# ASSESSMENT OF BACK-UP PLAN, DELAY, AND WAIVER OPTIONS AT PROJECT GATE REVIEWS

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## Abstract

In a staged development process, the planned work is not always complete at the gate review, yet a gate decision must be made. We present a more complete explanation of the reality of gate decision options, with the addition of Waiver (with and without re-review), Back-up plan, and Delay, along with Go and Kill. We also show how it is feasible to extend the simple decision tree modelling approach currently used for the Go/Kill choice to analyze the expected value of the broader set of options available. We demonstrate this new approach with studies from industrial application of the method. These case studies show that it is possible to estimate the parameters needed to conduct the decision tree analysis. Our case work also identifies heuristics that are prevalent in gate decisions. Coupling such heuristics with our decision analysis can formalize the underlying trade-offs and inform decision makers on the risks (or benefits) of waiver, delay, and back-up plan options.

**Keywords**: Gate reviews, Phase-gate process, Decision making, Project management, New product development

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## 1 INTRODUCTION

Much of today's industrial product and system development follows some type of a phase-gate process. (This process is also known as phase-review, stage-gate, toll-gate, or by other terms.) Work completed during each phase is reviewed at the subsequent gate. The gates are commonly considered Go/Kill decision points. At these points, before a commitment is made to invest in the next phase of development, decision makers review the project's progress and decide whether it is worth continuing to the next phase. A careful review of the gate deliverable checklist is prescribed.

The gate decision is a critical component of project control, and thus has been studied previously in some depth, as presented in Table 1. There exists a large amount of guidance and discussion of this Go/Kill model of the phase gate process, principally by Cooper who has written about the "stage-gate" process since the late 1980s (Cooper, 2008, 2011; Cooper and Kleinschmidt, 1987).

Another body of work has explored the sometimes-irrational Go/Kill decisions made in practice. The escalation of commitment literature explores the observed phenomenon of decision makers' tendencies to continue projects (not kill), despite evidence to suggest a nonviable outcome (Behrens and Ernst, 2014; Schmidt and Calantone, 2002).

In this work we explore the gate decision that occurs when the work is not complete by the gate. The incomplete work may be, for example, a failed or incomplete test, a delayed integration task, or unavailable market data. In these cases, a Go decision is not necessarily appropriate – it could be highly risky, given the nature of the missing deliverable. At the same time, a Kill decision may be an overreaction – to cancel the project based on an addressable problem may be forgoing a large amount of value. In reality, decision makers consider more options than simply Go and Kill. A broader set of options has been revealed in our gate work: gatekeepers can grant a waiver and proceed to the next phase, they can delay the project's entry to the next phase, or they can switch to a back-up plan. All of these options are exercised in practice, however they are not presented in the well-known and accessible phase-gate literature.

Some studies have expanded the model of the Go/Kill gate decision and included other options. The real options view of product development includes the abandonment option, analogous to Kill, continue option, analogous to Go, and adds an improve option – a "midcourse correction" described as delayed design freeze, engineering changes, or a change in the project team (Huchzermeier and Loch, 2001). Krishnan and Bhattacharya (2002) model a product development effort aiming to integrate a prospective technology. When the new technology is not fully validated by the required gate, the options available include committing to the new technology despite its risk (a Go decision), switching to a proven technology, or deferring commitment until later.

*Table 1. Related literature and context of this work*

| | Grounded in modeling, experimentation, large data sets | Grounded in industry cases; useful as a decision support model |
|---|---|---|
| Classic consideration of go vs. kill | Escalation of commitment (Behrens and Ernst, 2014; Schmidt and Calantone, 2002) | Cooper's stage-gate literature (Cooper, 2008, 2011; Cooper and Kleinschmidt, 1987) |
| Additional gate options considered | Real options (Huchzermeier and Loch, 2001)<br>Technology selection (Krishnan and Bhattacharya, 2002)<br>Interventions (van Oorschot et al., 2011) | *This work: understanding gate options and decision heuristics with real examples* |

Oorschot et al. (2011) describe various interventions as means of recovering from a delayed project. Several interventions heuristics are explored: do-nothing heuristic, analogous to Go; time heuristic, which involves an acceleration via increased team size; cost heuristic, which involves de-scoping of performance; and performance heuristic, where the delay is compensated for by increasing performance. These works provide useful insight on these specific options, however the complexity of their models results in an output that is hard for practitioners to consider and integrate into their own decision-making processes.

