BOP Operational Risk Estimation Using Real-time Data

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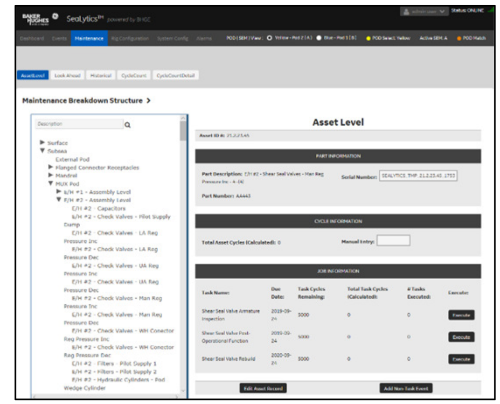
Agenda

- Representing Risks
- Probabilistic Risk Assessment
- Data
- Future Work

Roadmap to model & data driven insights



- **High integrity data recording**
- Platform standardization
- Cyber secure connectivity

- On rig/on shore apps
- **Equipment/operational models**
- **Analytics, insights**

- Optimized availability/TCO
- Utilization based maintenance
- **Pro active risk management**

Today industry is laying the foundation for a data driven platform, leading to new operational performance insights

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Risk Assessment Alternatives

Qualitative Risk Assessment – Risk assessments with low, med, high impact estimators – No risk model of the plant

Quantitative Risk Assessment:

- Numerical Impacts Defined
- Deterministic – Digital twin
- Probabilistic – Probabilistic Risk Assessment (PRA)

Representing Risks

Scenarios → **What can go wrong?**

Likelihoods →

Consequences →

All scenarios identified?
Are the probabilities accurate?

UNCERTAINTIES

https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120001369.pdf

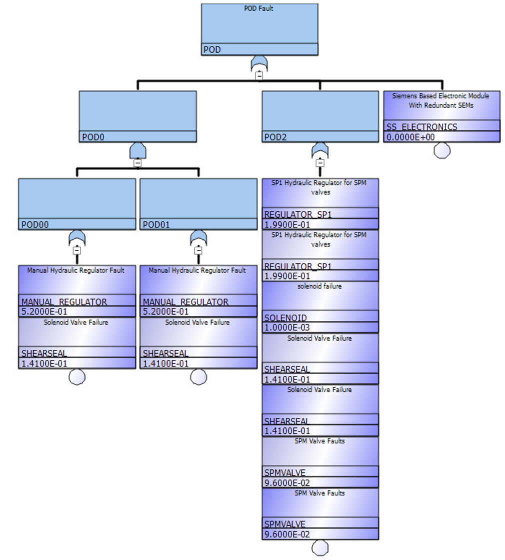
Probabilistic Risk Assessment

BSEE & NASA

"BSEE and NASA have developed a draft guide for the use of Probabilistic Risk Assessment (PRA) in the offshore oil and gas industry. The draft PRA Guide is the next step in evaluating PRA as a potential risk assessment tool for operators in a less-understood offshore environment for new technologies. In 2016, BSEE and NASA entered into an interagency agreement to, among other joint goals, evaluate the use of PRA in the offshore oil and gas industry[1]."

BSEE/NASA PRA Guide. Revision 1. October 26, 2017

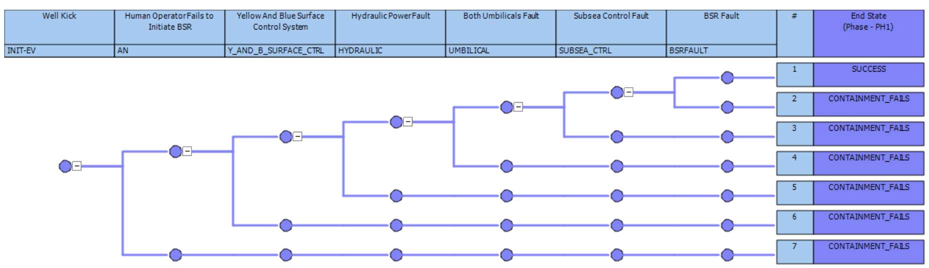
1. https://www.bsee.gov/what-we-do/offshore-regulatory-programs/risk-assessment-analysis/probabilistic-risk-assessment-analysis



What is a PRA?

