Developing Parametric Modelling for Class 4 Estimate of Pier and Jetty Construction by Analyzing Historical Databases using AI Tools & EVM Techniques [1, 2]

Rizkia Arifani Zain

ABSTRACT

The growth in energy demand, particularly in the oil & gas sector, influences investment decisions for jetty development to enhance supply capacity. The Dolphin Jetty, a prevalent type used by the National Oil Company, incorporates cylindrical or pile-like structures called dolphins to guide and moor vessels safely. As energy consumption in Indonesia shows a consistent upward trend, optimizing the supply chain and fuel distribution becomes imperative. In this context, maritime transportation, specifically through dolphin jetties, emerges as a strategic choice to efficiently meet fuel distribution needs. This paper emphasizes the importance of preparing Capital Expenditure (CAPEX) documentation in the feasibility studies stage, influencing the economic value of the investment. The paper uses historical data to introduce a parametric modeling approach for Dolphin-configured jetties, considering variations in mooring capacity, dead weight tonnage (DWT), and estimated construction implementation years. The outcomes aim to inform the CAPEX Class 4 preparation, contributing valuable insights for the economic assessment of jetty construction projects.

Keywords: Cost Estimate, Parametric Model, Estimation, AACE, Mooring Dolphin, Jetty, Pier, WBS, CAPEX, OmniClass, Construction, @RISK, National Oil Company, Artificial Intelligence, Econometrics, Data Analysis.

INTRODUCTION

National Oil Company Mooring Profile

Tanker is crucial in distributing refined fuel to end customers throughout Indonesia. The fuel distribution in Indonesia, with its more than 17,000 islands, relies heavily on tanker transportation as its primary mode of transportation. Consequently, facilities such as

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[2] This paper was originally prepared during a 6-month long Graduate-Level Competency Development/Capacity Building Program developed by PT Mitrata Citragraha and led by Dr. Paul D. Giammalvo to prepare candidates for AACE CCP or other Certifications. https://build-project-management-competency.com/our-faqs/

jetties play a significant role in the supply and distribution chain, where the continual improvement and construction of jetties are undertaken to enhance the reliability of the supply across Indonesia. The growth in energy demand, especially in oil & gas, significantly influences the investment decisions for Jetty development to enhance supply capacity and coverage days.

According to the Oil final consumption by-product data for Indonesia from 1990 to 2021[3], the energy consumption in Indonesia shows an upward trend each year.

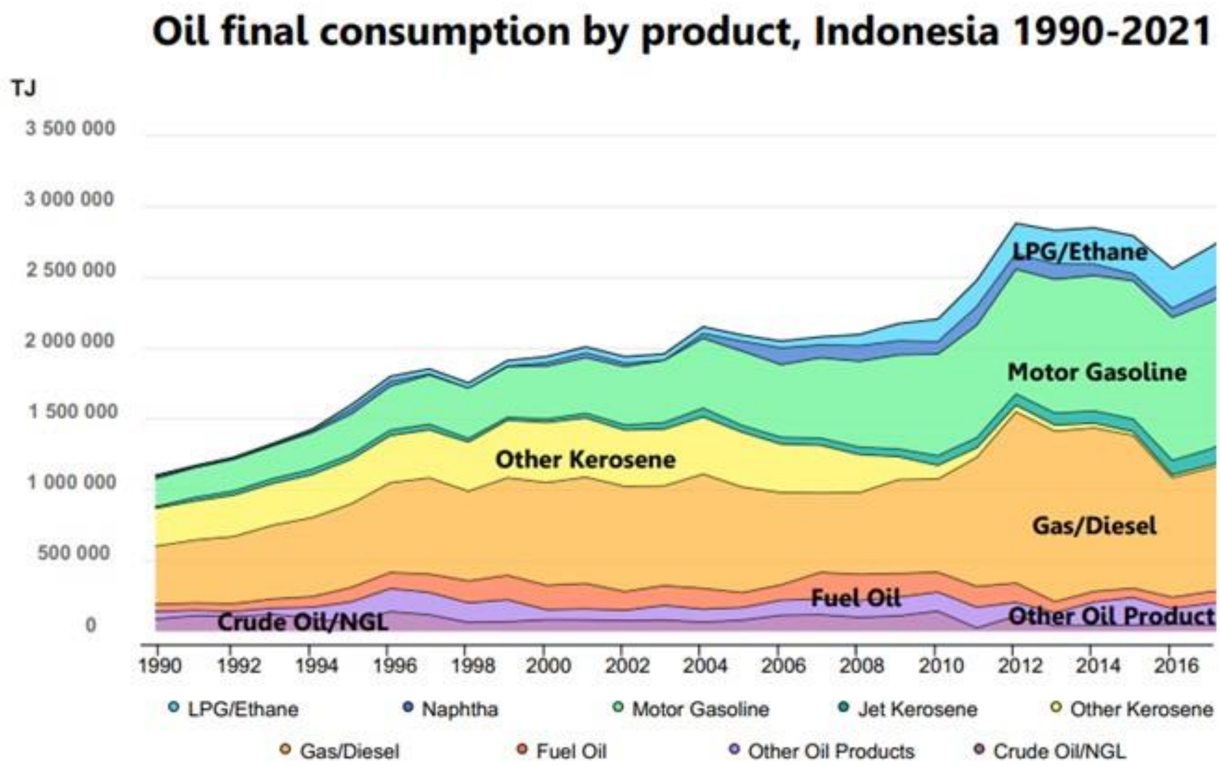

Figure 1-Oil final consumption by product, Indonesia 1990-2021

Furthermore, the jetties owned by the National Oil Company have a considerably long construction lifespan. The data on the Percentage of Mooring Facilities of Various Ages is evident, where the dominance of jetties with ages exceeding 30 years.[4] Consequently, the need for Jetty Development becomes a frequent investment activity to enhance infrastructure reliability and ensure supply security.

[3] Oil final consumption by product, Indonesia 1990-2021. (2016). Indonesia - Countries & Regions - IEA. IEA. https://www.iea.org/countries/Indonesia
[4] Pertamina. (2021). Infrastructure Masterplan: Strategic Roadmap of Synergy Optimization.

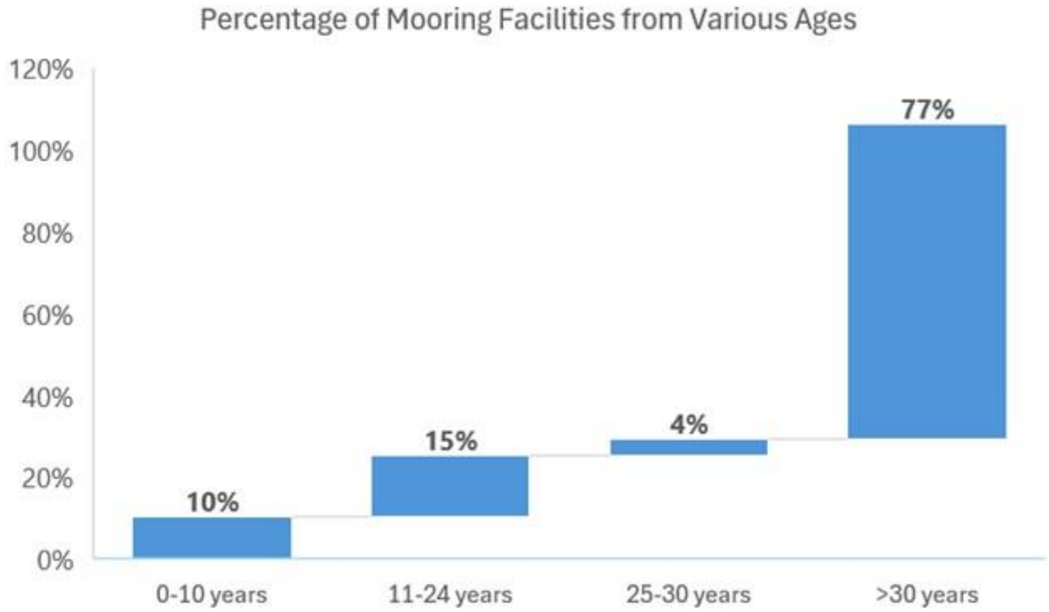

Figure 2-Percentage of Mooring Facilities from Various Ages

Most jetty types used by the National Oil Company are Dolphin Jetties. Dolphin jetty refers to a specific type of jetty structure that incorporates dolphins. Dolphins are cylindrical or pile-like structures made of concrete, steel, or other materials. They are often used in maritime engineering to guide ships or boats safely into berthing areas. A dolphin jetty typically consists of a series of these structures positioned strategically to aid in the navigation and mooring of vessels. The design and configuration of dolphin jetties vary based on the requirements of the port or terminal where they are installed.

Figure 3-Typical Mooring Dolphin Jetty [5, 6]

[5] Pertamina (Persero), P. T. (n.d.). Pertamina Dukung Transformasi Pertamina International Shipping Menjadi Subholding Integrated Marine Logistics, Untuk Mendorong Pertumbuhan Ekonomi di Indonesia | Pertamina. www.pertamina.com. Retrieved January 4, 2024, from https://www.pertamina.com/id/news-room/news-release/pertamina-dukung-transformasi-pertamina-international-shipping-menjadi-subholding-integrated-marine-logistics-untuk-mendorong-pertumbuhan-ekonomi-di-indonesia

[6] Youtupedia. (2022). Harbours, Ports, Quays, Wharves, Berths, Docks, Jetties & More. From https://www.youtube.com/watch?v=AEfsxLPF_cU

Cost Estimation

"Cost estimating is critical in any acquisition process and helps decision-makers evaluate resource requirements at milestones and other important decision points. It is the basis for establishing and defending budgets and drives affordability analyses. Cost estimates are crucial in establishing and conveying a realistic perspective on potential cost and schedule outcomes. These estimates are essential for planning the necessary work involved in a program's development, production, operation, maintenance, and disposal phases."[7]

	Primary Characteristic	***Secondary Characteristic***		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Table 1-Cost Estimate Classification Matrix for Process Industries [8]

The AACE RP 18R-97 is particularly well-suited for downstream industries, offering comprehensive guidelines for cost estimation and management in this sector, meeting the requirements of Jetty Cost Estimating. Its detailed methodology aligns with the intricacies of downstream processes, providing a tailored approach to project cost control. In contrast, AACE RP 87R-14 is more specific to upstream industries, focusing on exploration and drilling operations' unique challenges and characteristics.

Table 1 serves as an estimation classification system tailored for the process industries. For a more generalized matrix applicable across industries, consult Recommended

[7] United States Government Accountability Office. (2020). Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program.
[8] AACE International. (2020). AACE International Recommended Practice No. 18R-97 Cost Estimate Classification System – As Applied in Engineering, Procurement, And Construction For The Process Industries.

Practice 17R-97[9]. Alternatively, refer to other Relevant Practices (RPs) for industry-specific guidelines, offering additional details such as the Estimate Input Checklist and Maturity Matrix. These supplementary resources are crucial in determining the classification in various industries, providing a comprehensive framework for accurate and industry-specific cost estimation.

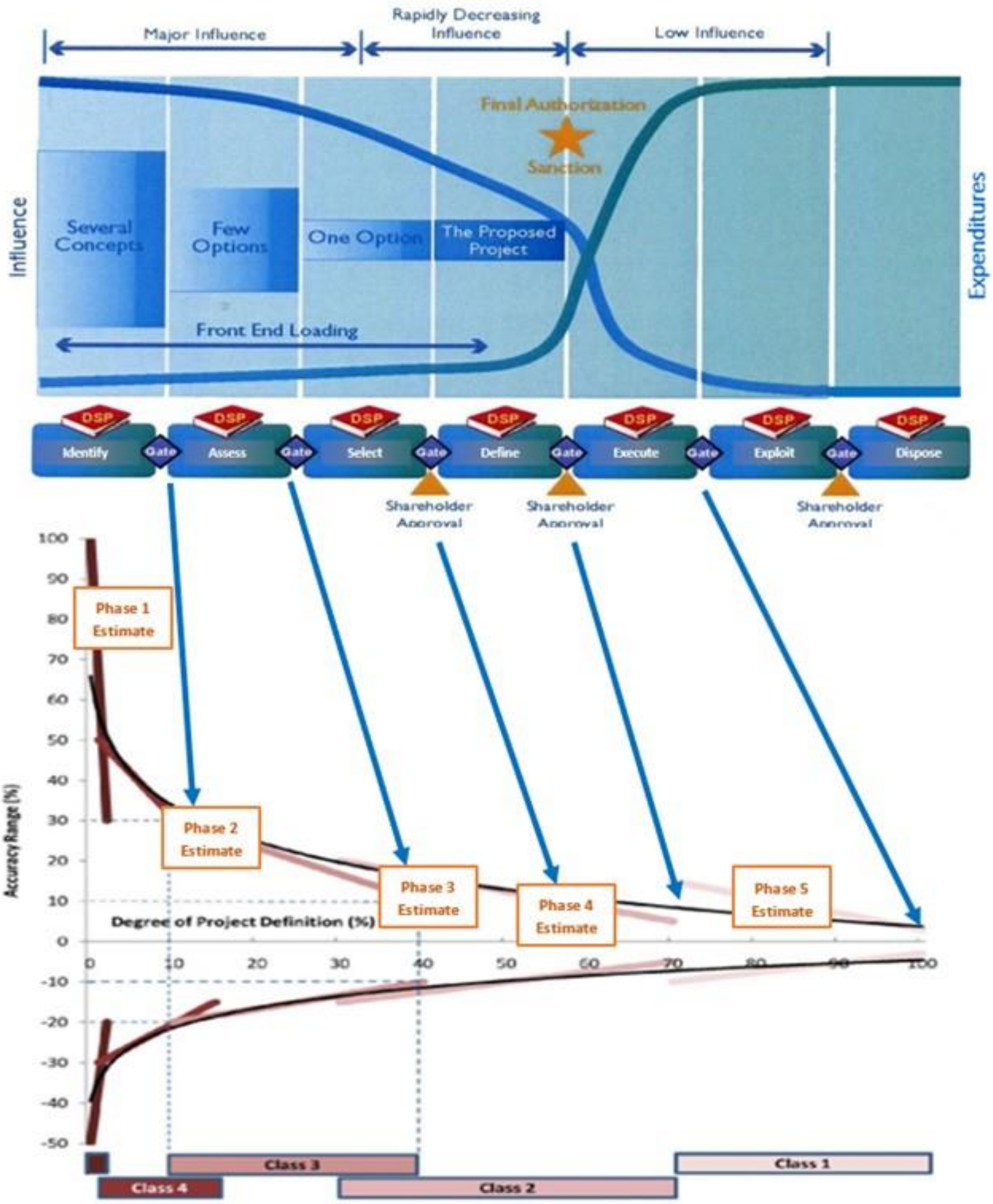

Figure 4-Asset Life Span[10] & Variability in Accuracy/Uncertainty Ranges[11]

[9] AACE International. (2020). AACE International Recommended Practice No. 17R-97 Cost Estimate Classification System.
[10] Giammalvo, Paul D. (2021). The Bigger Picture: Project Life Cycles from a Broader, Real-World Perspective 1. Project Management Journal. Vol. X.
[11] U.S. Department of Energy. (2011). Cost Estimating Guide

According to Figure 4, it can be observed that there is a relationship between the magnitude of Influence and Expenditures throughout the overall Asset Life Span. During Phase 1 to Phase 4 (Front End Loading), the level of influence tends to decrease until the Proposed Project is reached. Referring to AACE Class 4, the typical purpose of the obtained estimates is for a study or feasibility study.

Cost estimation is utilized in all stages of the investment process within the company. In the initial stages of feasibility studies, CAPEX Class 4 is employed. According to AACE Recommended Practice 18r-974[12], CAPEX Class 4 has a maturity level of project definition deliverables ranging from 1% - to 15%, with the methodology used being either equipment factored or parametric models.

A reasonable and supportable budget is essential to a program’s efficient and timely execution, and a reliable estimate is the basis of a reasonable budget. Cost estimates help assess the reasonableness of existing budgets and of contractors’ proposals. Cost estimates also help program offices justify budgets to the Congress, OMB, and department secretaries, among others. Moreover, cost estimates are often used to help determine how budget cuts may hinder a program’s progress or effectiveness.[13]

Parametric Modelling

“Parametric cost estimates are used to estimate equipment cost and the total cost at an acceptable error when there is little technical data about equipment and other capital cost items or engineering deliverables for submission to equipment manufacturers. The process entails creating a parametric model by utilizing equipment cost data collected over a specified time duration. Subsequently, through statistical methods, the model's coefficients are determined, and their accuracy and estimation capabilities are thoroughly examined. The best reference for reliable cost data is an organization's completed projects. Applying this data, using regression methods and statistical tests, a final model is proposed.” [14]

To support the creation of parametric modeling, the Author will collect historical data from jetty construction projects, which will then undergo analysis and comparison for each alternative.

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[12] AACE International. (2020). AACE International Recommended Practice No. 18R-97 Cost Estimate Classification System – As Applied in Engineering, Procurement, And Construction for The Process Industries.
[13] United States Government Accountability Office. (2020). Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program.
[14] AACE International. (2011). AACE International Recommended Practice No. 59R-10 Development of Factored Cost Estimates as Applied in Engineering, Procurement, And Construction for The Process Industries.

"The cost estimating process provides the foundational guidance for initiating, researching, assessing, analyzing, and presenting a cost estimate. The 12 steps are important for ensuring that cost estimates are developed and delivered in time to support important program decisions. The 12-step process represents a consistent methodology based on industry and government best practices that can be used across the government to develop, manage, and evaluate program cost estimates. By following a process of repeatable methods, agencies should be able to produce reliable estimates that can be clearly traced, replicated, and updated to manage their programs better and inform decision-makers of the risks involved." [15]

With the economic and population growth, the demand for energy, including fuel (BBM), tends to increase. In this context, maritime transportation or jetties become a strategic choice to meet BBM's distribution needs in Indonesia efficiently. The provision of infrastructure supporting this transportation can help optimize the supply chain and distribution of BBM, ensuring stability in availability across various regions.

Based on this, the need for the preparation of CAPEX as part of the investment documentation in the feasibility studies stage becomes critical and significantly influences the economic value of the investment. In the preparation of this paper, a study will be conducted on the historical data held by the company regarding the development of jetties over the past five years. The result of this paper is a parametric modeling for the construction of jetties with a Dolphin configuration. The outcomes of this parametric modeling will be used in the preparation of CAPEX Class 4 with variations in mooring capacity, dead weight tonnage (DWT), and estimated construction implementation years.

Ultimately, the goal of this paper is to answer the following questions:

1. Has the historical data performance met the data quality metrics of validity, precision, reliability, and accuracy?
2. What is the appropriate parametric model for determining the cost estimate of Jetty construction based on mooring capacity and dead weight tonnage (DWT)?
3. How can the selected parametric model meet the requirements of CAPEX Class 4 as needed in the feasibility studies stage?

[15] United States Government Accountability Office. (2020). Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program.

METHODOLOGY

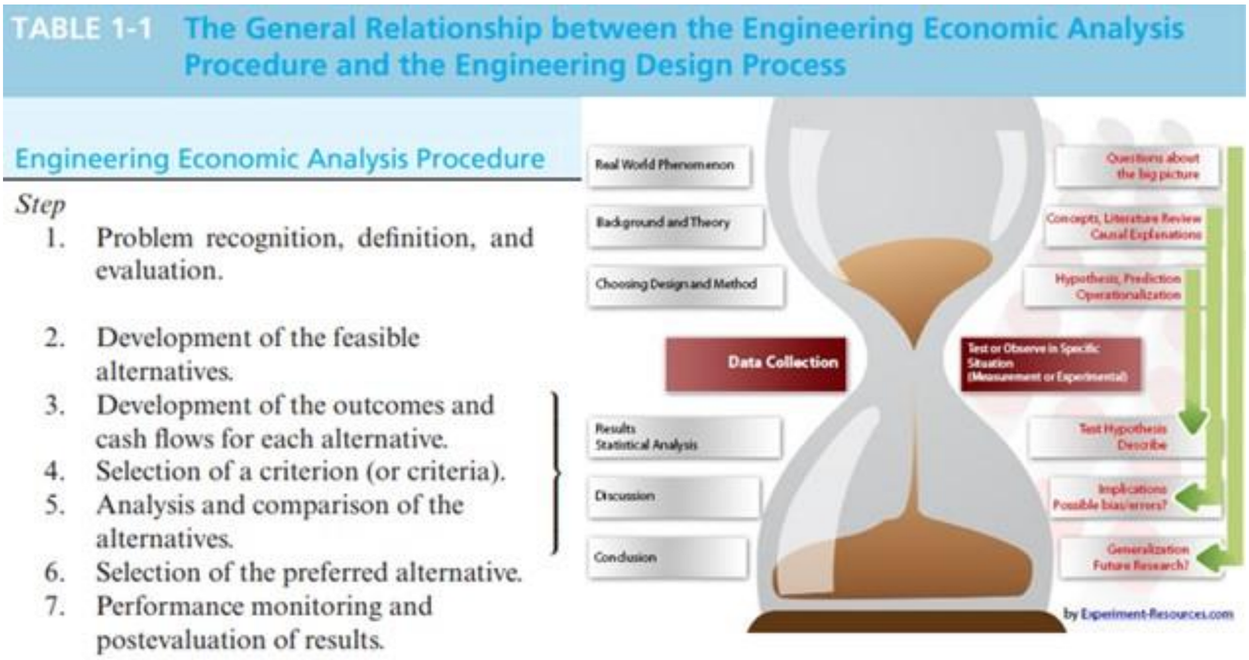


Figure 5-Engineering Economic Analysis Procedure[16]

In writing this paper, the methodology employed will reference the Engineering Economic Analysis Procedure[17] with seven steps of analysis.

