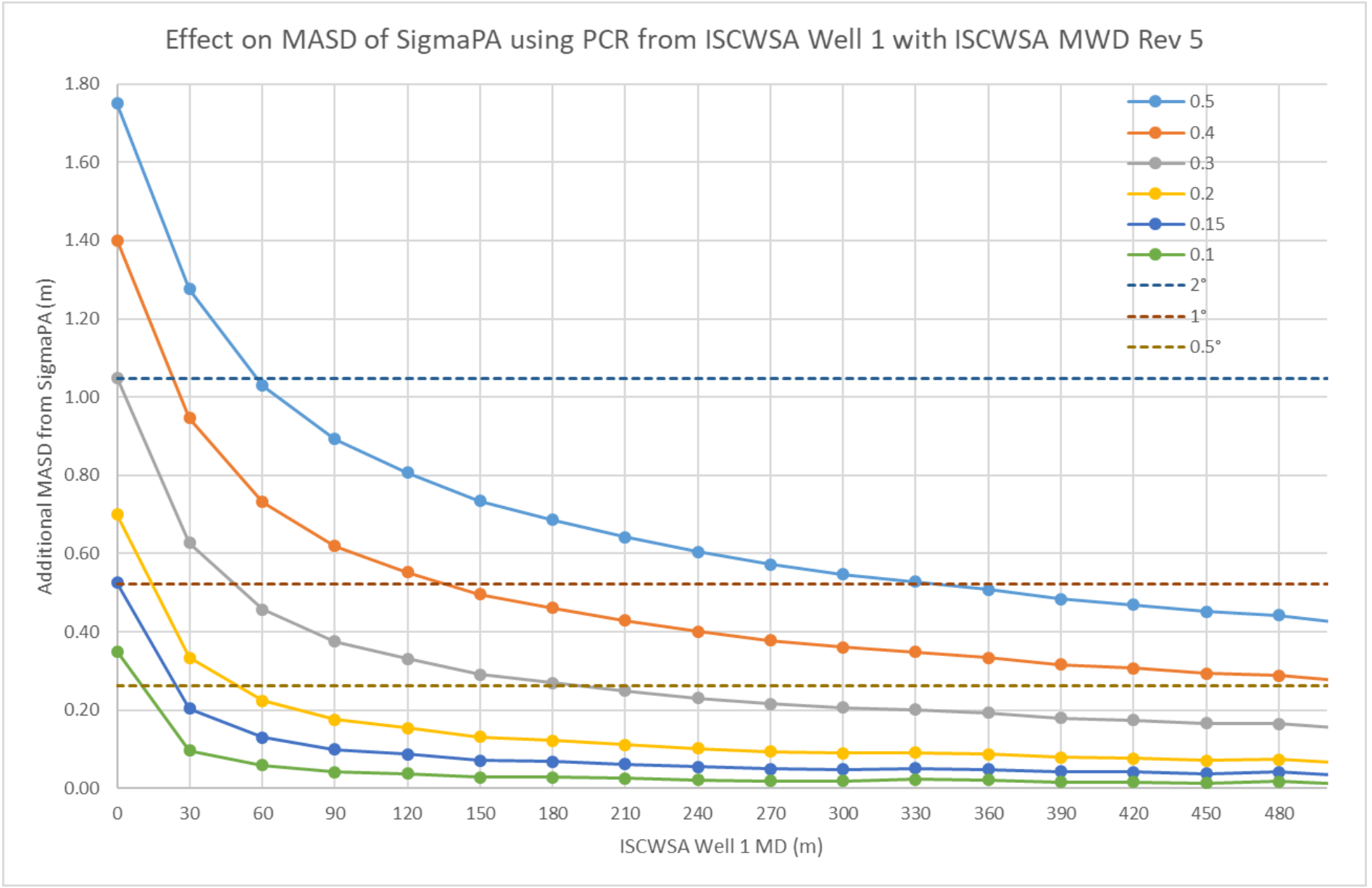
Project Ahead Uncertainty

ISCWSA Collision Avoidance Sub-committee

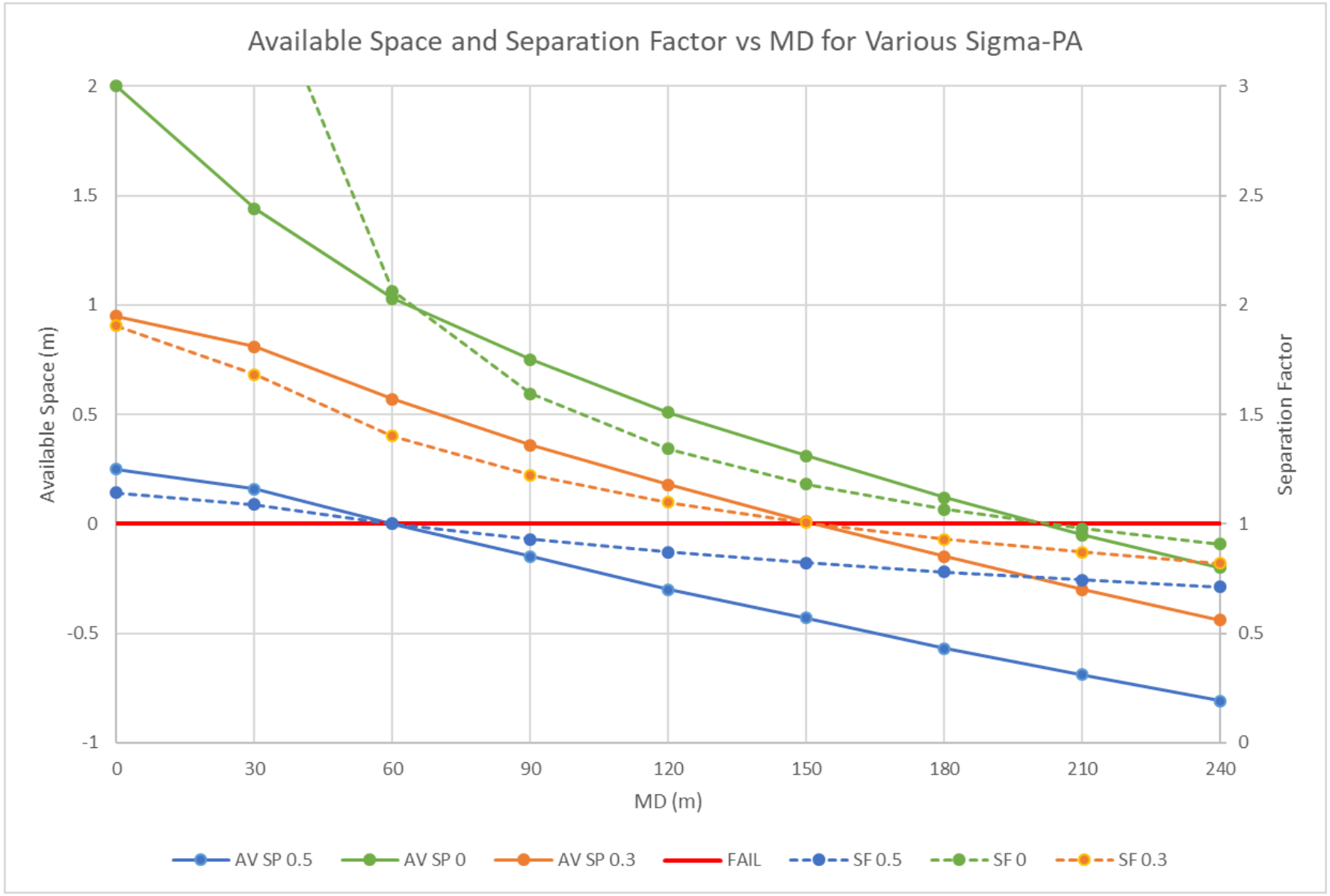
Project Ahead Uncertainty – Sigma PA

$$\frac{Dist - \left(HoleRad_{ref} + HoleRad_{off}\right) - Sm}{k\sqrt{\sigma_s^2 + \boldsymbol{\sigma_{pa}^2}}}$$

- SPE-187073 provides the following information
- *Quantifies the 1-SD [standard deviation] uncertainty in the projection ahead of the current survey station.*
- *Its value is partially correlated with the **projection distance**, determined as the current survey depth to the bit plus the next survey interval.*
- *The magnitude of the actual uncertainty also depends on the **planned curvature** and on the actual **BHA performance** at the wellbore attitude in the formation being drilled.*
- *The project-ahead uncertainty is only an approximation, and although it is predominantly oriented normal to the reference well, it is mathematically convenient to define σpa as being the radius of a sphere.*

