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SPE-181036-MS
Real Time Decision Making - Incorporating Dynamic Risk Management

Andrew Hartigan, Darryl Thrasher, Robin Adlam; Lone Star Analysis

Society of Petroleum Engineers

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Slide 2

What is Dynamic Risk Management?

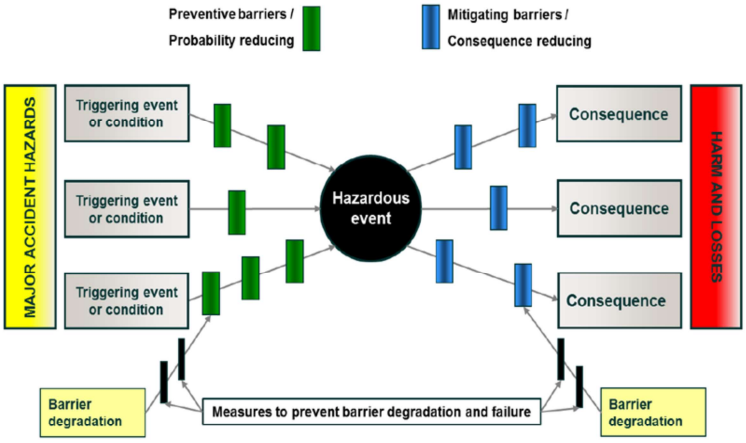
- A real-time, probabilistic assessment of current risk, incorporating all relevant data
- An active, continuously updated probabilistic model, built with historical, anecdotal and real-time data
- It allows users to visualize hazards, events, controls, threats, escalation factors and consequences, AND the interactive relationships between them

This presentation is about a demonstrated real-time risk modeling capability in a synthetic environment. The modeling software, processes and techniques are the result of 12 years of decision analysis work. The elegance of the risk tool is the amalgamation of data which combine to represent risk: historical data, real-time data and subject matter expert data. All resident within the model, updated every 5 seconds.

Slide 3

Digitally Connect your Bow Ties – With Data and Relationships

- Nodes in a Bow Tie interact in known ways
- Ranges of probabilistic data exist for all nodes
- You can combine Bow Ties in a virtual representation of your entire system or process



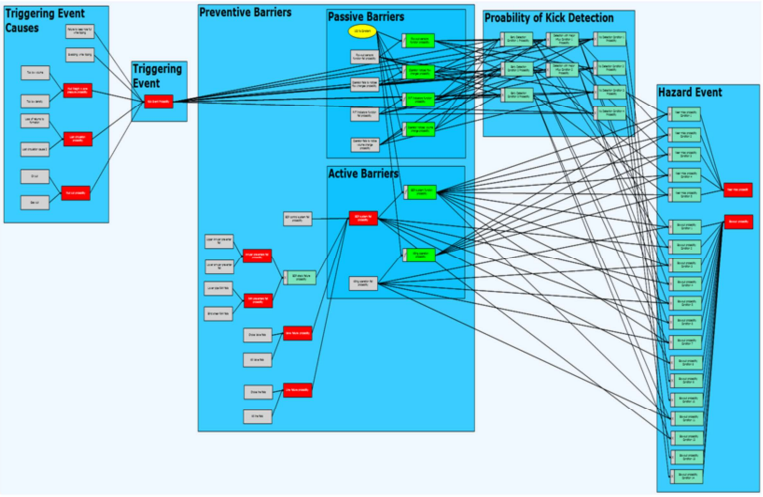
A 'Bow Tie' is a 2-dimensional representation of a hazardous event – common in the oil & gas industry. Triggering events and preventative barriers are diagrammed to the left, and mitigation opportunities and outcomes are depicted to the right – hence the appearance of a bow tie. This representation of risk is static. It does not enable continuous updates on the status of the preventative or mitigating barriers. Nor is it necessarily available when operators are making real-time decisions in extremis. A Dynamic Risk Model continuously updates the status of preventative and mitigating barriers with relevant real time data and influencing relationships to give operators a real-time representation of risk.

