



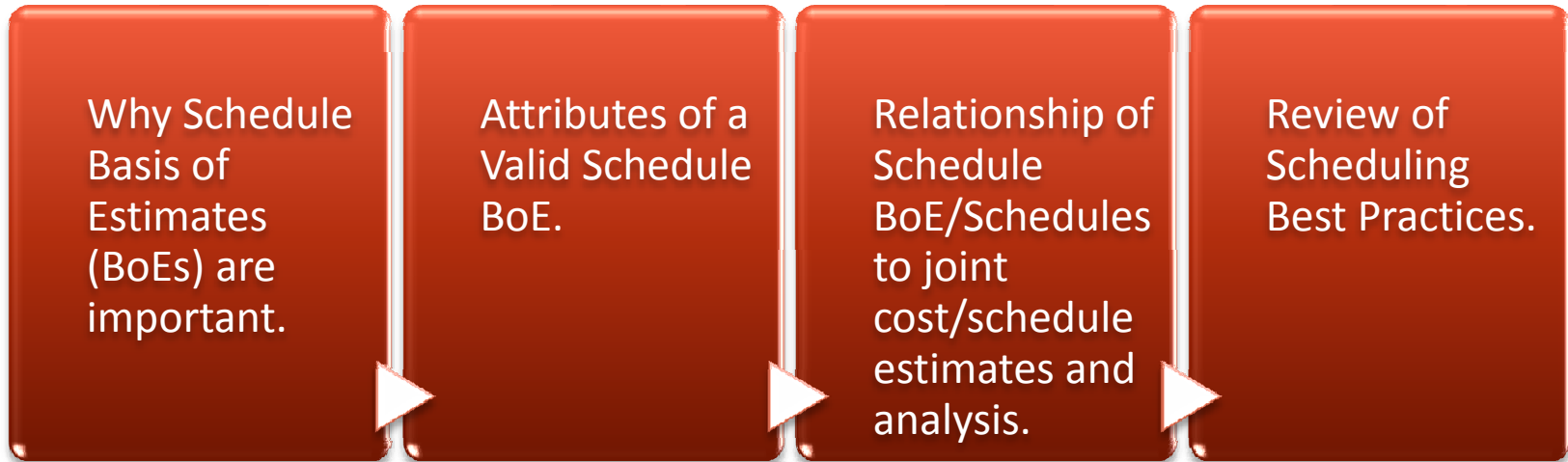
“Time is Money”: *The importance and desired attributes of Schedule Basis of Estimates (BoE).*

**Presented at:
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Workshop
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Topics





Importance of Schedule BoEs

- ▶ “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.
- ▶ What is a BoE?
 - No Definition in the CEBoK referencing schedule, only cost.
 - Relatively self explanatory.
- ▶ NASA NPR 7120.5 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. “