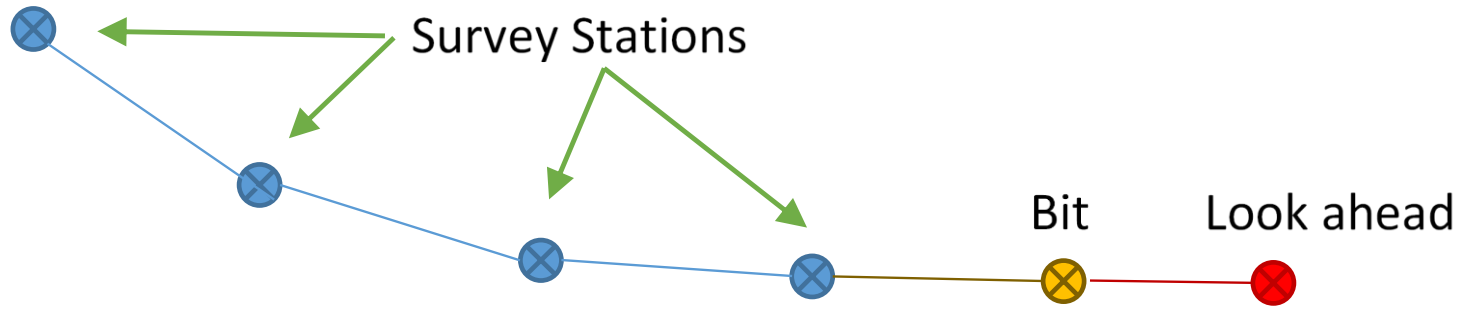


- Effect on MASD
- Parallel Wells - ISCWSA #1
- ISCWSA MWD R5
- Dashed lines horiz. drift @30m
- Equivalent to **required** directional control



- Available Space (AV SP; Left Axis)
  - Solid Lines
- Separation Ratio (R; Right Axis)
  - Dotted Lines
  - R Numerator=2m
- Value is Sigma-PA
  - σ_{pa}=0.5
  - σ_{pa}=0.3
  - σ_{pa}=0.0
- Ratio for σ_{pa}=0.0 is infinite at 0md

Factors in Project Ahead Uncertainty



- Projection to bit distance
- Look ahead distance

Typical Distances Drilled Blindly

Projection to bit

- bit to sensor distance

Scenario	Typical Range	
	(m)	(ft)
RSS Near-bit	1-5	3-15
RSS+MWD	5-10	15-30
Motor+MWD	15-25	50-80
Motor+MWD+Gyro	25-35	80-115
Motor+MWD+Drop Gyro	30-50	100-170

Lookahead Distance

- Projection to bit position at next survey
- Survey Course length
- Typically 30m/100ft for MWD
  - May survey every single 10m/30ft during tight collision zones
- Fully Continuous surveying would still leave Projection to bit distance as blind drilling

What about using steering data…

- Toolface orientation (High-side, magnetic, gyro)
  - Assumption: Toolface Orientation setting is already used in the projection
- Continuous/rotating/calculated inclination and/or azimuth
- Bending measurement / orientation
- Considerations
  - Sensor Position
  - Measurement accuracy
  - Data update rates
- SPE 199556 quotes a standard deviation of toolface precision of 20%
- example showing a difference of 4° in estimated bit inclination between human (29°) and (computer-generated) automated forward modelled (25°).

