55th General Meeting
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Virtual Conference

Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

SPE-208735

Modelling the Economic Impact of Spacing Uncertainty in Unconventional Long Laterals Due to Common Survey Practices

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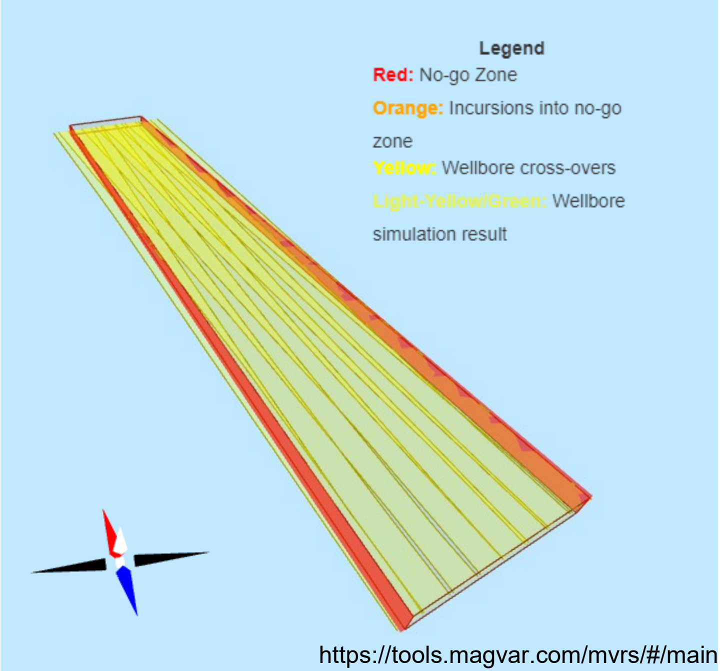
Marc Willerth, Helmerich & Payne

Reservoir Simulator
URTEC–2458814, Maus and DeVerse, 2016

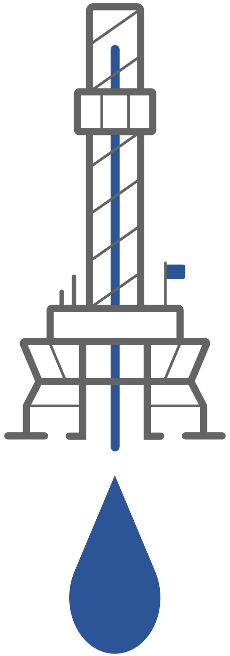
- Lateral Separation
  - Too close: Hydraulic communication
  - Too far: Incomplete recovery

- Can we associate a $$ amount?

- Conservative estimates
  - Gaussian, no vertical errors, survey requirements are met (QC, calibration, etc...)



Unexpected Losses



My Energy Bill is Too High!

- Possible fixes
  - Double paned windows
  - Seal door and window frames
  - Etc…
- My bill isn't going down…
- What if I forgot to close the door?!
- Overly optimistic
  - Need a data-driven solution
  - Better estimates of energy losses

Empirical Error Models
SPE-201740, Love et al., 2020

- Error Models developed by OWSG and ISCWSA
  - Based on service providers’ offshore operations
    - Level of accuracy not always appropriate for US land ops
  - Limited data

- Empirical Models based on more than 9,000 laterals (35,000 bit runs)

- Comparison of uncertainties with MWD, MWD+IFR1+MSA, **Empirical**

Empirical Error Models
SPE-201740, Love et al., 2020

Example:

- Drillstring Interference: Underestimated by more than 3x
- Separation confidence for parallel wells (10,000ft step out)
  - MWD: ±160ft
  - Empirical MWD: ±350ft (!!)
  - With survey management: ±100ft

How much does this optimism cost?

