Applied Earned Value Management Based on "Cost Engineering Principles"- With Practical Case Studies for Validation Purposes[1]

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INTRODUCTION

Two important papers, "It's Time to "Reboot" Earned Value Management"[2] and "Planning for the Future of Earned Value Management,"[3] were recently published in the March issue of the Defense Acquisition University's (DAU) blog.

In these well-written, well-documented papers, the authors summarized many years of relatively recent experience, both their own and that of others, telling us what, as taxpayers, we all knew intuitively, and that is "Earned Value Management" at least as practiced under ANSI 748 C or D has not worked, at least in the context of measuring and validating "value for money" by the US Governments stewardship of taxpayer funds. Specifically, one author posited that:

> *"Program leaders need to stop the bleeding and redirect budget resources when EVM analysis shows that progress is too slow, too expensive, and fails to meet performance goals or provide timely, reliable information.*
>
> *This is a fundamental change in emphasis. The audit-like DoD compliance process is sclerotic. It is implemented by external specialists who lack detailed knowledge of the project and have no stake in the outcome."*

When someone with the gravitas of these authors and others from the DAU[4] tells us it is time to rethink Applied Earned Value Management, don't you think we need to take his advice seriously?

Back around 2006, Brian Hobbs and Claude Besner published research showing that "Earned Value" was used "from limited to very limited use" and that "S-Curves and Statistical Process Control Charts" experienced "less than very limited use."[5] This was also followed in 2006 in published research by Chance Reichel, who told us, "Unfortunately, it seems as if this phrase or title, "Earned Value Management," is met and greeted with dread instead of the thought of

[1] How to cite this paper: Giammalvo, P. D. (2023). Applied Earned Value Management Based on "Cost Engineering Principles"- With Practical Case Studies for Validation Purposes, *PM World Journal,* Vol. XII, Issue IV, April.
[2] Abba, Wayne (2023) "It's Time to "Reboot" Earned Value Management" Defense Acquisition University Blog https://www.dau.edu/library/defense-atl/blog/Reboot-Earned-Value-Management
[3] Reynolds, Chad (2023) https://www.dau.edu/library/defense-atl/blog/PlanningfortheFutureofEarnedValueManagement
[4] Reynolds, Chad (2023) https://www.dau.edu/library/defense-atl/blog/PlanningfortheFutureofEarnedValueManagement
[5] 1 Claude Besner, B. Hobbs (2006) The Perceived Value and Potential Contribution of Project Management Practices to Project Success

usefulness."[6] Other published research indicates that very few project managers used EVM, at least not as the US DoD advocated it in the Earned Value Management Systems Intent Guide (EIA-748-D Intent Guide.[7])

More recently, Millennial Ms. Shohreh Ghorbani reiterated these same observations in several of her 2021 postings on Linked In. It was also mentioned on at least one occasion by Patrick Weaver in his postings in 2021-22 and was also discussed on several occasions between Dr. Ken Smith, Colonel USAF (Ret), Andrew J. Grandage, Ph.D., Assistant Professor, Political Science, at the Public Affairs Department Western Carolina University and the author of this article during 2022. Meaning that there is a broad consensus that what we have been doing is not working, and as Henry Ford supposedly told us, "If you always do what you've always done, you will always get what you always got," or Einstein, who told us "doing the same thing over and over again but expecting different results is the definition of insanity."

[6] Reichel, C. W. (2006). Earned value management systems (EVMS): "you too can do earned value management" Paper presented at PMI® Global Congress 2006—North America, Seattle, WA. Newtown Square, PA: Project Management Institute.
[7] NDIA (2018) "Earned Value Management Systems EIA-748-D Intent Guide"
https://cupdf.com/document/earned-value-management-systems-eia-748-d-intent-guide.html?page=1

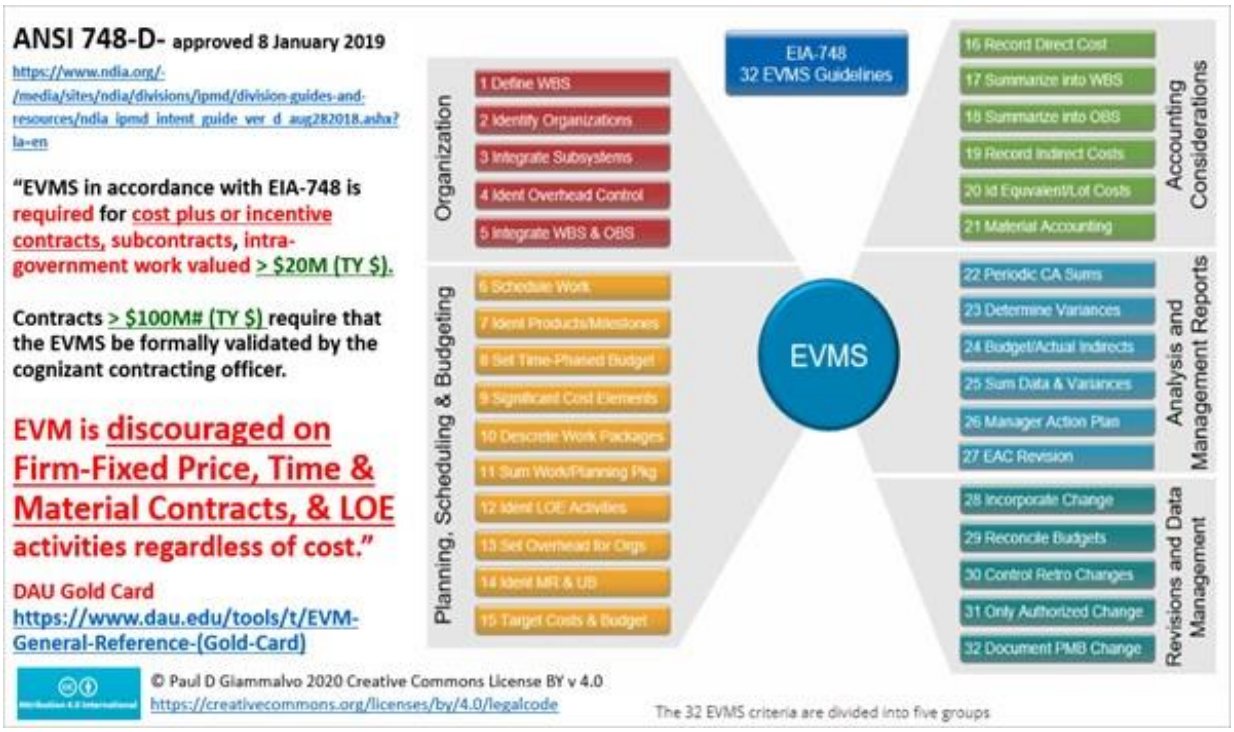


Figure 1- EVM as the US Government (and PMI[8], AACE[9] et al.) advocate using it TODAY.[10], [11]

In recent months, at least one group of international EVM advocates have organized with the following objectives:

- *To develop a message to convey EVM so that organizations will feel compelled to embrace it as a core business management practice.*
- *To devise a strategy to disseminate such a message globally and implement the strategy effectively using tested and PROVEN tactics.*

This group and perhaps others appear to agree on at least two major questions:

1) *"Given so many agree that Earned Value Management is an important and useful tool for both owners and contractors to manage their projects, then WHY is it not enjoying more widespread adoption?"*

[8] Practice Standard for Earned Value Management – Second Edition (2011) https://www.pmi.org/pmbok-guide-standards/framework/earned-value-management-2nd
[9] AACE (2014) "RP 81-31- Required Skills & Knowledge for Earned Value Management" https://www.pathlms.com/aace/courses/2928/documents/3864
[10] DAU Gold Card (2020) https://www.dau.edu/tools/t/EVM-General-Reference-(Gold-Card)
[11] Reichel, C. W. (2006). Earned value management systems (EVMS): "you too can do earned value management" Paper presented at PMI® Global Congress 2006—North America, Seattle, WA. Newtown Square, PA: Project Management Institute.

2) *"What changes need to be made to make EVM more acceptable or "user-friendly" to both owners and contractors to make them WANT to adopt it?'*

SO "WHERES THE BEEF"?

I am in full agreement with and in total support of this and any effort to advance the use of earned value in the management of projects. However, any such efforts should adhere to at least the following:

1. **To be effective, teams should be STRUCTURED in such a way that:**
   1.1. There are open and transparent communications to facilitate or encourage debate and discussion between or amongst the participants.
   1.2. The team must include key stakeholders with first-hand experience addressing the two objectives. They should also include (people who have SUCCESSFULLY implemented EVM as advocated by Gillette and Dana as a "Pay for Performance" or "Financial Management" or "Continuous Process Improvement" System, including such organizations as Freeport McMoran Indonesia, PT Smartfren Telecommunications et al.) In addition, FORMAL representation from the Association for the Advancement of Cost Engineering International (AACE)[12], [13] the International Cost Engineering Council (ICEC), the UK's Association of Cost Engineers (AcostE), or the Italian Association of Total Cost Management (AICE) should also be included. (As the Gillette and Dana model I am advocating is based on applied "cost engineering" or "engineering economics" tools & techniques, these organizations have already performed much of the necessary background research, such as Gary Cokins[14] and his Institute of Management Accountants (IMA)

2. **The most fundamental "Principles of Project Management must be exemplified."**
   2.1. A "root cause" analysis should be completed to identify the underlying reasons for what appears to be so much resistance to the adoption of EVM, despite near universal teaching of it by PMI[15], AACE[16], and other professional societies.
   2.2. Each initiative should create a WBS identifying the DELIVERABLES.
   2.3. There should be a PLAN, TIMELINE, or target delivery date for achieving objectives.

[12] Hollman, John (2016) "The Early History of Cost Engineering" TCM-2104.4
[13] AACE (2014) "RP 81-31- Required Skills & Knowledge for Earned Value Management" https://www.pathlms.com/aace/courses/2928/documents/3864
[14] Cokins, Gary and IMA (2006) "Implementing Activity Based Costing" https://vdocuments.net/implementing-activity-based-costing-on-management-accounting-table-of-contents.html?page=1
[15] Practice Standard for Earned Value Management – Second Edition (2011) https://www.pmi.org/pmbok-guide-standards/framework/earned-value-management-2nd
[16] AACE (2014) "RP 81-31- Required Skills & Knowledge for Earned Value Management" https://www.pathlms.com/aace/courses/2928/documents/3864

3. **The primary basis for any such effort to overcome apparent obstacles to the more widespread adoption of EVM should be the** 5 attributes of the Scientific Method[17]:

   - **Empirical Observation**
     The scientific method is empirical. That is, it relies on direct observation of the world and disdains hypotheses that run counter to observable fact. This contrasts with methods that rely on pure reason (including that proposed by Plato) and those that rely on emotional or other subjective factors.
   - **Replicable Experiments**
     Scientific experiments are replicable. If another person duplicates the experiment, he or she will get the same results. Scientists are supposed to publish enough of their method so that another person with appropriate training could replicate the results. This contrasts with methods that rely on experiences unique to a particular individual or a small group of individuals.
   - **Provisional Results**
     Results obtained through the scientific method are provisional; they are (or ought to be) open to question and debate. If new data arise that contradict a theory, that theory must be modified. For example, the phlogiston theory of fire and combustion was rejected when evidence against it arose.
   - **Objective Approach**
     The scientific method is objective. It relies on facts and the world as it is rather than on beliefs, wishes, or desires. Scientists attempt (with varying degrees of success) to remove their biases when making observations.
   - **Systematic Observation**
     Strictly speaking, the scientific method is systematic; that is, it relies on carefully planned studies rather than on random or haphazard observation. Nevertheless, science can begin from some random observation. Isaac Asimov said that the most exciting phrase to hear in science is not "Eureka!" but "That's funny." After the scientist notices something funny, he or she investigates it systematically.

