CALIBRATION OF A NEW TRANSIENT CT MODEL USING DOWNHOLE LOG DATA

ICoTA Round Table

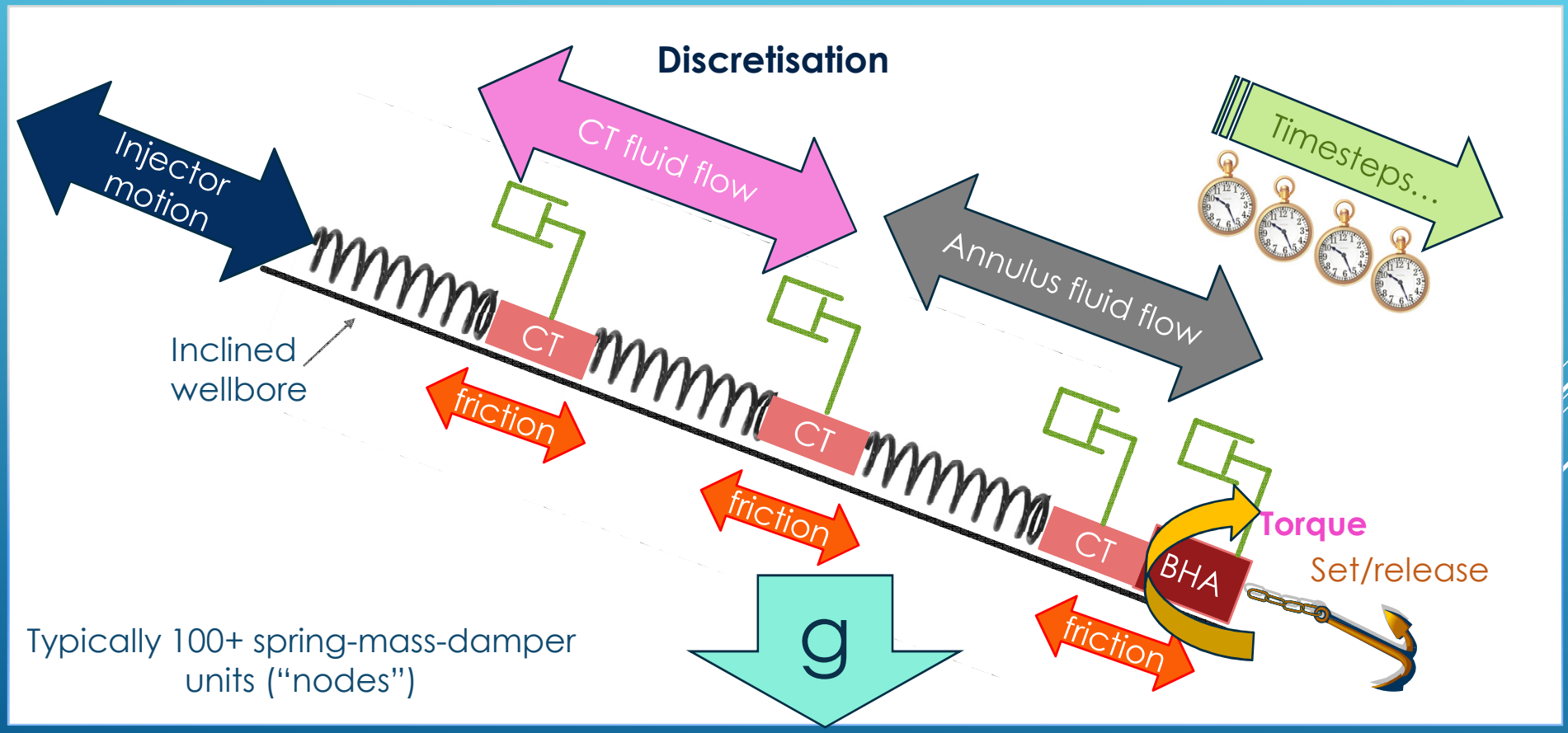
By Standen Scientific for NCS Multistage

21st October 2015

WHY A MODEL?

- Better understanding of BHA motion
  - Aid in tool operation
    - Locating and operating procedures
    - Interpretation of surface weight observations
  - Aid in tool development.

Model Parameters



FLUID DAMPING ALGORITHM

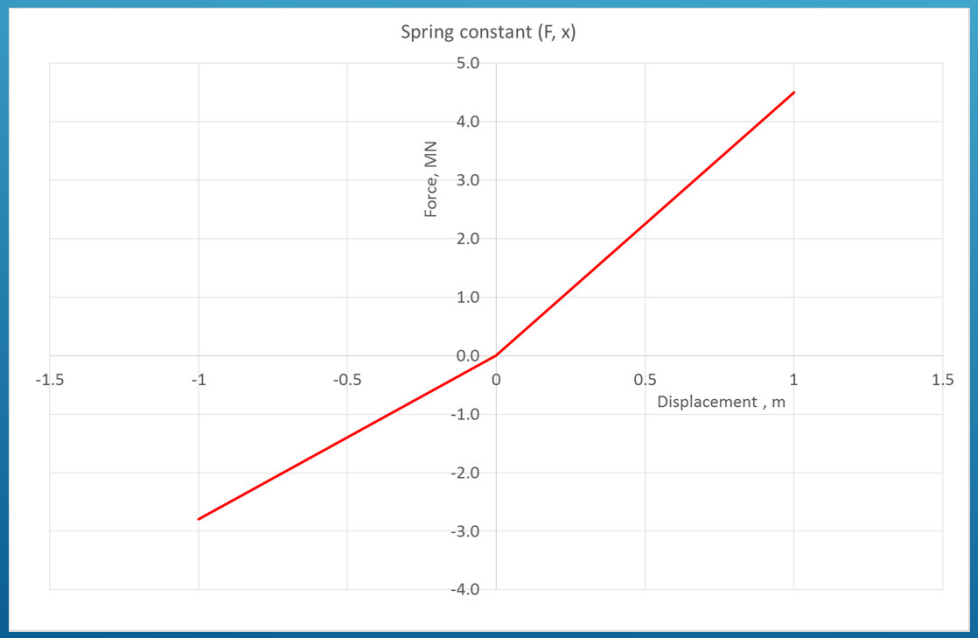
- Uses impulsive shear flow model
  - "Introduction to Fluid Mechanics", JL Fay, ch 6.
  - Each CT node has a subsidiary set of fluid nodes to solve the time-dependent fluid shear field.

FRICTION MODEL

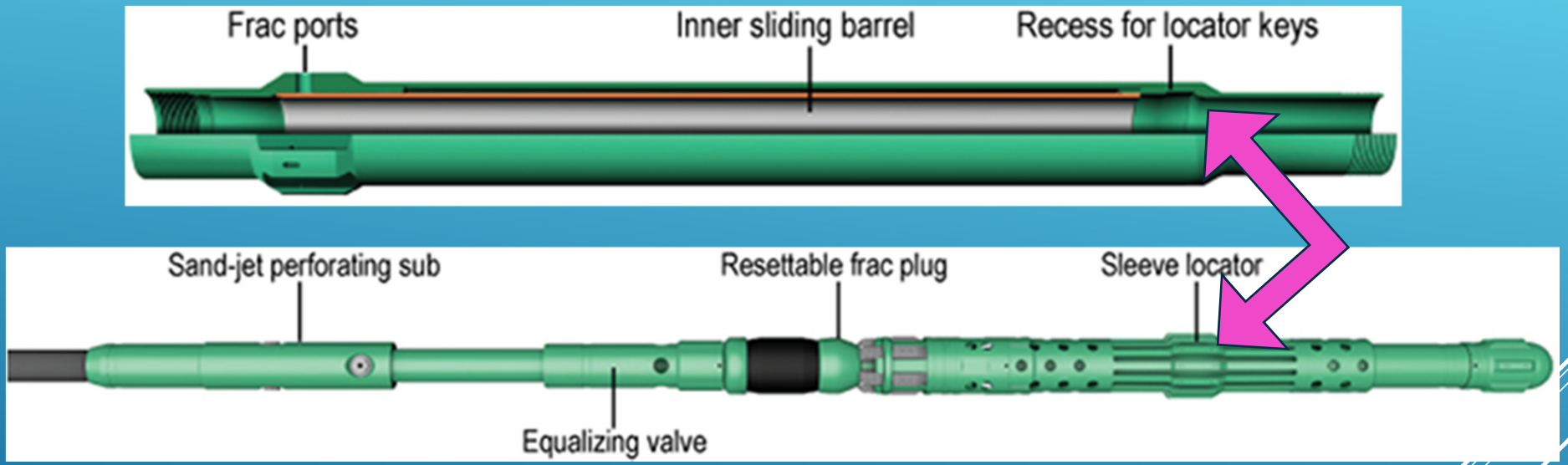
- Coulomb model
  - Coefficients for static and dynamic friction.
  - Stick/Slip is solved by including the available momentum change (per timestep) in the force balance on each node.
- Helical buckling
  - Non-linear contact force & friction are included.

SPRING CONSTANTS & BUCKLING

- Hooke's law if in tension.
- Helically buckled if in compression.
  - Assumes residual curvature of CT overrules sinusoidal transition.



BHA & SLEEVE


Frac ports
Inner sliding barrel
Recess for locator keys
Sand-jet perforating sub
Resettable frac plug
Sleeve locator
Equalizing valve

