Program	0 days		395 days		0 days		\$2,545,999.87					
1.1	Program Management	0 days		395 days		0 days		\$2,545,999.87			PM		
1.1.1	Program Start	0 days		0 days		0 days		\$0.00		4,6			
1.1.2	Launch Vehicle Design	100 days	Based on Project XYZ actual performance minus XYZ risks	120 days	Based on Project XYZ actual performance	145 days	Based on Project XYZ with possibility of loss of key resources	\$192,000.00	3	5	Eng	Risk 001: Design Delay (Likelihood = 25%; Consequence = 25 Day delay)	Estimate based on Project XYZ with adjustments for new part QQ
1.1.3	Payload Design	135 days		150 days		165 days		\$240,000.00	4	7	Eng	Risk 004: Design Delay (Likelihood = 40%; Consequence = 15 Day delay)	Estimate based on grassroots estimate
1.1.4	Software design	235 days		250 days		300 days		\$400,000.00	3	7	Eng	Risk 009: Design Delay (Likelihood = 25%; Consequence = 40 Day delay)	Estimate based on Project ABC with adjustment for new contractor schedule
1.1.5	Vehicle Payload Integration	110 days		125 days		150 days		\$449,999.98	5,6	8,9	Int,Test[1]	Risk 003: Design Delay (Likelihood = 25%; Consequence = 120 Day delay)	Estimate based on SME experience with XX years experience in vehicle payload
1.1.6	Launch	0 days		0 days		0 days		\$0.00	7				
1.1.6.1	Launch Delay Risk	0 days		0 days		60 days		\$0.00	7		Eng,Int	Risk 010: Launch Failure (Likelihood = 10%; Consequence =	Given fact, there is a possibility of AAA resulting in TUV

Were any anomalies or variances to NASA's standard WBS development practices used?

Who was involved in creating the duration estimates?

Task narrative, source of durations (parametric, expert opinion, etc.), logic, resource availability, etc.



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BACK-UP



Establishing the BOE

The Questions You *Should* Ask

	WBS	Durations / Uncertainty			Schedule Reserve	Cost Reserve	Opportunity/Risk Management	
		Pessimistic	Most Likely	Optimistic	Days	\$	Opportunities	Risks
<p>WELL DOCUMENTED</p> <p>By well documented it is meant that an estimate is thoroughly documented, including source data and significance, clearly detailed calculations and results, and explanations of why particular methods and references were chosen. Data can be traced to their source documents.</p>	<ul style="list-style-type: none"> ➤ Does the WBS exist? / Does a WBS Dictionary exist (including a technical baseline description)? ➤ Who was involved in creating the WBS, and were they the most qualified individuals to do so? / What is the source of the data? ➤ Are changes in the WBS from the original baseline documented and justified? Is the WBS current? ➤ Can the WBS be traced to the schedule and budget? / Does the WBS match the data being used to manage? ➤ Are the contracting and resource strategies identified? ➤ Have potential changes in scope been identified (new work, descopes, etc.)? ➤ Is the WBS verifiable? / Is the WBS configuration controlled? 	<ul style="list-style-type: none"> ➤ What method was used for determining the duration estimates? ➤ Who was involved in creating the duration estimates, and were they the most qualified individuals to do so? / What is the source of the data? ➤ Are changes in the schedule durations from the original baseline documented and justified? ➤ What assumptions were made with respect to the duration estimates? This includes any assumptions that were made with regard to the workweek schedule and planned use of overtime. ➤ Are the overall project schedule and key milestones identified? ➤ Is the schedule documentation verifiable? / Is the schedule configuration controlled? 	<ul style="list-style-type: none"> ➤ What method was used for determining the schedule reserve? ➤ Where is the schedule reserve managed? ➤ Is the schedule reserve funded or unfunded? ➤ Who was involved in determining the schedule reserve? / What is the source of the data? ➤ Are changes in the schedule reserve from the original baseline documented and justified? ➤ What assumptions were made with respect to the schedule reserve? ➤ Is the schedule reserve estimate current? ➤ Is the schedule reserve documentation verifiable? / Is the schedule reserve configuration controlled? 	<ul style="list-style-type: none"> ➤ What method was used for determining the cost reserve? ➤ Who was involved in determining the cost reserve, and were they the most qualified individuals to do so? / What is the source of the data? ➤ Are changes in the cost reserve from the original baseline documented and justified? ➤ What assumptions were made with respect to the cost reserve? ➤ Is the cost reserve estimate current? ➤ Is the cost reserve documentation verifiable? / Is the cost reserve documentation configuration controlled? 	<ul style="list-style-type: none"> ➤ Have opportunities and risks been identified and are they tied to the schedule, as defined risk/opportunity tasks or as a series of mitigations to resolve the risk? ➤ Who was involved in identifying the opportunities/risks, and were they the most qualified individuals to do so? / What is the source of the data? ➤ Are changes in the opportunities/risks from the original baseline documented and justified? ➤ Is it clear how the risks affect the critical path? How is this information documented? ➤ Is there a risk analysis report (if a risk analysis was performed)? ➤ Is the opportunity/risk documentation verifiable? / Is the opportunity/risk documentation configuration controlled? 			