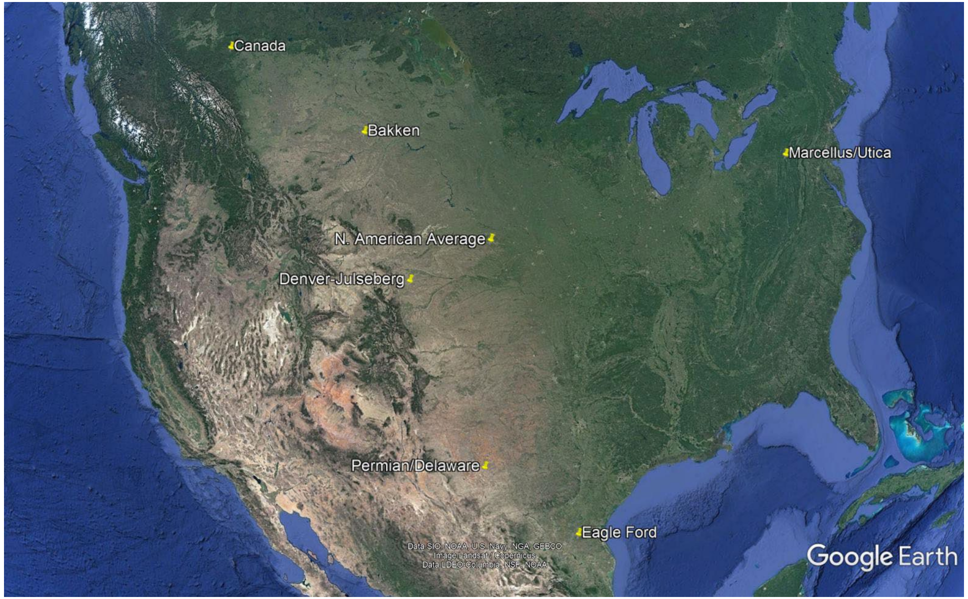
Experiment

- Create empirical MWD model
- Compare to classic MWD model recovery
- Compare to Survey Management recovery

- Other variables in simulator help compare effects of drilling procedure
  - Location
  - Lateral length
  - Separation
  - Azimuth

