Project management

WtE case study of Schedule, Cost and Risk Engineering

Project management and strategic planning

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1 Introduction

This report begins with a brief introduction and overview of the project, then goes into the background information of the project followed by a technical details/results section, and finally a conclusion. The WtE report presents a detailed analysis of the proposed Waste to Energy (WtE) project in Iceland, it focuses on the risk and financial assessment because it is necessary in order to determine whether the project is viable. This report's scope includes a comprehensive examination of the investment requirements, project income, operational costs, and potential risks associated with the operational phases and project in general. Through a systematic approach, this report aims to ensure stakeholders have a properly informed basis for decision-making, especially regarding the environmental and economic parts of the project along with going over the risk factors that potentially influence the WtE project with methods like Monte Carlo simulations estimating expected financial profit or losses. [2]

2 Background

The Waste to Energy (WtE) project in Helguvík Iceland aims to address the ever-increasing need for energy and the management of waste by building a 130,000-ton incineration plant in Helguvík. This project is in alignment with Europe's goal of having a circular economy, reducing landfill use and garbage export, and generating renewable energy. Using the most advanced technology available, the plant will produce heat and electricity in order to align with Iceland's environmental objectives and energy security goals. The project is a good example of sustainable development because it transforms combustible waste into energy while having a minimal environmental impact.[2]

3 Technical details

In this section, we delve into the technical intricacies underlying the financial analysis of our project. The analysis encompasses several key components, including the initial investment required, projected income and benefits, and a comprehensive risk assessment. Each subchapter provides a detailed examination of the methodologies employed and the considerations taken into account to ensure a robust evaluation of the project's financial feasibility and potential risks [2]

3.1 Introduction and initial investment

3.1.1 Demonstrate the project life cycle through a Gantt chart, including the major milestones and task relationship

A Gantt-chart was used to demonstrate the project life cycle. The Gantt chart illustrates the work to be completed over a period of time in relation to the time planned for the work. The incineration plant project is vast so proper preparatory work is essential. The project life cycle is expected to have a duration of 8 years from the decision to build and is expressed in the following chart.

The critical path is shown in red on the chart and it is the longest path from start to finish. It indicates the minimum time necessary to complete the entire project. Delays in parts of the critical path directly affect the time in which the project will be finished.

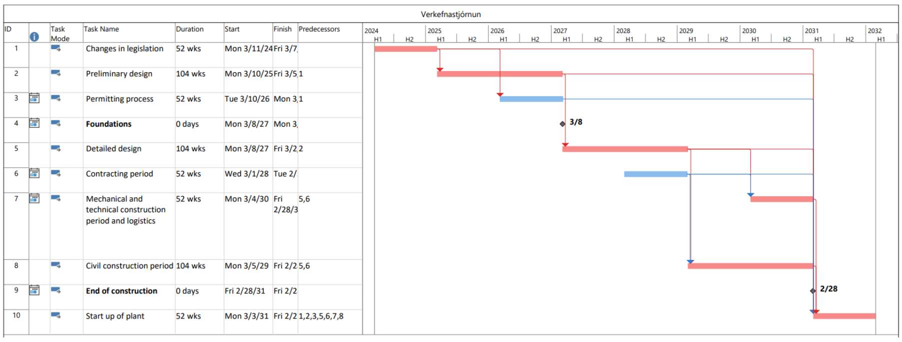

Figure 1: Incineration Gantt chart

3.1.2 Assuming 12% interest rate/year, estimate the cost of financing if all of the investment is paid back at the end of the construction period

In order to find the cost of financing you need to calculate how much interest and other dues you pay for the loan over the project period (furthermore in table 4 and table 5, the AACE class is used to igure out the expected range of accuracy of the estimate). For a bullet loan, in which you pay everything at the end of the loan period, the following formula can be used to calculate loan payment, **FV** is the future value of the loan, **i** is interests, **n** is number of years and **P** is the original loan amount,

$$FV = P \times (1 + i)^n$$

[1]

then using the original loan amount of 10.8 m€, 12% interest and 8 years the outcome would be a 26.7m€ cost of investment of which 15.9m€ is the interest.