We present a corresponding engineering decision support model, which is an extension of the simple decision tree modelling approach currently used for the Go/Kill choice. We include a more comprehensive explanation of the reality of gate decision options, with the addition of Waiver (with and without re-review), Back-up plan, and Delay, along with Kill. This model is used to analyse the expected value of the broader set of options available. Finally we demonstrate this new approach with studies from industrial application of the method. These case studies show that it is possible to estimate the parameters needed to conduct the decision tree analysis. Our case work also identifies heuristics that are prevalent in gate decisions. Coupling such heuristics with our decision analysis can formalize the underlying trade-offs and inform the decision maker on the risks (or benefits) of waiver, delay and back-up plan options.

## 2 REALISTIC OPTIONS AT THE GATE

Informed by the previously presented literature, and discussions with practitioners, we have identified a more comprehensive set of gate decision options considered when a deliverable is incomplete at the gate. The options are shown in Figure 1 and elaborated upon below.

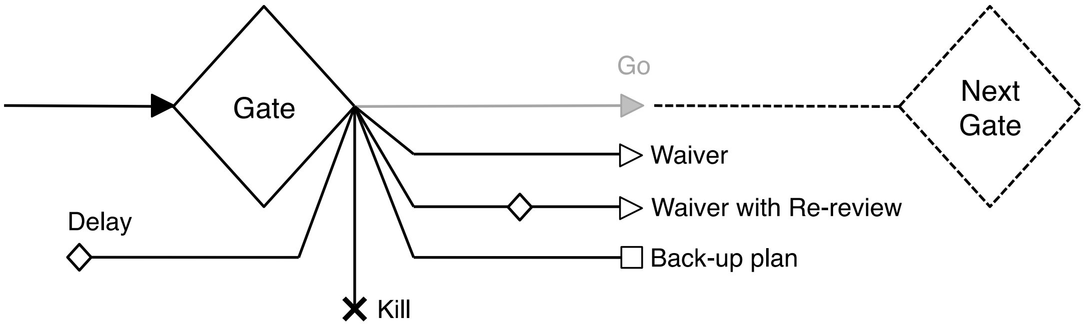



*Figure 1. Gate options available when a deliverable is incomplete*

**Waiver:** The project can be granted a waiver for the missing gate deliverable, acknowledging that the work is not complete but nevertheless allowing the project to move into the next phase so that the investment can be approved, and the rest of the team can move on with development. Often times applying for the waiver requires the generation of a plan for how the team will catch up in the next development phase, achieving the deliverables for both phases at the next gate. A successful waiver (when the work does get caught up) avoids both a delay to the project and a performance scope sacrifice. A failed waiver may induce time- and resource-intensive rework.

**Waiver with re-review:** A variant of the waiver is a waiver with re-review. In this case, an interim date is set for review of the incomplete work. At this re-review, action can be taken and a mid-phase adjustment can be made. This option allows the same progress of the project as the waiver, but provides an earlier opportunity for reviewing the outcome of the waiver, and making additional choices.

**Back-up plan:** Some projects identify a back-up plan for risky aspects of their project; for example, the back-up plan for a new technology may be a proven technology used in a previous model. Sometimes the back-up plan is a de-scoped, less desirable – and less risky – option; for example, it has less performance capability, or is more costly to develop or acquire. Other times the back-up plan is a riskier option, and is only a last resort. Back-up plans may have been considered as alternatives initially in project planning, or they may be identified only once the risk of development failure has been identified. Sometimes there is no explicit preference between Plan A and Plan B, and both options are pursued in parallel until a choice is triggered by new information.

**Delay:** At times the project will choose to delay entry into the next phase. The gate decision will be to remain in the current phase until the deliverable is complete. This option allows information to be generated before the commitment to the next phase is made. It also typically includes a delay to the project timeline, or alternatively an increase in resource cost to compensate for the compression of a future phase.

**Kill:** When the work is incomplete at the gate, the kill option may still be appropriate. This will depend on how critical the work or deliverable is, and how much confidence the team has in being able to recover value from the project. The decision to kill may be more likely if there is no viable back-up plan option available. There may be some salvage value to killing a project – organizational learning, technology progress, or selling of capital equipment, for example. A variant of Kill is Hold, where a project is put on hold until conditions change, for example until the market prices go up or the enabling ecosystem is more fully developed.

In the next section, we provide a means for decision makers to analytically consider these options.

## 3 DECISION TREE ANALYSIS

The Go/Kill model is typically accompanied with a decision-tree-style analysis, which Cooper calls Economic Commercial Value (Cooper, 2011). In this style of analysis, estimates are made for development costs, future earnings, and probabilities of success. Based on expected values, the decision maker can calculate whether there is greater expected future value in either going forward with the project or killing the project. We expand this decision tree modelling to include the additional gate options using the same structure and inputs, as shown below in Figure 2.

