

The True Origins of EVM: A historical approach to scheduling and incentive schemes^{1, 2}

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ABSTRACT

Earned Value Management has become a source of divisions. From the interpretation of its origins to its suitable applications, project managers seem to fail to reach consensus. While the private sector most often adopts it in Firm-Fixed Price contracts, this is precisely where US Defence Acquisition University discourages the method. Besides, if this technique is ordinarily said to have emerged in the 1960s, it actually arises from a lengthy evolution of both scheduling and incentive schemes. In fact, the very basis underlying EVM consists in paying for performance, a concept that appeared and developed concomitantly with the scheduling evolution and traces back to centuries AC.

Through the display of the evolution of scheduling and incentive schemes over time, and the presentation of the definition and functioning of EVM, this paper will expose the underlying roots of earned value and thus clarify its very merits in both project management and performance appraisal.

Key words: Earned Value Management, History of EVM, Evolution of Scheduling, History of Scheduling, History of Project Management, Evolution of EVM, Earned Value Origins

INTRODUCTION

Earned Value Management has become the “elephant in the room”³ that everyone is aware of, but so few are willing to discuss, and even less implement. One could even claim the EVM has become analogous to the 6 Blind Men of Hindustan, trying to describe an Elephant for which

¹ Editor’s note: This paper was prepared for the course “International Contract Management” facilitated by Dr Paul D. Giammalvo of PT Mitrata Citragraha, Jakarta, Indonesia as an Adjunct Professor under contract to SKEMA Business School for the program Master of Science in Project and Programme Management and Business Development. <http://www.skema.edu/programmes/masters-of-science>. For more information on this global program (Lille and Paris in France; Belo Horizonte in Brazil), contact Dr Paul Gardiner, Global Programme Director, at paul.gardiner@skema.edu.

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³ Martin, G. (n.d.). 'The elephant in the room' - the meaning and origin of this phrase. Retrieved November, 2018, from <https://www.phrases.org.uk/meanings/elephant-in-the-room.html>

everyone has their own interpretation of the origins, and the appropriate employments it can be put to. For instance, Earned Value is not used on firm fixed price contracts in the U.S government. In fact, the US Defence Acquisition University's EVM Gold Card (Appendix 1) states the method is discouraged on Firm-Fixed Price⁴, although this is precisely where it is the most often adopted in the private sector, not only in construction -with the milestone payments- but also in our daily transactions.

Professionals responsible for project performance are likely aware of Earned Value Management (EVM). This project management technique integrates the three related components of project performance: scope, schedule, and cost. By means of a few rates, the current status of the project can be established, enabling the manager to explore not only past history of the project but more importantly the current trends, forecast, and eventually improve performance. The use of EVM is notably promoted by the the US Governments Accountability Office (GAO) and the Office of Management and Budget (OMB), and practiced in a variety of industries, educational institutions and consulting firms. Some of the most renowned organisations adhering to the methodology include NASA, Project Management Institute (PMI), Defence Acquisition University, or again Acquisition Management (UK). However, it is not understood that EVM stands as a valuable tool for any project manager. Even though EVM has been adopted by a fair amount of countries especially since the 1980s⁵, outside of some government agencies and construction industry, earned value is not extensively used⁶, most certainly due to scarce understanding of its range of application.

⁴ Defense Acquisition University. (2018, September). Earned Value Gold Card. Retrieved from <https://www.dau.mil/tools/Lists/DAUTools/Attachments/19/20180904-gold%20card%201%20sided.pdf>

⁵ Humphreys, G. C. (2016, January). EVMS – AFTER THE EVOLUTION: THE LONG SLOW ROAD. Retrieved October, 2018, from <http://www.earnedschedule.com/Docs/EVMS - After the Evolution.pdf>

⁶ The perceived value and potential contribution of project management practices to project success. (2006). Retrieved November, 2018, from <https://www.pmi.org/learning/library/perceived-value-potential-contribution-project-management-8031>

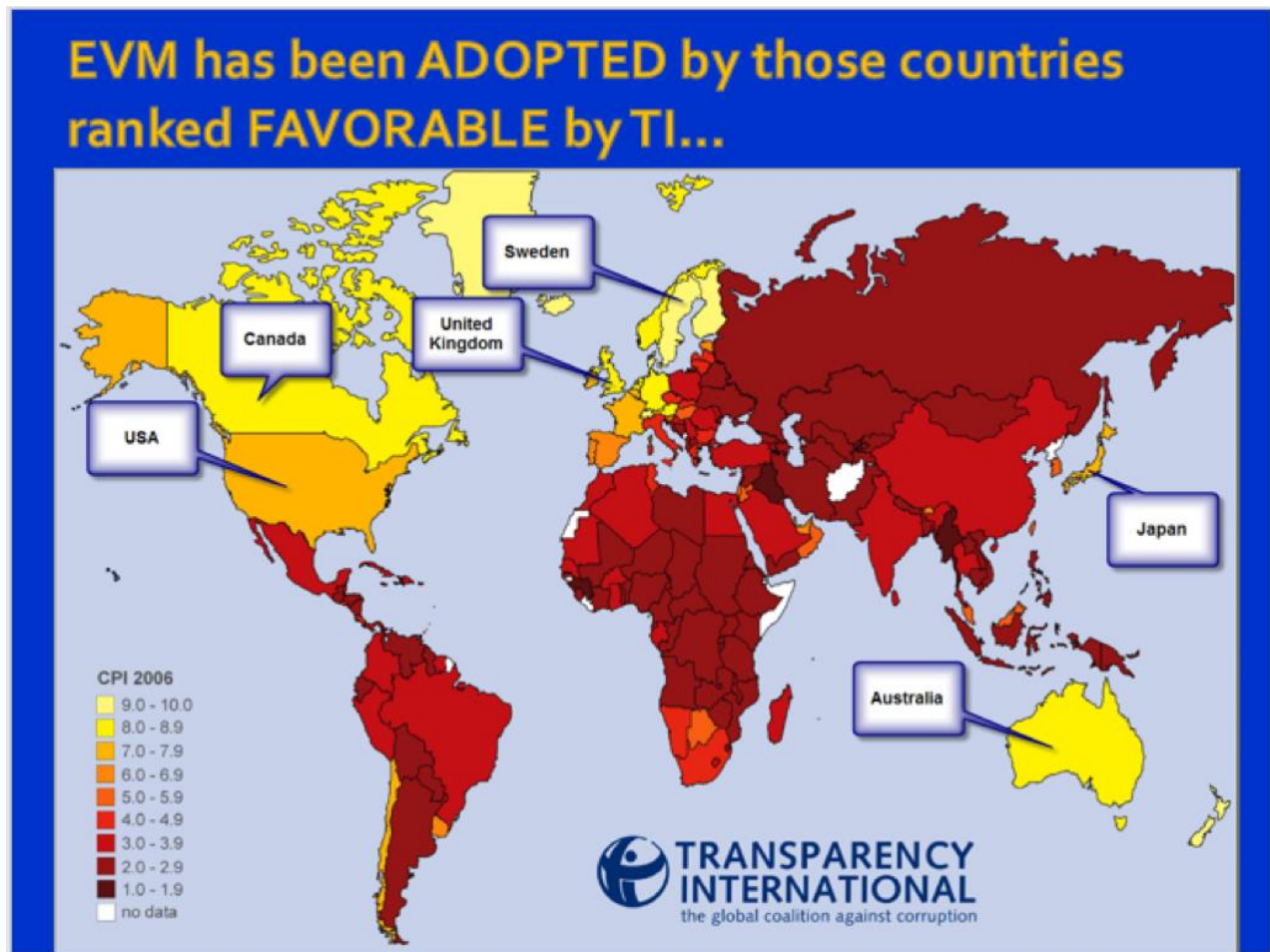


Figure 1. Adoption of EVM by countries (by P. Giammalvo and W. Abba)

If this technique is commonly said to have emerged in the 1960s⁷, it actually arises from a lengthy evolution of both scheduling and incentive schemes. As a matter of fact, the very basis underlying EVM consists in paying for performance, a concept that appeared and developed concomitantly with the scheduling evolution.