3.1.3 Present a table showing the project investment budget, based on the given information

A table was made using the investment budget, the budget includes a few major cost factors. A boiler, electrical equipment, flue gas treatment, turbine and generation system, auxiliaries, Civil works, and project administration. In addition, the estimated cost of land and cost of initial preparations, the permitting process, and administration costs (see table 4). This table was used in the calculation of the project investment budget (table 3).

Year	Loan remaining	Interest	Low -50%	High +100%
0	10.8		5.4	21.6
1	12.1	1.3	6.0	24.2
2	13.5	1.5	6.8	27.1
3	15.2	1.6	7.6	30.3
4	17.0	1.8	8.5	34.0
5	19.0	2.0	9.5	38.1
6	21.3	2.3	10.7	42.6
7	23.9	2.6	11.9	47.8
8	26.7	2.9	13.4	53.5

Table 2: In this table the loan and interests per year are listed for the normal high and medium expected financial cost, the interest are listed only for the normal expected cost (the investment according to AACE class 5 ranges from 13.4-53.5m€)

In the table above, a bullet loan is assumed, 12% interest and interest paid on the increase of the original sum.

Inital Investment (m€)	
Boiler	2
El Equipment	1
Flue Gas Treatment	1
Turbine And Generation System	0.5
Auxiliaries	2
Civil Works	1.5
Land	2
Admin Cost	0.8
Total Inital Investment:	10.8
Low Initial Investment: -50%	5.4
High Initial Investment: 100%	21.6
Bullet Payment Total	26.7
Bullet Payment Low	13.4
Bullet Payment High	53.5
Total Interest Payment	15.9
Total Interest Payment Low	8.0
Total Interest Payment High	31.9
Interest	12%
Years	8

Table 1: In this table the investment cost, interest, and years for the project are listed in order to calculate the financial cost

3.1.4 What kind of a budget is this, according to the classes of AACE and what is the expected range of total investment cost?

AACE Class	ANSI Classification	Typical Use	Project Definition	Expected Range of Accuracy	Other Terms
Class 5	Order-of-Magnitude	Strategic Planning; Concept Screening	0% to 2%	-50% to +100%	ROM; Ballpark; Blue Sky; Ratio
Class 4	Order-of-Magnitude	Feasibility Study	1% to 15%	-30% to +50%	Feasibility; Top-down; Screening; Pre-design
Class 3	Budgetary	Budgeting	10% to 40%	-20% to +30%	Budget; Basic Engineering Phase; Semi-detailed
Class 2	Definitive	Bidding; Project Controls; Change Management	30% to 75%	-15% to +20%	Engineering; Bid; Detailed Control; Forced Detail
Class 1	Definitive	Bidding; Project Controls; Change Management	65% to 100%	-10% to +15%	Bottoms Up; Full Detail; Firm Price

Table 3: AACE and ANSI Cost Estimate Classifications and Ranges

In order to find the type of budget according to the classes of AACE the above table was used in order to categorize the project by comparison with the data from previous chapters, 3.12 and 3.13

Since the project is at strategic planning stage with no detailed scope, project and technical specifications and feasibility of the project is being appraised, this is a very high level strategic planning and would most likely be categorized as Class 5 in the AACE according to this table above.

3.2 Income and benefits

The projection of income and benefits serves as a critical pillar in our financial analysis, providing invaluable insights into the anticipated returns and rewards linked with the project. In the forthcoming sub chapters, we will meticulously evaluate the financial feasibility of the project through a cost-benefit analysis. Additionally, we will calculate the return on investment to gauge the project's profitability and efficiency. Furthermore, through sensitivity analysis, our report will delve into the impact of fluctuations in key variables, including the cost of finance and the magnitude of costs and benefits, on the overall financial outcomes of the project.

3.2.1 Using the given assumptions, develop a simple CBA model to assess the financial feasibility of the project

The given assumptions were listed together and can be seen in figure 2 below.