Development costs involve engineering, tool development, rework, and capital costs. For each uncertain development activity, probabilities of success are assessed. Payoff values are assessed for both a successful outcome and a failure outcome: they are the resulting financial impacts based on the timing, quality, cost, and revenues associated with each outcome.

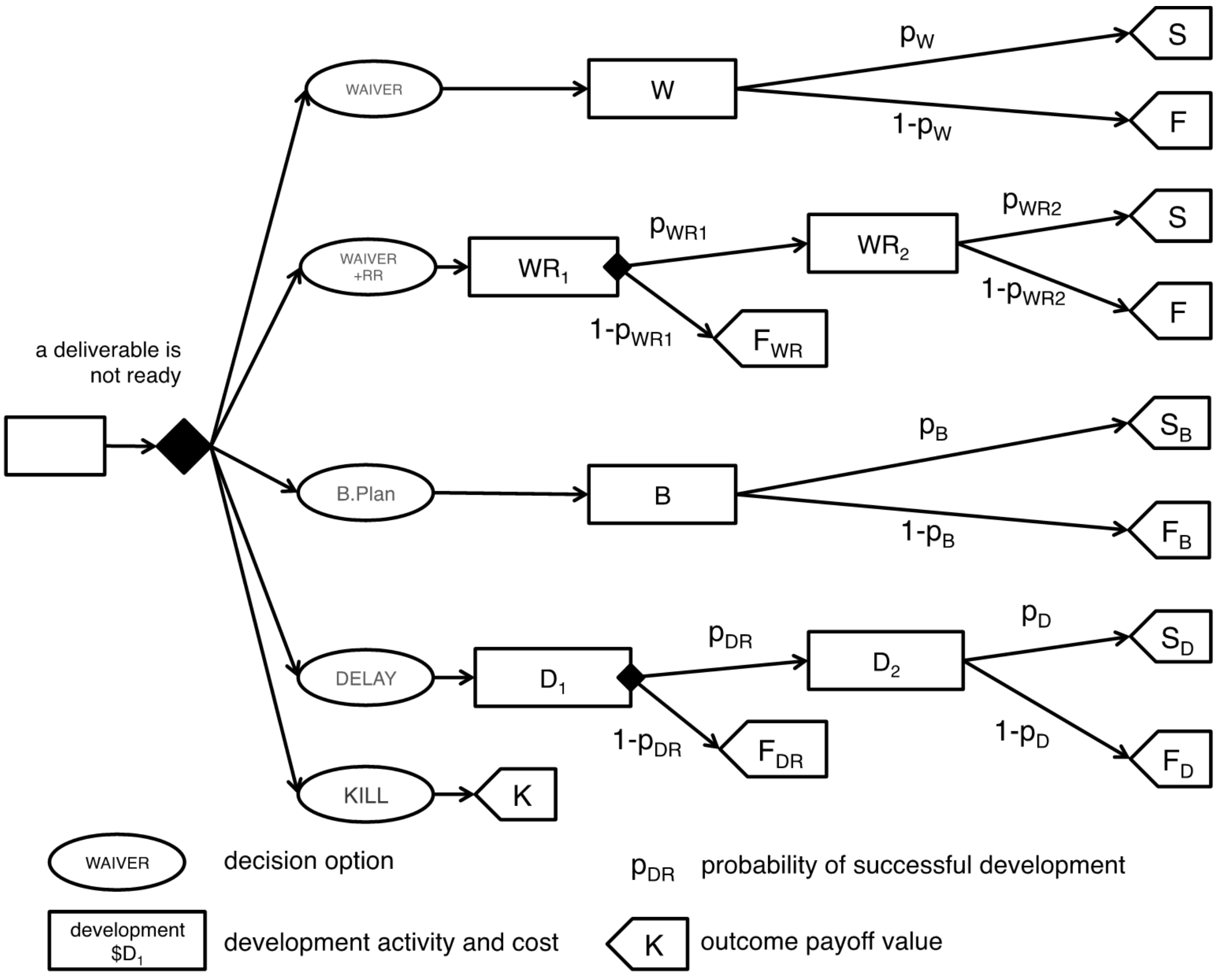
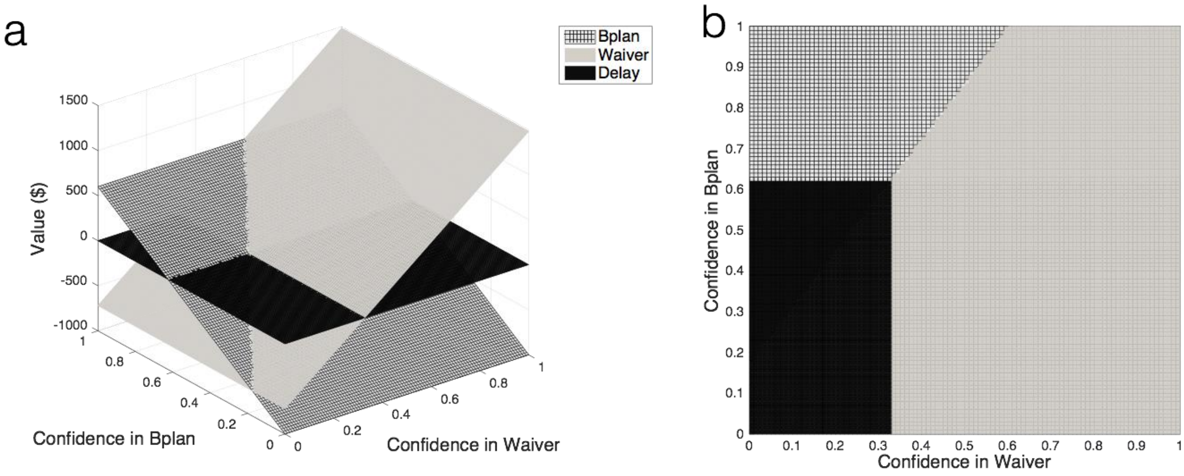