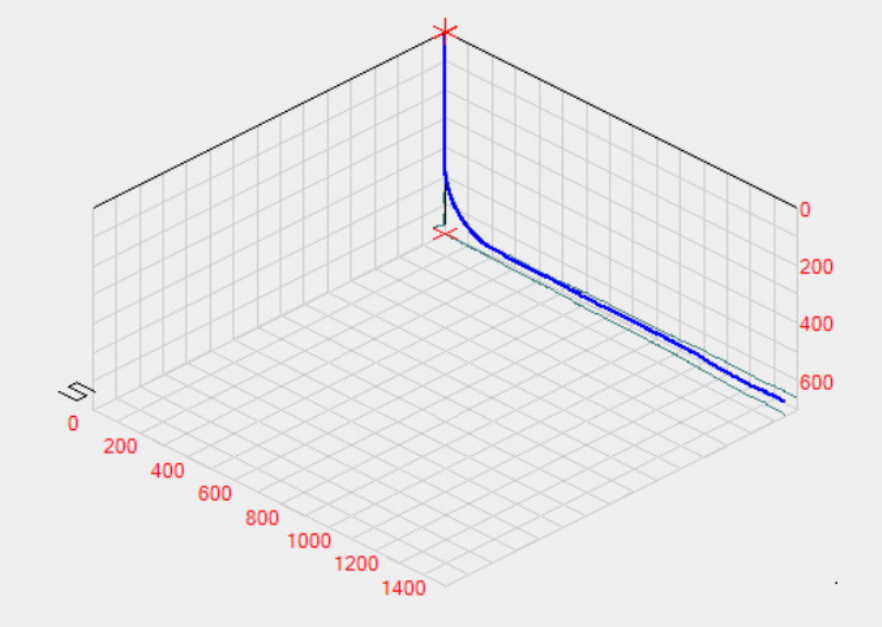
BHA FOR FIELD CALIBRATION

Push/pull force
Accelerometer
Pressure
Temperature

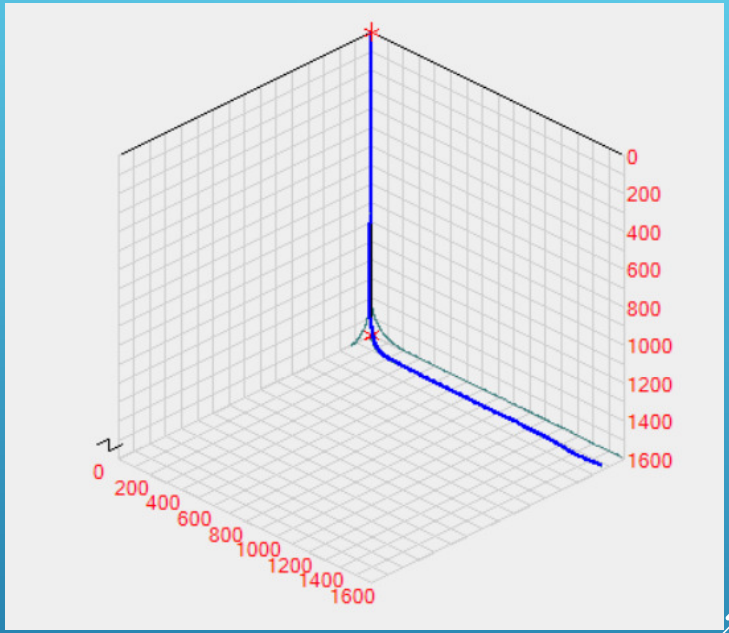
Memory gauge subs

Push/pull force
Pressure
Temperature

WELLS



Job 001
4" id 16 sleeves
CT string 2 3/8 0.156

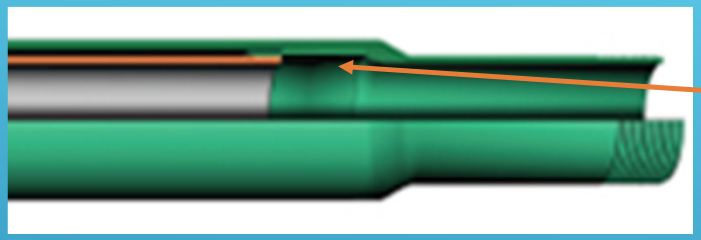


Job 013
4" id 25 sleeves
CT string 2 3/8 0.156

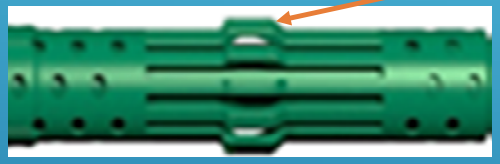
AVAILABLE DATA

- Surface
  - Weight, speed, pressures, rates.
  - 1 second intervals.
- BHA
  - Pressure, temperature, force, acceleration at 1 second intervals.
  - Acceleration burst mode when triggered by 1 g; 350Hz for 1.6 seconds.

CALIBRATION FOCUS



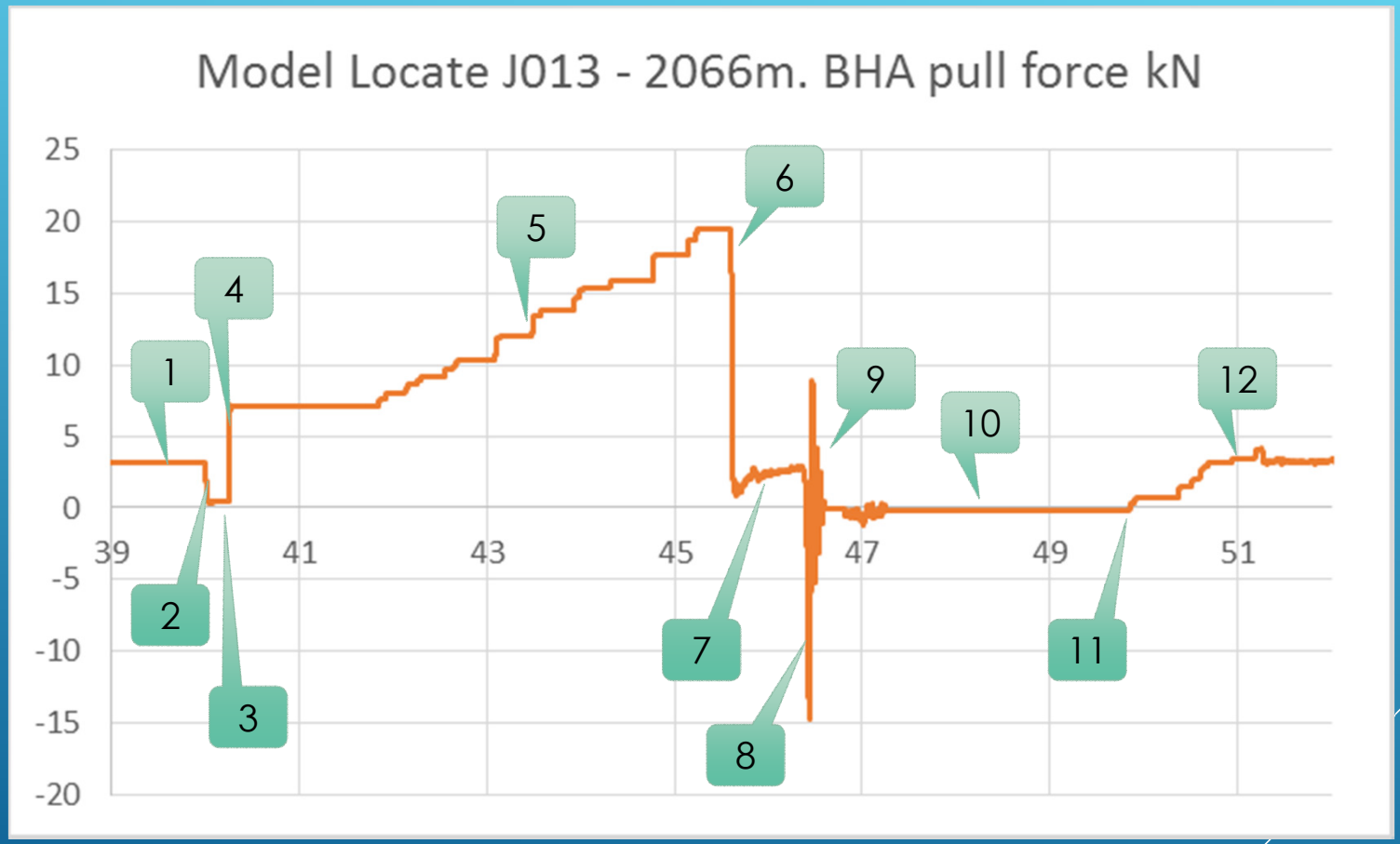
Recess is 46mm
Longer than keys



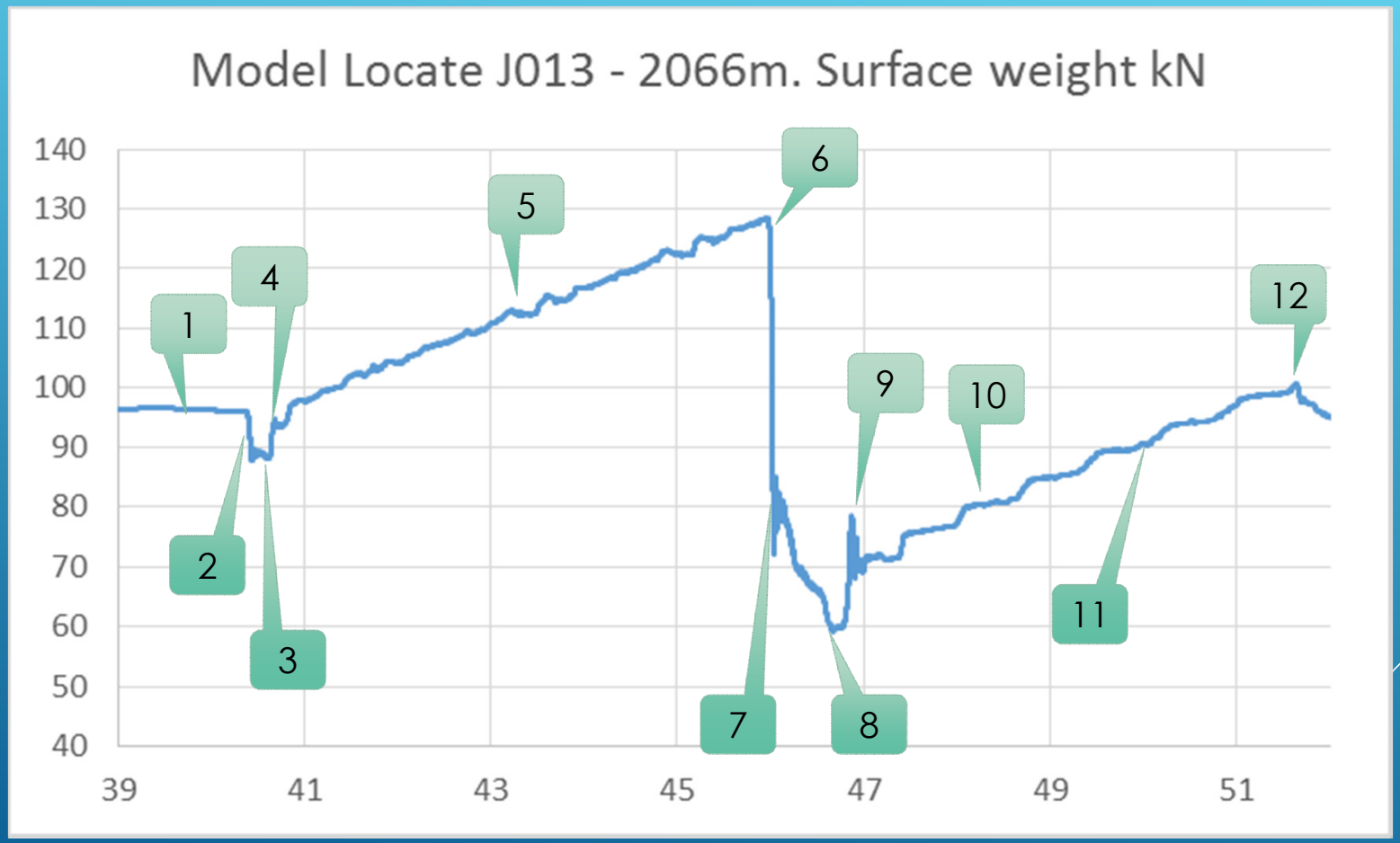
Locate at 5 m/min
Pull-thru at 5 – 12 m/min

"Locate" means pull thru to find the recess
then run back in to set.