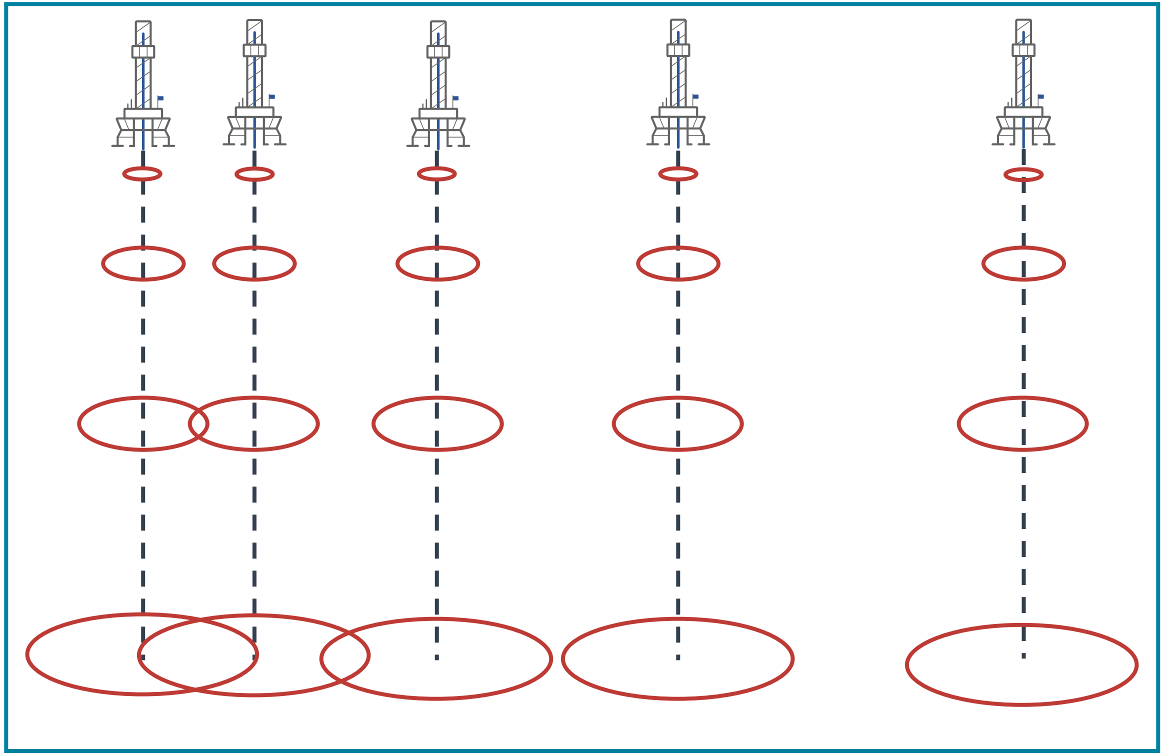
Locations and typical azimuths

- Canada
- Bakken
- Denver Julesburg
- Eagle Ford
- Marcellus/Utica
- Permian/Delaware