*Figure 2. Decision tree model of expanded set of gate options*

This method allows the decision-maker to compute the expected values of the available options and select the option with the maximum expected value. Recognizing that confidence assessments are difficult to make without bias, we envision the following graphical representation as a means of presenting information to the decision maker in the form of a broader probability space. Each option is represented as a plane in the selected probability/confidence space, as shown in Figure 3a. The optimal choice is one that maximizes value, and thus Figure 3b shows a two dimensional view of optimal choice for each probability combination.




*Figures 3a and 3b. Decision space represented in terms of confidence in each option*

We envision this analysis also to be useful as a model-based input during the decision process at the gate. Teams can assess confidence in the options, then check the model to see where the optimal choice is, based on the inputs considered. We would expect that if the confidence estimates placed the team close to the edge of any zone, a more thorough conversation would ensue to reach the decision.
In order to demonstrate the use and test the limits of the model on real projects, we conducted several case studies, two of which are presented in the next section.

## 4 APPLICATION EXAMPLES

We worked closely with BP in Houston to apply our gate decision analysis method to two cases within one major offshore oil and gas project. Thunder Horse is BP's largest production and drilling platform in the Gulf of Mexico. Thunder Horse was designed to access a 1-billion-barrel reservoir, and achieved start of production in June 2008. Still, 58M barrels of oil are inaccessible from the original project; the Thunder Horse Expansion (THSX) project aims to drill four new wells and install additional subsea infrastructure to access this stranded oil.

### 4.1 Case 1: In-Line Inspection Tool

Regulators require oil flowlines be inspected by an in-line inspection tool (ILI tool) shown in Figure 4. An ILI tool must be used to conduct a baseline inspection prior to start of production. This tool inspects the integrity of the interior of the flowlines without interrupting the flow, and operates via a spring-loaded linkage against the pipe wall. It is propelled through the pipeline by the flow of the product. The design of the THSX ILI tool proved to be technically challenging because the original Thunder Horse subsea system has 12-inch diameter flowlines, however the expansion is designed with 10-inch flowlines. A non-standard dual-diameter ILI tool was therefore under development for this project.
One requirement to be completed during the Preliminary Engineering and Definition phase is an operational environment test, i.e. technology is to be tested in the future operational environment. For the case of the ILI tool, this would involve demonstration in a dual-diameter subsea test loop.
The project arrived at the scheduled exit gate of Preliminary Engineering and Definition, which precedes entry to the Detailed Engineering and Execution phase. The ILI operational environment test was not complete. The decision whether to proceed to the next phase was performed by a gate authority, a committee of BP employees of various areas of expertise, some from the project and some external to the project.

Since the gate deliverable was incomplete, a Go decision was not appropriate. Accessing this stranded oil was of very high value to BP, and so killing the entire THSX project did not make sense. Instead the project considered three options:

- Apply to the gate authority for a waiver – explain how there is high confidence that by the next gate, the operational environment test will be successfully completed in addition to the next gate's requirements.
- Switch to the back-up plan – qualify two ILI tools of different diameters for the two flowline sections.
- Delay entry to Detailed Engineering and Execution until the test is complete – delay production.

