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Probabilistic Approach to Deriving Oil Spill Size

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ABSTRACT

Oil spill is one of the most significant consequences of a drilling process failure such as Loss of Well Control. Catastrophic oil spills are very rare events, but the damages inflicted by them may last for generations. In this presentation we describe a probabilistic approach towards estimating the size of a potential catastrophic oil spill resulting from loss of well control (LOWC) on the OCS. In building the probabilistic model, we have taken into consideration the conclusion that the factors determining a catastrophic oil spill differ from the factors for smaller spills.

There is no deterministic method that can be used to predict what the potential is for having an oil spill from an offshore drilling operation. More frequently, the cases of loss of well control end up with gas release rather than oil. In order for a significant oil spill to happen, evidently the loss of well control must happen very close to, or at an oil reservoir. The superposition of precursory failures has to take place in order to have a blowout resulting in large oil spill.
Considering the phenomenon of **Large Oil Spills** (over 1000 bbls), we have built a simple probabilistic model with the following three components:

1. **Component One:** A **Trigger Event (T)**. Invariably, the Loss of Well Control (LWC) or blowout during drilling, completion, workover or some other well intervention plays the role of a trigger for the Oil Spill. Oil spills, however, do not happen as a result of every blowout. So, we are mostly focusing on the types of blowouts, which are able to produce oil spills, and that implies taking into account a subset of all cases of LWC. As there are daily activities on the platform that can result in smaller spills, we do not take those into account. The mechanism for large oil spills is different from the mechanism of small spills. The Probability of the Trigger Event is derived from empirical world-wide frequencies of blowouts that either have resulted in large oil spills (not a significant number), or had the potential for triggering large oil spills.

2. **Component Two**: **Oil Spill Daily Rate (R),** measured in barrels of oil per day (bopd) is a measurable spill factor, depending on the reservoir pressure, formation properties, friction, and flow barriers inside the borehole. The flow rate is governed by the laws of fluid dynamics. Still, it is subject to random influences and in the context of our model, it is

considered a random variable. Due to the fact that only a few catastrophic oil spills have resulted from blowouts anywhere in the world, there has been a statistically insignificant number of real-life observations. Thus, in order to derive the statistical distribution of the Oil Spill Daily Rate we have resorted to using the flow rates from the Worst Case Discharge (WCD) calculations. The WCD numbers were obtained through proprietary reservoir simulations.

3. **Component Three**: **Spill Duration (D)**, i.e. the time between when the spill begins, and the moment when the spill is stopped by some means (e.g. drilling a relief well, formation collapse, or regaining control)

The value of the **Spill Volume (V)** is a random variable, which is derived as a product of two independent exponentially distributed variables- the Oil **Spill Daily Rate** (**R)** and the **Oil Spill Duration** (**D**), i.e. **V= R * D**. Thus, the volume **V** will be an exponentially distributed random variable whose expectation is the product of the expectations of **R** and **D** according to the law of total expectation-
E (V) = E(R) * E (D). The Probability Density Function (**PDF**) of the exponential distribution is determined by that expected or the mean value, i.e. by **E (V).** Therefore, the probability for the spill volume V to fall within certain interval is defined by the following integral:

$$P(\alpha < V < \beta) = \int_{\alpha}^{\beta} f(x)\,dx, \text{ where } f(x) = \text{PDF of } V$$

This probability expresses the numerical values of the oil spill, but in order to derive the probability of such oil spill taking place, the above probability has to be multiplied by the probability of the Trigger Event. Thus, the final probability of the event of large spill volume occurring and having a size within the above interval becomes a product of the probabilities of the underlying events:

P (oil spill of given size) = P (Trigger Event) * P (α<V<β)

This two-step probabilistic model has allowed us to derive probability of oils pills on the OCS of various sizes.