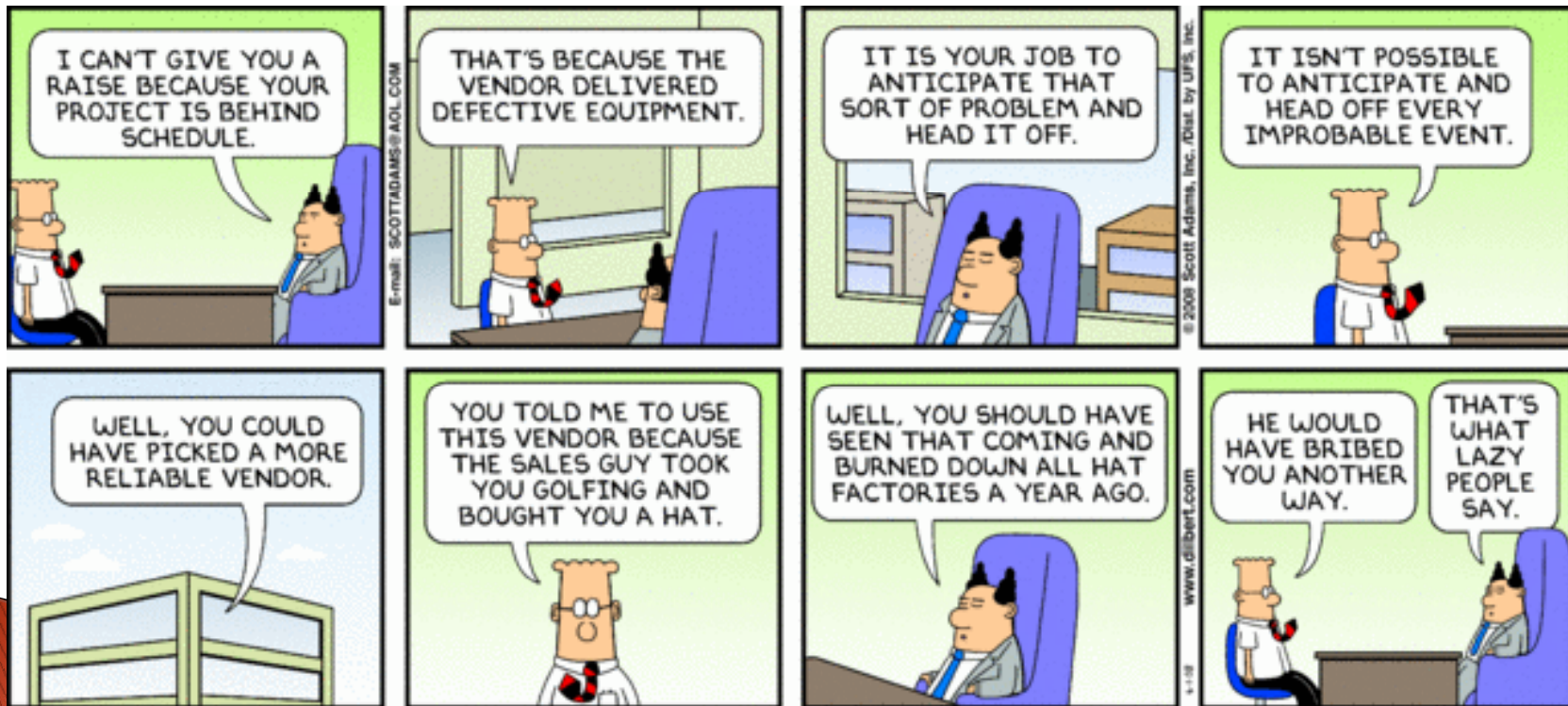
Cost Growth Reasons	1970s	1980s	1990s	2000s
Inadequate definitions prior to agency budget decision and to external commitments	X	X	X	X
Optimistic Cost Estimates/Estimating Errors	X	X	X	X
Inability to execute initial schedule baseline	X	X	X	X
Inadequate risk assessments	X	X	X	X
Higher technical complexity of projects than anticipated	X	X	X	X
Changes in Scope (Design/Content)	X	X	X	X
Inadequate assessment of impacts of schedule changes on cost		X	X	X
Annual Funding instability			X	X
Eroding in-house technical expertise			X	X
Poor tracking of contractor requirements against plans			X	X
Launch Vehicle			X	
Reserve Position adequacy		X		X
Lack of Probabilistic estimating		X		X
"Go as you can afford" Approach				X
Lack of formal document for recording key technical, schedule and programmatic assumptions (CARD)**				X

*Source: “Cost Estimating Requirements to Support New Congressional Reporting Requirements” NASA February 2007



Taking the road best planned

- ▶ Basis of Estimate (BoE): *the foundation on which programs/projects are planned and defined.*
- ▶ BoEs shall be developed within the parameters of requirements, not idealistic hopes (ex. Budget and Launch Date).