   These 5 attributes should be the STANDARDS against which ALL research on "project management" should be developed, including the PMBOK Guide 8th Edition and any "standards of practice" or "recommended practices." (RP's)

SOME "BEST TESTED AND PROVEN" SOLUTIONS

Here is what I have been recommending and continue to recommend to anyone interested in answering the research questions:

[17] 5 Characteristics of the Scientific Method (2018) https://sciencing.com/five-characteristics-scientific-method-10010518.html

1. Joe Pusz admin@thepmoleader.com has set up a very well-designed "PMO Leader" website https://www.thepmoleader.com/tpl-home that would make an IDEAL platform for those interested in helping to answer the research questions and hopefully overcome resistance, where we could participate in an OPEN and TRANSPARENT discussion forum. There appear to be 2500+ members on Joe's Forum, and as long as the POSTING RULES require contributions to conform to the 5 Attributes of the Scientific Method, it should attract people with REAL, FIRST-HAND EXPERIENCE to contribute to answering the research questions:
   1.1. "Given that many agree that Earned Value Management is an important and useful tool for owners and contractors to manage their projects, then WHY is it not enjoying more widespread adoption?"
   1.2. "What changes need to be made to make EVM more acceptable or "user-friendly" to owners and contractors to make them WANT to adopt it?'

IF Joe's website is deemed inappropriate, perhaps one of the EVMDT team members could set up a comparable website where open and transparent discourse can occur?

2. Here is the LITERATURE REVIEW that I have compiled: (roughly in order of importance or relevance to answering the research questions)

2.1. Halbert Powers Gillette and Richard Turner Dana (1909) "Cost Keeping and Management Engineering: A Treatise for Engineers, Contractors, and Superintendents Engaged in the Management of Engineering Construction."

2.2. Taylor, Frederick (1911) "The Principles of Scientific Management" https://play.google.com/books/reader?id=qE3CAgAAQBAJ&pg=GBS.PA13.w.1.0.306_27&hl=en

2.3. Fayol, Henri (1916) "Administration Industrielle et Generale (General and Industrial Management)" https://play.google.com/books/reader?id=WFp5DQAAQBAJ&pg=GBS.PT2

2.4. Frederick Winslow Taylor, Frank Bunker Gilbreth (1912) "Principles of Scientific Management/Primer of Scientific Management" https://gilbrethnetwork.tripod.com/gbooks.html

2.5. Gilbreth, Frank & Lillian, "Applied Motion Study," NY, Sturgis & Walton Co., 1917. https://gilbrethnetwork.tripod.com/gbooks.html

These references are ESSENTIAL READING if we want to understand that although the US Air Force reinvented "Earned Value Management" in the 1960s, it probably originated with the 16th Century Guilds of England and France and there is substantial evidence that EVM evolved during the 18th Century Industrial Revolution as a "Pay for Performance" or "Incentive Payment System" designed to IMPROVE WORKFLOW PROCESSES and INCREASE THE PAY TO THE WORKER based on those improvements. (See Taylor's "Pig Iron Experiment") This quote from Taylor on page 20 is the "smoking gun " that clearly and unequivocally links "payment to performance," which is the very heart of what today is known as "Earned Value Management," at least as the private sector practices it.

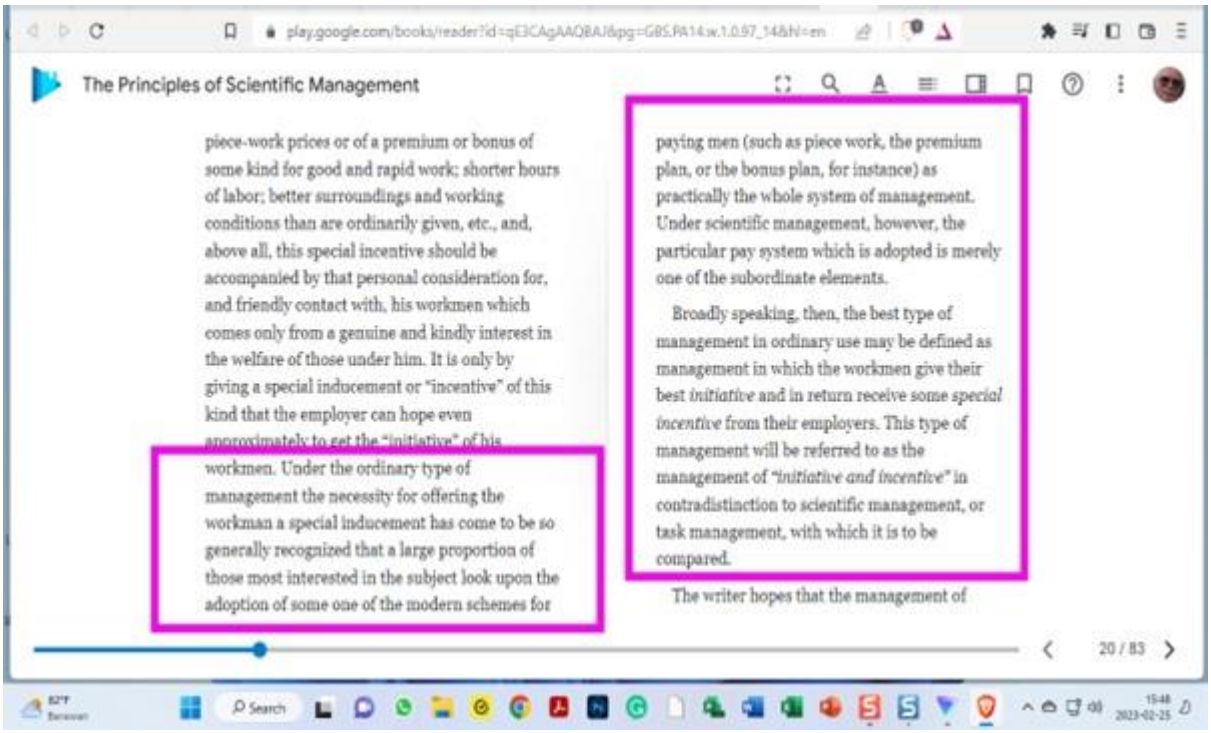


Figure 2- Quote from Frederick Taylor's "Principles of Scientific Management" page 20[18]

The following references are case studies or "white papers" we have published showing the impacts of implementing Earned Value Management, not as the DAU/DoD/PMI [19] /AACE [20] advocate it based on ANSI 748 C/D but on what Gillette and Dana advocate in their "Cost Keeping and Management Engineering: A Treatise for Engineers, Contractors, and Superintendents Engaged in the Management of Engineering Construction.

2.6) Giammalvo (2022) https://pmworldlibrary.net/wp-content/uploads/2022/09/pmwj121-Sep2022-Giammalvo-origins-and-history-of-evm-a-contractors-perspective.pdf

2.7) Giammalvo (2020) https://pmworldlibrary.net/wp-content/uploads/2020/02/pmwj90-Feb2020-Giammalvo-Letter-to-Editor-on-subject-of-earned-value.pdf

2.8) Giammalvo (2019) https://pmworldlibrary.net/wp-content/uploads/2019/01/pmwj78-Jan2019-Giammalvo-EVM-early-indicator-of-clean-governance.pdf

2.9) Giammalvo (2019) https://pmworldlibrary.net/wp-content/uploads/2019/02/pmwj79-Feb2019-Giammalvo-Activity-Based-Costing.pdf

[18] Taylor, Frederick (1911) "The Principles of Scientific Management" https://play.google.com/books/reader?id=qE3CAgAAQBAJ&pg=GBS.PA13.w.1.0.306_27&hl=en
[19] Practice Standard for Earned Value Management – Second Edition (2011) https://www.pmi.org/pmbok-guide-standards/framework/earned-value-management-2nd
[20] AACE (2014) "RP 81-31- Required Skills & Knowledge for Earned Value Management" https://www.pathlms.com/aace/courses/2928/documents/3864

2.10) Giammalvo (2019) https://pmworldlibrary.net/wp-content/uploads/2019/11/pmwj87-Nov2019-Giammalvo-Letter-to-Editor-on-the-history-of-evm.pdf

2.11) Giammalvo (2013) https://pmworldlibrary.net/wp-content/uploads/2013/04/pmwj9-apr2013-giammalvo-do-small-contractors-comply-ANSI748-FeaturedPaper.pdf

2.12) Giammalvo (2013) https://pmworldlibrary.net/wp-content/uploads/2013/07/pmwj12-jul2013-giammalvo-practical-look-enterpreneurial-contractors-evm-FeaturedPaper.pdf

2.13) Giammalvo (2022) https://build-project-management-competency.com/ptmc-training-standards-and-specifications-individual/

2.14) Giammalvo (2021)/PT Expo Presentation https://www.academia.edu/63094162/_Successful_vs_Failed_PMO_Case_Studies_including_a_Root_Cause_Analysis_sharing_Lessons_Learned_How_to_Do_It_PT_Expo_Presentation_All_Locations_Dates_06_16_2021

And here are two papers from my students that contain important information you are unlikely to find in other places

2.14) Wibiksana (2013) https://pmworldlibrary.net/wp-content/uploads/2013/01/PMWJ2-Sep2012-WIBIKSANA-EVM-Adapted-for-UndergroundMining-StudentPaper.pdf

2.15) Taybi (2019) https://pmworldlibrary.net/wp-content/uploads/2019/09/pmwj85-Sep2019-Taybi-is-evm-consistent-with-sharia-law.pdf

Lastly, here are two presentations that show just how badly broken any system is that uses Earned Value based on ANSI 748 C or D, along with RECOMMENDATIONS on what needs to be done to FIX those weaknesses.

2.16) Glenn Butts (NASA) (2009 and 2010) https://www.slideshare.net/NASAPMC/glennbutts-mega-projects-estimates

2.17) Prof Bent Flyvbjerg, Oxford Univ (2009) https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=1935014

CONSISTENT WITH SCIENTIFIC METHOD ATTRIBUTE #2, REPLICABLE EXPERIMENTS[21]

My professional THEORY or HYPOTHESIS is that the "tools & techniques" associated with "Earned Value Management" are used far more FREQUENTLY than people realize. Not only do we use the most basic form of EVM each week when we go grocery shopping (See Figure 18), but the fundamental tools and techniques identified and advocated by Taylor, the Gilbreths, Fayol, and especially Gillette and Dana are "alive and well"- that they permeate much of the work we do for no other reason than, done CORRECTLY, EVM is nothing more than "applied common sense." BUT few people realize that what they are doing has a name, and that name is "Earned Value Management."

[21] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

Scientific Method Attribute #2- Replicable Experiments

> ***Scientific experiments are replicable.*** *If another person duplicates the experiment, he or she will get the same results.* ***Scientists are supposed to publish enough of their method so that another person with appropriate training could replicate the results****. This contrasts with methods that rely on experiences unique to a particular individual or a small group of individuals.*[22]

For that reason, I have put together 3 "experiments" or "real-life case studies" that anyone can duplicate and use to validate (or refute if they wish) my theory or hypothesis to see if they are or are not correct and if you do agree, you are free to ADAPT for their own use.

Experiment #1- Earned Value ("Earned Time") Applied to FIT BIT Exercise Data

In order to stay as fit as I can, given my age and limited spare time to go to a gym, I practice what is known as "High-Intensity Interval Training" or HIIT.[23]

This is the image of the home gym I use. This machine provides a workout for all the major muscle groups with 15 different sets of exercises.