The concept of scheduling is far from being new, for it has been used to erect monuments such as pyramids some 5 000 years ago, design military strategies (Sun Tzu wrote his Art of War in 504 BC), or again build roads to connect civilizations. The origin of EVM, for its part, could date back to the Old Testament, with Deuteronomy that states a needy servant should be given daily wages⁸. Later on, the Sharia law prescribed providing wages to the employees soon enough for

⁷ Wayne, A. F. (2017, March). The Evolution of Earned Value Management. Retrieved October, 2018, from <https://www.dau.mil/library/defense-atl/blog/Defense-ATandL--March-April-2017-2-The-Evolution-of-Earned-Value-Management>

⁸ Deuteronomy 24:14-15: The Wages You Have Withheld By Fraud. (2014, January 09). Retrieved November, 2018, from <https://edgeinducedcohesion.blog/2012/01/25/deuteronomy-2414-15-the-wages-you-have-withheld-by-fraud/>

them to fulfil their daily basic necessities⁹, as well as offered guidance on how to schedule one's day around the 5 daily prayers. These concepts were then formalized in the 1700's and the 1800's as part of the industrialization changes, marked by new productivity and planning requirements.

Scheduling later transformed accordingly to the changing work ethics, incentive schemes and technical means. It is by the 1950's that performance could be more effectively apprehended – and thus appraised - with CPM scheduling¹⁰. The method paved the way for the design of Earned Value Management, which met major recognition and knew increasing applications over time.

This paper will first provide with a thorough presentation of the evolution of scheduling and incentive schemes over time, and then tackle the very definition and functioning of EVM. In this way, the underlying roots of earned value as well as its merits in both project management and performance appraisal should be made clear to the reader.

METHODOLOGY

Before exploring the very functioning of EVM, an overview of the evolution of the concept earned value but also scheduling schemes and incentive plans seems beneficial. As a matter of fact, as mentioned in the introduction, EVM was not created in 1960 by the U.S. Given its underlying basis is **payment for performance**¹¹ (also known as Quantum Meruit), its history thus traces back years before CE, and is closely linked to the of scheduling and incentive plans schemes. The use of incentive compensation plans originated in our earliest records of history¹², however, using incentives was not based upon objective measures. For this reason the discoveries and various changes in scheduling history are inseparable from the evolution of Earned Value Management. The author designed a timeline illustrating the evolution process and relationships between, EVM, Scheduling and Incentive plans. It can be divided in four distinct periods.

1. Combined historical approach to Scheduling, Incentive pay and Earned Value Management, 25 00 BC to 221 AD

⁹ Majeed, A. A. (2016, January). EMPLOYER -EMPLOYEE OBLIGATIONS IN ISLAM. Retrieved November, 2018, from <https://www.linkedin.com/pulse/employer-employee-obligations-islam-ajmal-bin-abdul-majeed/>

¹⁰ Weaver, P. (2007, May). THE ORIGINS OF MODERN PROJECT MANAGEMENT. Retrieved October, 2018, from https://mosaicprojects.com.au/PDF_Papers/P050_Origins_of_Modern_PM.pdf

¹¹ Giammalvo, P. (2018). Course handouts

¹² Beer, M., & Cannon, M. D. (2004). PROMISE AND PERIL IN IMPLEMENTING PAY-FOR-PERFORMANCE. Retrieved November, 2018, from <https://pdfs.semanticscholar.org/52b7/40937699a903ba49bc871067da26dec77d35.pdf>

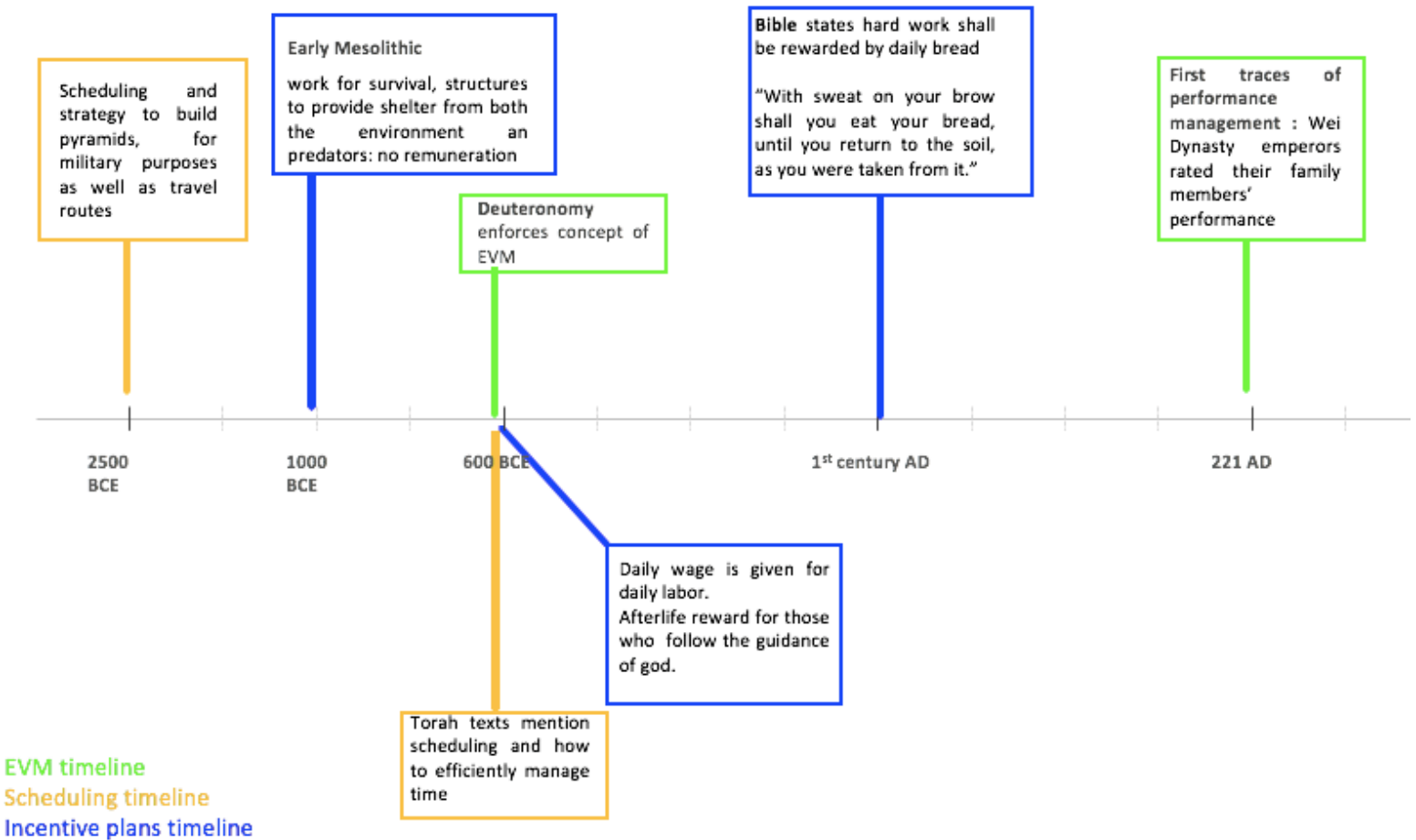


Figure 1: History of Scheduling, Incentive pay and Earned Value Management (EVM) 2500BCE to 221 AD (by author)

The very concept of “scheduling” is far from being new. The pyramids were erected some 2500 years ago¹³, immense travel routes projects were designed and Sun Tzu wrote about strategies and scheduling for military purposes in the 5th century AD.¹⁴

Besides, it should be stressed out that the very conception of work and thus work remuneration and incentive schemes used to be quite different from today's. During the early Mesolithic era, work was achieved for only survival purposes. The idea of remuneration was unrelated to work execution.

It is in the **Old Testament** that EVM takes its roots, as the Hebrew Bible, Deuteronomy 24:14-15 reads: “You shall not oppress a hired servant who is poor and needy, Each day you shall give

¹³ Weaver, P. (2012, December). Henry L Gantt, 1861 - 1919 A retrospective view of his work. Retrieved October, 2018, from https://mosaicprojects.com.au/PDF_Papers/P158_Henry_L_Gantt.pdf

¹⁴ Weaver, P. (2018). A BRIEF HISTORY OF SCHEDULING - BACK TO THE FUTURE -. [online] Mosaicprojects.com.au. Available at: https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduling.pdf

him his wages, and not let the sun go down on it”.¹⁵ Daily wage should thus be given for daily labor, as well as afterlife rewards will be granted to those who followed the guidance of god. Besides, Torah texts mention scheduling as well as how to efficiently manage one’s time.