Step 1 – Problem Definition

Currently, the company has a rule of thumb in the development of jetty construction investment based on historical project data. However, this approach has shown several weaknesses based on the data from previous projects:

1. The estimated values derived from previous historical data do not accurately reflect market price trends for such work in the future.
2. High fluctuations in material prices often lead to projects being under budget, necessitating re-scoping and resulting in the inability to achieve ideal standard fulfillment.
3. The estimation process is time-consuming due to the need to update historical data to obtain accurate market prices.

This study aims to explore alternative solutions through a Parametric Model, which will be used as the basis for cost estimation in jetty construction based on the common Dead

[16] Steps of the Scientific Method – The Stages of Scientific Research. (n.d.). Explorable.com. https://explorable.com/steps-of-the-scientific-method
[17] Sullivan, W., Wicks, E., & Koelling, C. (2023). Engineering Economy (17th ed.). Pearson.

Weight Tonnage (DWT) capacity owned by the company in its distribution operations using oil tankers. The data utilized will include historical cost estimates held by the company over the past five years in accordance with AACE Estimate Level 4 – Level 2.

Dolphin Structure

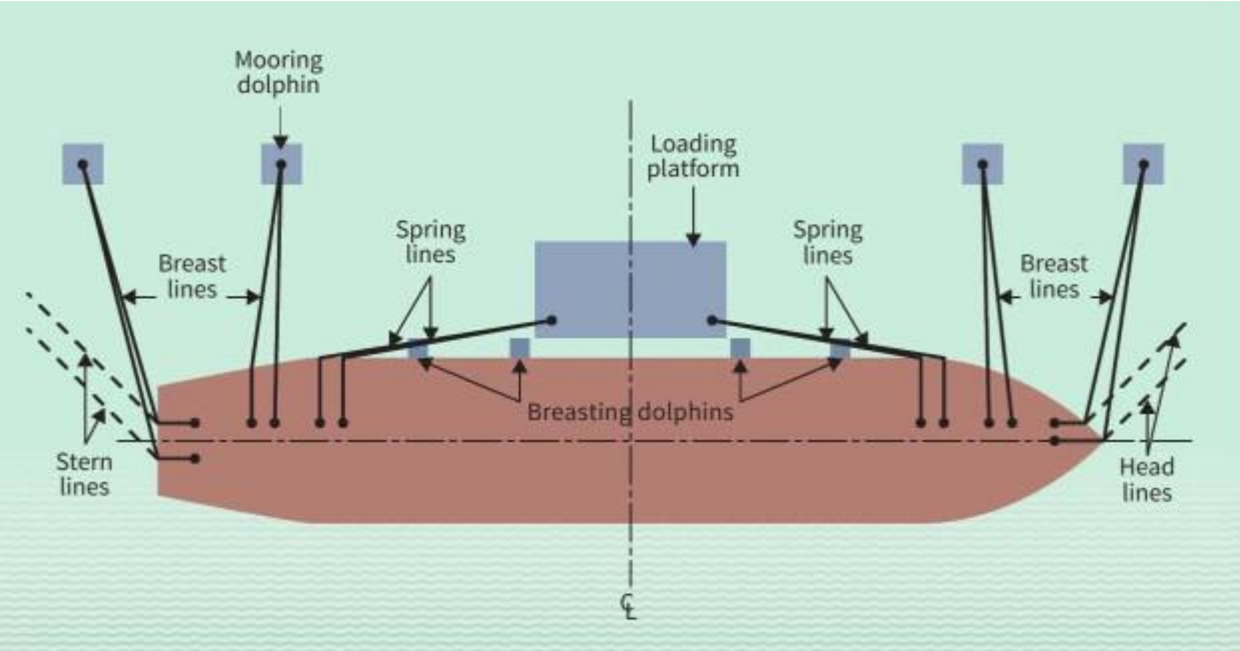


Figure 6-A Typical mooring pattern [18]

The company has numerous mooring facilities utilized in tanker operations across Indonesia, such as Single Point Mooring (SPM), Conventional Buoy Mooring (CBM), Island Berth, and Dolphin. According to company data, there are over 124 Dolphin Jetties, constituting approximately 86% of the total owned jetties. The Dolphin comprises the following principal structures:

1. **Jetty Head / Loading Platform**: A vertically anchored structure serving as a platform where supporting equipment like Marine Loading Arms, Hoses, Cranes, etc., are installed.

2. **Breasting Dolphin**: This anchored structure is used to absorb the impact of a ship during berthing. Usually, there are two or more structures positioned to serve as the berthing location for the ship, equipped with rubber fenders and bollards.

[18] Oil Companies International Marine Forum. (2018). Mooring Equipment Guidelines (MEG4), Fourth Edition 2018.

3. **Mooring Dolphin**: These are piles driven into the ground in waterways and harbors to provide ships with a location to dock or moor, utilizing installed bollards

Tanker "DWT" refers to the Deadweight Tonnage of a tanker. Deadweight Tonnage is a measurement of the total cargo weight that a ship can carry, including cargo, fuel, ballast, provisions, and other supplies. It represents the difference between the displacement of a ship when it is fully loaded and when it is empty. In the context of a tanker, DWT is a crucial metric because it indicates the vessel's capacity to transport liquid cargo, such as oil or chemicals. Tankers are classified into various categories based on their deadweight tonnage.

Step 2 – Development of Alternatives

Parametric Modelling

The first step in developing a parametric model is to establish its scope. This includes defining the end use, physical characteristics, critical components, and cost drivers of the model, taking into consideration the type of process to be covered, the type of costs to be estimated (such as TIC and TFC), and the accuracy range. [19]

A Cost Estimation Relationship (CER) is a mathematical model that depicts the cost of an engineering project as a function of one or more design variables. CERs serve as valuable tools as they enable estimators to generate cost estimates rapidly and efficiently. These relationships streamline the estimation process by establishing a quantitative connection between the project's cost and the influential design parameters. As a result, CERs facilitate quick and convenient cost estimation, providing a practical solution for project planners and estimators.

The first step in any engineering analysis is to define the problem to be addressed. A well-defined problem is much easier to solve. For the purposes of cost estimating, developing a WBS is an excellent way of describing the elements of the problem. A review of the completed WBS can also help identify potential cost drivers for the development of CERs.[20]

[19] AACE International. (2011). AACE International Recommended Practice No. 59R-10 Development of Factored Cost Estimates as Applied in Engineering, Procurement, And Construction for The Process Industries.
[20] Sullivan, W., Wicks, E., & Koelling, C. (2023). Engineering Economy (17th ed.). Pearson.

OmniClass for WBS

The Author will use the OmniClass Table to develop a typical Work Breakdown Structure (WBS) for the construction phase. OmniClass is designed to provide a versatile framework for classifying information throughout the entire lifecycle of a building project.

OMNICLASS®

The 15 inter-related *OmniClass* tables are:

- Table 11 - Construction Entities by Function
- Table 12 - Construction Entities by Form
- Table 13 - Spaces by Function
- Table 14 - Spaces by Form

- Table 21 - Elements
- Table 22 - Work Results
- Table 23 - Products

- Table 31 - Phases
- Table 32 - Services
- Table 33 - Disciplines
- Table 34 - Organizational Roles
- Table 35 - Tools
- Table 36 - Information

- Table 41 - Materials
- Table 49 - Properties

Figure 7-OmniClass Table Classification

Based on that, historical data from Jetty Construction will be normalized to obtain a general scope of work for Jetty Construction. For this purpose, a tool in the form of a Work Breakdown Structure (WBS) is used according to the typical scope of work owned by the Company in Jetty Construction (see detailed in **Appendix C)**. The results of the WBS are as follows:

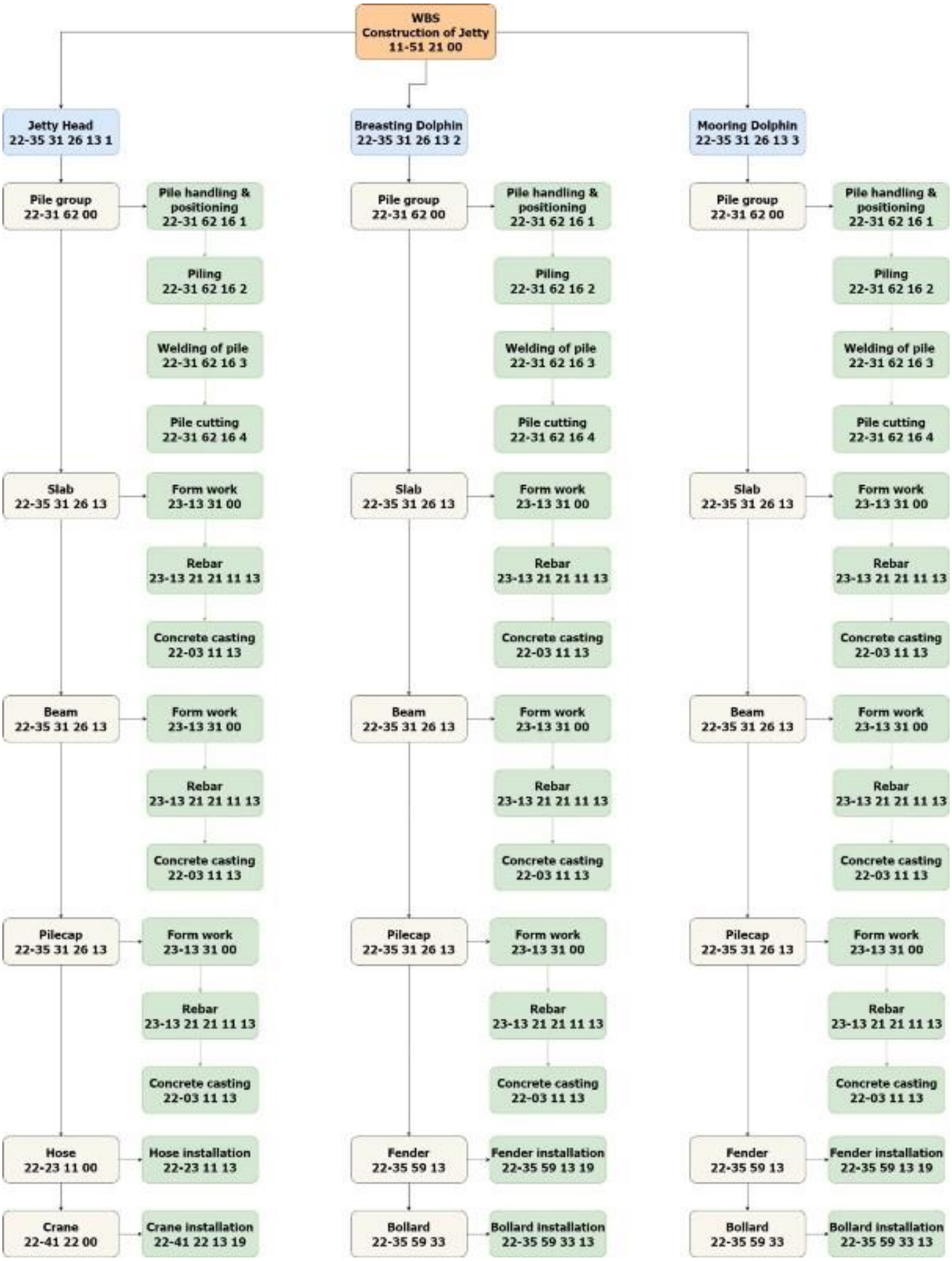


Figure 8-Typical jetty construction WBS

Through parametric modeling, an approach will be taken using the cost estimation relationship, where several alternative equations will be evaluated.

Evaluation Criteria

After formulating the Cost Estimation Relationship (CER) equation, it is essential to assess how effectively the CER can predict costs, a process known as model validation. This step involves validating the accuracy and reliability of the CER in estimating project costs. The development of the CER and its appropriate application should be documented for transparency and future reference. Model validation can be achieved using statistical "goodness of fit" measures. These measures include:

1. **Standard Error:**
   Standard error is a statistical metric that quantifies the average of the predicted values from the actual values in the dataset. A lower standard error indicates a more accurate prediction. The standard error (SE) measures the average amount by which the actual cost values and the predicted cost values vary. The SE is calculated by:

$$\boldsymbol{SE} = \sqrt{\frac{\sum_{i=1}^{n}(y_i - Cost_i)^2}{n-2}}$$

Equation 1-Standard Error

   Where:
   $Cost_i$ is the cost predicted by using the CER with the independent variable values for the dataset.
   Y_i is the actual cost.

2. **Correlation Coefficient:**
   The correlation coefficient functions as a metric to assess the strength and direction of the linear relationship between predicted and actual values. This metric provides valuable insight into the extent to which changes in one variable align with changes in another, presenting a quantitative measure of their association. The correlation coefficient ranges from -1 to 1, with 1 indicating a perfect positive correlation, -1 indicating a perfect negative correlation, and 0 indicating no correlation. The correlation coefficient (R) gauges the proximity of actual data points to the regression line. R-square is calculated as:

$$\boldsymbol{R^2} = \frac{SS_{Regression}}{SS_{Total}}$$

Equation 2-R Square

Where:
$SS_{regression}$ is the sum of the squared residuals (difference between actual and predicted values).
SS_{Total} is the total sum of squares (difference between actual values and the mean of actual values)

These statistical metrics provide a quantitative assessment of how well the CER aligns with the actual cost data. A well-fitted Cost Estimation Relationship (CER) is characterized by a low standard error and a high correlation coefficient. These indicators signify the model's precision in predicting costs, demonstrating its effectiveness in capturing the relationship with the specified design variables.

Step 3 – Development of Prospective Outcomes

Data Collection and Normalization

Data can come from within the organization (internal sources) or from outside sources (external sources). Costs of similar projects in the past are one source of data. Published cost information is another source of data. Once collected, data must be normalized to account for differences due to inflation, geographical location, labor rates, and so on. For example, cost indexes or the price inflation techniques described in Chapter 8 can be used to normalize costs that occurred at different times. Consistent definition of the data is another essential part of the normalization process.[21]

In this study, the Author gathers historical data from jetty projects conducted by the company over the past five years. The data collection process is defined with the following limitations:

1. **Type of Jetty:** A Jetty is designed with the terminology Dolphin Jetty, comprising main components such as Jetty Head, Breasting Dolphin, and Mooring Dolphin.
2. **Class of Jetty:** Jetties are categorized based on their Deadweight Tonnage (DWT) capacity, including 3500 DWT, 6500 DWT, 17,500 DWT, 35,000 DWT, and 50,000 DWT.
3. **Estimation Level:** Historical data utilized adheres to the AACE Estimate Level 4 – Level 2, providing a standardized framework for categorizing the depth and detail of cost estimates.
4. **Source of Data:** The data used is sourced internally from the company's records and documentation, ensuring that it reflects the organization's own historical jetty projects.

[21] Sullivan, W., Wicks, E., & Koelling, C. (2023). Engineering Economy (17th ed.). Pearson.

Below is the provided template outlining the costs of Jetty Construction, specifying the respective year and capacity. Detailed data will be presented in **Appendix B.**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		"As Planned"									"As Built"			
2	1 Project #	2 Capacity (DWT) (Sorted Small to Large)	3 Start Date (MM/YEAR)	4 Finish Date (MM/YEAR)	5 Duration Planned Months	6 AFE Approved Cost (HIDDEN)	7 Average Price of Gold (Midpoint)	8 Original Ounces of Gold (Midpoint)	9 Actual Acceptance Cost (ACWP) (HIDDEN)	10 Average Price of Gold (Midpoint)	11 Actual Ounces of Gold Equivalency	12 Actual Duration (Months)	13 As-Built CPI (BCWP/ACWP)	14 As-Built SPI (BCWP/BCWS)
3	1	Input	Input	Input	Input	Input	Input	=F3/G3	Input	Input	=H3/I3	Input	=F3/I3	=E3/L3
4	2	Input	Input	Input	Input	Input	Input	=F4/G4	Input	Input	=H3/I4	Input	=F4/I4	=E4/L4
5	3	Input	Input	Input	Input	Input	Input	=F5/G5	Input	Input	=H3/I5	Input	=F5/I5	=E5/L5
6	4	Input	Input	Input	Input	Input	Input	=F6/G6	Input	Input	=H3/I6	Input	=F6/I6	=E6/L6
7	5	Input	Input	Input	Input	Input	Input	=F7/G7	Input	Input	=H3/I7	Input	=F7/I7	=E7/L7
8		Input	Input	Input	Input	Input	Input	=F8/G8	Input	Input	=H3/I8	Input	=F8/I8	=E8/L8
9														
10		Input	Input	Input	Input	Input	Input	=F9/G9	Input	Input	=H3/I9	Input	=F9/I9	=E9/L9
11	90	Input	Input	Input	Input	Input	Input	=F10/G10	Input	Input	=H3/I10	Input	=F10/I10	=E10/L10
12	91	Input	Input	Input	Input	Input	Input	=F11/G11	Input	Input	=H3/I11	Input	=F11/I11	=E11/L11
13	92	Input	Input	Input	Input	Input	Input	=F12/G12	Input	Input	=H3/I12	Input	=F12/I12	=E12/L12
14	93	Input	Input	Input	Input	Input	Input	=F13/G13	Input	Input	=H3/I13	Input	=F13/I13	=E13/L13
15	94	Input	Input	Input	Input	Input	Input	=F14/G14	Input	Input	=H3/I14	Input	=F14/I14	=E14/L14
16	95	Input	Input	Input	Input	Input	Input	=F15/G15	Input	Input	=H3/I15	Input	=F15/I15	=E15/L15
17							Mean (Average) Database (P50	=AVERAGE(H3:H15)			=AVERAGE(K3:K15)		=AVERAGE(M3:M15)	=AVERAGE(N3:N15)
18							MEDIAN Database (Most Frequent Value)	=MEDIAN(H3:H15)			=MEDIAN(K3:K15)		=AVERAGE(M3:M15)	=AVERAGE(N3:N15)
19							Standard Deviation	=STDEV.P(H3:H15)			=STDEV.P(K3:K15)		=STDEV.P(M3:M15)	=STDEV.P(N3:N15)
20														
21														
22						23	P50+ 3 Sigma	=H24+(3*H18)	22					
23							P50+ 2 Sigma	=H24+(2*H18)						
24						21	P50+ 1 Sigma	=H24+H18						
25							P50 (Mean)	=AVERAGE(H3:H15)	15					
26						18	P50- 1 Sigma	=H24-H18						
27							P50- 1 Sigma	=H24-(2*H18)	19					
28						20	P50- 1 Sigma	=H24-(3*H18)						
29														
30	16						Upper SPECIFICATION LIMIT- Median or Mean (Your choice) + 5%	=H17+(5%*H16)						
31							Lower SPECIFICATION LIMIT- Median or Mean (Your choice) + 5%	=H17-(5%*H16)	17					

Table 2-Historical Data Template

- **(2.1) Project:** Number of historical projects. Population of 95 comparable projects from 2019 to present.
- **(2.2) Capacity:** Categorized based on their Deadweight Tonnage (DWT) capacity, including 3500 DWT, 6500 DWT, 17,500 DWT, 35,000 DWT, and 50,000 DWT.
- **(2.3) Start Date:** Project start date. (Issuance of the Notice to Proceed)
- **(2.4) Finish Date:** Project finish date. (Acceptance and put in service)
- **(2.5) Duration Planned:** Total duration planned. (BCWS)
- **(2.6) AFE Approved Cost:** Original budgeted cost at approval.
- **(2.7) Average Price of Gold:** Gold Price at Midpoint (Mid-Year) of the Project START or FINISH.
- **(2.8) Original Ounces of Gold**: Ounces of Gold Equivalent from AFE Approved Cost **(AFE Approved Cost / Average Price of Gold)**
- **(2.9) Actual Acceptance Cost:** Total project cost at finish. (ACWP)
- **(2.10) Average Price of Gold:** Gold Price at Midpoint (Mid-Year) of the project finish.
- **(2.11) Actual Ounces of Gold Equivalency:** Ounces of Gold Equivalent from Actual Acceptance Cost ACWP **(Actual Acceptance Cost ACWP / Average Price of Gold)**

- **(2.12) Actual Duration:** Total duration of the project, from the kickoff meeting until completion/commissioning
- **(2.13) As-Built CPI:** Cost Performance Index of Project (BCWP/ACWP) or **(AFE Approved Cost/Actual Acceptance Cost)**
- **(2.14) As-Built SPI:** Schedule Performance Index of Project (BCWP/BCWS) or **(Duration Planned/Actual Duration)**
- **(2.15) P50 (Mean):** Average of Ounces of Gold from the historical project.
- **(2.16) Upper Specification Limit (USL):** Predetermined and specified in the contract documents. In this instance, we are considering using +5% from Median.
- **(2.17) Lower Specification Limit (USL):** Predetermined and specified in the contract documents. In this instance, we are considering using -5% from Median.
- **(2.18) (2.19) (2.21) (2.22):** The control limit from addition/deduction of standard Deviations (Sigma or δ) that a value lies to either the left (-values) or right (+values) any calculated cost or duration falls when compared to the mean or average value.
- **(2.20) Upper Control Limit:** These are calculated values using Statistical Process Control Chart formulas, taking the mean or average actual value (2.15) and adding 3 Sigma or +3δ) to calculate the UCL. This value changes over time and tends to get narrower the more data points you collect.
- **(2.23) Lower Control Limit:** These are calculated values using Statistical Process Control Chart formulas, taking the mean or average actual value (2.15) and deducting 3 Sigma or -3δ to calculate the LCL. This value changes over time and tends to get narrower the more data points you collect.