My workouts are a total of 90 minutes long, done three times a week (M, W, and F) using between 5 to 15 kilograms (11 to 33 lbs) of weights, and consist of 10 – 15 minutes of intensive workout (between 40 to 60 repetitions) followed by 2-3 minutes of rest. (For more on the importance of rest periods, read Taylor's "Pig Iron Experiment")

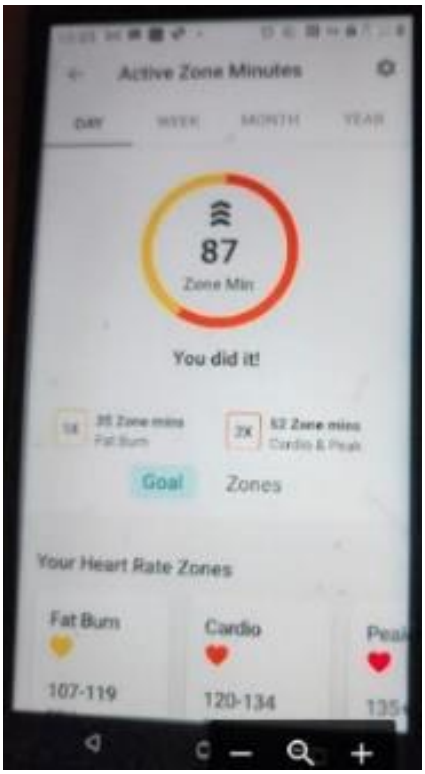
Figure 3- Exercise Equipment for Experiment #1

[22] "5 Attributes of the Scientific Method" (2018) https://sciencing.com/five-characteristics-scientific-method-10010518.html

[23] High-Intensity Interval Training (HIIT) is a type of training technique in which you give all-out, one hundred percent effort through quick, intense bursts of exercise, followed by short, sometimes active recovery periods. It increases the body's need for oxygen during the effort and creates an oxygen shortage, causing your body to ask for more oxygen during recovery. https://dailyburn.com/life/fitness/high-intensity-hiit-workout/

I track my progress using "Fit Bit Charge 5" which is a worn device (much like a watch) that measures a host of bodily KPIs, but for this case study, I am interested in tracking the MINUTES spent in "Fat-Burn Mode," (Zone 1) the minutes spent in Zone 2 (Cardio) and the minutes spent in Zone 3 (Peak). The relevance is consistent with the research by Taylor & Fayol, the Gilbreths, Gillette, and Dana, where the weighting is not the same. You "earn" one minute for every minute you are in Zone 1, but for each minute in Zone 2 or Zone 3, you earn TWO minutes for every minute in these zones. (To all the Earned Schedule advocates, are you paying close attention to this?) So the OBJECTIVE is to OPTIMIZE THE WORKOUT to achieve the highest possible EARNED MINUTES given a STANDARDIZED workout, including rest periods. As I only got my FitBit for Christmas, I don't yet have enough DATA to determine what COMBINATION of Repetitions, Weight, Rest Periods, and any other variables will consistently yield the MOST EARNED MINUTES. (To anyone trying to link EVM to "Benefits Realization"- "Earned Minutes" in this example MAY translate theoretically into potential HEALTH BENEFITS, but no GUARANTEES that I will or will not become more healthy, which is why I cannot see how using EVM enables us to track BENEFIT REALIZATION.) Note that when I have sufficient data, I will experiment using MS Power BI and also AI's Chat GPT to do the optimization analysis.

Figure 4- FitBit Zones



Here is the actual RECORDED DATA to date:

		Variables					Input data				Calculated Values					
Day	Date	Total Weight in Kilos	Total Weight in Pounds #	Number of Repetitions (Count)	Rest Time in Minutes	Planned Time in Minutes	Actual Time in Minutes	Zone 1- Fat Burn in Minutes	Zone 2- Cardio in Minutes	Zone 3- Peak in Minutes	TOTAL EARNED Minutes	Earned/ Actual (CPI)	Earned/ Planned (SPI)	Total Calories Burned	Calories/ Actual Time (Mins)	Calories/ Earned Time (Mins)
M	09-Jan-23	14,280	31,416	50	3	90	91	46	24	22	92	1.01	1.02	217	2.38	2.36
W	11-Jan-23	14,280	31,416	50	3	90	91	51	39	12	102	1.12	1.13	303	3.33	2.97
F	13-Jan-23	14,280	31,416	50	3	90	91	46	26	20	92	1.01	1.02	207	2.27	2.25
M	16-Jan-23	14,280	31,416	50	3	90	88	62	28	34	124	1.41	1.38	320	3.64	2.58
W	18-Jan-23	14,280	31,416	50	3	90	91	85	35	50	170	1.87	1.89	349	3.84	2.05
F	20-Jan-23	14,280	31,416	50	3	90	91	83	23	60	166	1.82	1.84	379	4.16	2.28
M	23-Jan-23	14,280	31,416	50	3	90	87	66	36	30	132	1.52	1.47	309	3.55	2.34
W	25-Jan-23	14,280	31,416	50	3	90	89	48	24	24	96	1.08	1.07	252	2.83	2.63
F	27-Jan-23	14,280	31,416	50	3	90	88	41	21	20	82	0.93	0.91	186	2.11	2.27
M	30-Jan-23	14,280	31,416	50	3	90	83	59	29	30	118	1.42	1.31	294	3.54	2.49
W	01-Feb-23	14,280	31,416	50	3	90	85	62	26	36	124	1.46	1.38	276	3.25	2.23
F	03-Feb-23	14,280	31,416	50	3	90	69	79	33	46	158	2.29	1.76	362	5.25	2.29
M	06-Feb-23	14,280	31,416	50	3	90	76	67	37	30	134	1.76	1.49	147	1.93	1.10
W	08-Feb-23	14,280	31,416	50	3	90	83	56	32	24	112	1.35	1.24	283	3.41	2.53
F	10-Feb-23	14,280	31,416	50	3	90	91	57	25	32	114	1.25	1.27	254	2.79	2.23
M	13-Feb-23	14,280	31,416	50	3	90	82	64	28	36	128	1.56	1.42	267	3.26	2.09
W	15-Feb-23	14,280	31,416	50	3	90	83	77	35	42	154	1.86	1.71	315	3.80	2.05
F	17-Feb-23	14,280	31,416	50	3	90	82	63	33	30	126	1.54	1.40	305	3.72	2.42
M	20-Feb-23	14,280	31,416	50	3	90	87	83	43	40	166	1.91	1.84	370	4.25	2.23
W	22-Feb-23	14,280	31,416	50	3	90	79	102	38	64	204	2.58	2.27	390	4.94	1.91
F	24-Feb-23	14,280	31,416	50	3	90	71	70	34	36	140	1.97	1.56	325	4.58	2.32
M	27-Feb-23	14,280	31,416	50	3	90	77	100	40	60	200	2.60	2.22	401	5.21	2.01
W	01-Mar-23	14,280	31,416	50	3	90	91	68	34	24	126	1.38	1.40	222	2.44	1.76
F	03-Mar-23	14,280	31,416	50	3	90	84	62	36	26	124	1.48	1.38	303	3.61	2.44

Figure 5- Showing Planned vs. Actual Data Over Time with EVM Calculations (Earned TIME)[24]

[24] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

Lastly, before we want to conduct any "data analysis," we first want to validate that our workout process is both CAPABLE in measuring what we are targeting and IN CONTROL using "Statistical Process Control Charts" (SPC).

Day	M	W	F	M	W	F	M	W	F	M	W	F	M	W	F	M	W	F	M	W	F	M	W	F
Date	09-Jan-23	11-Jan-23	13-Jan-23	16-Jan-23	18-Jan-23	20-Jan-23	23-Jan-23	25-Jan-23	27-Jan-23	30-Jan-23	01-Feb-23	03-Feb-23	06-Feb-23	08-Feb-23	10-Feb-23	13-Feb-23	15-Feb-23	17-Feb-23	20-Feb-23	22-Feb-23	24-Feb-23	27-Feb-23	01-Mar-23	03-Mar-23
SPI	1.02	1.13	1.02	1.38	1.89	1.84	1.47	1.07	0.91	1.31	1.38	1.76	1.49	1.24	1.27	1.42	1.71	1.4	1.84	2.27	1.56	2.22	1.41	1.38
CPI	1.01	1.12	1.01	1.41	1.87	1.82	1.52	1.08	0.93	1.42	1.46	2.29	1.76	1.35	1.25	1.56	1.86	1.54	1.91	2.58	1.97	2.6	1.38	1.48
USL	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
LSL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Target	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
StDev	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.408	0.4079	0.4079	0.4079	0.408	0.408	0.408	0.408	0.4079	0.4079	0.4079	0.408	0.408	0.4079
UCL +3	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.757	2.7565	2.7565	2.7565	2.757	2.757	2.757	2.757	2.7565	2.7565	2.7565	2.757	2.757	2.7565
Mean	1.533	1.533	1.533	1.533	1.533	1.533	1.533	1.533	1.533	1.533	1.533	1.5327	1.5327	1.5327	1.533	1.533	1.533	1.533	1.5327	1.5327	1.5327	1.533	1.533	1.5327
LCL -3	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.309	0.3089	0.3089	0.3089	0.309	0.309	0.309	0.309	0.3089	0.3089	0.3089	0.309	0.309	0.3089

Figure 6- This is the same data from Figure 5 set up to generate a Statistical Process Control Chart[25]

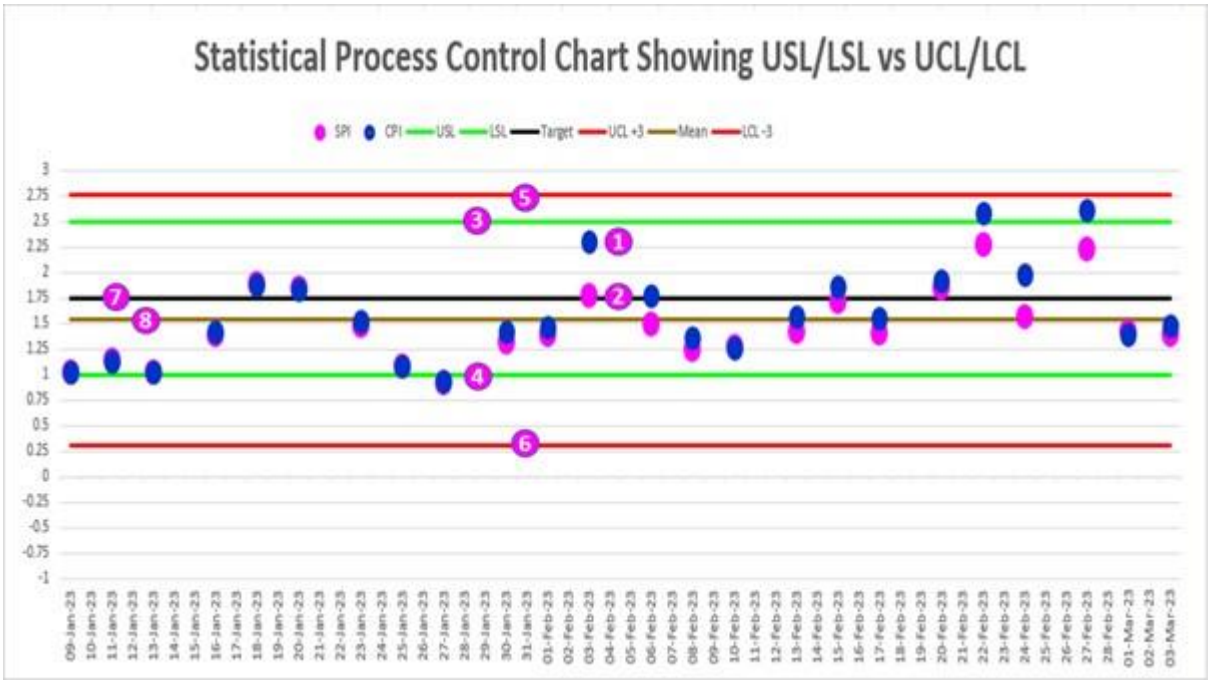


Figure 7- Data from Figure 6 shown as a Statistical Process Control Chart[26]

Figure **(7.1)** shows the daily SPI values, while in Figure **(7.2)**, we have logged the daily CPI values. In figure **(7.7)**, we have the AVERAGE or target value of 1.75 earned minutes per minute of exercise, while in Figure **(7.3)**, we see the UPPER SPECIFICATION LIMIT (USL) and in Figure **(7.4)**, we find the LOWER SPECIFICATION LIMIT (LSL). It is the USER who defines these values. In Figure **(7.5)** is the UPPER CONTROL LIMIT (UCL), while Figure **(7.6)** is the LOWER CONTROL LIMIT (LCL). Unlike the USL and LSL, which are user-defined, the UCL and LCL are CALCULATED values, which according to Deming, are +/- 3 Standard Deviations

