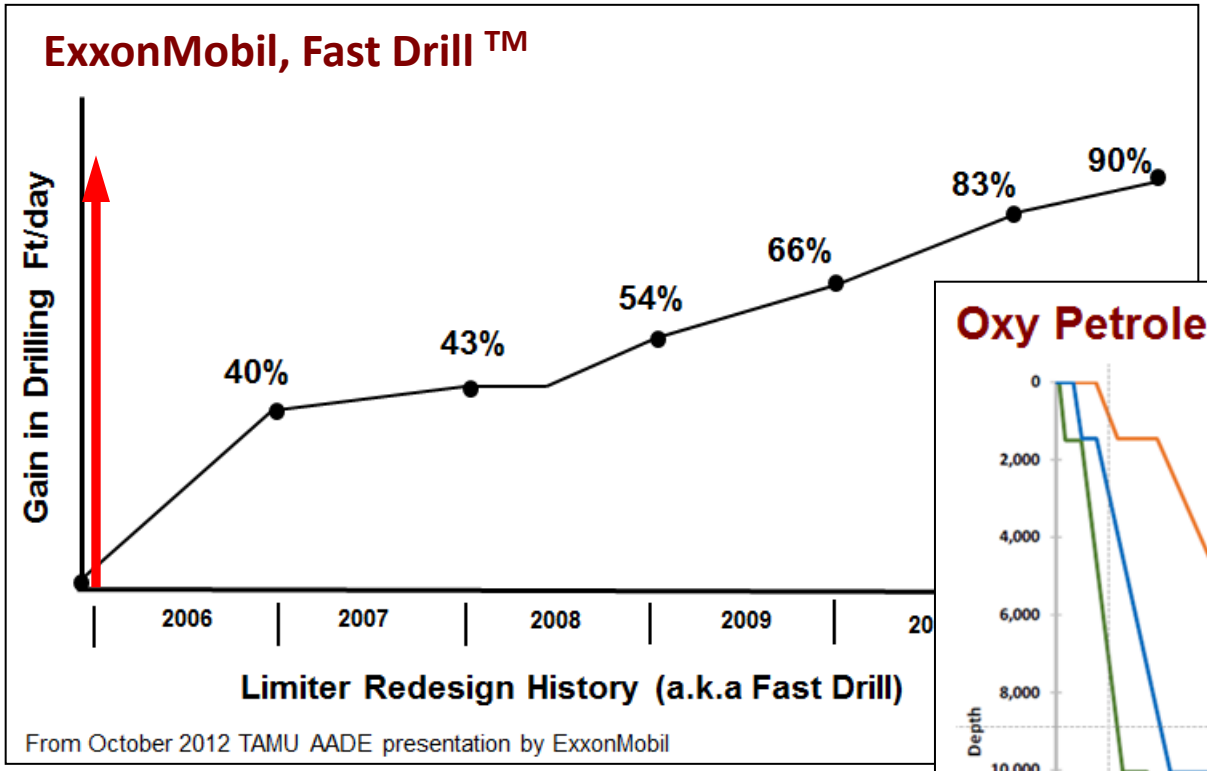
Physics-Based Drilling Practices

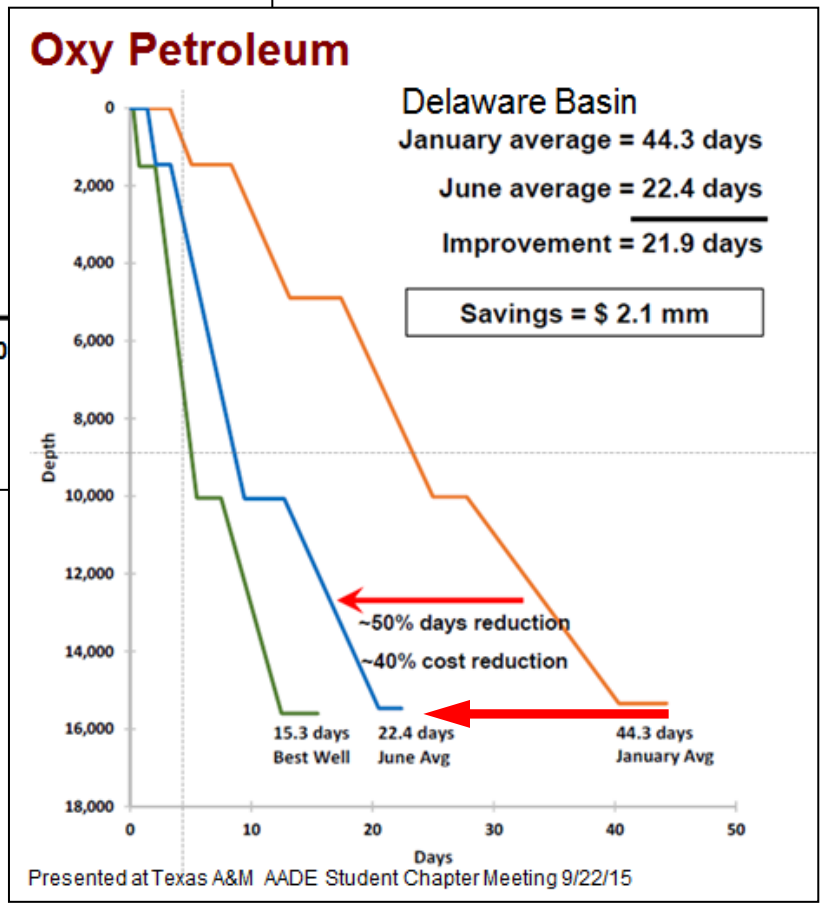
A Step Change in Geothermal Drilling Performance

