Significant improvement in well cost estimation and control is required

• Effective well cost estimation and control is critical
• Many poor practices across drilling industry
• Classification of costs provides a foundation
• Linkage to schedule, uncertainty and risks drives the outcome
• Probabilistic estimation has value typically not seen
• Effective well cost estimation and control workflow
• Time to do it right
  ➢ Drilling & Completion Cost Estimation and Control Framework
Drilling & Completion Cost Estimation and Control Framework

Class 1 – Detailed Control

- **Level 1**: Project Milestones
- **Level 5**: Working Level Schedules
- **High Level**: Detailed line item Analysis and mitigation
- **Activate Contingencies**

Class 2 – AFE Detailed Control Baseline

- **Level 2**: Project Summary Schedule
- **Level 4**: Functional Intermediate Schedule
- **Level 3**: Integrated Project Schedule
- **Major schedule & Cost Impact**
- **Mitigation & Management Plans Developed**

Class 3 – Budget Authorization 1st Control Estimate

- **Level 3**: Integrated Project Schedule
- **Detailed accuracy**
- **Characterization from probability analysis defines the accuracy for decision making**

Class 4 – Feasibility Preliminary Budget

- **Level 4**: Functional Intermediate Schedule
- **Level 5**: Working Level Schedules
- **High Level**: Detailed line item Analysis and mitigation
- **Mitigation & Management Plans Developed**
- **Activate Contingencies**

Class 5 – Concept Screening

- **Level 1**: Project Milestones
- **Level 2**: Project Summary Schedule
- **Level 3**: Integrated Project Schedule
- **Level 4**: Functional Intermediate Schedule
- **Level 5**: Working Level Schedules

**Scheduling**

**Risk**

- **Large range from Analogous Data**
- **Simple cost ranges**
- **Improved Confidence in values**
- **Final Distributions**

**Probability Analysis**

- **High Level**: Detailed line item Analysis and mitigation
- **Mitigation & Management Plans Developed**
- **Activate Contingencies**

**Probability Analysis**

- **S curves**
- **Tornado diagrams**
- **P10 / P50 / P90 Distributions**

**Final Distributions**

**Top Down**

- **Costs sufficient to enable early decision making**
- **Range is large.**
- **Wide accuracy, development of cost range character for decision making**
- **Defines the cost against which the drilling operation will be measured**

**Bottom Up**

- **Highly detailed cost tracking to provide manager with continuous detailed status against plan**
- **Reference for invoice reconciliation**
Why does the industry need to improve?

• Well feasibility costs drive the economic analysis – leading to a decision to implement a project.
• Drilling budget and AFE define a significant component of the expenditure of an operating company.
• Actual well costs define the expenditure made – provide reconciliation to the invoiced quantities.
Poor practices are prevalent

- Deterministic estimates used when uncertainty and risk prevail
- Wrong people make the estimate
- Estimators lack a defined system and training
- Contingency is a fixed percentage (often 10%)
- Probabilistic estimating is misapplied through lack of understanding
- AFE variances after overruns occurred
Cost classes follow a standard

- Defined by AACEI and DOE
- Logical stages that match well design / programming
- Creates consistency with facilities and FDP

<table>
<thead>
<tr>
<th>Estimate Class</th>
<th>Project Definition</th>
<th>End Usage</th>
<th>Methodology</th>
<th>Expected Accuracy range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 5 (0 – 2%)</td>
<td>Very low Limited effort Quick preparation</td>
<td>Concept Screening</td>
<td>Analogy, judgment, factoring, modeling</td>
<td>+30 to +100% -20 to -50%</td>
</tr>
<tr>
<td>Class 4 (2 – 15%)</td>
<td>Low Feasibility / study Preliminary budget approval / gate approval</td>
<td>Probabilistic</td>
<td></td>
<td>+20 to +50% -15 to -30%</td>
</tr>
<tr>
<td>Class 3 (10 – 40%)</td>
<td>Medium Budget authorization or control Support full funding, 1st control estimate</td>
<td>Semi detailed unit cost Probabilistic for risk / uncertainties</td>
<td></td>
<td>+10 to +30% -10 to -20%</td>
</tr>
<tr>
<td>Class 2 (30 – 70%)</td>
<td>High AFE Detailed control baseline Expenditures will be reported against this</td>
<td>Detailed unit cost Probabilistic for risk / uncertainties</td>
<td></td>
<td>+5 to +20% -5 to -15%</td>
</tr>
<tr>
<td>Class 1 (50 – 100%)</td>
<td>Complete Detailed Control Current control estimate</td>
<td>Detailed unit cost Deterministic with contingencies</td>
<td></td>
<td>+3 to +15% -3 to -10%</td>
</tr>
</tbody>
</table>
Probabilistic estimation is a powerful tool

