



BOP Operational Risk Estimation Using Real-time Data

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Agenda

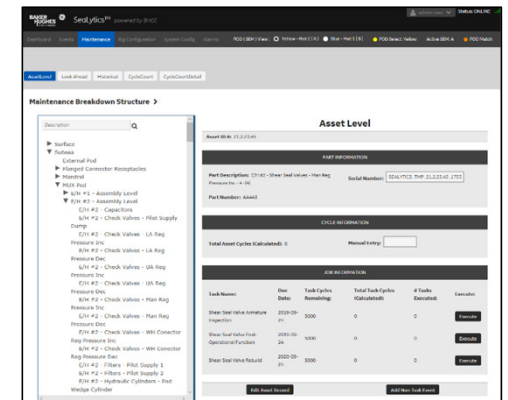
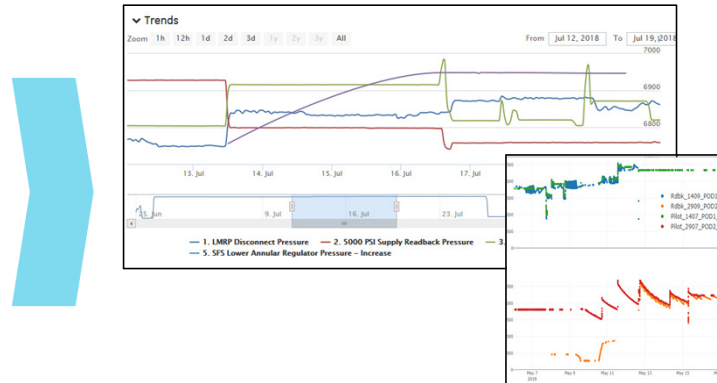
- Representing Risks