The **Bible**, for its part, then considered work as the curse of mankind from the beginning of its history: after the expulsion from paradise, hunger, thirst and the need for shelter became inescapable incentives for work. The Bible asserts daily labor requires daily wage, otherwise this would be theft. It reads: “With sweat on your brow shall you eat your bread, until you return to the soil, as you were taken from it.”

It is some 200 centuries later that the very concrete traces of performance management were noticed, when Wei Dynasty emperors rated their family members’ performance.¹⁶

2. Combined historical approach to Scheduling, Incentive pay and Earned Value Management, Roman era to the 1660s

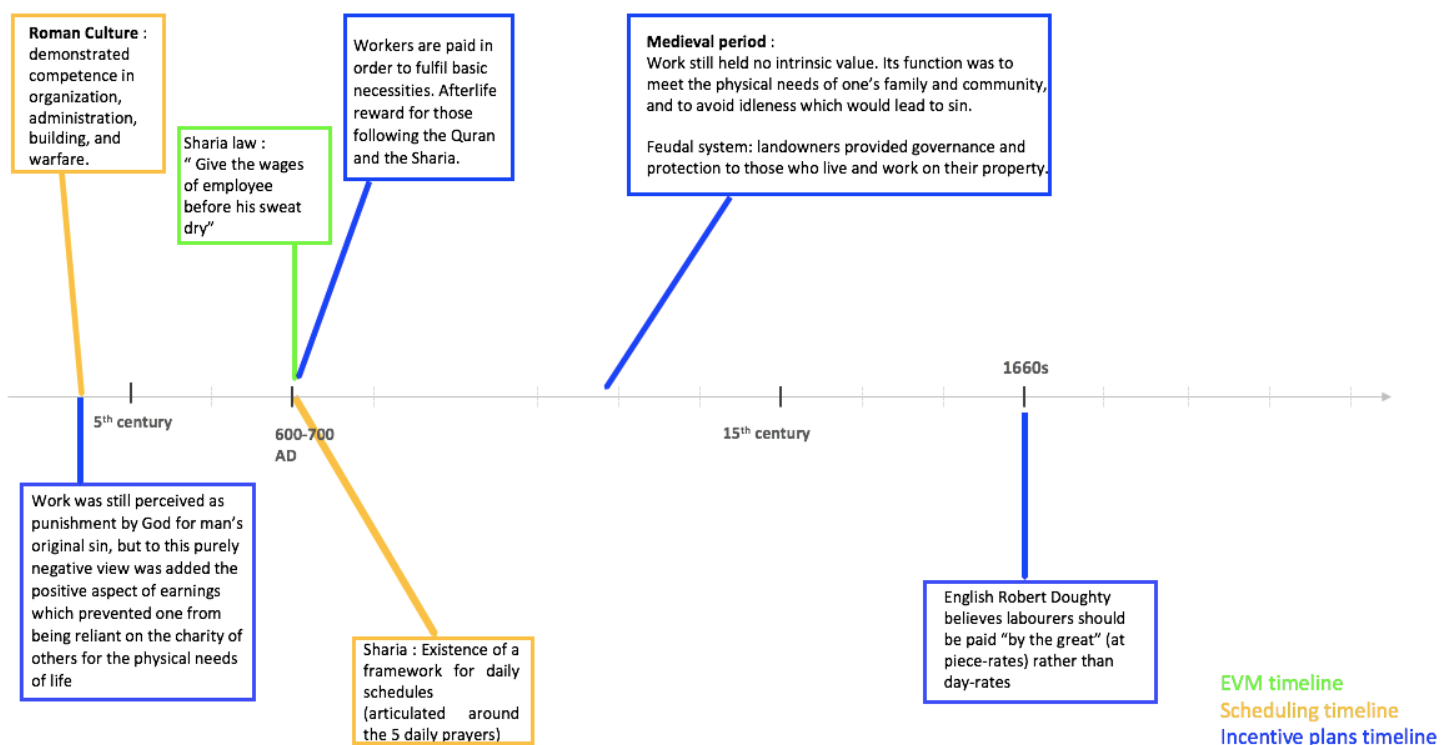


Figure 2: History of Scheduling, Incentive pay and Earned Value Management (EVM) Roman era to the 1660s (by Author)

¹⁵ Deuteronomy 24:15. (n.d.). Retrieved November, 2018, from <https://biblehub.com/deuteronomy/24-15.htm>

¹⁶ Rotenberg, Z. (2018, July 23). History of Performance Management. Retrieved November, 2018, from <https://www.atiim.com/blog/history-performance-management/>

The Bible's punishment vision was still present during the Roman's period. However, the positive aspect of earnings which prevented one from being reliant on the charity of the others for the physical needs of life was added to this purely negative view¹⁷. Besides, the Romans demonstrated high levels of competence in scheduling, organizing, building and warfare.

By 650, Islam proposed an approach similar to the Bible with regards to EVM, scheduling and incentive plans. The **Sharia law** indeed takes a firm position against economic exploitation and advocates daily wages for the workers. It reads: "Give the wages of employee before his sweat dry"¹⁸

By stressing the fact that delay may cause difficulty to the employee – for he might not have money to buy food and other basic necessities – , the Sharia law actually addressed a current major topic in project management, namely the of prompt payment. As a matter of fact, contractors, regardless of their size, live and die by their cash flows. For this reason, paying promptly represents a crucial standard related to Earned Value Management.¹⁹

It also proposes scheduling frameworks for daily life, articulated around the 5 daily prayers. Besides, as the Bible, it mentions afterlife rewards for those following its laws and the Quran. The Medieval era, for its part, represents an interesting period with regards to the incentive schemes; under the feudal system, landowners remunerated work by providing rights of settlement and protection to the workers of their property²⁰.

It is in the late Seventeenth Century England that the usual incentive schemes were questioned with the concept of **payment "by the great"** (or piece-rate as we know it). In *Work, Reward and Labour Discipline in Late Seventeenth Century England*, Steve Hindle relates that in June 1662, Sir Richard Newdigate of Arbury condemned the indolence of one of the agricultural labourers employed on his lands, commenting he "lyes abed and will not work". For the first time in well over a century, the fortunes of employers and especially landlords, were being undermined by falling rents, stagnant prices and increasing wages. Because labor was in relatively short supply in late seventeenth- century England, it was believed that 'the very fabric of society could be threatened, not just by rising wages and costs, but by a swelling independence among the working masses, which commonly manifested itself in a refusal to engage wholeheartedly in unremitting toil'²¹. At this time, a growing consensus was emerging among the propertied elite, considering

¹⁷ Hill, R. B. (1996). History of Work Ethic. Retrieved November 2018, from <http://rhill.coe.uga.edu/workethic/hist.htm>

¹⁸ Malouni, F. (2010, April). PROJECT MANAGEMENT: EARNED VALUE AND PROMPT PAYMENT PRACTICES OBSERVED FROM VIEW OF ISLAMIC SYARIAH LAW. Retrieved November 2018

¹⁹ Dr. Paul Giammalvo (2018). Course handouts

²⁰ Hill, R. B. (1996). History of Work Ethic. Retrieved November 2018, from <http://rhill.coe.uga.edu/workethic/hist.htm>

²¹ R. Millward. (1981). The Emergence of Wage Labor in Early Modern England. Retrieved November, 2018, from <https://www.sciencedirect.com/science/article/abs/pii/0014498381900188>

“the higher the wages laborer’s and artisans received, the less they worked, and that, while low wages bred industry and diligence, high wages bred laziness, disorderliness and debauchery’. This, then, could be considered as a greatly troubling time in the large history of relations between master and man, and came with various challenges to employers who required not only to recruit, retain and discipline the labor force but also to incentivize productivity among their employee. Despite this consensus, opinion was divided over whether work could be best incentivized through piece-rates or wage-rates. As a matter of fact, the difficulty lied in the belief that “if labourers were paid day-rates, they would hardly ‘do one dayes worke in twoe’, but if they were employed at piece-rates ‘then on the contrary they will as hastily slubber itt over’²².

Sir Edward Verney was in that sense one of the early defendants of piece-rate incentive scheme, considering day-rates only encourage laborer’s to “fiddle about”, but might be encouraged to work harder id they were paid “by the great”.

