Introduction to Torque and Drag

1/10/2023

#vdoorlocksmith

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Agenda

- Background
- History of T&D models
- Basics of how they work
- Applications for T&D modeling
- Common Misconceptions and Mistakes
- Some thoughts on software
- The Future

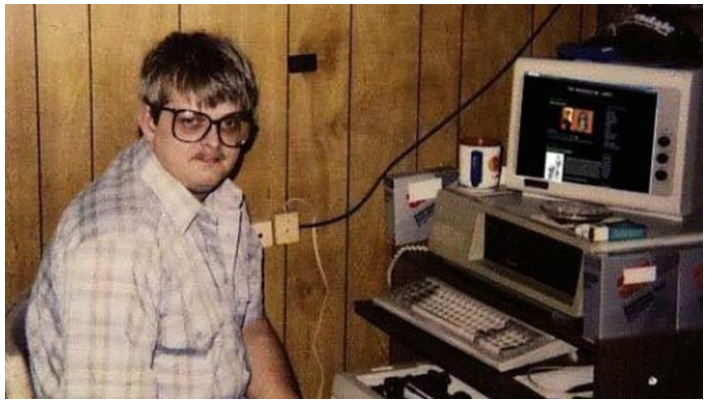
A Little Background

- Ranch Kid, Born in Montana
- Husband and Father of 3 Boys
- 23 years a DE
- Gearhead

What I think I do

What my kids think I do

What my Mom thinks I do



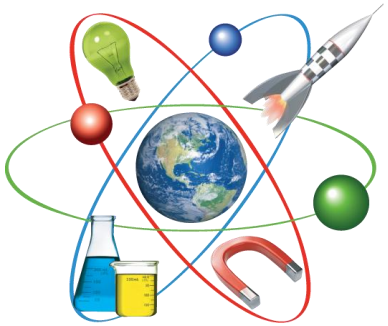
What I actually do

Thought Process

- Herrick outlined 4 methods that humans use to approach a problem

Herrick, David "Methodology: The Fivefold Way", Society of Professional Well Log Analysts, June 2002

Method	Data	Model
Drugs	X	
Religion		X
Science	X	X
Politics		



Vocabulary

- Friction (f) – Force that resists motion ($f=\mu N$)
- Coefficient of Friction (μ) – Empirical value that defines the ratio of friction force to normal force
  - Not the same thing as Friction Factor (FF), but often used interchangeably
- Normal Force (N) – Force pushing into the hole perpendicular to the wellpath
- Tension / Compression – Force acting along the axis of the string
- Torque – Force acting along the circumference that resists rotational movement
- Soft String – T&D model that assumes the string follows the path like a wet noodle
- Stiff String – T&D model that takes pipe stiffness into account

History

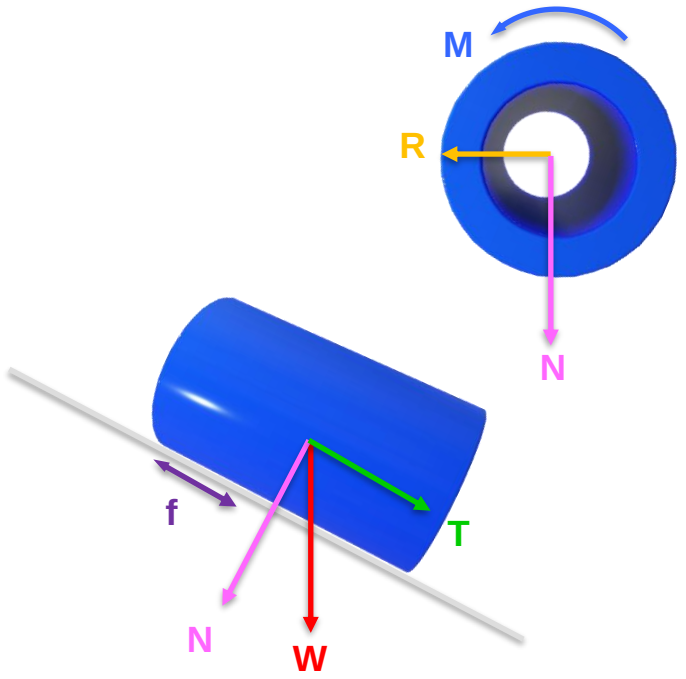
- 1984 – SPE 11380: Johancsik, Friesen, & Dawson (Exxon) – First Soft-String Model
- 1988 – SPE 18047: Ho – First Stiff String Model
- 1993 – SPE 25503: Wu & Juvkam Wold – First reliable buckling model
- A lot more has been said about the subject – give these names a search on onePetro
  - Dr. Robert Mitchell
  - Dr. Robello Samuel
  - Dr. Stefan Miska
  - Dr. Stéphane Menand
  - Colin Mason