2018 Geothermal Resource Council Annual Meeting
Reno, Nevada
14-17 October, 2018

Fred Dupriest P.E.
Texas A&M University

Somethings Different: Physics-Based, Limiter-Redesign

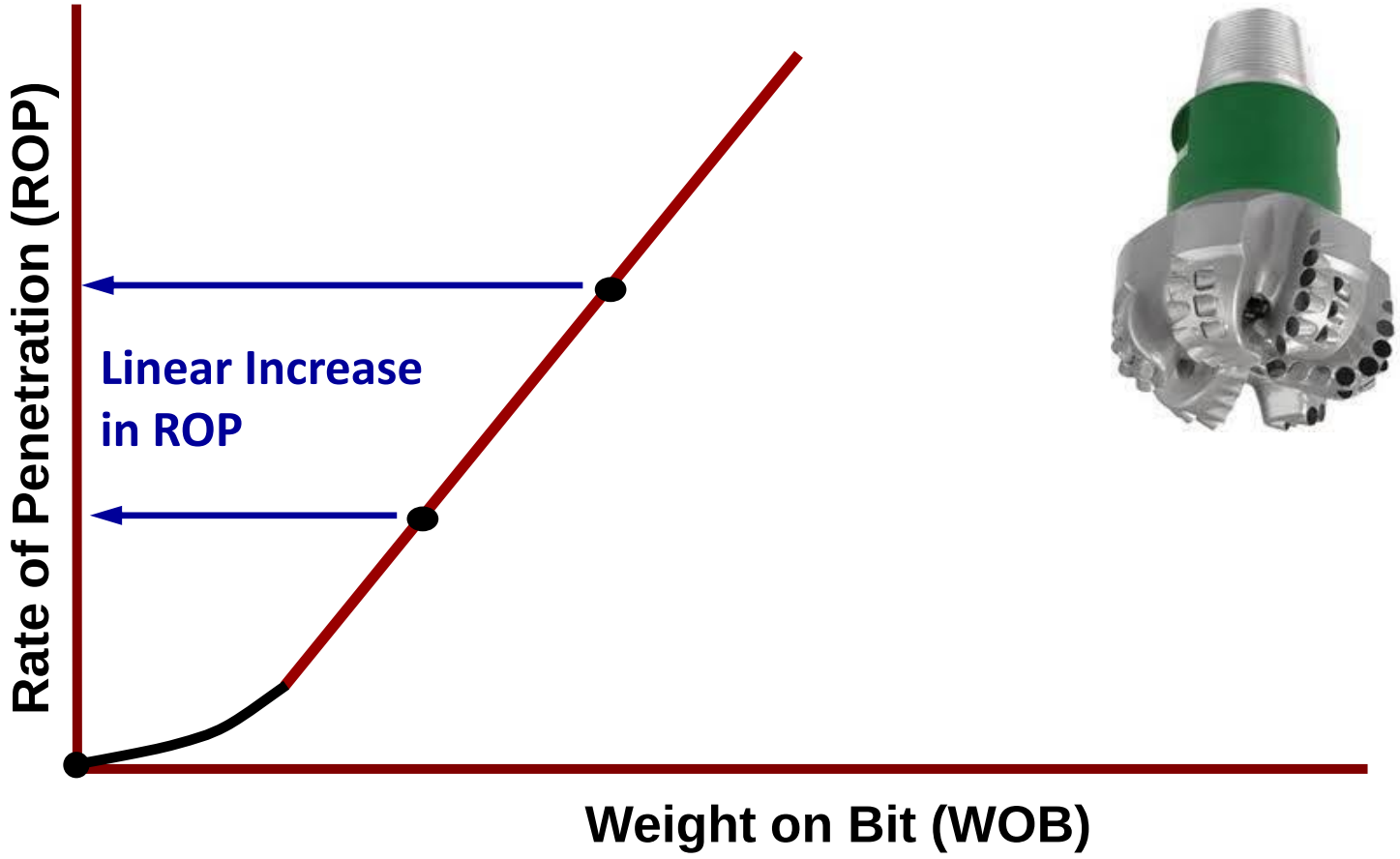