- 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

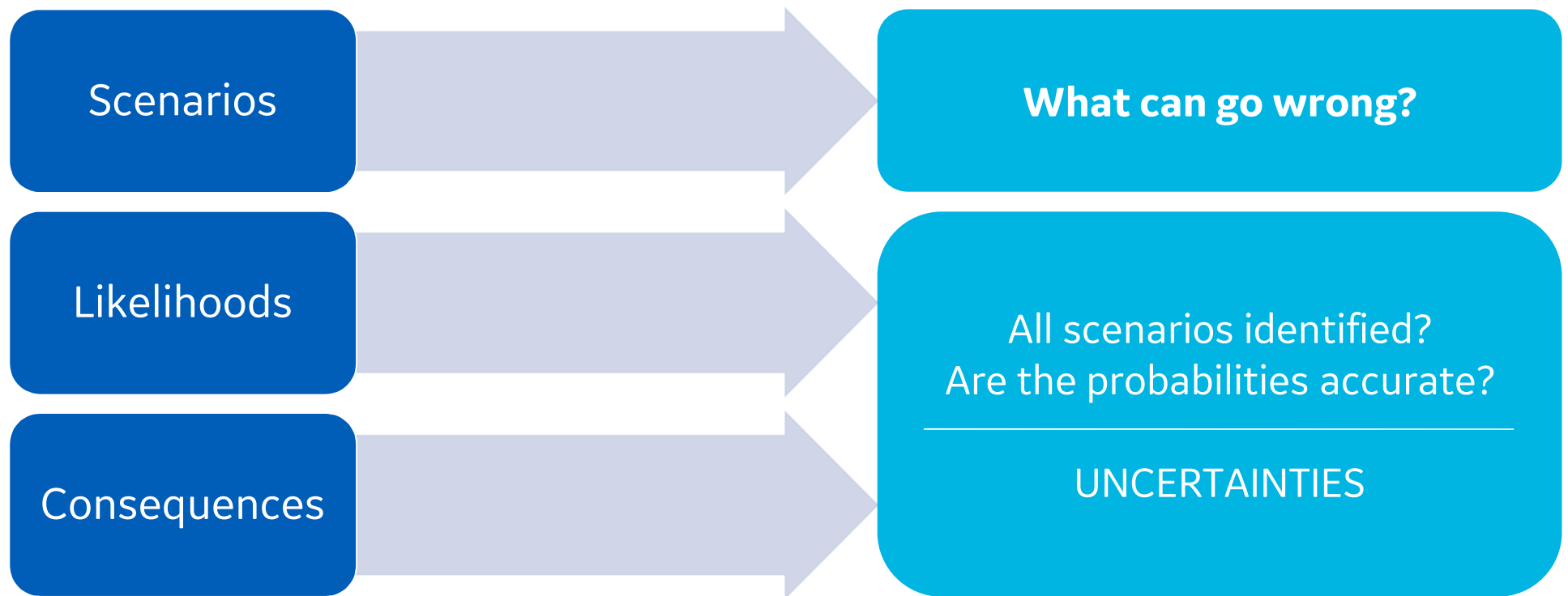
Risk Assessment Alternatives

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



<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 industry¹.”

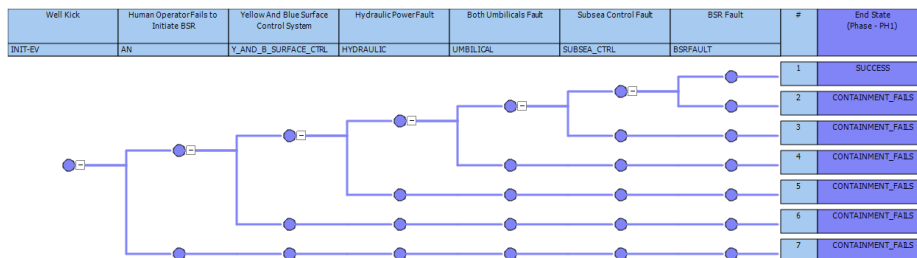
[BSEE/NASA PRA Guide. Revision 1. October 26, 2017](#)