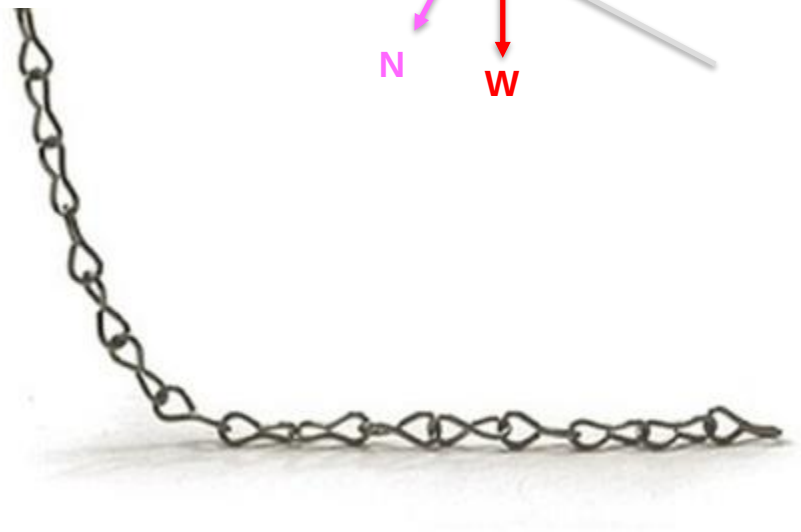
Facts About Friction That May Surprise You

1. Is proportional to the normal force
2. *Does not* depend on the contact area
3. *Does* depend on the two surfaces
4. Static is greater than dynamic
5. Speed does not change the amount of friction

How do the models Work?

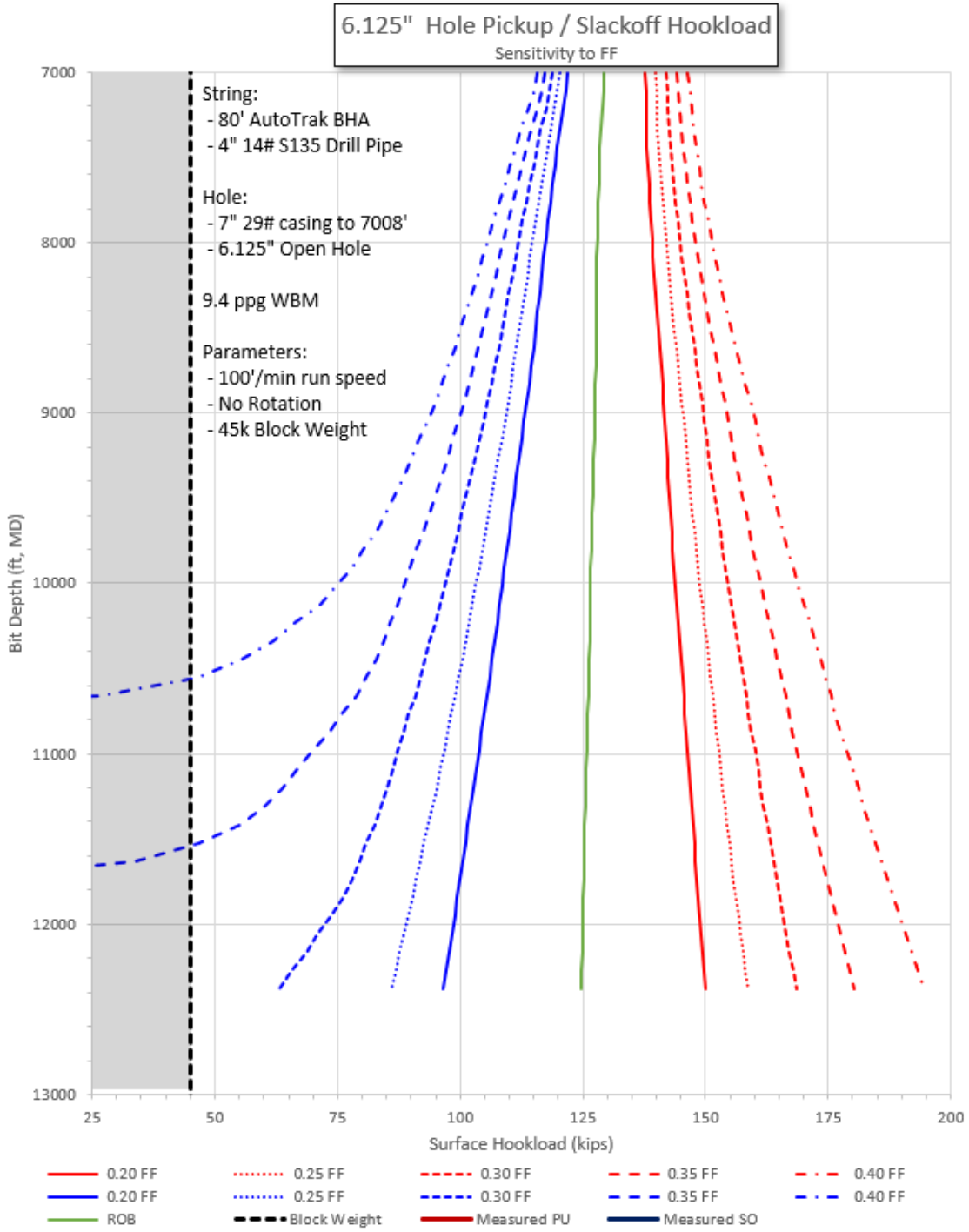
1. Breaks the string into small sections (usually 100')
2. Starting at the bottom, calculates;
   a) How much of the pipe weight (**W**) is trying to slide downhole (**T**)
   b) How much of the pipe weight is pushing into the side (**N**)
   c) Calculates Drag force (μ x **N**) = **f**
      - Adds **f** to **T** if we pull out
      - Subtracts **f** from **T** if we move down
   d) Calculates Torque force (μ x **R** x **N**) = **M**
3. Move to the next section up the hole and repeats