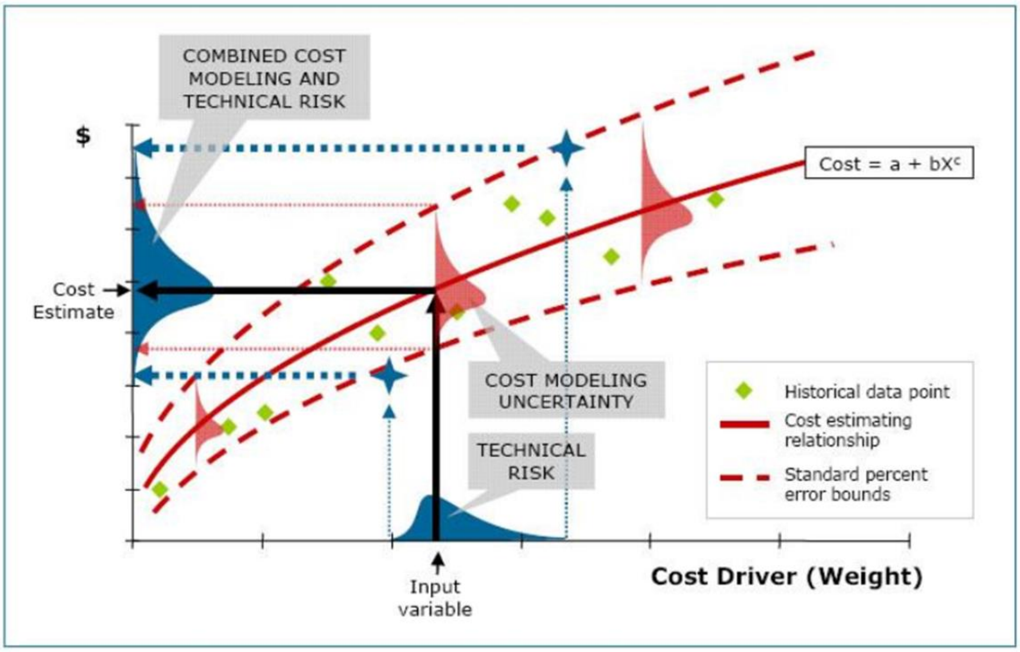


Figure 9-NASA's Cost Modeling and Technical Input Risk[22]

[22] U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0, Appendix G: Cost Risk and Uncertainty Methodologies. CreateSpace Independent Publishing Platform.

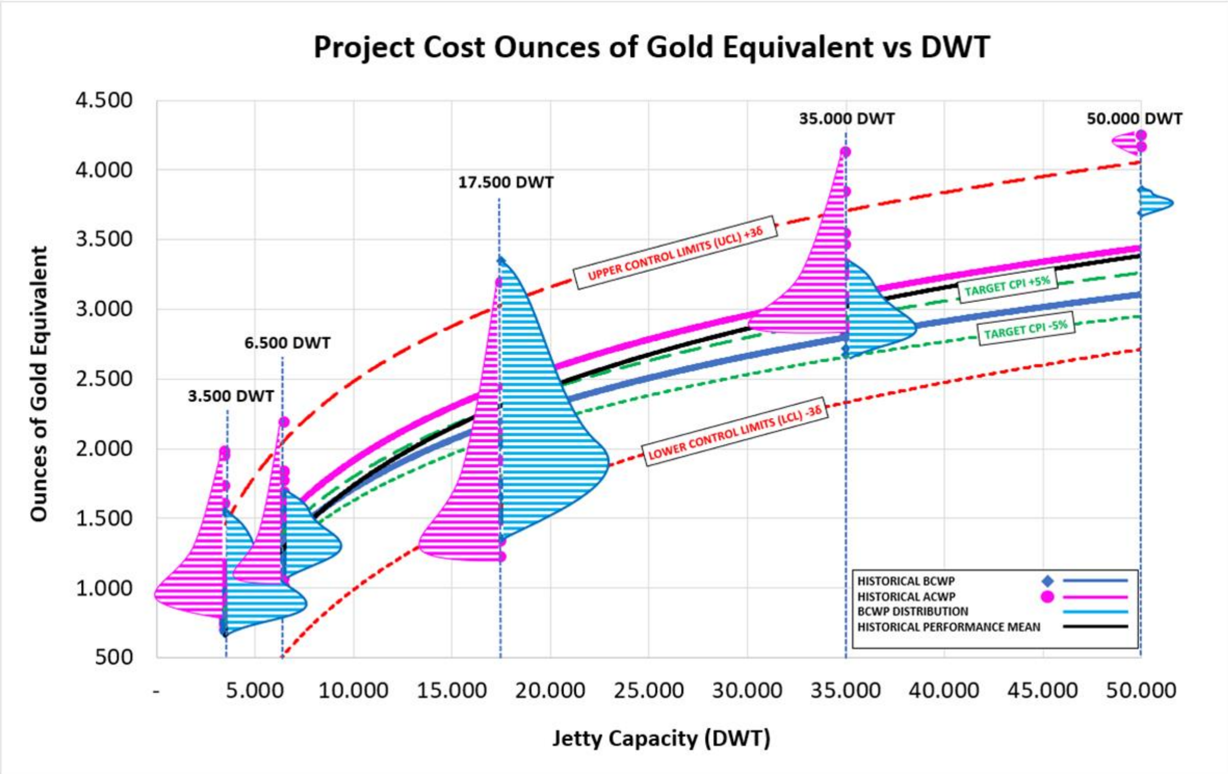
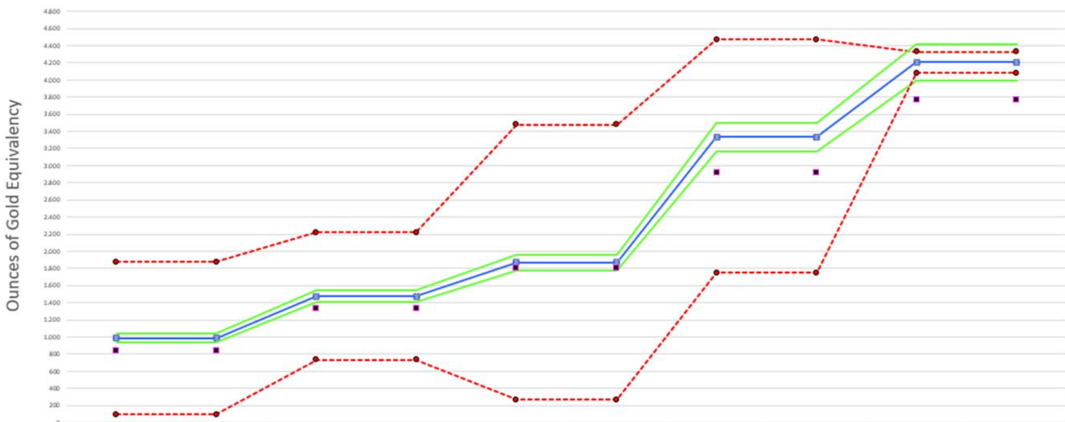


Figure 10-Historical Project Cost vs. DWT-1



	3500 SPI	3500 CPI	6500 SPI	6500 CPI	17,500 SPI	17,500 CPI	35,500 SPI	35,500 CPI	50,000 SPI	50,000 CPI
UCL (Oz of Gold)	1.876	1.876	2.218	2.218	3.475	3.475	4.470	4.470	4.330	4.330
USL (Oz of Gold)	1.035	1.035	1.550	1.550	1.964	1.964	3.499	3.499	4.415	4.415
As Built Mean (Oz of Gold)	986	986	1.477	1.477	1.871	1.871	3.333	3.333	4.205	4.205
LSL (Oz of Gold)	937	937	1.403	1.403	1.777	1.777	3.166	3.166	3.995	3.995
LCL (Oz of Gold)	96	96	735	735	266	266	1.751	1.751	4.079	4.079
Estimated AFE (Oz of Gold)	843	843	1.337	1.337	1.805	1.805	2.913	2.913	3.774	3.774
Actual Duration (Calendar Days)	80	80	115	115	166	166	263	263	269	269

Figure 11-Historical Project Cost vs. DWT-2

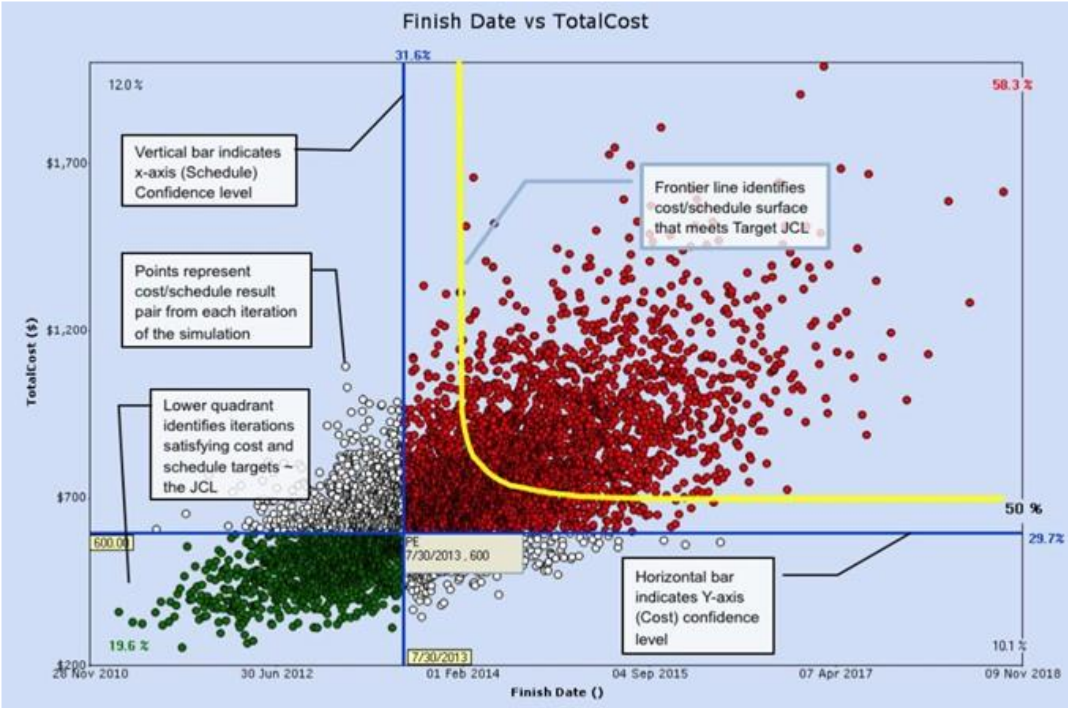


Figure 12-NASA's Scatter Plot[23]

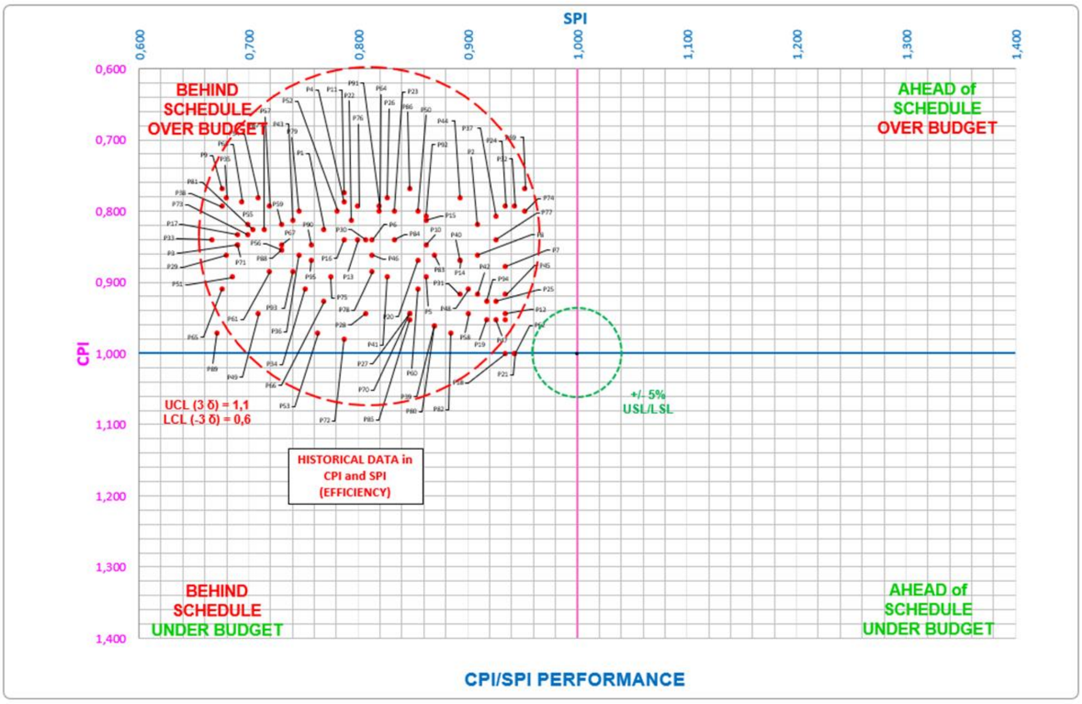


Figure 13-Scatter Plot from Historical Data

[23]U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0, Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis. CreateSpace Independent Publishing Platform.

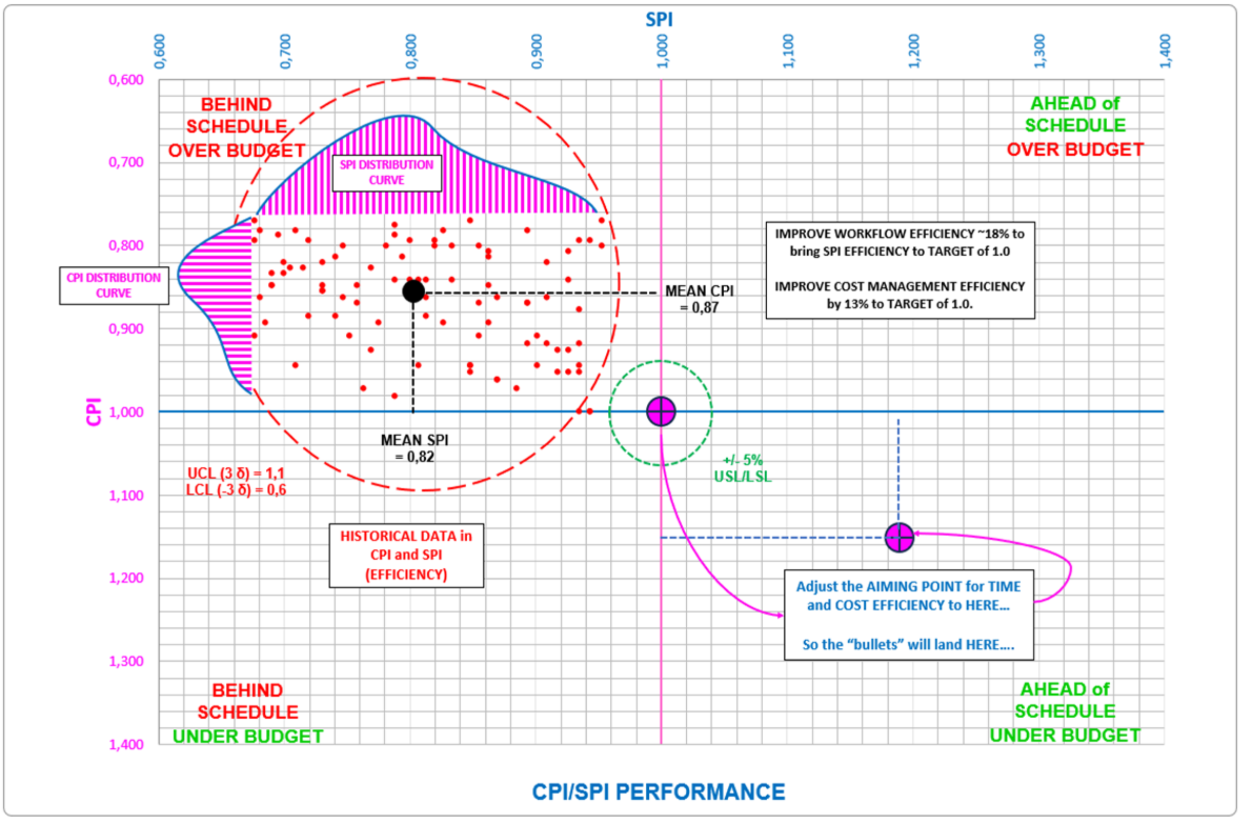


Figure 14-Aiming Point of Scatter Plot

Figure 9 illustrates NASA's Cost Modeling and Technical Input Risk. The process of cost estimating risk assessment involves the consideration of cost, schedule, and technical risks, which are subsequently incorporated into the cost estimate. To measure the cost impacts arising from these risks, it is essential to identify their sources. NASA cost analysts should focus on three key sources of risk and ensure that the cost calculation model adequately accommodates these factors.[24] :

1. The risk is inherent in the cost-estimating methodology.
2. The risk is inherent in the technical and programmatic aspects of the systems being developed.
3. The risk is inherent in the correlation between WBS elements.

For-profit companies typically operate with the primary goal of generating profit for shareholders. Project objectives often revolve around revenue generation, cost efficiency, and market competitiveness. Government-owned not-for-profit organizations, such as NASA, focus on fulfilling a public service or mission. Their objectives are often

[24] U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0, Appendix G: Cost Risk and Uncertainty Methodologies. CreateSpace Independent Publishing Platform.

tied to advancing scientific knowledge, exploration, or other public interest goals. Considering these principles, a modification was made to Figure 9 to examine the distribution of the historical project database concerning the Cost Performance Index (CPI), explicitly referencing the Jetty Capacity measured in Deadweight Tonnage (DWT), as shown in Figure 10. To determine the ultimate success or failure of our projects, we have incorporated the following additional constraints:

1. **Upper and Lower Control Limits (UCL and LCL)**
   These values are derived by computing the mean or average actual value, which is 18.5, and then adding three sigmas (+3δ) to calculate the UCL and deducting three sigma (-3δ) to determine the LCL. This value is dynamic and tends to become narrower as more data points are collected over time.