- North American Average



Other Variables

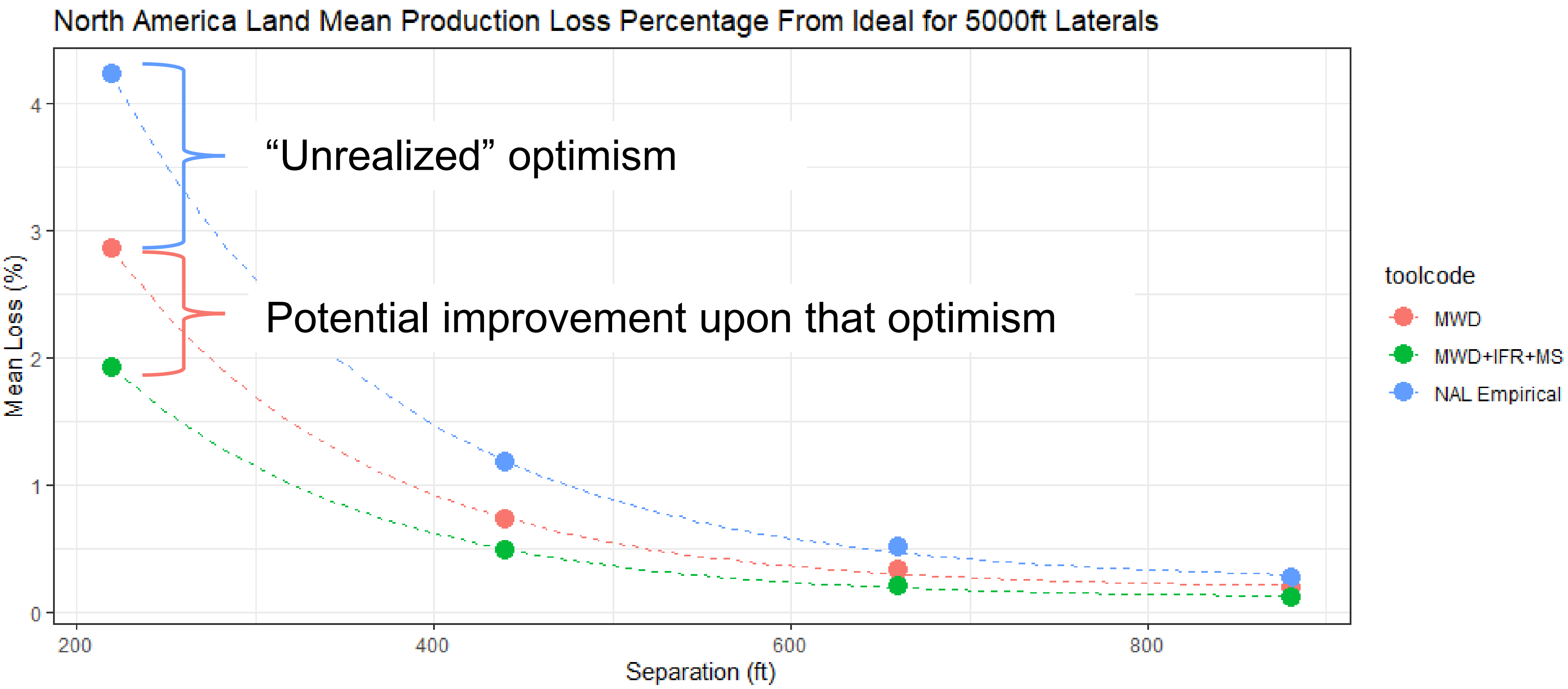
- Lateral Spacing
  - 220ft, 440ft, 660ft, 880ft
- Lateral Length
  - 5,000ft, 10,000ft, 15,000ft