New equipment

Initial investment	Total cost (€)
Boiler	-2.000.000
Electriacl equipment	-1.000.000
Flue gas treatment	-1.000.000
Turbine and generation syste	-500.000
Auxiliaries	-2.000.000
Civil works	-1.500.000
Land	-2.000.000
Admin cost	-800.000
	-10.800.000

Benefits per year

Income	Cost/tonn (€)	Quantity (tonn)	Totla benefits (€)
Selling hot water			1.600.000
Selling electricity			2.200.000
Gate fee	225	130.000	29.250.000
			33.050.000

Costs per year

Costs	Cost/tonn (€)	Quantity (tonn)	Total cost (€)
Cost of finance (year 1)			-1.296.000
Operational cost (year 9-15)	-160	130.000	-20.800.000

Interest rate	12%
Discount rate	12,00%

Figure 2: Given assumptions

Subsequently a CBA model was constructed encompassing a consideration of costs, benefits, scrap value and taxes spanning a period of 15 years. Utilizing this mode, the net present value was calculated and found to be 4.669.406 €. Given the positive NPV determined through the analysis, it is evident that the project holds the potential to yield profit.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial investment	-10.800.000															
Finance cost		-1.296.000	-1.451.520	-1.625.702	-1.820.787	-2.039.281	-2.283.995	-2.558.074	-2.865.043							
Operational cost		0	0	0	0	0	0	0	-20.800.000	-21.528.000	-22.281.480	-23.061.332	-23.868.478	-24.703.875	-25.568.511	-26.463.409
Benefits per year		0	0	0	0	0	0	0	33.050.000	34.206.750	35.403.986	36.643.126	37.925.635	39.253.032	40.626.889	42.048.830
Scrap value																540.000
Taxes		0	0	0	0	0	0	0	-1.876.991	-2.535.750	-2.624.501	-2.716.359	-2.811.431	-2.909.831	-3.011.676	-3.225.084
Net benefits		-1.296.000	-1.451.520	-1.625.702	-1.820.787	-2.039.281	-2.283.995	-2.558.074	7.507.966	10.143.000	10.498.005	10.865.435	11.245.725	11.639.326	12.046.702	12.900.337
NPV =	4.669.406															

Figure 3: CBA and calculated NPV

3.2.2 What is the Return on Investment (ROI)?

The Return on Investment (ROI) is a financial metric used to evaluate the profitability of an investment relative to its cost.

$$\text{ROI} = \frac{\text{Net Profit}}{\text{Cost of Investment}} \times 100 \tag{1}$$

And therefore

$$\text{ROI} = \frac{4.669.406}{10.800.000} \times 100 = 43\% \tag{2}$$

In this case the ROI is positive which indicates that the return or profit gained from the investment exceeds the initial cost of the investment.

3.2.3 Impact on the NPV, sensitivity analysis

Two sensitivity analyses were conducted to evaluate the impact of key variables on the net present value (NPV) of the project. The first analysis, see figure 4, focuses on assessing variations in the NPV in response to changes in the cost of finance and the gate fee.

Senistivity analysis - NPV (€)

Cost of finance (interest rate)	8%	10%	12%	14%	16%
Gate fee (€)					
100	-27.052.690	-25.772.690	-27.719.425	-29.887.751	-32.300.202
125	-20.574.924	-19.294.924	-21.241.659	-23.409.985	-25.822.436
150	-14.097.158	-12.817.158	-14.763.892	-16.932.218	-19.344.670
175	-7.619.391	-6.339.391	-8.286.126	-10.454.452	-12.866.904
200	-1.141.625	138.375	-1.808.360	-3.976.686	-6.389.137
225	5.336.141	6.616.141	4.669.406	2.501.080	88.629
250	11.813.907	13.093.907	11.147.173	8.978.847	6.566.395

Figure 4: How the NPV changes when the cost of finance and gate fee changes

As can be seen above the NPV decreases as the cost of finance increases which indicates a negative relationship between the two. On the other hand there is a positive relationship between gate fee and NPV since an increase in gate fee leads to an increase in NPV. While gate fee variations notably affect NPV, changes in interest rates and therefore cost of finance have a smaller impact.

The second sensitivity analysis, see figure 5, focuses on assessing variations in the NPV in response to additional operational costs and benefits.

Senistivity analysis - NPV (€)

Carbon benefit (€)	0	500.000	1.000.000	1.500.000	2.000.000
Carbon cost (€)					
0	4.669.406	5.665.986	6.662.565	7.659.145	8.655.724
500.000	3.672.827	4.669.406	5.665.986	6.662.565	7.659.145
1.000.000	2.676.248	3.672.827	4.669.406	5.665.986	6.662.565
1.500.000	1.679.668	2.676.248	3.672.827	4.669.406	5.665.986
2.000.000	683.089	1.679.668	2.676.248	3.672.827	4.669.406

Figure 5: How the NPV changes with additional operational costs and benefits

As can be seen when the additional benefits increase so does the NPV and when additional costs increase the NPV decreases. Furthermore, when additional costs and benefits are equivalent, NPV remains constant, suggesting a point of equilibrium where the impact of costs and benefits offsets each other.