Risk Informed Safety Case

- Comprehensive, structured analysis method
- Uses fault trees to calculate failure probabilities of subsystems
- Allows for straight forward modeling of common cause failures
- Uncertainty analysis and sensitivity analysis are part of the process
- Consequence analysis is done using event trees to calculate system probabilities

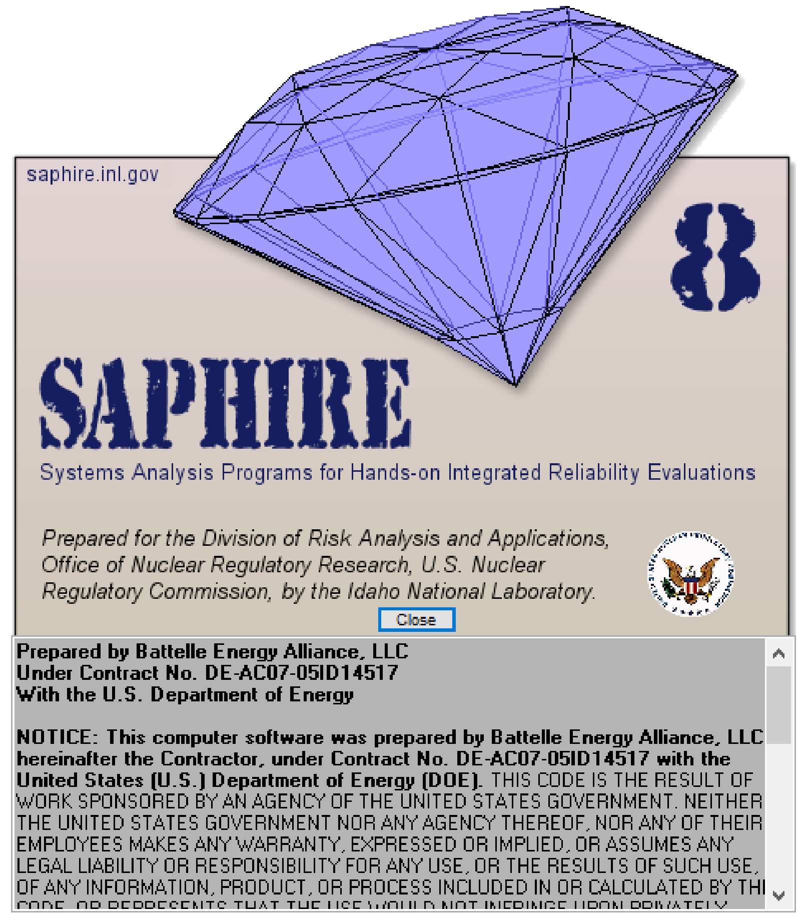


Each business must establish their acceptable risk thresholds prior to deploying the tool

Saphire Modeling Tool

Used by NASA & BSEE

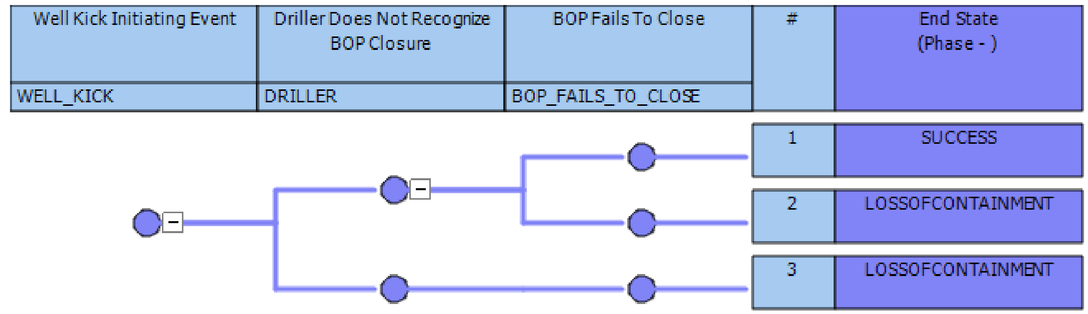
- Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
- Developed for the Nuclear Regulatory Commission
- In use since 1987



How does a PRA work?