3. Combined historical approach to Scheduling, Incentive pay and Earned Value Management, 1750s to 1920s

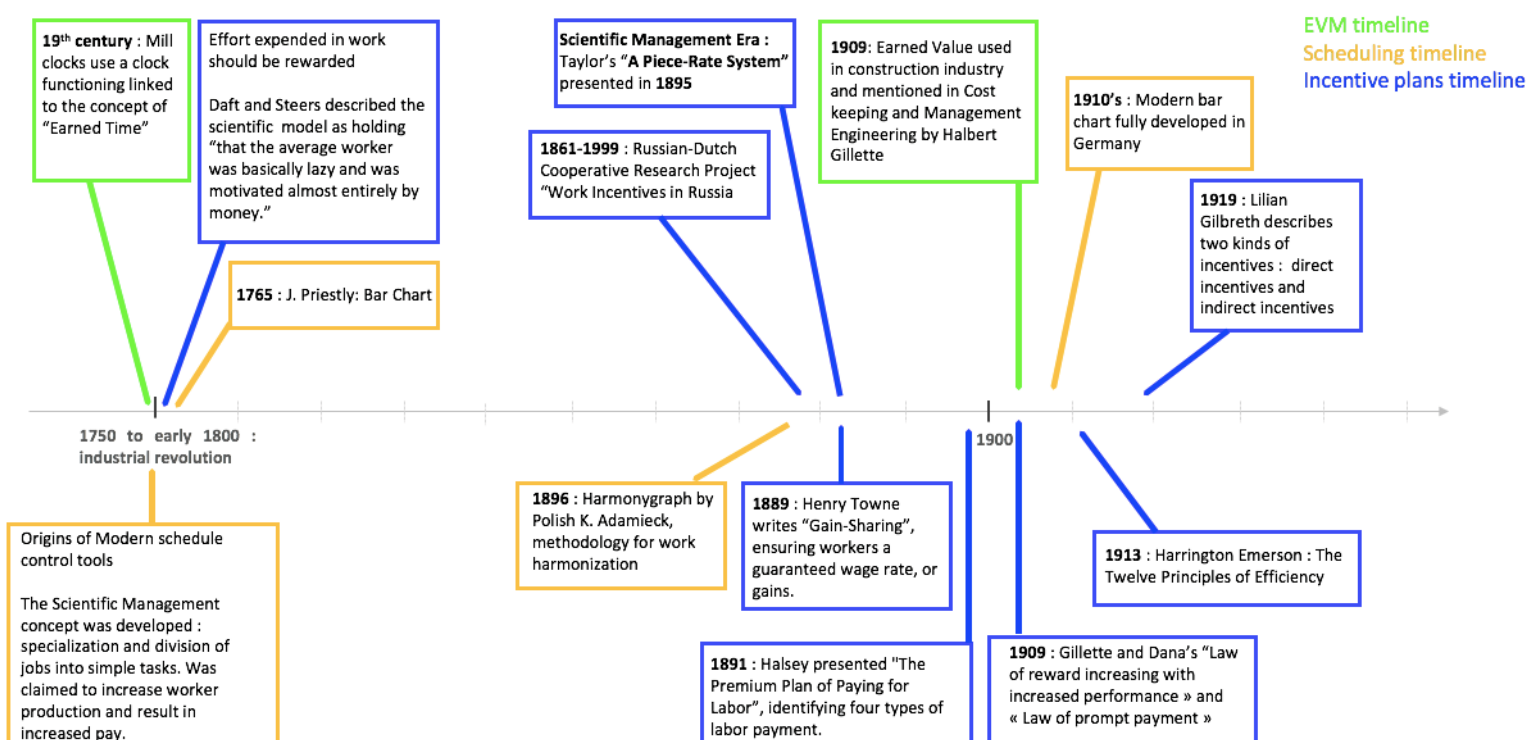


Figure 3 History of Scheduling, Incentive pay and Earned Value Management (EVM) from 1750s to 1920s

²²R. Millward. (1981). The Emergence of Wage Labor in Early Modern England. Retrieved November 2018, from <https://www.sciencedirect.com/science/article/abs/pii/S0014498381900188>

Even though the piecework system has origins at least to the Medieval Era, the rise of mechanization and **industrialization** made it a central point in U.S labor history. The period between 1750 to early 1800 thus played a major part in the breaking of previously skilled crafts into unskilled tasks, as well as encouraging the rise of the “gaining the most profit at least cost” practice. In that sense, industrialization embodies the origins of modern schedule control tools, with notably the creation of the Barchat by Joseph Priestley in 1765.

Concomitantly, the concept of EVM was already applied in Europe with **the mill clocks**. The Rees Cyclopedia mentions that Victorian Britain could boast an analog Earned Value machine in the form of “mill clocks” as soon as in the early 19th century. Some mills had a special-designed clock providing both pacing of the work and tracking of progress with respect to the plan: “Many mills have a clock turned by the mill; close to another clock regulated by a pendulum. Both are made with dials and hands exactly alike, but one has a title on the dial, mill time, and the other, clock time”²³. Then, while the hands of the mill clack moved following the amount of worked accomplished, the pendulum clock measured the passing of time. In a properly regulated mill, the two clocks would not differ by more than a few minutes.

But more importantly, the closest use of Earned Value as we know it today can be linked back to 1909, with **Halbert Gillette and R.T. Dana’s** book ***Cost Keeping and management engineering***. This treatise for engineers and contractors in construction presents various progress charts following the concepts such as estimated cost, actual cost, and performance. The Channeler Chart²⁴ (fig 15, Appendix 2) for instance, that displays the performance and unit cost of work done, looks identical to the SPI and CPI charts used today. Besides, an example of general progress blue print (fig 69, Appendix 3) is presented, with explanations on how costs of work amounts of work accomplished are kept by sections and sub-sections.

Finally, the **Summary Progress Chart** (fig 68, Appendix 4) might be one of the most compelling evidences Earned Value Management did not just appear in the last 1960’s. The description accompanying it reads that in connection with these progress charts, “Mr. Moore has a unique summary progress chart upon which is carried forward and maintained a continuous record of the job, the information being obtained from the summary report of the time sheet. The essential idea of this summary progress chart is to have at all times a condensed, complete history of the work, not so much with reference to the detail unit cost of each item of work, but more especially with reference to a comparison between the estimated total cost and the actual total cost. This

²³ Hills, R. L. (1970). *Power in the industrial revolution*. Retrieved November 2018.

²⁴ Gillette, H., & Dana, R. T. (1909). *Cost Keeping and Management Engineering*. Retrieved November 2018.

comparison allows an intelligent idea to be made of the portion of work done, and indicates at once whether actual cost is less than the estimated cost or exceeds it.”²⁵

Alongside their contribution in the use of progress charts to measure performance and project's progresses, Gillette and Dana also stated various laws with regards to incentives. **The Law of Reward Increasing With Increased Performance** states that rewards should be proportionate to the work. They add that “the wage system is responsible in the first place for lack of sufficient incentive to good performance”²⁶. **The Law of Prompt Reward**, for its part, asserts that any punishment or reward that is remote in the time of its application has a relatively weak influence in influencing a man's conduct. For this reason, the reward or punishment must promptly follow the act. According to them, “a weekly or daily statement of earning, followed by prompt payment, is a stimulus essential in securing the maximum output of workmen”. As mentioned earlier, prompt payment represents one of today's pillars -and challenges- in project and contract management.

Then, the period spanning the late 1800s to the early 1920s is known as the **scientific management era**. During this period, the basic premise of reward systems, namely “to maintain employee motivation in order to increase production and sustain a competitive edge, while keeping costs low”²⁷ - has been especially dominant. As a matter of fact, the scientific management was a period marked by a strong focus on and development of incentive schemes²⁸. With the Premium Plan of Paying for Labor, 1981, Halsey presented the four types of labor payment over which many economist will argue during this period. They were presented as:

- the day's-work plan: the workman is paid for the time spent upon his task
- the piece-work plan: the worker is paid relatively to the amount of work done)
- the profit-sharing plan: (in addition to regular wages, the worker is offered a certain percentage of the company's final profits

²⁵ Gillette, H., & Dana, R. T. (1909). *Cost Keeping and Management Engineering*, p 180. Retrieved November 2018.

²⁶ Gillette, H., & Dana, R. T. (1909). *Cost Keeping and Management Engineering*, p 15-16. Retrieved November 2018.