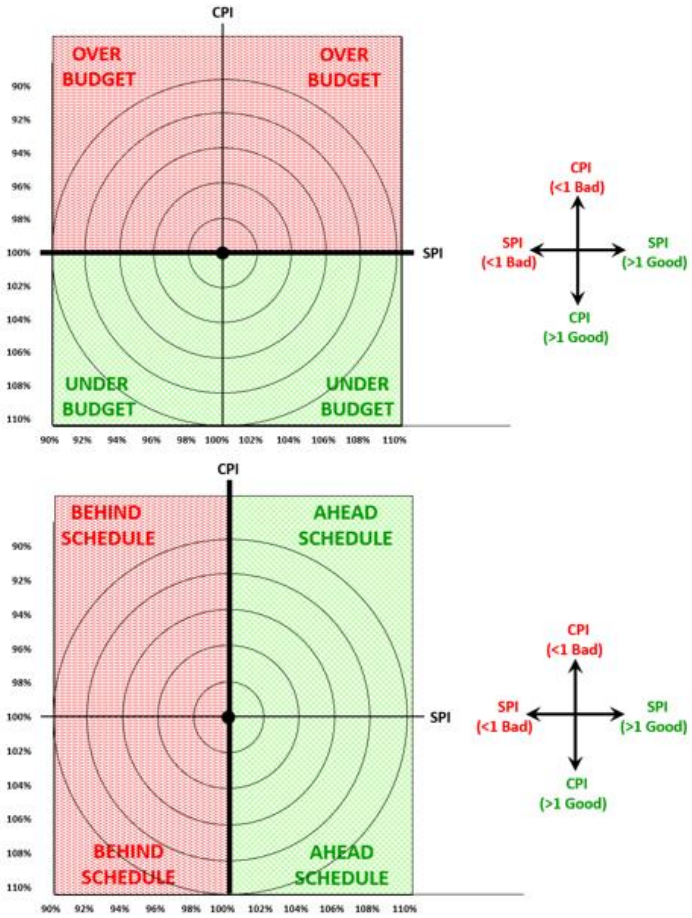
[25] [25] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.
[26] For an EXCELLENT resource on using Excel for Statistical Process Control Charts, visit "SPC for Excel" https://www.spcforexcel.com/home Even if you don't purchase their software, they do an OUTSTANDING job explaining how to read and interpret the results to help us make sound management decisions.

(Sigma) from the Statistical Mean. A simplistic SPC analysis shows the Workout Process is IN STATISTICAL CONTROL (No readings falling outside of the UCL or LCL) and is CAPABLE of meeting the TECHNICAL SPECIFICATIONS. (Most readings fall between the USL and LSL)

Now that we have established empirical evidence that our workflow processes are both IN STATISTICAL CONTROL AND are CAPABLE OF MEETING the SPECIFICATIONS or TARGETS, we can now start to look in more detail to learn what modifications to the workflow process are producing POSITIVE results and which are moving us in the wrong direction.

Before I get too involved in explaining case studies, several people asked me why I violated convention by ranking the CPI scale (Y-axis) in DESCENDING order from top to bottom, and the explanation is simple. Based on client feedback- what our paying clients wanted to see on their dashboards- was a gauge that showed any readings ABOVE the SPI line (X-axis) as being OVER BUDGET, likewise, any readings BELOW the SPI line (X-axis) are UNDER BUDGET.

Figure 8- CPI vs. SPI "Bullseye Chart" Explained more



The same thinking applied to the CPI (Y-axis) line. Any reading to the left of the CPI line (Y-axis) is BEHIND SCHEDULE, while anything to the RIGHT of the CPI line (Y-axis) is AHEAD of SCHEDULE.

As Abraham Lincoln told us, "you can please some of the people all of the time, and you can please all of the people some of the time, but you cannot please all of the people all of the time. So I will leave it up to you to determine which convention most effectively communicates the message to your clients and stakeholders as clearly and simply as possible.

As we can see from Figure 9, by cross-referencing what is shown here against what Gillette and Dana taught us, we can create an ANALYSIS using the SPI and CPI to compare our COST and TIME EFFICIENCY against our TARGET. And as Deming taught us with his "Red Bead/White Bead" experiment, every process ("workflow") has NATURAL VARIABILITY.

For any hunters or target shooters, this graph allows us to visually see the variability of our workflow processes by tracking where our "bullets" are landing relative to the target "Bullseye." We can also see if any TRENDS are developing, which, if we look, we can see that although the readings vary (Deming's natural variability) that the overall trend is towards "Under Budget" and "Ahead of Schedule," which is

exactly what we want- that our exercise routine is delivering MORE value or potential benefit for the investment in time and energy.

Figure 9 shows that our "bullseye" is a CPI vs. SPI MATRIX between 1 and 2.5 or BETTER if possible. Explained another way. What we are trying to find out is what combination of variables (repetitions, weights, rest periods, etc.) will yield the MOST BENEFIT (measured by Earned Minutes) given a target or "STANDARD time frame (i.e., 90 minutes)

Date	Work-Out #	SPI	CPI
08-Jan	0	1.00	1.00
09-Jan	1	1.01	1.02
11-Jan	2	1.12	1.13
13-Jan	3	1.01	1.02
16-Jan	4	1.41	1.38
18-Jan	5	1.87	1.89
20-Jan	6	1.82	1.84
23-Jan	7	1.52	1.47
25-Jan	8	1.08	1.07
27-Jan	9	0.93	0.91
30-Jan	10	1.42	1.31
01-Feb	11	1.46	1.38
03-Feb	12	2.29	1.76
06-Feb	13	1.76	1.49
08-Feb	14	1.35	1.24
10-Feb	15	1.25	1.27
13-Feb	16	1.56	1.42
15-Feb	17	1.86	1.71
17-Feb	18	1.54	1.40
20-Feb	19	1.91	1.84
22-Feb	20	2.58	2.27
24-Feb	21	1.97	1.56
27-Feb	22	2.60	2.22
01-Mar	23	1.38	1.40
03-Mar	24	1.48	1.38

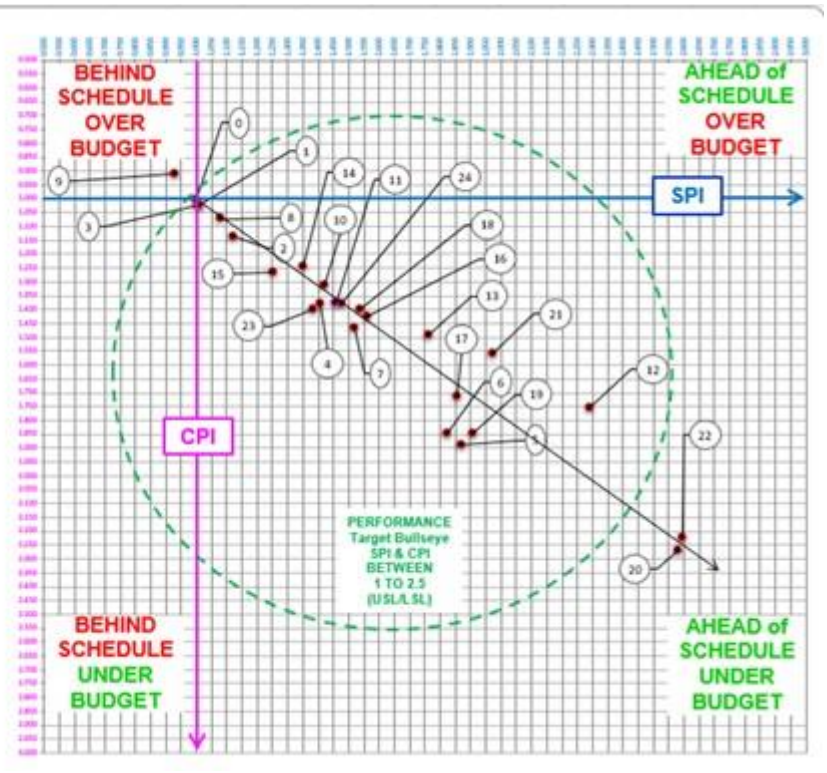


Figure 9 - CPI vs. SPI "Bullseye Chart" With Data from Figure 5[27]

In Figure 9, each "bullet hole" represents a single workout based on the X-Y score of CPI (Y-Axis) and SPI (X-Axis). As explained above, anything BELOW the SPI line is UNDER BUDGET, and anything OVER the SPI line is OVER BUDGET. Likewise, any reading to the LEFT of the CPI line is BEHIND SCHEDULE, while any reading to the RIGHT of the CPI line is AHEAD OF SCHEDULE.

What this very powerful graph tells us at a single glance is:

1) Is our project in trouble in terms of TIME? COST?
2) IF our project is in trouble, how much? Just a little bit or a lot?
3) Is our performance improving (getting closer to the bullseye or heading in a South-easterly direction), or are we heading Northwest, getting worse?

Each circled number represents the SPI vs. CPI of a single workout in sequential order, and as you can see, our existing exercise regime is NOT consistently "hitting our bullseye." Given that our objective is to

[27] [27] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

maximize the "earned minutes," which at least in theory should produce "Health Benefits," what we want to look at are any "bullets" that fall outside the Lower (1.00) and Upper (2.50) Specifications limits. We look at reading #9 in the upper left-hand quadrant and see what happened during that workout, noting that we do NOT want to repeat that. On the other hand, if we look at readings #20 and #22 and as we EXCEEDED the target efficiencies, we want to see what factors enabled us to beat our target SPI (time efficiency) and CPI (cost efficiency).

While not definitely seen in the day-on-day numbers, it does appear there is a general trend that we are heading in a south-easterly direction- towards the "below cost and ahead of schedule" quadrant.

Now the question is, looking at this information, will what is shown on these dashboard gauges be important to you as an OWNER? How about you as a CONTRACTOR? Should this information be something you are MANDATED to use, or is it so important to you in helping you make tactical and strategic decisions that you will use it voluntarily?

As a contractor with 50+ years of experience working on projects with single-digit net profit margins and winning only 1 in 5 of the projects we bid, we believe we have been able to stay in business by using what Gillette and Dana showed us, updated for use in Excel and Access databases as shown in Figures 7, 9 and

Experiment #2- Earned Value Management being used by the Gold Mining Reality TV Shows[28]

As the vast majority of our clients come from the oil, gas, and mining sectors, every week, I watch the various gold mining reality shows on the Discovery Channel.

- ✓ Gold Rush Season 13- https://www.tvinsider.com/show/gold-rush/
- ✓ Dave Turin's Lost Mine- https://www.tvinsider.com/show/gold-rush-dave-turins-lost-mine/

While I reference episodes from both shows, I have a special interest in Dave Turin's Lost Mine, Season 4. Why? Because having lived in Valdez, Alaska, for 2 years while working as a project controls manager for Norcon constructing Alyeska's Ballast Water Treatment Plant, and while there, as Glacier Creek runs right next to Valdez, my kids and I spent many happy (but cold) hours panning for gold in this same river. (With some minimal success) This mine is not as remote as it may look on TV, being located only about 5-6 miles north of Valdez, AK.

Notwithstanding any debates about how "real" these programs are, for the purposes of analyzing how they use the fundamental tools & techniques associated with Earned Value Management, here are the basic facts. The mining season lasts approximately 6 months (26 weeks), starting in mid-April or early May and ending between the middle of October to mid-November. So one of the major risk factors is how early you can start mining and how long you can mine gold before the weather ends your ability to mine. For Turin's mining operations, he bases his plans on 6 months (26 weeks) from mid-April to mid-October. These shows also highlight the reasons why I am no fan of using "Integrated Master Plans" and advocate the use of "Rolling Wave Planning" (Known as "SCRUMS" or "SPRINTS" by our IT colleagues.) for use in running our business. At least in construction, there are too many variables to try to create a "plan" that, as Field Marshall Helmuth von Moltke told us way back in 1865, "survives first contact with the enemy" or the immortal words of wisdom from General Dwight Eisenhower who told us in 1951 that "plans are

[28] [28] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

useless but planning is essential." Watch a few episodes to understand why long-range "planning" is, IMPO, largely a waste of time.

The normal work week is 10 – 12 hours per day, 7 days a week. Consistent with Taylor, Fayol (also a mining engineer), the Gilbreths, Gillette, and Dana, payment is based on a 5% per person share of the gold mined over and above the amount of gold required to cover the operating costs. While we can certainly debate how "real" these reality shows are and the fact that the participants are also well-paid as actors/actresses, there is no question that they all exemplify how Earned Value Management is used in much the same way as Gillette and Dana described it 120 years ago.