The event tree

- Event trees model the scenarios
- These result in the likelihood of a consequence
- The calculation combines the probabilities of the underlying fault trees

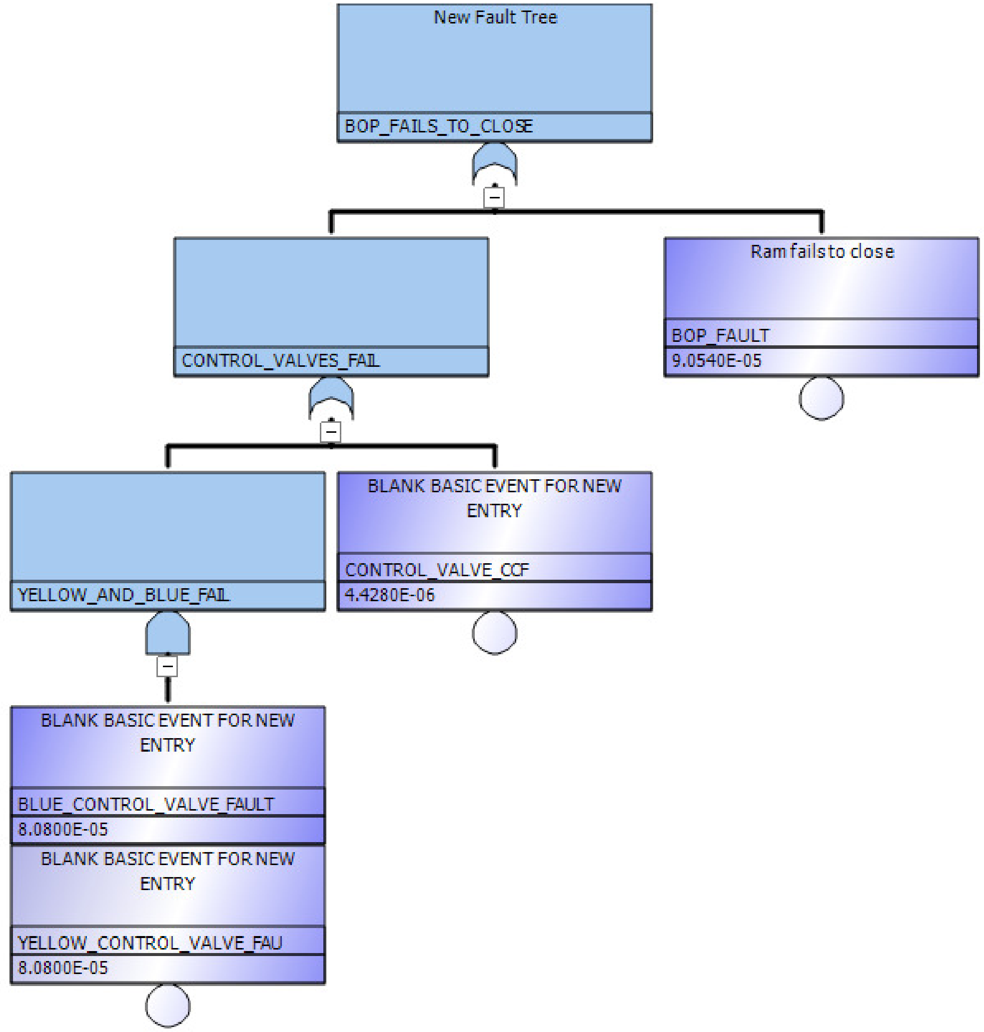


Note: Highly simplified for illustration only

How does a PRA Work?

The fault tree

- Fault trees model the likelihood of an event occurring e.g., the BOP fails to close
- Fault trees consist of basic events and logical combinations
- The failure rates come from the best available data
- Models should include common cause failures