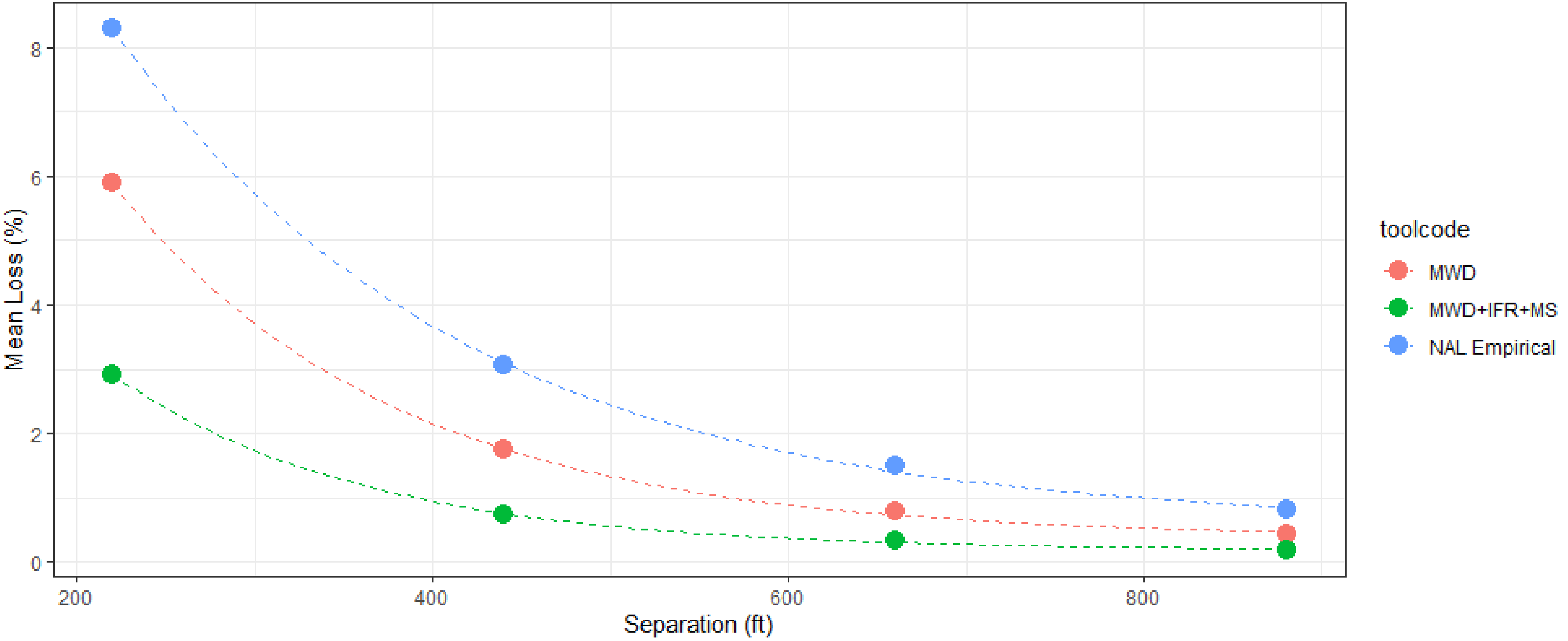
North America Land Average

Latitude: 42.28°

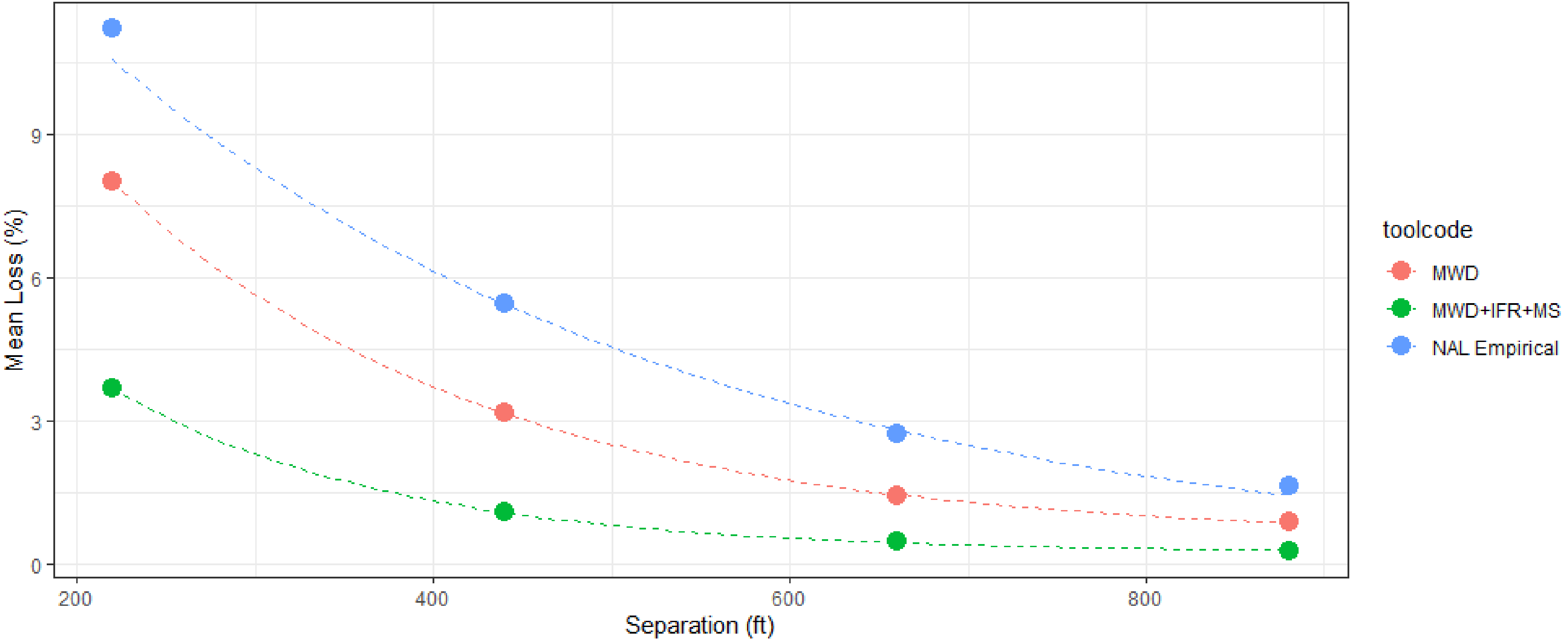
Azimuth: 345°

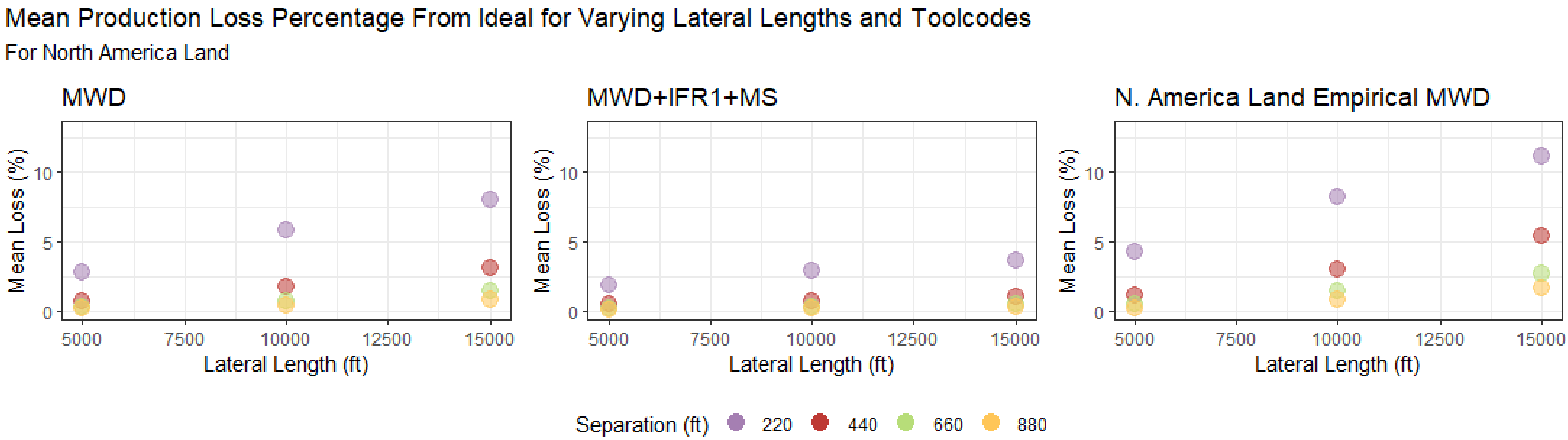

North America Land Mean Production Loss Percentage From Ideal for 5000ft Laterals
"Unrealized" optimism
Potential improvement upon that optimism
Mean Loss (%)
4
3
2
1
0
200
400
600
800
Separation (ft)
toolcode
MWD
MWD+IFR+MS
NAL Empirical

North America Land Mean Production Loss Percentage From Ideal for 10,000ft Laterals



North America Land Mean Production Loss Percentage From Ideal for 15,000ft Laterals