2. **Upper and Lower Specifications Limits (USL and LSL)**
   In contrast to the dynamically calculated and evolving UCL and LCL, the USL and LSL are predetermined and specified in the contract documents. In this case, we consider using -5% and +5%

Figure 12 is a scatter plot used by NASA for depicting joint confidence in dates and costs. The crosshair in this plot is a tool that can be manipulated to specific dates and cost points, with the horizontal bar representing the confidence level in costs and the vertical bar indicating the confidence level in the schedule. It's important to note that the scatter plot is explicitly designed to illustrate protection scenarios. However, the provided cautionary note suggests that it should not be used as guidance. Instead, it is recommended to consider the scatter plot as a starting point for making trade-offs between cost and schedule. [25]

By calculating and plotting the Schedule Performance Index (SPI) and the Cost Performance Index (CPI) from Historical Data, the Author used the Bullseye Diagram shown in Figure 13 & Figure 14 to give insights into our project's status concerning time and cost against the baseline plan. This analysis allows us to categorize our project into different quadrants:

1. **Upper Right Quadrant:** Indicates the project is ahead of schedule but over budget.
2. **Upper Left Quadrant:** Suggests the project is behind schedule and over budget.
3. **Lower Right Quadrant:** Indicates the project is ahead of schedule and under budget.

[25] U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0, Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis. CreateSpace Independent Publishing Platform.

4. **Lower Left Quadrant:** Suggests the project is behind schedule but under budget.

By visually representing these indices on a plot, stakeholders can quickly assess the project's performance in terms of both time and cost, enabling more informed decision-making and targeted interventions as needed.

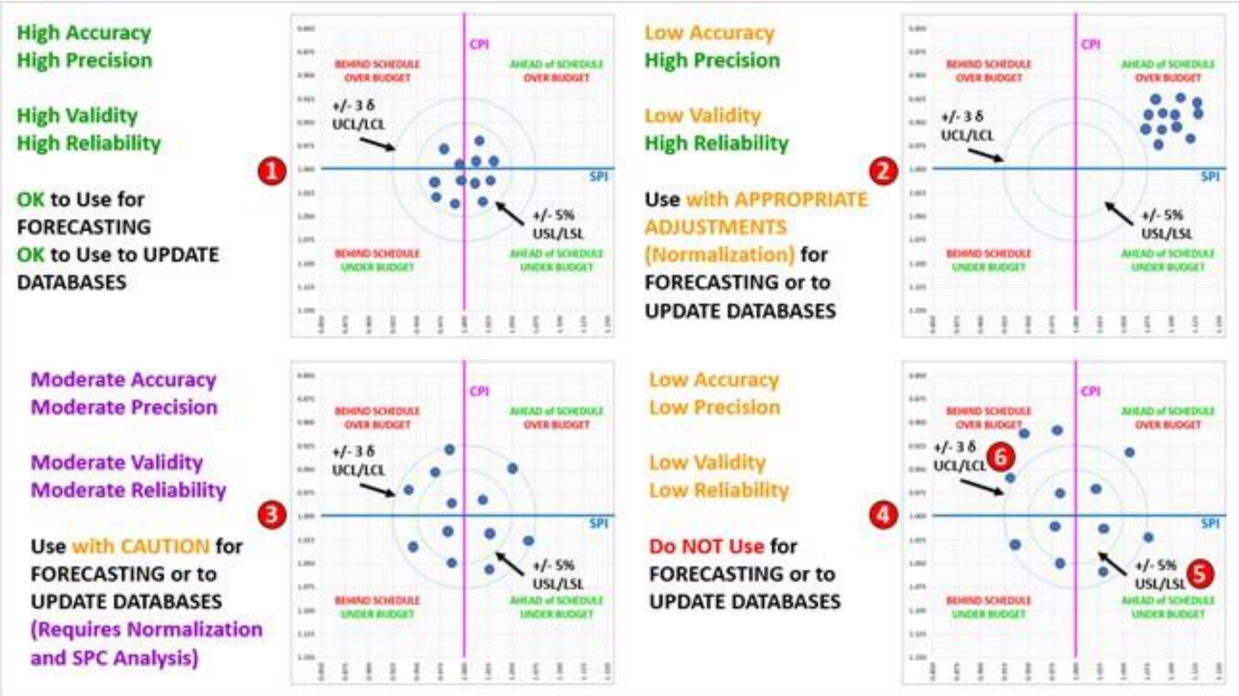


Figure 15-Illustrating Data Quality Metrics Validity, Precision, Reliability, and Accuracy[26]

When faced with challenges, it becomes crucial to explore practical solutions from that Historical Data distribution. Here are two proposed approaches to enhance project performance:

1. Improve your asset efficiency to boost both the Schedule Performance Index (SPI) and Cost Performance Index (CPI).
2. Alternatively, by adjusting the aiming point, you essentially change the graphical representation of your project's performance. However, this doesn't fix the root cause of inefficient asset utilization. The real solution lies in addressing and enhancing asset efficiency for sustained improvement.

Given the above, the Author will conduct an analysis focused on improving CPI by implementing budget calculations for Capital Expenditure (CAPEX) using a parametric modeling approach based on historical data on project cost performance.

[26] PTMC Team and Dr. Paul D. Giammalvo. (2021). Managing-Quality-Assurance-Quality-Control.

From the available 95 historical data points, the Author conducted a Log-Normal distribution simulation using @RISK Palisade Software. The simulation resulted in a confidence level ranging from P-5 to P-95. In the context of a high-risk program, opting for a higher confidence level estimate (e.g., 70 or 80 percent) can (1) enhance the organization's assurance of success within the program's budget[27]. Considering this, the Author chose a confidence level of P-80 for both schedule and cost, which will serve as the foundational data for performing parametric estimates. These estimates will yield equations to calculate the Cost of Jetty Construction.

The collected data were normalized to 2025 using the Gold Price Index. 2025 is forecasted as the schedule for those projects if the tender starts in 2024. "The Gold Price Index is a financial tool that tracks the value of gold over time and is often used as a hedge against inflation or currency fluctuations." Normalizing the data using this index involves adjusting the jetty construction costs from 2019 to 2024 to the equivalent value in 2025, considering changes in the price of gold.

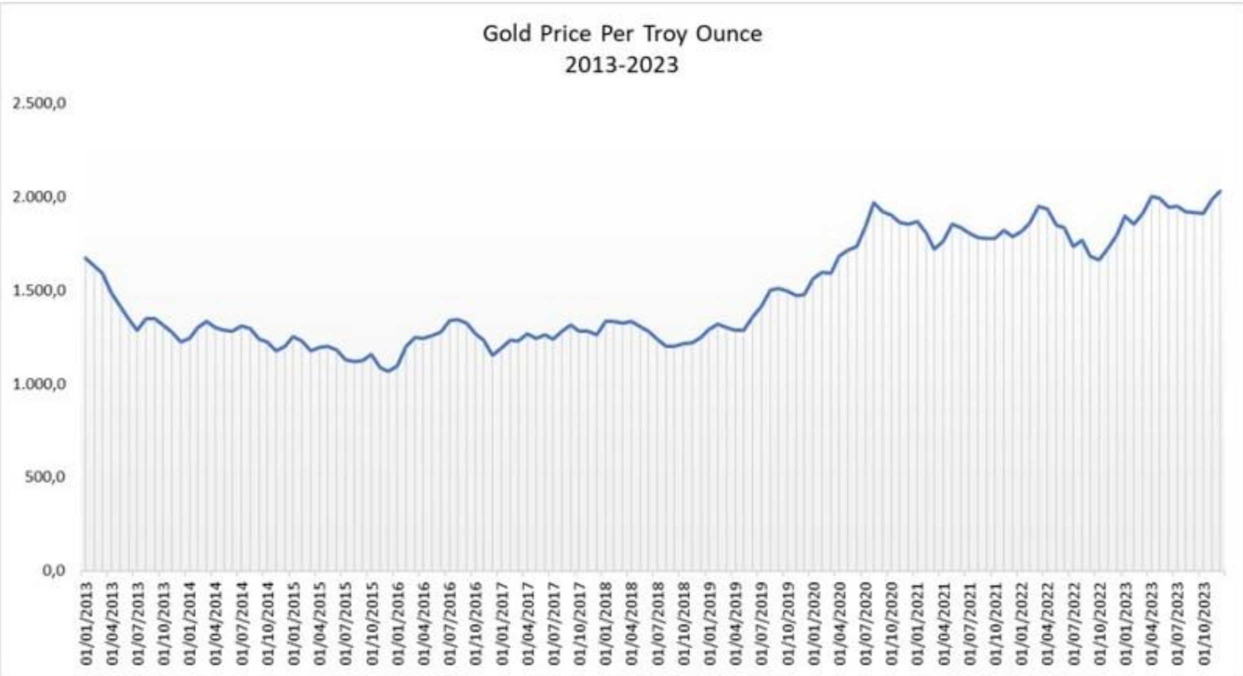


Figure 16-Gold Price Per Troy Ounce[28]

From the above chart, the Author determined the average gold price for 2018 to July 2023 to become the baseline, as follows:

[27] United States Government Accountability Office. (2020). Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program.
[28] Gold spot price and cost of gold. (2024, January 26). World Gold Council. https://www.gold.org/goldhub/data/gold-prices#registration-type=google&just-verified=1

Year	Average Gold Price per Year
2013	$ 1.411,0
2014	$ 1.266,2
2015	$ 1.160,1
2016	$ 1.248,3
2017	$ 1.257,1
2018	$ 1.269,1
2019	$ 1.392,2
2020	$ 1.769,6
2021	$ 1.799,6
2022	$ 1.800,8
2023	$ 1.942,7

Table 3-Average Gold Price Index from 2013 to 2023

In forecasting the gold price index until the year 2025, the @RISK Palisade software is utilized, making use of the @RISK Time Series feature. There are three groups of @RISK Time Series functions: **ARMA (autoregressive moving average)** processes, **GBM (geometric Brownian motion)** and its variations, and the **ARCH (autoregressive conditional heteroscedasticity)** process and its variations. [29]

The **GBM (Geometric Brownian Motion)** process and its various forms are continuous-time stochastic processes. They find widespread application in financial contexts, particularly in the pricing of options. In financial scenarios, the time series variable is frequently associated with either the price of a security or the change in price, commonly known as the return. Unlike ARMA (Auto Regressive Moving Average) processes, GBM processes often do not assume stationarity. For instance, when the time series variable represents a security price, it might exhibit an upward drift, indicating a tendency for the price to increase over time.

By using the @RISK Time Series, the Author employs the Auto Fit feature. Based on the gold price index results shown in Figure 15, forecasting is conducted until 2025. The obtained result suggests that the appropriate approach in @RISK is with **Risk BMMRJD**. Risk BMMRJD generates a Brownian motion process with mean reversion and jump-diffusion. It combines the features of Risk BMMR (Brownian motion with mean reversion) and jump-diffusion.

[29] Time series functions. (n.d.). help.palisade.com. https://help.palisade.com/v8_3/en/@RISK/Function/Time-Series-Functions.htm

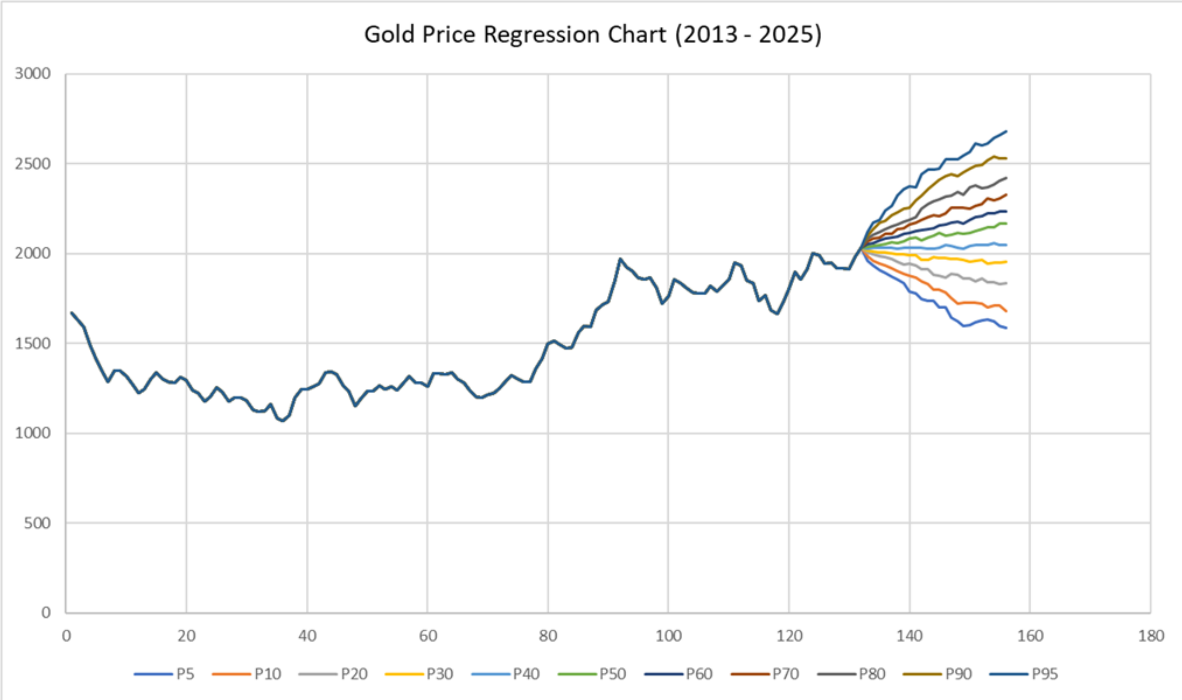


Figure 17-Gold Price Regression Chart using @RISK Palisade (2013 - 2025)

For a high-risk program, adopting a higher confidence level estimate (70 or 80 percent) can be used to (1) increase the organization's confidence in success within the program's budget, (2) make some provision for risks unknown at the time but likely to appear as the program progresses, and (3) reduce the likelihood that the organization will have to re-baseline the program because the program's contingency is expended before program completion. However, budgeting to a higher confidence level for multiple projects within a portfolio can result in an unaffordable portfolio budget and limit the number of programs that can be funded within that portfolio. [30]

Based on the baseline presented in Table 2 & Table 3 and the cost predictions made using the Gold Price Index, the Author built projected Jetty Construction Costs in 2025, with **a confidence level of P-80**, as displayed in **Appendix B.**

Step 4 – Selection of Decision Criterion

Model Formulation

Following the normalization of the data, the Author devised four distinct models aimed at capturing the relationship between Jetty Capacity (DWT) and Year-to-Built:

[30] United States Government Accountability Office. (2020). Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program.

Model 1 – Linear Model

The linear model is expressed as:

$$Linear: \ Cost = C_1 + \ C_2 \, x + \ C_3 \, y$$

Equation 3-Linear Model

X = Capacity in DWT

Y = Year-to-Built

C_1, C_2, & C_3= Coefficients to be estimated

Model 2 – Power Model

The power model is expressed as:

$$Power: \ Cost = C_1 + \ C_2 \, x^{C_4} + \ C_3 \, y^{C_5}$$

Equation 4-Power Model

X = Capacity in DWT

Y = Year-to-Built

C_1, C_2, C_3, C_4 & C_5 = Coefficients to be estimated

Model 3 – Logarithmic Model

The logarithmic model is expressed as:

$$Logarithmic: \ Cost = C_1 + \ C_2 \ log \, x + \ C_3 \ log \, y$$

Equation 5-Logarithmic Model

X = Capacity in DWT

Y = Year-to-Built

C_1, C_2, C_3, C_4 & C_5 = Coefficients to be estimated

Model 4 – Exponential Model

The exponential model is expressed as:

$$Exponential: \ Cost = C_1 + \ C_2 exp^{C_4 x} + \ C_3 exp^{C_5 y}$$

Equation 6-Exponential Model

X = Capacity in DWT

Y = Year-to-Built

C_1, C_2, C_3, C_4 & C_5 = Coefficients to be estimated

Coefficient Formulation Using Solver® for Excel

Solver for Excel stands as an optimization tool designed to identify the optimal solution for a problem by adjusting specific variable values to minimize or maximize an objective function. Within regression analysis, Solver can be employed to estimate coefficients, aiming to minimize the sum of squared residuals—a common objective in linear regression. The process of employing Solver for Excel in estimating regression coefficients involves the following steps:

a. Define the objective function, for instance, the sum of squared residuals (SSR).
b. Specify the cells containing the coefficients to be estimated.
c. Set constraints, if necessary, such as allowing negativity constraints.
d. Choose a solution method, like GRG Nonlinear.
e. Execute Solver and interpret the results.

Project's Dataset

Comprising 95 projects, each representing a unique combination of year and jetty capacity, the dataset exhibits a diverse range of scenarios. The Author extracts the actual project cost for each year and jetty capacity, ensuring that the data accurately reflects the real-world conditions and cost structures of each project. To project costs into 2025, the Author utilizes a P80 confidence level of the gold index by using the @RISK Time Series, representing a conservative estimate and instilling greater confidence that the escalated costs will not surpass the estimated values. This aligns with industry best practices for risk management in cost estimation.

Step 5 - Analysis and Comparison Alternative

The formula equation will be compared by evaluating several predetermined parameters. After employing all the project data, the results from this modeling exercise are summarized as follows:

Linear Model:

$$Cost = (1.703.623{,}98) + 1.617.691{,}01\left(\frac{x}{10.000}\right) + 124.224{,}30\,(y - 2019)$$

Equation 7-Linear Model for Construction Cost

Power Model:

$$Cost = 1 + 193.635{,}98\left(\frac{x}{10.000}\right)^{2{,}53} + 13{,}71\,(y - 2019)^{6{,}94}$$

Equation 8-Power Model for Construction Cost

Logarithmic Model:

$$Cost = 862.877,77 + 7.225.136,79 \log\left(\frac{x}{10.000}\right) + 5.942.796,16 \log(y - 2019)$$

Equation 9-Logarithmic Model for Construction Cost

Exponential Model:

$$Cost = 65,50 + 128.913,35\ exp^{\left(\frac{x}{10.000}\right)} + 9.332,14\ exp^{(y-2019)}$$

Equation 10-Exponential Model for Construction Cost

Cost = Construction Cost in USD
X = Capacity in DWT
Y = Year-to-Construct
C_1, C_2, C_3, C_4 & C_5 = Coefficients to be estimated

	LINEAR	POWER	LOGARITHMIC	EXPONENTIAL
NUM OF SAMPLE	95	95	95	95
STANDARD ERROR	411.461,45	790.304,63	656.363,80	1.233.202,39
MEAN SQUARE ERROR	407.896.234.843,59	1.057.237.688.703,42	1.307.877.430.279,19	4.638.346.314.546,61
ROOT MSE	638.667,55	1.028.220,64	1.143.624,69	2.153.682,04
R^2	0,960	0,854	0,899	0,644
ADJUSTED R^2	0,960	0,852	0,898	0,640
F VALUE	2.253,50	543,05	829,12	168,22
SIGNIFICANT F	0,000	0,000	0,000	0,000

Table 4-Summary of Model Calculation and Analysis using ANOVA

COEFFICIENT	LINEAR	POWER	LOGARITHMIC	EXPONENTIAL
C1	1.703.622,98	1,00	862.877,77	65,50
C2	1.617.691,01	193.635,98	7.225.136,79	128.913,35
C3	124.224,30	13,71	5.942.796,16	9.332,14
C4		2,53		1,00
C5		6,94		1,00

Table 5-Coefficient for Each Model

1. **Linear Model:**

- The low Standard Error, MSE, and RMSE indicate that the linear model has a small spread of residuals, suggesting a good fit.
- The high R-squared (0.960) implies that approximately 96% of the variance in the dependent variable is explained by the linear model.
- The high F Value (2,253.50) and significant F value (0.000) suggest that the linear model is statistically significant.

2. Power Model:

- The higher Standard Error, MSE, and RMSE compared to the linear model indicate a more extensive spread of residuals, suggesting a less precise fit.
- The lower R-squared (0.854) suggests that the power model explains less variance in the dependent variable compared to the linear model.
- The lower F Value (543.05) and significant F value (0.000) still indicate statistical significance but to a lesser extent than the linear model.

3. Logarithmic Model:

- The intermediate values for Standard Error, MSE, and RMSE suggest a moderate fit for the logarithmic model.
- The R-squared value (0.899) is between the linear and power models, indicating a better fit than the power model but not as good as the linear model.
- The higher F Value (829.12) and significant F value (0.000) suggest statistical significance.

