Integrating Physical Progress with a Prompt Payment Process Using Earned Value Management [1]

Claudio M Olivieri

ABSTRACT

Surveys reveal that problems with efficiency in the field often lead to payment reductions and delays. In turn, slow payments cause cash flow problems that reduce a construction business' ability to finish work quickly, effectively stunting the growth of their business.[2] The "proposed" model aims to end the construction's vicious cycle of "late payments and low productivity." This research developed a solution that integrates the progress with the payment process. A "how-to" guide to close the interface loop between Owners and Contractors through an activity-based management approach supported by a robust data model. This "proposed" technique enables a simple payment system that ensures the Contractor is paid promptly for work performed and protects the Owner from defects in the work. The findings significantly improve payment timeframes from the current industry average of 83 days to 28 days. Considering the substantial benefits for every party, the author strongly advocates starting to act diligently in this respect.

Keywords: Governance and Integration, Stakeholder Expectations, Progress, Earned Value, Contracts, Procurement, Supply, Payment, Cash Flow, Databases

INTRODUCTION

Background

"30% of all construction projects end in disputes, because no one is on the same page"[3] by the ARCADIS Global Construction Disputes Report 2019.

As stated in peer-reviewed research, "Unfortunately, far too many projects end up with disputes, claims, and counterclaims. HK&A published their CRUX Report (2020) that concluded:

- 1,185 projects with a combined CAPEX worth more than US$1.8 trillion analyzed.
- The cumulative value of sums in dispute exceeded US$48.6 billion.
- On average, claimed values reached almost 56% of project's planned capital cost.

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[2] Wolfe Jr, S. (2020, April 30). *2020 Report: Construction suffers from wasted time & slow payment*. Retrieved September 30, 2021, from Levelset: https://www.levelset.com/blog/2020-report-construction-wasted-time-slow-payment/
[3] From AEC Profiles. (2019). *30% of construction projects end in dispute*. Retrieved from AEC Profiles: https://www.aecprofiles.com/30-percent-of-construction-projects-end-in-dispute

- Extensions of time claimed together would amount to 593 years.
- Resultant delays would typically extend original schedules by more than 71%.
- While changes in scope are still most often to blame, design-related problems are now entrenched near the top rankings.
- The other most often recurring causes are:
  - poor management of third parties,
  - inadequate contract management, and
  - deficiencies in workmanship."[4]

Recent research on the subject reveals four (4) main categories of claims leading to disputes.

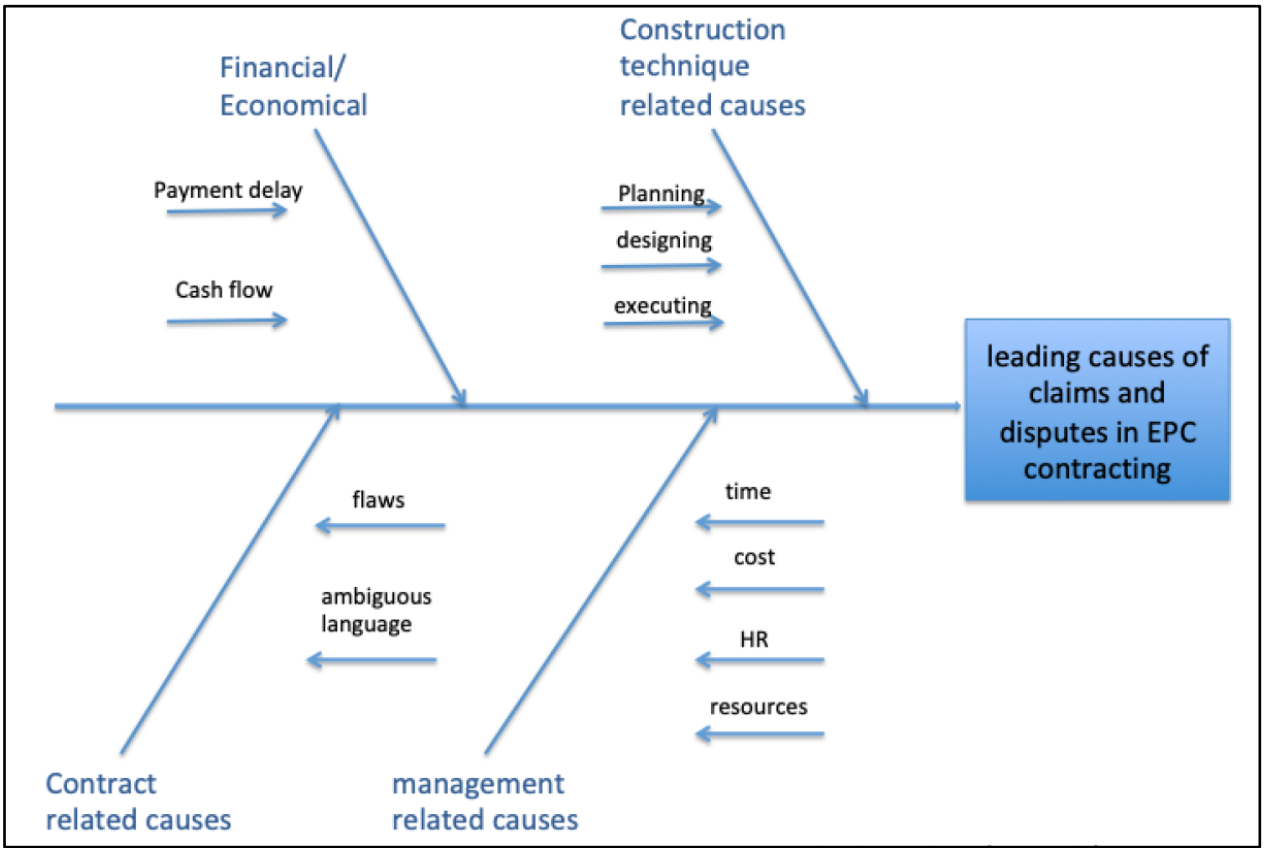

Figure 1: Fishbone diagram showing leading causes of construction claims (Zhao, 2019)[5]

This technical paper focuses on integrating the progress with the payment process to mitigate some of the root causes identified in ***Figure 1***. The EVM technique derived as an evolution from the relationship between Owners and Contractors to address the issues associated with the

[4] From PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*
[5] From Zhao, W. (2019). The root cause of claims and disputes in construction industry and solution analysis. *PM World Journal*, *8*(5). https://pmworldlibrary.net/wp-content/uploads/2019/06/pmwj82-Jun2019-Zhao-root-cause-of-claims-and-disputes-in-construction.pdf

prompt payment of traded products that conformed to the terms and conditions agreed between both parties[6].

After thousands of years from its conception and centuries away from its formal implementation[7], the EVM technique still shows drawbacks. For example, there are challenges related to the interfaces across the different groups involved in the payment process between Owners and Contractors in the construction industry (i.e., engineering, procurement, construction, contracts, QA/QC, accounting). Not addressing these fatal flaws has led to costly time, money, and stress disputes.

Related work

The goal of this endeavor builds upon groundwork research about mapping the data stored by separate groups (i.e., precisely, the project controls systems with the ERP system) by adopting standard sets of coding structures through an activity-based management structured interface [8].