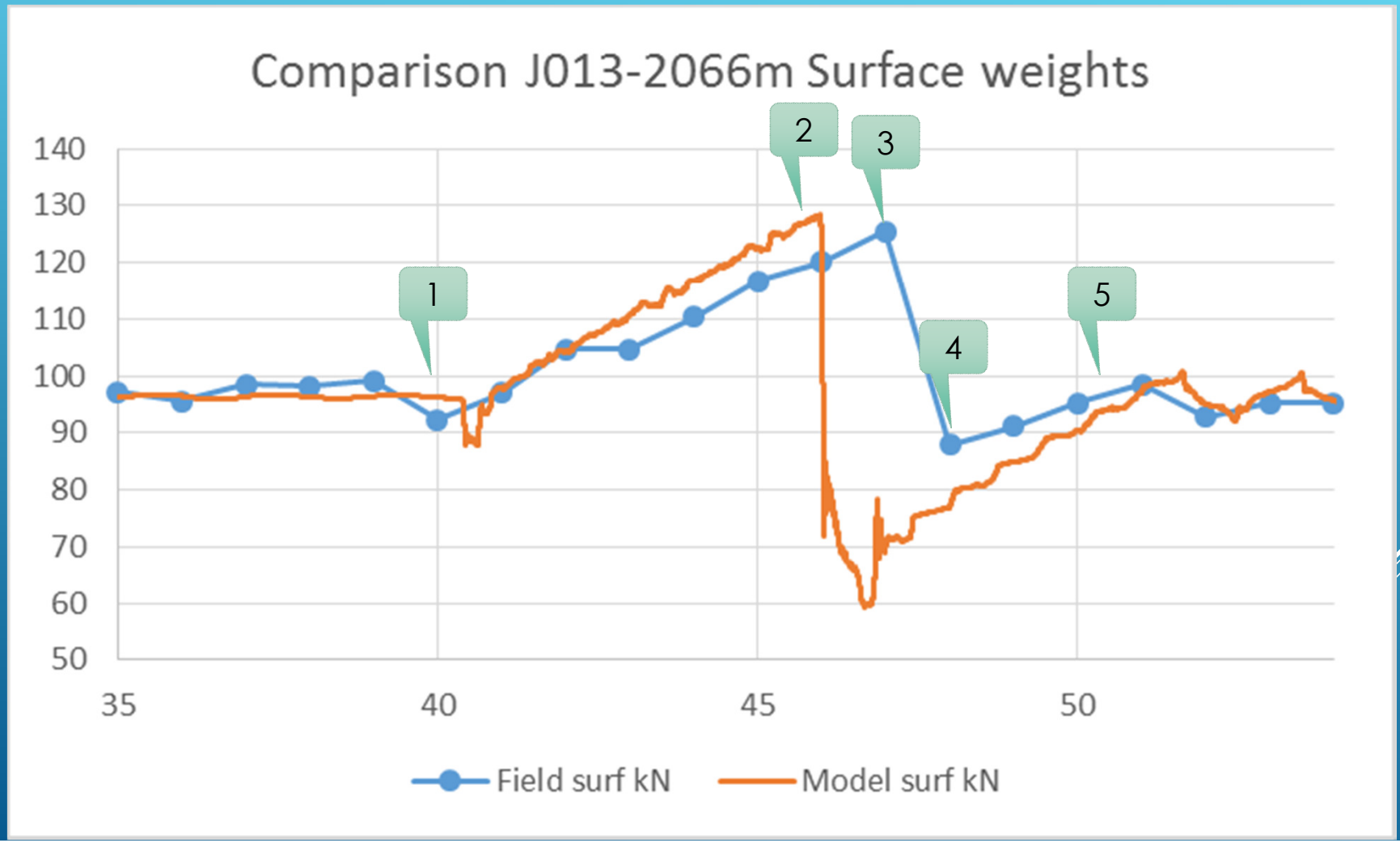
CALIBRATION POINTS – PULL FORCE



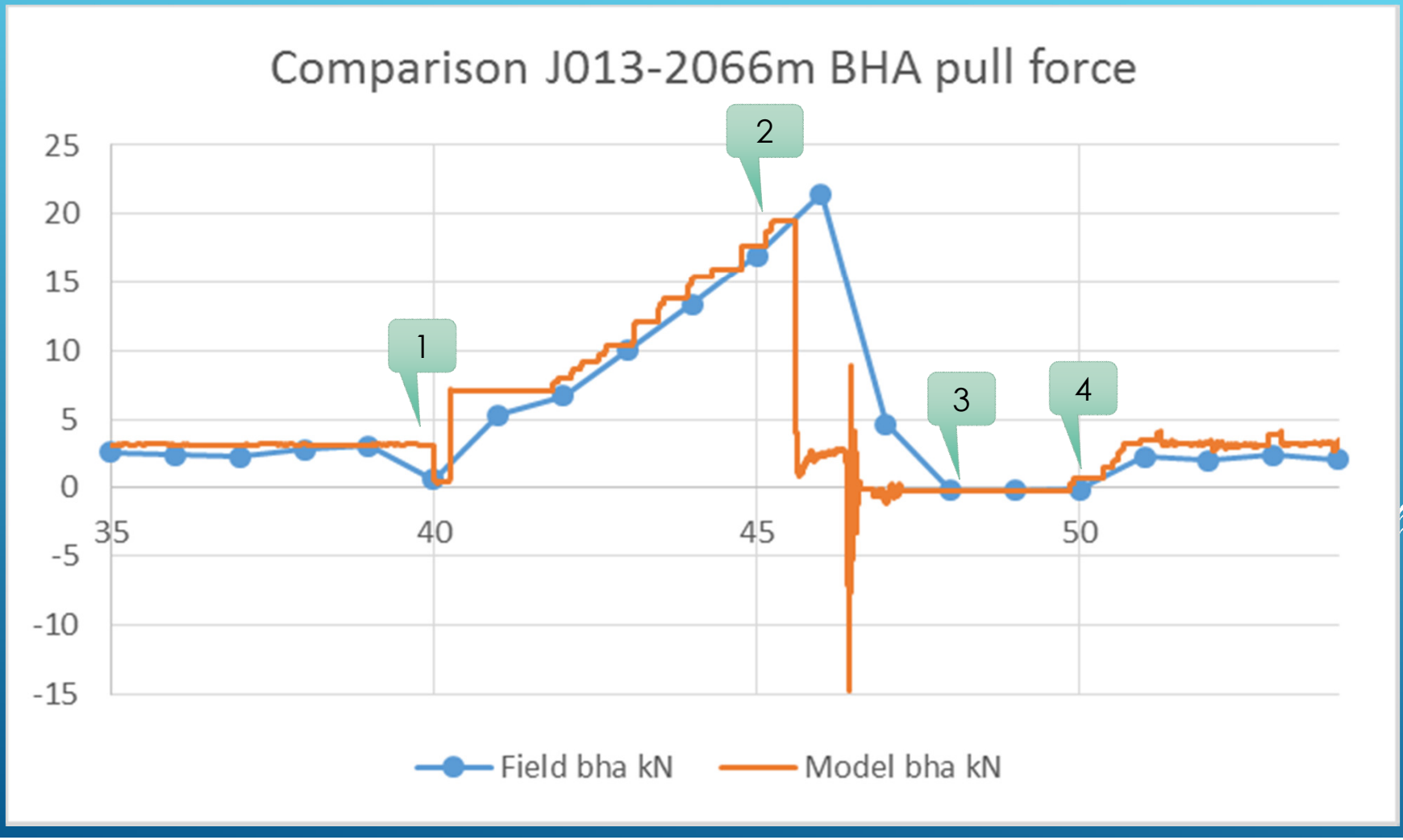
CALIBRATION POINTS – SURFACE WEIGHT



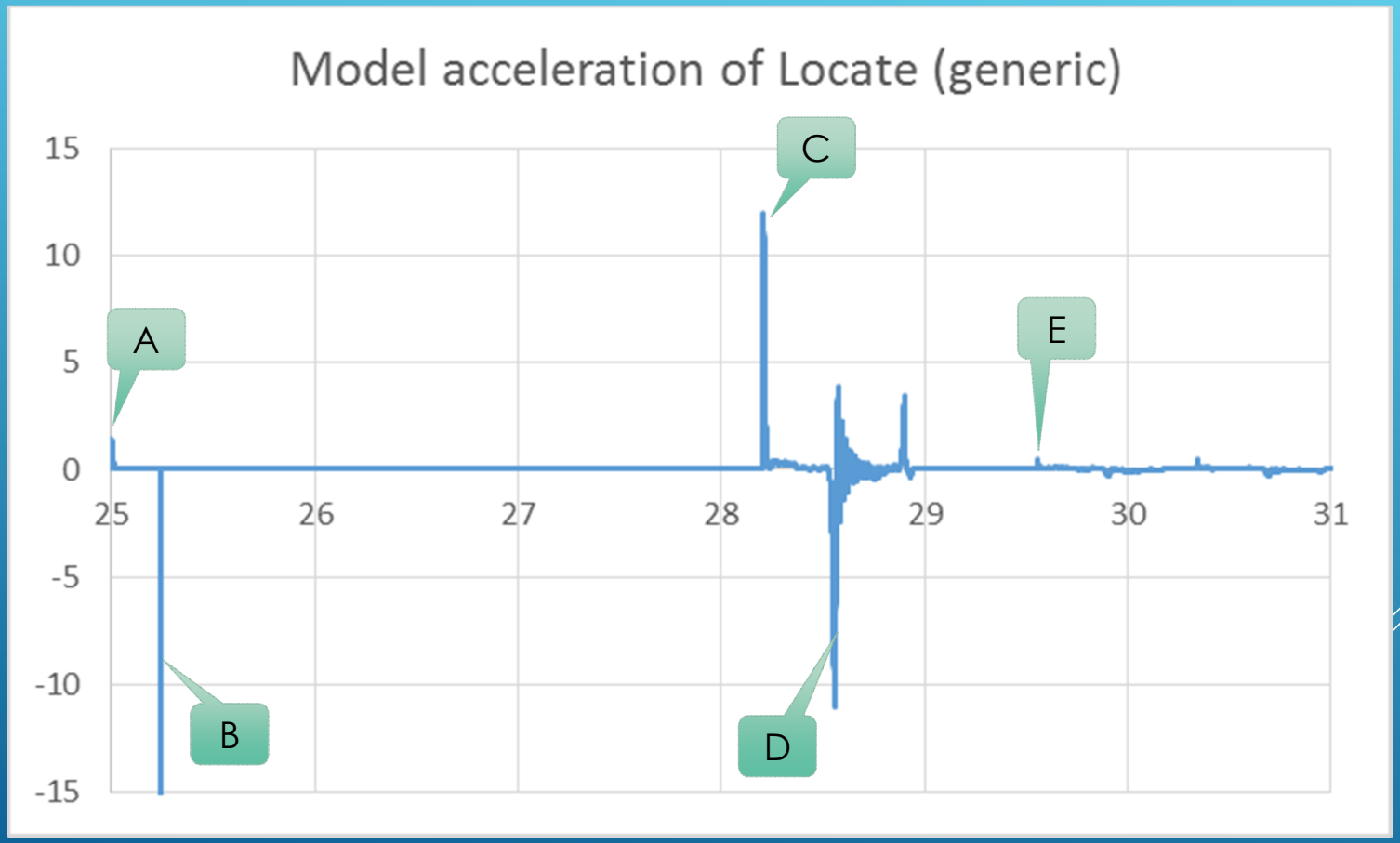
COMPARISON 1



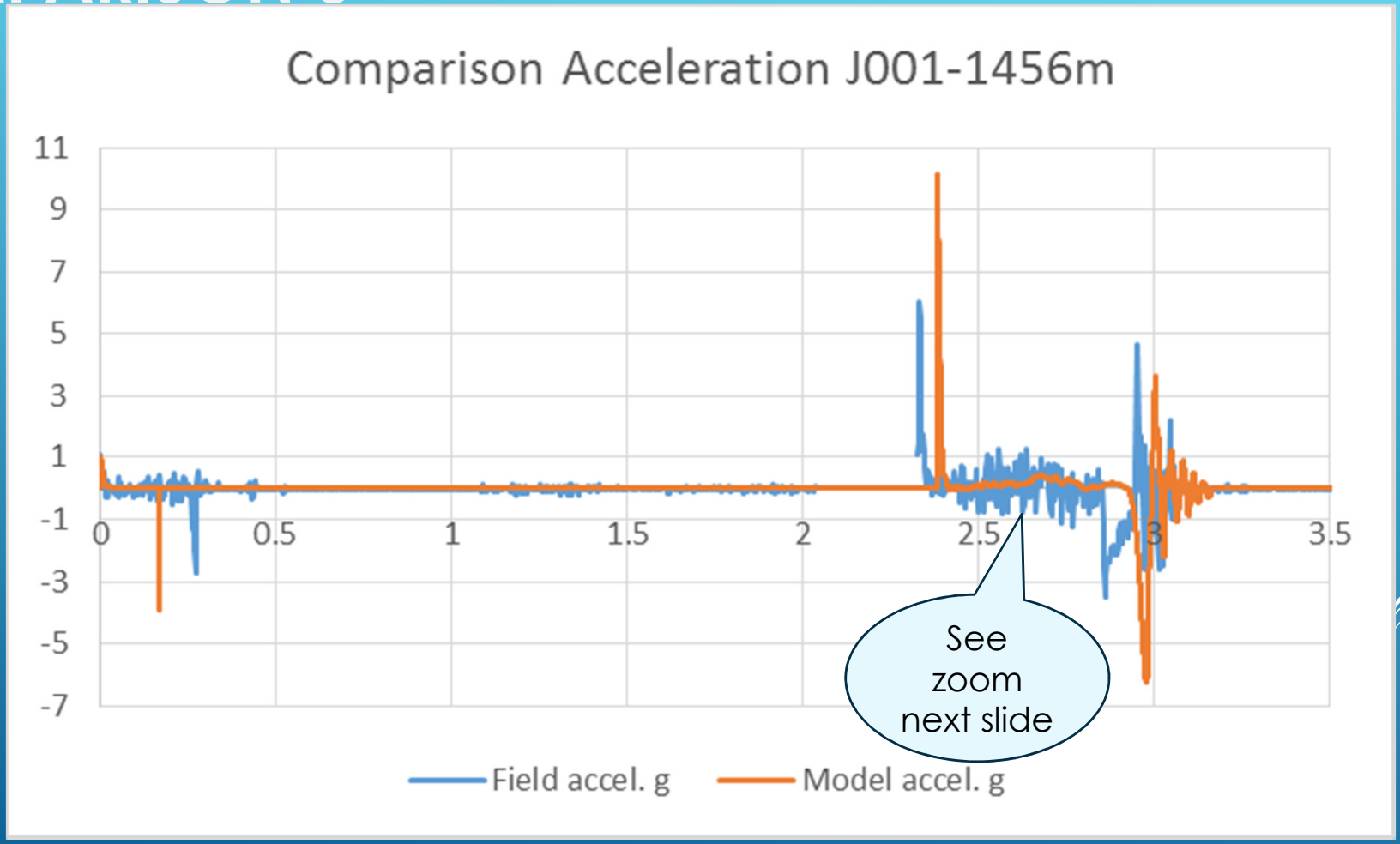
COMPARISON 2



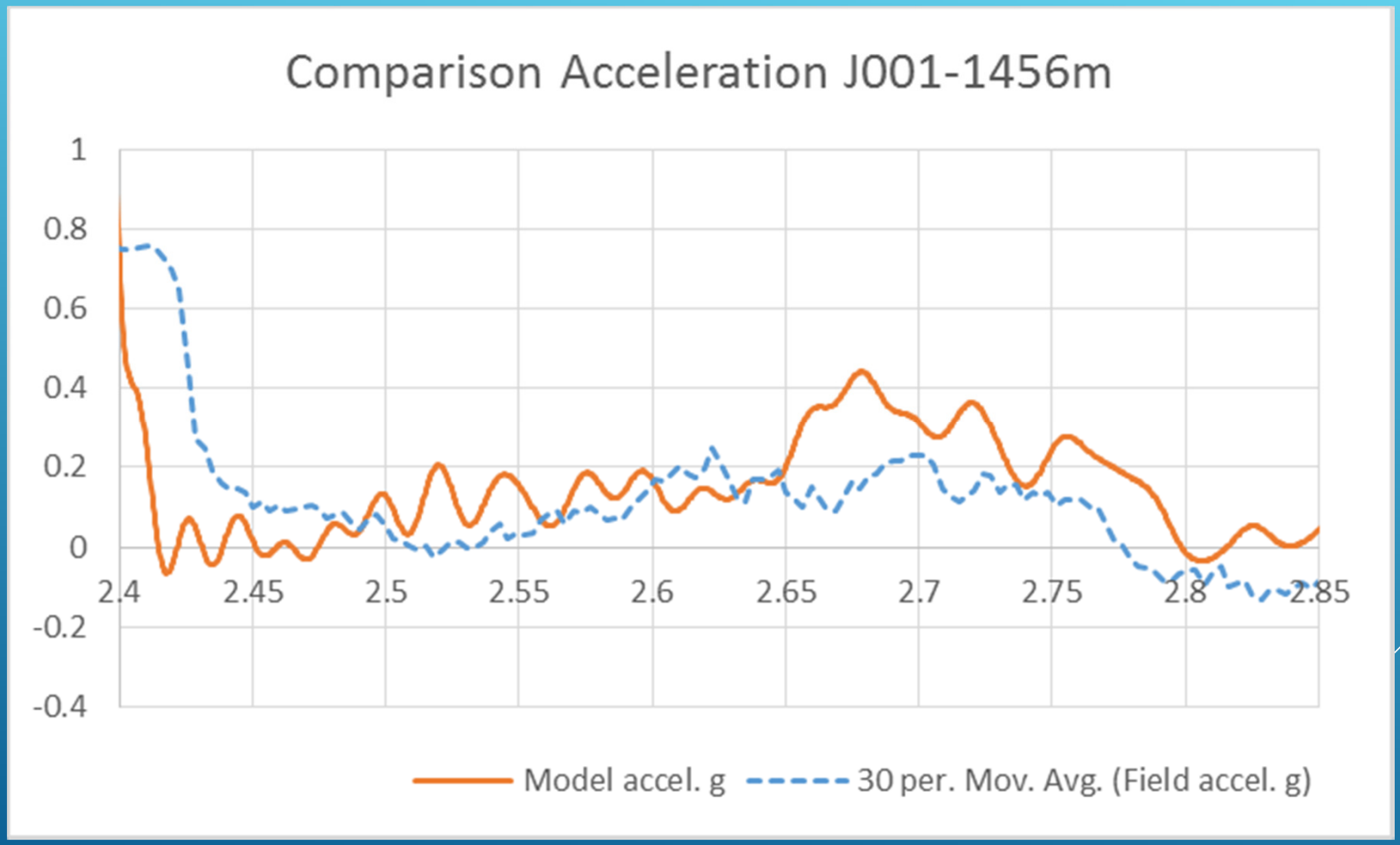
CALIBRATION POINTS – ACCELERATION



COMPARISON 3

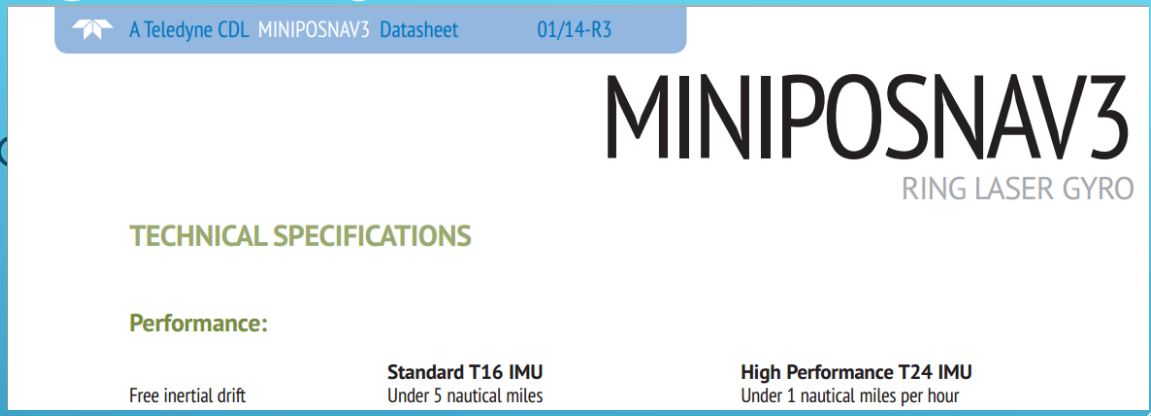