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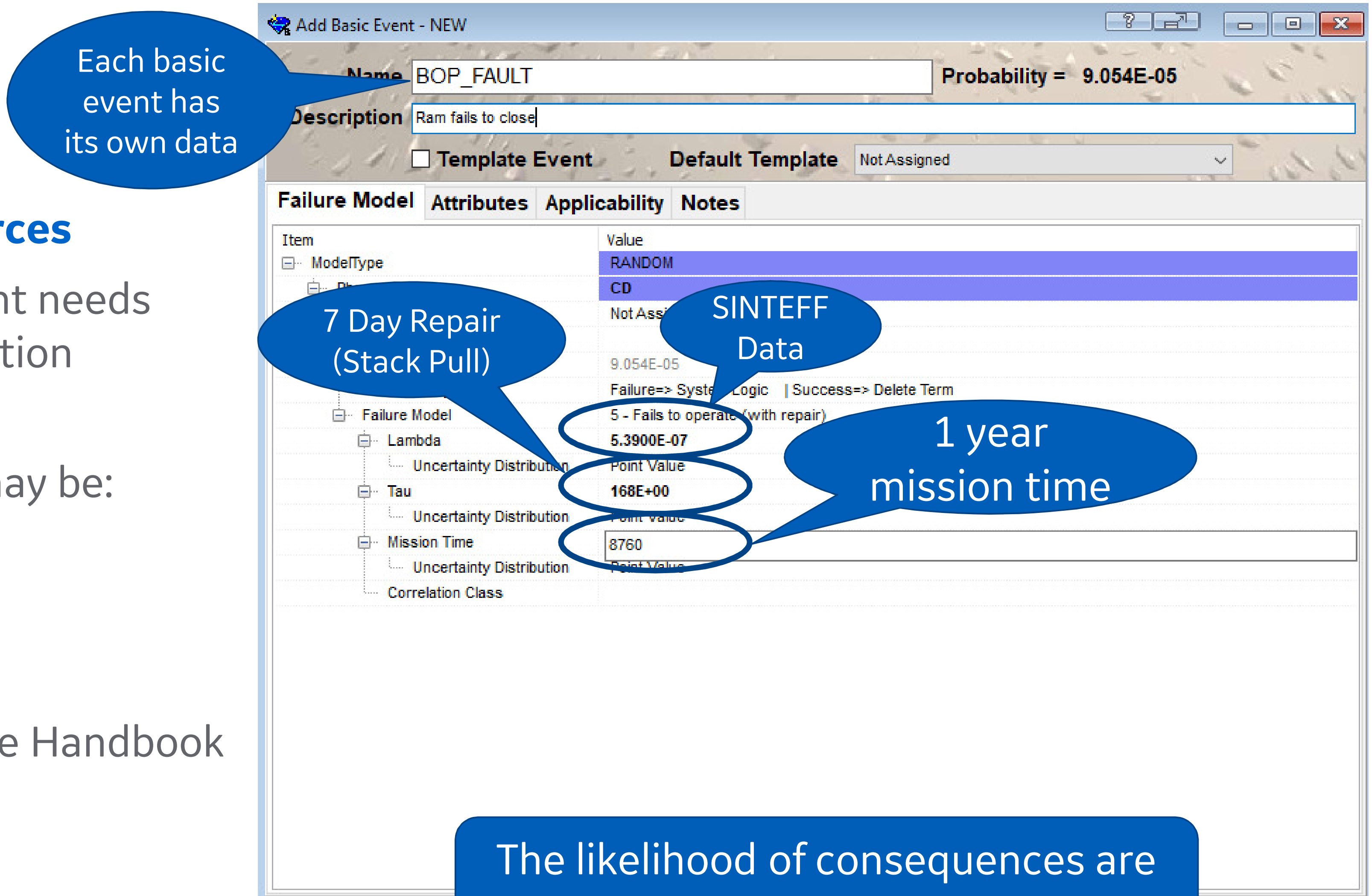
Initial Data

Standard Sources

Each component needs data for calculation

Data sources may be:

- SINTEFF
- OREDA
- Mil Std 217
- Naval Warfare Handbook
- Field Data



The likelihood of consequences are determined by the data

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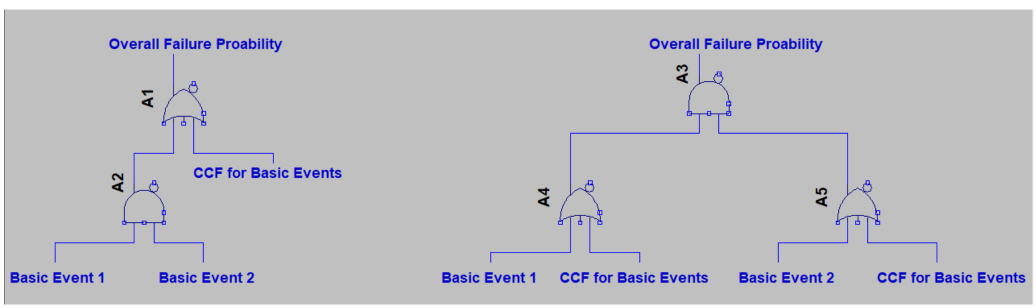
System PRA Complexity