*Figure 4. An in-line inspection (ILI) tool. Image used with permission, http://www.atcopipelines.com/upr/Media/*

The decision tree for this case is shown in Figure 5. The detailed values for each option are presented below.

**Waiver:** The development required to pass the test and perform further development to the next gate was estimated to be \$5M. Successful development of the dual diameter tool would be considered the project baseline. If the waiver failed (i.e. development of the dual-diameter tool was incomplete by the next gate) the team would use two ILI tools, one for inspection of the 10-inch section and one for the 12-inch section. Developing and operating these two tools has an expected cost difference of \$19.5M.

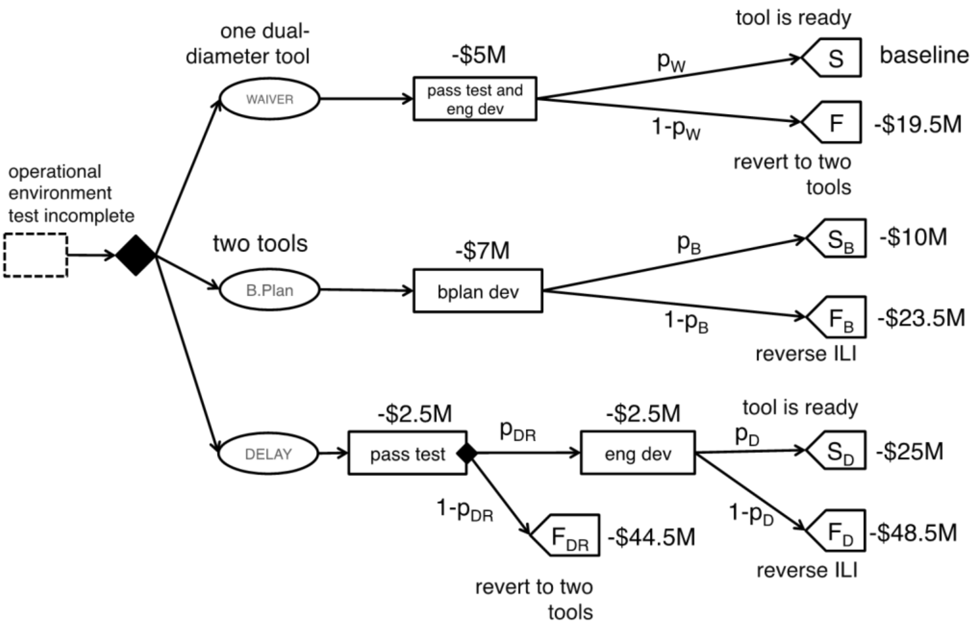



*Figure 5. Decision tree model for in-line inspection tool case*

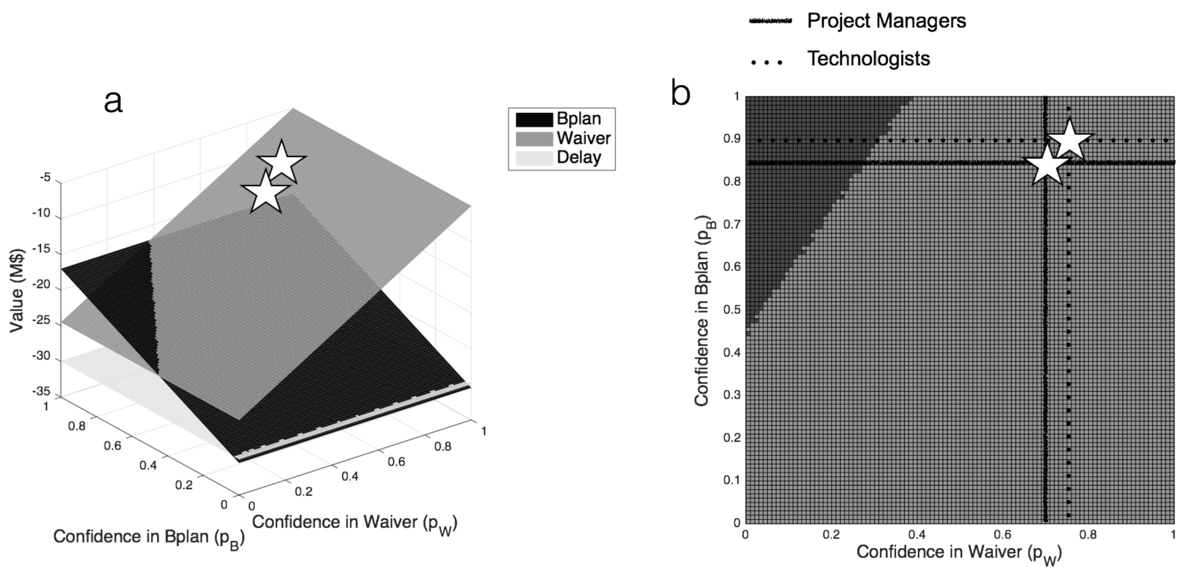
**Back-up plan:** The team could decide to use two tools now at this gate. This decision would result in a \$7M development cost and \$10M operational efficiency penalty for deferred production due to increased inspection time over the field life. If the two tools are not successfully developed, the contingency is to do a more difficult "reverse-inspection" which would require periodic shutdowns to do inspections. This option has double the operational efficiency penalty, equal to $20M and would involve $3.5M in development costs.