COMPARISON 3



POSITION FROM ACCELEROMETERS

- Double-integrate the acc
  - Very prone to errors.


A Teledyne CDL MINIPOSNAV3 Datasheet 01/14-R3

MINIPOSNAV3

RING LASER GYRO

TECHNICAL SPECIFICATIONS

Performance:

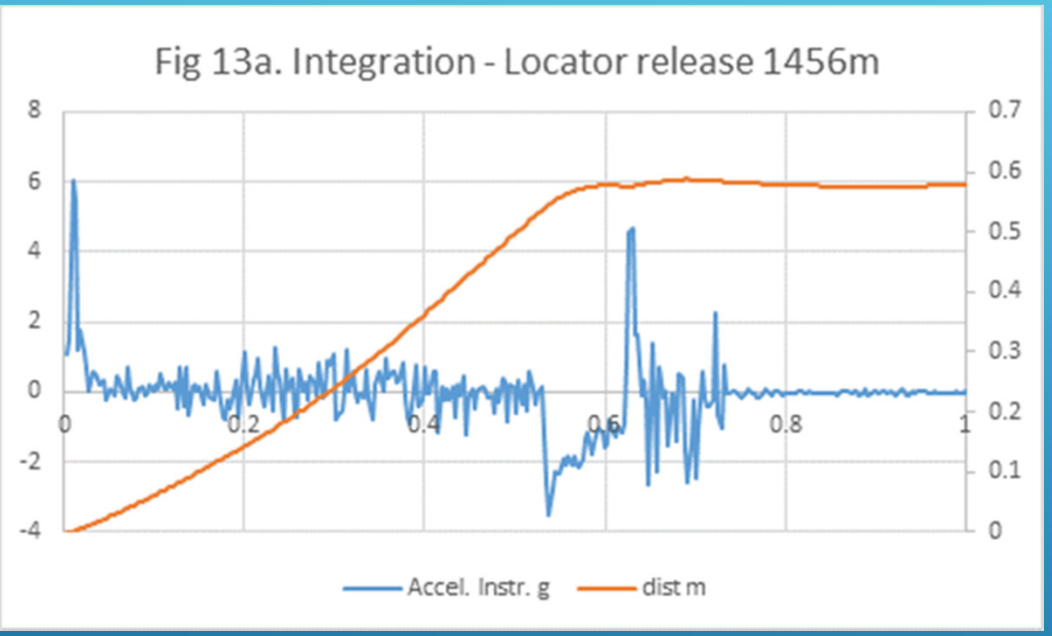
	Standard T16 IMU	High Performance T24 IMU
Free inertial drift	Under 5 nautical miles	Under 1 nautical miles per hour