4. Exponential Model:

- The highest values for Standard Error, MSE, and RMSE indicate a more extensive spread of residuals and a less accurate fit for the exponential model.
- The lowest R-squared (0.644) suggests that the exponential model explains the least amount of variance in the dependent variable.
- The lower F Value (168.22) and significant F value (0.000) indicate statistical significance but at a lower level compared to other models.

From a statistical standpoint, the **linear model** appears to be the most appropriate as it has the lowest errors, highest R-squared, and significant F value.

Step 6 - Selection of Preferred Alternative

The linear model becomes the equation model with the lowest errors, highest R-squared, and significant F value. This model is the choice for projecting Jetty Construction Costs using the following equation:

$$\boldsymbol{Cost} = (\mathbf{1.703.623,98}) + \mathbf{1.617.691,01}\left(\frac{\boldsymbol{x}}{\mathbf{10.000}}\right) + \mathbf{124.224,30}\,(\boldsymbol{y} - \mathbf{2019})$$

Equation 11-Proposed Equation for Jetty Construction Cost

Cost = Construction Cost in USD
X = Capacity in DWT
Y = Year-to-Construct

The equation comprises two factors determining the value of a project: Jetty Capacity (in DWT) and the estimated time for the completion of the work. The coefficient for the adjusted year-to-construct indicates the evolution of construction costs since 2019, based on the Project Database from 2019-2024.

This equation, derived by combining the Project Database from 2019-2024 and a regression of the Gold Price Index using @RISK Time Series at a Confidence Level P-80, is expected to increase the organization's confidence in project success within the budget, account for potential unknown risks, and reduce the likelihood of re-baselining as the program progresses.

Step 7 - Performance Monitoring and Post-Evaluation of Result

Ensuring the ongoing accuracy and relevance of the equation model chosen is crucial, and achieving this requires a systematic approach to regular performance monitoring. The following steps can be undertaken to facilitate this process:

- **Establish a Feedback Loop:**
  Create a feedback loop that integrates real-world insights into ongoing model refinement, ensuring adaptability and continuous improvement.

- **Data Benchmarking:**
  The project's historical database system offers a significant advantage by furnishing benchmarking data, metrics, and factors, serving as a valuable resource for reviewing and validating estimates. During the estimate review and validation process, it is crucial to incorporate a benchmarking report. This report compares ratios and factors from the estimate under review with historical values derived from similar types of projects stored in the database, enhancing the accuracy and reliability of the estimation process. Your system should be able to store data from external projects as well if this information can be obtained. This will allow you to make benchmark comparisons with both external data and your own internal company project metrics.[31]

- **Statistical Software Packages (e.g., R, Python with Pandas, MATLAB):**
  Utilize statistical software for comprehensive analysis of model results. Calculate performance metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and other correlation coefficients to assess accuracy.

[31] Pickett, T. W., & Elliott, B. G. (2007). EST.02 Transforming Historical Project Data into Useful Information. AACE International Transactions.

CONCLUSION

Based on the previously presented explanation, we can now revisit each question and its corresponding answer, as follows:

1. Has the historical data performance met the data quality metrics of validity, precision, reliability, and accuracy?

Figure 13 and Figure 14 illustrate the historical project performance, indicating that the SPI & CPI are situated in the Upper Left Quadrant (behind schedule and over budget). Historical performance SPI of ~0.67 to 0.95 and in terms of CPI (93/95 Project) = 98% fell between 0.77 to 0.98 and only 2 projects finished on budget exactly. Monitoring a project's performance can be achieved by applying Upper and Lower Control Limits (UCL and LCL), calculated by adding three sigma (+3δ) for UCL and deducting three sigma (-3δ) for LCL, to control the workflow in a project. For the business case, the Upper Specification Limit (USL) and Lower Specification Limit (LSL) are predetermined and specified in the contract documents. In this instance, we are considering using -5% and +5% (0.95 to 1.05).

Figure 10 reveals a critical insight into necessary actions with the average of 18% enhancement required for the optimal utilization of physical and human resources, falling within the range of 0.95 to 1.05. Similarly, there is an average 13% improvement that needs to be made in the effective utilization of financial assets. These findings provide a clear directive for strategic efforts to elevate the efficiency of both our physical and human assets, as well as our financial investments. The historical data indicates that the scatter plot of SPI & CPI is in the Upper Left Quadrant (the project is behind schedule and over budget). The distribution of SPI & CPI from historical projects, showing characteristics of Low Accuracy-High Precision & Low Validity-High Reliability. However, the data completely missed the target due to its close clustering. Despite the high precision and reliability, we can still use this data with appropriate adjustments. To address this, a parametric approach is employed, adjusting each location using the Construction Robustness Index and clustering the Total Project Cost by implementing the WBS Structure.

2. What is the appropriate parametric model for determining the cost estimate of Jetty construction based on mooring capacity and dead weight tonnage (DWT)?

While single-point estimates have long been prevalent in valuing projects within the oil and gas industry, their practical application often leads to under-budgeting and schedule delays due to inadequate project definition. By offering only specific values for parameters, single-point estimates overlook potential outcome ranges and scenario likelihoods, limiting insights into project cost and timeline variability. To avoid such issues, an alternative method that is not a single-point estimate and can consider the uncertainties that arise in a project is needed. Glenn Butts offered the following reasons for underestimating back in 2010, “Unrealistic & Optimistic Assumptions” based on that RAND Study, which affected 74% of Cost Growth[32]. Throughout the GPCCAR, one of the common themes is the ethical, if not legal, importance for project control professionals to continually test and validate assumptions, both in terms of time and costs.[33]

3. How can the selected parametric model meet the requirements of CAPEX Class 4 as needed in the feasibility studies stage?

Cost estimation's critical role spans all stages of the company's investment process, with CAPEX Class 4, recommended by AACE (Recommended Practice 18r-974), employed during initial feasibility studies. This class, with a project definition maturity ranging from 1% to 15%, relies on methodologies such as Equipment Factored or parametric models. With the average of ~11% between Projected Cost (by Parametric Model) vs. Original Project Cost, referring to AACE (Recommended Practice 18r-974), this value is still below Expected Accuracy Error (L: -15% to -30% & H: +20% to +50%) for Class 4 Estimate.

Employing parametric models to determine Jetties' construction costs enables the company to streamline and improve the accuracy of CAPEX Class 4 calculations during feasibility studies. The inclusion of variables such as Jetty Capacity (in DWT) and Year-to-Construct results in a precise Total Project Cost for Jetty construction. This method ensures a more thorough grasp of project dynamics and facilitates well-informed investment decisions. The utilization of Confidence Level P-80 for Gold Index Regression is expected to strengthen the organization's confidence in achieving project success within budgetary constraints. It considers potential unknown risks, reduces the likelihood of re-baselining as the program progresses, and improves the performance of the project SPI & CPI within the target bullseye ranges of 0.95 to 1.05.

FUTURE RESEARCH

Following the conclusion above, historical project data plays a significant role in modeling parametric cost estimates. According to Project Performance, both CPI and SPI need to be maintained between the Upper/Lower Specification Limit and Upper/Lower Control Limit. The Parametric Model of Cost Estimate can be used in developing CAPEX Class 4 during feasibility studies. To maintain both Cost and Schedule performance of the project, further research is needed to determine the Equation Model based on

[32] Giammalvo, P.D. (2021). Project Management Caught in a 1960’s Time Warp – The Sequel? – Part 2. http://www.maxwideman.com/guests/time_warp/exploring.htm
[33] PTMC Team and Dr. Paul D. Giammalvo. (2021). Unit 10- Managing Cost Estimating And Budgeting.

scheduling. It is hoped that with the approach of the equation model for Cost and Scheduling, the Front-End Loading phase in the project stages can achieve maturity level according to Estimate Class 4.

Bibliography

1. AACE International. (2020). AACE International Recommended Practice No. 17R-97 Cost Estimate Classification System.
2. AACE International. (2020). AACE International Recommended Practice No. 18R-97 Cost Estimate Classification System – As Applied In Engineering, Procurement, And Construction For The Process Industries.
3. AACE International. (2011). AACE International Recommended Practice No. 59R-10 Development of Factored Cost Estimates as Applied in Engineering, Procurement, And Construction for The Process Industries.
4. ArcelorMittal - Steel Sheet Piles. (n.d.). Dolphins in maritime structures. Retrieved January 3, 2024, from https://sheetpiling.arcelormittal.com/applications/maritime-infrastructures/dolphins/
5. Badan Pusat Statistik. (2022). Statistik Transportasi Laut Volume 8, 2023.
6. Benefits of good FEL (Front-End Loading). (n.d.). www.linkedin.com. Retrieved January 4, 2024, from https://www.linkedin.com/pulse/benefits-good-fel-front-end-loading-javad-malekani/
7. Chad, Paul & Kyriazis, Elias & Motion, Judy. (2013). Development of a Market Orientation Research Agenda for the Nonprofit Sector. Journal of Nonprofit & Public Sector Marketing. 25. 1-27. 10.1080/10495142.2013.759814.
8. Commodities Portfolio Optimization Using @RISK's Time Series Analysis Tool. (n.d.). LinkedIn. https://www.linkedin.com/pulse/commodities-portfolio-optimization-using-risks-time-series-hernandez/
9. Davis, D. (2011, October 15). The MacLeamy curve. Daniel Davis. https://www.danieldavis.com/macleamy/
10. Explorable.com. (n.d.). Steps of the Scientific Method – The Stages of Scientific Research. https://explorable.com/steps-of-the-scientific-method
11. Giammalvo, P. D. (2018). OmniClass coding & Activity Based Costing Mapping ERP "Chart of Accounts" to Building Information Modeling Software Using OmniClass Coding Structures and Activity Based Costing/Management- A CONTRACTOR'S perspective. SSRN Electronic Journal, 10.2139/ssrn.3519739.
12. Giammalvo, P. D. (2021). Project Management Caught in a 1960's Time Warp – The Sequel? – Part 2. http://www.maxwideman.com/guests/time_warp/exploring.htm

13. Giammalvo, Paul D. (2021). The Bigger Picture: Project Life Cycles from a Broader, Real-World Perspective 1. Project Management Journal. Vol. X.

14. IEA. (2016). Oil final consumption by product, Indonesia 1990-2021. Indonesia - Countries & Regions - IEA. IEA. https://www.iea.org/countries/Indonesia

15. Montang, S. Y. (2023). Revolutionizing Feasibility Studies: A Proprietary Complex Model for Atmospheric API 650 Storage Tank Cost Estimation in National Oil Company; PM World Journal, Vol. XII, Issue X, October.

16. Newnan, D. G., Eschenbach, T., & Lavelle, J. P. (2012). Engineering economic analysis.

17. OmniClass. (2020). Introduction and User's Guide. https://www.csiresources.org/standards/omniclass

18. OmniClass. (2020). Construction Entities by Function - Table 11. https://www.csiresources.org/standards/omniclass

19. OmniClass. (2020). Spaces by Function - Table 13. https://www.csiresources.org/standards/omniclass

20. OmniClass. (2020). Elements (includes Designed Elements) - Table 21. https://www.csiresources.org/standards/omniclass

21. OmniClass. (2020). Work Results - Table 22. https://www.csiresources.org/standards/omniclass

22. OmniClass. (2020). Phases - Table 31. https://www.csiresources.org/standards/omniclass

23. Pickett, T. W., & Elliott, B. G. (2007). EST.02 Transforming Historical Project Data into Useful Information. AACE International Transactions.

24. Pertamina. (2021). Infrastructure Masterplan: Strategic Roadmap of Synergy Optimization.

25. Pertamina (Persero), P. T. (n.d.). Pertamina Dukung Transformasi Pertamina International Shipping Menjadi Subholding Integrated Marine Logistics, Untuk Mendorong Pertumbuhan Ekonomi di Indonesia | Pertamina. www.pertamina.com. Retrieved January 4, 2024, from https://www.pertamina.com/id/news-room/news-release/pertamina-dukung-transformasi-pertamina-international-shipping-menjadi-subholding-integrated-marine-logistics-untuk-mendorong-pertumbuhan-ekonomi-di-indonesia

26. PTMC Team and Dr. Paul D. Giammalvo. (2021). Unit 5- Managing-Quality-Assurance-Quality-Control.

27. PTMC Team and Dr. Paul D. Giammalvo. (2021). Unit 9- Managing Planning and Scheduling.

28. PTMC Team and Dr. Paul D. Giammalvo. (2021). Unit 10- Managing Cost Estimating And Budgeting.

29. Sullivan, W., Wicks, E., & Koelling, C. (2023). Engineering Economy (17th ed.). Pearson.

30. Time series functions. (n.d.). help.palisade.com. https://help.palisade.com/v8_3/en/@RISK/Function/Time-Series-Functions.htm

31. U.S. Department of Energy. (2011). Cost Estimating Guide.

32. U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0. CreateSpace Independent Publishing Platform.

33. U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0, Appendix G: Cost Risk and Uncertainty Methodologies. Createspace Independent Publishing Platform.

34. U.S. National Aeronautics and Space Administration. (2017). NASA Cost Estimating Handbook Ver 4.0, Appendix J: Joint Cost and Schedule Confidence Level (JCL) Analysis. CreateSpace Independent Publishing Platform.

35. United States Government Accountability Office. (2020). Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program.

36. Youtupedia. (2022). Harbors, Ports, Quays, Wharves, Berths, Docks, Jetties & More. From https://www.youtube.com/watch?v=AEfsxLPF_cU

APPENDIX A. GOLD PRICE INDEX & @RISK TIME SERIES OUTPUT

Gold price per troy ounce - Major consumer and producer currencies
Source: Bloomberg, Datastream, ICE Benchmark Administration, World Gold Council