**Delay:** The team could delay passing the gate until the subsea test is complete. The estimated 3-month delay to production would have a $25M impact. The other outcomes in the delay option are components of previously described scenarios.

Discussions with the team revealed total confidence in the success of the testing that would occur as a result of the delay ($p_{DR}$ = 1.0). In other words, if the whole project was delayed because of this one tool, there would be such an increase in attention and resources that there is no doubt the test would be successfully passed. Therefore we prune the $F_{DR}$ branch of the decision tree.

We asked two separate functions of the project team to assess probabilities of success. The project managers had 70% confidence in the dual-diameter tool development ($p_W$), and 85% in the development of two tools ($p_B$), versus 75% and 90% respectively for the technology specialists. These confidence estimates are shown on the output graphic of Figure 6, along with the delay option given a best-case scenario confidence in that option ($p_D$ = 1.0).

We see in the output graphics that the delay option is entirely dominated by the waiver option. The optimal choice is the back-up plan only in the case of very low confidence in the waiver and high confidence in the back up plan. The actual confidence estimates of both functions place the optimal decision squarely in the waiver zone.




*Figures 6a and b. Model output for in-line inspection tool case*

In this case, the team did apply for and receive a waiver to the next phase. Within two quarters, the operational environment test had been passed and work was proceeding on the deliverables of the next phase.

## 4.2 Case 2: Subsea Injection Valve Control

The 58M barrels of stranded oil will be accessed from four new wells. These wells are threatened by asphaltene deposition, which may plug the tubing and valves in the well. To cope with asphaltene deposition, the THSX project will inject chemical inhibitors which keep the asphaltenes dissolved and avoid damage. The chemical injection metering valves (CIMVs) are controlled and monitored by an auxiliary control module (ACM) which is installed subsea, as shown in Figure 7.

The project arrived at the scheduled exit gate of Preliminary Engineering and Definition without having completed the operational environment test on the ACM – in this case a pressure test in a hyperbaric chamber.

At the gate, the team considered:

- Applying to the gate authority for a waiver – explain how there is high confidence that by the next gate the hyperbaric test will be completed in addition to the next gate's requirements.

- Switch to the back-up plan – use a subsea control module (SCM), a proven technology used in many other subsea control applications.

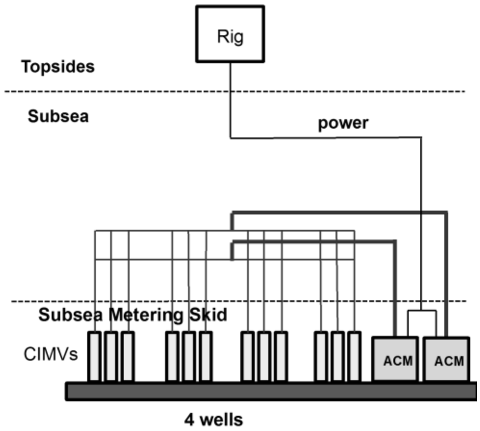



*Figure 7. Subsea set-up of ACM for subsea injection valve control*

The decision tree for this case is shown in Figure 8. The values for each option are presented below.
**Waiver:** Developing the ACM would cost $2.1M to demonstrate in hyperbaric testing and complete development. We benchmark success to the successful ACM development. If the ACM fails to develop by the subsequent gate, the project will choose to switch to an old technology, a communications hub (CH), which would require topsides rework ($10M) and would not be ready for one additional quarter, delaying production, with a $25M impact. The reason the team could not then switch to the back-up plan is that the SCM development requires much more time to develop.
**Back-up plan:** The project could switch from the ACM to the SCM now. The SCM has the same performance as the ACM, and could be developed in the same timeline. It would cost $5.8M to develop. A failed SCM development would result in minor schedule slip for rework, estimated to be negligible cost.