As shown in Figure 10 below, I have compiled the data from each Episode. This case study was chosen so that anyone interested in more details can watch each episode to understand the REALITIES of most projects, especially those in construction. Another reason this case study was chosen is that it is very similar to our most successful REAL PMO case study, which is the savings that Freeport Indonesia Copper and Gold mine realized by implementing a PMO based on earned value management that documented savings of USD 65 million over a 4 year period.[29], [30] So while this example has been chosen so that anyone can follow up with the details, it also reflects a very real and very successful "PMO Implementation."

Worth mentioning at this point is that consistent with what we know from Frank and Lillian Gilbreth's research, along with that of Taylor and Fayol, that both Dave Turin (in Episode 9) and Parker Schnabel in "Gold Rush- Season 10" used "Motion and Time Study" tools and techniques to OPTIMIZE their workflow processes. This stands as more irrefutable evidence that the ultimate roots of Earned Value hark back to the work of Taylor, Fayol, Gilbreths, Gillette, and Dana and that the OBJECTIVE of the Earned Value Data is to continuously improve or optimize the workflow process. This is the SECRET to "selling" the importance of EVM Tools & Techniques for general applications beyond construction and manufacturing. (See "Gold Rush- Season 10 "Hiring Jessica" https://www.youtube.com/watch?v=87sLm_JdAmw and https://www.youtube.com/watch?v=Gt8LMlmUIY4)

Notably, as Parker Schnabel learned the hard way in Season 10, employees do not perceive motion and time studies[31] very favorably, thus, we need to be very cautious in introducing this practice. This is even worse with the proliferation of CCTV cameras in the workplace, used for security purposes. For better or worse, using facial recognition software, these security cameras also can be used for productivity analysis.

[29] Freeport McMoran Indonesia Copper and Gold Mine Case Study (2004-04) https://build-project-management-competency.com/ptmc-training-standards-and-specifications-individual/
[30] Wibiksana (2013) https://pmworldlibrary.net/wp-content/uploads/2013/01/PMWJ2-Sep2012-WIBIKSANA-EVM-Adapted-for-UndergroundMining-StudentPaper.pdf
[31] Monsters & Critics (2019) "Parker Schnabel angers his entire crew in Gold Rush exclusive preview" https://www.monstersandcritics.com/tv/parker-schnabel-angers-his-entire-crew-in-gold-rush-exclusive-preview/

Earned Value Applied to Dave Turin's "Glacier Creek Mine", Valdez, Alaska https://www.amazon.com/Gold-Rush-Dave-Turins-Season/dp/B09X1CTW99/ref=atv_pr_sw_sc			
Season Length (Worst Case)	20.00	Weeks	$1,955,000
Season Length (Best Case)	30.00	Weeks	
Original Target Production	600.00	Ounces	
Wash Plant Capacity			
Original "Old Dan" (35 or 50?)	35.00	CY/Hour	
Roach	100.00	CY/Hour	
Eagle	200.00	CY/Hour	$905,165
Actual Start	W7		
Actual Finish	W20		
Revised Target Production	450.00	Ounces	$368,085
Actual Production 463 W20	463.00	Ounces	
Revised Target Production	450.00	Ounces	
Actual Production 463 W20	463.00	Ounces	
Average Price Gold/OZ	$1,955.00		
Average Cost to Mine/Oz	$795.00		
	Ounces/Wk	Oz/Cum	Episode
W0	0.00	0.00	
W1	0.00	0.00	
W2	0.00	0.00	
W3	0.00	0.00	
W4	0.00	0.00	
W5	0.00	0.00	EP 1
W6	0.00	0.00	EP 2
W7	0.00	0.00	EP 3
W8	8.25	8.25	EP 4
W9	12.95	21.20	EP 5
W10	18.60	39.80	EP 6
W11	54.10	93.90	EP 7
W12	40.65	134.55	EP 8
W13	48.85	183.40	EP 9
W14	27.00	210.40	EP 10
W15	31.60	242.00	EP 11
W16	25.55	267.55	EP 12
W17	53.40	320.95	EP 13
W18	61.90	382.85	EP 14
W19	50.10	432.95	EP 15
W20	30.05	463.00	EP Bust?
W21			
W22			

Figure 10- Input Data Compiled by Watching the Videos[32]

[32] [32] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

As a lot of cost and productivity information needs to be converted from Metric Tonnes to Troy Ounces, there are 32,150.75[33] ounces of 24k gold per metric tonne, and one of the major "unknown" risks is how much gold each ton of paydirt contains. While none of the gold mining shows tell us the actual costs, research indicates that $795 "all inclusive" costs to mine an ounce of placer gold, ranging between $650 and $825 per ounce in North America.[34] These costs will be used to demonstrate how these companies are using the fundamental tools & techniques associated with what we call "Earned Value Management," which, at least as advocated by Gillette, Dana, Taylor, and Fayol, is nothing more than "applied common sense"- that there is empirical evidence that many people are using these "tools and techniques" even though they don't call what they are doing "Earned Value Management."

Here is the "Cost and Resource Loaded Schedule." (Note that IMPO, there is no need to cost or resource load MSP or P6. Excel or Access works just fine in all but the largest, most complex projects, a "lesson learned" from our experiences with Freeport)

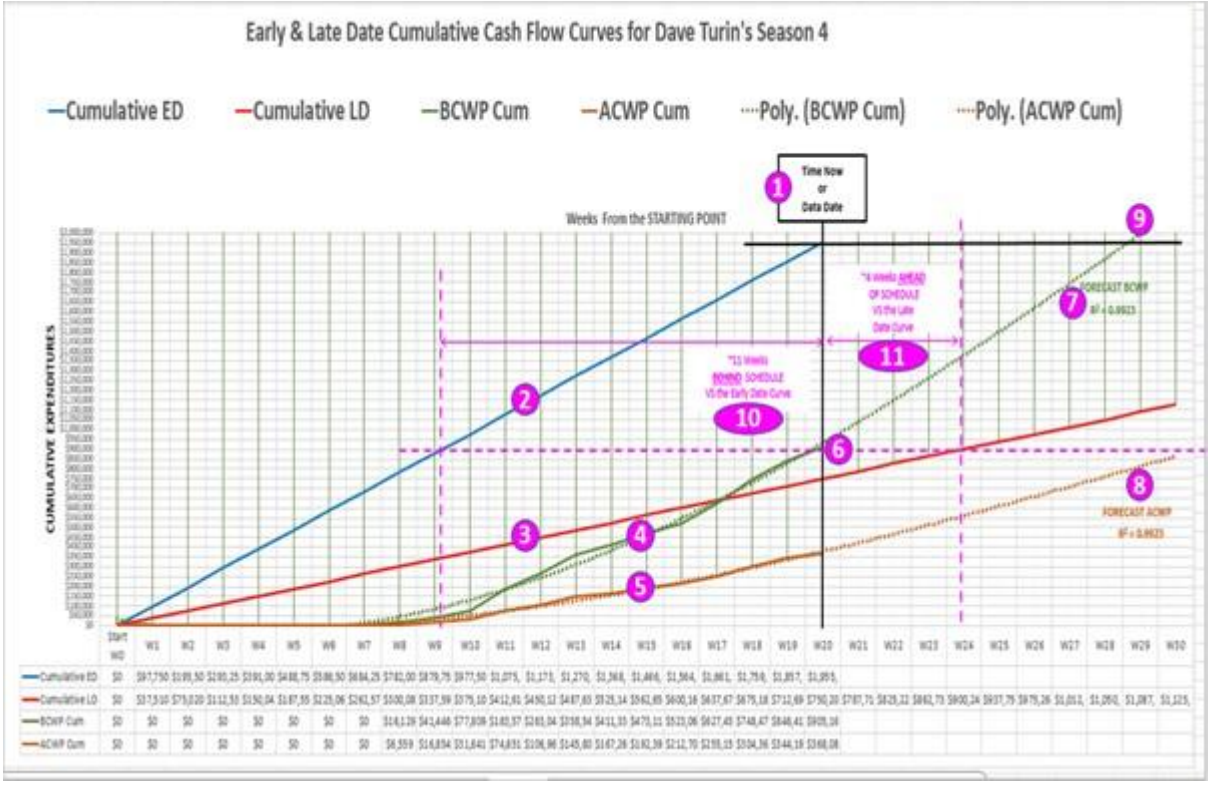


Figure 11- Input Data from Figure 10 set up in an Excel Spreadsheet for Earned Value Analysis[35]

This starts with the Data Date or "Time Now" line **(11.1**), which is now at the END of the season (W20). While we are showing the end of the "project," this same analysis would have been performed at the end of each week from the beginning. **(11.2)** This line is the Early Date Curve, which, because we are

[33] https://www.traditionaloven.com/metal/precious-metals/gold/convert-tonne-metric-t-of-gold-to-troy-ounce-tr-oz-gold.html
[34] Ibid
[35] [35] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

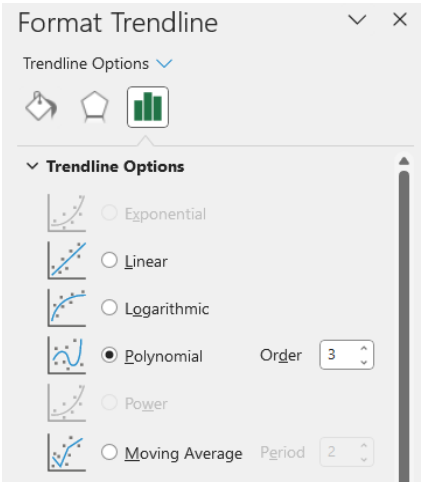
monitoring an OPERATIONAL project, we do not use S curves but divide the target production (600 ounces of gold) divided by the number of weeks (20), yielding the original target production per week. (30 oz). You can see this is exactly how we set up the Freeport McMoran EVM analysis, which you can see if you go HERE https://build-project-management-competency.com/ptmc-training-standards-and-specifications-individual/ and scroll down to Slide #21. Likewise, line **(11.3)** shows us the Late Date Curve. Using the same formula- 600 ounces of gold/30 weeks = production target of 20 Troy Oz/Week. As we can see, Dave and his team also used a form of "TCPI" (To Complete Performance Index) by taking the cumulative target production to date – Actual Production (Earned Ounces)/remaining weeks. As they started late, this value is now up to 53 Ounces Per Week.

Line **(11.4)** is our BCWP or "Earned Value" calculations which are calculated by multiplying the actual number of ounces of gold weighed at the end of each week X the average market value of an ounce of gold between April and October of 2021, which is $1,995 per ounce.[36] Line **(11.5)** shows us the ACWP from when we actually started production in W7 until the end of the season in W20. By comparing the BCWP to the ACWP, we can see that IF our ACWP was correct (and that number is not ever divulged in the show), so we used an AVERAGE of $795/ounce), indicating that to the degree the $795 was accurate, that this operation was actually quite profitable.

Point **(11.6)** indicates where our BCWP line **(11.4)** intersects our Time Now Line **(11.1)**, and we can see if we draw a horizontal line from Point **(11.6)** until it intersects the BCWS ED curve **(11.2**) and the BCWS LD Curve **(11.3)** we can see that we ended up the season 11 weeks LATE against the ED schedule **(11.10)** but 4 weeks AHEAD against the LD Schedule. **(11.11)** Here is yet another example showing that "earned time" or "earned schedule" is now and always has been an integral part of Earned Value Management dating back to the days of Taylor, Fayol, Gantt, Gillette, and Dana.

But there is even more!!!