Recognizing these differences enables stakeholders to make informed decisions to mitigate risks and enhance financial performance.

3.3 Risk assessment

3.3.1 What parameters are the most sensitive and have the strongest impact on the feasibility?

To determine which parameters are the most sensitive and have the strongest impact on feasibility, first a PERT analysis was conducted using the three-point estimates provided in this case study. The three-point estimate provides estimated values for each parameter: an estimate for the most likely outcome, an optimistic outcome and a pessimistic outcome. The Program Evaluation and Review Technique (PERT) analysis uses these three values to come up with an expected value based on weighted averages, with the most likely estimate being given more weight. The PERT analysis also calculates the standard deviation and variance for each parameter based on the three point estimates. The PERT analysis for this case study can be seen in table 4.

Parameter	Optimistic	Most Likely	Pessimistic	Expected Value	Standard Deviation	Variance
Total Operating Expenses	4	10	16	10	2	4
Gate Fee (€/ton)	100	175	250	175	25	625.0
Materials year 1	35	58	80	58	7.5	56.3
Annual Income Hot Water	1.3	1.6	2.1	1.6	0.13	0.017
Annual Income Electricity	1.4	2.2	2.7	2	0.2	0.04

Table 4: Three Point Estimation Method, values are in m€/year and processed materials are measured in tons

The standard deviation gives a measurement of the uncertainly of the expected value. The greater the standard deviation, the less confidence in the calculated estimate. In this case study the standard deviation for the parameters of total operating expenses, gate fee and tons of processed material are the highest of the five parameters. The gate fee has the highest standard deviation of the three, indicating that the expected value calculated for the gate fee has the greatest uncertainly and therefore could have the greatest impact on feasibility, followed by tons of processed material and then total operating expenses.

3.3.2 How could this information be used in the early stages of the project?

As risks are inherent in every project and cannot be completely avoided, it is important to manage the inevitable risks of the project. Through risk management, project teams attempt to identify and manage the potential risks to minimize their impact. One method of risk management in the early stages of a project is probability analysis, the probability analysis methods that this project utilized were the three point method and PERT analysis. These types of risk management help identify uncertainties in parameters which allows the project team to assess how each uncertain parameter could impact the overall project profit prior to completion and operation.

3.3.3 Arrange a Monte Carlo simulation to estimate the expected profit and the ratio of possible risk of loss in 500-1000 trials.

The Monte Carlo simulation is a mathematical technique that predicts possible outcomes of an uncertain event, in this case the uncertain event is project profitability. A Monte Carlo simulation of 1,000 trials was conducted to estimate the expected profit and ratio of possible risk of loss for the project. The assumptions for the inputs into the Monte Carlo simulation can be seen in figure 6. A growth deviation of 45% was utilized.

Assumptions	
Project period (years)	15
Initial investment (m€)	26.70
Sales year (m€)	13.95
Direct cost/year (m€)	10.00
Indirect cost/year (m€)	0.00
Risk free rates (%)	12%
Market risk (%)	0%
Market growth (%)	3.5%
Income tax (%)	20%
Growth deviation (SD)	45%

Figure 6: Input assumptions into the Monte Carlo simulation

The results from the Monte Carlo simulation can be seen in figure 7, the x-axis is representative of the Profit and the y-axis is representative of the Frequency of Outcomes. Over 1,000 iterations, the majority of the profit results is hovered around 0€.