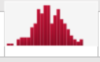
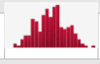
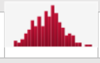
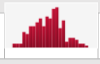
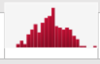
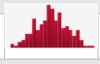
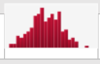
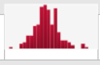
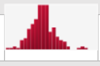
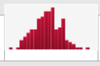
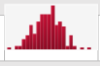
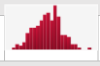
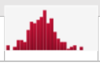
No	YEAR	USD	@RISK Output	P5	P10	P20	P30	P40	P50	P60	P70	P80	P90	P95
1	31/01/2013	1.671,0		1.671,0	1.671,0	1.671,0	1.671,0	1.671,0	1.671,0	1.671,0	1.671,0	1.671,0	1.671,0	1.671,0
2	28/02/2013	1.627,6		1.627,6	1.627,6	1.627,6	1.627,6	1.627,6	1.627,6	1.627,6	1.627,6	1.627,6	1.627,6	1.627,6
3	29/03/2013	1.592,9		1.592,9	1.592,9	1.592,9	1.592,9	1.592,9	1.592,9	1.592,9	1.592,9	1.592,9	1.592,9	1.592,9
4	30/04/2013	1.485,1		1.485,1	1.485,1	1.485,1	1.485,1	1.485,1	1.485,1	1.485,1	1.485,1	1.485,1	1.485,1	1.485,1
5	31/05/2013	1.413,5		1.413,5	1.413,5	1.413,5	1.413,5	1.413,5	1.413,5	1.413,5	1.413,5	1.413,5	1.413,5	1.413,5
6	28/06/2013	1.342,4		1.342,4	1.342,4	1.342,4	1.342,4	1.342,4	1.342,4	1.342,4	1.342,4	1.342,4	1.342,4	1.342,4
7	31/07/2013	1.286,7		1.286,7	1.286,7	1.286,7	1.286,7	1.286,7	1.286,7	1.286,7	1.286,7	1.286,7	1.286,7	1.286,7
8	30/08/2013	1.347,1		1.347,1	1.347,1	1.347,1	1.347,1	1.347,1	1.347,1	1.347,1	1.347,1	1.347,1	1.347,1	1.347,1
9	30/09/2013	1.348,8		1.348,8	1.348,8	1.348,8	1.348,8	1.348,8	1.348,8	1.348,8	1.348,8	1.348,8	1.348,8	1.348,8
10	31/10/2013	1.316,2		1.316,2	1.316,2	1.316,2	1.316,2	1.316,2	1.316,2	1.316,2	1.316,2	1.316,2	1.316,2	1.316,2
11	29/11/2013	1.275,8		1.275,8	1.275,8	1.275,8	1.275,8	1.275,8	1.275,8	1.275,8	1.275,8	1.275,8	1.275,8	1.275,8
12	31/12/2013	1.225,4		1.225,4	1.225,4	1.225,4	1.225,4	1.225,4	1.225,4	1.225,4	1.225,4	1.225,4	1.225,4	1.225,4
13	31/01/2014	1.244,8		1.244,8	1.244,8	1.244,8	1.244,8	1.244,8	1.244,8	1.244,8	1.244,8	1.244,8	1.244,8	1.244,8
14	28/02/2014	1.301,0		1.301,0	1.301,0	1.301,0	1.301,0	1.301,0	1.301,0	1.301,0	1.301,0	1.301,0	1.301,0	1.301,0
15	31/03/2014	1.336,1		1.336,1	1.336,1	1.336,1	1.336,1	1.336,1	1.336,1	1.336,1	1.336,1	1.336,1	1.336,1	1.336,1
16	30/04/2014	1.299,0		1.299,0	1.299,0	1.299,0	1.299,0	1.299,0	1.299,0	1.299,0	1.299,0	1.299,0	1.299,0	1.299,0
17	30/05/2014	1.287,5		1.287,5	1.287,5	1.287,5	1.287,5	1.287,5	1.287,5	1.287,5	1.287,5	1.287,5	1.287,5	1.287,5
18	30/06/2014	1.279,1		1.279,1	1.279,1	1.279,1	1.279,1	1.279,1	1.279,1	1.279,1	1.279,1	1.279,1	1.279,1	1.279,1
19	31/07/2014	1.311,0		1.311,0	1.311,0	1.311,0	1.311,0	1.311,0	1.311,0	1.311,0	1.311,0	1.311,0	1.311,0	1.311,0
20	29/08/2014	1.296,0		1.296,0	1.296,0	1.296,0	1.296,0	1.296,0	1.296,0	1.296,0	1.296,0	1.296,0	1.296,0	1.296,0
21	30/09/2014	1.238,8		1.238,8	1.238,8	1.238,8	1.238,8	1.238,8	1.238,8	1.238,8	1.238,8	1.238,8	1.238,8	1.238,8
22	31/10/2014	1.222,5		1.222,5	1.222,5	1.222,5	1.222,5	1.222,5	1.222,5	1.222,5	1.222,5	1.222,5	1.222,5	1.222,5
23	28/11/2014	1.176,3		1.176,3	1.176,3	1.176,3	1.176,3	1.176,3	1.176,3	1.176,3	1.176,3	1.176,3	1.176,3	1.176,3
24	31/12/2014	1.202,3		1.202,3	1.202,3	1.202,3	1.202,3	1.202,3	1.202,3	1.202,3	1.202,3	1.202,3	1.202,3	1.202,3
25	30/01/2015	1.251,9		1.251,9	1.251,9	1.251,9	1.251,9	1.251,9	1.251,9	1.251,9	1.251,9	1.251,9	1.251,9	1.251,9
26	27/02/2015	1.227,2		1.227,2	1.227,2	1.227,2	1.227,2	1.227,2	1.227,2	1.227,2	1.227,2	1.227,2	1.227,2	1.227,2
27	31/03/2015	1.178,6		1.178,6	1.178,6	1.178,6	1.178,6	1.178,6	1.178,6	1.178,6	1.178,6	1.178,6	1.178,6	1.178,6
28	30/04/2015	1.197,9		1.197,9	1.197,9	1.197,9	1.197,9	1.197,9	1.197,9	1.197,9	1.197,9	1.197,9	1.197,9	1.197,9
29	29/05/2015	1.199,1		1.199,1	1.199,1	1.199,1	1.199,1	1.199,1	1.199,1	1.199,1	1.199,1	1.199,1	1.199,1	1.199,1
30	30/06/2015	1.181,5		1.181,5	1.181,5	1.181,5	1.181,5	1.181,5	1.181,5	1.181,5	1.181,5	1.181,5	1.181,5	1.181,5
31	31/07/2015	1.130,0		1.130,0	1.130,0	1.130,0	1.130,0	1.130,0	1.130,0	1.130,0	1.130,0	1.130,0	1.130,0	1.130,0
32	31/08/2015	1.117,5		1.117,5	1.117,5	1.117,5	1.117,5	1.117,5	1.117,5	1.117,5	1.117,5	1.117,5	1.117,5	1.117,5
33	30/09/2015	1.124,5		1.124,5	1.124,5	1.124,5	1.124,5	1.124,5	1.124,5	1.124,5	1.124,5	1.124,5	1.124,5	1.124,5
34	30/10/2015	1.159,3		1.159,3	1.159,3	1.159,3	1.159,3	1.159,3	1.159,3	1.159,3	1.159,3	1.159,3	1.159,3	1.159,3
35	30/11/2015	1.085,7		1.085,7	1.085,7	1.085,7	1.085,7	1.085,7	1.085,7	1.085,7	1.085,7	1.085,7	1.085,7	1.085,7
36	31/12/2015	1.068,3		1.068,3	1.068,3	1.068,3	1.068,3	1.068,3	1.068,3	1.068,3	1.068,3	1.068,3	1.068,3	1.068,3
37	29/01/2016	1.097,4		1.097,4	1.097,4	1.097,4	1.097,4	1.097,4	1.097,4	1.097,4	1.097,4	1.097,4	1.097,4	1.097,4
38	29/02/2016	1.199,9		1.199,9	1.199,9	1.199,9	1.199,9	1.199,9	1.199,9	1.199,9	1.199,9	1.199,9	1.199,9	1.199,9
39	31/03/2016	1.246,3		1.246,3	1.246,3	1.246,3	1.246,3	1.246,3	1.246,3	1.246,3	1.246,3	1.246,3	1.246,3	1.246,3
40	29/04/2016	1.242,3		1.242,3	1.242,3	1.242,3	1.242,3	1.242,3	1.242,3	1.242,3	1.242,3	1.242,3	1.242,3	1.242,3
41	31/05/2016	1.259,4		1.259,4	1.259,4	1.259,4	1.259,4	1.259,4	1.259,4	1.259,4	1.259,4	1.259,4	1.259,4	1.259,4
42	30/06/2016	1.276,4		1.276,4	1.276,4	1.276,4	1.276,4	1.276,4	1.276,4	1.276,4	1.276,4	1.276,4	1.276,4	1.276,4
43	29/07/2016	1.337,3		1.337,3	1.337,3	1.337,3	1.337,3	1.337,3	1.337,3	1.337,3	1.337,3	1.337,3	1.337,3	1.337,3
44	31/08/2016	1.341,1		1.341,1	1.341,1	1.341,1	1.341,1	1.341,1	1.341,1	1.341,1	1.341,1	1.341,1	1.341,1	1.341,1
45	30/09/2016	1.326,0		1.326,0	1.326,0	1.326,0	1.326,0	1.326,0	1.326,0	1.326,0	1.326,0	1.326,0	1.326,0	1.326,0
46	31/10/2016	1.266,6		1.266,6	1.266,6	1.266,6	1.266,6	1.266,6	1.266,6	1.266,6	1.266,6	1.266,6	1.266,6	1.266,6
47	30/11/2016	1.236,0		1.236,0	1.236,0	1.236,0	1.236,0	1.236,0	1.236,0	1.236,0	1.236,0	1.236,0	1.236,0	1.236,0
48	30/12/2016	1.151,4		1.151,4	1.151,4	1.151,4	1.151,4	1.151,4	1.151,4	1.151,4	1.151,4	1.151,4	1.151,4	1.151,4
49	31/01/2017	1.192,6		1.192,6	1.192,6	1.192,6	1.192,6	1.192,6	1.192,6	1.192,6	1.192,6	1.192,6	1.192,6	1.192,6
50	28/02/2017	1.234,4		1.234,4	1.234,4	1.234,4	1.234,4	1.234,4	1.234,4	1.234,4	1.234,4	1.234,4	1.234,4	1.234,4
51	31/03/2017	1.231,1		1.231,1	1.231,1	1.231,1	1.231,1	1.231,1	1.231,1	1.231,1	1.231,1	1.231,1	1.231,1	1.231,1
52	28/04/2017	1.265,6		1.265,6	1.265,6	1.265,6	1.265,6	1.265,6	1.265,6	1.265,6	1.265,6	1.265,6	1.265,6	1.265,6
53	31/05/2017	1.245,0		1.245,0	1.245,0	1.245,0	1.245,0	1.245,0	1.245,0	1.245,0	1.245,0	1.245,0	1.245,0	1.245,0
54	30/06/2017	1.260,3		1.260,3	1.260,3	1.260,3	1.260,3	1.260,3	1.260,3	1.260,3	1.260,3	1.260,3	1.260,3	1.260,3
55	31/07/2017	1.236,2		1.236,2	1.236,2	1.236,2	1.236,2	1.236,2	1.236,2	1.236,2	1.236,2	1.236,2	1.236,2	1.236,2
56	31/08/2017	1.282,3		1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3
57	29/09/2017	1.315,0		1.315,0	1.315,0	1.315,0	1.315,0	1.315,0	1.315,0	1.315,0	1.315,0	1.315,0	1.315,0	1.315,0
58	31/10/2017	1.279,5		1.279,5	1.279,5	1.279,5	1.279,5	1.279,5	1.279,5	1.279,5	1.279,5	1.279,5	1.279,5	1.279,5
59	30/11/2017	1.282,3		1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3	1.282,3
60	29/12/2017	1.261,3		1.261,3	1.261,3	1.261,3	1.261,3	1.261,3	1.261,3	1.261,3	1.261,3	1.261,3	1.261,3	1.261,3
61	31/01/2018	1.331,7		1.331,7	1.331,7	1.331,7	1.331,7	1.331,7	1.331,7	1.331,7	1.331,7	1.331,7	1.331,7	1.331,7
62	28/02/2018	1.331,5		1.331,5	1.331,5	1.331,5	1.331,5	1.331,5	1.331,5	1.331,5	1.331,5	1.331,5	1.331,5	1.331,5
63	30/03/2018	1.324,7		1.324,7	1.324,7	1.324,7	1.324,7	1.324,7	1.324,7	1.324,7	1.324,7	1.324,7	1.324,7	1.324,7
64	30/04/2018	1.334,7		1.334,7	1.334,7	1.334,7	1.334,7	1.334,7	1.334,7	1.334,7	1.334,7	1.334,7	1.334,7	1.334,7
65	31/05/2018	1.303,0		1.303,0	1.303,0	1.303,0	1.303,0	1.303,0	1.303,0	1.303,0	1.303,0	1.303,0	1.303,0	1.303,0
66	29/06/2018	1.281,6		1.281,6	1.281,6	1.281,6	1.281,6	1.281,6	1.281,6	1.281,6	1.281,6	1.281,6	1.281,6	1.281,6
67	31/07/2018	1.238,5		1.238,5	1.238,5	1.238,5	1.238,5	1.238,5	1.238,5	1.238,5	1.238,5	1.238,5	1.238,5	1.238,5
68	31/08/2018	1.201,3		1.201,3	1.201,3	1.201,3	1.201,3	1.201,3	1.201,3	1.201,3	1.201,3	1.201,3	1.201,3	1.201,3
69	28/09/2018	1.198,5		1.198,5	1.198,5	1.198,5	1.198,5	1.198,5	1.198,5	1.198,5	1.198,5	1.198,5	1.198,5	1.198,5
70	31/10/2018	1.215,4		1.215,4	1.215,4	1.215,4	1.215,4	1.215,4	1.215,4	1.215,4	1.215,4	1.215,4	1.215,4	1.215,4
71	30/11/2018	1.221,0		1.221,0	1.221,0	1.221,0	1.221,0	1.221,0	1.221,0	1.221,0	1.221,0	1.221,0	1.221,0	1.221,0
72	31/12/2018	1.247,9		1.247,9	1.247,9	1.247,9	1.247,9	1.247,9	1.247,9	1.247,9	1.247,9	1.247,9	1.247,9	1.247,9
73	31/01/2019	1.291,8		1.291,8	1.291,8	1.291,8	1.291,8	1.291,8	1.291,8	1.291,8	1.291,8	1.291,8	1.291,8	1.291,8
74	28/02/2019	1.320,1		1.320,1	1.320,1	1.320,1	1.320,1	1.320,1	1.320,1	1.320,1	1.320,1	1.320,1	1.320,1	1.320,1
75	29/03/2019	1.300,9		1.300,9	1.300,9	1.300,9	1.300,9	1.300,9	1.300,9	1.300,9	1.300,9	1.300,9	1.300,9	1.300,9
76	30/04/2019	1.286,5		1.286,5	1.286,5	1.286,5	1.286,5	1.286,5	1.286,5	1.286,5	1.286,5	1.286,5	1.286,5	1.286,5
77	31/05/2019	1.284,0		1.284,0	1.284,0	1.284,0	1.284,0	1.284,0	1.284,0	1.284,0	1.284,0	1.284,0	1.284,0	1.284,0
78	28/06/2019	1.359,0		1.359,0	1.359,0	1.359,0	1.359,0	1.359,0	1.359,0	1.359,0	1.359,0	1.359,0	1.359,0	1.359,0
79	31/07/2019	1.413,0		1.413,0	1.413,0	1.413,0	1.413,0	1.413,0	1.413,0	1.413,0	1.413,0	1.413,0	1.413,0	1.413,0
80	30/08/2019	1.498,8		1.498,8	1.498,8	1.498,8	1.498,8	1.498,8	1.498,8	1.498,8	1.498,8	1.498,8	1.498,8	1.498,8

APPENDIX A. GOLD PRICE INDEX & @RISK TIME SERIES OUTPUT

No	YEAR	USD	@RISK Output	P5	P10	P20	P30	P40	P50	P60	P70	P80	P90	P95
81	30/09/2019	1.511,3		1.511,3	1.511,3	1.511,3	1.511,3	1.511,3	1.511,3	1.511,3	1.511,3	1.511,3	1.511,3	1.511,3
82	31/10/2019	1.494,8		1.494,8	1.494,8	1.494,8	1.494,8	1.494,8	1.494,8	1.494,8	1.494,8	1.494,8	1.494,8	1.494,8
83	29/11/2019	1.470,0		1.470,0	1.470,0	1.470,0	1.470,0	1.470,0	1.470,0	1.470,0	1.470,0	1.470,0	1.470,0	1.470,0
84	31/12/2019	1.476,0		1.476,0	1.476,0	1.476,0	1.476,0	1.476,0	1.476,0	1.476,0	1.476,0	1.476,0	1.476,0	1.476,0
85	31/01/2020	1.560,7		1.560,7	1.560,7	1.560,7	1.560,7	1.560,7	1.560,7	1.560,7	1.560,7	1.560,7	1.560,7	1.560,7
86	28/02/2020	1.597,1		1.597,1	1.597,1	1.597,1	1.597,1	1.597,1	1.597,1	1.597,1	1.597,1	1.597,1	1.597,1	1.597,1
87	31/03/2020	1.591,9		1.591,9	1.591,9	1.591,9	1.591,9	1.591,9	1.591,9	1.591,9	1.591,9	1.591,9	1.591,9	1.591,9
88	30/04/2020	1.682,9		1.682,9	1.682,9	1.682,9	1.682,9	1.682,9	1.682,9	1.682,9	1.682,9	1.682,9	1.682,9	1.682,9
89	29/05/2020	1.716,4		1.716,4	1.716,4	1.716,4	1.716,4	1.716,4	1.716,4	1.716,4	1.716,4	1.716,4	1.716,4	1.716,4
90	30/06/2020	1.732,2		1.732,2	1.732,2	1.732,2	1.732,2	1.732,2	1.732,2	1.732,2	1.732,2	1.732,2	1.732,2	1.732,2
91	31/07/2020	1.843,3		1.843,3	1.843,3	1.843,3	1.843,3	1.843,3	1.843,3	1.843,3	1.843,3	1.843,3	1.843,3	1.843,3
92	31/08/2020	1.968,6		1.968,6	1.968,6	1.968,6	1.968,6	1.968,6	1.968,6	1.968,6	1.968,6	1.968,6	1.968,6	1.968,6
93	30/09/2020	1.922,2		1.922,2	1.922,2	1.922,2	1.922,2	1.922,2	1.922,2	1.922,2	1.922,2	1.922,2	1.922,2	1.922,2
94	30/10/2020	1.900,3		1.900,3	1.900,3	1.900,3	1.900,3	1.900,3	1.900,3	1.900,3	1.900,3	1.900,3	1.900,3	1.900,3
95	30/11/2020	1.863,5		1.863,5	1.863,5	1.863,5	1.863,5	1.863,5	1.863,5	1.863,5	1.863,5	1.863,5	1.863,5	1.863,5
96	31/12/2020	1.856,0		1.856,0	1.856,0	1.856,0	1.856,0	1.856,0	1.856,0	1.856,0	1.856,0	1.856,0	1.856,0	1.856,0
97	29/01/2021	1.867,0		1.867,0	1.867,0	1.867,0	1.867,0	1.867,0	1.867,0	1.867,0	1.867,0	1.867,0	1.867,0	1.867,0
98	26/02/2021	1.808,2		1.808,2	1.808,2	1.808,2	1.808,2	1.808,2	1.808,2	1.808,2	1.808,2	1.808,2	1.808,2	1.808,2
99	31/03/2021	1.718,2		1.718,2	1.718,2	1.718,2	1.718,2	1.718,2	1.718,2	1.718,2	1.718,2	1.718,2	1.718,2	1.718,2
100	30/04/2021	1.761,7		1.761,7	1.761,7	1.761,7	1.761,7	1.761,7	1.761,7	1.761,7	1.761,7	1.761,7	1.761,7	1.761,7
101	31/05/2021	1.853,2		1.853,2	1.853,2	1.853,2	1.853,2	1.853,2	1.853,2	1.853,2	1.853,2	1.853,2	1.853,2	1.853,2
102	30/06/2021	1.834,6		1.834,6	1.834,6	1.834,6	1.834,6	1.834,6	1.834,6	1.834,6	1.834,6	1.834,6	1.834,6	1.834,6
103	30/07/2021	1.807,1		1.807,1	1.807,1	1.807,1	1.807,1	1.807,1	1.807,1	1.807,1	1.807,1	1.807,1	1.807,1	1.807,1
104	31/08/2021	1.784,0		1.784,0	1.784,0	1.784,0	1.784,0	1.784,0	1.784,0	1.784,0	1.784,0	1.784,0	1.784,0	1.784,0
105	30/09/2021	1.777,3		1.777,3	1.777,3	1.777,3	1.777,3	1.777,3	1.777,3	1.777,3	1.777,3	1.777,3	1.777,3	1.777,3
106	29/10/2021	1.776,9		1.776,9	1.776,9	1.776,9	1.776,9	1.776,9	1.776,9	1.776,9	1.776,9	1.776,9	1.776,9	1.776,9
107	30/11/2021	1.820,2		1.820,2	1.820,2	1.820,2	1.820,2	1.820,2	1.820,2	1.820,2	1.820,2	1.820,2	1.820,2	1.820,2
108	31/12/2021	1.786,7		1.786,7	1.786,7	1.786,7	1.786,7	1.786,7	1.786,7	1.786,7	1.786,7	1.786,7	1.786,7	1.786,7
109	31/01/2022	1.816,8		1.816,8	1.816,8	1.816,8	1.816,8	1.816,8	1.816,8	1.816,8	1.816,8	1.816,8	1.816,8	1.816,8
110	28/02/2022	1.856,3		1.856,3	1.856,3	1.856,3	1.856,3	1.856,3	1.856,3	1.856,3	1.856,3	1.856,3	1.856,3	1.856,3
111	31/03/2022	1.947,8		1.947,8	1.947,8	1.947,8	1.947,8	1.947,8	1.947,8	1.947,8	1.947,8	1.947,8	1.947,8	1.947,8
112	29/04/2022	1.933,9		1.933,9	1.933,9	1.933,9	1.933,9	1.933,9	1.933,9	1.933,9	1.933,9	1.933,9	1.933,9	1.933,9
113	31/05/2022	1.848,3		1.848,3	1.848,3	1.848,3	1.848,3	1.848,3	1.848,3	1.848,3	1.848,3	1.848,3	1.848,3	1.848,3
114	30/06/2022	1.833,8		1.833,8	1.833,8	1.833,8	1.833,8	1.833,8	1.833,8	1.833,8	1.833,8	1.833,8	1.833,8	1.833,8
115	29/07/2022	1.736,4		1.736,4	1.736,4	1.736,4	1.736,4	1.736,4	1.736,4	1.736,4	1.736,4	1.736,4	1.736,4	1.736,4
116	31/08/2022	1.765,7		1.765,7	1.765,7	1.765,7	1.765,7	1.765,7	1.765,7	1.765,7	1.765,7	1.765,7	1.765,7	1.765,7
117	30/09/2022	1.683,0		1.683,0	1.683,0	1.683,0	1.683,0	1.683,0	1.683,0	1.683,0	1.683,0	1.683,0	1.683,0	1.683,0
118	31/10/2022	1.664,5		1.664,5	1.664,5	1.664,5	1.664,5	1.664,5	1.664,5	1.664,5	1.664,5	1.664,5	1.664,5	1.664,5
119	30/11/2022	1.726,5		1.726,5	1.726,5	1.726,5	1.726,5	1.726,5	1.726,5	1.726,5	1.726,5	1.726,5	1.726,5	1.726,5
120	30/12/2022	1.796,7		1.796,7	1.796,7	1.796,7	1.796,7	1.796,7	1.796,7	1.796,7	1.796,7	1.796,7	1.796,7	1.796,7
121	31/01/2023	1.898,6		1.898,6	1.898,6	1.898,6	1.898,6	1.898,6	1.898,6	1.898,6	1.898,6	1.898,6	1.898,6	1.898,6
122	28/02/2023	1.854,5		1.854,5	1.854,5	1.854,5	1.854,5	1.854,5	1.854,5	1.854,5	1.854,5	1.854,5	1.854,5	1.854,5
123	31/03/2023	1.912,7		1.912,7	1.912,7	1.912,7	1.912,7	1.912,7	1.912,7	1.912,7	1.912,7	1.912,7	1.912,7	1.912,7
124	28/04/2023	2.000,4		2.000,4	2.000,4	2.000,4	2.000,4	2.000,4	2.000,4	2.000,4	2.000,4	2.000,4	2.000,4	2.000,4
125	31/05/2023	1.990,2		1.990,2	1.990,2	1.990,2	1.990,2	1.990,2	1.990,2	1.990,2	1.990,2	1.990,2	1.990,2	1.990,2
126	30/06/2023	1.942,9		1.942,9	1.942,9	1.942,9	1.942,9	1.942,9	1.942,9	1.942,9	1.942,9	1.942,9	1.942,9	1.942,9
127	31/07/2023	1.948,9		1.948,9	1.948,9	1.948,9	1.948,9	1.948,9	1.948,9	1.948,9	1.948,9	1.948,9	1.948,9	1.948,9
128	31/08/2023	1.920,0		1.920,0	1.920,0	1.920,0	1.920,0	1.920,0	1.920,0	1.920,0	1.920,0	1.920,0	1.920,0	1.920,0
129	29/09/2023	1.917,0		1.917,0	1.917,0	1.917,0	1.917,0	1.917,0	1.917,0	1.917,0	1.917,0	1.917,0	1.917,0	1.917,0
130	31/10/2023	1.913,0		1.913,0	1.913,0	1.913,0	1.913,0	1.913,0	1.913,0	1.913,0	1.913,0	1.913,0	1.913,0	1.913,0
131	30/11/2023	1.985,3		1.985,3	1.985,3	1.985,3	1.985,3	1.985,3	1.985,3	1.985,3	1.985,3	1.985,3	1.985,3	1.985,3
132	29/12/2023	2.029,3		2.029,3	2.029,3	2.029,3	2.029,3	2.029,3	2.029,3	2.029,3	2.029,3	2.029,3	2.029,3	2.029,3
133	31/01/2024	2.044,0	2.044,0	1.961,4	1.982,9	2.003,9	2.017,0	2.028,7	2.039,1	2.054,0	2.068,7	2.082,0	2.100,2	2.118,6
134	28/02/2024	2.050,5	2.050,5	1.932,0	1.957,7	1.995,2	2.012,1	2.033,3	2.043,4	2.056,9	2.085,1	2.104,8	2.134,0	2.169,6
135	31/03/2024	2.054,7	2.054,7	1.905,6	1.945,0	1.985,3	2.007,4	2.031,5	2.048,3	2.070,7	2.090,5	2.121,0	2.169,5	2.184,7
136	29/04/2024	2.058,3	2.058,3	1.892,3	1.935,6	1.978,0	2.007,8	2.031,6	2.053,2	2.081,7	2.110,6	2.137,3	2.181,4	2.237,7
137	31/05/2024	2.061,7	2.061,7	1.868,7	1.919,5	1.967,1	2.002,6	2.032,3	2.060,9	2.086,6	2.106,9	2.149,2	2.210,7	2.265,7
138	30/06/2024	2.065,1	2.065,1	1.857,0	1.899,8	1.955,4	1.995,1	2.027,8	2.059,3	2.095,8	2.133,9	2.162,5	2.230,5	2.322,7
139	29/07/2024	2.068,4	2.068,4	1.835,0	1.886,2	1.939,8	1.995,5	2.033,3	2.069,8	2.107,6	2.141,4	2.176,9	2.249,3	2.358,0
140	31/08/2024	2.071,8	2.071,8	1.789,6	1.874,3	1.941,2	1.990,0	2.032,4	2.082,7	2.112,9	2.159,4	2.184,9	2.255,5	2.375,9
141	30/09/2024	2.075,1	2.075,1	1.779,6	1.863,4	1.933,9	1.991,8	2.033,3	2.087,0	2.122,6	2.170,2	2.202,4	2.295,7	2.366,5
142	31/10/2024	2.078,5	2.078,5	1.745,0	1.847,3	1.911,5	1.966,2	2.032,7	2.073,7	2.132,2	2.188,6	2.249,8	2.324,2	2.443,5
143	30/11/2024	2.081,8	2.081,8	1.736,6	1.827,9	1.914,1	1.963,3	2.028,4	2.090,3	2.134,8	2.201,4	2.276,1	2.358,4	2.464,9
144	30/12/2024	2.085,2	2.085,2	1.734,9	1.799,5	1.879,7	1.978,3	2.026,9	2.097,0	2.139,5	2.210,3	2.291,2	2.384,8	2.464,9
145	31/01/2025	2.088,5	2.088,5	1.699,5	1.796,3	1.877,2	1.976,0	2.031,1	2.112,0	2.155,4	2.207,5	2.303,3	2.410,5	2.471,4
146	28/02/2025	2.091,9	2.091,9	1.697,5	1.781,3	1.865,7	1.973,6	2.049,0	2.100,4	2.161,0	2.224,8	2.316,9	2.428,5	2.523,5
147	31/03/2025	2.095,2	2.095,2	1.644,1	1.754,2	1.885,0	1.970,5	2.041,5	2.106,4	2.171,3	2.252,0	2.321,2	2.439,7	2.522,5
148	28/04/2025	2.098,6	2.098,6	1.624,1	1.723,2	1.880,3	1.967,1	2.029,8	2.116,7	2.176,6	2.255,0	2.341,9	2.429,9	2.523,4
149	31/05/2025	2.101,9	2.101,9	1.595,1	1.725,3	1.858,9	1.962,6	2.027,5	2.109,6	2.164,3	2.256,3	2.328,2	2.452,1	2.544,9
150	30/06/2025	2.105,3	2.105,3	1.602,2	1.727,1	1.858,6	1.955,7	2.041,3	2.112,3	2.188,1	2.248,5	2.368,7	2.473,5	2.566,7
151	31/07/2025	2.108,6	2.108,6	1.618,3	1.727,1	1.844,9	1.961,5	2.046,9	2.125,5	2.204,0	2.263,0	2.376,7	2.485,4	2.610,2
152	31/08/2025	2.112,0	2.112,0	1.629,3	1.721,4	1.858,3	1.964,7	2.049,5	2.134,3	2.206,3	2.276,5	2.363,3	2.490,9	2.600,1
153	29/09/2025	2.115,3	2.115,3	1.630,2	1.699,3	1.838,2	1.946,0	2.047,6	2.145,3	2.221,7	2.303,6	2.366,8	2.520,0	2.612,1
154	31/10/2025	2.118,7	2.118,7	1.620,1	1.712,7	1.838,8	1.947,9	2.057,2	2.146,9	2.220,7	2.298,3	2.383,1	2.537,8	2.642,0
155	30/11/2025	2.122,0	2.122,0	1.597,3	1.709,6	1.829,2	1.950,3	2.046,6	2.164,1	2.233,5	2.308,4	2.402,4	2.530,3	2.660,6
156	31/12/2025	2.125,4	2.125,4	1.588,4	1.678,2	1.835,7	1.954,5	2.044,9	2.164,3	2.234,8	2.328,9	2.421,6	2.531,5	2.681,5