²⁷ L. Caudill, H. and D. Porter, C. (2014). An Historical Perspective of Reward Systems: Lessons Learned from the Scientific Management Era. [online] Macrothink.org. Available at: <http://www.macrothink.org/journal/index.php/ijhrs/article/viewFile/6605/5519>

²⁸ B. A., F. R., L. C., P. M., Michael, & P. V. (2012, January). Paying for Performance: Incentive Pay Schemes and Employees' Financial Participation. Retrieved November 2018, from <http://cep.lse.ac.uk/pubs/download/dp1112.pdf>

- and the premium plan: the time to achieve a given task is determined from previous experience, and the employee is offered a premium for every hour by which he reduces that very time, in addition to the usual daily wages)

The scientific management is said to have been introduced by Taylor's *A Piece-Rate system* in 1895, which discussed the need for incentive plans that would offer high wages to the workers and low costs to the employer, while promoting individual pay for performance.

By greatly rewarding workers who reached the standards while giving a much lower pay to those who didn't meet the requirements, this differentiated piece-rate system was Taylor's remedy to cooperative reward systems such as the one of Towne-Halsey. The Towne-Halsey plan was "an early form of payment-by-results in which the worker was paid a bonus for exceeding target production but not in proportion to the amount by which he exceeded target"²⁹. The worker then received a bonus of between a one third and one half of the difference between standard time and actual time rather than the total difference.

Harrington Emerson, for his part, placed the efficiency reward last in his book *The Twelve Principles of Efficiency*, 1913. According to him, the demarcation between efficiency and inefficiency should not be so sharp. He established a bonus system grouping efficiency ranges and equating a percent bonus for each range. A worker would thus receive a bonus for simply attaining the 100 percent efficiency level and an additional bonus based on the actual time saved.³⁰ In 1919, Frank and Lilian Gilbreth would then identify two kinds of incentives, namely direct incentives which combine both pride and ambition of the worker, and indirect incentives which correspond to rewards and punishments.

Finally, the interest for incentive schemes in this period was not only specific to the U.S, for in the 1900s, the International Institute of Social History started a three-year Russian-Dutch Cooperative Research Project named "Work Incentives in Russia, 1861-1899: Compensation, Commitment and Coercion".

4. Combined historical approach to Scheduling, Incentive pay and Earned Value Management 1920s to present

²⁹ L. Caudill, H. and D. Porter, C. (2014). An Historical Perspective of Reward Systems: Lessons Learned from the Scientific Management Era. [online] Macrothink.org. Available at: <http://www.macrothink.org/journal/index.php/ijhrs/article/viewFile/6605/5519>

³⁰ L. Caudill, H. and D. Porter, C. (2014). An Historical Perspective of Reward Systems: Lessons Learned from the Scientific Management Era, p133. [online] Macrothink.org. Available at: <http://www.macrothink.org/journal/index.php/ijhrs/article/viewFile/6605/5519>

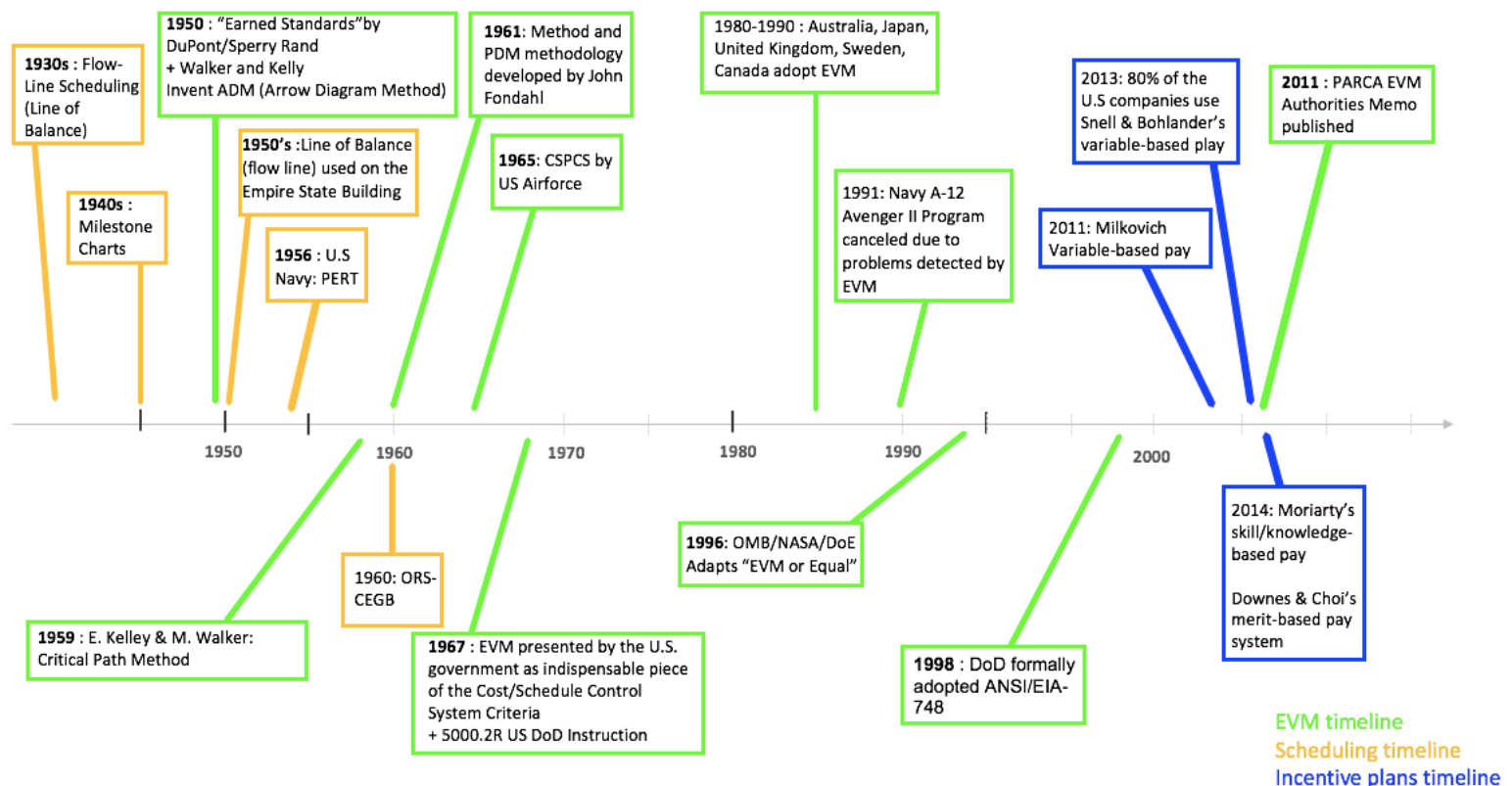


Figure 4 History of Scheduling, Incentive pay and Earned Value Management (EVM) from 1920s to present (by Author)

The period between the 1930's and late 1960s could be considered as the modern history of EVM. This interval of time prove particularly dense in the development of scheduling and performance assessment methods, correspondingly to the technological advances. However, the period did not witness major outbreaks with regards to incentives. In 1948, Yoder will state on the matter that "... all the many plans are similar in a number of features. The name of their designer, generally attached to them, frequently appears as the biggest single difference"³¹

Back to scheduling evolution, the 1930s were marked by the emergence of Flow-line scheduling, used notably for the construction of the Empire State Building in record times. Milestone Charts, for their part, appeared in the 1940s and differed from the bar charts in that they showed only a single date and use triangles instead of bars, enabling significant space saving.

Later, in the early 1950s, Goodyear company developed the Line of Balance (LOB) technique, addressing mainly repetitive works such as skyscrapers, highways or pipeline tunnels. Year 1956 is another landmark in the history of scheduling, as Kelley and Walker developed the Critical

³¹ L. Caudill, H. and D. Porter, C. (2014). An Historical Perspective of Reward Systems: Lessons Learned from the Scientific Management Era. [online] Macrothink.org. Available at: <http://www.macrothink.org/journal/index.php/ijhrs/article/viewFile/6605/5519>

Path Method (CPM), a computerized project management tool using UNIVAC1 (one of the very first computers installed in a commercial business). The challenge consisted in solving the time-cost conundrum, namely identifying the right tasks that can reduce time without significantly impacting costs, rather than flooding a project with labour to recover lost time. However, the CPM system remained expensive due to its computer-based nature.