Schedule and Cost BoEs

- ▶ Limited best practices for schedule BoE, especially when compare to guidance for cost BoEs.
- ▶ Extensive guidance, attributes of suitable schedules.
 - Primarily end product guidance
- ▶ Schedules are the foundation for cost loading
 - Schedule quality contributes significantly to cost estimate/analysis quality

COST BASIS OF ESTIMATE PPBE15 - SUMMARY										
www DO NOT CHANGE FORMATTING BETWEEN THESE LINES www										
WBS Title:										
WBS:	000000.00.00									
Project Manager:										
BOE POC:										
IPT:	Choose									
Appropriation Source:	Choose									
Base Filename:		BOE-Choose_WBS_000000-00-00	usrtxt	.xsm						Save As
Time Phasing of Budget (\$K), WYEs, and FTEs (FY2014 through FY2018): Provide Time Phasing Cost (Cumulative for all Orgs). If breakdown by organization is required, please use "PM Work Area" below Red Line.										
000000.00.00	PY14	PY15	PY16	PY17	PY18					Total
FTE Labor Cost (\$K)										\$ -
WYE Labor Cost (\$K)										\$ -
NASA ODC (\$K)										\$ -
WYEODC (\$K)										\$ -
Conf Costs (\$K)										\$ -
PP&D Costs (\$K)										\$ -
Travel Costs (\$K)										\$ -
TOTAL by PY (\$K)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
FTE										0
WYE										0

Cost BoE Example

A quality schedule BoE and program/project schedule form the foundation for program/project success.

➤ *They also enhance utilization Joint Confidence Level (JCL) assessments as effective programmatic tools.*



Desired Attributes of Schedule BoEs

- ▶ **Traceable**
 - Schedule and Schedule BoE maps to WBS that satisfies project goals.
- ▶ **Reasonable**
 - Presented in a logical manner. Based on normal work schedules, durations do not exceed one month, no duration padding, include key resources.
- ▶ **Sound**
 - Information and assumptions are clearly documented. Durations are consistent throughout schedule. Level of Efforts (LOEs) flagged and are not on critical path.
- ▶ **Verifiable**
 - Sources for estimates identified; for example: standards, expert judgment, analogous comparisons, parametric analysis, brainstorming, etc.
- ▶ **Valid**
 - Durations and schedule logic support project objectives/requirements. No negative slack or float.
- ▶ **Accurate/Consistent**
 - Assumptions/rules applied throughout schedule, activity owners develop schedule estimates as much as possible. Application of learning curve for schedule durations used prudently.
- ▶ **Complete**
 - Inclusion of three point estimates, or similar duration estimates, and risk information included and well documented.

Source: NASA Independent Program Assessment Office Programmatic Assessment Group



What does a Schedule BOE Look Like?

- ▶ It looks like a detailed Schedule...

WBS	Task Name	Minimum Duration	Duration	Maximum Duration	Cost	Predec	Succes	Resource Names	Risks	Notes
1.0	Imaginary Program	0 days	395 days	0 days	\$2,546,000.00					
1.1	Program Management	0 days	395 days	0 days	\$2,546,000.00			PM		
1.1.1	Program Start	0 days	0 days	0 days	\$0.00		4,6			
1.1.2	Launch Vehicle Design	100 days	120 days	145 days	\$192,000.00	3	5	Eng	Design Delay (25 Day delay)	Estimate based on Project XYZ
1.1.3	Payload Design	135 days	150 days	165 days	\$240,000.00	4	7	Eng	Design Delay (15 Day delay)	Estimate based SME input
1.1.4	Software design	235 days	250 days	300 days	\$400,000.00	3	7	Eng	Design Delay (50 Day delay)	Estimate based on Project ABC
1.1.5	Vehicle Payload Integration	110 days	125 days	150 days	\$450,000.00	5,6	8,9	Int,Test[1]	Design Delay (25 Day delay)	Estimate based SME input
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	Launch Failure (60 Day Delay)	

Most Likely duration for the task

Resource description, traceability

Potential risk and impacts associated with task

Ex. 3-point duration estimates

Task narrative, source of durations, parametric, expert opinion, etc. Is task tied to a project plan, success criteria, etc.

Transparent, Traceable, Defendable



Inadequate Schedule BoEs



- ▶ Repeat: Budgets are not suitable for Cost BoEs and therefore notional deadlines (ex. Launch date) are not suitable for Schedule BoEs.
 - Independently derived duration estimates.
 - Significant issue for large Government projects.