APPENDIX A. GOLD PRICE INDEX & @RISK TIME SERIES OUTPUT

@RISK - Swap-Out Summary
Performed By: Rizkia Arifani Zain
Date: Wednesday, January 31, 2024 3:51:09 PM

Conv.	Name	Cell	Function	Graph	Minimum	Maximum	Mean	Mode	Median	Std. Deviation
Range: 1/31/2024										
OK	1/31/2024 / Output	E139	RiskOutput()		1.904,92	2.154,24	2.042,08	2.026,18	2.039,14	46,19
Range: 1/31/2025										
OK	1/31/2025 / Output	E151	RiskOutput()		1.518,93	2.768,65	2.096,99	1.877,61	2.112,05	235,84
Range: 10/31/2024										
OK	10/31/2024 / Output	E148	RiskOutput()		1.639,15	2.655,90	2.085,16	2.127,98	2.073,69	194,93
Range: 10/31/2025										
OK	10/31/2025 / Output	E160	RiskOutput()		1.383,87	3.082,11	2.129,78	1.952,72	2.146,93	320,25
Range: 11/30/2024										
OK	11/30/2024 / Output	E149	RiskOutput()		1.587,18	2.732,47	2.092,67	1.864,22	2.090,34	210,51
Range: 11/30/2025										
OK	11/30/2025 / Output	E161	RiskOutput()		1.358,25	3.003,41	2.137,29	2.224,61	2.164,11	324,24
Range: 12/30/2024										
OK	12/30/2024 / Output	E150	RiskOutput()		1.565,69	2.794,68	2.094,57	2.342,81	2.097,01	225,12
Range: 12/31/2025										
OK	12/31/2025 / Output	E162	RiskOutput()		1.345,91	2.957,52	2.139,26	2.176,35	2.164,31	333,07
Range: 2/28/2024										
OK	2/28/2024 / Output	E140	RiskOutput()		1.845,11	2.299,79	2.049,17	2.056,46	2.043,39	72,56
Range: 2/28/2025										
OK	2/28/2025 / Output	E152	RiskOutput()		1.475,50	2.756,09	2.101,25	1.810,16	2.100,36	247,73
Range: 3/31/2024										
OK	3/31/2024 / Output	E141	RiskOutput()		1.847,83	2.340,83	2.053,31	2.085,61	2.048,34	87,42
Range: 3/31/2025										
OK	3/31/2025 / Output	E153	RiskOutput()		1.467,45	2.850,47	2.103,65	2.162,36	2.106,43	260,64
Range: 4/28/2025										
OK	4/28/2025 / Output	E154	RiskOutput()		1.424,71	2.914,83	2.102,96	2.127,66	2.116,72	268,44
Range: 4/29/2024										
OK	4/29/2024 / Output	E142	RiskOutput()		1.731,02	2.422,20	2.059,80	2.123,45	2.053,19	106,41
Range: 5/31/2024										
OK	5/31/2024 / Output	E143	RiskOutput()		1.702,49	2.508,63	2.062,81	2.068,25	2.060,89	122,99
Range: 5/31/2025										
OK	5/31/2025 / Output	E155	RiskOutput()		1.335,02	2.957,47	2.103,61	2.116,65	2.109,63	281,18
Range: 6/30/2024										
OK	6/30/2024 / Output	E144	RiskOutput()		1.727,86	2.511,66	2.067,99	2.147,01	2.059,27	142,08
Range: 6/30/2025										
OK	6/30/2025 / Output	E156	RiskOutput()		1.280,34	3.031,81	2.109,45	2.138,86	2.112,32	293,33
Range: 7/29/2024										
OK	7/29/2024 / Output	E145	RiskOutput()		1.683,01	2.525,65	2.072,52	2.040,27	2.069,77	154,01
Range: 7/31/2025										
OK	7/31/2025 / Output	E157	RiskOutput()		1.241,63	3.068,28	2.113,73	2.421,24	2.125,51	296,09
Range: 8/31/2024										
OK	8/31/2024 / Output	E146	RiskOutput()		1.649,32	2.587,86	2.076,31	2.083,15	2.082,71	166,27
Range: 8/31/2025										
OK	8/31/2025 / Output	E158	RiskOutput()		1.342,40	3.073,78	2.119,53	2.247,53	2.134,31	297,93
Range: 9/29/2025										
OK	9/29/2025 / Output	E159	RiskOutput()		1.363,28	3.111,34	2.123,67	2.157,09	2.145,27	310,85
Range: 9/30/2024										
OK	9/30/2024 / Output	E147	RiskOutput()		1.613,65	2.618,16	2.081,24	2.066,21	2.087,05	178,99

APPENDIX B. PROJECT DATA

	"As Planned"						"As Built"				
Project #	Capacity (DWT)	Start Date (MM/YEAR)	Finish Date (MM/YEAR)	Duration Planned (Days)	Average Price of Gold (Midpoint)	Original Ounces of Gold (Midpoint)	Average Price of Gold (Midpoint)	Actual Ounces of Gold Equivalency	Actual Duration (Days)	As-Built CPI (BCWP/ACWP)	As-Built SPI (BCWP/BCWS)
Project 1	3.500	November 2021	December 2021	53	1.799,60	707,48	1.799,58	856,06	69	0,83	0,77
Project 2	3.500	January 2021	March 2021	60	1.799,60	758,05	1.799,58	924,83	66	0,82	0,91
Project 3	3.500	April 2021	May 2021	58	1.799,60	758,05	1.799,58	894,51	84	0,85	0,69
Project 4	3.500	March 2021	April 2021	53	1.799,60	706,88	1.799,58	897,75	67	0,79	0,79
Project 5	3.500	May 2021	June 2021	51	1.799,60	707,48	1.799,58	792,38	60	0,89	0,86
Project 6	3.500	December 2021	January 2022	53	1.799,60	707,48	1.800,80	841,34	65	0,84	0,81
Project 7	3.500	March 2021	April 2021	52	1.799,60	691,89	1.799,58	788,76	56	0,88	0,93
Project 8	3.500	January 2021	February 2021	56	1.799,60	691,89	1.799,58	802,60	61	0,86	0,91
Project 9	3.500	November 2021	December 2021	55	1.799,60	683,08	1.799,58	888,02	82	0,77	0,68
Project 10	3.500	April 2021	May 2021	58	1.799,60	754,91	1.799,58	890,81	67	0,85	0,86
Project 11	3.500	August 2021	September 2021	55	1.799,60	728,36	1.799,58	939,60	70	0,78	0,79
Project 12	3.500	March 2021	April 2021	56	1.799,60	698,00	1.799,58	739,89	60	0,94	0,93
Project 13	3.500	June 2021	July 2021	57	1.799,60	760,28	1.799,58	904,75	71	0,84	0,80
Project 14	3.500	August 2021	September 2021	58	1.799,60	769,53	1.799,58	884,98	64	0,87	0,89
Project 15	3.500	September 2021	October 2021	55	1.799,60	698,00	1.799,58	858,55	64	0,81	0,86
Project 16	3.500	May 2021	June 2021	53	1.799,60	698,00	1.799,58	830,63	67	0,84	0,79
Project 17	3.500	November 2021	December 2021	58	1.799,60	769,53	1.799,58	923,45	84	0,83	0,69
Project 18	3.500	April 2021	May 2021	54	1.799,60	698,00	1.799,58	698,01	58	1,00	0,93
Project 19	3.500	December 2021	January 2022	56	1.799,60	740,29	1.800,80	776,79	61	0,95	0,92
Project 20	3.500	August 2021	September 2021	55	1.799,60	740,29	1.799,58	851,35	65	0,87	0,85
Project 21	3.500	November 2021	December 2021	60	1.799,60	740,29	1.799,58	740,30	63	1,00	0,94
Project 22	3.500	July 2021	September 2021	63	1.799,60	831,29	1.799,58	1.022,50	80	0,81	0,79
Project 23	3.500	April 2021	June 2021	66	1.799,60	831,29	1.799,58	1.039,13	79	0,80	0,83
Project 24	3.500	March 2021	April 2021	60	1.799,60	756,85	1.799,58	953,65	64	0,79	0,93
Project 25	3.500	July 2021	August 2021	57	1.799,60	756,85	1.799,58	817,41	62	0,93	0,93

APPENDIX B. PROJECT DATA

	"As Planned"						"As Built"				
Project #	Capacity (DWT)	Start Date (MM/YEAR)	Finish Date (MM/YEAR)	Duration Planned (Days)	Average Price of Gold (Midpoint)	Original Ounces of Gold (Midpoint)	Average Price of Gold (Midpoint)	Actual Ounces of Gold Equivalency	Actual Duration (Days)	As-Built CPI (BCWP/ACWP)	As-Built SPI (BCWP/BCWS)
Project 26	3.500	December 2021	January 2022	54	1.799,60	675,03	1.800,80	863,46	65	0,78	0,83
Project 27	3.500	May 2021	June 2021	57	1.799,60	778,93	1.799,58	825,68	68	0,94	0,85
Project 28	3.500	November 2021	December 2021	56	1.799,60	741,26	1.799,58	785,75	70	0,94	0,81
Project 29	3.500	September 2021	October 2021	55	1.799,60	741,26	1.799,58	859,88	81	0,86	0,68
Project 30	3.500	July 2021	August 2021	54	1.799,60	741,26	1.799,58	882,12	68	0,84	0,81
Project 31	3.500	May 2021	June 2021	60	1.799,60	778,93	1.799,58	849,05	67	0,92	0,89
Project 32	3.500	March 2021	May 2021	71	1.799,60	929,45	1.799,58	1.171,13	75	0,79	0,94
Project 33	3.500	February 2021	April 2021	74	1.799,60	929,45	1.799,58	1.106,06	111	0,84	0,67
Project 34	3.500	August 2021	October 2021	74	1.799,60	974,06	1.799,58	1.071,48	98	0,91	0,75
Project 35	3.500	November 2021	March 2022	122	1.799,60	1.544,81	1.800,80	1.976,04	179	0,78	0,68
Project 36	3.500	August 2021	October 2021	62	1.799,60	837,71	1.799,58	971,75	83	0,86	0,75
Project 37	3.500	January 2021	March 2021	70	1.799,60	929,45	1.799,58	1.152,54	75	0,81	0,93
Project 38	3.500	September 2021	December 2021	120	1.799,60	1.544,81	1.799,58	1.946,49	178	0,79	0,68
Project 39	3.500	September 2021	December 2021	119	1.799,60	1.544,81	1.799,58	1.606,62	137	0,96	0,87
Project 40	3.500	April 2021	June 2021	73	1.799,60	929,45	1.799,58	1.068,88	82	0,87	0,89
Project 41	3.500	February 2021	June 2021	121	1.799,60	1.544,81	1.799,58	1.730,21	146	0,89	0,83
Project 42	6.500	August 2019	November 2019	95	1.392,20	1.449,47	1.392,20	1.579,93	105	0,92	0,91
Project 43	6.500	June 2019	September 2019	92	1.392,20	1.372,80	1.392,20	1.688,54	124	0,81	0,74
Project 44	6.500	January 2019	March 2019	84	1.392,20	1.202,97	1.392,20	1.539,81	94	0,78	0,89
Project 45	6.500	February 2019	May 2019	94	1.392,20	1.372,80	1.392,20	1.496,35	101	0,92	0,93
Project 46	6.500	August 2019	October 2019	81	1.392,20	1.187,77	1.392,20	1.377,81	99	0,86	0,81
Project 47	6.500	March 2019	May 2019	86	1.392,20	1.200,69	1.392,20	1.260,73	93	0,95	0,93
Project 48	6.500	June 2019	August 2019	78	1.392,20	1.125,92	1.392,20	1.238,51	86	0,91	0,90
Project 49	6.500	February 2019	April 2019	82	1.392,20	1.214,63	1.392,20	1.287,51	116	0,94	0,71
Project 50	6.500	November 2019	February 2020	106	1.392,20	1.509,42	1.769,59	1.484,40	124	0,80	0,85

APPENDIX B. PROJECT DATA

	"As Planned"						"As Built"				
Project #	Capacity (DWT)	Start Date (MM/YEAR)	Finish Date (MM/YEAR)	Duration Planned (Days)	Average Price of Gold (Midpoint)	Original Ounces of Gold (Midpoint)	Average Price of Gold (Midpoint)	Actual Ounces of Gold Equivalency	Actual Duration (Days)	As-Built CPI (BCWP/ACWP)	As-Built SPI (BCWP/BCWS)
Project 51	6.500	September 2019	November 2019	88	1.392,20	1.313,99	1.392,20	1.471,67	128	0,89	0,68
Project 52	6.500	February 2019	April 2019	88	1.392,20	1.255,06	1.392,20	1.568,83	113	0,80	0,78
Project 53	6.500	July 2019	September 2019	81	1.392,20	1.255,06	1.392,20	1.292,71	106	0,97	0,76
Project 54	6.500	August 2019	October 2019	86	1.392,20	1.313,99	1.392,20	1.681,91	121	0,78	0,71
Project 55	6.500	October 2019	December 2019	85	1.392,20	1.255,06	1.392,20	1.531,18	122	0,82	0,70
Project 56	6.500	June 2019	September 2019	99	1.392,20	1.509,42	1.392,20	1.766,02	136	0,85	0,73
Project 57	6.500	February 2019	May 2019	102	1.392,20	1.449,47	1.392,20	1.826,34	141	0,79	0,72
Project 58	6.500	October 2019	January 2020	99	1.392,20	1.449,47	1.769,59	1.208,78	110	0,94	0,90
Project 59	6.500	December 2019	February 2020	83	1.392,20	1.285,73	1.769,59	1.234,07	114	0,82	0,73
Project 60	6.500	November 2019	January 2020	86	1.392,20	1.285,73	1.769,59	1.112,69	100	0,91	0,85
Project 61	6.500	September 2019	November 2019	89	1.392,20	1.285,73	1.392,20	1.452,88	123	0,88	0,72
Project 62	6.500	November 2019	January 2020	85	1.392,20	1.285,73	1.769,59	1.011,53	90	1,00	0,94
Project 63	6.500	December 2019	February 2020	85	1.392,20	1.285,73	1.769,59	1.062,11	91	0,95	0,93
Project 64	6.500	September 2019	December 2019	91	1.392,20	1.285,73	1.392,20	1.607,16	111	0,80	0,82
Project 65	6.500	March 2019	May 2019	87	1.392,20	1.233,64	1.392,20	1.357,01	129	0,91	0,68
Project 66	6.500	July 2019	September 2019	87	1.392,20	1.233,64	1.392,20	1.332,33	114	0,93	0,77
Project 67	6.500	February 2019	April 2019	84	1.392,20	1.233,64	1.392,20	1.455,70	115	0,85	0,73
Project 68	6.500	February 2019	April 2019	88	1.392,20	1.285,73	1.392,20	1.632,88	126	0,79	0,69
Project 69	6.500	August 2019	November 2019	117	1.392,20	1.681,40	1.392,20	2.185,82	123	0,77	0,95
Project 70	6.500	March 2019	June 2019	108	1.392,20	1.509,55	1.392,20	1.600,12	127	0,94	0,85
Project 71	6.500	April 2019	July 2019	109	1.392,20	1.559,10	1.392,20	1.839,74	158	0,85	0,69
Project 72	6.500	March 2019	June 2019	108	1.392,20	1.559,10	1.392,20	1.590,28	138	0,98	0,79
Project 73	17.500	February 2019	June 2019	126	1.392,20	1.752,46	1.392,20	2.102,95	180	0,83	0,70
Project 74	17.500	November 2019	February 2020	98	1.392,20	1.361,27	1.769,59	1.338,70	102	0,80	0,95
Project 75	17.500	November 2019	March 2020	136	1.392,20	1.747,71	1.769,59	1.539,98	176	0,89	0,78