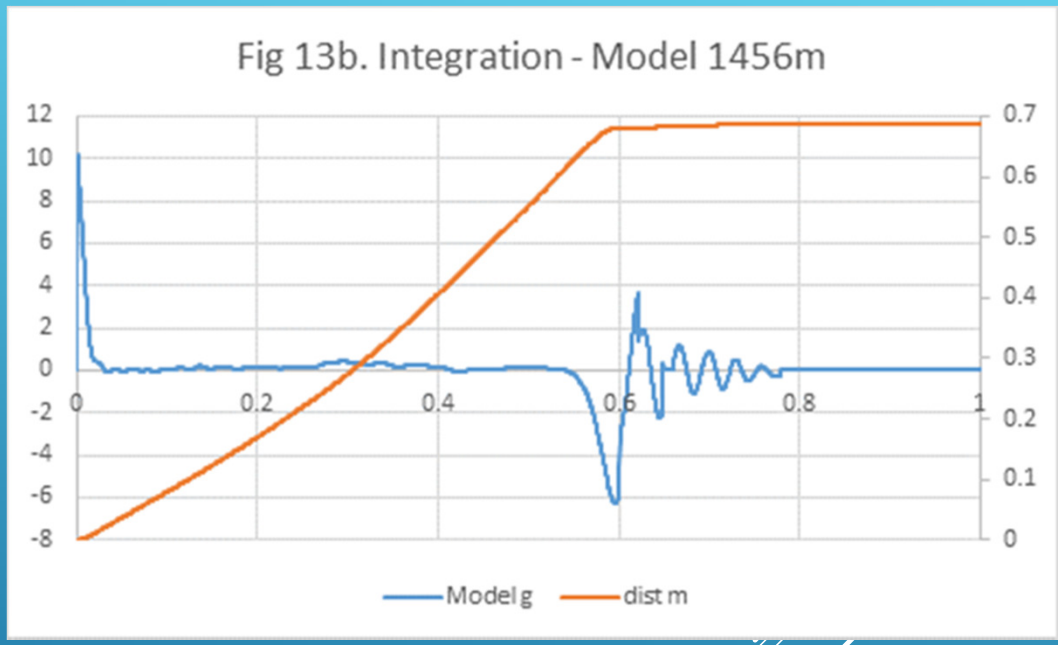
  - We know the times when the BHA is stationary so can zero-out the bias error.
  - This was the only error-reduction treatment given to the data.

POSITION FROM ACCELEROMETERS

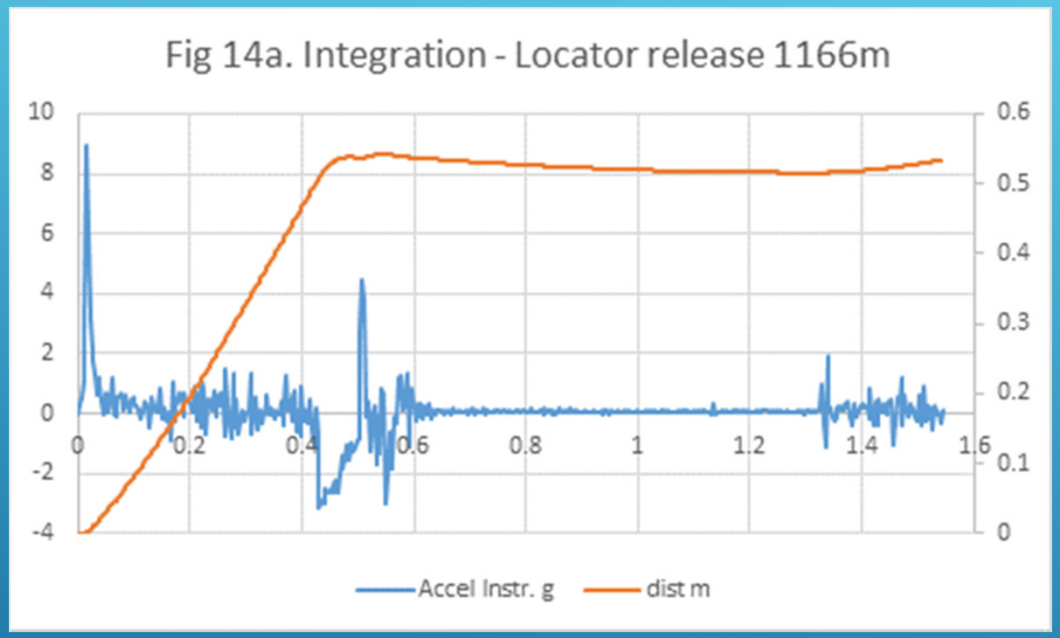
- Slope of 2 degrees off horizontal gives an output of 0.035 g from the accelerometer…
- Integrates to 0.17m in 1 second.

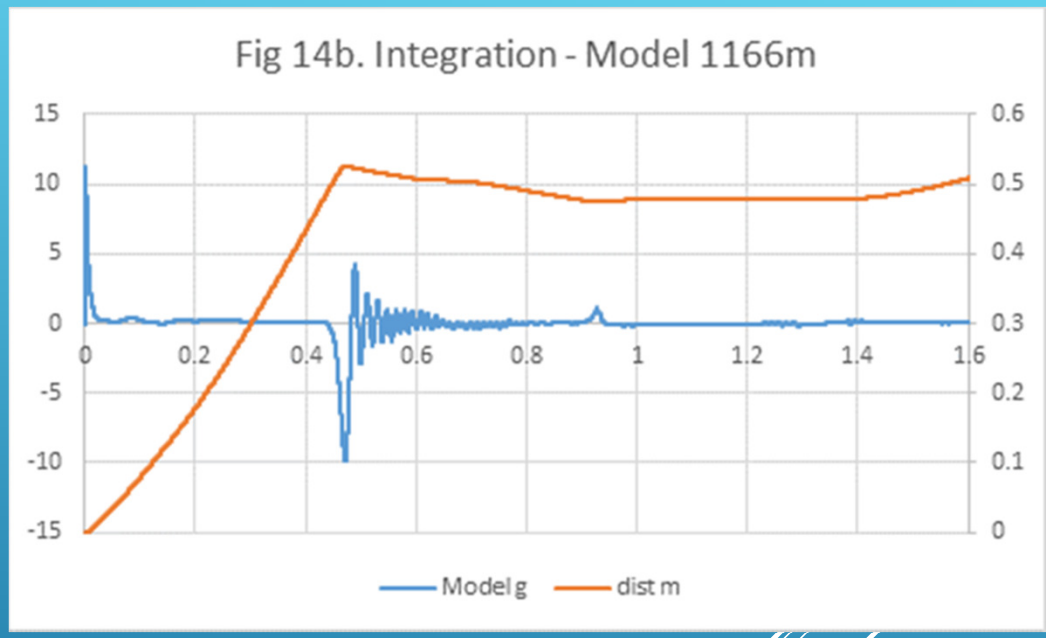
COMPARISON 4A





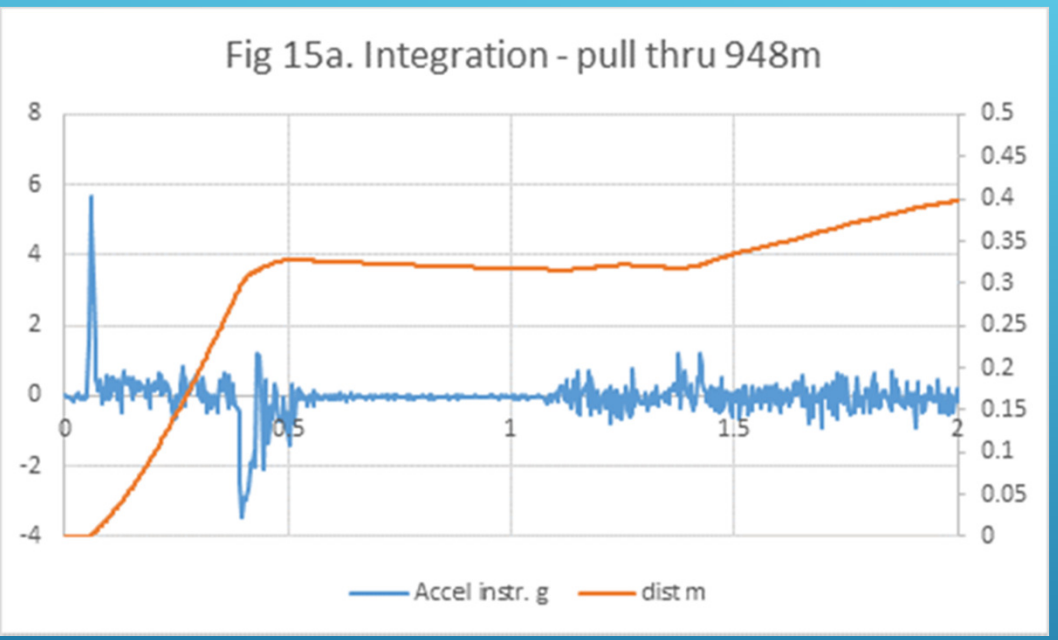
COMPARISON 4B

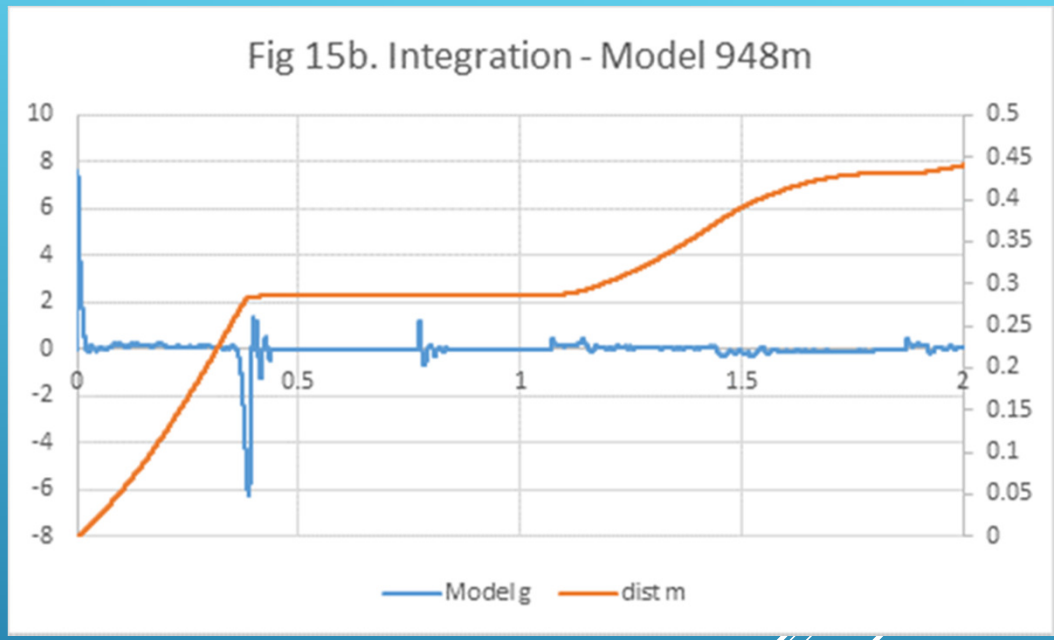




Result: close match between initial distance traveled on locator release; also rebound of BHA back downhole, followed by stationary period and moving again at 1.4 sec.