[6] From Giammalvo, P. D. (2019). Activity based costing (ABC) - The other side of the earned value coin? *PM World Journal*, *8*(2). https://pmworldlibrary.net/wp-content/uploads/2019/02/pmwj79-Feb2019-Giammalvo-Activity-Based-Costing.pdf
[7] From Geneste, S. (2019). The true origins of EVM: A historical approach to scheduling and incentive schemes. *PM World Journal*, *8*(9). https://pmworldlibrary.net/wp-content/uploads/2019/10/pmwj86-Oct2019-Geneste-the-true-origins-of-evm.pdf
[8] From Giammalvo, P. D. (2018). Mapping ERP "Chart of Accounts" to building information modeling software using Omniclass coding structures and activity-based costing/management - A contractor's perspective. *PM World Journal*, *7*(4). https://pmworldlibrary.net/wp-content/uploads/2018/04/pmwj69-Apr2018-Giammalvo-ERP-and-BIM-Omniclass-coding-marriage-featured-paper-1.pdf

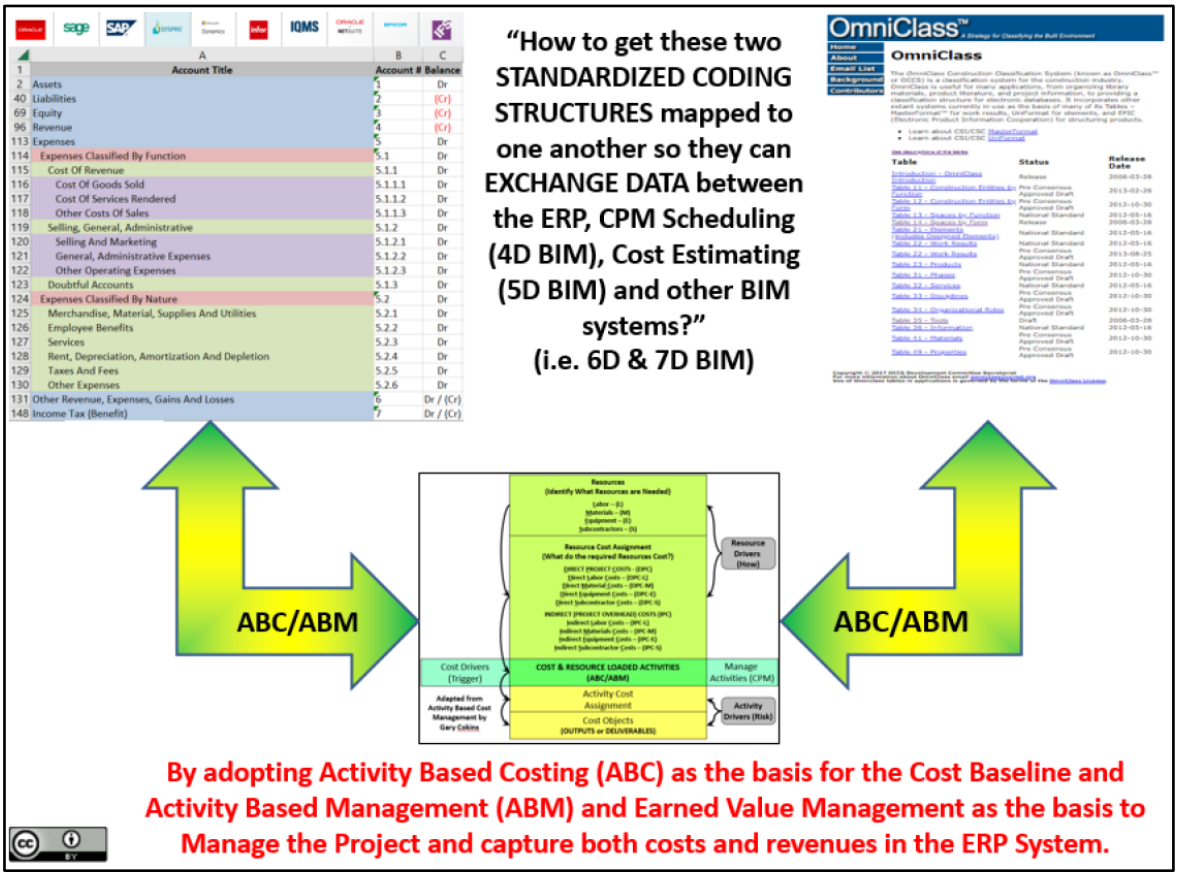

Figure 2: Integration through an activity-based management structured interface (Giammalvo, Mapping ERP "Chart of Accounts" to building information modeling software using Omniclass coding structures and activity based costing/management - A contractor's perspective, 2018)[9]

[9] From Giammalvo, P. D. (2018). Mapping ERP "Chart of Accounts" to building information modeling software using Omniclass coding structures and activity-based costing/management - A contractor's perspective. *PM World Journal*, *7*(4). https://pmworldlibrary.net/wp-content/uploads/2018/04/pmwj69-Apr2018-Giammalvo-ERP-and-BIM-Omniclass-coding-marriage-featured-paper-1.pdf

System model

Figure 3 displays the EVM fundamental concepts. First, the Owner does not have to purchase goods or services that are substandard, containing latent or patent defects. Instead, it gets to test for the quality of the product or services it is purchasing. It is up to the Contractor to provide sufficient proof that the products, goods, or services meet the requirements established by the Owner following the contract agreed between both parties. The next step is to measure the physical quantity taken, and then the Owner pays the Contractor promptly for what it has received.[10]

Figure 3: Underlying concept of earned value management (PTMC Team & Giammalvo, 2021)[11]

PROBLEM STATEMENT

From all the leading causes of disputes and claims on projects, as identified in ***Figure 1***, it has been found out that the most critical one is the hindrances often encountered in the payment process.[12]

[10] From PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*
[11] From PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*
[12] From PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*

This issue has significant repercussions, as it is the primary driver of poor performance by the contractors who starve for working capital.

The research questions that this technical paper aims to address are the following ones:

1. How could the payment system or process be simplified to ensure that Contractors are paid promptly for work performed in substantial compliance with the contract documents?
2. How could this "proposed" payment system or process also protect the Owner from latent and patent defects in the work?

Proposed solution

The thesis of this technical paper consists in developing a flowchart underpinned by an activity-based management structured interface. A data model relating the information stored in the myriad of databases from the "fit for purpose" systems adopted in the companies achieves this result. Thus, this solution provides:

1. Independence from the selection of specific software that gives a competitive edge to a particular group (e.g., Primavera P6® or MS Project® to schedulers, SAP® or other ERP to accountants), and
2. Data integrity and consistency would enable Owners and Contractors to retrieve the required information seamlessly from a unique source to prepare the properly integrated reports for analysis and assessment per their needs.

METHODOLOGY

Development of the feasible alternatives

The study analyzes and assesses the competing techniques by comparing the flowcharts and interface philosophies of the "business as usual" and the "proposed" models.

<u>Development of the outcomes for each alternative</u>

1. "Business as usual" model

   The flowchart displayed below in ***Figure 4*** is based on the author's experience working in secondment positions within the Owners' team in the mining sector.