Importance to Joint Cost/Schedule Confidence Level Development

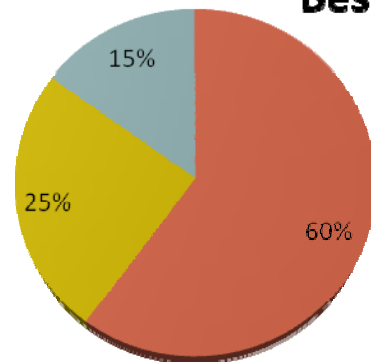


- ▶ Growing implementation of Joint Cost/Schedule Confidence Level (JCL) highlights importance of Schedules.
- ▶ JCL development procedure steps:
 1. Develop the Schedule (60%)
 2. Cost Load the Schedule (25%)
 3. Incorporate Risks (Cost/Schedule)
 4. Conduct Uncertainty Risk Analysis
 5. Obtain Results and Plot outputs
 6. Analyze Results and Refine

(15%)

Best Practice Time Percentage per JCL Task

* Source NASA Cost Analysis Division (CAD)



■ Schedule Development

■ Cost Loading

■ Risk/Uncertainty/Refinement



Scheduling Best Practices

- ▶ GAO Ten Best Practices for high quality and reliable schedules:
 1. Capturing all Activities
 2. Sequencing all Activities
 3. Assigning Resources to all Activities
 4. Establishing Duration of all Activities
 5. Tracing Schedule Horizontally and Vertically
 6. Validating Critical Path
 7. Ensuring Reasonable Total Float
 8. Conducting Schedule Risk Analysis
 9. Incorporating Schedule Updates
 10. Maintaining Baseline Schedule



Capturing All Activities

- ▶ **Comprehensive plan of effort required to complete the program/project, regardless of the party completing the work.**
- ▶ **Based on Work Breakdown Structure (WBS).**
- ▶ **Combination of:**
 - Milestones (start and finish minimum), must have clear conditions for completion
 - Detail Activities
 - Summary Activities
- ▶ **Levels of Effort (LOE) best represented as an activity that derives duration from detailed activities, aka Hammock activities.**
 - No measureable output
 - No physical product
 - No deliverable
- ▶ **Integrated Master Schedule (IMS) utilization.**
- ▶ **Consistent standard for activity names.**
- ▶ **Activities traced to documents or deliverables through code or other reference number methodology.**



Sequencing All Activities

- ▶ Logic between all activities.
- ▶ Finish-to-Start relationships primarily utilized.
- ▶ **At least one predecessor and successor for each activity, except for Start and Finish milestones.**
 - Justification for activities that do not.
- ▶ Does not contain Start-to-Finish logic.
- ▶ No logic applied to summary activities.
- ▶ Document justification for date constraints, if required (ex. Launch windows).
- ▶ Lags only used to document the passage of time between activities.
 - Attempt to avoid by breaking activities into smaller tasks.
 - Documented with justification.
- ▶ **Examine activities with many predecessors and successor tasks for validity.**



Assigning Resources to All Activities

- ▶ Reflect the resources needed to do the work.
- ▶ Either Labor or Non-Labor. Fixed or Variable.
 - Labor: Humans
 - Non-Labor: Contract, consumable material, machines, or other purchased equipment
- ▶ **Direct Labor, Overhead, and material assigned to work and planning packages allowing for total cost identification.**
- ▶ Logic explanation of resource estimates
- ▶ Resource information stored in assignment form. If assignments are not possible, methodology to feed information to schedule is required.
- ▶ Compare total resources required by resource loaded schedule with budget and contract cost contracts.
- ▶ Conduct resource leveling on schedules that include detailed resource estimates based on historical and sound estimating methodologies, low uncertainty.



Establishing Durations of All Activities

- ▶ Durations are related to the assigned resources and estimated work.
- ▶ Durations are shorter than 2 working months, or 44 working days.
- ▶ **As short as possible, to support measurement of the effort.**
- ▶ Avoid very short duration, less than 1 day, increases rate of update and can cause problems with estimating and analysis tools.
- ▶ Maintain units throughout schedule (day, week, hour, etc.)
- ▶ Estimated under normal conditions, not accelerated to meet project challenges.
- ▶ Assumptions clearly documented.
- ▶ **Durations estimates for a WBS element map and correspond to cost BoEs for the same element.**
- ▶ Schedule Calendars specify working times. Avoid holidays, weekends.