Slide 4

Demonstration of Dynamic Risk Management

Applied to the Deepwater Horizon Transition to Production Example

- This is a visual representation of a Well Blowout Bow Tie
- Nodes are filled with auditable data
- Relationships between nodes are identified with connecting lines – and probabilistic maths



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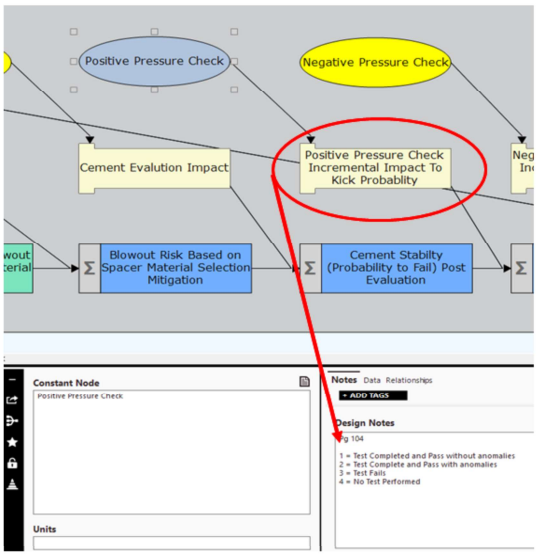
This is a portion of a dynamic risk model representing an oil well blowout which has been applied to the Deepwater Horizon blowout in April, 2010. The nodes depicted on the slide contain probabilistic data which represent the effect of barriers on preventing or mitigating a well blowout. The lines represent relationships between contributing factors.

What Data? What Math?

- Data don't have to be perfect to provide valuable and accurate predictive risk measures
- This example shows quantitative measures applied to a non-quantitative event
- These quantitative data have an "influence" on nominal / historic likelihoods of a hazard

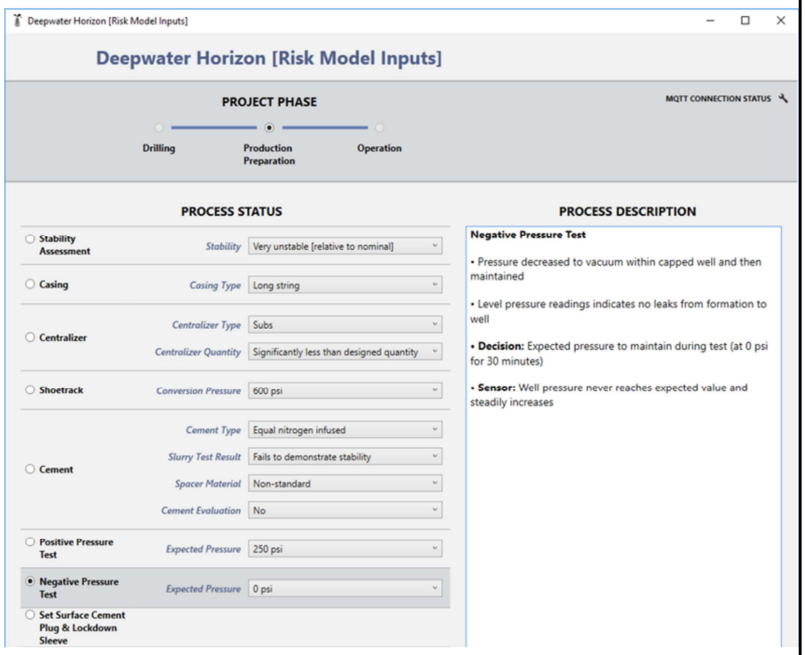


Qualitative contributions to risk can be quantified in a Dynamic Model. Here is an example of values being applied to the success of a positive pressure check.