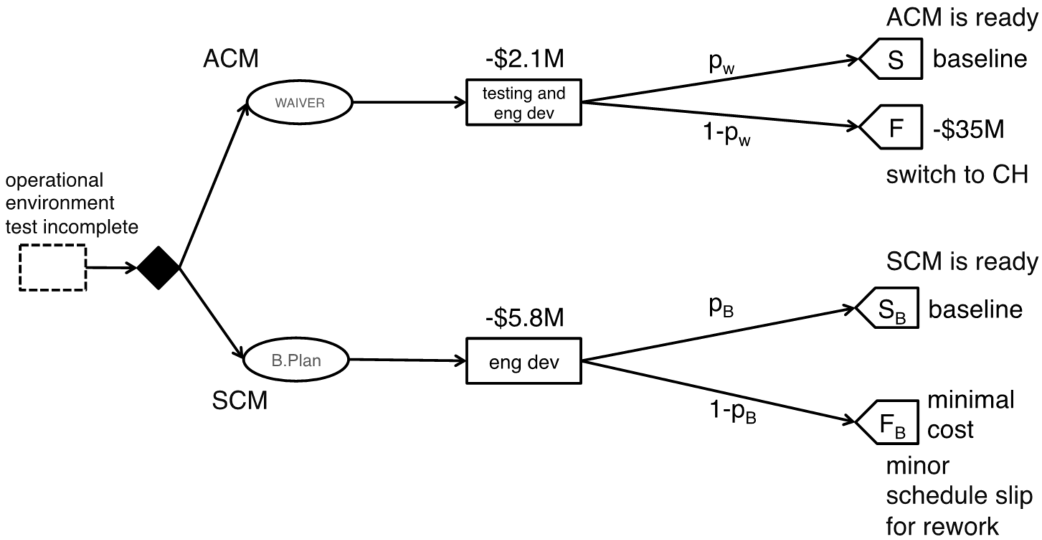
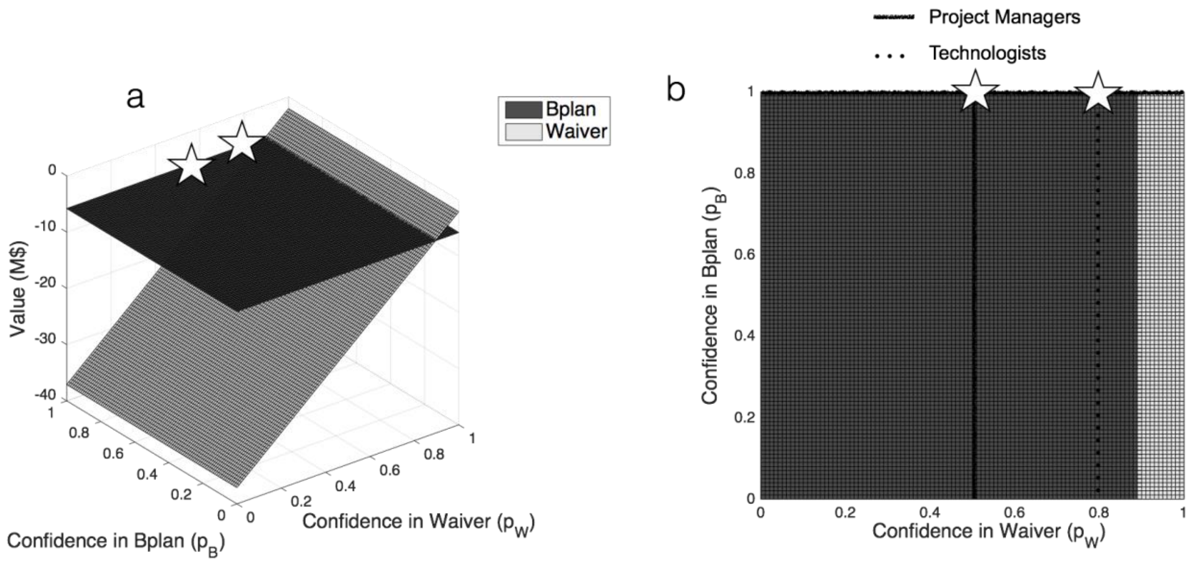



*Figure 8. Decision tree for subsea injection valve control case*

Again we had two separate functions of the project team assess probabilities of success. The project managers had 50% confidence in the ACM ($p_W$), and 100% in the development of the SCM ($p_B$), versus 80% and 100% respectively judged by the technology specialists. These confidence estimates are shown on the output graphic of Figure 9. Discussions with the team revealed no uncertainty in the successful development of the SCM, as it was a well-proven and understood subsystem used in previous BP projects. Therefore we prune the $F_B$ branch in the analysis output in Figure 9.
We see that the model would suggest switching to the back up plan (SCM) except if the confidence in the waiver (ACM) is greater than 90%. The technologists' confidence estimate places the optimal

decision close to the edge of the zone, perhaps indicating that a more thorough investigation should be conducted. The project managers' estimate is squarely in the back-up plan zone.