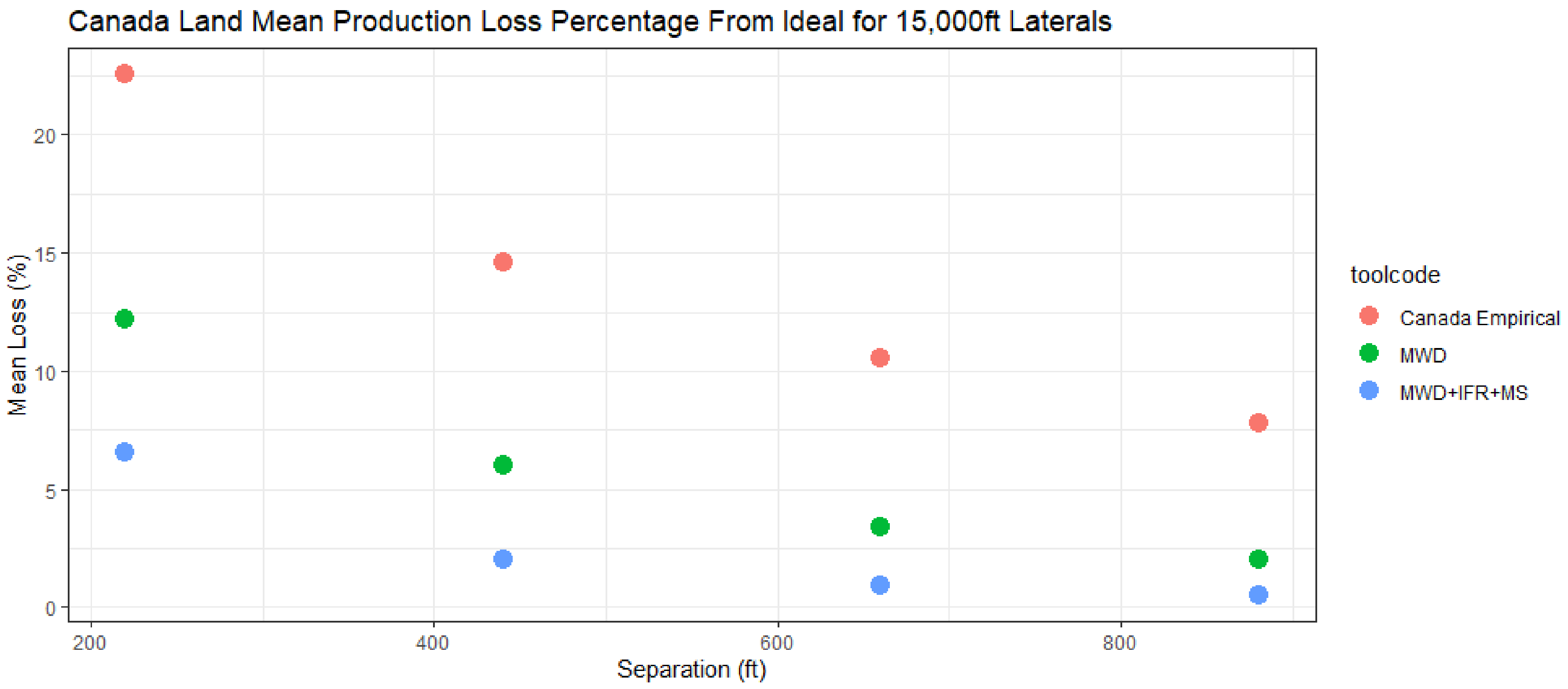



Mean Production Loss Percentage From Ideal for Varying Lateral Lengths and Toolcodes
For North America Land
MWD
MWD+IFR1+MS
N. America Land Empirical MWD
Mean Loss (%)
0
5
10
5000
7500
10000
12500
15000
Lateral Length (ft)
Separation (ft)
220
440
660
880

Extreme Scenario: Canada

Latitude: 54.51°

Azimuth: 315°


Canada Land Mean Production Loss Percentage From Ideal for 15,000ft Laterals
Mean Loss (%)
20
15
10
5
0
200
400
600
800
Separation (ft)
toolcode
Canada Empirical
MWD
MWD+IFR+MS

The Cost of Optimism

For common spacing and lateral lengths (880ft separation, 15,000' lateral)

- Exacerbated with closer spacing/ longer laterals

- MWD: Losses estimated to be ~ **1-3%** of ideal (up to 8%)

- Empirically: Closer to ~ **2.5-5%** (up to 11%)
  - Due to common MWD survey practices in different basins

- Survey management and proper QC: ~ 0.5-1% (up to 3.7%)

The Cost of Optimism

- Losses increase quickly with:
  - Reduced separation
  - Increased lateral length