COMPARISON 4C





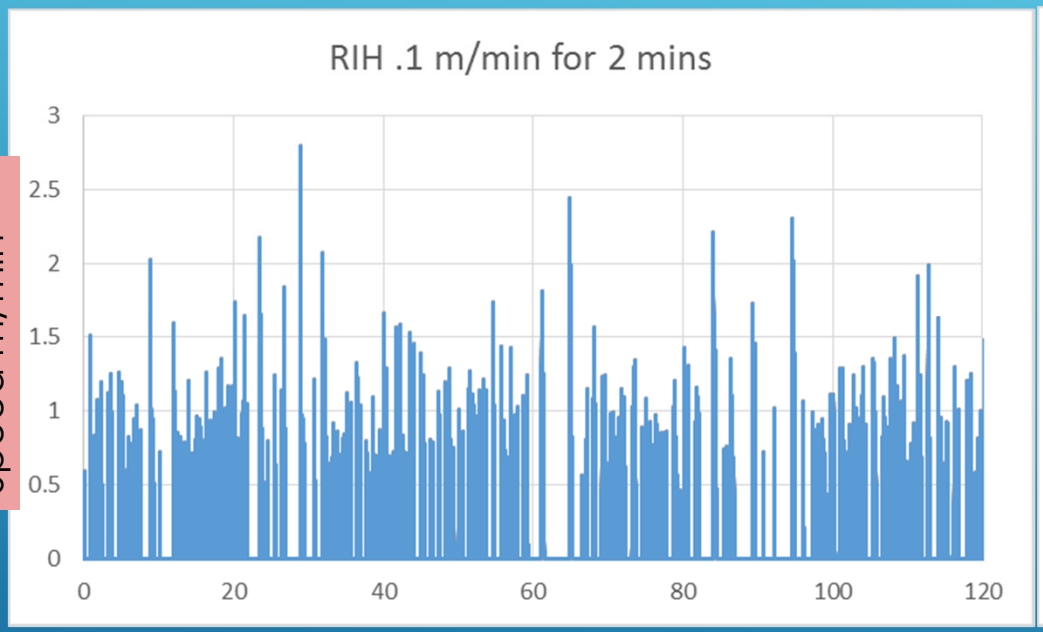
Result: close match of initial distance travelled

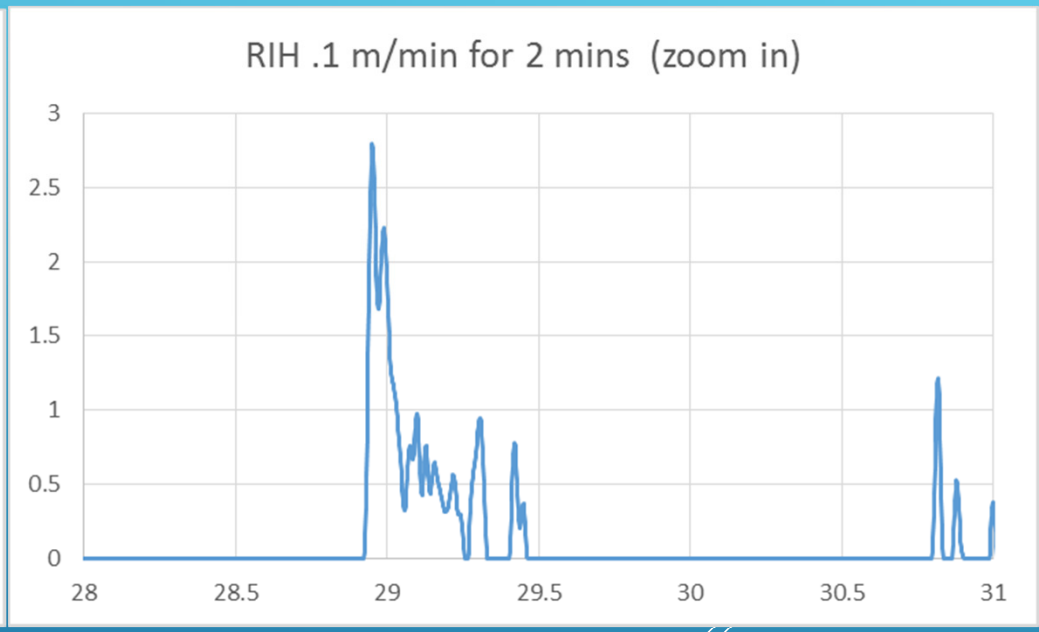
and distance travelled after resuming motion at 2 sec.

HYPOTHETICAL

- 1000m, 2” string being run horizontally in 4” pipeline
- No BHA. Friction coeffs are 0.25 & 0.25 x 1.3

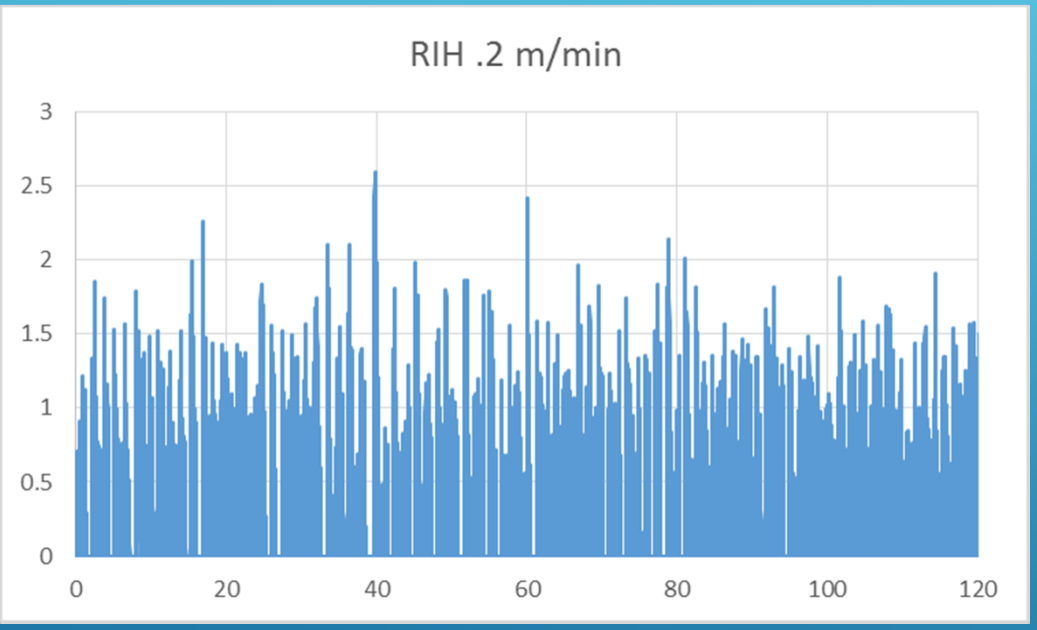
RIH 0.1 M/MIN

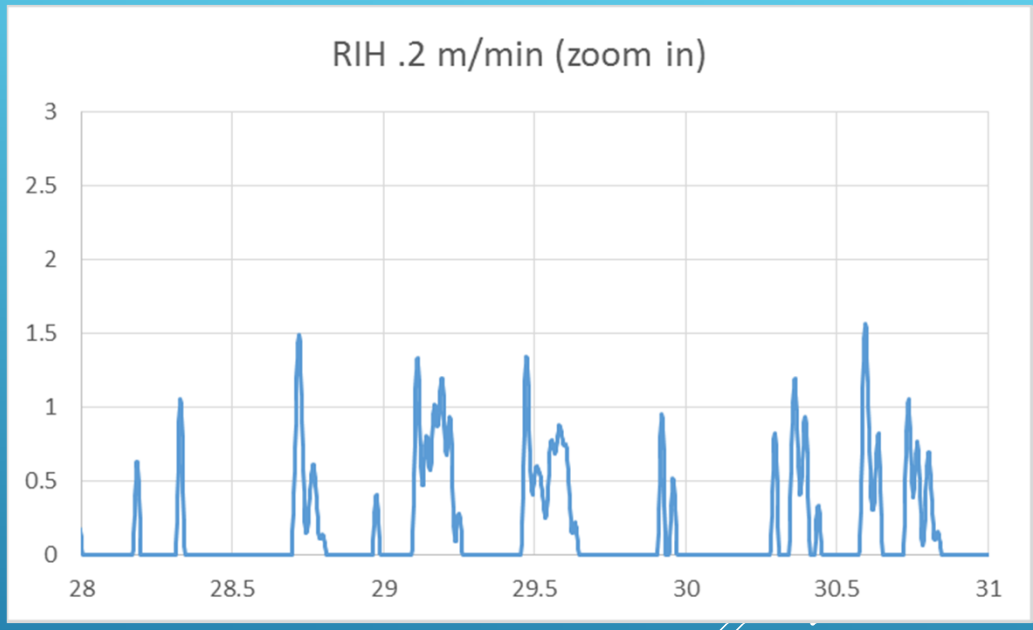




Spikes to 25 times the injector speed.
Stuck 81% of the time.
No discernible pattern.
Deterministically chaotic.

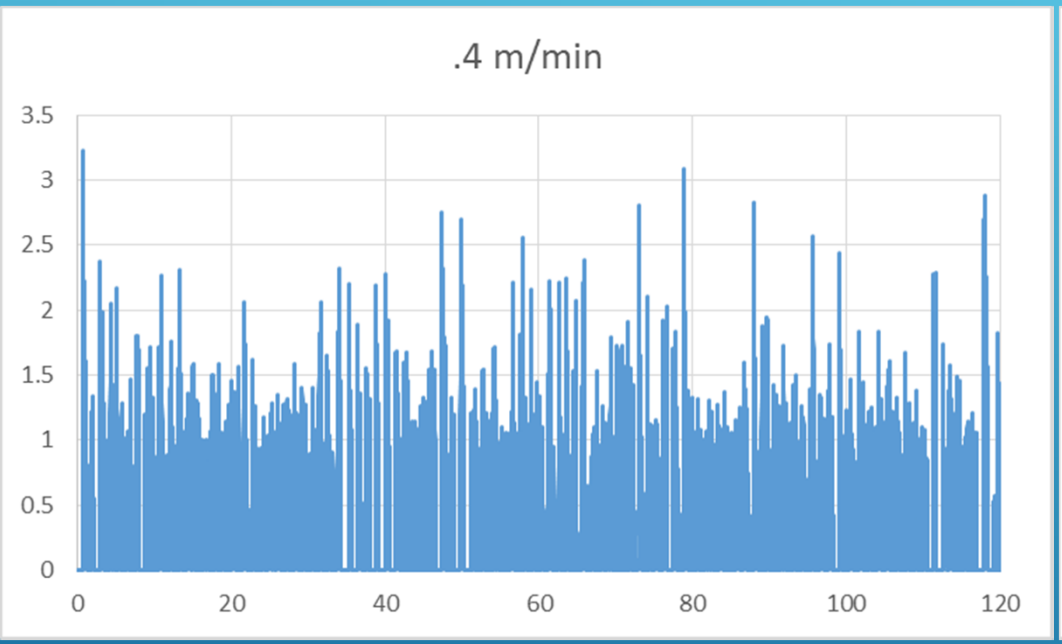
RIH 0.2 M/MIN

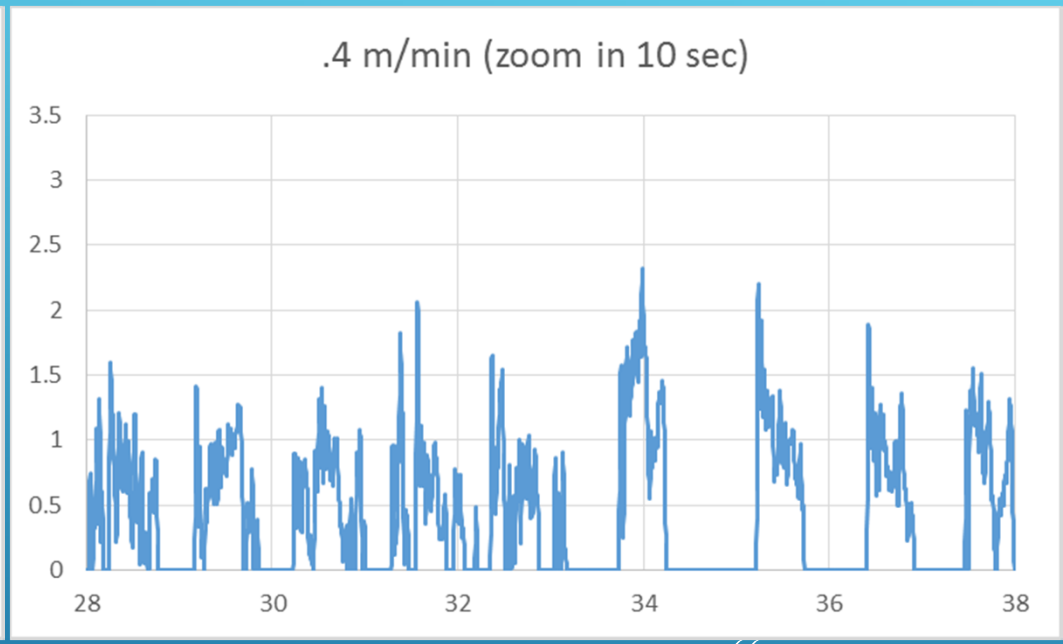




Spikes are about the same height even though the injector speed has doubled.
Stuck 64% of the time.
No discernible pattern.