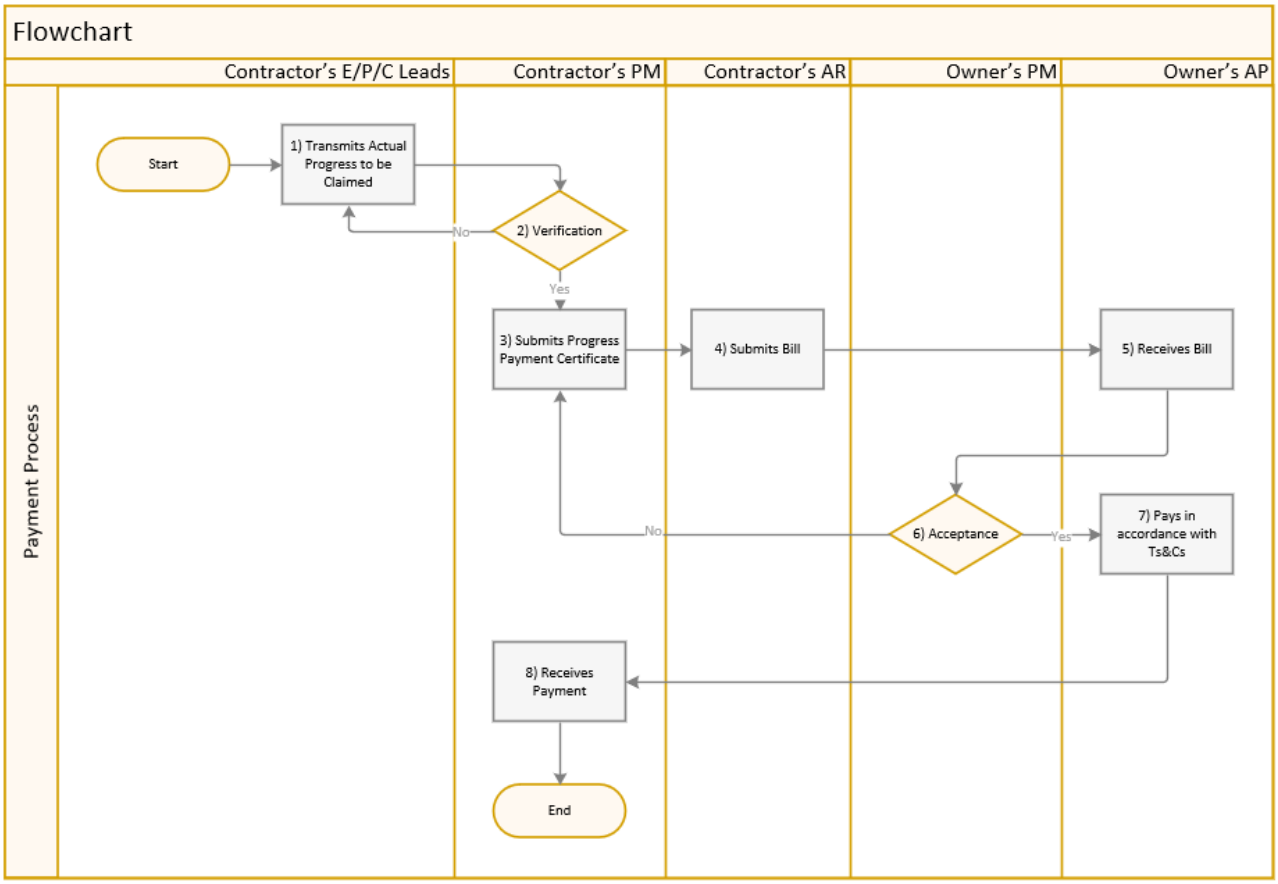

Figure 4: Flowchart of "business as usual" model (Olivieri, 2021)[13]

a. Firstly, the engineering, procurement, and construction (E/P/C) leads on the Contractor's side are responsible for kicking-off the process as per the cadence stipulated in the project execution plan (driven by the contract agreed with the Owner) by transmitting the progress to be claimed in that period.
b. Next, the project manager (PM) on the Contractor's side verifies the claimed quantities. If these are determined incorrect, the E/P/C leads are required to amend them.
c. Then the Contractor's PM prepares a progress payment certificate (PPC) by applying the contract rates to the quantities and submits it to Accounts Receivable (AR) to initiate the bill preparation.
   Regarding the PPC, usually, there is no standardized form. Each Contractor lays it out at their discretion. Some only provide materials' invoices, personnel, and equipment timesheets as support documentation for reference—others, not even that.
d. The Contractor's AR then submits the bill to the Owner's Accounts Payable (AP).
e. In turn, the Owner's AP requests acceptance of the bill by the Owner's PM.

[13] By author.

f. The Owner's PM reviews the PPC, and if accepted, it instructs AP to pay the bill following the agreed terms and conditions. Otherwise, the Owner's PM challenges the Contractor's PM and request to amend the PPC.
g. Finally, after the agreed payment timeframe, the Contractor's AR should receive the payment in their bank account.

Regarding the sources of information to retrieve the data required for proper monitoring and

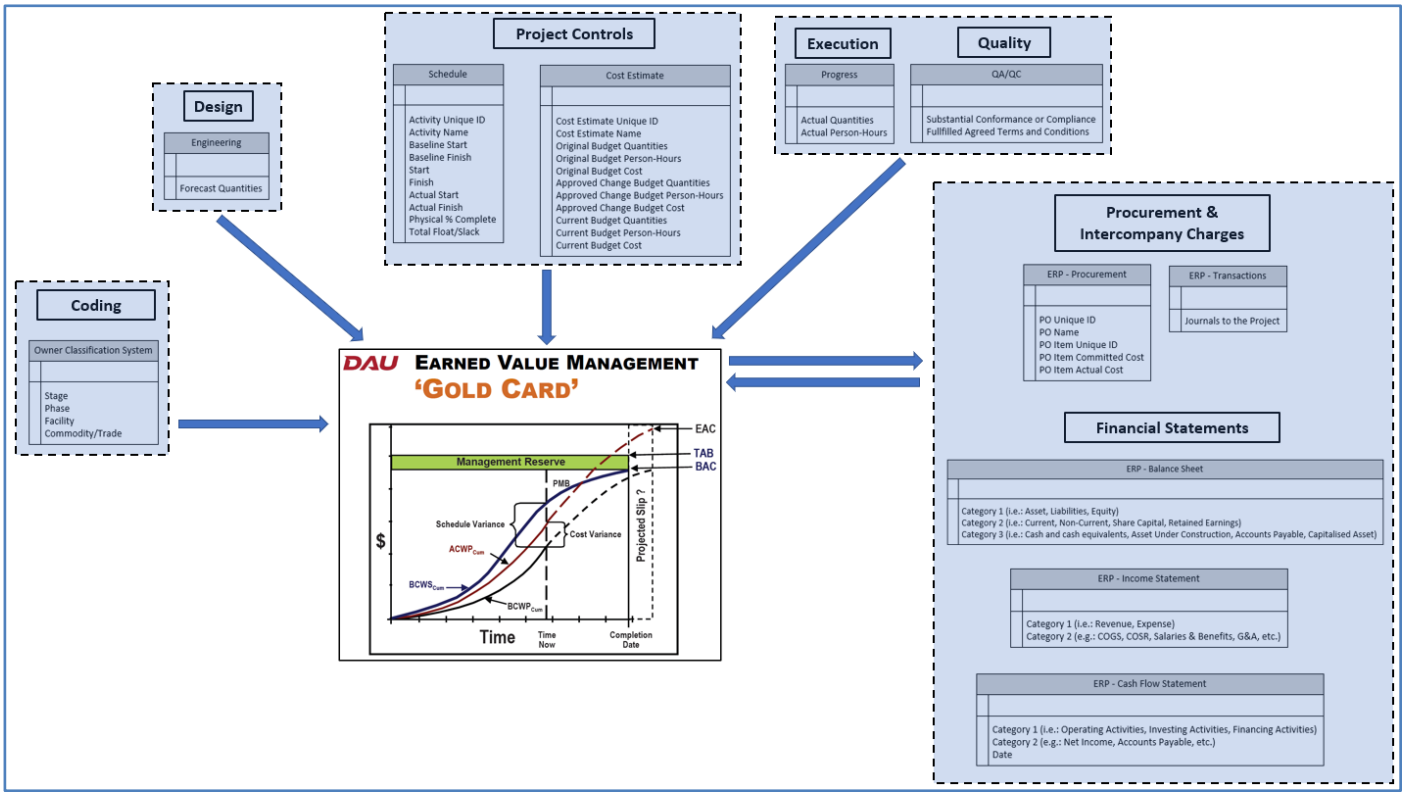

Figure 5 below). Furthermore, the industry usually perceives the "project controls" discipline as a "cost accounting" function; it is generally under-resourced. Hence:

a. Earned value is not compulsory and customarily not reported by the Owner's project controls teams,
b. Due to time constraints, the required level of detail (activity-based management ideally) cannot map the various sources. Thus, the resulting report consolidates the data at a higher "rolled-up" summary level that doesn't provide the necessary information to perform a rigorous analysis and assessment.

As a result, the only monitoring and control activity that the Owner's PMO regularly performs is comparing the planned value S-curve and the actual cash flow extracted from the ERP. The estimate to complete (ETC) is roughly estimated based on the schedule, the remaining purchase order funds, the remaining unallocated budget, and a basic trending system.