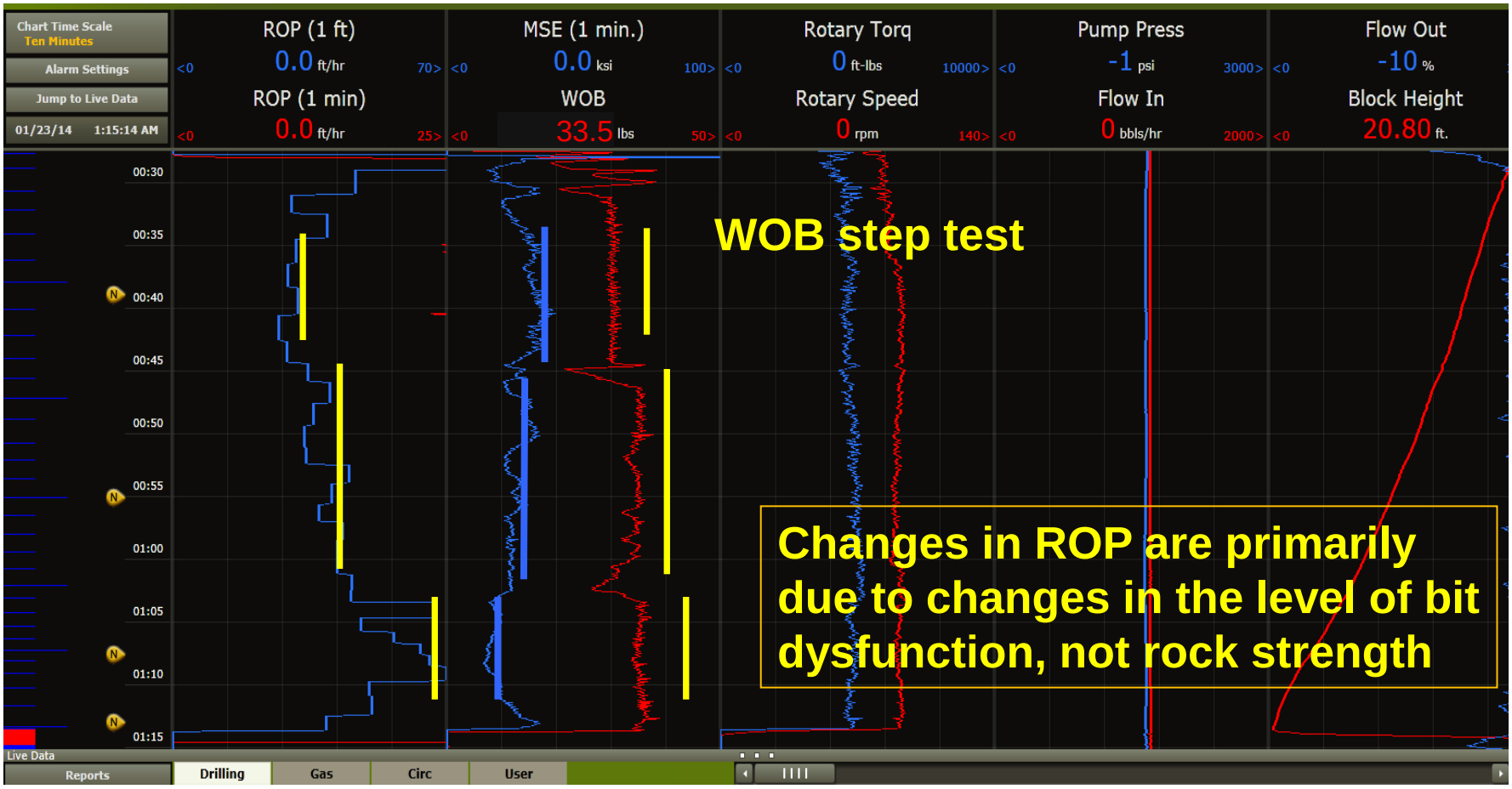
Change was due to "programmatic" initiative to Implement training and physics-based practices, as well as workflow changes to support continuously redesign of limiters

