Decision-Making Technology for Oil and Gas

Using the industry's only genuinely coupled hydraulic fracturing, wellbore, and reservoir simulator

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Quantitative Optimization

Market conditions, company objectives, and operational constraints are constantly evolving

Optimization must be multifaceted

Drilling inventory is a finite resource

Trial and error is an inefficient optimization method

The subsurface is complex and hard to predict

Computational models are now highly predictive
Dynamic Pricing Environment

Death, taxes, and volatility are constant
Optimal Design is a Function of Oil Price

At higher commodity pricing, tighter spacing prevails as greater interference is tolerated
Nuanced and changing objectives

- Each point is a specific design scenario
Nuanced and changing objectives

- Each point is a specific design scenario.
Nuanced and changing objectives

- NPV is not the only performance objective
- NPV is in competition with other metrics, like ROI
Rising Oil Price Lifts All Scenarios

- $40/bbl
- $55/bbl
- $80/bbl
- $100/bbl

Well spacing

Absolute NPV/section
Optimal Design is a Function of Oil Price

- $40/bbl
- $55/bbl
- $80/bbl
- $100/bbl

Well spacing

Absolute NPV/section
Why Optimal Design Matters

Well spacing

Absolute NPV/section

$40/bbl

$55/bbl

$80/bbl

$100/bbl
Why Optimal Design Matters

Absolute NPV/section vs Well spacing

$40/bbl

$55/bbl

$80/bbl

$100/bbl

7% loss in NPV/section
Need the Ability to Forecast Performance From Inputs

depletion  petrophysics  geology  geomechanics  well-landing

Kaufman et al., 2019
Who is ResFrac?

• ResFrac was founded in 2015 to support science-based decision making

• Leveraged years of research of co-founder Dr. Mark McClure at Stanford and UT at Austin

• Rapid adoption across the shale patch with 80%+ YoY growth since inception

• Only commercial modeling software that fully couples fracture, reservoir, and geomechanics dynamics

Case studies in every major basin co-authored with operators
ResFrac Provides a Holistic Modeling Software

Fracture Propagation

Geomechanics

Reservoir Flow

Economics

Only commercial solution to fully-couple fracturing, geomechanics, and reservoir
Why is Now Different?

The last five years have yielded unprecedentedly detailed, in-situ measurements of hydraulic fractures.

- Albrecht et al., 2022
- Raterman et al., 2019
- Cipolla et al., 2022
Why ResFrac?

Numerical models can replicate and **predict** these behaviors.
Collaborative Study Demonstrated Results Driven by Physics

- 7 Operators
- 10 High-fidelity data sets
- 4 Basins

Results and behaviors consistent within basins, different by basin
Coupled-Physics Unveils Parameter Dependencies

Well spacing

Cluster spacing

Proppant loading
Negative Returns to Increased Well Spacing

- Wells too close suffer from adverse interference
- Wells too far apart leave unexploited resource behind
Diminishing Returns to Increase Proppant

- Too little proppant and wells are under-stimulated
- Too much proppant and additional cost does not recover incremental
Coupled Model Reveals Symbiotic Relations

• Colored circles identify corresponding cases
• As well spacing is increased, optimizer tries to compensate by pumping more proppant
Applied Optimizations – HFTS 2

- Consortia of 16 operators and DOE funded most detailed analysis of subsurface to-date
- Detailed characterization and modeling of:
  - Fracture propagation
  - Depletion and productive zones
  - Communication between wells
Optimization Identified 60% Uplift in NPV/Section

• Optimized: landing zone, well spacing, cluster spacing, proppant loading
• Cluster spacing shows plateau then decreasing NPV/section
• Proppant loading shows returns to higher volumes until plateauing

Figure 19 Proxy model results - NPV/section vs Cluster spacing and Proppant loading at the optimal Well spacing
Chart showing point at which optimization released

- Steady growth across all markets
- Optimization and automation workflows now make up more than half the usage
Quantitative Optimization

Computational models are now highly predictive

Optimal design is a function of fracturing, reservoir, operational, and economic considerations

Modeling workflows empower operators to accelerate their innovation cycle
Thank you!

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Appendix
ResFrac was Founded in 2015 to Support Science-Based Decision Making

**Dr. Mark McClure**  
CEO and Co-founder  
Stanford PhD  
UT at Austin Professor  
Fracture and geothermal expert  
Harts 40 Under 40

**Dr. Charles Kang**  
CTO and Co-founder  
Stanford PhD  
Hank Ramey Award  
Optimization and hydraulic fracturing expert

**Garrett Fowler**  
COO  
Stanford MS  
Operator/service company background  
SPE Regional Technical Award

**Joe Frantz**  
Sr. Executive Advisor  
Previous executive roles at Range Resources and CEO of Unbridled Resources

**Dr. Mark Zoback**  
Sr. Executive Advisor  
Stanford Professor  
World-renowned geomechanics expert  
Countless awards