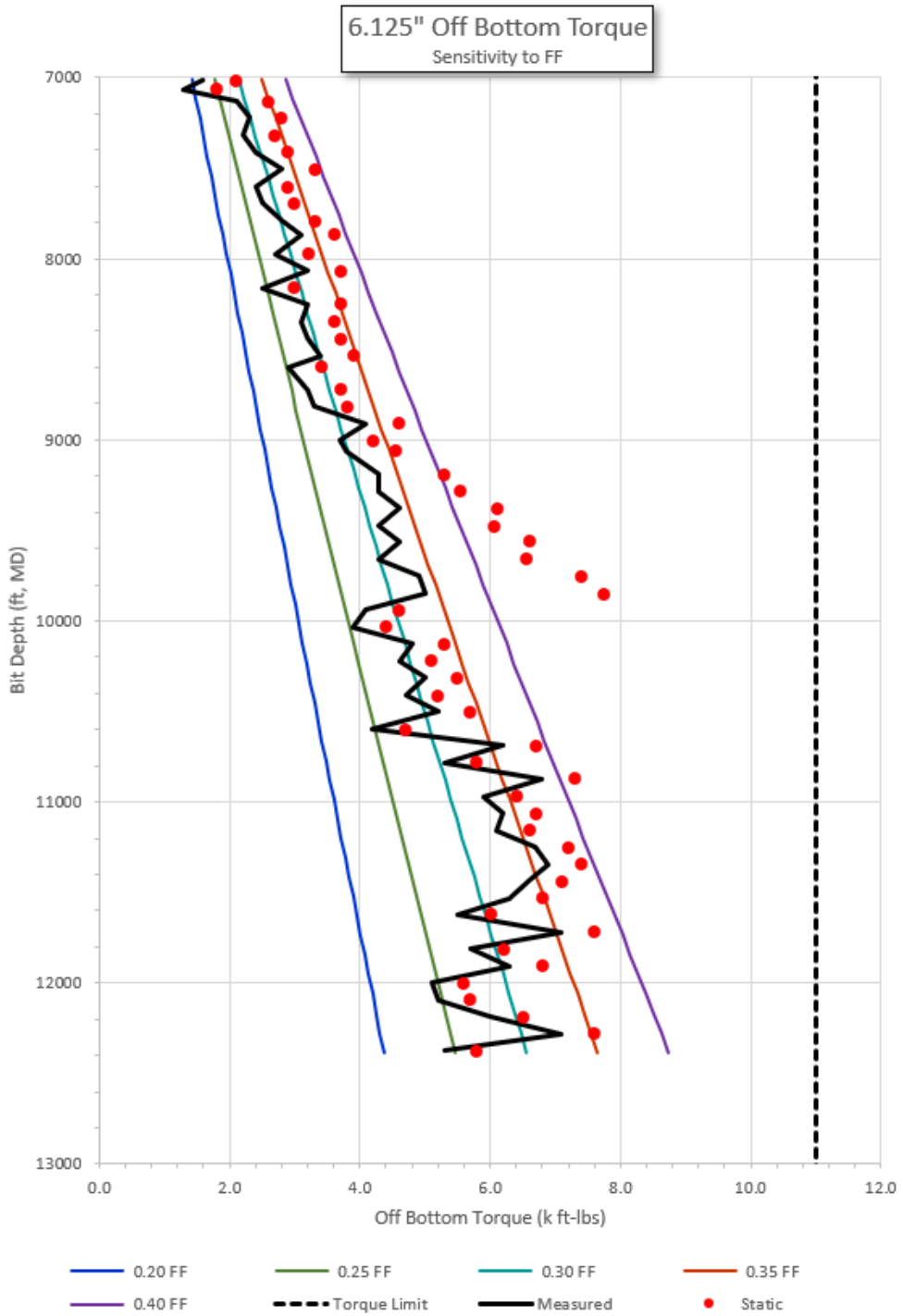




It’s a little more complicated…

- There are other factors that influence the drag / tension in the string
- Those that we can account for:
  - Fluid friction (pumping, surge, swab, etc.)
  - Additional normal force due to buckling
  - Additional normal force due to bending*
- Those that we can’t account for:
  - Cuttings bed height
  - Cuttings bed composition / lithology
  - Micro tortuosity
  - Differential sticking effects


6.125" Hole Pickup / Slackoff Hookload
Sensitivity to FF
String:
- 80' AutoTrak BHA
- 4" 14# S135 Drill Pipe
Hole:
- 7" 29# casing to 7008'
- 6.125" Open Hole
9.4 ppg WBM
Parameters:
- 100'/min run speed
- No Rotation
- 45k Block Weight
Bit Depth (ft, MD)
Surface Hookload (kips)
0.20 FF
0.25 FF
0.30 FF
0.35 FF
0.40 FF
ROB
Block Weight
Measured PU
Measured SO


6.125" Off Bottom Torque
Sensitivity to FF
Bit Depth (ft, MD)
Off Bottom Torque (k ft-lbs)
0.20 FF
0.25 FF
0.30 FF
0.35 FF
0.40 FF
Torque Limit
Measured
Static

Applications

Planning

- Drill string design
- Casing Design
- Rig sizing
- Casing and Drill Pipe Wear
- Trajectory planning
- Cementing Planning
- Centralization / Standoff
- BHA Tendency
- Liner Hangers and Packer setting
- Completion tool manipultation