Establishing the BOE

The Questions You *Should* Ask



	WBS	Durations / Uncertainty			Schedule Reserve	Cost Reserve	Opportunity/Risk Management	
		Pessimistic	Most Likely	Optimistic	Days	\$	Opportunities	Risks
<p>COMPREHENSIVE</p> <p>An estimate is comprehensive if it has enough detail to ensure that cost elements are neither omitted nor double counted. All schedule-influencing ground rules and assumptions are detailed in the estimate's documentation.</p>	<ul style="list-style-type: none"> ➤ Is the WBS complete? / Is any work double-counted? / Does the WBS include all work packages, which include all cost elements and deliverables? / Are there areas of the WBS that are not defined? ➤ What assumptions are there with respect to the WBS? 	<ul style="list-style-type: none"> ➤ Is all work accounted for in the schedule? Is any work double counted in the schedule? ➤ What assumptions are there with respect to the schedule durations? ➤ Are the schedule durations current? 	<ul style="list-style-type: none"> ➤ Is all schedule reserve clearly identified in the schedule? / Is any schedule reserve double-counted? ➤ How does the "needed" amount of schedule reserves identified compare to the schedule reserves available? 	<ul style="list-style-type: none"> ➤ Are appropriate cost reserves tied to the schedule (liens, encumbrances, risk mitigations, etc.)? / Are any cost reserves double-counted? ➤ How does the "needed" amount of cost reserves (UFE) identified compare to the cost reserves available? 	<ul style="list-style-type: none"> ➤ Is the risk list reflective of what would be expected for the current point in the lifecycle (greater uncertainty for early lifecycle phases and more discrete risks identified later in the lifecycle)? / Are any risks double counted? (Are any risks identified that should instead be captured as uncertainty, and vice versa?) ➤ What assumptions are there with respect to the opportunities and risks? 			
<p>ACCURATE</p> <p>An estimate that is accurate is unbiased, the work is not overly conservative or overly optimistic, and is based on an assessment of most likely costs. Few, if any, mathematical mistakes are present those that are minor.</p>	<ul style="list-style-type: none"> ➤ Are the WBS and WBS Dictionary properly captured/documented? ➤ Have any reviews of the WBS taken place? 	<ul style="list-style-type: none"> ➤ Does the overall project schedule accurately reflect the work to be done? (Is the Critical Path reasonable?) ➤ Have any reviews of the schedule durations taken place (especially with respect to EVM/schedule trends)? 	<ul style="list-style-type: none"> ➤ Have any reviews of the schedule reserve taken place? 	<ul style="list-style-type: none"> ➤ Have any reviews of the cost reserve taken place? 	<ul style="list-style-type: none"> ➤ If formal risk analyses have been performed, are the calculations accurate (are calendars, resources, risks, opportunities, uncertainty reading in correctly)? ➤ Has the plan (schedule) been modified to reflect/incorporate the results of any risk analyses that have been performed? / Is the schedule risk-informed? ➤ Have any reviews of the opportunity/risk list taken place? 			



Establishing the BOE

The Questions You *Should* Ask

	WBS	Durations / Uncertainty			Schedule Reserve	Cost Reserve	Opportunity/Risk Management	
		Pessimistic	Most Likely	Optimistic	Days	\$	Opportunities	Risks
CREDIBLE As for credibility, any limitations of the analysis because of uncertainty or bias surrounding data or assumptions are discussed. Major assumptions are varied, and other outcomes are recomputed to determine how sensitive they are to changes in the assumptions. Risk and uncertainty analysis is performed to determine the level of risk associated with the estimate.	<ul style="list-style-type: none"> ➤ Were any anomalies or variances to NASA's standard WBS development practices used? ➤ Was the WBS used to inform the level of UFE/contingency/reserves/margin required by the project? ➤ Does the WBS reflect the appropriate phasing of cost/resources? ➤ Is the WBS executable? 	<ul style="list-style-type: none"> ➤ Are the estimating methodologies used for schedule durations appropriate for the application (analogy/heritage/new technology/bottoms-up/SERs, as well as cost/risk/resource-informed)? ➤ Have appropriate project and key resource calendars been applied to the schedule? ➤ Have major assumptions with respect to schedule duration uncertainty been varied and other outcomes recomputed to determine their sensitivity to changes in assumptions? ➤ Has a schedule uncertainty analysis been performed to determine the level of uncertainty associated with the IMS as a whole? 	<ul style="list-style-type: none"> ➤ Are the methodologies used for estimating the schedule reserve appropriate (analogy/heritage/new technology/bottoms-up/SERs, as well as cost/risk/resource-informed)? ➤ Were schedule benchmarks used for comparison? Were there any inconsistencies? If so, what are they? 	<ul style="list-style-type: none"> ➤ Are the estimating methodologies used for cost reserves appropriate for the application (analogy/heritage/new technology/bottoms-up/CERs, as well as risk/resource-informed)? ➤ Have cost reserves (unallocated future expense (UFE)) been identified for possible changes in scope (new work, descopes, etc.)? ➤ Were cost benchmarks used for comparison? Were there any inconsistencies? If so, what are they? 	<ul style="list-style-type: none"> ➤ Have any formal risk analyses been performed? If so, what was the methodology and was it appropriate? ➤ Have major assumptions with respect to opportunities and risks been varied and other outcomes recomputed to determine their sensitivity to changes in assumptions? ➤ Has a schedule risk analysis been performed to determine the level of risk associated with the IMS as a whole? 			