Basic Physics (How something really works)

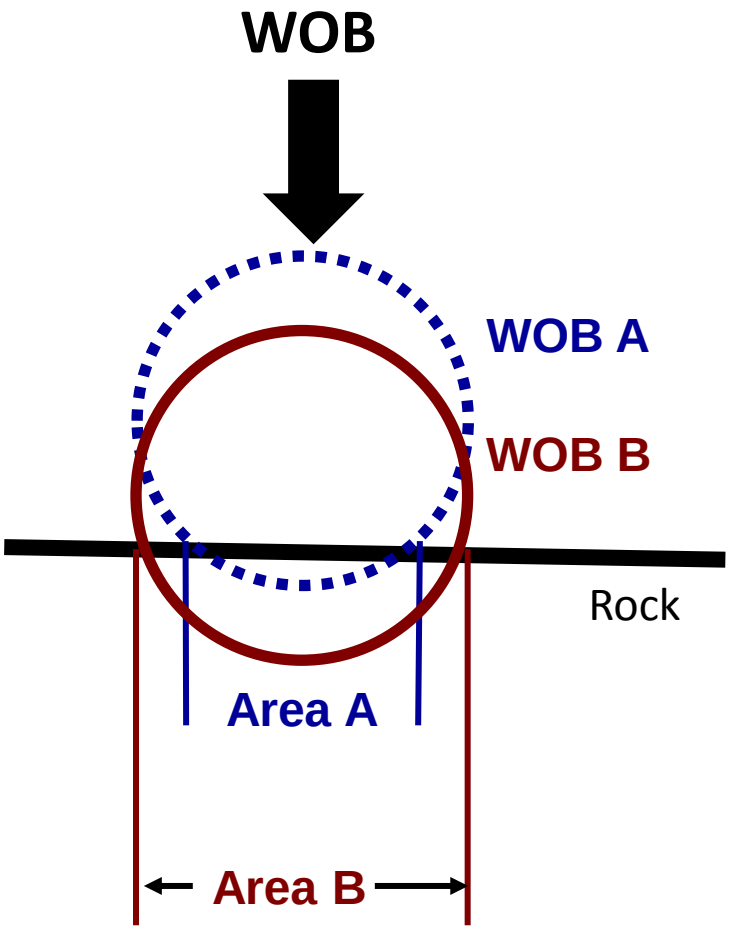
Drill rate is easy with an efficient bit. Just raise WOB or RPM and it goes up linearly with either. People don't know this.



Mechanical Specific Energy (MSE) Challenged Us to Understand The Physics of Everything (not be empirical)

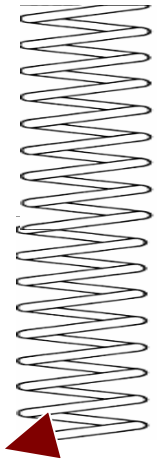


Some More Basic Physics:
Higher WOB Itself Does Not Wear the Bit Faster

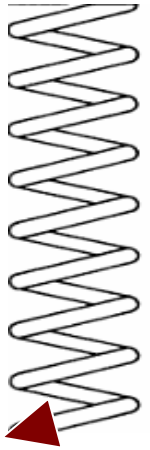


Bits wear at the tip from "sliding distance". Doubling WOB cuts sliding distance in half (wear/ft in half)