Slide 6

User Interface

- Pulldown menus show the resultant risk of decisions – before they are made
- Each choice is modeled – selection of any option will show the outcome risk of the hazard occurring
- This enables "what-if" evaluation of alternative choices in advance of decisions

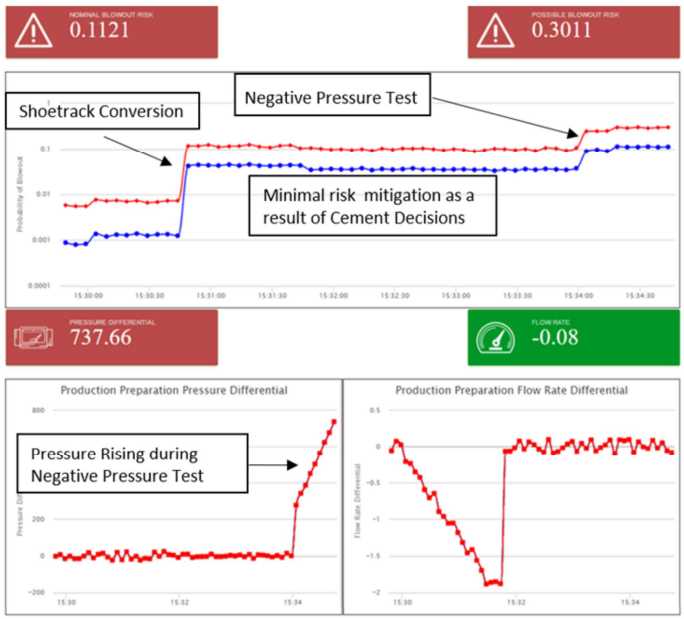


This slide shows the user interface to a Dynamic Risk Model. Decisions which could possibly contribute to risk have pulldown menus with optional choices. An operator selection of any choice will update the model with risk which would result from actually making the decision evaluated via the pulldown menu. This enables operators to "what-if" their decisions before they make them. In the case of Deepwater Horizon, these decisions were made by different companies in different geographic locations at different times. The tool enables the aggregation of risk factors into a single location, in real-time, to give decision makers current risk context.

Slide 7

Live Data Feeds & Model Outputs

- Model output shows risk likelihood updates every 5 seconds
- The blue line is 'most likely' risk, the red line is the 10% likelihood, or 1 in 10 likelihood of a blowout
- Real-time well data delivered in the bottom of the chart is incorporated into risk likelihood
  - Pressure Differential
  - Flow Rate Differential



The top right set of lines on this chart show the most likely risk of a well blowout (blue), and the 10% likely risk of a well blowout (red). Each dot on the lines represents 5 seconds of time – the interval between model updates. Most evident from this portion of the timeline is the increase in risk of a blowout when the shoetrack conversion failed to occur at the correct pressure. And then the increase in risk when the real-time pressure data indicated an increase in well pressure during the negative pressure test. The bottom right portion of the chart shows the real-time data feeds of pressure and flow rates from the well – incorporated into the risk model. The vertical axis in the top chart is logarithmic. At the negative pressure test point of this well transition to production, the risk of a well blowout was 1000 times greater than the nominal blowout risk of a High Pressure High Temperature drilling evolution. A dynamic risk model would enable decision makers to understand 'current state' of risk before proceeding with operations.

Slide 8

Summary

- Contributions to risk come from different organizations, different times and different geographic locations
- A Dynamic Risk Model captures and aggregates all data and decisions that affect real-time risk
- A model enables decision makers to 'what if' decisions before they are made
- Real-time data feeds to risk models provides game-changing insight in time to alter the outcome of events
  - Risk of Hazards occurring
  - Risk of equipment failing
  - Risk of operations being inefficient

The authors believe the demonstration of a Dynamic Risk model shows value for decision makers in potentially high risk situations. All available information is updated and available to effectively inform decisions at the time they are being made.

Thank You / Questions