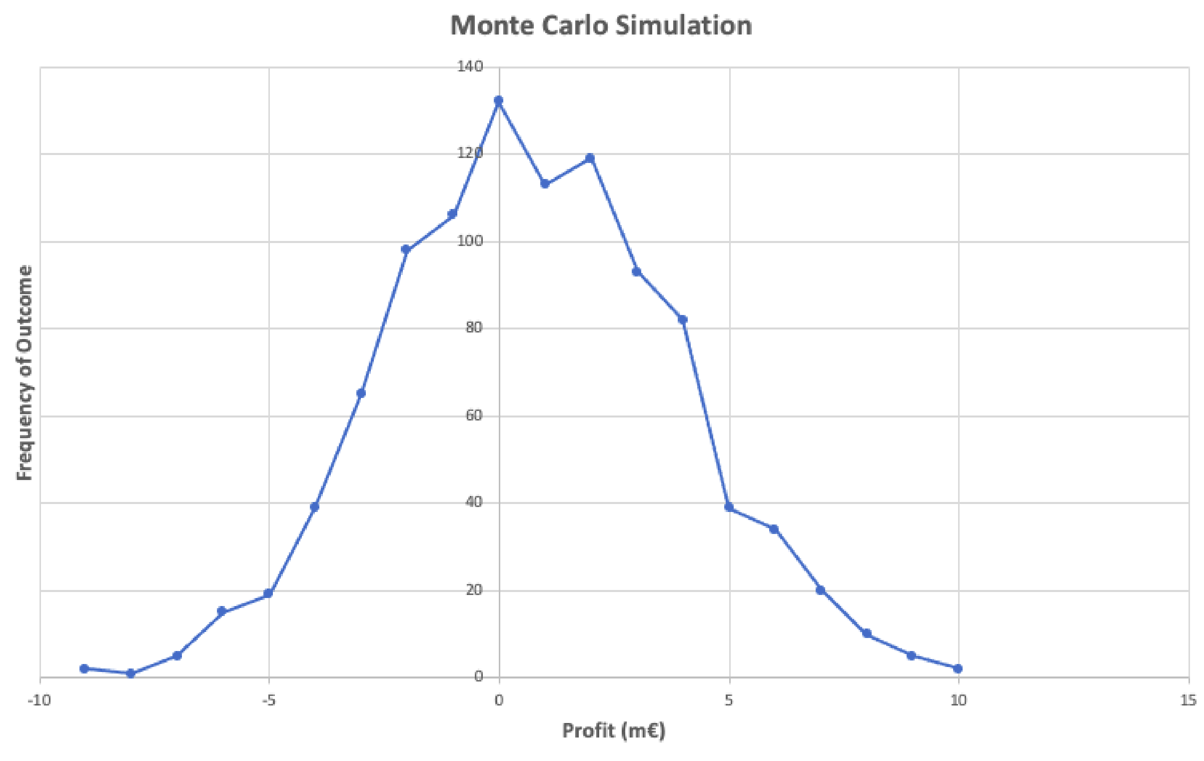

Figure 7: Monte Carlo simulation graph: Frequency of Outcome vs Profit

The assessment for the minimum profit, maximum profit, and profit risk of less than 0m€ for 1,000 iterations can be seen in figure 8. It is important to note that each time the Monte Carlo simulation is calculated in excel, slightly different values are given as this is a randomized calculation.

Assessment	
MIN	-9.27
MAX	11.22
PROFIT RISK < 0M	47%
ROCI	-1%

Figure 8: Assessment Calculations from Monte Carlo simulation

The results of the Monte Carlo simulation indicate that a project profit of less than 0m€ occurred in approximately 50% of the trials.

3.3.4 Develop a risk assessment matrix and assess the risk value based on given information by likelihood of occurrence and impact if occur.

To develop a risk assessment matrix for the provided risk events, we will categorize each risk based on its likelihood of occurrence and the impact it would have if it did occur. Since specific scales for likelihood and impact were not provided, we will use a general 1-5 scale for both dimensions (where 1 is low and 5 is high). The risk value is determined by multiplying the likelihood by the impact.

Risk event	Likelihood (1-5)	Impact (1-5)	Risk
Negative Public Perceptions	4	3	12
Insufficient Technology	3	5	15
Redundancy due to New Energy Resources	2	5	10
Community Attitude	3	4	12
Increase in Emission Fees	3	5	15
Investor Bankruptcy	2	5	10
Worldwide Financial Crisis	3	4	12
Professional Incompetence	4	4	16
Populist Politics	3	3	9
Volcanic Activities	2	5	10

Table 5: Risk assessment matrix

Likelihood Rating: This is of course an estimation, but negative public perceptions (1) and community attitude (8) are rated higher because of the increasing awareness and sensitivity towards environmental projects.