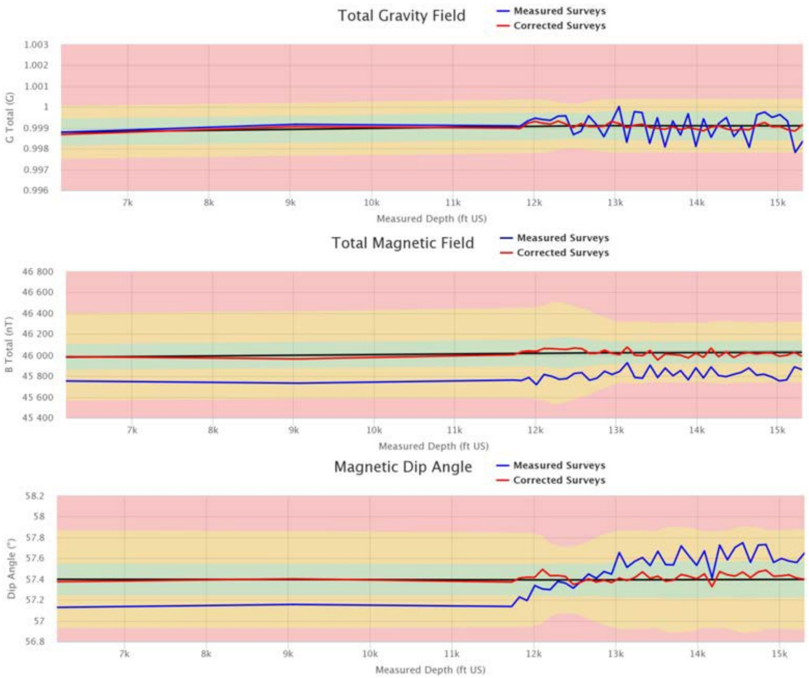
- Increasing survey accuracy isn't just for collision or lease line avoidance
  - Better quality control or high accuracy survey methods

- Better surveys, better recovery

Thank You - Questions

Appendix

Importance of QC for Survey Management



ISCWSA Error Model for MWD Tool Code and Associated NAL Empirical Tool Code

Code	Term Description	MWD Magnitude	Error Term	NAL Error Magnitude	Units
ABXY-TI1S	MWD TF Ind: X and Y Accelerometer Bias	0.004	Cross Axial Gravity Bias	0.007	m/s2
ABXY-TI2S	MWD TF Ind: X and Y Accelerometer Bias	0.004	Cross Axial Gravity Bias	0.007	m/s2
ABZ	MWD: Z-Accelerometer Bias	0.004	Cross Axial Gravity Bias	0.007	m/s2
ASXY-TI1S	MWD TF Ind: X and Y Accelerometer Scale Factor	0.0005	Cross Axial Gravity Scale	0.001	-
ASXY-TI2S	MWD TF Ind: X and Y Accelerometer Scale Factor	0.0005	Cross Axial Gravity Scale	0.001	-
ASXY-TI3S	MWD TF Ind: X and Y Accelerometer Scale Factor	0.0005	Cross Axial Gravity Scale	0.001	-
ASZ	MWD: Z-Accelerometer Scale Factor	0.0005	Cross Axial Gravity Scale	0.001	-
MBXY-TI1S	MWD TF Ind: X and Y Magnetometer Bias	70	Cross Axial Magnetic Bias	60	nT
MBXY-TI2S	MWD TF Ind: X and Y Magnetometer Bias	70	Cross Axial Magnetic Bias	60	nT
MBZ	MWD: Z-Magnetometer Bias	70	Cross Axial Magnetic Bias	60	nT
MSXY-TI1S	MWD TF Ind: X and Y Magnetometer Scale Factor	0.0016	Cross Axial Magnetic Scale	0.0027	-
MSXY-TI2S	MWD TF Ind: X and Y Magnetometer Scale Factor	0.0016	Cross Axial Magnetic Scale	0.0027	-
MSXY-TI3S	MWD TF Ind: X and Y Magnetometer Scale Factor	0.0016	Cross Axial Magnetic Scale	0.0027	-
MSZ	MWD: Z-Magnetometer Scale Factor	0.0016	Cross Axial Magnetic Scale	0.0027	-
AMIL	MWD: Axial Interference - SinI.SinA	220	Drill String Interference	700	nT

Latitude Dependent Errors - Uncertainty and Parallel/Anti-Parallel Combined Covariance

Tool Code		MWD &. NAL Error			MWD+IFR1+MS			
Code	Term Description	Uncertainty	Parallel	Anti-Parallel	Uncertainty	Parallel	Anti-Parallel	Units
DECG	MWD: Declination - Global	0.36	0	0.72	0.15	0	0.3	deg
DBHG	MWD: BH-Dependent Declination - Global	5000	0	10000	1500	0	3000	deg.nT

Example of Azimuth Distribution in Different Basins