Execution

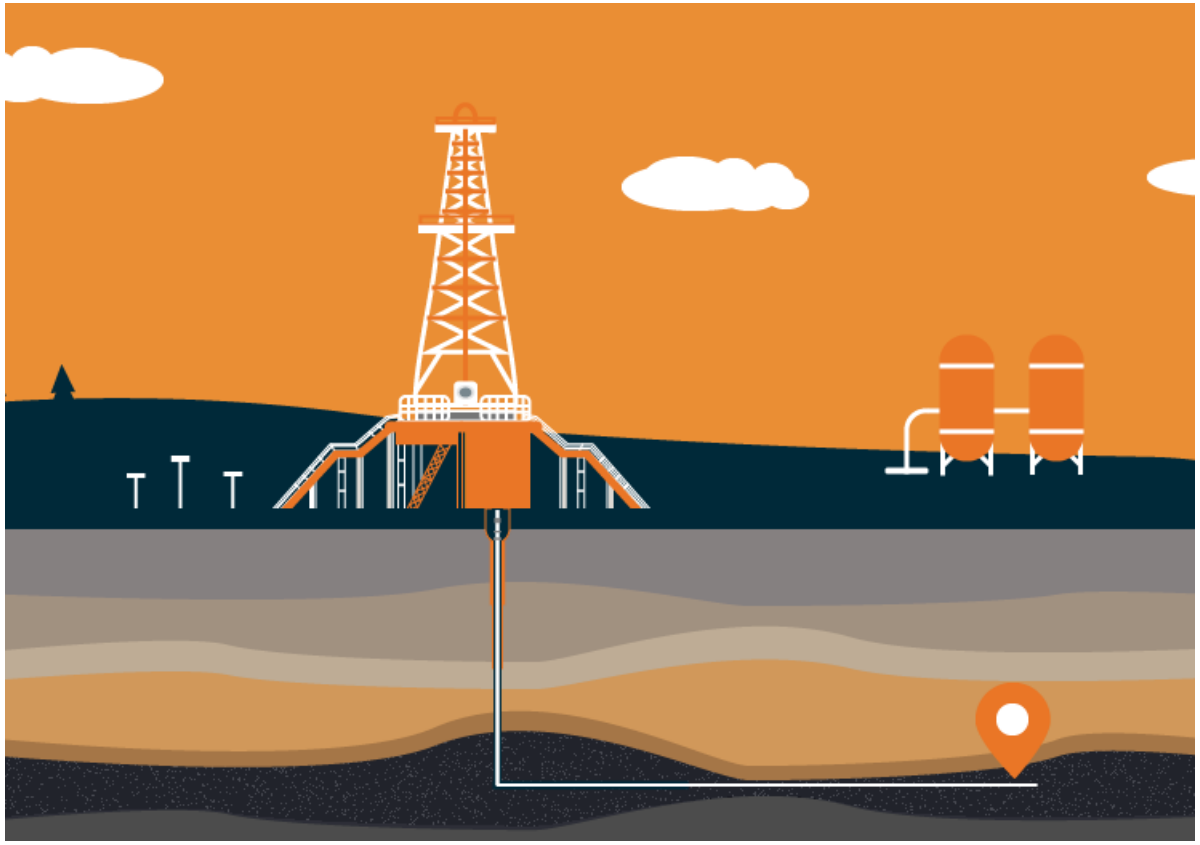
- Hole Condition Monitoring
  - Cuttings Bed Height
  - Differential Sticking
  - Wellbore Instability
  - Hole Geometry
- Cementing Operations
- Stuck Pipe Operations
- Sag Correction

Misconceptions

- The string is in compression when you are running in and in tension while pulling out
- The friction factor (FF) is the same for all operations
- A good FF is 0.20 in cased hole and 0.30 in open hole
- The FF is *known* and *controllable*
- Stiff string is more accurate than soft string
  - Sort of…
  - We don't know the hole size and shape
  - We don't really know the trajectory
  - Similar to measuring the diameter of a walnut…