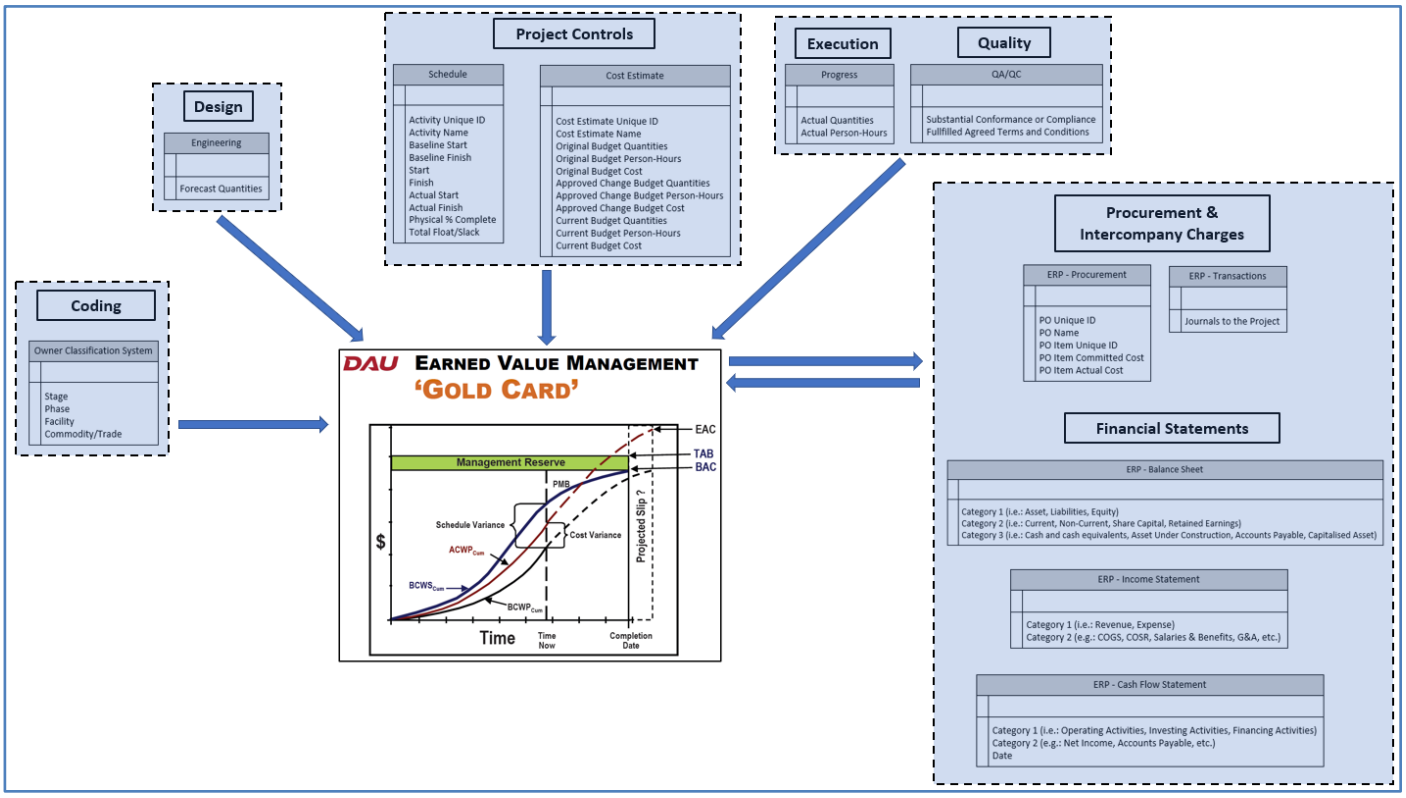

Figure 5: Disjointed data model of "business as usual" model (PTMC Team & Giammalvo, 2021)[14] (Defense Acquisition University, 2020)[15] "Proposed" model

The flowchart displayed below in ***Figure 6*** is based on the research undertaken. It articulates into one consolidated process the "best tested and proven practices" found from reputable sources (i.e., professional associations, technical papers, colleagues). It provides a holistic framework for this puzzle that belongs to the project control process, part of the overall strategic asset management.

h. In this case, as abovementioned in *Figure 3* (describing the underlying concept of earned value), the Contractor can only claim goods or services that are in "Substantial Conformance or Compliance" to the technical specifications, which is one of the three criteria required by Owners to accept a deliverable. Hence, the test for the quality of the products or services to be claimed is the first step by the Contractor to provide sufficient proof (per the agreed contract) that these deliverables meet the requirements established.

[14] Adapted from PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices"*.
[15] From Defense Acquisition University. (2020, June). *Earned value management general reference (Gold card)*. Retrieved November 25, 2021, from https://www.dau.edu/tools/t/EVM-General-Reference-(Gold-Card)

i. Next, the engineering, procurement, and construction (E/P/C) leads on the Contractor's side are responsible for transmitting the progress claimed in that period. This action fulfills another criterion of the three required by Owners to accept a deliverable, which is to specify the measured quantity being physically in place.

j. Subsequently, the project manager (PM) on the Contractor's side verifies the claimed quantities. If these are determined incorrect, the E/P/C leads are required to amend them. Otherwise, the PM (or his Contract Owner delegate) verifies that fulfills the agreed terms and conditions stipulated in the contract, the last of the three criteria required by Owners to accept a deliverable.

k. Then the Contractor's PM prepares a progress payment certificate (PPC) and submits it to the Owner's PM for approval.
Regarding the PPC, the study recommends adding a clause during the contract formation process to establish the adoption of a standard form that allows proper traceability of originally committed quantities, work-hours, and costs, and any approved variations actuals. In summary, all the information required for proper monitoring and control at the right level (i.e., activity-based management) would enable the calculation of the performance measurements and include the status of the retainage. Below, in ***Figure 7***, a sample of an excellent PPC from the cost control system CMS (construction management system) is displayed for reference.

The PPC should include all the documentation required to support the claim per the agreed contract between both parties.

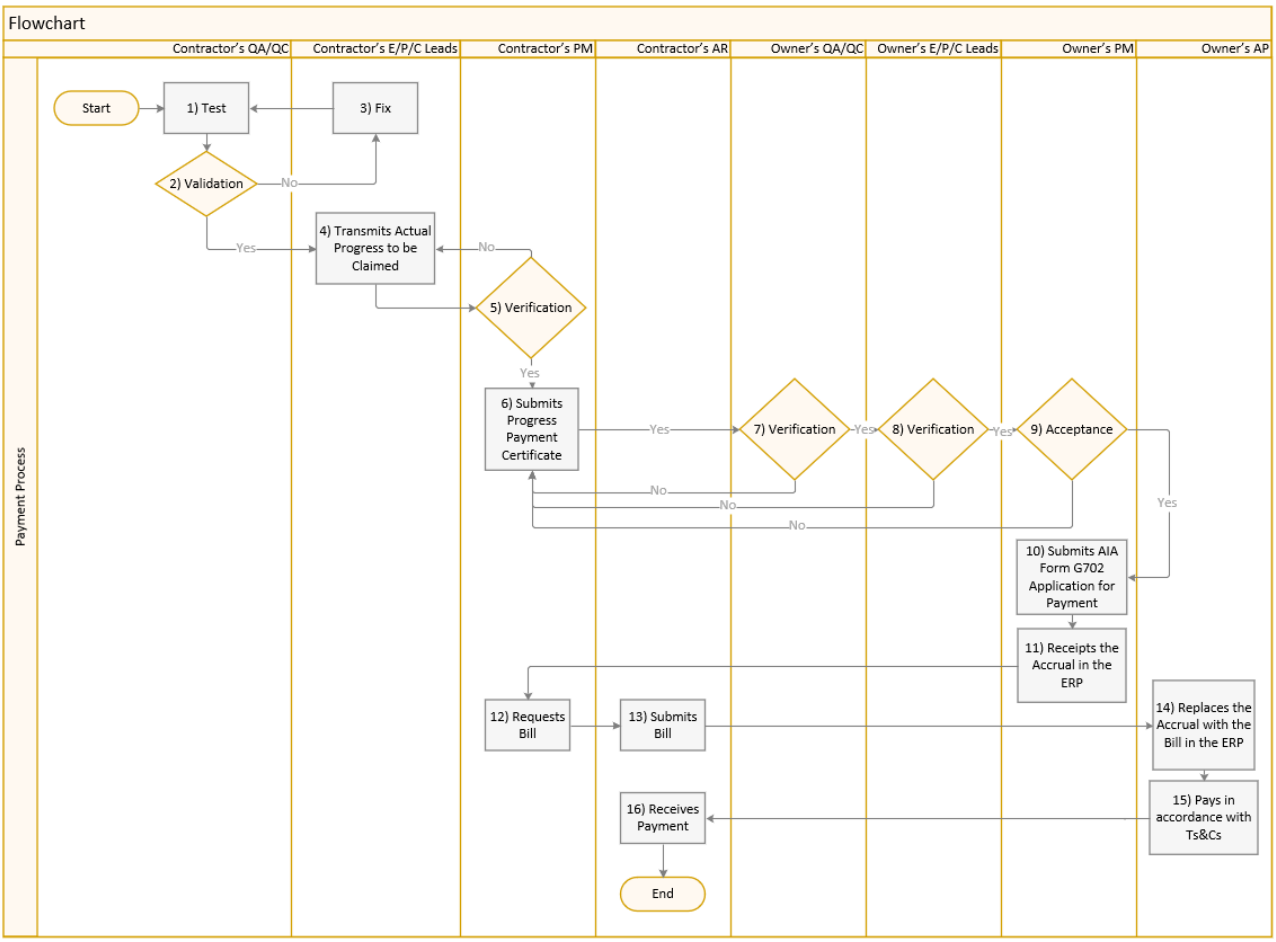

Figure 6: Flowchart of "proposed" model (By author)[16]