Figure 12 "Best Fit Options



Using the "Best Fit" ("Add Trendline") curve feature in Excel, we can use the actual data to FORECAST both the BCWP lines **(11.7)** and the ACWP lines **(11.8)** into the future, which shows us in **(11.9)** that had Dave started at the very beginning of the season, he would have come very close to achieving his original goal of 600 Troy Ounces. To determine which "Best Fit" curve to use, we want the X^2 value to be as high as possible, certainly above 0.90, usually requiring us to use one of the polynomial forecasts. (2nd, 3rd or 4th Order Polynomial) Over 30 years using this method has proven much more ACCURATE, PRECISE, RELIABLE, and VALID in forecasting the EAC time and EAC cost than using "Earned Time" or "Earned Schedule." For more on this topic, reference this paper from another of our top students, Stephen Patterson, on FORECASTING EAC Time & Cost.[37]

[36] Gold Prices 100 Year Historical Chart (n.d.) https://www.macrotrends.net/1333/gold%20price
[37] Patterson, Stephen (2018) "A Comparison Between 8 Forecasting Methods" https://pmworldlibrary.net/wp-content/uploads/2018/01/pmwj66-Jan2018-Paterson-comparison-of-8-common-forecasting-methods-featured-paper.pdf

Looking at point **(11.6)**, we can see that, based on the "real" productivity, we achieved the REVISED number of ounces of gold from 600 down to 450. In fact, we actually beat the revised target by 13 ounces. (463 ounces) Also, if you look at point **(11.9),** you can see that IF we continued the weekly production as forecast **(11.8)** using the Excel "Best Fit" feature, we can see that we would have come very close to achieving our target of 600 ounces by week 29. Why is that important for us to know for next year? Because we started LATE by 7 weeks and our PROJECTED FINISH was week 29, we know that IF we can start next year on time, there is a reasonable probability that we will finish in 29 – 7 = 22 weeks, which is well within the normal range duration estimate for a season. This is the real beauty of using EVM Data as a powerful management tool.

We can see that the forecast BCWP line **(11.7)** and ACWP line **(11.8)** are DIVERGING, which is an indication of how well we are managing our COSTS in such a way that each ounce of gold we mine is actually MORE profitable as the ratio between the costs of production and market value of the gold being produced is DIVERGING. Of course, it could have been CONVERGING or tracking in parallel, which we need to know and understand when making any number of management decisions.

Lastly, we can see from the line **(11.10)** and **(11.11)** by applying the concepts of "Earned Time" or "Earned Schedule" (which is now and always has been the basis for earned value as documented by Taylor, Fayol, Gillette, and Dana et al.) we can see that we achieved our REVISED target of 450 ounces of gold during W20, which is 11 weeks behind the EARLY DATE curve but 4 weeks AHEAD of the LATE DATE CURVE. We can also see that the BEST we could produce 600 ounces was in 20 weeks, and the absolute worst case (constrained by weather) is 30 weeks. This knowledge is critical for planning the following year's production and investment decisions.

To address an important issue raised by Dr. Ken Smith in last month's article "Earned Value! Are you doing it right? Wrong? Or Not at all?"[38] while all of these values are an approximation, the level of granularity can be whatever we feel is necessary and appropriate to effectively "manage" the costs and productivity. ("Process Workflow") So while we have used the AVERAGE market value of an ounce of gold, if we wanted to be more accurate, we could have used the actual gold price on the day we measured the production at the end of the week. Likewise, we could have done the same for the **(11.5)** "Actual Cost of Work Performed" (ACWP) Line. For the purposes of this analysis, we used an AVERAGE "all-in" cost per ounce of $795. IF we had wanted to increase our data's ACCURACY, RELIABILITY, PRECISION, and VALIDITY, we could have recorded the actual weekly costs down to the penny. And we could have further broken them down into Direct vs. Indirect costs or any other cost breakdown structure we feel necessary to manage those costs effectively. (For more on Activity Based Costing/Activity Based Management, see these three articles:

1) https://pmworldlibrary.net/wp-content/uploads/2018/04/pmwj69-Apr2018-Giammalvo-ERP-and-BIM-Omniclass-coding-marriage-featured-paper-1.pdf
2) https://pmworldlibrary.net/wp-content/uploads/2019/02/pmwj79-Feb2019-Giammalvo-Activity-Based-Costing.pdf

[38] Smith, K. F. (2023). EARNED VALUE ALERT! *Are You Doing It Right, Wrong, or At All?* commentary, *PM World Journal*, Vol. XII, Issue III, March. Available online at https://pmworldjournal.com/wp-content/uploads/2023/03/pmwj127-Mar2023-Smith-earned-value-alert-commentary.pdf

3) https://www.studocu.com/row/document/north-south-university/managerial-accounting/implementing-activity-based-management/9970383

Experiment #3- Earned Value Management for Earning a Masters Degree in Project Management

Earned Value Applied to Earning a Master of Science in Project Management from George Washington University	Duration (Weeks)	Credit Hours	Cost/Credit Hour = $1,395	Est Hours Homework Planned (6 hours per Credit Hour per week)	Cost /Lot Hour $50	Total Cost Per Course	Percent Complete	Earned Time (Credit Hours)	Earned Value	Actual Hours Homework	Actual Cost of Each Course @ $50/hour	Total Actual Cost of Program
DNSC 6250, Project Economics and Finance, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6252, Risk Analysis for Decision Making, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6254, Risk Measurement and Management, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6251, Cost Estimation and Control, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6255, Collaborative Decision Making and Portfolio Optimization, 3	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6261, Project Management Principles, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6262, Directed Computational Project Management, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6267, Planning and Scheduling, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6290, Special Topics, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
MBAD 6224, Decision Making and Data Analysis, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6210, Decision and Risk Analytics, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6218, Time Series Forecasting for Analytics, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
DNSC 6225, Business Process Simulation, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6237, International Project Management, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6239, Project Governance, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6302, Programming for Analytics I, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6303, Programming for Analytics II, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
DNSC 6306, Decision Models, 1.5 Credit	7	1.5	$2,993	63	$3,150	$6,143		0	$0		$0	$2,993
MGT 6210, Leading Teams, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
MGT 6215, Conflict Management and Negotiations, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
MGT 6253, Leadership and Executive Development, 3 Credits	14	3	$5,985	126	$6,300	$12,285		0	$0		$0	$5,985
TOTALS	224	48		2016	$100,800	$196,560		0	0			$95,760
Required Hours to Graduate 30 credits, including 24 credits in REQUIRED COURSES							0%	0				
Required Hours to Graduate 30 credits, including 6 credits in ELECTIVE COURSES							0%	0				
Required Hours to Graduate= 30 credits							0%	0				
Best Case Duration (Months)	12	Mo										
Worst Case Duration (Months)	24	Mo										
Most Likely Duration (Months)	15	Mo										
Mean Duration	17	Mo										
Sigma	2	Mo										
P40 (- .23 Sigma)	14.5	Mo										
P50 (Mean)	17.0	Mo										
P75 (+ .68 Sigma)	19.1	Mo										
P90 (+1.29 Sigma)	19.6	Mo										
Original Budget (Tuition)	$93,850											
Original Budget (Homework Budget)	$63,000											
Total Original Budget (BAC)	$102,850											

Figure 13- Input Data From the GWU Master of Science Degree Requirements and Constraints[39]

This is a real case study I developed and implemented when earning my Master's degree in Project Management from George Washington University back in 2001 – 2002. This method also forms the basis for how I have been teaching Earned Value Management to our academic students and our corporate clients. The key to teaching EVM is to make it REAL for people. When you put them in the position where they have "skin in the game" (both in terms of time and money), you will find they not only develop an intimate understanding of EVM but are more effective in adapting the tools and techniques for different projects. (Contrary to the ANSI 748 C or D, not all EVM Tools & Techniques are appropriate or necessarily used on all projects every time)

The data shown in Figure 13 comes directly from the current George Washington University Masters Degree in Project Management. The challenge or objective is to create a plan to yield a duration as close as possible to all students' P50 (average) duration.[40]

In Figure 14 below, we see the FROM THE Data Date at the end of the 10th Month. **(14.1)** And we can see the Early **(14.2)** and Late Date S-Curves **(14.3),** understanding that because I was working full time, I knew

[39] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.
[40] GWU Master of Science Degree Requirements and Constraints (2023) https://business.gwu.edu/mspm

the ED curve was unrealistic (which, according to research by both Glenn Butts and Bent Flyvbjerg is more often than not, a norm) We can also see the BCWP curve **(14.4)** and the ACWP curve **(14.5)**

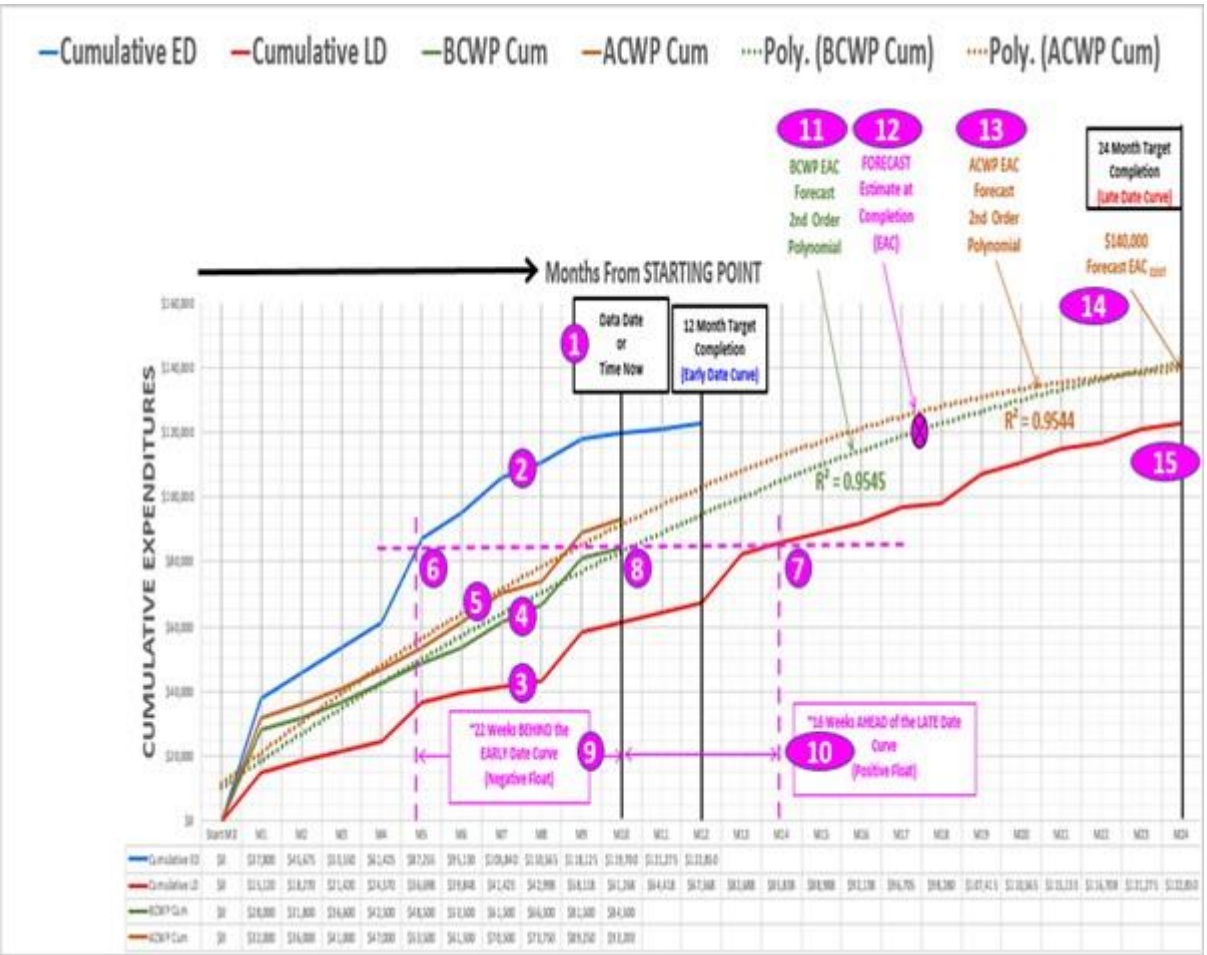


Figure 14- ED and LD Curves PLUS Actual (Leveled) Curve[41]

By drawing a horizontal line from where the BCWP (14.4) line intersects the Time Now Line **(14.1)** and EXTEND it to where it intersects the Early Date Curve **(14.6)** and Late Date Curve **(14.7),** we can apply the concept of "Earned Time" or "Earned Schedule" (which, as evidenced by the work of Taylor, Fayol, Gillette, and Dana et al., is now and always has been a core element of what has evolved into earned value) we can see that my actual performance lagged behind the ED curve by about 22 weeks (which is OK as we knew the ED curve was overly optimistic) and that I have a comfortable "safety buffer" of about 16 weeks before I am in danger of crossing the LD Curve, meaning I have negative float. The position where the BCWP **(14.4)** intersects the Time Now Line **(14.1)** is known as the LEVELLED CURVE and shows what is considered a desirable situation of a well-managed project, with actual progress being comfortably positioned roughly halfway between the ED and LD curves. As the difference between points **(14.6)** and **(14.7)** represents the TOTAL FLOAT on the project, the closer the BCWP-Time Now intersection gets to

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the LD Curve is the RISK TRIGGER. This is why when people show only the ED curve, it indicates they don't fully understand how to use the S-Curves and EVM effectively.