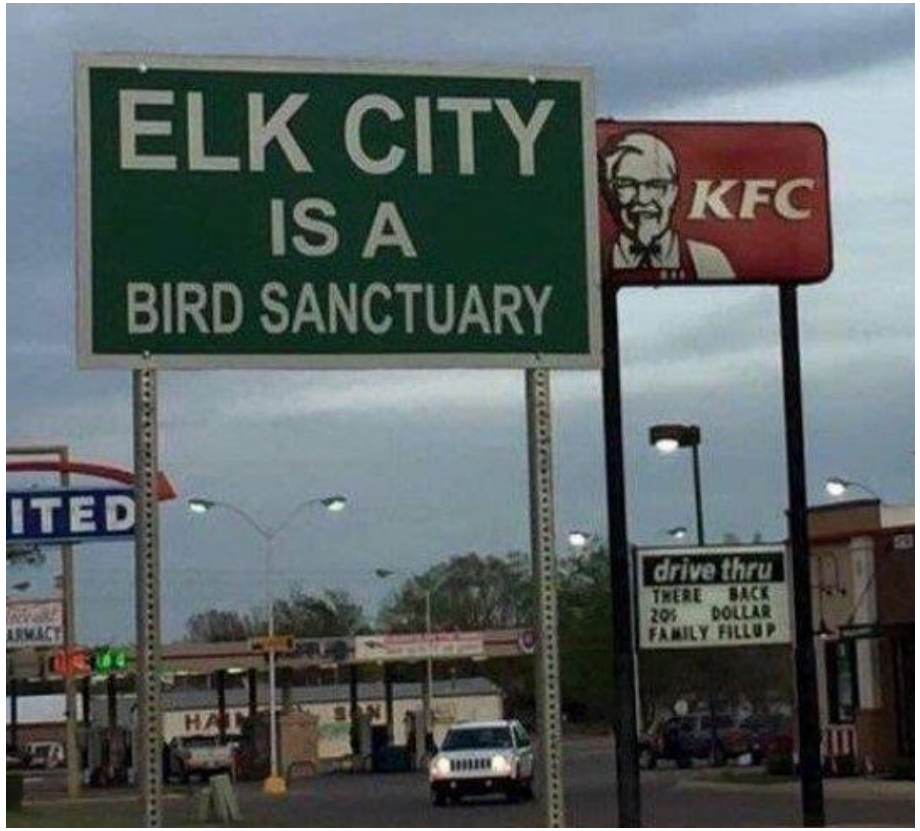
Most-Common Questions

- Are 2, 3, or 4 mile laterals possible in our field?
- Can we slide at TD, or do we need RSS?
- Do we need HWDP / where to place it?
- Do we need high torque drill pipe?
- Will casing slide to bottom?
- Do we need a bigger rig?
- How far can we drill?



Dumb Things We Do

- Assume wells longer than what we've drilled before aren't drillable
- Assume that crazy looking wellpaths aren't drillable
- Only run T&D in an attempt to prove what we already "know"
- Fail to investigate T&D implications on completions
- Drill the well, then run T&D
- Expect RSS to solve all our problems
- Expect the CoF and the FF to be the same number
- Lose sleep over macro DLS in the lateral
- Pay too-little attention to shallow DLS
- Ignore torque (until we can't rotate)
- Blame the mud when something goes wrong



Characteristics of Good Software

- Is “wellbore-focused”, not “scenario-focused”
- “Easy to Use”
  - Vast library of common components
  - Can copy/paste scenarios and components
  - Sensible default settings
  - Multiple sensitivities
  - Can view loads at different points in the string or wellbore
- Computations are quick (instantaneous) and automatic
- Graphical output with smart scales that can be conveniently manipulated
- Couples T&D and Hydraulics - computes them simultaneously

Characteristics of Bad Software

- Monolithic system built by a committee
- Structured by developers and data scientists rather than users
- Obsession with “the cloud”
- Redundant input
- No copy/paste
- Tons of options that no one understands
- Still uses original code from the 90’s
  - Has a “Run” or “Calculate” button
  - Writes to disk
  - Have to wait for calculations
- Separate Modules