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

Risk Informed Safety Case

-
- ```

graph TD
 POD[POD] --> POD0[POD0]
 POD --> POD2[POD2]
 POD0 --> POD00[POD00]
 POD0 --> POD01[POD01]
 POD00 --> MHRF[Manual Hydraulic Regulator Fault]
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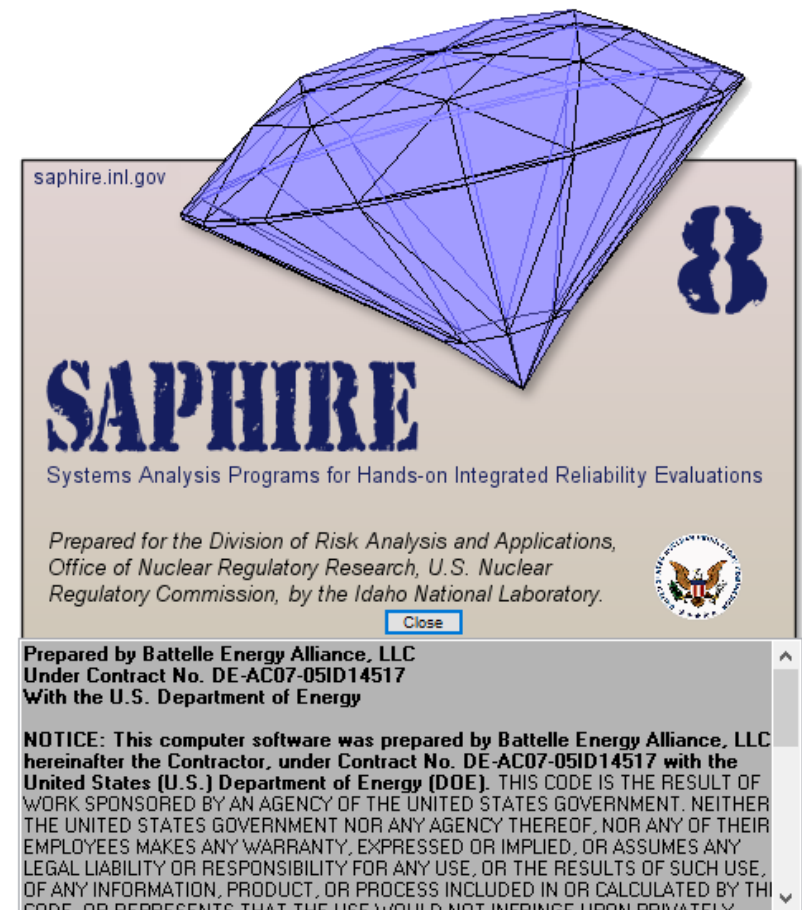


Each business must establish their acceptable risk thresholds prior to deploying the tool

# Sapphire 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

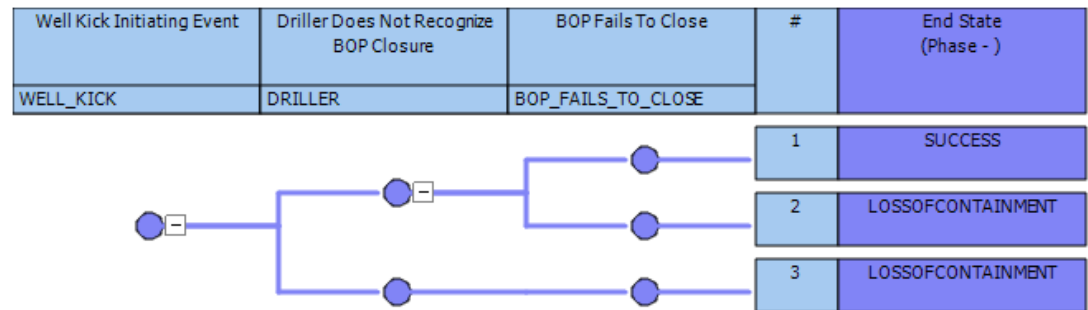




# How does a PRA work?

## 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

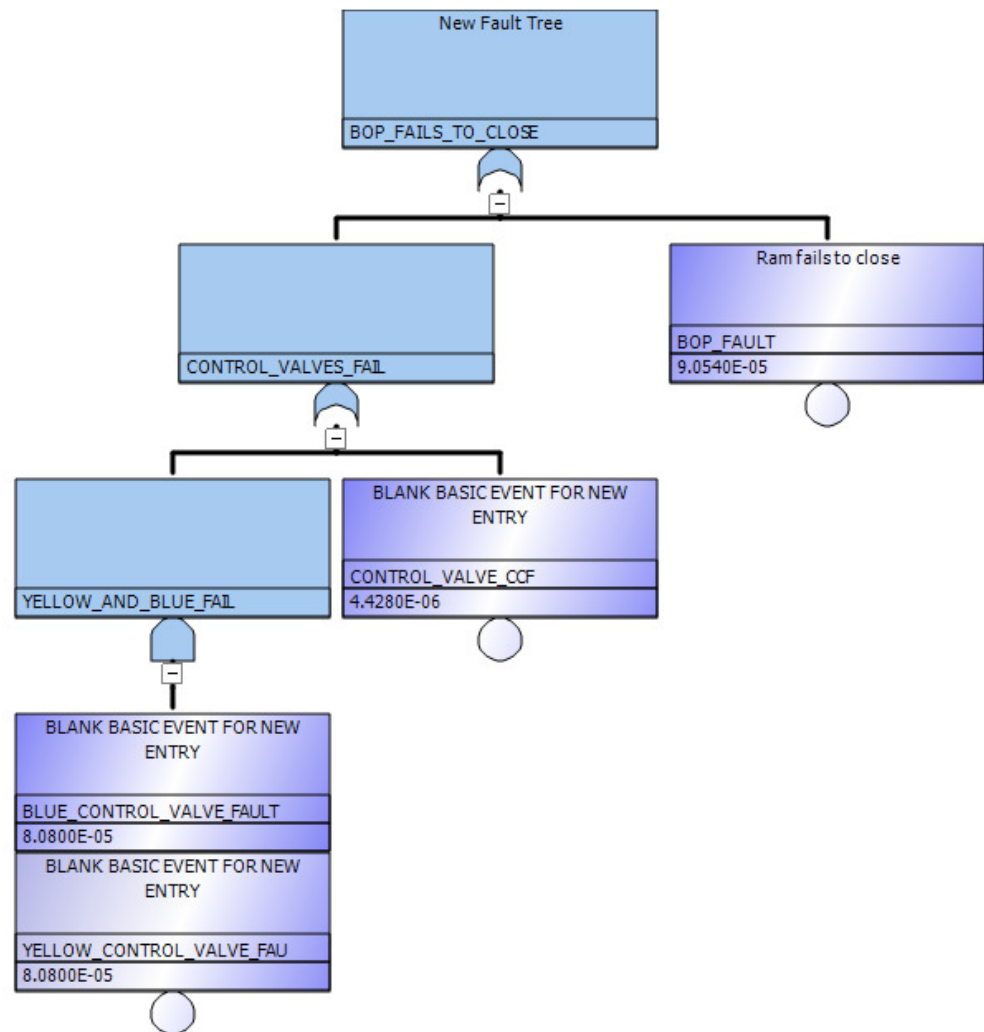


Note: Highly simplified for illustration only

# 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



## Initial Data

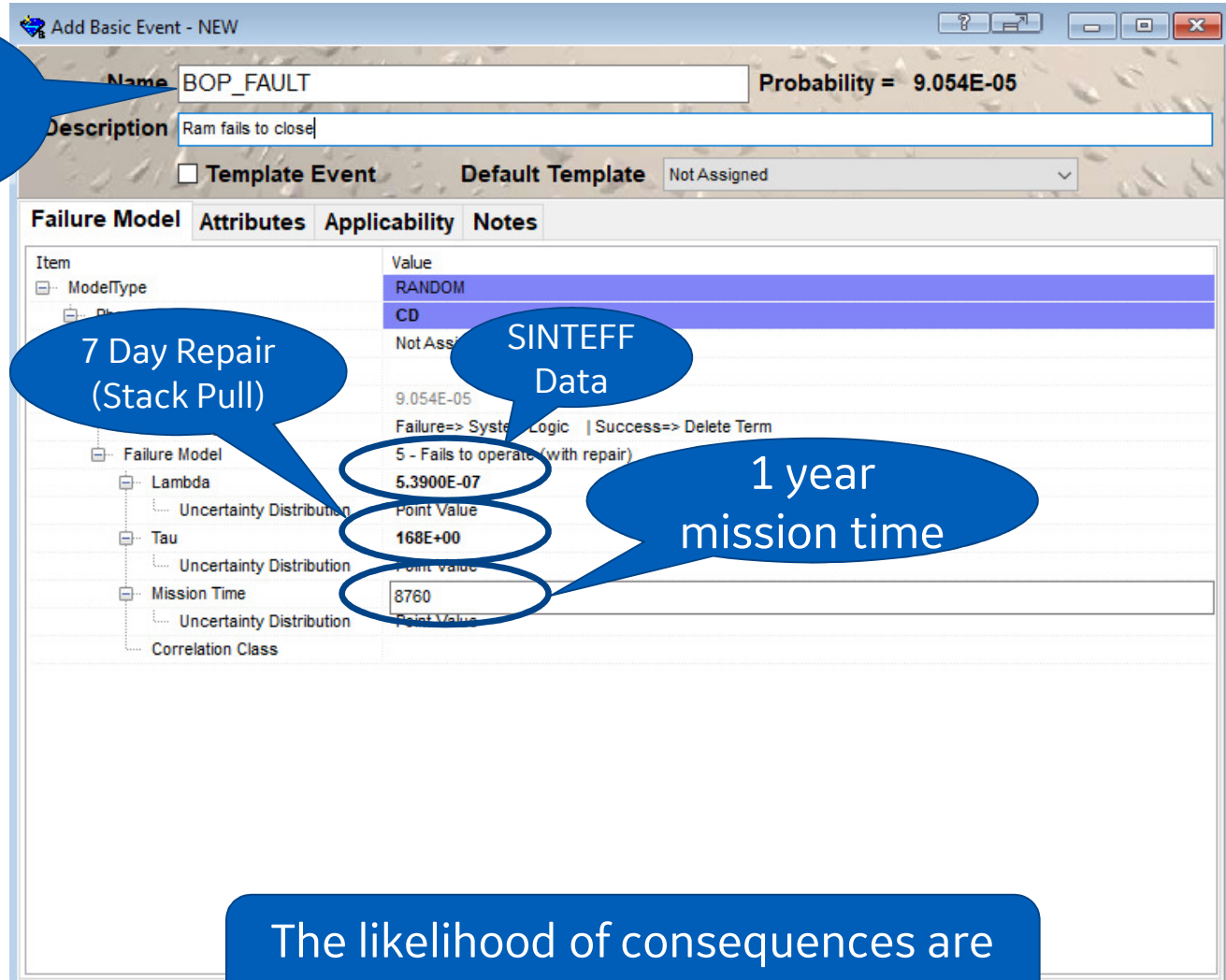