• Most effective method to incorporate uncertainties & risks
  – quantified
  – graphically displayed
• Transparent method to view through class development
• P90 provides a logical contingency funding level
• Methodologies exist to correctly apply Monte Carlo simulation
  – Distribution types for time / cost variances
  – Roll up to limited summed activities / costs
“S” Curve development for a well

- View the effects of uncertainties
- View the effects of risks
- Define the contingency based on transparent logic

Base well cost estimate considering uncertainties in costs and activities.

Total Contingency summed from identified contributors.

Base well cost estimate adding risk events and impacts.
Maturing the cost estimate effect on “S” curve

- Maturing the cost estimate alters the probability profile
- Later cost estimates ought to fit within earlier cost estimates unless the scope has changed

Probabilistic estimate matures, curves become steeper:
- Less risk
- Less uncertainty.

Most likely well cost ranges reduced as risks and uncertainties are managed during the planning process:
- Mean
- P10/P90
Tornado diagrams rank the sources of uncertainty

- Visually identify most influence
- Identify opportunities to invest to reduce uncertainties and risks based on their hierarchical influence on the well cost.
Well cost estimation and control can be improved significantly through adopting an effective workflow

- Design a suitable well cost template
  - Activity based costing
- Define responsibility – Drilling Department
- Adopt the cost classes
- Link to schedule and risk management
- Distinguish Exploration / Appraisal from Development well cost cycle
Class 5 – Concept Screening
- Level 1: Project Milestones
  - High Level
  - Risk
  - Probability Analysis
  - Scheduling
  - Top down

Class 4 – Feasibility
- Preliminary Budget
- Level 2: Project Summary Schedule
  - Major schedule & Cost Impact
  - Mitigation & Management Plans Developed
  - Detailed analysis & mitigation
  - Increased Granularity
  - S-curves
  - Tornado diagrams
  - P10 / P50 / P90 Distributions
  - Final Distributions
  - Wide accuracy, development of cost range character for decision making
  - Defining the cost against which the drilling operation will be measured
  - Level 3: Integrated Project Schedule
  - Level 4: Functional Intermediate Schedule
  - Level 5: Working Level Schedules

Class 3 – Budget Authorization
- 1st Control Estimate
- Level 1: Project Milestones
  - Detailed line item analysis and mitigation
  - Large range from Analogous Data
  - Broad Range
  - Simple cost ranges
  - Top down

Class 2 – AFE
- Detailed Control Baseline
- Level 1: Project Milestones
  - Activate Contingencies
  - Final Distributions
  - Top down

Class 1 – Detailed Control
- Level 1: Project Milestones
  - Reference for invoice reconciliation
  - Highly detailed cost tracking to provide manager with continuous detailed status against plan

SPE/IADC 173148 – Well Cost Estimation and Control – John de Wardt
Recommendations and Conclusions

- Develop a well cost estimation and control process based on best practice
- Follow the class levels
- Integrate schedule and risk into cost estimation
- Assign competent resources
- Apply probabilistic methods in a competent manner
- The cost ranges are the ranges – do not make them up
Acknowledgements

Co-Author: Susan Peterson, Risked Decisions

Thank You / Questions

John de Wardt