- All components need to be modeled
- SEMs, power supplies, and surface cabinets can be aggregated if subsystem data exists
- Each analyst may organize fault trees differently, standard arrangements are necessary

Data Type	Number of Records
Fault Trees (Tops)	65
Fault Trees (All)	222
Event Trees (Tops)	5
Event Trees (All)	5
Basic Events	1620
Gates	957
Sequences	16
End States	6
Change Sets	0
Flag Sets	0
Histograms	0
Model Types	1
Phases	1



Complexity of modeling

- Over 1600 parts
- Nearly 1000 equations

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Improving data

Uncertainties result from data sources

- Initial models are based on JIP & standards data

- Bayes theorem[1] states:

$$P(B|A) = \frac{P(A|B)P(B)}{P(A)}$$

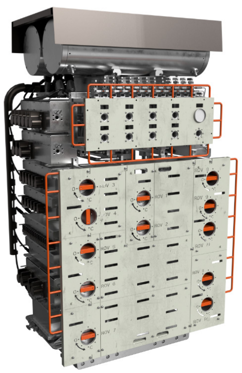
Which means the posterior distribution is determined by data modifying the prior distribution

Standards Data	Industry Data	Baysien Modified	Equipment Specific Data
Mil Std 217 Naval Warfare Handbook NPRD	SINTEFF OREDA JIP Work	Industry or Standards Data Coupled with SeaLytics Field Data Manually Updated Using Bayes Theorem	Industry or Standards Data Coupled with SeaLytics Field Data Automatically Updated Using Bayes Theorem
Available Today	Available Today	Short Term	**Future**

1. O'Connor, P., (2005), Practical Reliability Engineering, 4th ed.

We can use SeaLytics data to create a posterior distribution that more closely models rig specific equipment

Highest availability at lowest cost to own

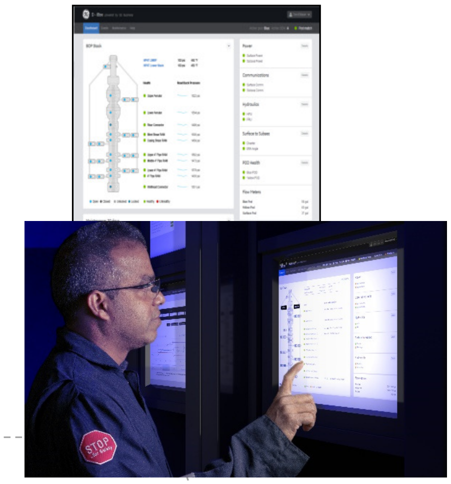


Integrated Control System

- SeaONYX™ Surface Control System
- SeaPrime™ Subsea MUX Control System

SeaLytics BOP Advisor™

Data analytics from your operations allow operational visibility and predictive, condition based maintenance.



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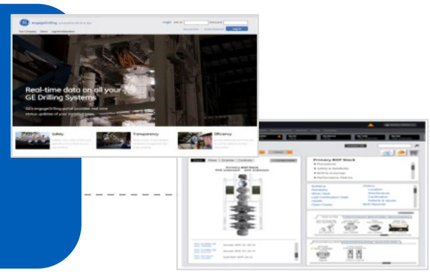
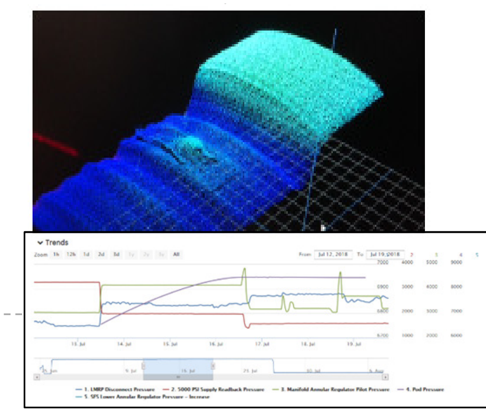


Analytics & Inspection Technology

Digital inspection tool, automatic reporting, on shore support with analytics.



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