Impact Rating: Considers the severity of the consequence if the risk occurs. For example, emission fees increase (2) and investors' financial instability (5) are given a high impact rating due to their direct, substantial effects on project costs and viability.

Risk Value Calculation: Multiplying the likelihood by the impact provides a rough estimate of the risk's priority level. This helps in focusing mitigation strategies on higher-scoring risks.

3.3.5 Can you identify any black swans in the information given on this project? Why is it a black swan?

Definition: Black Swan events are highly unpredictable incidents with severe impacts. These events are outliers beyond normal expectations, carry extreme impacts, and are often rationalized in hindsight.

Black swan in the project:

Worldwide Financial Crisis: While economic downturns are part of economic cycles, a sudden and severe financial crisis (like the 2008 financial crisis) fits the Black Swan criteria due to its global impact, unpredictability, and the after-the-fact explanations of its causes.

Volcanic activity: while significant, may not constitute a Black Swan event due to its ongoing nature and the prior knowledge of such activities in the region. Of course an unpredictable and massive eruption that continues for several month (like the one is currently in Grindavik) constitutes a black swan for his impact on the site and possibly can damage the plant.

3.3.6 If a black swan was identified, what could be a potential reaction by the project team?

If a Black Swan event is identified, affecting a project such as the waste-to-energy (WtE) facility, the project team would need to implement a series of strategic, adaptive, and resilient responses to manage and mitigate the unexpected and severe impacts of the event. Here is a potential reaction strategy:

Immediate Actions

· Crisis Management Activation: Immediately convene the project's crisis management team or committee. This team should include senior leadership and key decision-makers with the authority to act swiftly.

· Impact Assessment: Conduct a rapid but thorough assessment of the Black Swan event's immediate and potential long-term impacts on the project. This includes understanding safety implications, operational disruptions, financial impacts, and stakeholder concerns.

· Communication: Develop and execute a communication plan addressing all key stakeholders, including employees, investors, local communities, customers, and regulators. Transparency and timely information are critical to managing perceptions and expectations during a crisis.

Strategic Planning and Adaptation

· Scenario Planning: Engage in scenario planning to understand possible futures that could unfold from the Black Swan event. This helps in preparing for various outcomes and developing flexible strategies.

· Resource Allocation: Reevaluate and possibly reallocate resources, including finances, personnel, and materials, to ensure that the most critical areas of the project are supported during the crisis.

· Regulatory Compliance and Engagement: Work closely with governmental and regulatory bodies to ensure compliance with any new requirements and to seek support or relief measures that may be available.

Long term plan and Recovery

· Innovation and Problem-solving: Encourage innovative thinking to find new solutions to the challenges posed by the Black Swan event. This may involve adopting new technologies, processes, or methodologies.

· Strengthening Partnerships: Engage with partners, suppliers, and other stakeholders to strengthen relationships and develop collaborative approaches to overcome the crisis.

· Learning and Integration: Document lessons learned from managing the Black Swan event and integrate these insights into future project planning and risk management practices. This includes updating risk assessments, emergency response plans, and business continuity strategies.

· Long-term Strategic Review: Once the immediate crisis is managed, conduct a long-term review of the project's strategy, objectives, and risk management framework. This may involve reevaluating the project's feasibility or implementing more robust risk mitigation measures.

4 Conclusion/Final word

In our examination, we evaluated the financial and project management aspects of a proposed Waste-to-Energy (WtE) plant in Helguvik, Iceland, including timeline planning through a Gantt chart, investment budgeting, and cost analysis.

Critical to our analysis was the Cost-Benefit Analysis (CBA) and sensitivity analysis, which highlighted the importance of gate fees and operating expenses as pivotal to the project's Net Present Value (NPV) and overall feasibility.

We highlighted the need for effective risk management early on, emphasizing strategic planning and resource allocation to address predictable risks such as cost fluctuations and regulatory changes, while also preparing for less predictable 'Black Swan' events.

Our focus was on proactive measures including clear communication and stakeholder engagement to navigate potential risks, ensuring the project is well-positioned to handle unforeseen challenges.

Ultimately, the success of the WtE plant hinges on detailed planning and adaptive risk management strategies that cover both anticipated and unanticipated risks, securing the project against the unpredictable nature of large-scale project implementation.

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