[16] By author.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1			CMS999										CMS MANUAL
2			GTS Software Pty Ltd										PRELIMINARY PROGRESS PAYMENT CERTIFICATE
3													*** PAYMENT CURRENCY AUD ***
4			C:\The GTS Vault\CMS\CMS Training Exercise Data\CMS Manual Training Database 002 (BCX).mdb										
5	PROGRESS PAYMENT # 001 *** PAYMENT CURRENCY AUD ***			REFERENCE INVOICE(S):									
6	1001-C - Concrete Works - Cearpenters Pty Ltd									Period Ending 27-Feb-2012			
7	PACKAGE REVISION/GROUP/PACKAGE DETAIL			COMMITMENT				PREVIOUS PAYMENTS		This Payment # 001		TOTAL TO DATE	
8	Item	Cost Code	Description	Unit	Quantity	Unit Price	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
11	Base Contract: 27-Feb-2012												
12	**AA - Mob & Demob**												
13	1	9100.Z.1	Mobilisation	pc	100.0	0.00	1,500,000.00	0.0	0.00	0.0	0.00	0.0	0.00
14	2	9200.Z.1	Demobilisation	pc	100.0	0.00	350,000.00	0.0	0.00			0.0	0.00
17	Total Group: AA						1,850,000.00		0.00		0.00		0.00
18	**BB - Permanent Facilities**												
19	3	1100.CAA.1	Primary Crushing Concrete	m3	9,500.0	LS	15,500,000.00	0.0	0.00	500.0	815,789.47	500.0	815,789.47
20	4	1200.CAA.1	Secondary Crushing Concrete	m3	4,500.0	LS	7,000,000.00	0.0	0.00	200.0	311,111.11	200.0	311,111.11
21	5	1300.CAA.1	Screening Concrete	m3	1,800.0	LS	4,700,000.00	0.0	0.00		0.00	0.0	0.00
22	6	1100.CAA.1	MCC Foundations	m3	100.0	0.00	300,000.00	0.0	0.00			0.0	0.00
25	Total Group: BB						27,500,000.00		0.00		1,126,900.58		1,126,900.58
28	Total Base Contract:						29,350,000.00		0.00		1,126,900.58		1,126,900.58
31	Total Contract: 1001-C						29,350,000.00		0.00		1,126,900.58		1,126,900.58
34				Retained:					0.00				0.00
37				Sub-Total:					0.00		1,126,900.58		1,126,900.58
38				Less Previous Payments:									0.00
41				**Total Amount Due Excluding GST:**					***** PAYMENT CURRENCY AUD *****				1,126,900.58
44				**Date Due under agreement 1001-C:**									27-Mar-2012

Figure 7: Progress payment certificate sample (GTS Software, 2014)[17]

l. The Owner's PM delegates the detailed verification of the PPC and its support package to its QA/QC and E/P/C leads delegates. Once checked, the Owner's PM performs the final review and endorses the PPC. Otherwise, the Contractor's PM is challenged and requested to amend the PPC.

m. Subsequently, a "best tested and proven practice"[18] is recommended: the Owner's PM should submit an "AIA Form G702 Application for Payment" so that the Contractor can attach it to the bill as evidence of the Owner's representative approval for payment. Also, the Owner's PM should arrange the accrual entry into the ERP in the interim to keep the project information in real-time.

n. Next, the Contractor's PM hands over the approved "AIA Form G702 Application for Payment" to the Contractor's Accounts Receivable (AR) and initiates the bill preparation.

o. The Contractor's AR then submits the bill to the Owner's Accounts Payable (AP).

p. In turn, the Owner's AP replaces the interim accrual with the bill in the ERP.

q. The Owner's AP makes the arrangements to pay the bill following the agreed terms and conditions of the contract.

r. Finally, after the agreed payment timeframe, the Contractor's AR should receive the payment in their bank account.

[17] From GTS Software. (2014). *Construction management system CMS V3 User Guide* (3.6 ed.).
[18] From PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*

Regarding the sources of information to retrieve the data required for proper monitoring and control of the project, this distinctive approach aims to achieve a consistent integration of the information. A data model underpins the resulting database that adopts "Activity-based management" as the backbone to map the data from myriad sources (please refer to ***Figure 8*** below). Concisely, the following steps summarize the process:

1) Identify database sources (i.e., the repository of information from the "fit for purpose" applications implemented by the different departments).
2) Map the data by adopting the "Activity-based management" technique and relate this database with the sources through the key fields.
3) Retrieve information from this integrated and unified database to analyze and assess the specific metrics required by each group for decision-making. For example:
    i. Project controls: performance measurements.
    ii. Accounting: asset capitalization and the 3 main financial statements (i.e., income statement, balance sheet, and cash flow statement).
4) Prepare dashboards based on the sourced information as well as calculated metrics for reporting.

Nowadays, with the state of affairs of the IT platforms, the goal could be achieved working in collaboration with the IT department:

a. Business analytics: tools like Power BI® and others enable Companies to retrieve information from diverse sources. By project controls preparing a proper technical specification defining the architecture of the data model, the IT department could implement the required solution.

b. User-friendly apps: tools like Power Apps® and others enable Companies to design "fit for purpose" forms that could simplify the data entry process for personnel, which could, in turn, improve tracking closer to real-time and reliability. The IT department could implement the required solution by project controls preparing a proper technical specification defining the form's layout and how it fits in the overall data model.

c. Workflows: tools like Power Automate® and others enable Companies to enforce governance rules built into the process itself. The IT department could implement the required solution by project controls preparing a proper technical specification defining the sequence and delegation of authority for approval workflows.