Each basic event has its own data

## Standard Sources

Each component needs data for calculation

Data sources may be:

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

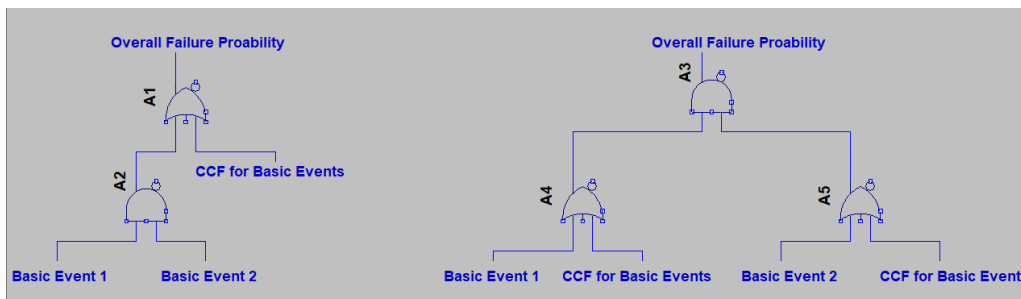


| Item                                           | Value        |
|------------------------------------------------|--------------|
| ModelType                                      | RANDOM       |
| CD                                             | 9.054E-05    |
| Not Assigned                                   | Not Assigned |
| Failure=> System Logic   Success=> Delete Term |              |
| 5 - Fails to operate (with repair)             |              |
| Lambda                                         | 5.3900E-07   |