HARBOR FREIGHT
QUALITY TOOLS LOWEST PRICES

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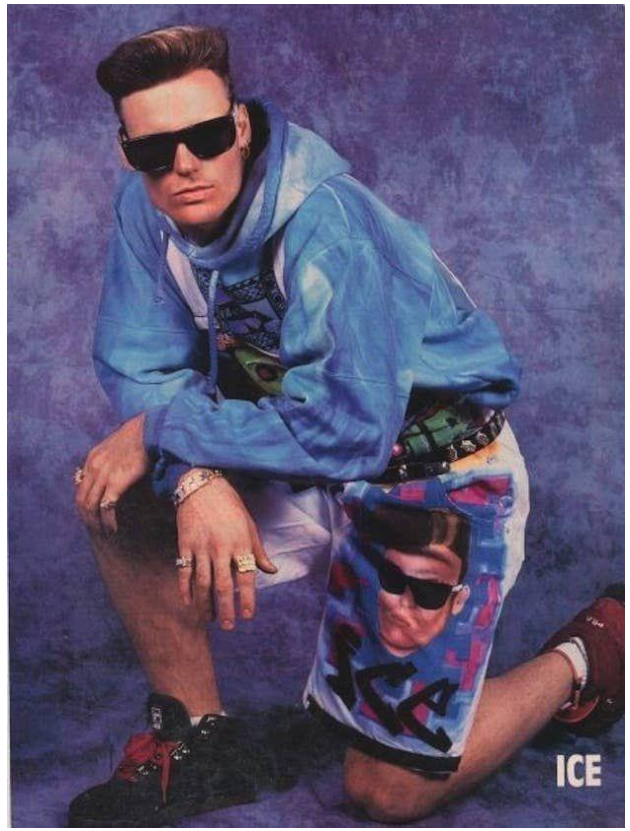
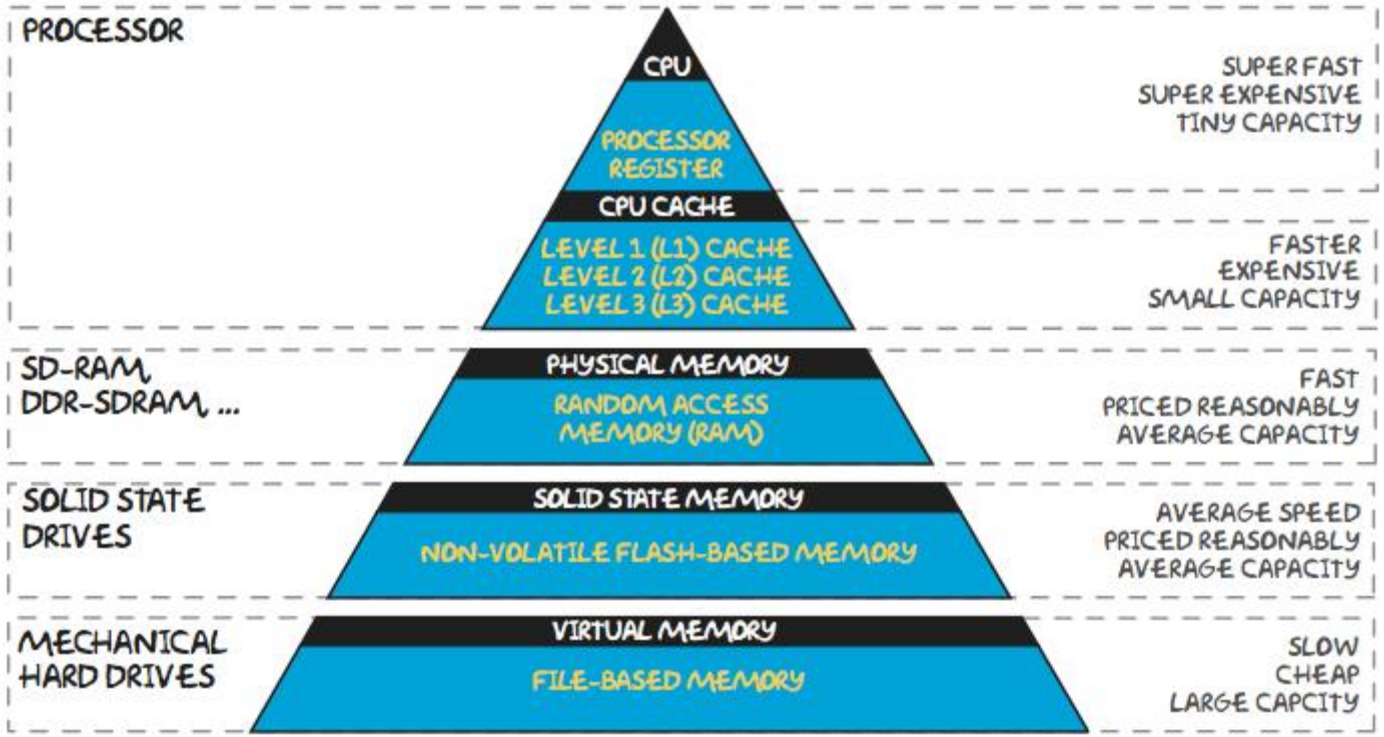
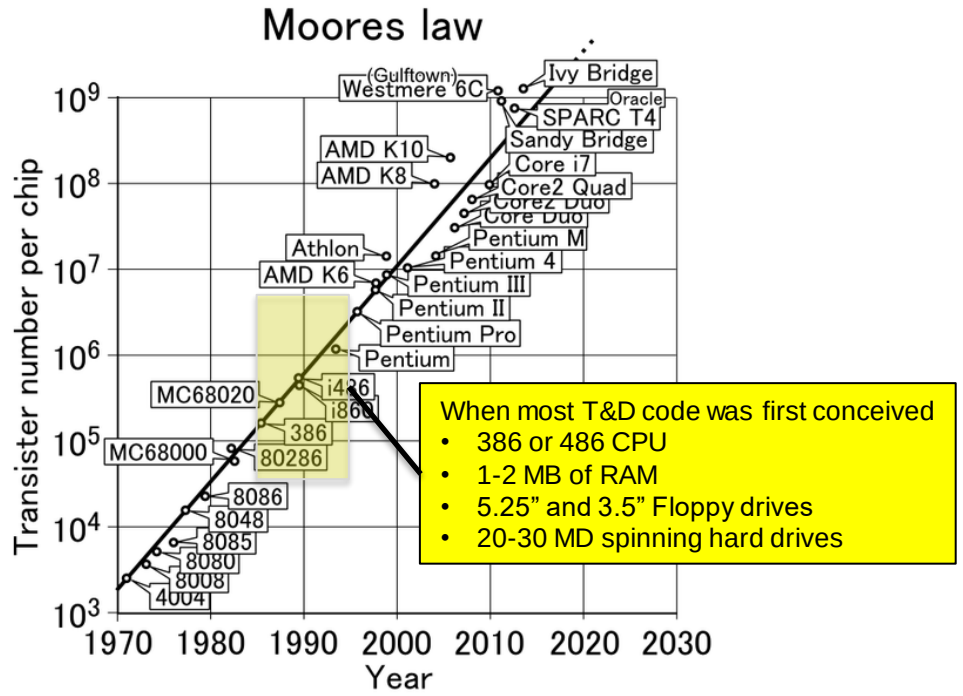