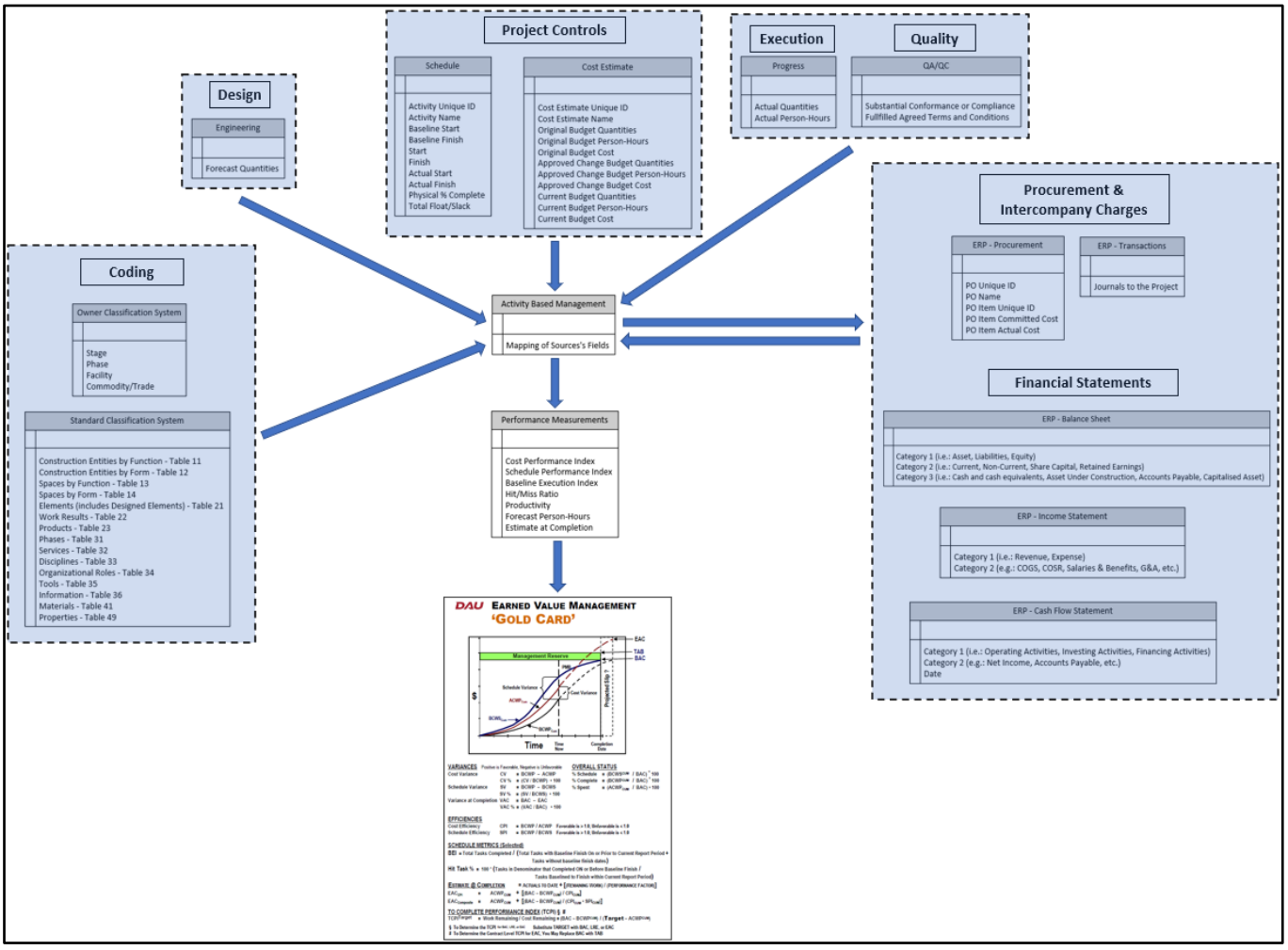

Figure 8: Integrated data model of "proposed" model (PTMC Team & Giammalvo, 2021)[19] (Defense Acquisition University, 2020)[20]

Selection of criteria[21]

The study adopts a multi-attribute decision-making compensatory model that analyzes and compares both approaches with an average weighting technique to substantiate the preeminence of the selected alternative.

Below, there is a list of the attributes considered for the assessment:

1. Contractor's cash flow management,
2. Unrecoverable exposure of delivered products,

[19] Adapted from PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*
[20] From Defense Acquisition University. (2020, June). *Earned value management general reference (Gold card).* Retrieved November 25, 2021, from https://www.dau.edu/tools/t/EVM-General-Reference-(Gold-Card)
[21] Adapted from PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices".*

3. Owner-contractor relationship, and
4. Cost of system implementation.

Attribute	Rank	Normalized Weight
Contractor's cash flow management	1	0.40
Unrecoverable exposure of delivered products	2	0.30
Owner-contractor relationship	3	0.20
Cost of system implementation	4	0.10

Table 1: Attributes' rank and normalized weight (By author)[22]

Contractor's cash flow management	Rank	Dimensionless Value
High	1	1.00
Medium	2	0.50
Low	3	0.00

Unrecoverable exposure of delivered products	Rank	Dimensionless Value
High	3	0.00
Medium	2	0.50
Low	1	1.00

Owner-contractor relationship	Risk Rank	Dimensionless Value
High	1	1.00
Medium	2	0.50
Low	3	0.00

Cost of system implementation	Rank	Dimensionless Value
High	3	0.00
Medium	2	0.50
Low	1	1.00

Table 2: Attributes' dimensionless values (By author)[23]

FINDINGS

Analysis of the alternatives

1. Payment timeframe

The "proposed" approach would enable an effective contractor's cash flow management. As strongly advocated in peer-reviewed research[24], this issue remains one of the leading causes of disputes and claims on projects, which in turn provokes poor performance of the contractors. "In 2018, it took contractors an average of 83 days to get paid, according to an annual PWC report. That number increased from 74 days in 2017..."[25]

[22] By author.
[23] By author.
[24] Adapted from PTMC Team, & Giammalvo, P. D. (2021). *Project controls/PMO handbook of "best tested and proven practices"*.
[25] From Budde, N. (2017, July 27). *Why Does it Take So Long to Get Paid in Construction? And What Can I Do About It?* Retrieved March 31, 2021, from Levelset: https://www.levelset.com/blog/why-does-it-take-so-long-to-get-paid-in-construction-and-what-can-i-do-about-it/

Even FIDIC general conditions, a well-known reference, establish a typical sequence of interim payment events that envisages at least 56 days (sub-clause 14.11) from the Contractor's statement submitted to the Owner's Representative seen in ***Figure 9***.

These duration ranges are outrageous, and the aim should be to align them to more reasonable timespans. Targeting monthly payments, in alignment with the most common frequency around (e.g., progress reports, progress payment claims, salaries), is possible by implementing the "proposed" model.

The study recommends processing the "Earned Value" acceptance weekly to build the foundations to increase the likelihood of prompt compliance. This way, the effort of QA/QC tests, validations, fixes, and the verification of the measured quantity to be physically in place spreads across the month. Thus, verifying and accepting the monthly progress payment claim by the Owner within a week is more manageable (i.e., reducing the workload of a whole month of information to just the most recent week, as the Owner had already accepted the previous progress). Please, refer to ***Figure 10*** below.

Hence, the "proposed" model would facilitate:

a. proper arrangement of working capital requirements in advance by contractors,
b. reduction of Contractor's financial risk,
c. easy identification of inefficient processes that delay prompt payments, which could trigger the investigation of its root causes:
    a. honest causes (e.g., non-contributing activities or non-activities embedded in the QA/QC process),
    b. dishonest causes (e.g., deliberate procrastination of payments for the sake of improving the Owner's cash flow contour).

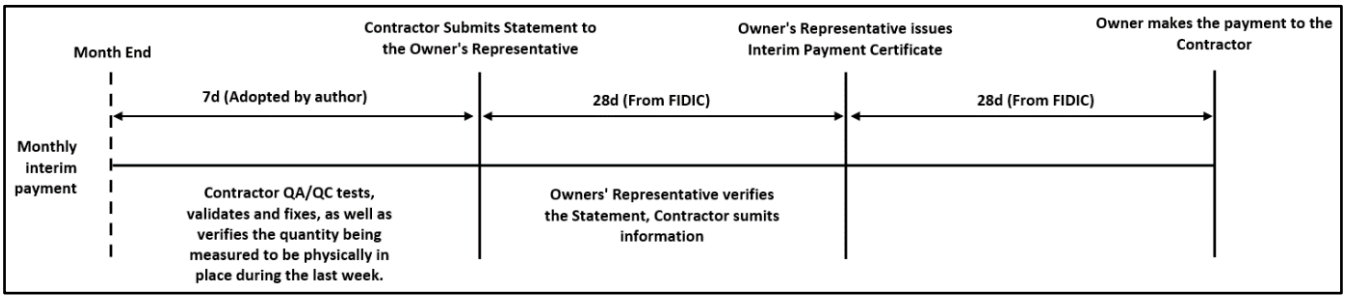

Figure 9: Typical sequence of payment events envisaged in clause 14 (Gould, 2016)[26]

[26] Adapted from Gould, N. (2016). Managing your FIDIC contract. *Institution of Civil Engineers* (p. 49). Dubai: Fenwick Elliott LLP.

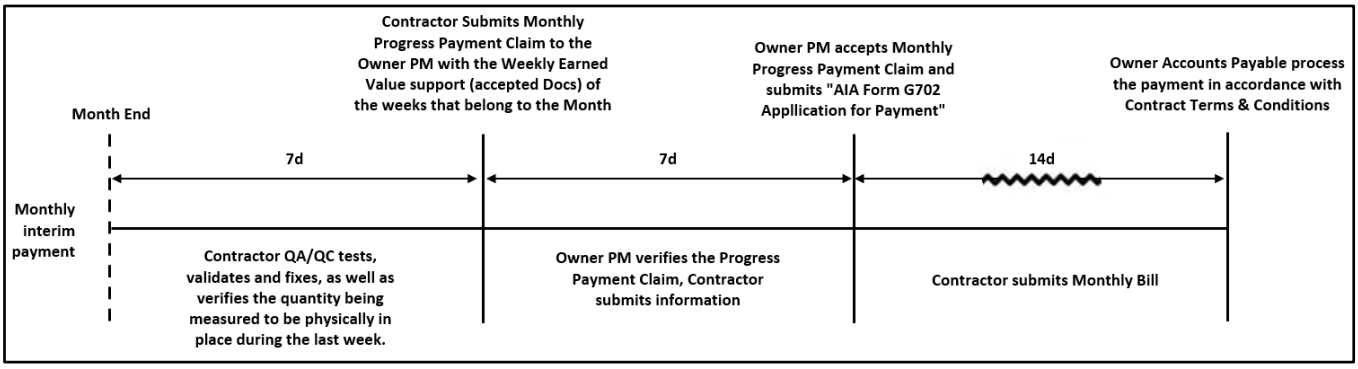

Figure 10: Sequence of payment events envisaged in "proposed" model (By author)[27] Reliability of data integrity

The integrated data model that underpins the "proposed" model's payment process should eliminate the dubious actual cost of work performed values reported by the "business as usual" disarticulated data model currently used in the industry. In the author's experience, several ad-hoc sanity checks that consisted of very time-consuming accrual reviews revealed significant omissions of work incurred but not billed nor accounted for in the system.