In the meantime, the PERT system was developed by the U.S navy. PERT was founded on a similar basic approach as CPM, only it focused on time as the key variable where CPM considered time as fixed, and the cost of achieving the target time varied. Project managers were eventually offered to bypass the expensive computer-based CPM system in 1961, thanks to Dr John Fondahl's Precedence Diagramming Methods.

Finally, the development of “**modern EVM**”³² in 1967 overcame deficiencies in the CPM-PERT technique. As part of the Polaris mobile submarine-launched ballistic missile project, the Air Force pioneers gathered industry's best management practices in defense policy as 35 criteria for industrial management systems. EVM was soon presented by the U.S. government as an indispensable piece of the Cost/Schedule Control System Criteria (C/SCSC) to comprehend the budgetary parts of projects. Between 1980 and 1990, Australia, United Kingdom, Japan, Sweden and Canada adopted EVM and the concept emerged to be used by managers and executives³³. In the wake of this growing adoption, the Navy A-12 Avenger II Program was canceled by the secretary of Defense Dick Cheney due to problems detected by EVM in 1991³⁴, and the PARCA Earned Value Management Central Repository was created to improve the quality, utility and availability of EVM as a joint effort between Defense Cost and Resource Center (DCARC), and Office of the Under Secretary of Defense (OUSD), led by the Director of Performance Assessment Root Cause Analysis (PARCA)³⁵.

5. Functioning of EVM

The Guild describes Earned Value Management (EVM) as “a system consisting of a toolbox of tested and proven project management tools, techniques or methods for capturing physical

³² Note: because, as demonstrated earlier, the very outbreak of EVM did not take place in the 1960s, the author will refer to the technique developed by Air Force as “modern EVM”

³³ College of Performance Management. (2016). The History of EVM – A Timeline. Retrieved October 2018, from <http://www.mycpm.org/the-history-of-evm/>

³⁴ Christensen, D. S. (1998). THE COSTS AND BENEFITS OF THE EARNED VALUE MANAGEMENT PROCESS. Retrieved October, 2018, from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.196.3738&rep=rep1&type=pdf>

³⁵ PARCA. (n.d.). PARCA Earned Value Management Central Repository. Retrieved November, 2018, from <https://www.acq.osd.mil/evm/>

progress, measuring, assessing and evaluating that physical progress against an approved baseline and looking at both historic performance and predicted or forecast performance, analyzing and evaluating the impacts and making recommendation.”³⁶

In other words, using EVM as a management tool helps identifying whether a project is headed in the wrong direction, and this early enough to take appropriate action to correct it.

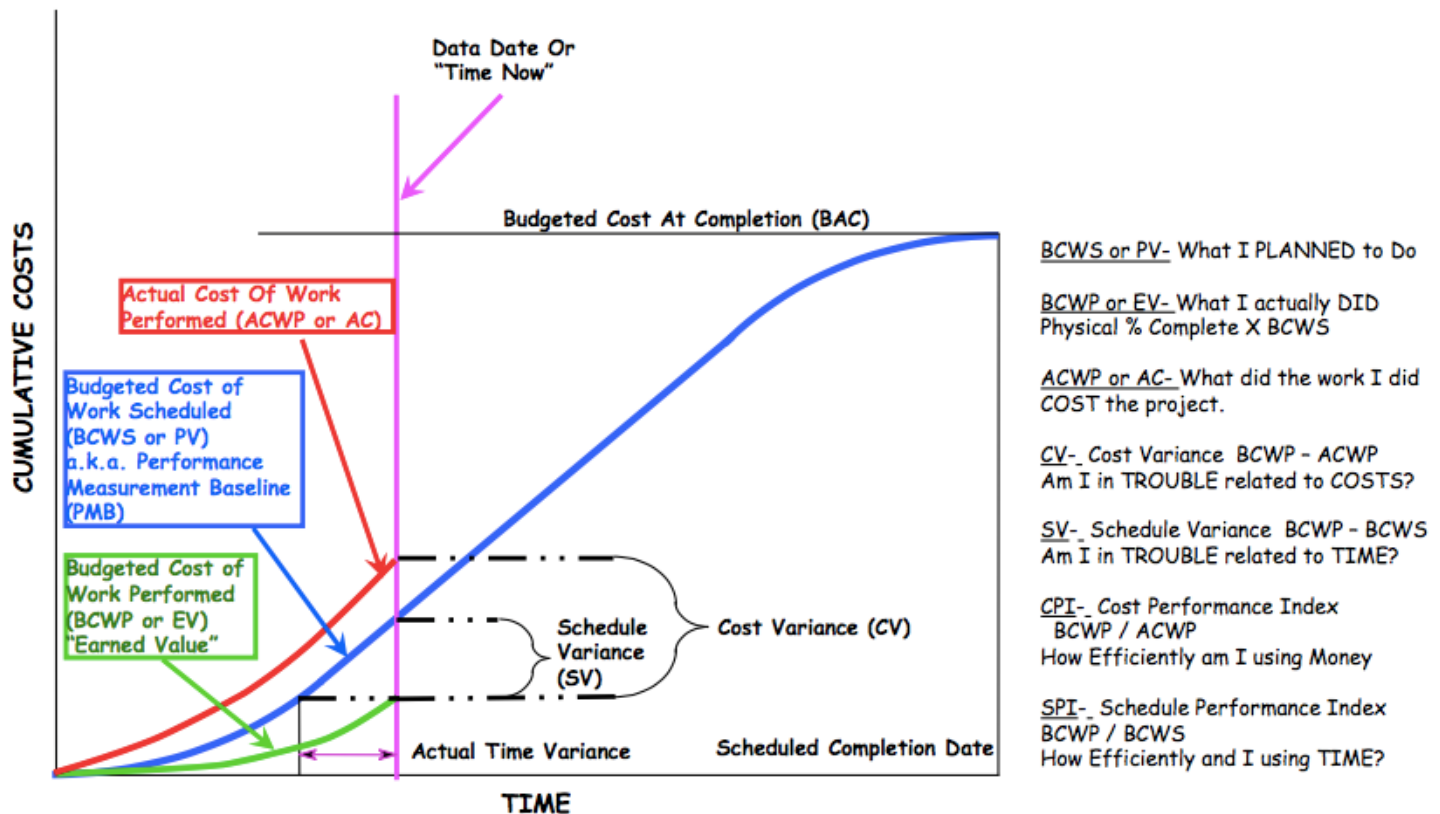


Figure 5. Earned Value Analysis (by Dr. Paul Giammalvo, course handout, 2018)

The earned value analysis requires various inputs:

- **BCWS**– *Budgeted Cost of Works Scheduled- or PV*: represents the cost of what has been planned to do;
- **BCWP** – *Budgeted Cost of Work Performed –or EV*: measure the physical progress of works, namely what has actually been done. This is what is called Earned Value
- **ACWP** – *Actual Cost of Work Performed – or AC*: the amount payable for the work done so far;
- **BAC** – *Budget at Completion* – total planned cost of the whole project

³⁶ 21. Guild of Project Controls. (2015, November 2). Introduction to Managing Project Progress. Retrieved from <http://www.planningplanet.com/guild/gpccar/introduction-to-managing-project-progress>

Project status indicators are the following:

- **CV – Cost Variance:** measures the difference between planned and actual cost of work achieved so far. If negative, the project is over budget:

$$CV = ACWP - BCWP$$

- **SV – Schedule Variance:** measures the difference between the actual and the planned progress. Despite the fact its interpretation is a time difference, it tackles the difference of the planned cost of work achieved and planned cost of work that should have been achieved. If negative, it indicates a delay:

$$SV = BCWP - BCWS$$

- **CPI – Cost Performance Index:** comparison between the planned and actual value of work achieved, if less than 1, the project has cost more than planned. If greater than 1, savings were made.

$$CPI = BCWP / ACWP$$

- **SPI – Schedule Performance Index:** comparison between the planned cost of works achieved and planned cost of works planned; if less than 1, it indicates a delay:

$$SPI = BCWP / BCWS$$

EVM then provides a real-time analysis on the performance of the project that is priceless for both the owner and the contractor: the owner is offered a rigorous overview on the project progress and can have confidence in it, while the contractor benefits from an easier way to identify and address project's performance issues. Besides, the guild advocates linking performance based on earned value to prompt payment for work done in substantial conformance to the specifications and requirements and otherwise meeting or fulfilling the contractual requirements³⁷.

