Quantifying The Value Of Information

Every oil and gas company frequently makes decisions in situations where the result is not directly measurable in terms of impact on costs and revenue. This article presents the concept of Value of Information and discusses how this approach can assist in the decision process, using a simple example and a more realistic case.

Today there is no well-developed theory on the "correct" way of selecting among development alternatives for oil and gas fields. Many are familiar with the theories for asset allocation (for example, the Capital Asset Pricing Method) developed to achieve an optimal selection of stock portfolios. While these theories may or may not be applicable to the equity market, for various reasons these theories don't directly apply to oil and gas projects.

Theoretically, you should consider both project and corporate results and make a decision based on a full analysis of the total cash flow. At one extreme you could optimize the mean value without any consideration of the uncertainties. Alternatively, your company policy may be "we can't afford to lose money on this project," effectively making risk the deciding criterion.

In reality, most companies probably look at a project in isolation rather than integrating it into the corporate cash flow. Evaluations typically include an "expected" case based on a best guess of all the parameters, an "upside" case and a "failure" case. The upside and failure cases may be derived from probability distributions (P10 and P90), or they may represent best guesses of the best- and worst-case scenarios. A decision is then made by some qualitative evaluation of reward and risk.

Once we have an initial selection of development options, we may ask ourselves whether we should collect information to help select the best development scenario. The simple answer is "only if my project economics are improved more than it costs me to gather and process the information."

Before we look at a more realistic example, let's first consider a theoretical situation.

The Value Of Perfect Information

Assume that we are making a development plan for a reservoir where we are convinced that we either have a "high" case with 200 million bbl, or a "low" case with 100 million bbl of oil, each with a 50/50 chance of occurring. We also have just two development alternatives called "large" and "small."

Our company only makes decisions based on Net Present Value (NPV), and when we calculated the economics in terms of NPV for the development alternatives in the "high" and "low" reserve case, we found the results presented in Table 1.

At the same time that we are considering the development alternatives, suppose someone offers to sell us a "Magic Probe" which somehow can measure exactly whether we are in the high or low reserve scenario. To determine how much we would be willing to pay for such a tool, we build the decision tree in Fig. 1.

You can see that the "yes" and "no" branches are identical, except for the sequence of the chance and decision node. Thus, the effect of obtaining perfect information is to move the uncertain outcome before the decision point. The conclusion is that the value of the "yes" branch is $150 million and the "no" branch is $125 million, and we should therefore be willing to pay $25 million for the Magic Probe.

TABLE 1. NET PRESENT VALUE, $MILLIONS

	High Reserves	Low Reserves
Large Development	200	50
Small Development	150	100

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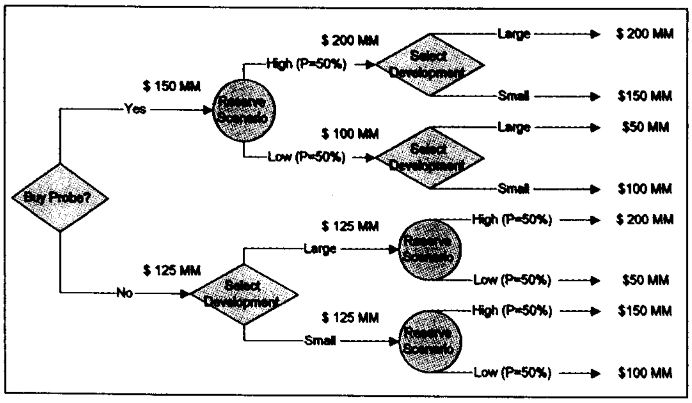

Fig. 1. To illustrate the value of perfect information, a Magic Probe would result in the above net present values for the simple case of large and small development options.

It is worth noting that the above decision tree is also useful to estimate the Value of Control. Value of Control is important if you have the option to actually influence your probability distributions, for example in a workover situation. Suppose Merlin the Wizard came by and offered to make sure you had "high" reserves. A quick look at the decision tree would tell you that you would be willing to pay him $75 million for his services, $50 million if you had already purchased the Magic Probe.

Value Of Imperfect Information

In the real world, the information we gather is associated with some uncertainty. Let's assume that we are considering three development scenarios: Development A, Development B and Abandonment. A preliminary selection of Development B was based on a risk analysis of all the developments using the methods described earlier.