Due to time constraints, the required level of detail (activity-based management ideally) cannot map the diverse sources of the "business as usual" data model. Thus, the information does not adequately analyze and assess the accruals due to the absence of a proper initial setup.

2. Contractual payment risk allocation

In the opinion of the author, current "business as usual" clauses like "no-lien," "pay-if-paid," or "pay-when-paid" are among the worst tested and proven practices. These provisions allocate an undue risk to the Sub-contractors (usually the weakest supply chain link from a financial perspective), who do not control these external factors. If adequately quantified, the most likely outcome would be an exponential increase of costs to mitigate these threats, or many companies going out of business, as was found out recently in the abovementioned surveys. Any of both outcomes would ultimately affect the Owners in a long-term view.

Regarding liens, one of the best tested and proven practices is the "conditional lien waivers," which protect both parties (Owner and Contractor) and improve the document flow by streamlining and speeding up the payment process.

[27] By author.

3. **Setup and rollout**

   The only detriment that the study observes in the "proposed" model would be the associated time and costs related to the additional steps required to set it up from the beginning (i.e., the Contractor and the Owner must agree to the contractual terms and conditions). However, the benefits obtained from this solution ultimately outweigh these costs.

Comparison of the alternatives

Table 3 below shows the score obtained for each model by attribute and as a total, following the criteria previously stipulated.

		"Business as usual" model			"Proposed" model		
Attribute	Normalized Weight	Attribute Value	Dimensionless Value	Score	Attribute Value	Dimensionless Value	Score
Contractor's cash flow management	0.40	Low	0.00	0.00	High	1.00	0.40
Unrecoverable exposure of delivered products	0.30	High	0.00	0.00	Low	1.00	0.30
Owner-contractor relationship	0.20	Low	0.00	0.00	High	1.00	0.20
Cost of system implementation	0.10	Medium	0.50	0.05	High	0.00	0.00
			Score Total	0.05		Score Total	0.90

Table 3: "Business as usual" versus "proposed" approaches score comparison (By author)[28]

Selection of the preferred alternative

As previously hinted in the analysis and comparison of the alternatives' sections, the "proposed" model ended up with the higher score appraisal, thus confirming its predominance as the "recommended practice" to be adopted by the cost engineering profession.

<u>Performance monitoring and post-evaluation of results</u>

1. **Focalized approach**

   The author recommends a statistical process control chart to be adopted as the technique to measure the improvement of the primary root cause addressed in this study: "payment days from cut-off date" after implementing the "proposed" model. In addition, the author suggests the following:

   - Metric: Payment days from cut-off date.
   - Target value (28 days): As per the "proposed" model.

[28] By author.

- Upper specification limit (35 days): For this study case, it is deemed appropriate to add 7 days on top of the target value to concede that the process is within specification during its early implementation phase.

- Upper FIDIC limit (63 days): By sub-clause 14.11 of FIDIC general conditions, a typical sequence of interim payment events envisages to take at least 56 days. Acknowledging FIDIC contracts as one of the most renowned globally is considered an essential comparing parameter. The author also added 7 days from the month end to capture the compilation of last week's documents and the preparation of the PPC.

- Upper control limit (3 sigmas): An addition of 3 sigmas over the mean or average value of the data points is adopted as the limit to deem the process under control. For illustration purposes, the author uses the current industry average of 83 days as a starting point.

Figure 11 below shows a sample of a template that would enable the performance measurement.

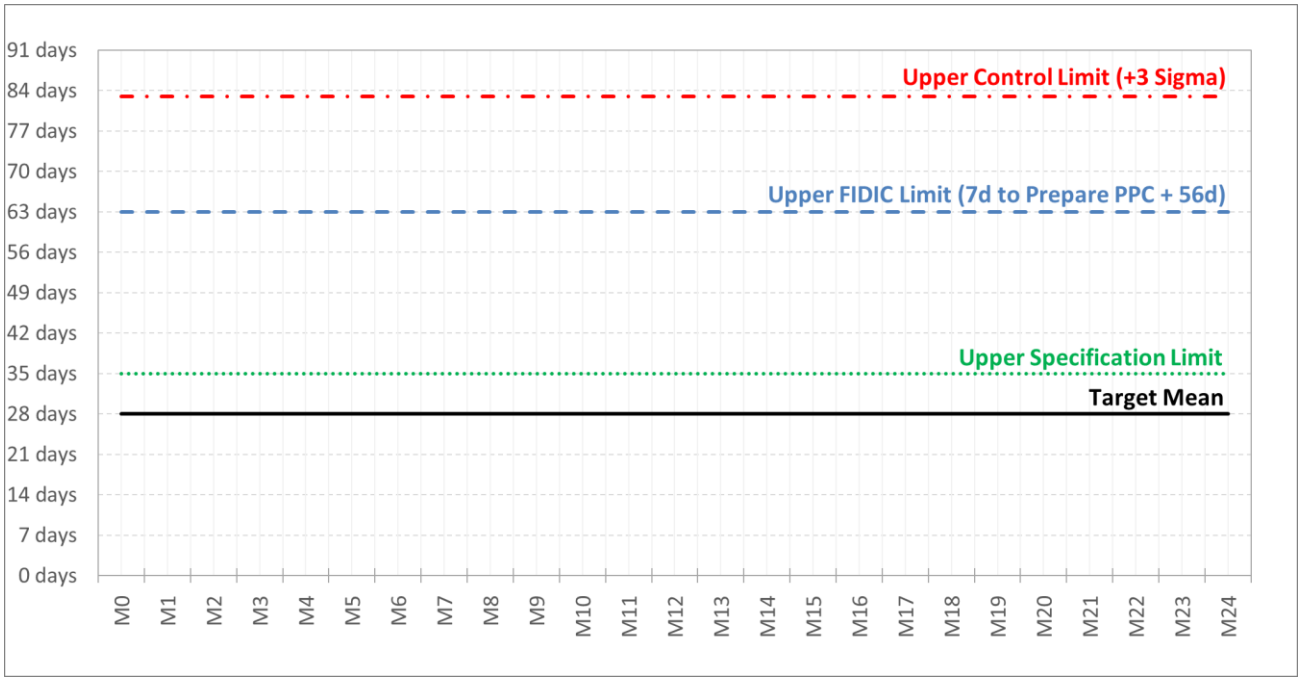

Figure 11: Statistical process control chart applied to analyze payment timeframes (By author)[29]

[29] By author.

2. Comprehensive approach

Once the industry corrects the most critical and urgent root cause (i.e., payment days from cut-off date), the focus on mitigating the disruptions should shift to the next one. Then, following the "Theory of Constraints" process, from the root causes identified in "***Figure 1: Fishbone diagram showing leading causes of construction claims*** ", the industry should identify the new bottleneck of the chain.

The author suggests a Pareto chart to monitor and communicate the information concisely to the leadership, enabling them to assess the situation and decide what steps to take next. As a first pass, the study allocates a normalized weight to establish the measurement framework to the leading causes of construction claims based on their relative ranking position in the author's opinion. When implemented in practice, the industry should calibrate these weights using a facilitation method, like dot-voting, across the right stakeholders (especially those with high power and high interest).

Then this status starting point should be compared against the regular monitoring of the evolving state of affairs.

Category	Root Cause	Rank	Running Total	Normalized Weight
Financial / economical	Payment delay	1	17%	17%
Financial / economical	Cash flow	2	32%	15%
Management related causes	Resources	3	45%	14%
Management related causes	HR	4	58%	12%
Management related causes	Time	5	68%	11%
Construction technique related causes	Planning	6	77%	9%
Construction technique related causes	Executing	7	85%	8%
Management related causes	Cost	8	91%	6%
Construction technique related causes	Designing	9	95%	5%
Contract related causes	Ambiguous language	10	98%	3%
Contract related causes	Flaws	11	100%	2%

Table 4: Root causes' rank and normalized weight (By author)[30]

[30] By author.