FINDINGS

The historical approach of Earned value, scheduling and incentives directed in this paper demonstrated Earned Value Management took its roots years before the commonly thought birth of EVM in the 1960s. Performance assessment trace back to 221 A.D. frameworks for daily schedules appeared as soon as the 7th century with the Sharia law, and the concept of earned time was used in the Mill clock functioning back in the 19th century. Besides, the concept of prompt payment, which should be considered inseparable from EVM basis, has been claimed ever since the writing of the book of Deuteronomy, some 3000 years ago. But more importantly, Gillette

³⁷ Planning Planet. (n.d.). Guild of Project Controls Compendium and Reference. Retrieved October 30, 2018, from: <http://www.planningplanet.com/guild/gpccar/introduction-to-managing-project-controls>

and Dana's *Cost Keeping and Management Engineering* represents the most eloquent proof that Earned Value Management as we know it was already used in the construction industry more than half a century before the commonly recognized birth of EVM in 1967.

CONCLUSION

If earned value is generally claimed to have emerged in the late 1960s with the U.S AirForce, a thorough historical examination of the combined evolution of Earned value, scheduling and payment incentives demonstrates EVM roots go back to the Old Testament and Sharia law. Alongside the industrialization's increasing need for performance, new systems such as the "Piece Work" system were developed back in the 17th and are still in use today. In fact, the various incentive schemes developed in the following centuries certainly "rhyme" with those of today³⁸. For this reason, understanding the basis underlying EVM namely "pay for performance" leads to a better understanding of the rise of the concept many centuries ago, as well as its very merits.

Besides, this historical approach reminded the central position of prompt payment in the history of incentive schemes, tracing back to the Deuteronomy and the Quran. It seems imperative to remind the values of this concept today, as one the main causes of claims and disputes on projects are due to the lack of working capital allocated to the contractors...

APPENDIX

Appendix 1: Combined history of EVM, scheduling and incentives

<i>Date</i>	<i>EVM timeline</i>	<i>Scheduling Timeline</i>	<i>Incentive Plans Timeline</i>
<i>BCE</i>		<i>Scheduling and strategy were used some 2500 years ago to build pyramids, for military purposes as well as travel routes</i>	
<i>from 2000-1000BCE</i>			<i>During early Mesolithic era, different works and creation of extensive structures to provide shelter from both the environment and predators: no remuneration</i>

6th century BCE	<i>The book of Deuteronomy enforces the concept of EVM 24:14-15 reads: “You shall not oppress a hired servant who is poor and needy, Each day you shall give him his wages, and not let the sun go down on it, for he is poor and has set his heart on it; lest he cry out against you to the Lord, and it be a sign to you.”</i>	<i>Torah texts Talk mentions scheduling and how to efficiently manage time.</i>	<i>Daily wage is given for daily labor. Afterlife reward for those who follow the guidance of god.</i>
1st century AD	<i>The Bible assumes that daily labor requires a daily wage so that it is not theft</i>		<i>Hard work shall be rewarded by daily bread “With sweat on your brow shall you eat your bread, until you return to the soil, as you were taken from it.”</i>
221 AD	<i>First traces of performance management: Wei Dynasty emperors rated their family members’ performance</i>		
Roman culture - Until 5th century		<i>Demonstrated competence in organization, administration, building, and warfare.</i>	<i>Work was still perceived as punishment by God for man’s original sin, but to this purely negative view was added the positive aspect of earnings which prevented one from being reliant on the charity of others for the physical needs of life</i>
600-700	<i>Sharia law reads: “Give the wages of employee before his sweat dry”(Ibn Majah, Hadith no. 2468)</i>	<i>Existence of a framework for daily schedules (articulated around the 5 daily prayers)</i>	<i>Workers are paid in order to fulfil basic necessities.</i>

			<i>Afterlife reward for those following the Quran and the Sharia.</i>
Medieval period 5th century - 15th century			<p><i>work still held no intrinsic value. its function was to meet the physical needs of one's family and community, and to avoid idleness which would lead to sin</i></p> <p><i>Feudal system: landowners provided governance and protection to those who live and work on their property.</i></p>
1660s			<i>English Robert Doughty believes labourers should be paid "by the great" (at piece-rates) rather than day-rates</i>
1750 to early 1800 : Industrial Revolution	<i>19th century: Mill clocks use a clock functioning linked to the concept of "Earned Time"</i>	<i>Origins of Modern schedule control tools</i> <i>the scientific management concept was developed, predicated on specialization and division of jobs into simple tasks. Scientific management was claimed to increase worker production and result in increased pay.</i> 1765: J. Priestly: Bar Chart	<i>Effort expended in work should be rewarded</i> <i>Daft and Steers described the scientific model as holding "that the average worker was basically lazy and was motivated almost entirely by money."</i>

<p>1880's to 1920's: Scientific Management Era</p>	<p>1909: Earned Value used in construction industry and mentioned in Cost keeping and Management Engineering by Halbert Gillette</p>	<p>1896: Harmonygraph, by Polish K. Adamiecki methodology for 'work harmonization': Aimed at creating harmonious teams, practical scheduling, and compatible, measurable means of production</p> <p>1910's: Modern bar chart is fully developped .Schürch' barchart. The bar chart correlates activities and time in a graphical display allowing the timing of work to be determined but not interdependencies</p>	<p>Scientific Management Era: Taylor'sswort a paper, "A Piece-Rate System:" presented to the ASME in 1895, called scientific management. Identify that workers would not increase their productivity unless assured a good liberal increase, which must be permanent.</p> <p>1889: Henry Towne (president of the American Society of Mechanical Engineers "ASME"), writes "Gain-Sharing", a plan that ensured workers a guaranteed wage rate, or gains.</p> <p>1891: Halsey presented a paper entitled "The Premium Plan of Paying for Labor." In this paper Halsey presents four types of labor payment:</p> <ul style="list-style-type: none"> • The day's-work plan • The <u>piece-work</u> plan • The <u>profit-sharing</u> plan • The premium plan <p>The International Institute of Social History started a three-year Russian-Dutch Cooperative Research Project "Work Incentives in Russia, 1861-1999: Compensation, Commitment and Coercion</p> <p>1900s: beginning of US labor mechanization and</p>
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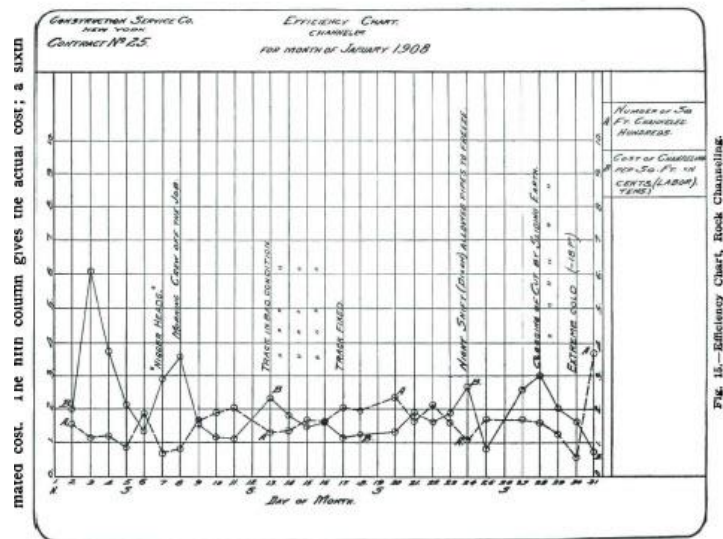
			<p><i>development of piece-rate system</i></p> <p>1913: Harrington Emerson : <i>The Twelve Principles of Efficiency</i>, he placed the efficiency reward last. Emerson felt the worker needed more flexibility in being able to receive a bonus. Thus, he “found it undesirable to make the line of demarcation so sharp between efficiency and inefficiency”</p> <p>1919: Lilian Gilbreth describes two kinds of incentives: direct incentives and indirect incentives</p>
<p>1920s - 1950s</p>	<p>1950: “Earned Standards” DuPont/Sperry Rand</p> <p>1950: Walker and Kelly Invent ADM (Arrow Diagram Method)</p> <p>1959: E. Kelley & M. Walker: Critical Path Method The development of CPM1956. as computerized project management tool. Mathematics to management the schedule that included 61 activities, 8 timing restraints and 16 dummies</p>	<p>1930s: Flow-Line Scheduling (Line of Balance)</p> <p>1940s: Milestone Charts</p> <p>1950’s: Good Year Company: Line of Balance (flow line) used on the Empire State Building</p> <p>1956: U.S Navy: PERT</p>	