There are lots of things you can do to obtain more reservoir information: shoot seismic, log and test old wells, drill new wells, conduct a pilot waterflood, etc. You need to decide the best way to spend your money to gather information, so you calculate the correlation coefficients between your input and result parameters to rank which input has

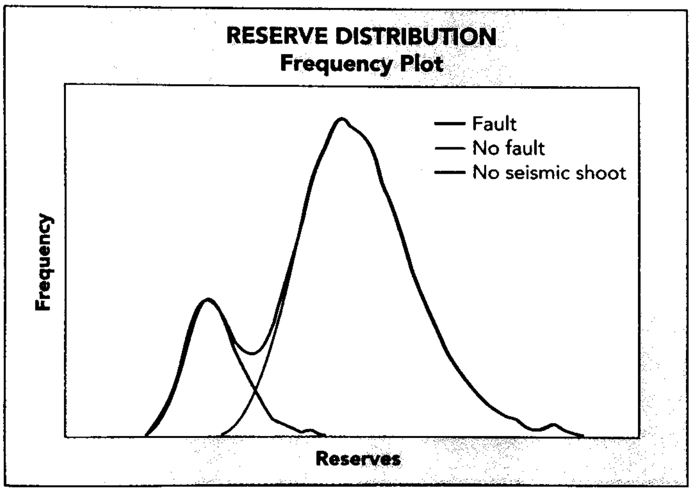

Fig. 2. The probability distributions for the reserves are assumed to be as shown above without shooting seismic. If a fault is present, less oil will be produced.

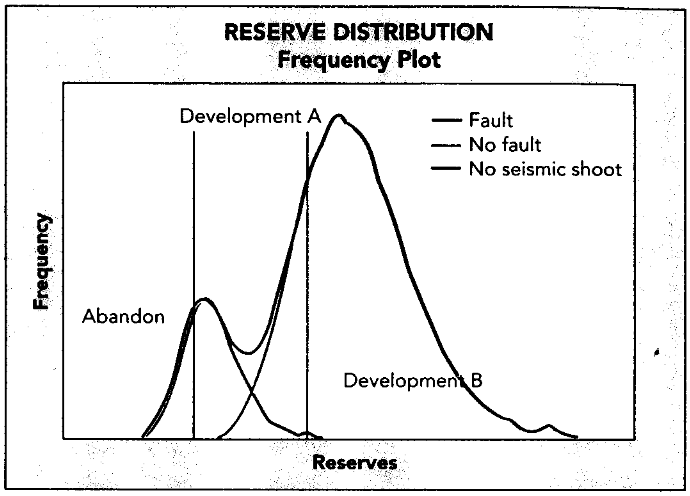

Fig. 3. The decision cut-off points for each development scenario have been added to the reserves distribution plot in Fig. 2. The small facility, Development A, would be economically feasible between the vertical lines, whereas the larger one, Development B, would be advised for situations further to the right.

the largest influence on your economics. Various commercial software packages are available to assist in these kinds of sensitivity analyses.

Assume that you decided to look at the value of shooting new seismic. The first thing you need to determine is how you believe the seismic information is going to change your assessment of the reservoir parameters. Let's assume that the main purpose is to confirm or reject the theory of a fault that would significantly reduce the expected reserve potential.

You postulate there is a 25% probability that you will confirm the fault and a 75% chance you will reject the fault theory if you shoot the seismic. You also estimate that the reserve distributions in the two situations would be as shown in Fig. 2.

It is important to ensure that the assumptions for probability distributions are consistent for alternative strategies. In mathematical terms, this translates into obeying Bayes Rule:

$$P(A)=\sum_{i=1}^{\infty} P(A_i)P(A \mid A_i)$$

Or in this example where R represents the reserves distribution and "|" is read as "given":

$$P(R)=P(R \mid Fault)P(Fault)+P(R \mid NoFault)P(NoFault)$$

At the point in time when you make a decision whether or not to measure a parameter, that parameter has the same distribution regardless of what you decide. It is a common mistake to assume that distributions are different at that point. Most often the confusion is caused by the fact that the probability distribution will change after the parameter is measured.

For example, the statement "Our analysis shows 100 million bbl of oil, but with seismic we expect to find 120 million bbl" is inconsistent. However, the statement "Our analysis shows a 50/50 chance of having either 100 million bbl

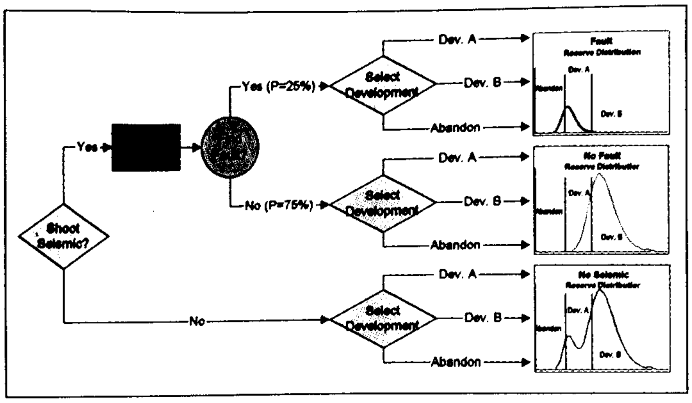

Fig. 4. Because the reserves distribution is independent of whether seismic is shot, the composite distribution of the top two branches (fault plus no fault) must be the same as the bottom branch (no seismic).

or 120 million bbl of oil, but with seismic we will know the correct number" is consistent.