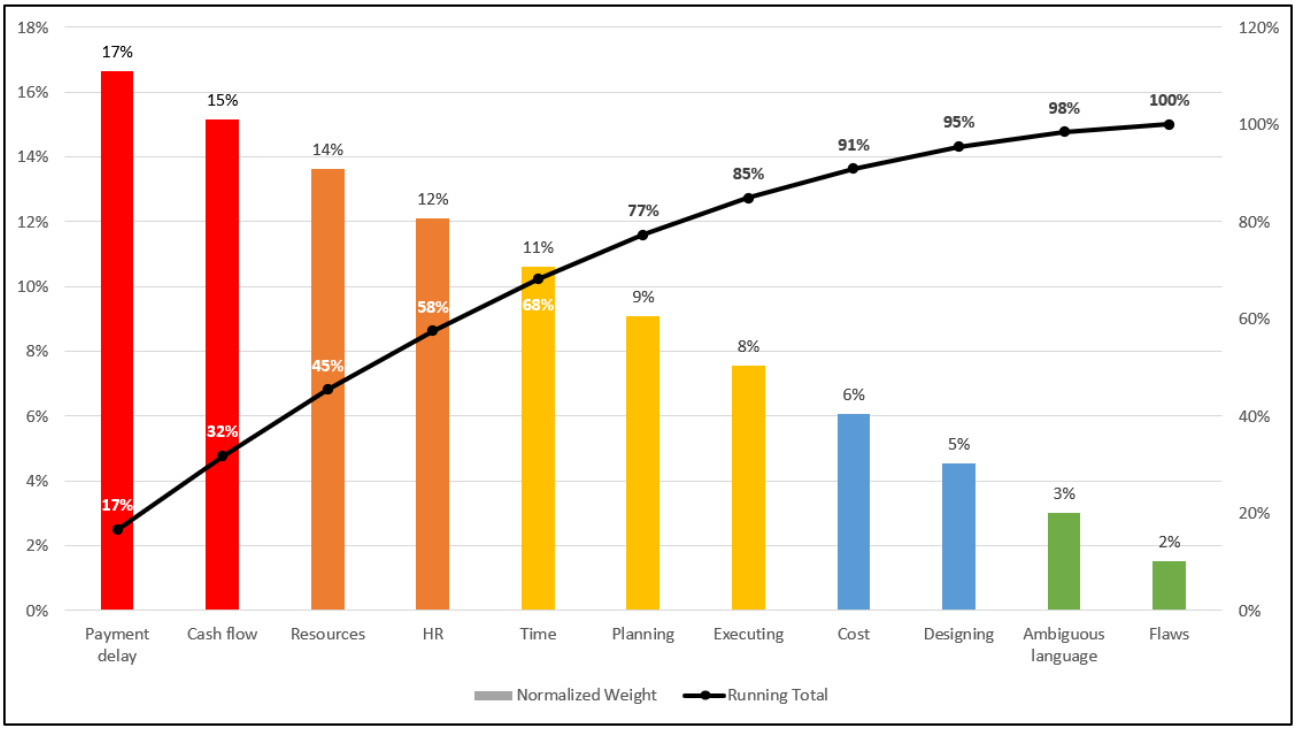

Figure 12: Pareto chart to monitor the root causes' evolvement (By author)[31]

[31] By author.

Roll out strategy

Suppose the industry deems the obtained results to support the statement that the "proposed" model is a "best tested and proven" technique. In that case, the following action is to decide the optimum path forward to roll out the enhanced practice. For this step, the author suggests applying the Cynefin framework. It considers several factors (e.g., learning curve, resistance to change) to identify the current domain of the companies and enable the leadership to follow a deployment strategy with the right resources that would increase the likelihood of its successful implementation. Based on the preliminary information, it seems that the current situation may likely belong to the "complicated" domain (please, refer to ***Figure 13*** below), which would require the following decision-making approach:

1. Sense,
2. Analyze, and
3. Respond.

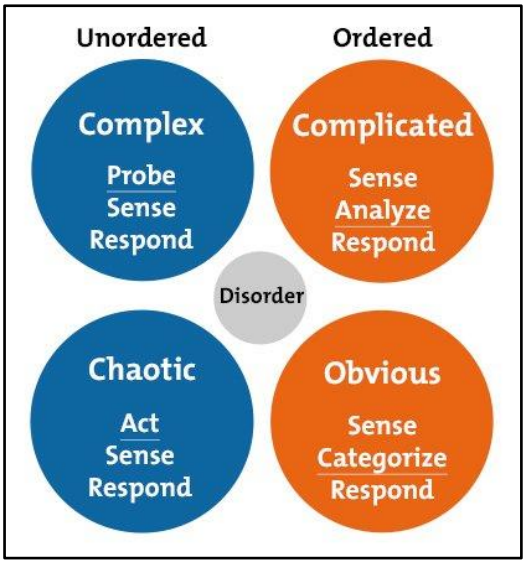

Figure 13: The Cynefin framework diagram (Snowden & Boone, 2007)[32]

[32] Snowden, D. J., & Boone, M. E. (2007). A leader's framework for decision making. *Harvard Business Review*. Retrieved from https://hbr.org/2007/11/a-leaders-framework-for-decision-making

CONCLUSION

This technical paper noted that the industry was in clear need of a simple payment system or process that could ensure that Contractors were paid promptly for work performed in substantial compliance with the contract documents. At the same time, this "proposed" payment system or process should also protect the Owner from both latent and patent defects in the work, which was another identified gap.

The research has developed a solution that integrates the progress with the payment process. A "how-to" guide to close the interface loop between Owners and Contractors through an activity-based management approach supported by a robust data model.

The first outstanding benefit of this "proposed" model has been a reduction of payment timeframes from the current industry average of 83 days to 28 days, outranking the well-known FIDIC general conditions, which envisaged to take at least 56 days.

Secondly, but equally important, the benefit is that the process protects the Owner simultaneously. The payment is intrinsically related to the earned value, which requires QA/QC tests and quantity verification to be physically in place for the claimed amount.

Based on these outcomes, both parties (i.e., Owners and Contractors) across the industry should be starting to take active actions diligently towards adopting processes and systems that mitigate the root causes of disruption in the industry. As discussed at the beginning of this study, the main ones are waste time, loss of money and reputation, cash flow, and payment delays.

Finally, a bundle of following benefits would spin off as a by-product of the "proposed" technique in this dissertation that advances the Project Management practices in the construction industry by reinforcing itself through a virtuous cycle:

- healthier relationships between Owners and Contractors,
- improved financial management by Contractors,
- business growth opportunities for Contractors,
- and better productivity rates achieved for Owners.

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About the Author

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Claudio M. Olivieri's track record is in the mining, petrochemical, and energy resource industries. His 14+ years' experience includes project controls for multi-disciplinary capital work projects in various roles, including planning and scheduling, cost estimation, cost control, contract administration, and procurement.

Claudio's most recent experience is with Glencore APAC copper projects, where he provides complete project controls services. Before this, he served as a project controls engineer for Newcrest's Lihir capital projects; Rio Tinto's Gove sustaining capital works program; Auctus Resources Mungana process plant builds; and WDS/CPECC JV for the Arrow DomGas project. Claudio has also undertaken estimating roles such as Rio Tinto's Mount Pleasant Coal Mine Pre-feasibility and Feasibility Studies; Licella's Biomass to Biocrude FEED study, Queensland; QGC's Curtis LNG FEED study. Upon arrival in Australia, he also occupied a combined estimator and cost control role for the Wafi-Golpu project in PNG.

Claudio's communication skills are excellent with internal and external stakeholders. In addition, he is proficient in QUEST, CMS, MS Project, Primavera P6, and a broad selection of ERP, document control, and engineering software.

Claudio holds a Bachelor of Engineering (Chemical) from the Buenos Aires Institute of Technology (ITBA) and a Diploma of Project Management from Engineers Education Australia. He is an active member of Engineers Australia (EA), the Association for the Advancement of Cost Engineering (AACE), and a committee member of the Australian Cost Engineering Society (ACES). Currently, Dr. Paul D. Giammalvo is mentoring him.

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