Line **(14.8)** utilizes the "Best Fit Curve" feature in Excel, and where the Best Fit Curve intersects a horizontal line between the BCWS ED and BCWS LD curve is where the FORECAST completion date is. **(14.9).** While it didn't matter in this case, we can also use the "Best Fit" curve feature to forecast the Cost at Completion **(14.10)** and **(14.11)**

For those interested in adapting this type of case study for use in an academic setting, here are three examples from two of our recent top graduates:
Ms. Anastasia Pratiwi- https://fabdap2022.wordpress.com/2022/09/20/w24-0_aa_earned-value-method-analysis-update-on-feed-project/ and https://fabdap2022.wordpress.com/2022/10/01/w25-0_aa_individual-performance-analysis/
Mr. Rizky Feryansiah- https://pioneeraace2022.wordpress.com/2023/03/31/w25-0_rf_individual-baseline-calculation-on-rf-projects-performance/comment-page-1/#comment-120

This is also a good time to follow up on an important issue Dr. Ken Smith raised in his March commentary "Earned Value! Are you doing it right? Wrong? Or Not at all?"[42] In this article, he raised the perfectly valid point that EVM data is almost always an APPROXIMATION rather than an accurate and precise value. In Figure 15 below, I use this case study to illustrate his point.

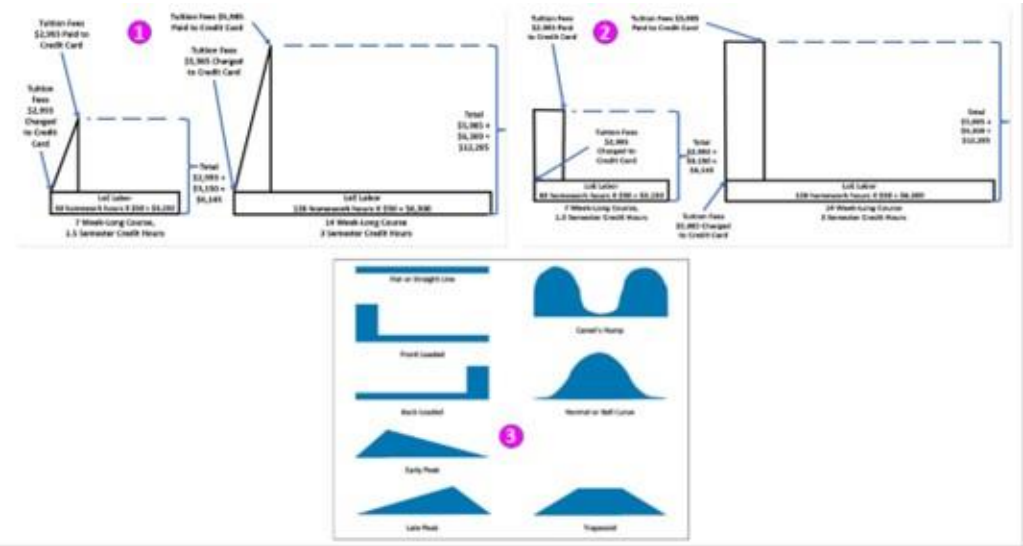

Figure 15- illustrates the Actual Cash Flows vs. the "As Shown" Cash Flows with the Options.

Illustrating the fact that the EVM data almost always contain some degree of approximations, you can see in Figure **(15.1)** what the actual cash flow was, where the bill for the course was charged against my credit card the moment I signed up for the course, but I had ~30 days before I had to pay the credit card bill. However, the labor portion of the course ran from the day I signed up until I finished the course. In Figure **(15.2),** you can see how it was shown in the S-Curve, where the Course fees were spread over 1

[42] Smith, K. F. (2023). EARNED VALUE ALERT! *Are You Doing It Right, Wrong, or At All?* commentary, *PM World Journal*, Vol. XII, Issue III, March. Available online at https://pmworldjournal.com/wp-content/uploads/2023/03/pmwj127-Mar2023-Smith-earned-value-alert-commentary.pdf

month for both the 1.5 Credit and 3 Credit hour course, while the Labor portion was spread over 8.6 weeks for the 1.5 credit course and 12.9 weeks for the 3 credit course.

While the labor portion could have been shown more "technically correct" if allocated using a trapezoidal or "turtle" distribution **(15.3),** over the years, I have failed to see any "added value" to be gained by going to this level of detail. At some point, "sound professional judgment" and "common sense" must be applied. As noted, MORE attention to detail is required to capture the ACWP and actual PRODUCTIVITY. This applies to both OWNERS and CONTRACTORS, but more so to contractors who use today's cost and productivity data to price and bid on tomorrow's projects.

Another example where there are approximations is given the classes were 7 and 14 weeks long; the duration of the 1.5 credit classes was shown as being two months (8.6 weeks) long, while the 3 Credit courses are shown as being 14.6 weeks long (3 months). In Figure **(15.3),** I have also shown the cost distributions you can choose from using MSP or Primavera's P6. Being candid, in the 50+ years I have been in this business using EVM as a core business competency, I almost always use "straight line" or "flat" distribution and have never had any problems either as an OWNER or CONTRACTOR.

Also worth noting is that I do not cost or resource load either MSP or P6. We use Excel or Access databases ONLY. Why? Because using Excel offers so many more options to analyze and present the data to the stakeholders, PLUS, if challenged, we can quickly show the formulas "behind the screen."

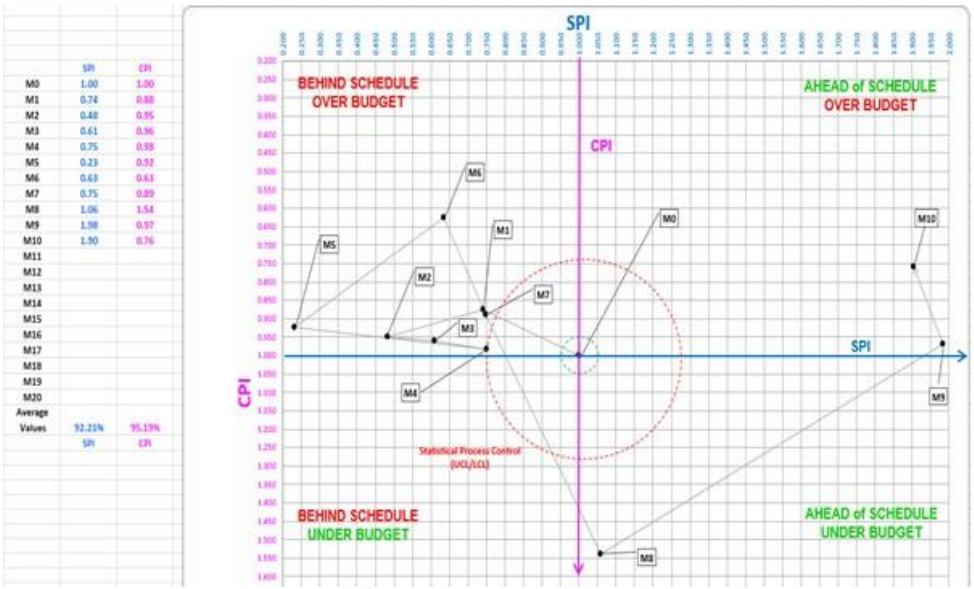

Figure 16- SPI vs. CPI Target Chart[43]

To explain how to use the SPI vs. CPI Target Chart shown in Figure 16, you can see that my actual performance from the Start through M7 was running LATE and OVER BUDGET. **(16.2)** Late because I was not taking the courses as originally planned, and the time I spent doing homework was in excess of what I had budgeted. Seeing I was falling behind in Months 8, 9, and 10, I used this information to "crash" the activities, and in doing so, I ended up catching up in terms of time but blowing my budget even more.

[43] To access full-size graphics and/or DOWNLOAD the Excel Templates, go HERE https://build-project-management-competency.com/1-4-1-11-unit-11/ Line Items 3548 to 4024 and Figures 101 to 114.

(16.3) These are the kinds of management decisions that are commonly made based on this specific dashboard gauge. Up to now, our focus has been on the SPI and CPI measured against the BCWS ED and BCWS LD data. For the Actual Costs and Actual Productivity, because we use today's cost and productivity data to cost or price and schedule tomorrow's projects, we tend to be far more ACCURATE and PRECISE in capturing and recording ACTUAL COSTS and ACTUAL PRODUCTIVITY because that is the data we are using to FORECAST cost and completion dates and in updating our cost and productivity databases, we want to ensure that forecasts and cost estimates are VALID and PRECISE.

Figure 17 shows examples of cost and productivity data when measured against the Upper and Lower SPECIFICATIONS Limits (UCL/LCL) and the Upper and Lower CONTROL Limits (UCL/LCL). Why

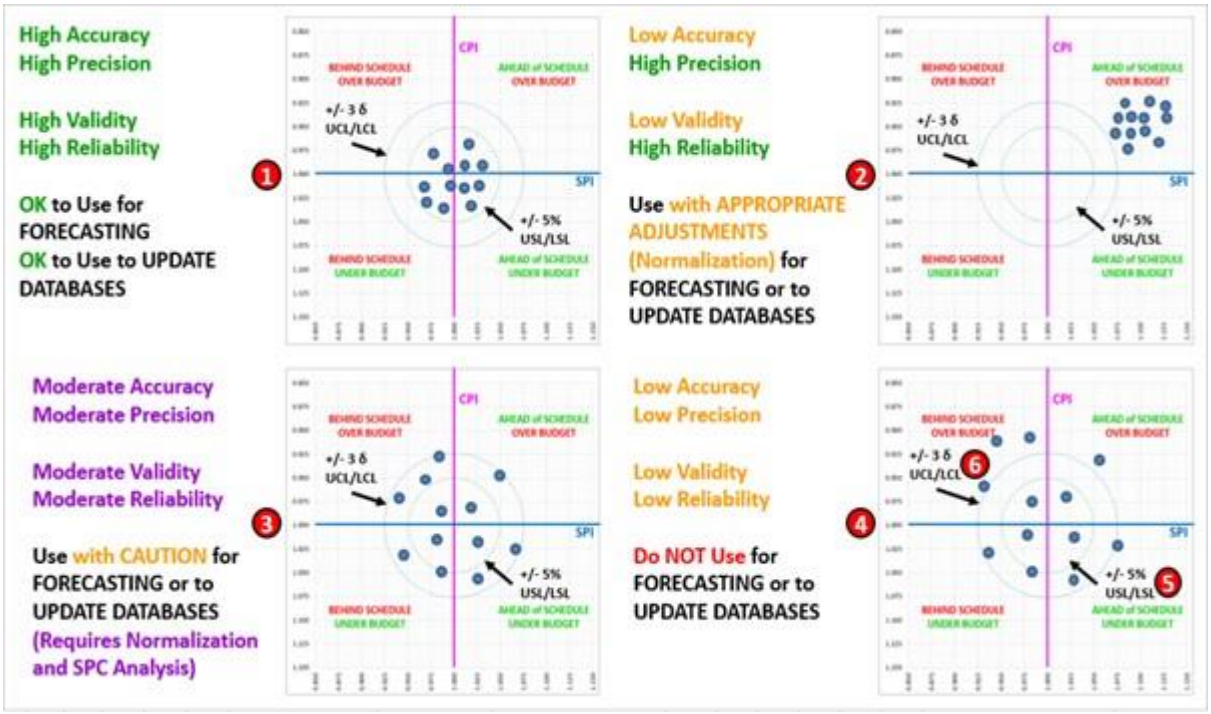

Figure 17- Showing the 4 Quality Standards we apply to the ACTUAL DATA (ACWP & BCWP)[44]

do we use SPI and CPI and not SV or CV? Because if we use money and enter that into our database, it means that each year we have to adjust the monetary values to bring them into "current year" or "future year" values. (Adjusted for currency exchange rates, inflation, etc.) While if we use SPI and CPI, there is no need to adjust for anything other than changes in the crew composition and productivity rates.