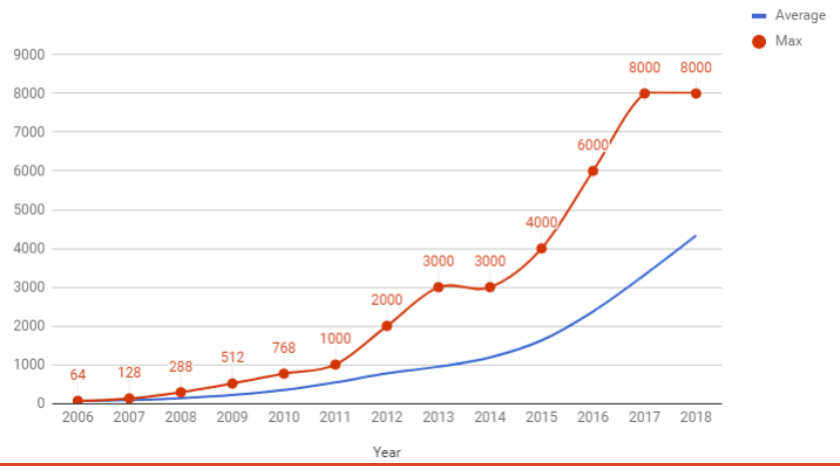
30 Years of Hardware Advancement





When most T&D code was first conceived
- 386 or 486 CPU
- 1-2 MB of RAM
- 5.25” and 3.5” Floppy drives
- 20-30 MD spinning hard drives

RAM capacity through the years (in MB)



2023 New Years T&D Resolutions

- DE's: Participate in this series and become comfortable and competent running T&D
- Management: Buy your DE's good software and pay for them to learn how to use it
- Software : Keep investing. Make it better, faster, and easier to use. Listen to the users.
- AI Companies: You current offering isn't all that useful – let's improve this year!
  - Can't do planning
  - Can't manipulate inputs
  - Doesn't account for hydraulic friction, fillups, flotation, reaming, centralizers, swivels, etc.
  - Some of them don't even use a physics model!
    - *Data without a model isn't science*

The Future for Software

- T&D software needs to integrate hydraulics and geomechanics *without over-complicating things*
- T&D and Hydraulics models need to feed into rig instrumentation – SMARTin Decker??
  - We *<u>really</u>* need modeled vs. actual T&D and hydraulics on the cement unit
- Software that hasn't had a full overhaul in the past 15-20 years… **should**
  - Just like a small-block Chevy, after 100,000 miles you need to rebuild it
  - Technology is better today than it was in 1985 – fuel injection, electronic ignition, tighter tolerances
  - While you're at it, why not do an LS swap and a twin-turbo kit? We'd all have a lot more fun…