<p>1960s-2000</p>	<p><i>Method and PDM methodology developed by John Fondahl in 1961, non-computer' alternative to CPM.</i></p> <p>1962 US Navy Pert/Cost</p> <p>1965 US Airforce CSPCS</p> <p>1967, EVM presented by the U.S. government as an indispensable piece of the Cost/Schedule Control System Criteria (C/SCSC) to comprehend the budgetary parts of projects</p> <p>1967 US DoD C/SCSC Instruction 5000.2R</p> <p>1980-1990: Australia, Japan, United Kingdom, Sweden, Canada Adopt EVM</p> <p>1991: Secretary of Defense Dick Cheney canceled the Navy A-12 Avenger II Program due to problems detected by EVM</p> <p>The U.S National Government chose to remove C/SCSC before 1996 and moved in the path of a more adaptable EVM System (EVMS).</p> <p>1996, OMB/NASA/DoE Adapts "EVM or Equal"</p> <p>The American National Standards Institute (ANSI)/Electronic</p>	<p><i>1970s PERT was developed by the US Navy Special Projects Office, Bureau of Ordnance (SPO) invention of the term 'critical path'.</i></p> <p>'Programmer Evaluation Research Task</p> <p><i>Knowledge of the sequencing of activities' and 'a careful time estimate for each activity.</i></p> <p>ORS-CEGB 1960 which by</p> <p><i>these systems migrated to the 'mini computers' of the 1970s and 80s but remained expensive</i></p> <p><i>computer based scheduling 1990s no one was doing manual scheduling gant the number of people creating schedules on a part time, untrained basis exploded more expensive mini systems.</i></p>	
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	<p><i>Industries Alliance (EIA) distributed rules for EVMS at first in 1998</i></p> <p><i>EVM</i></p> <p><i>1998 ANSI/EIA 748 I</i></p>		
2000-today	<p>2011: PARCA EVM Authorities Memo published</p>		<p>2011: Milkovich, <i>Variable-based pay, which includes the use of bonuses, stipends, and other forms of incentivized rewards, offer organizations more flexibility in implementing their compensation strategies in comparison to fixed-based pay programs.</i></p> <p>2013: Snell and Bohlander <i>variable-based pay 80% of companies in the United States use it. Individualized pay is highly promoted.</i></p> <p>2014: Moriarty, <i>Skill/knowledge-based pay, and its close derivatives called competency-based pay and values-based pay, is an individual incentive system that rewards employees for skills, knowledge, and competencies, as opposed to the positions they hold</i></p> <p>2014: Downes & Choi, <i>Merit-based pay systems that reward employees for their individual and</i></p>

			oftentimes, group performance, have their roots in equity theory. Organizations must then balance the need to reward top performers without alienating the remaining workforce.
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Appendix 2: Progress chart from *Cost Keeping and Management Engineering*, by Gillette, H., & Dana, R. T. (1909).



Appendix 3: Blueprint progress chart from *Cost Keeping and Management Engineering*, by Gillette, H., & Dana, R. T. (1909).

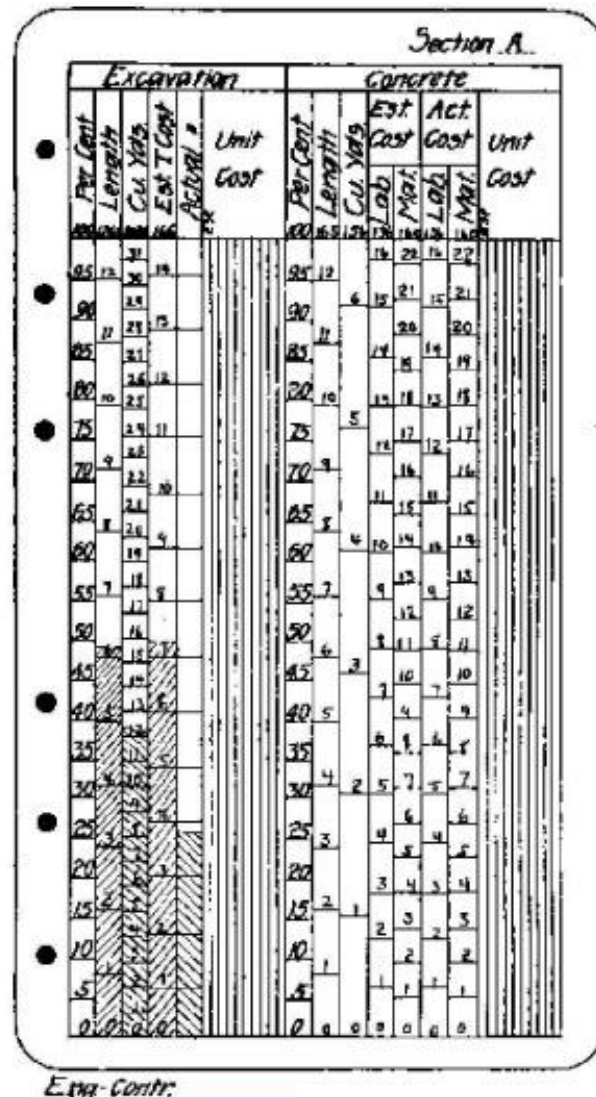


Fig. 68.—Progress Chart (See p. 180).

Appendix 4: Summary progress chart from *Cost Keeping and Management Engineering*, by Gillette, H., & Dana, R. T. (1909).

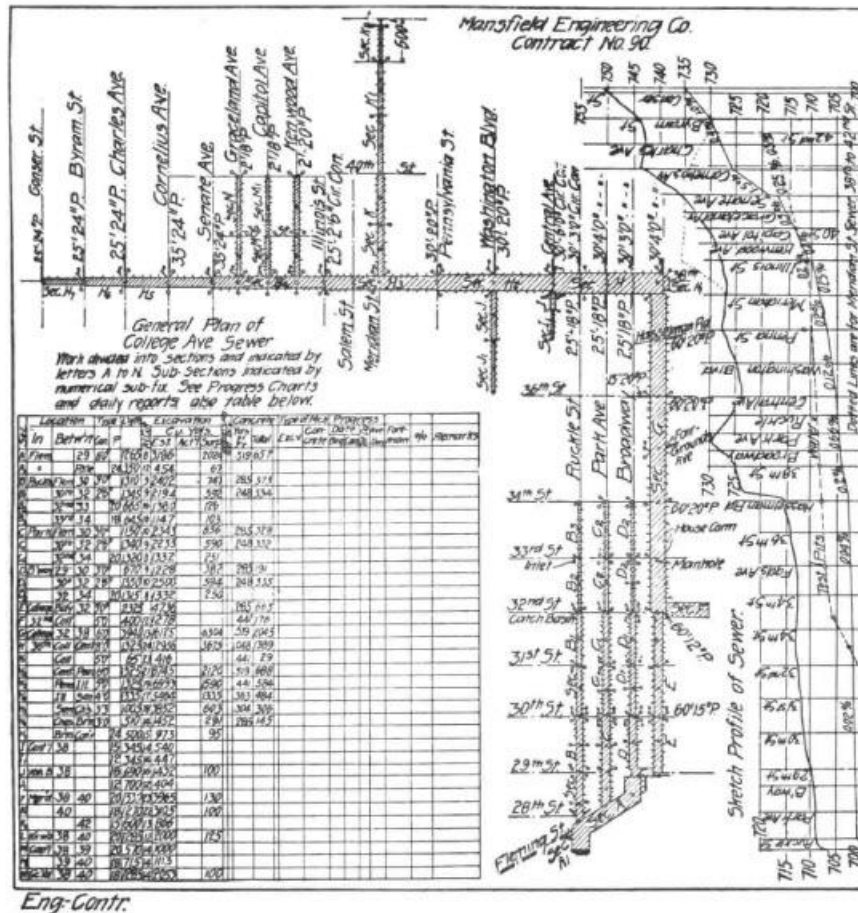


Fig. 69.—General Progress Blue Print.

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Sophie Geneste is a trilingual Project Management and Business Development Masters student at SKEMA Business School, Paris. Born in Burgundy, France, she first studied translation and international relations before entering SKEMA, in 2016.

In 2017 she was president of a 30-student organization, which created an Oratory Contest opened to 500 students (*Prix Cicéron*), opened a Model United Nations (MUN) delegation and directed a printed press review.

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