Therefore, when we construct the decision tree, the reserve distribution in the "No Seismic Shoot" case (Fig. 3) must be identical to the risk-weighted reserve distributions of the possible outcomes in the "Seismic Shoot" case (the "fault" and "no fault" lines in Fig. 4).

Next, we need to determine the level of reserves (cut-off) at which one development becomes more profitable than another. Remember that if the same development is optimal regardless of the reserve volume, there is absolutely no reason to shoot the seismic since the only benefit (given our simplistic assumptions) is a better estimate of reserves. The reserve distributions and cut-offs are presented in Fig. 3.

Recall that we had selected Development B based on a risk analysis of all alternatives. This was done assuming no seismic shoot. Therefore we use the "No Seismic Shoot" reserve distribution, which is also the sum of the probability weighted distributions for the seismic shoot branch.

Looking at the plot and given only the "No Seismic Shoot" line it seems to make sense that we chose Development B. The plot also qualitatively shows benefits from shooting the seismic. If we don't find a fault, we can almost rule out that we are in a situation where we should abandon the field. If we find a fault, chances are very low that Development B would be the optimal development.

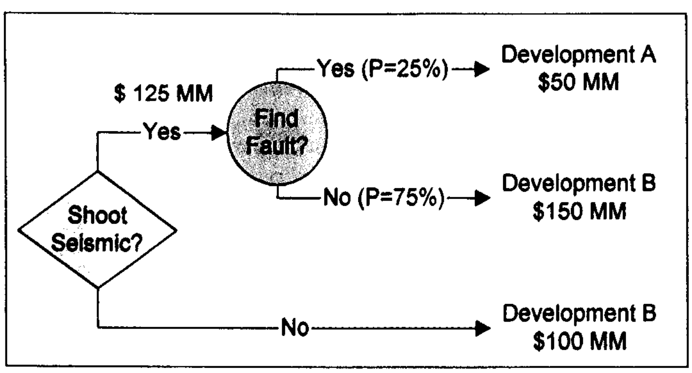

Fig. 5. The Net Present Value of the three branches in Fig. 4 shows the results of the full uncertainty analysis given a 25% chance of finding a fault.

We are finally ready to build the decision tree that will allow us to decide whether we should shoot the seismic (Fig. 4).

At the end of each branch you can see the previously calculated reserve distributions, which we must use when we calculate the value of the "fault," "no fault" and "no seismic shoot" branches. We have already solved the "no seismic shoot" branch in the initial screening of the projects, and we found that Development B had the best economics. So we only need to solve the "fault" and "no fault" branches. We need to do a full uncertainty analysis on all six alternatives, the same way we did the analysis of the three alternatives in the "no seismic shoot" branch. The decision tree in Fig. 4 was simplified (Fig. 5) to show the results of the full uncertainty analysis.

In this example, Development A came out favorably in the "fault" branch, and Development B came out best in the two other branches. The NPV of the project when you shoot seismic is $125 million and $100 million without seismic. Consequently, the value of shooting the seismic is $25 million and we should therefore be willing to spend up to that much to obtain seismic information.

Even though we limited ourselves to one uncertainty parameter (reserves) in this example, the concept is applicable in situations with information on several parameters. In reality, however, the number of decision branches will grow exponentially with the number of variables, and the decision tree will quickly become unmanageable.

Conclusion

Project evaluation is subjective and depends on risk tolerance, strategies, company resources and many other factors. Consequently, there is no theoretically "correct" method established for doing these analyses. When you make decisions facing uncertainty, you may be willing to pay to reduce or eliminate the uncertainty. The two examples above demonstrated the Value of Information approach to estimate how much you would be willing to spend for additional data. Using decision trees can be valuable for understanding how the new information will impact your project.

A prerequisite for calculating the Value of Information is an accurate life-cycle project model. Various software tools have recently become available to assist in development of these types of models. ●

ABOUT THE AUTHOR

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