| Uncertainty Distribution                       | Point Value  |
| Tau                                            | 168E+00      |
| Uncertainty Distribution                       | Point Value  |
| Mission Time                                   | 8760         |
| Uncertainty Distribution                       | Point Value  |
| Correlation Class                              |              |

The likelihood of consequences are determined by the data

# 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



| <u>DATA TYPE</u>   | <u>NUMBER OF RECORDS</u> |
|--------------------|--------------------------|
| 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

# Improving data

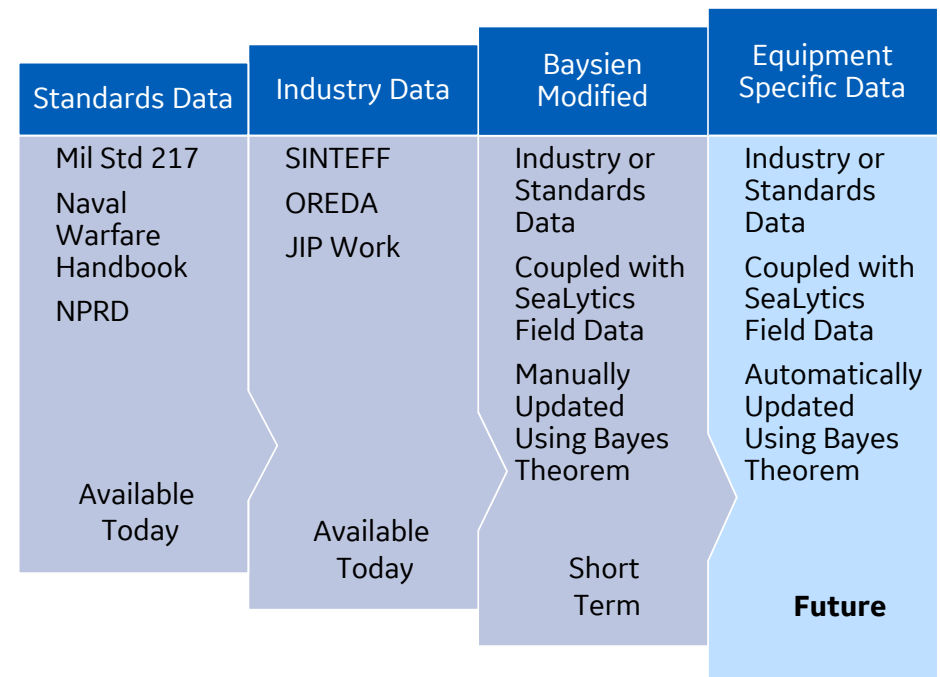
