Risk Management at NASA and Its Applicability to the Oil & Gas Industry

**OPERATIONAL EXCELLENCE IN OIL AND GAS**

November 7, 2017

David Kaplan
NASA/Johnson Space Center
david.i.kaplan@nasa.gov
1. Why is NASA’s experience relevant to offshore oil and gas?

2. What is Probabilistic Risk Assessment (PRA)?

3. What is the relationship between NASA and BSEE Headquarters?

4. What is NASA presently doing with Anadarko Petroleum Corporation and with Shell International Exploration and Production?
International Space Station

Visitors to the International Space Station by Country

United States: 141 people
Canada: 7 people
Brazil: 1 person
Germany: 3 people
Great Britain: 1 person
Netherlands: 1 person
Belgium: 1 person
Spain: 1 person
France: 3 people
Italy: 1 person
Russia: 45 people
Kazakhstan: 1 person
Japan: 7 people
South Korea: 1 person
Malaysia: 1 person
South Africa: 1 person
International Space Station

ISS Configuration
As of May 2011 (ULF6 - STS-134)
International Space Station
Complex Operations Dependent on Human Involvement
Ongoing Resupply Operations
ISS Mission Control Center
Isolated and Not Easily Accessible
1. Why is NASA’s experience relevant to offshore oil and gas?

2. What is Probabilistic Risk Assessment (PRA)?

3. What is the relationship between NASA and BSEE Headquarters?

4. What is NASA presently doing with Anadarko Petroleum Corporation and with Shell International Exploration and Production?
QUALITATIVE risk assessment is commonly based on experience or expertise and results in categorical estimates of risk.

QUANTITATIVE risk assessment leverages empirical data to determine and assign numerical values to risk.
First, Define the “End States” of the PRA Analysis
Major Steps to Perform a PRA

Define End States
List of consequence of incident

Examples:
- Loss of life
- Loss of facility
- Shutdown
- Fire
- Blowout
- Leak
- Exceeding limits

Master Logic Table/Diagram
List of initiating events

Examples:
- Hazard Reports
- Functional Analysis
- FMEAs
- Previous risk assessments
- External event assessment

Event Trees

Examples:
- Sequences of operation
- Timelines
- Operational Procedures
- Operational Rules/Assumptions
- Malfunction Procedures

PRA Software

Data Analysis

Examples:
- Training Manuals
- System Architecture
- Engineering Expertise
- P&IDs
- Human Error
- Common Cause

Fault Trees

Examples:
- Customer Data
- Industry Databases
  - OREDA
  - ICON
  - Well Master
- NPRD db
- EPRD db
- Other Assessments

Cut Sets
- Contributors
- Failure Scenario Combinations

Risk Levels with Uncertainties for Selected End States.

Relative Risk Drivers
Notional Master Logic Diagram for a Well Kick While Drilling

Excessive Delta P between Well Bore and Formation (Well Kick)

Low Fluid Pressure at Bottom Hole
- Loss of Mud Column from Riser
  - Inadvertant LMRP Disconnect
  - Mud Slide
  - Emergency Disconnect
- BOP/LMRP Interface Leak
- Riser Failure

Increase in Pressure at Bottom Hole
- Swab Effect
- Unexpected Increase in Formation Pressure
  - Negative Pressure Testing Failure
  - Underbalanced Mud
- Formation Fracture Due to Increased Pressure at Bottom Hole
  - Unexpected Overpressure Zone (After BOP is set)
  - Shallow Gas (Prior to Setting BOP)

Initiating Events
- Surge Effect
- High Pressure During Cementing
- Overbalanced Mud
- Incorrect Mud Density/Volume
- Incorrect Fracture Pressure Data/Weak Formation
  - Ballasting Failure
  - Loss of Adequate Thrusters
  - Loss of Position Reference
  - Severe Weather/Currents
  - Human Error
  - Collision
  - Incorrect Mud Density
Example Event Tree for Response to an Unexpected Overpressure Zone While Drilling
Notional Example of End State Probabilities with Uncertainty

- **Well Killed by Relief Well**: 1 in 604,000 (8.1E-6)
- **Well Killed by Well Cap**: 1 in 97,100
- **Well Killed by ROV**: 1 in 23,000
- **Limited Release**: 1 in 3,080

**Left-point**: 5th percentile
**Break-point**: Mean
**Right-point**: 95th percentile

**Probabilities**

- **Lowest Probability**
- **Highest Probability**
Data in this figure does not represent any particular facility. Rankings may be different for slightly different designs or operational procedures/practices.
Probabilistic Risk Assessment: Applications for the Oil & Gas Industry
1. Why is NASA’s experience relevant to offshore oil and gas?

2. What is Probabilistic Risk Assessment (PRA)?

3. What is the relationship between NASA and BSEE Headquarters?

4. What is NASA presently doing with Anadarko Petroleum Corporation and with Shell International Exploration and Production?
Mission Statement: The Bureau of Safety and Environmental Enforcement (BSEE) works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.
NASA – BSEE Interagency Agreement

March 17, 2016

5 Year Agreement

NASA’s probabilistic risk assessment technique
NASA Tasks for 2017

PRA Procedures Guide for Offshore Applications (DRAFT)

Deep water Drilling PRA

Subsea Production Hardware PRA

PRA Data Needs
1. Why is NASA’s experience relevant to offshore oil and gas?

2. What is Probabilistic Risk Assessment (PRA)?

3. What is the relationship between NASA and BSEE Headquarters?

4. What is NASA presently doing with Anadarko Petroleum Corporation and with Shell International Exploration and Production?
End State: Loss of Containment

Initiating Events:
- Well Kick Occurs
- Loss of Position
“Well Kick” Initiating Event:
→ Human Error Dominates over Failure of Equipment

“Loss Of Position” Initiating Event:
→ Failure of Blind Shear Ram and Shuttle Valves were Important Contributors

Data used in this study are generic in nature. The current model results are viewed as preliminary at this time.
Dynamic Positioning System (DPS) Model

End State: Loss of Location

Initiating Events:
- Drift-off
- Drive-off
- Push-off

Class 3 Drilling Vessel
Expand the PRA Model to Include:

- BOP Surface Control Systems & Control System Sensors
- Emergency Disconnect Sequence
- Dead Man & Auto-Shear Sequences
- Hydraulic Lines and MUX Cables
- Mud System Sensors, Mud Logger Sensors; Driller Shack Sensors
- Tool Pusher Monitoring; Company Man Monitoring; Real Time Shore-Based Monitoring
New *Well Control Rule* from BSEE [30 CFR 250.734 (a)(3)] will require additional subsea accumulator volume for hydraulic fluids.