Tracing Schedule Horizontally and Vertically

- ▶ Horizontally Traceable:
 - Logical relationship between different program elements.
 - **Logic from start to finish integrating the entire scope.**
 - Milestones represent key decision points (KDP)s and deliverables with traced predecessor activities to ensure relationship validity.
 - Ability to reforecast key milestone dates through schedule logic.
- ▶ Vertically Traceable:
 - Demonstrates data is consistent across all schedule levels: summary, intermediate, and detailed.
 - Allows traceability to higher level milestones.
 - **Allows lower level schedule to be rolled up to the summary level without loss of information and logic.**



Validating Critical Path

- ▶ Does not include LOE activities, summary activities, or other unusually long activities.
- ▶ Continuous path from the status date to the major milestones.
- ▶ **Does not include constraints, reducing the importance of activities driving milestone dates.**
- ▶ Not driven by lags and leads.
- ▶ **Derived in summary schedules by vertical integration, not selected activities that management presupposed as important.**
- ▶ Used as a tool for managing the program/project:
 - Vetted and justified critical path continuously through program lifecycle.
 - Used to focus on activities that represent risks to meeting milestones or deliverables.

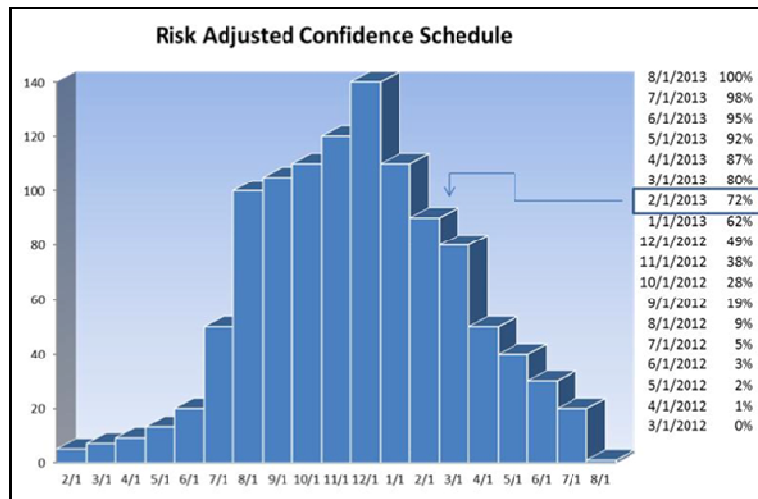


Ensuring Reasonable Total Float

- ▶ Float values are reasonable and accurately reflect program schedule flexibility.
- ▶ Large float is examined.
- ▶ **Total float is calculated to milestones, deliverables, and entire program.**
- ▶ Float used to examine resource allocation.
- ▶ **Continuous reviews of float during program lifecycle.**
- ▶ Date constraints that cause negative float are justified, if significant, recovery plans evaluated and implemented.



Conducting Schedule Risk Analysis (SRA)



- ▶ SRA conducted to determine:
 - Likelihood that the completion date will occur.
 - Schedule risk contingency reserve for completion by a specific date.
 - Risks identification most likely to delay the project.
 - Contingency reserve for each risk.
 - Activities impacted by schedule risk identified.
- ▶ SRA has low, most likely, and high duration estimates.
- ▶ SRA accounts for correlation.
- ▶ Risk are prioritized on probability and magnitude of impact (assessment).
- ▶ **SRA data and methodology documented.**
- ▶ SRA highlights contributors/drivers to the critical path.
- ▶ **Baseline schedule includes a schedule contingency to cover risks. Contingency is based on results of SRA.**
- ▶ SRA is conducted periodically, not a one off endeavor.