*Figures 9a and b. Model output for subsea injection valve control case*

In this case, the team disagreed with the model: they applied for and were granted a waiver for the ACM. In discussions with the team to understand this difference, three factors were identified:

1. A myopic scope fixation. The logic given for choosing the ACM over the SCM was their concern over difference in development cost: the ACM would cost roughly one-third the cost of the SCM to develop. The team was managing to their own current phase budget, and discounting possible value consequences later in the project.
2. Overlooking the ACM failure outcome consequence. The back-up plan dominates the optimal decision map because the waiver option failure scenario has a very high-loss outcome. When asked to make their confidence explicit, team members estimated 50% or 20% perceived chance of failure, which are not insignificant and thus appreciably lower the expected value.
3. The ACM solution was reported to provide more redundancy to the system than the SCM. This input was not communicated during site visits or considered in the team's decision papers or the waiver application. It was noted in one senior management report, which suggests it may be a useful factor to quantify as an input to this model.

## 5 INSIGHTS FROM THE CASE STUDIES

These case study demonstrations revealed that analytical consideration of the realistic (expanded) set of gate options does not require complex implementation. According to our case partners at BP and two companies in other industries, useful decision support can be provided from a straightforward decision tree analysis and output graphic. We also discovered that this analysis is based on data that are available and/or assessable by development teams, and thus could be readily implemented on projects.

We discovered that the model can represent different estimates of confidence, facilitating a discussion of heuristics, biases, and information gaps between the decision option championed by different functions in the organization at the gate. Our cases provide anecdotal evidence that project managers are more conservative in their technology risk assessment than the technology experts themselves. A decision-making process supported by our model can quantify the impact of different decision options and reveal when a difference of opinion is important to understand and when it is not.

There are several extensions envisioned for this work. For example, some of these decision options are recursive, and the outcome of one choice will open up another set of choices. This is currently reflected in the model using expected value, but it may be more powerful to add the complexity of multi-phase decisions and contingency choices. This analysis will prove difficult to graphically illustrate for a decision support tool but still simple to compare expected values for each decision, and thus reveal interesting insights.

Another extension is the incorporation of sensitivity analysis information to the model output, thus allowing the decision makers to understand which estimates have the most influence on the value maximizing output. Of particular interest are the relative errors in assessing probabilities versus the assessment of terminal values in our decision tree. We wonder if an extension which calculates and presents confidence thresholds and asks the decision-maker whether their confidence is above or below the threshold may be a more effective way to handle this uncertainty.

It should be noted that this model considers only those decision factors that the team decides to quantify for inputs to the model. The decision's true value may be influenced by many qualitative factors, including: politics, platform or portfolio effects, decision myopia, brand, performance incentives, competition, market uncertainty, and other difficult-to-quantify factors. We expect that this model can help facilitate the identification and discussion of these factors, even if they cannot be included in the quantitative analysis.

None of the cases observed considered the option of waiver with re-review. We chose to continue to include this option in our set of gate choices, given that we have collected anecdotal evidence to suggest the waiver and re-review is implemented by thoughtful decision makers. This option provides the benefit of the momentum into the next phase, with increased investment and work proceeding for the rest of the project, while accounting for the incomplete deliverable early enough to allow another project decision to recover value.

Future work could expand this model to consider the multi-project context of large organizations, or the multi-deliverable nature of gate reviews. We currently view each deliverable in isolation but in reality, a delay caused by one incomplete deliverable may allow another incomplete deliverable time to catch up, too. On the other hand, the delay may adversely affect the development of another subsystem, due to expectations of suppliers or contractors.

## 6 CONCLUSION

We develop a realistic representation of gate decision options through the incorporation of options such as Waiver (with and without re-review), Back-up plan, and Delay – along with the standard Go and Kill options. This is accomplished through an expansion of the simple decision tree modelling approach currently used for the Go/Kill choice to analyse the expected value of the broader set of options available. Finally we demonstrate this new decision support model with application case studies from industry and reveal the insights gained from these examples. This structured gate-decision model also provides an opportunity to explore the rational versus intuitive decision making that occurs in these critical gate decisions. Future work could address the decision maker myopia and other qualitative factors observed in this study.

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