APPENDIX B. PROJECT DATA

	"As Planned"						"As Built"				
Project #	Capacity (DWT)	Start Date (MM/YEAR)	Finish Date (MM/YEAR)	Duration Planned (Days)	Average Price of Gold (Midpoint)	Original Ounces of Gold (Midpoint)	Average Price of Gold (Midpoint)	Actual Ounces of Gold Equivalency	Actual Duration (Days)	As-Built CPI (BCWP/ACWP)	As-Built SPI (BCWP/BCWS)
Project 76	17.500	February 2019	May 2019	112	1.392,20	1.517,41	1.392,20	1.911,93	140	0,79	0,80
Project 77	17.500	November 2019	February 2020	117	1.392,20	1.588,66	1.769,59	1.487,33	127	0,84	0,93
Project 78	17.500	March 2019	June 2019	113	1.392,20	1.546,06	1.392,20	1.747,05	138	0,88	0,81
Project 79	17.500	May 2019	August 2019	119	1.392,20	1.659,75	1.392,20	2.074,69	159	0,80	0,75
Project 80	17.500	December 2019	March 2020	107	1.392,20	1.491,51	1.769,59	1.220,37	123	0,96	0,87
Project 81	17.500	November 2019	June 2020	240	1.392,20	3.349,39	1.769,59	3.188,46	341	0,83	0,70
Project 82	17.500	April 2019	August 2019	151	1.392,20	2.032,86	1.392,20	2.093,85	170	0,97	0,88
Project 83	35.000	March 2023	September 2023	190	1.942,70	2.798,70	1.942,74	3.246,42	218	0,86	0,87
Project 84	35.000	July 2023	January 2024	186	1.942,70	2.675,91	2.029,29	3.048,46	224	0,84	0,83
Project 85	35.000	October 2023	April 2024	194	1.942,70	2.815,47	2.029,29	2.830,10	229	0,95	0,85
Project 86	35.000	December 2023	July 2024	243	1.942,70	3.317,68	2.029,29	4.128,95	286	0,77	0,85
Project 87	35.000	November 2023	July 2024	244	1.942,70	3.317,68	2.029,29	3.843,10	341	0,83	0,71
Project 88	35.000	December 2023	June 2024	186	1.942,70	2.721,11	2.029,29	3.047,84	255	0,85	0,73
Project 89	35.000	April 2023	October 2023	200	1.942,70	2.798,70	1.942,74	2.882,60	298	0,97	0,67
Project 90	35.000	May 2023	November 2023	188	1.942,70	2.798,70	1.942,74	3.302,39	248	0,85	0,76
Project 91	35.000	November 2023	June 2024	218	1.942,70	2.938,82	2.029,29	3.544,91	266	0,79	0,82
Project 92	35.000	March 2023	September 2023	202	1.942,70	2.791,02	1.942,74	3.460,80	234	0,81	0,86
Project 93	35.000	August 2023	March 2024	220	1.942,70	3.072,97	2.029,29	3.324,28	297	0,88	0,74
Project 94	50.000	September 2023	April 2024	222	2.029,29	3.854,59	2.029,29	4.162,96	242	0,93	0,92
Project 95	50.000	September 2023	April 2024	224	2.029,29	3.692,80	2.029,29	4.246,72	295	0,87	0,76

APPENDIX C. OMNICLASS WBS FOR JETTY CONSTRUCTION

No	Criteria	Omniclass Title	Table		Omniclass Number
1	**Construction of Jetty**	**Marine Transportation Terminal**	**11**	**Construction by Entities**	**11-51 21 00**
1.1	**Jetty Head**	**Jetties**	**22**	**Work Result**	**22-35 31 26 13 1**
1.1.1	Pile group	Driven Piles	22	Work Result	22-31 62 00
1.1.1.1	Procurement	Procuring	32	Service	32-11 55 00
1.1.1.1.1	Procurement of Steel Pile	Pile Casings (Linings)	23	Product	23-13 29 11 11 11
1.1.1.2	Piling Work	Steel Piles	22	Work Result	22-31 62 16
1.1.1.2.1	Pile handling & positioning	Steel Piles	22	Work Result	22-31 62 16 1
1.1.1.2.2	Piling	Steel Piles	22	Work Result	22-31 62 16 2
1.1.1.2.3	Welding of pile	Steel Piles	22	Work Result	22-31 62 16 3
1.1.1.2.4	Pile cutting	Steel Piles	22	Work Result	22-31 62 16 4
1.1.1.3	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.1.1.3.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.1.1.3.2	Rebar	Reinforcing Steel	23	Product	23-13 31 21 11 11
1.1.1.3.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.1.1.4	Jacketing Pile	Underwater Waterproofing	32	Service	22-35 53 63
1.1.1.4.1	Surface preparation	Underwater Waterproofing	32	Service	22-35 53 63 1
1.1.1.4.2	Prime coating	Underwater Waterproofing	32	Service	22-35 53 63 2
1.1.1.4.3	Wrapping	Underwater Waterproofing	32	Service	22-35 53 63 3
1.1.1.4.4	Top coating	Underwater Waterproofing	33	Service	22-35 53 63 4
1.1.1.5	Painting Work	High-Performance Coatings	22	Work Result	22-09 96 00
1.1.1.5.1	Surface preparation	Marine Coatings	32	Work Result	22-09 96 26 1
1.1.1.5.2	Prime coating	Marine Coatings	22	Work Result	22-09 96 26 2
1.1.1.5.3	Intermediate coating	Marine Coatings	22	Work Result	22-09 96 26 3
1.1.1.5.4	Top coating	Marine Coatings	22	Work Result	22-09 96 26 4
1.1.2	Slab	Concrete Jetties	22	Work Result	22-35 31 26 13
1.1.2.1	Procurement	Procuring	32	Service	32-11 55 00
1.1.2.1.1	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.1.2.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.1.2.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.1.2.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.1.2.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.1.3	Beam	Concrete Jetties	22	Work Result	22-35 31 26 13
1.1.3.1	Procurement	Procuring	32	Service	32-11 55 00
1.1.3.1.1	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.1.3.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.1.3.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.1.3.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.1.3.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.1.4	Pilecap	Concrete Jetties	22	Work Result	22-35 31 26 13
1.1.4.1	Procurement	Procuring	32	Service	32-11 55 00
1.1.4.1.1	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.1.4.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.1.4.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.1.4.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.1.4.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.1.5	Hose	Facility Fuel Piping	22	Work Result	22-23 11 00
1.1.5.1	Procurement	Procuring	32	Service	32-11 55 00
1.1.5.1.1	Procurement of Hose	Flexible Pipe Couplings	23	Product	23-27 49 13
1.1.5.2	Equipment Installation	Facility Fuel Systems	22	Work Result	22-23 10 00
1.1.5.2.1	Hose installation	Facility Fuel-Oil Piping	22	Work Result	22-23 11 13
1.1.6	Crane	Cranes and Hoists	22	Work Result	22-41 22 00
1.1.6.1	Procurement	Procuring	32	Service	32-11 55 00
1.1.6.1.1	Procurement of Crane	Hydraulic Jib Cranes	23	Product	23-23 17 23 11 15
1.1.6.2	Equipment Installation	Cranes	22	Work Result	22-41 22 13
1.1.6.2.1	Crane installation	Jib Cranes	22	Work Result	22-41 22 13 19

APPENDIX C. OMNICLASS WBS FOR JETTY CONSTRUCTION

No	Criteria	Omniclass Title	Table		Omniclass Number
1.2	**Breasting Dolphin**	**Jetties**	**22**	**Work Result**	**22-35 31 26 13 1**
1.2.1	Pile group	Driven Piles	22	Work Result	22-31 62 00
1.2.1.2	Procurement	Procuring	32	Service	32-11 55 00
1.2.1.2.1	Procurement of Steel Pile	Pile Casings (Linings)	23	Product	23-13 29 11 11 11
1.2.1.2	Piling Work	Steel Piles	22	Work Result	22-31 62 16
1.2.1.2.1	Pile handling & positioning	Steel Piles	22	Work Result	22-31 62 16 1
1.2.1.2.2	Piling	Steel Piles	22	Work Result	22-31 62 16 2
1.2.1.2.3	Welding of pile	Steel Piles	22	Work Result	22-31 62 16 3
1.2.1.2.4	Pile cutting	Steel Piles	22	Work Result	22-31 62 16 4
1.2.1.3	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.2.1.3.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.2.1.3.2	Rebar	Reinforcing Steel	23	Product	23-13 31 21 11 11
1.2.1.3.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.2.1.4	Jacketing Pile	Underwater Waterproofing	32	Service	22-35 53 63
1.2.1.4.1	Surface preparation	Underwater Waterproofing	32	Service	22-35 53 63 1
1.2.1.4.2	Prime coating	Underwater Waterproofing	32	Service	22-35 53 63 2
1.2.1.4.3	Wrapping	Underwater Waterproofing	32	Service	22-35 53 63 3
1.2.1.4.4	Top coating	Underwater Waterproofing	33	Service	22-35 53 63 4
1.2.1.5	Painting Work	High-Performance Coatings	22	Work Result	22-09 96 00
1.2.1.5.1	Surface preparation	Marine Coatings	32	Work Result	22-09 96 26 1
1.2.1.5.2	Prime coating	Marine Coatings	22	Work Result	22-09 96 26 2
1.2.1.5.3	Intermediate coating	Marine Coatings	22	Work Result	22-09 96 26 3
1.2.1.5.4	Top coating	Marine Coatings	22	Work Result	22-09 96 26 4
1.2.2	Slab	Concrete Jetties	22	Work Result	22-35 31 26 13
1.2.2.1	Procurement	Procuring	32	Service	32-11 55 00
1.2.2.1.2	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.2.2.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.2.2.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.2.2.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.2.2.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.2.3	Beam	Concrete Jetties	22	Work Result	22-35 31 26 13
1.2.3.1	Procurement	Procuring	32	Service	32-11 55 00
1.2.3.1.2	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.2.3.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.2.3.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.2.3.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.2.3.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.2.4	Pilecap	Concrete Jetties	22	Work Result	22-35 31 26 13
1.2.4.1	Procurement	Procuring	32	Service	32-11 55 00
1.2.4.1.2	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.2.4.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.2.4.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.2.4.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.2.4.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.2.5	Fender	Marine Fenders	22	Work Result	22-35 59 13
1.2.5.1	Procurement	Procuring	32	Service	32-11 55 00
1.2.5.1.2	Procurement of Fender	Boat Fenders	23	Product	23-39 21 11 11 13
1.2.5.2	Equipment Installation	Marine Specialties	22	Work Result	22-35 59 00
1.2.5.2.1	Fender installation	Rubber Marine Fenders	22	Work Result	22-35 59 13 19
1.2.6	Bollard	Marine Bollards and Cleats	22	Work Result	22-35 59 33
1.2.6.1	Procurement	Procuring	32	Service	32-11 55 00
1.2.6.1.2	Procurement of Bollard	Bollards	23	Product	23-11 29 35
1.2.6.2	Equipment Installation	Marine Specialties	22	Work Result	22-35 59 00
1.2.6.2.1	Bollard installation	Cast-Steel Marine Bollards and Cleats	22	Work Result	22-35 59 33 13

APPENDIX C. OMNICLASS WBS FOR JETTY CONSTRUCTION

No	Criteria	Omniclass Title	Table		Omniclass Number
1.3	**Mooring Dolphin**	**Jetties**	**22**	**Work Result**	**22-35 31 26 13 1**
1.3.1	Pile group	Driven Piles	22	Work Result	22-31 62 00
1.3.1.3	Procurement	Procuring	32	Service	32-11 55 00
1.3.1.3.1	Procurement of Steel Pile	Pile Casings (Linings)	23	Product	23-13 29 11 11 11
1.3.1.3	Piling Work	Steel Piles	22	Work Result	22-31 62 16
1.3.1.3.1	Pile handling & positioning	Steel Piles	22	Work Result	22-31 62 16 1
1.3.1.3.2	Piling	Steel Piles	22	Work Result	22-31 62 16 2
1.3.1.3.3	Welding of pile	Steel Piles	22	Work Result	22-31 62 16 3
1.3.1.3.4	Pile cutting	Steel Piles	22	Work Result	22-31 62 16 4
1.3.1.3	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.3.1.3.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.3.1.3.2	Rebar	Reinforcing Steel	23	Product	23-13 31 21 11 11
1.3.1.3.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.3.1.4	Jacketing Pile	Underwater Waterproofing	32	Service	22-35 53 63
1.3.1.4.1	Surface preparation	Underwater Waterproofing	32	Service	22-35 53 63 1
1.3.1.4.2	Prime coating	Underwater Waterproofing	32	Service	22-35 53 63 2
1.3.1.4.3	Wrapping	Underwater Waterproofing	32	Service	22-35 53 63 3
1.3.1.4.4	Top coating	Underwater Waterproofing	33	Service	22-35 53 63 4
1.3.1.5	Painting Work	High-Performance Coatings	22	Work Result	22-09 96 00
1.3.1.5.1	Surface preparation	Marine Coatings	32	Work Result	22-09 96 26 1
1.3.1.5.2	Prime coating	Marine Coatings	22	Work Result	22-09 96 26 2
1.3.1.5.3	Intermediate coating	Marine Coatings	22	Work Result	22-09 96 26 3
1.3.1.5.4	Top coating	Marine Coatings	22	Work Result	22-09 96 26 4
1.3.2	Slab	Concrete Jetties	22	Work Result	22-35 31 26 13
1.3.2.1	Procurement	Procuring	32	Service	32-11 55 00
1.3.2.1.3	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.3.2.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.3.2.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.3.2.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.3.2.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.3.3	Beam	Concrete Jetties	22	Work Result	22-35 31 26 13
1.3.3.1	Procurement	Procuring	32	Service	32-11 55 00
1.3.3.1.3	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.3.3.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.3.3.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.3.3.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.3.3.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.3.4	Pilecap	Concrete Jetties	22	Work Result	22-35 31 26 13
1.3.4.1	Procurement	Procuring	32	Service	32-11 55 00
1.3.4.1.3	Procurement of Concrete/Precast	Structural Concrete	23	Product	23-13 31 11
1.3.4.2	Concrete Work	Concrete Forming	22	Work Result	22-03 11 00
1.3.4.2.1	Form work	Concrete Formwork	23	Product	23-13 31 00
1.3.4.2.2	Rebar	Reinforcing Bars	23	Product	23-13 21 21 11 13
1.3.4.2.3	Concrete casting	Structural Cast-in-Place Concrete Forming	22	Work Result	22-03 11 13
1.3.5	Bollard	Marine Bollards and Cleats	22	Work Result	22-35 59 33
1.3.5.1	Procurement	Procuring	32	Service	32-11 55 00
1.3.5.1.3	Procurement of Bollard	Bollards	23	Product	23-11 29 35
1.3.5.2	Equipment Installation	Marine Specialties	22	Work Result	22-35 59 00
1.3.5.2.1	Bollard installation	Cast-Steel Marine Bollards and Cleats	22	Work Result	22-35 59 33 13

APPENDIX D. LINEAR MODEL & ANOVA OUTPUT

Linear Equation

C1	C2	C3				
1.703.623	1617691	124224				
X	**Y**	**Z**	**Actual Cost**	**Predicted Cost**	**Residual**	**Residual^2**
50.000	2025	1	$10.537.426	$ 10.537.424	$ 2	$ 4
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
50.000	2025	1	$10.537.426	$ 10.537.424	$ 2	$ 4
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907

APPENDIX D. LINEAR MODEL & ANOVA OUTPUT

X	Y	Z	Actual Cost	Predicted Cost	Residual	Residual^2
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
3.500	2025	1	$ 2.193.101	$ 3.015.161	$ -822.059	$ 675.781.549.907
17.500	2025	1	$ 4.232.170	$ 5.279.928	$-1.047.758	$ 1.097.797.591.449
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ -	$ -
35.000	2025	1	$ 8.033.944	$ 8.110.887	$ -76.943	$ 5.920.259.042
						$ 38.750.142.310.141

R Square	MSE
0,960	**403.647.315.731**

APPENDIX D. LINEAR MODEL & ANOVA OUTPUT

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,980
R Square	0,960
Adjusted R Square	0,960
Standard Error	411.461,449
Observations	95,000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1,000	381.518.618.639.049,000	381.518.618.639.049,000	2.253,499	0,000
Residual	93,000	15.744.948.746.661,700	169.300.524.157,652		
Total	94,000	397.263.567.385.711,000			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	- 768.024,263	102.892,033	- 7,464	0,000	- 972.347,448	- 563.701,078	- 972.347,448	- 563.701,078
X Variable 1	1,071	0,023	47,471	0,000	1,026	1,115	1,026	1,115

APPENDIX E. POWER MODEL & ANOVA OUTPUT

Power Equation

C1	C2	C3	C4	C5		
1	193636	14	3	7		
X	**Y**	**Z**	**Cost**	**Predicted Cost**	**Residual**	**Residual^2**
50.000	2025	1	$10.537.426	$ 14.766.842	$-4.229.416	$ 17.887.960.457.772
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
50.000	2025	1	$10.537.426	$ 14.766.842	$-4.229.416	$ 17.887.960.457.772
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244

APPENDIX E. POWER MODEL & ANOVA OUTPUT

X	Y	Z	Cost	Predicted Cost	Residual	Residual^2
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
3.500	2025	1	$ 2.193.101	$ 3.448.933	$-1.255.832	$ 1.577.113.636.244
17.500	2025	1	$ 4.232.170	$ 4.232.376	$ -206	$ 42.528
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
6.500	2025	1	$ 3.500.468	$ 3.500.468	$ 0	$ 0
35.000	2025	1	$ 8.033.944	$ 8.033.943	$ 1	$ 1
						$ 100.437.580.426.825

R Square	MSE
0,854	**1.046.224.796.113**

APPENDIX E. POWER MODEL & ANOVA OUTPUT

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,924
R Square	0,854
Adjusted R Square	0,852
Standard Error	790.304,628
Observations	95,000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1,000	339.177.496.698.776,000	339.177.496.698.776,000	543,048	0,000
Residual	93,000	58.086.070.686.935,000	624.581.405.235,860		
Total	94,000	397.263.567.385.711,000			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	- 184.238,373	184.829,716	- 0,997	0,321	- 551.273,560	182.796,813	- 551.273,560	182.796,813
X Variable 1	0,897	0,038	23,303	0,000	0,820	0,973	0,820	0,973

APPENDIX F. LOGARITHMIC MODEL & ANOVA OUTPUT

Logarithmic Equation

C1	C2	C3
862.878	7225137	5942796

X	Y	Z	Cost	Predicted Cost	Residual	Residual^2
50.000	2025	1	$10.537.426	$ 10.537.426	$ -0	$ 0
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
50.000	2025	1	$10.537.426	$ 10.537.426	$ -0	$ 0
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -

APPENDIX F. LOGARITHMIC MODEL & ANOVA OUTPUT

X	Y	Z	Cost	Predicted Cost	Residual	Residual^2
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
3.500	2025	1	$ 2.193.101	$ 2.193.101	$ -	$ -
17.500	2025	1	$ 4.232.170	$ 7.243.255	$-3.011.086	$ 9.066.635.986.024
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
6.500	2025	1	$ 3.500.468	$ 4.135.545	$ -635.078	$ 403.323.457.399
35.000	2025	1	$ 8.033.944	$ 9.418.238	$-1.384.294	$ 1.916.269.894.265
						$ 124.248.355.876.523

R Square	MSE
0,899	**1.294.253.707.047**

APPENDIX F. LOGARITHMIC MODEL & ANOVA OUTPUT

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,948
R Square	0,899
Adjusted R Square	0,898
Standard Error	656.363,804
Observations	95,000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1,000	357.197.917.126.593,000	357.197.917.126.593,000	829,124	0,000
Residual	93,000	40.065.650.259.118,100	430.813.443.646,431		
Total	94,000	397.263.567.385.711,000			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	408.073,979	132.275,171	3,085	0,003	145.401,705	670.746,253	145.401,705	670.746,253
X Variable 1	0,750	0,026	28,795	0,000	0,698	0,802	0,698	0,802

About the Author

Rizkia Arifani Zain

Jakarta, Indonesia

Rizkia Arifani Zain is an engineer with seven years of professional experience in the oil and gas sectors. Currently, he works as a cost engineer at the national oil company of Indonesia. Several projects have been completed, such as offshore pipeline & fixed platform EPCI project, fuel terminal project, fuel terminal jetty, SPM/CBM, and other downstream projects. He holds a bachelor's degree in mechanical engineering from Bandung Institute of Technology (ITB). He is attending a distance learning mentoring course, under the tutelage of Dr. Paul D. Giammalvo, CDT, CCE, MScPM, MRICS, GPM-m Senior Technical Advisor, PT Mitrata Citragraha, to attain Certified Cost Professional certification from AACE International.

Rizkia Arifani Zain resides in Jakarta, Indonesia, and his email address is rizkia.arifani.z@gmail.com