In Figure **(17.1),** we can see that all data points are falling within the 5% target, meaning that because our original estimate was both ACCURATE and PRECISE, it has VALIDITY and RELIABILITY for inclusion into our cost and productivity databases. In Figure **(17.2),** we can see the "bullets" were tightly grouped (PRECISE) and that if we use them for forecasting or estimating, they are RELIABLE, but to make them ACCURATE and VALID, we need to adjust them to the Bullseye. Because, at least in North America, there are so many

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hunters and target shooters, it is very easy to teach this concept in a way that makes it easy to understand what management decisions need to be made to get the "bullets" to land within the circle of the bullseye.

The remaining images should be self-explanatory, but it provides more proof that the EVM data's purposes are designed to help managers achieve or realize CONTINUOUS PROCESS IMPROVEMENTS in the workflow processes. With the current interest in "Big Data," "Data Analysis," and "Data Analytics," this type of data lends itself very nicely to using AI and Machine Learning tools & techniques. (i.e., MS Power BI or AI's Chat GPT)

WHAT CAN WE CONCLUDE?

The facts are undeniable. The roots of what we call Earned Value Management most likely originated during the 16th century by the Trade and Craft Guilds as a "prompt payment for services or products delivered" ("Cash On Delivery" or C.O.D) payment system but evolved and were perfected during the 18th century Industrial Revolution and DOCUMENTED in great detail by Frederick Taylor, Henri Fayol, Frank and Lillian Gilbreth, Henry Gantt and especially Halbert Gillette and Richard Dana as a "COST ENGINEERING" or "ENGINEERING ECONOMICS" study or discipline.

1) Earned Value Management is a "pay for performance" or "incentive payment system" that originated and remains based on "earned time" or "earned schedule." It links INCREASED PRODUCTIVITY (Taylor's INITIATIVE) to PROMPT PAYMENT (Taylor's INCENTIVE) to justify and appropriately compensate for that increase. (See Taylor's Pig Iron Example for additional PROOF)

2) Data generated by what we call Earned Value Management permeates operations management today in the form of piecework and any professional or tradesperson who quotes prices based on a unit-in-place basis and then bills based on the actual quantity provided, delivered, or installed. This includes lawyers who quote a fixed price for preparing a will, a divorce, property closing (or any other service); a dentist who charges a fixed fee for filling a cavity; an auto repair person who charges a fixed fee for an oil change, a flooring installer who quotes you a fixed unit price to supply & install carpet or tile. And the list is almost endless.

3) The PURPOSE or END OBJECTIVE in calculating the EVM Data and ANALYZING it is to enable those responsible for managing the workflow processes to OPTIMIZE the efficiency of the process in terms of both time and cost. This is the "secret" to selling the use of EVM to those in the project management community who have yet to adopt and embrace what is little more than "applied common sense" that we use each week when we go grocery shopping.

4) You CANNOT manage a project by trying to manage the money. IF you manage the PROCESS WORKFLOW, the money (and time) will follow. (Hence the importance of Activity Based Costing and Activity Based Management)[45]

SO WHAT IS NEXT? WHAT "ACTIONABLE ITEMS" CAN WE IMPLEMENT IMMEDIATELY?

I strongly support efforts to answer the following research questions :

1) *"Given so many agree that Earned Value Management is an important and useful tool for both owners and contractors to manage their projects, then WHY is it not enjoying more widespread adoption?"*
2) *"What changes need to be made to make EVM more acceptable or "user-friendly" to both owners and contractors to make them WANT to adopt it?'*

I also think it is essential that if we want to generate SUPPORT and BUY IN, to overcome what will undoubtedly be considerable resistance from both governments and the many professional societies purporting to represent the practice of project management, an open and transparent process must be used, exemplifying the fundamental tenets we subscribe to as project managers and, most importantly, to do so in a manner that meets the 5 attributes of the Scientific Method. I urge anyone interested in answering these questions to meet these criteria.

Accordingly, I have provided everyone and anyone who is interested with:

1) Credible published references going back more than 120 years on the ORIGINS of Earned Value Management as a "Cost Engineering" or "Engineering Economics" discipline or function.
2) Provided real-life examples showing how using this method has resulted in documented savings and improved workflow processes.
3) Provided examples showing how others can "test" or "validate" my hypothesis, theories, and factual claims.
4) Provided examples showing how I have been implementing and teaching Earned Value Management based on the concepts, formulas, and procedures advocated by Frederick Taylor, Henri Fayol, Frank and Lillian Gilbreth, Henry Gantt, Halbert Gillette, and Richard Dana from 120 years ago.

Consistent with these attributes, I also recommend the engagement of professional "cost engineering societies," including AACE, IcostE, AICE, and ICEC, to embrace and support the advancement of EVM. Much of the hard work has been done; all of my research is published under Creative Commons License BY SA, meaning there is no cost nor any constraints on using any of what I have contributed other than citing them appropriately. I would also hope that others would do the same. There is no need to enable or encourage using our donated and

[45] Cokins, Gary and IMA (2006) "Implementing Activity Based Costing" https://vdocuments.net/implementing-activity-based-costing-on-management-accounting-table-of-contents.html?page=1

shared knowledge as the basis to "fatten the piggybanks" of ANY professional society. To quote Industrial Psychologist Eliot Friedson, "The only difference between the trade unions and the professional societies lies in the sanctimoniousness of the latter."[46]

I have no clue if what I propose is the ONLY answer or solution to the research questions. Based on 50+ years of running our businesses using this "Cost Engineering" or "Economic Engineering" approach, as advocated by Taylor, Fayol, Gilbreth, Gillette, and Dana, as our "Core Business Competencies" however, I am 100% certain that what I have provided is A solution. And that "solution" is consistent with what we advocate as "best tested and PROVEN" project management practices and meets the 5 attributes of the Scientific Method, therefore qualifying as worthy of further consideration and validation.

Assuming the published research from KPMG and AIPM, Prof Bent Flyvbjerg, and NASA's Glenn Butts and Wayne Abba et al. remains valid to you and your projects, what have you lost by running a "pilot project" to test what we have shown here?

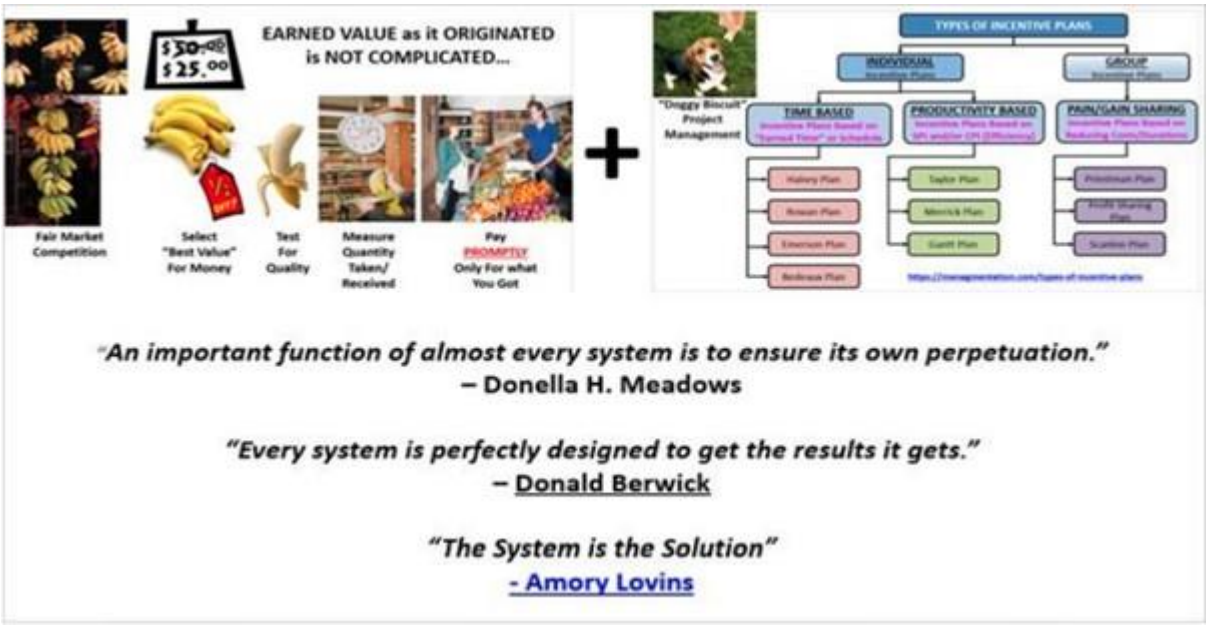

Figure 18- The SYSTEM is the SOLUTION

Anyone interested in learning how to implement EVM as we advocate using it, or have any questions or need help and guidance, we are available as mentors, facilitators, and consultants. Contact our President Director, Ms. Yani Suratman, at yanisuratman@gmail.com or WhatsApp her at +6281-6187-3992 to explore how we can best help you.

[46] Freidson, Eliott, (2001) "Professionalism- The Third Logic on the Practice of Knowledge" https://press.uchicago.edu/ucp/books/book/chicago/P/bo3621932.html

About the Author

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Dr. Paul D. Giammalvo, CDT, CCE (#1240), MScPM, MRICS, is a Senior Technical Advisor (Project Management) to PT Mitratata Citragraha. (PTMC), Jakarta, Indonesia. www.build-project-management-competency.com. He is noted for the development and delivery of graduate level, blended learning curricula designed for the mid-career path, English as Second Language (ESL) professionals to develop competency in the local practitioner and build capacity for the local organizations. For 25+ years, he has been developing and delivering Project Management training and consulting throughout South and Eastern Asia Pacific, the Middle East, West Africa, and Europe.

He is also active in the Global Project Management Community, by playing a "thought leadership" role for the Association for the Advancement of Cost Engineering International, (AACEI) http://www.aacei.org/ since 1991; He has also been active in two IPMA member organizations: The Green Project Management Association (GPM) http://www.greenprojectmanagement.org/ where he served on the Certification Board of Directors for two years and the American Society for the Advancement of Project Management http://www.asapm.org/ for which he served for four years on the BoD as Director of Marketing. He also sat on the Board of Directors of the Global Alliance for Project Performance Standards (GAPPS), www.globalpmstandards.org, Sydney, Australia and is active as a regional leader. Currently, he is a compensated consultant to the International Guild of Project Controls. http://www.planningplanet.com/guild as the primary author of their "Compendium and Reference" as well as the chief architect of their competency-based credentialing program. http://www.planningplanet.com/guild/certification

He has spent 35 of the last 50 years working on large, highly technical international projects, including such prestigious projects as the Alyeska Pipeline and the Distant Early Warning Site (DEW Line), upgrades in Alaska and the Negev Airbase Constructors, Ovda, Israel and the Minas Oil Field in Rumbai, Sumatra. His current client list includes Fortune 500 major telecommunications, oil, gas and mining companies plus the UN Projects Office and many other multi-national companies, NGO organizations and Indonesian Government Agencies.

In addition to 45+ years of hands-on field experience, Dr. Giammalvo holds an undergraduate degree in Construction Management, his Master of Science in Project Management through

the George Washington University and was awarded his PhD in Project and Program Management through the Institute Superieur De Gestion Industrielle (ISGI) and Ecole Superieure De Commerce De Lille (ESC-Lille) under the supervision of Professor Christophe Bredillet. "Dr. PDG" can be contacted at pauldgphd@gmail.com.

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