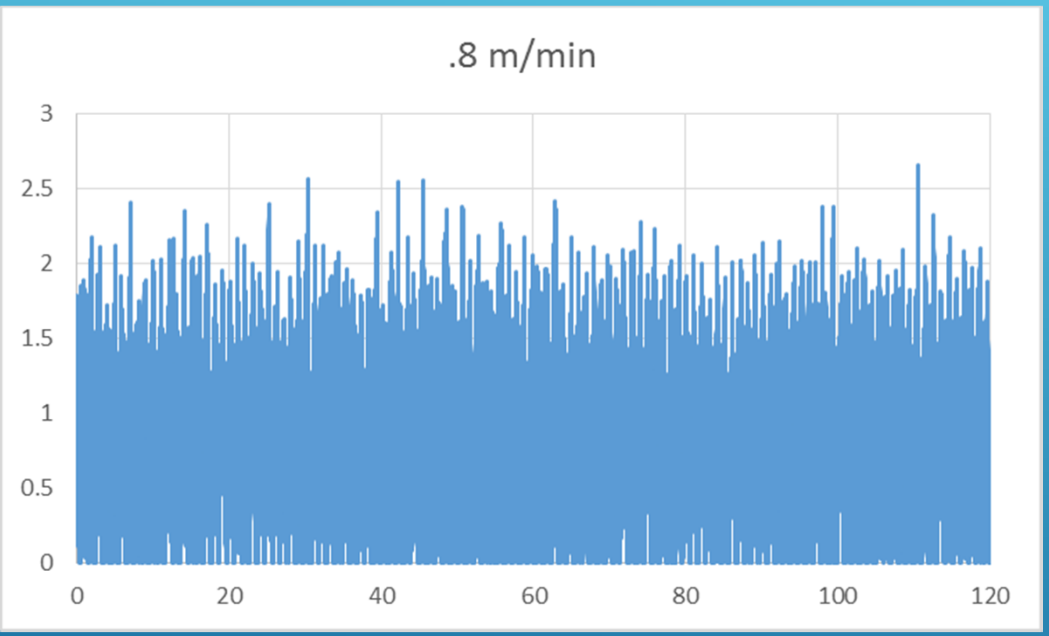
RIH 0.4 M/MIN

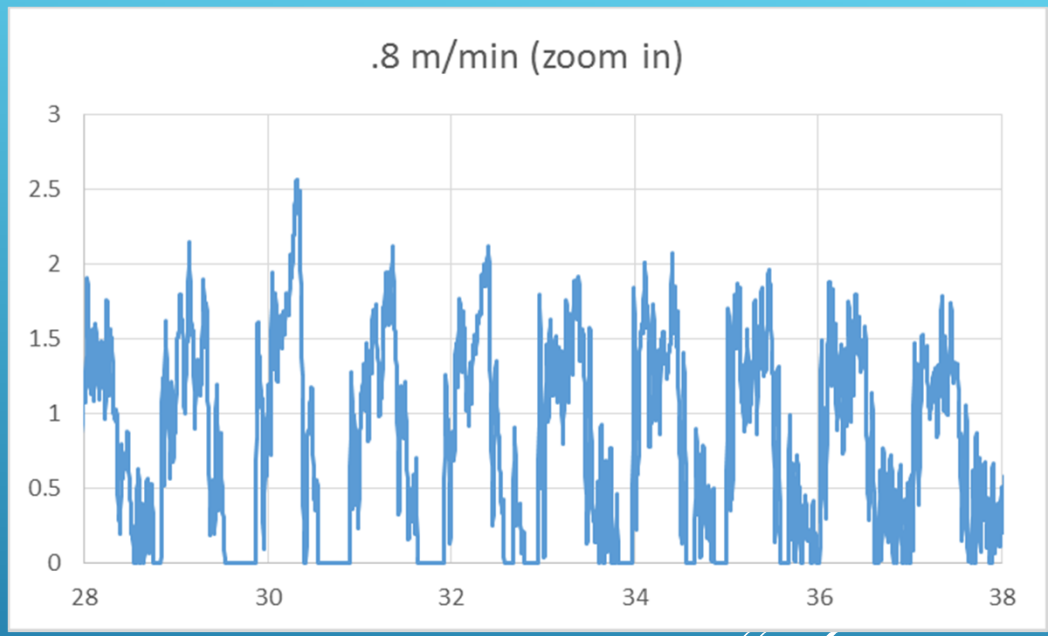




Spikes still about the same height even though the injector speed has again doubled.
Stuck 43% of the overall 120 secs time.
Indications of periodic motion.

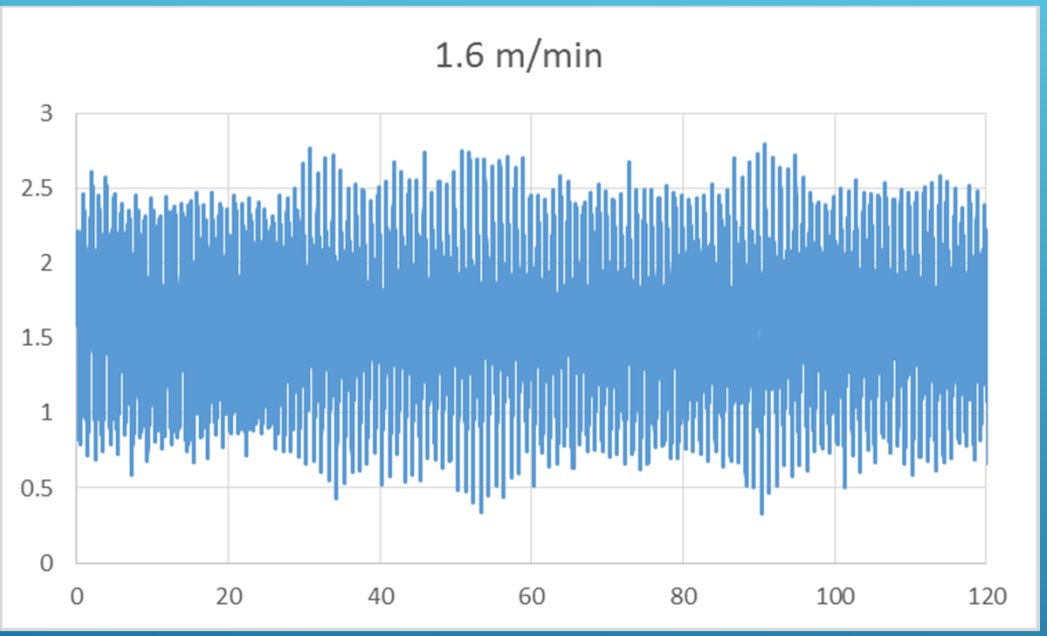
RIH 0.8 M/MIN

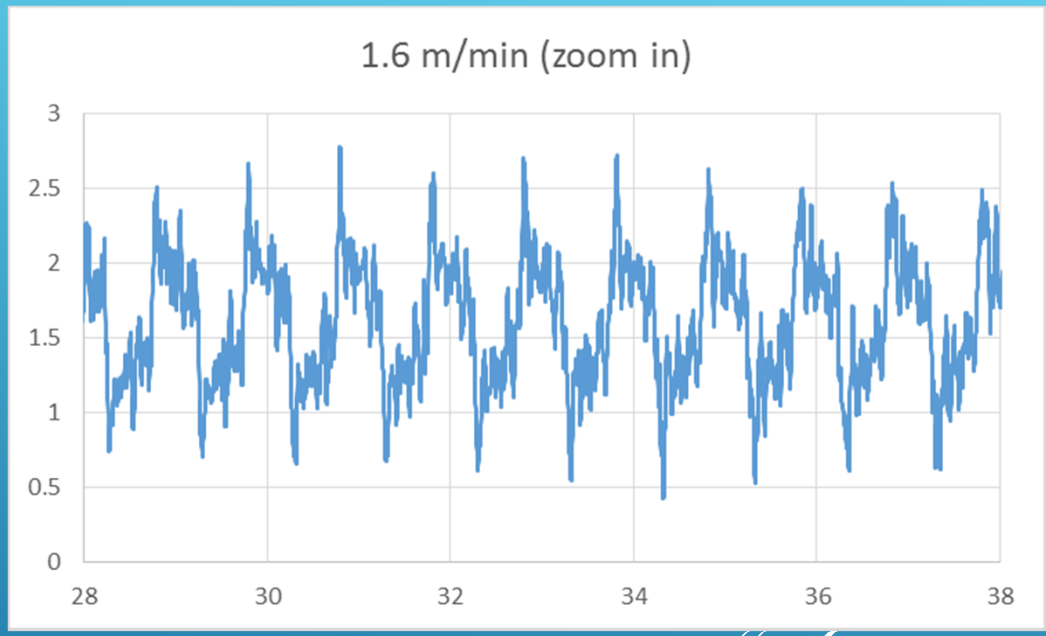




Stuck 18% of the overall 120 secs time.
Stronger periodic motion.