20k lbs WOB
@ 50 fph
32,038 ft of sliding

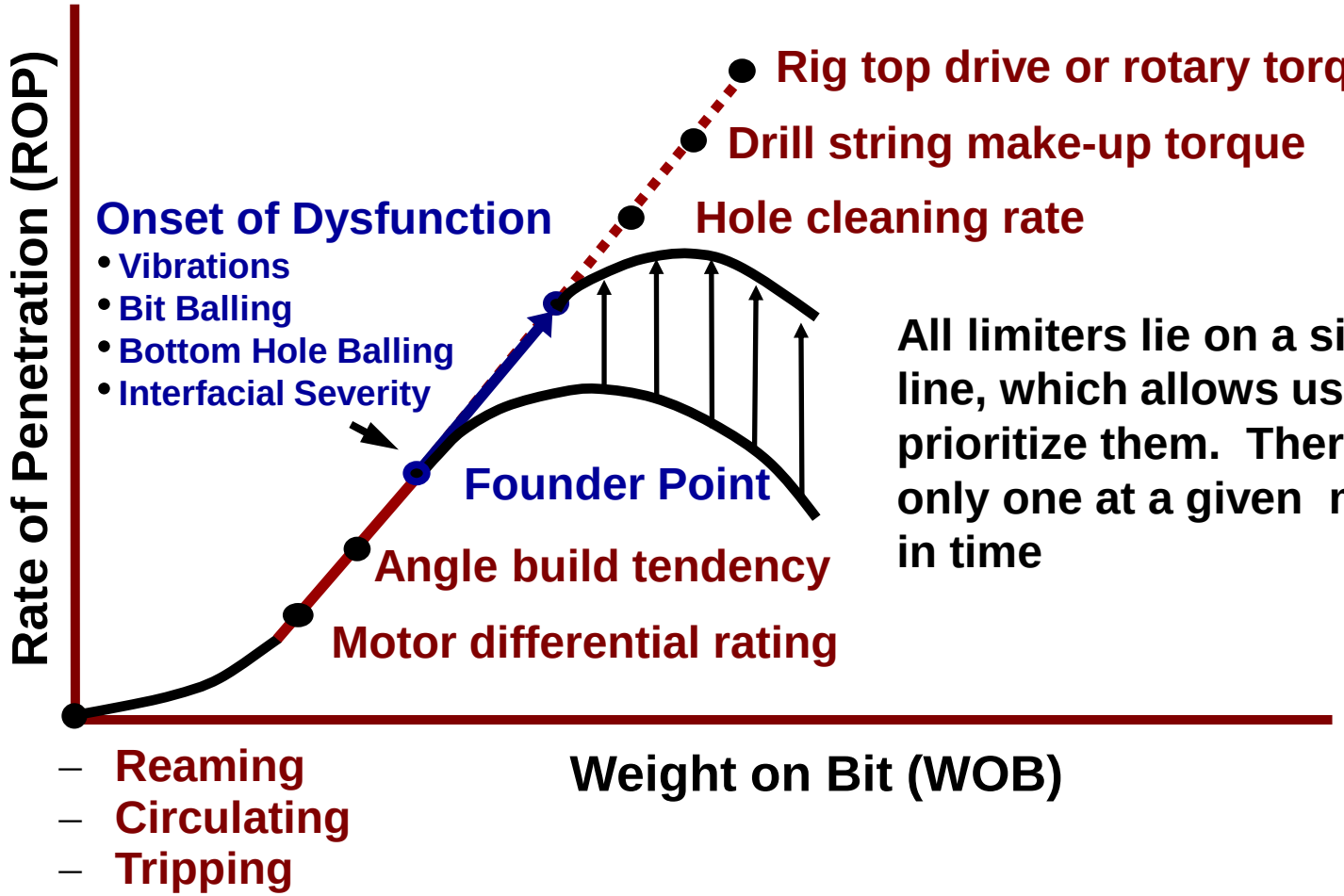


60k lbs WOB
@ 150 fph
10,679 ft of sliding



Limiter Redesign™

Run WOB step tests and identify what limits it. Redesign it until something else does. Repeat.



All limiters lie on a single line, which allows us to prioritize them. There can be only one at a given moment in time

Trouble Time Goes Down

If you just raise WOB empirically,
trouble time goes up the faster you drill

If you redesign what limits WOB before raising it,
trouble time goes down the faster you drill

We must teach the people how things really work (physics) and invent new workflow, or there's no fertile ground for physic-based practices or performance

A Path Forward for Geothermal

1. Compile existing physics and known redesign practices. Texas A&M's High Performance Drilling may be a good start (physics and 134 practices)
2. Develop changes in daily workflow to ensure the entire organization is working to continually redesign limiters (i.e., Limiter Redesign™, Pioneer PXDrill™, Apache HPD™, Oxy Drilling Dynamics™)
3. Conduct step tests and determine dominant limiters to WOB
4. Develop training and put the entire team in the room at the same time. Include all key vendor and contractor personnel. Management too.
    1. The physics (how things really work)
    2. What the driller can do in real time to extend the limiter (WOB)
    3. What the engineer can redesign post-drill to extend the limiter (WOB}
    4. Operator's workflow changes must be integrated into the training
5. Reinforce classroom training with surveillance of digital data by engineers and discussion of limiters in daily management calls. Keep redesigining.
6. Expect 2-3 years of leaning into the wind to change empirical to physics-based culture