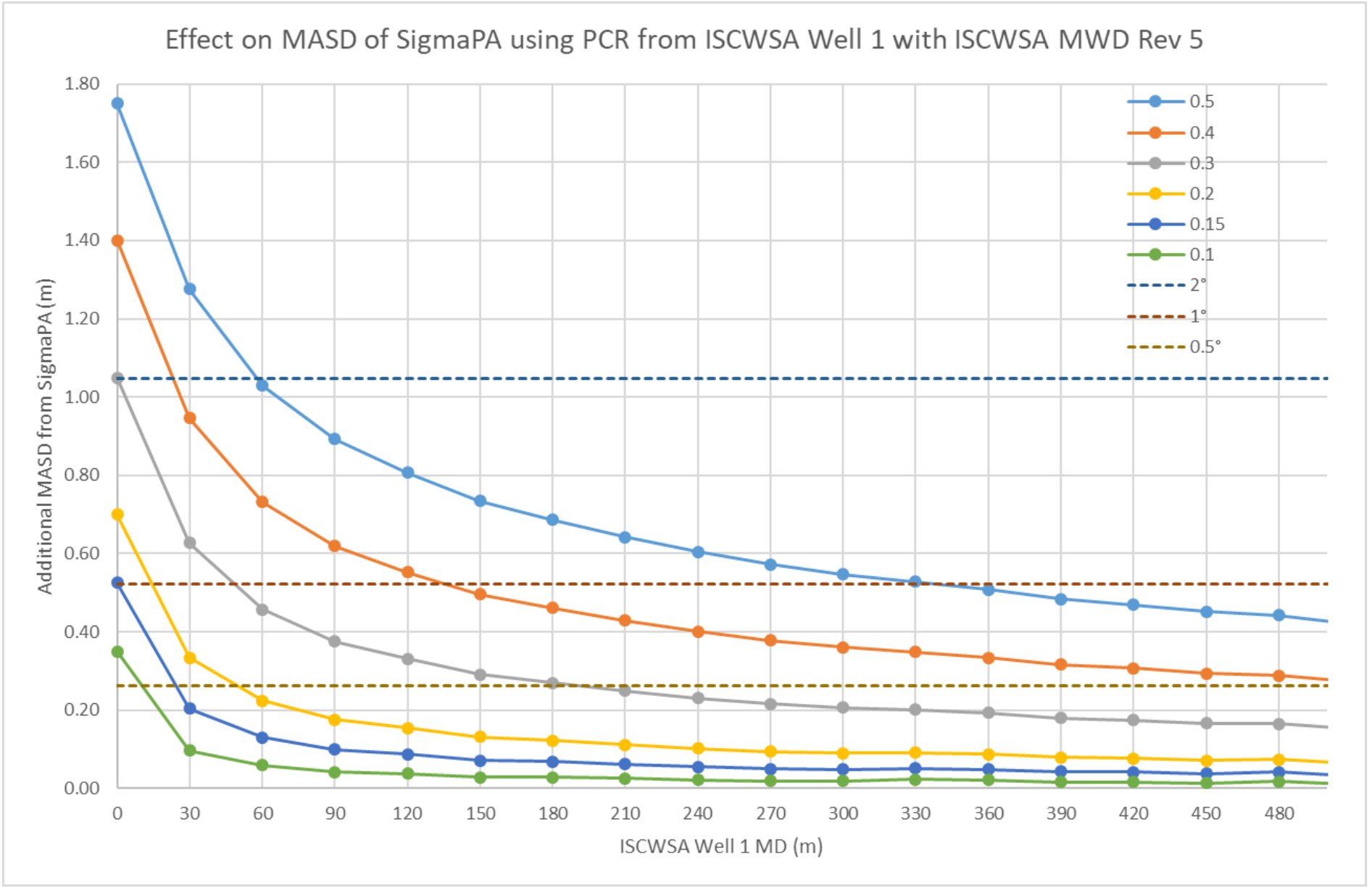
Guidance for choosing a value for σ_{pa}

- a holistic approach is required incorporating:
  - Corporate risk profile
  - Previous experience in similar campaigns
  - Directional sensor to bit distance
  - Project ahead distance (survey interval)
  - Angular control from BHA
- Prior to adjusting the WPTS published rule a **thorough risk analysis** should be performed
- A rule of thumb is to adopt a value of **0.01 meter per meter (1%) total projection to bit and Lookahead distance**.

Options to publish as CA Workgroup?

Rule	Proj to bit (m)	Lookahead (m)	σ_{pa} (m)	Angular Control equivalent
WPTS	-	≤30	0.5	≤2.5°
10m survey	≤20	≤10	0.3	≤0.5°
Continuous survey	≤10	≤5	0.15	≤0.15°

- Angular Control Equivalent is the directional control required throughout the collision risk zone
- Do we want to incorporate the continuous survey option?
  - I would be OK in not including it from the ISCWSA
  - Add a note stating the minimum σ_{pa} should be set to = 0.15



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