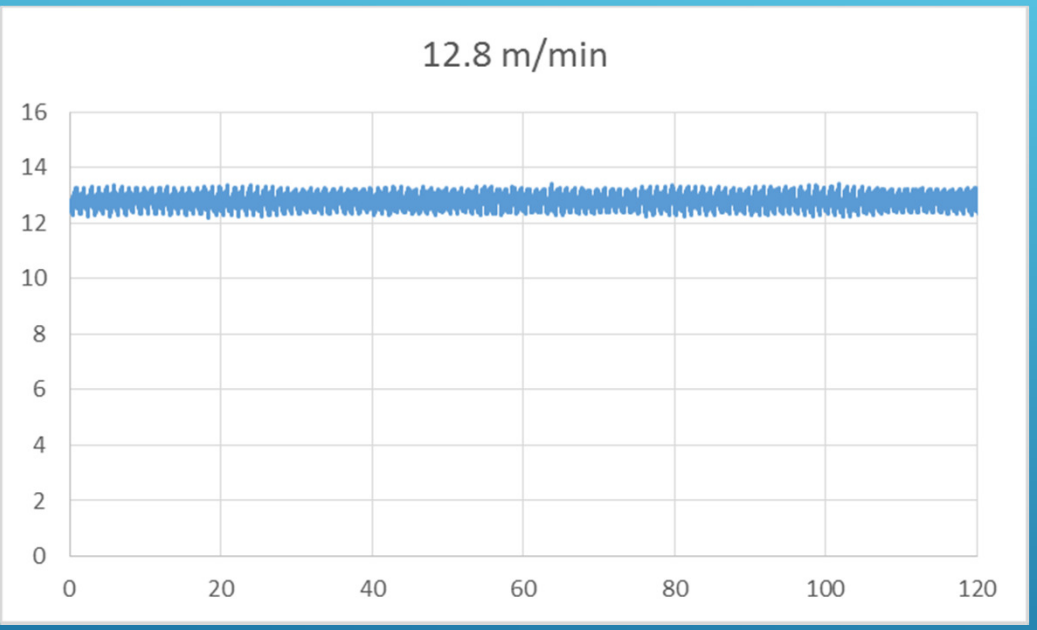
RIH 1.6 M/MIN

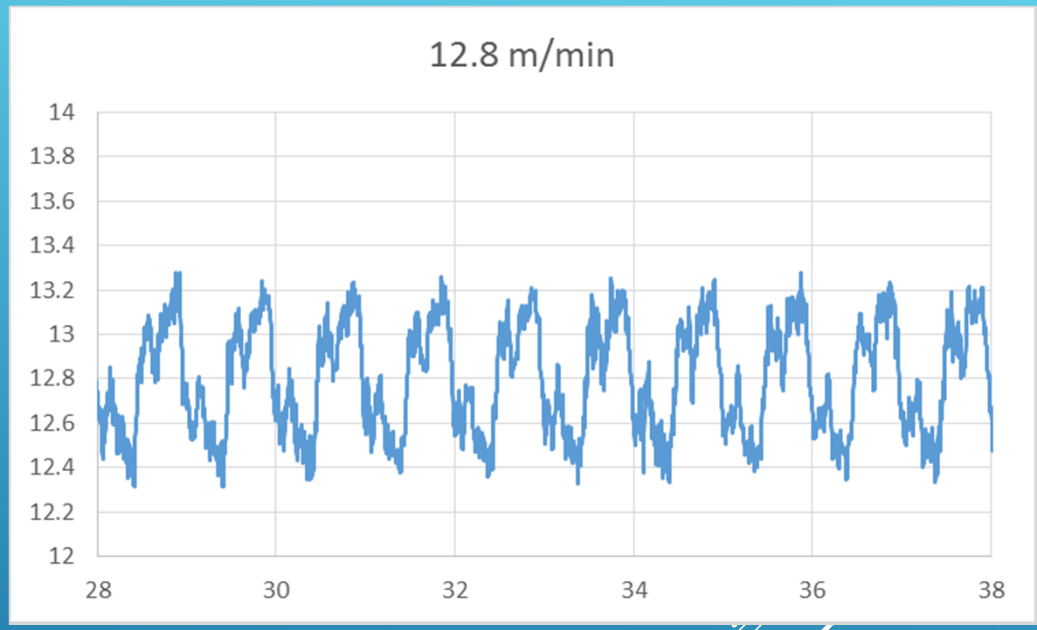




No longer sticking.
Noisy periodic motion.
Peak to peak range is at least equal to RIH rate.

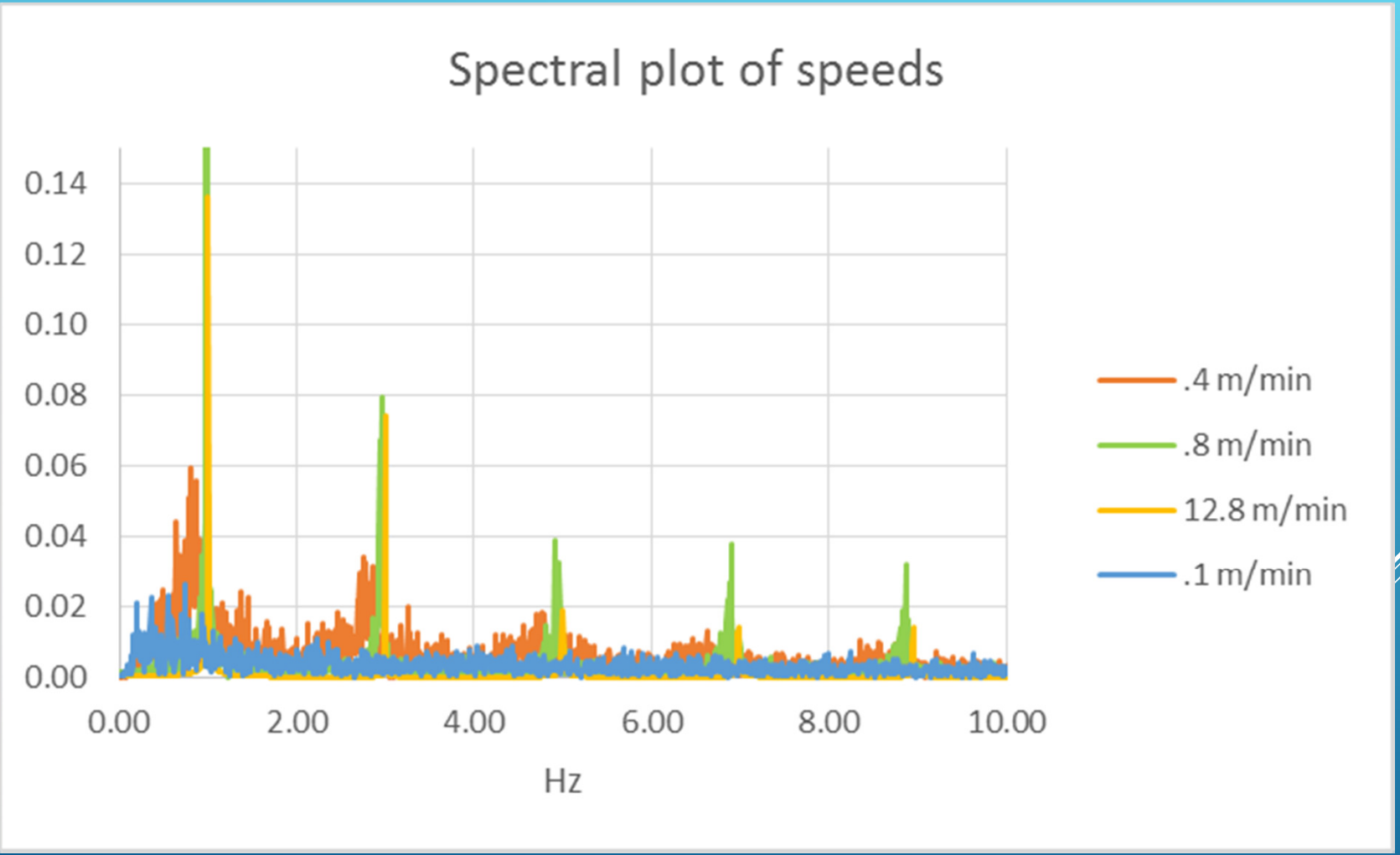
RIH 1.6 M/MIN



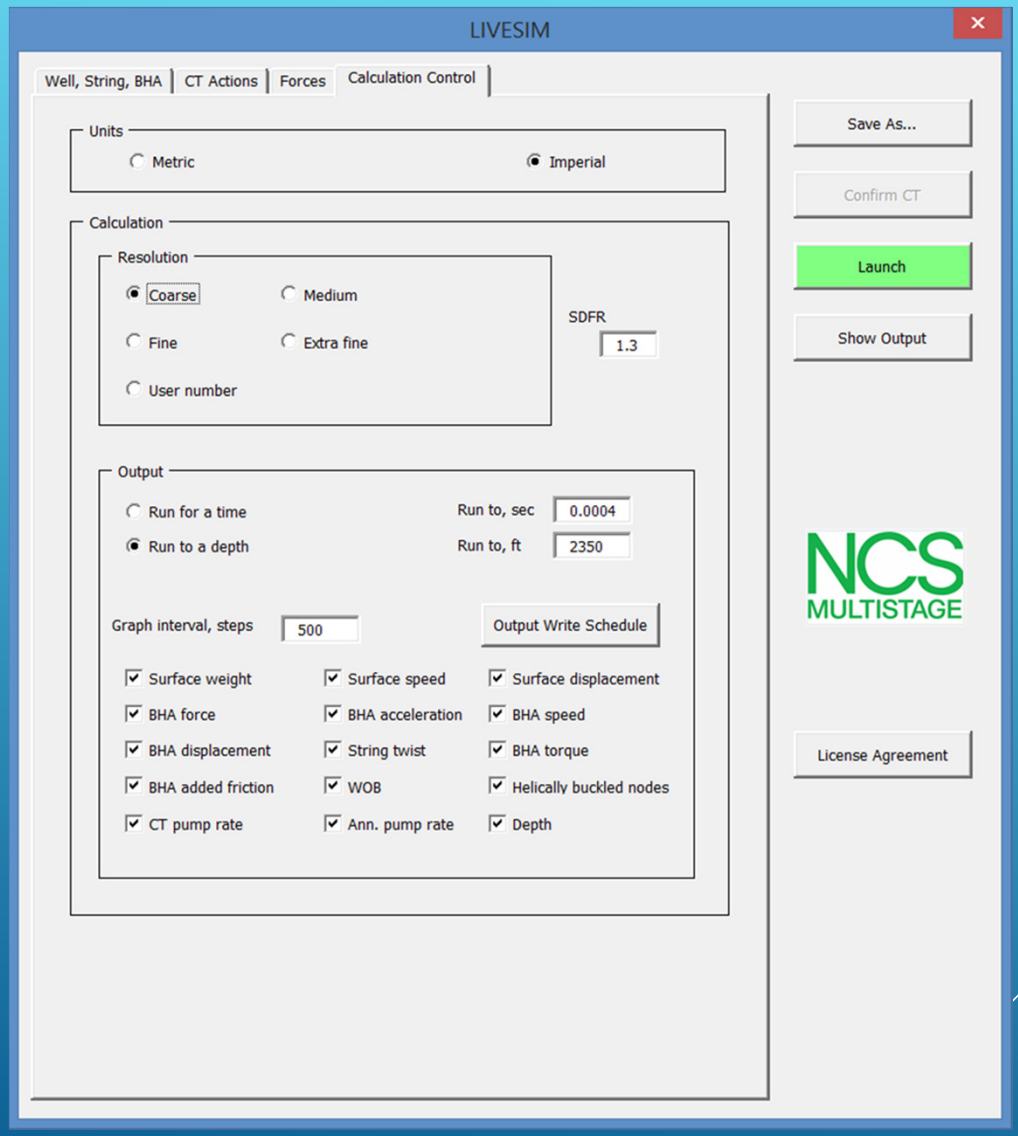


Normal speeds.
Periodic motion continues – just like bowing a violin.

FFT – SPECTRAL ANALYSIS



≈ THE END ≈


LIVESIM
Well, String, BHA
CT Actions
Forces
Calculation Control
Units
Metric
Imperial
Calculation
Resolution
Coarse
Medium
Fine
Extra fine
User number
SDFR
1.3
Output
Run for a time
Run to a depth
Run to, sec
0.0004
Run to, ft
2350
Graph interval, steps
500
Output Write Schedule
Surface weight
Surface speed
Surface displacement
BHA force
BHA acceleration
BHA speed
BHA displacement
String twist
BHA torque
BHA added friction
WOB
Helically buckled nodes
CT pump rate
Ann. pump rate
Depth
Save As...
Confirm CT
Launch
Show Output
NCS MULTISTAGE
License Agreement