Incorporating Schedule Updates

- ▶ Progress is periodically recorded and updated.
- ▶ At least one in-progress activity is critical.
- ▶ Behind activities have a remaining duration estimate and the impact of delay has been assessed.
- ▶ LOE activities are updated with percentages.
- ▶ Actual work progress is tracked in lieu of updating durations.
- ▶ Identification of schedule lead responsible for updates.
- ▶ **Schedule structure is examined after each update to ensure logic is not missing or broke, constraints are still valid and necessary, and there are no conditions that would impede ability of schedule to forecast dates.**
- ▶ All updates are versioned and archived.



Maintaining Baseline Schedule

United States Government Accountability Office
Applied Research and Methods

GAO

Work package: install first floor joists

DURATION

start

finish

Planning

Scheduling

Best Practices for project schedules

"From May 30, 2012 - April 30, 2013, GAO is seeking input and feedback on this Exposure Draft from all interested parties. See page 2 for more information."

May 2012
GAO-12-120G

- ▶ Set at program initiation.
- ▶ Basis for measuring performance, EVM.
- ▶ Original configuration of the program plan.
- ▶ Compared to the current schedule to track variances.
- ▶ **Consider Baseline Schedule Document:**
 - Defines Assumptions
 - IMS organization
 - Logic
 - Resource Approach
 - How to use schedule
 - Ground rules for calendars, lags, constraints, long activities, contingency development, critical path development, and total float.
- ▶ Consider program process for schedule revisions.
- ▶ Consider the metrics used to assessment schedule.



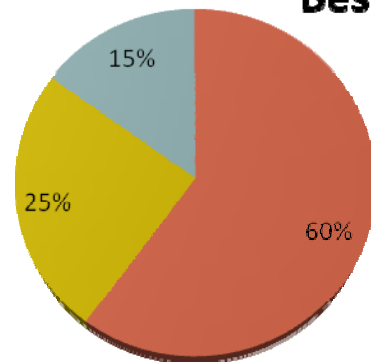
Repeat: Importance to Joint Cost/Schedule Confidence Level Development

- ▶ **Best Practices highlight the importance of putting in the required effort for schedule development.**
- ▶ **JCL development procedure steps:**
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■ Schedule Development

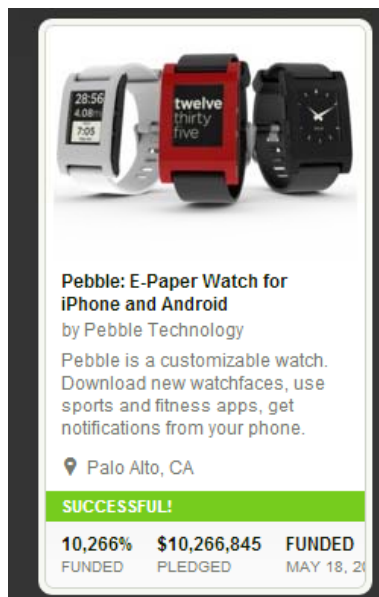
■ Cost Loading

■ Risk/Uncertainty/Refinement



Problem for all

- ▶ **Kickstarter.** Funding platform for creative projects.
(www.kickstarter.com)
- ▶ **84% of top 50 Kickstarter projects are late or have yet to deliver.**



On time	Ukiyo-e Heroes	Amanda Palmer	Zombicide	Lumi	MaKey MaKey	Kings of War	Cloud FTP	CineSkates Camera Sliders
Slightly tardy	Alpha	Digispark	Rhino Slider	Brydge	Pathfinder Online Demo	Laser Cutter/Engraver	B9Creator	Hand Stylus
	Order of the Stick Reprint	Pocket TV	Cookoo watch	MetaWatch Strata	TakTik	Apollo Dress Shirt	HuMn Wallet	Elevation Dock
	Luna Tik Touch Pen	Video Game High School	Printrobot					
Pretty late ...	Solid Titanium Pen + Stylus	Geode from iCache	Flint and Tinder	Remeemask	Windowfarms	Hidden Radio & Bluetooth Speaker	Twine	ZBoard
Where the ^%\$# is it!?	Oculus Rift	Ogre Designer's Edition	The Banner Saga	Touch Time	Double Fine Adventure	The Porthole	Castle Story	Leisure Suit Larry
	Pebble watch	gTar	BronyCon: The Documentary	Genie	Digital Bolex	Galileo	ZPM Espresso Machine	