## Uncertainties result from data sources

- Initial models are based on JIP & standards data

- Bayes theorem<sup>1</sup> 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



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

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

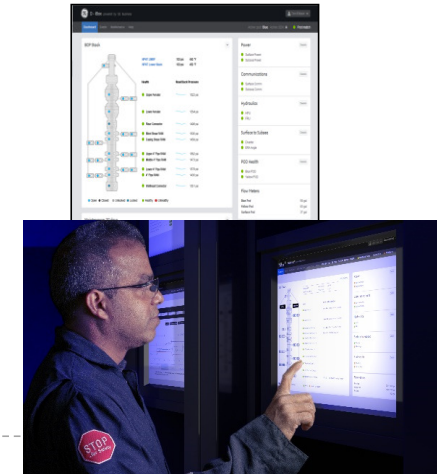
# Highest availability at lowest cost to own

## Integrated Control System

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

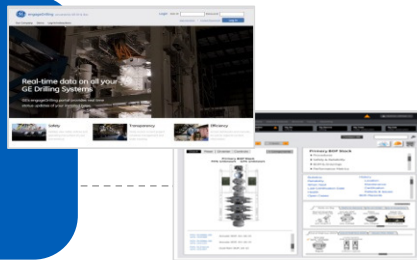
## SeaLytics BOP Advisor™

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



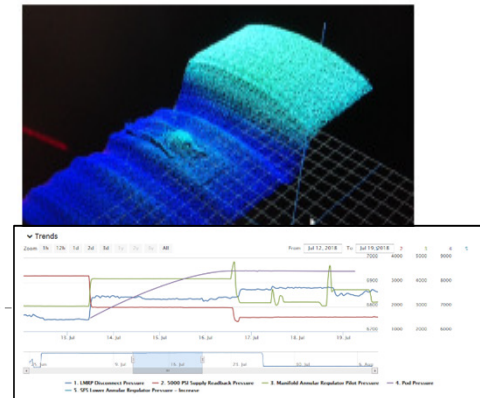
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Digital inspection tool, automatic reporting, on shore support with analytics.



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