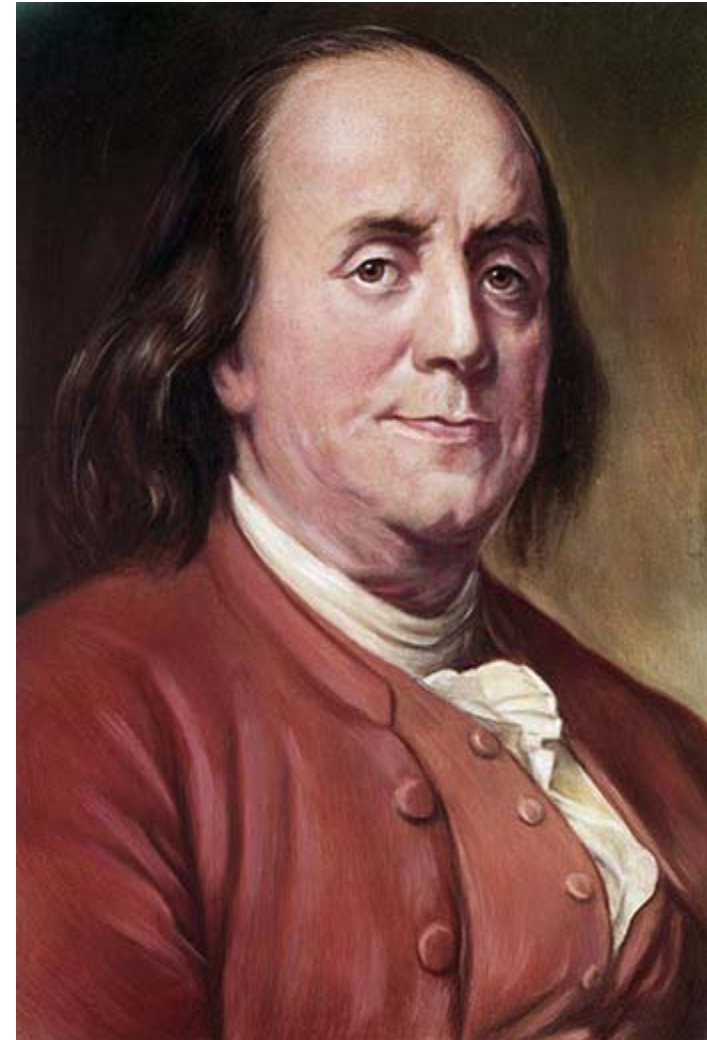




Questions?

- ▶ “Remember, that **time** is money. He that can earn ten shillings a day by his labor, and goes abroad, or sits idle, one half of that day, though he spends but six pence during his diversion or idleness, ought not to reckon that the only expense; he has really spent, or rather thrown away, five shillings besides.”

- ▶ “In short, the way to wealth, if you desire it, is plain as the way to market. It depends chiefly on two words, **industry** and **frugality**; that is, waste neither **time** nor **money**, but make the best use of both. Without industry and frugality nothing will do, and with them everything. He that gets all he can honestly, and saves all the gets (necessary expense expected), will certainly become **rich**, if that Being who governs the world, to whom all should look for a blessing on their honest endeavors, doth not, in His wise providence, otherwise determine.”
 - Benjamin Franklin, Advice to a Young Tradesman, 1748



*Source: smithsonian.com



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Additional Resources:

- AACE International Recommended Practice No. 38R-06, “Documenting the Schedule Basis”, TCM Framework: 7.2 – Schedule Planning and Development. December 8, 2011.
- GAO, “GAO Schedule Assessment Guide, Best Practices for project schedules.” May 2012.
<http://www.gao.gov/assets/600/591240.pdf>
- NASA/SP-2010-3403, “NASA Schedule Management Handbook,” March 2011.