

November 29, 2018

# The Risking V

## One Company's Evolution of Risking Concepts and Applications

Energy lives here™

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Risk Coordinator Workshop

# Setting the Stage

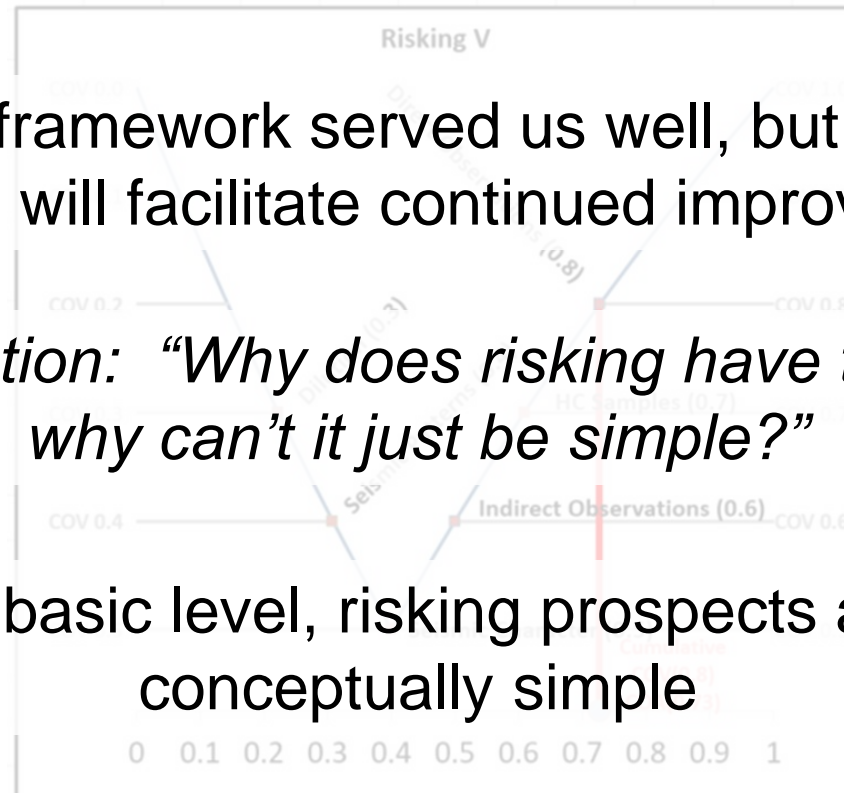
As part of ongoing efforts to improve analyses, ExxonMobil is updating our geologic risking process – this is a bit of a retrospective...

The previous framework served us well, but the proposed changes will facilitate continued improvements

*Common Question: “Why does risking have to be so hard – why can’t it just be simple?”*

At the most basic level, risking prospects and plays is conceptually simple

In practice, a number of complexities must be addressed



# Foundational Concepts

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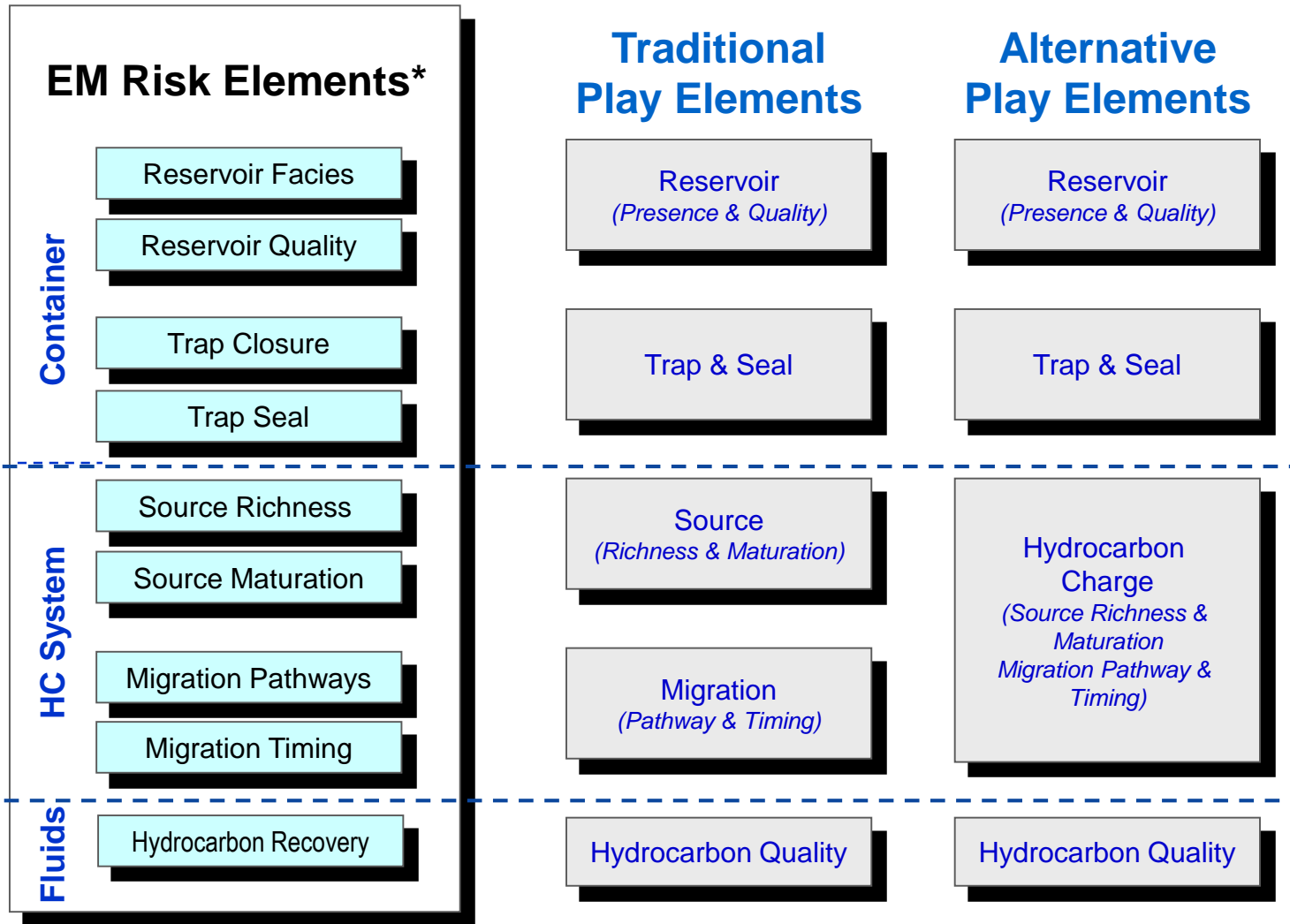
Start with some foundational concepts that speak to how we got to this point and constrain how we want to move forward...

## Foundational concepts:

- Explicit linkage to geology using standard play elements (*reservoir, source, etc*)
- Explicit partitioning of dependent (play) and independent (prospect) risk components (*a.k.a, split risking*)
- Explicit assessment minimum (*definition of geologic success*)
- Explicit separation of geologic and economic success

- Documented Base Rates and explicit Lines of Evidence (*with Bayesian update*)
- Explicit separation of geologic favorability (or unfavorability) from level of confidence or data constraints (*existing concept, new approach*)
- Capability to track results and calibrate to historical drilling outcomes (*Assessment Tracking Database*)

# Geologic Play Elements



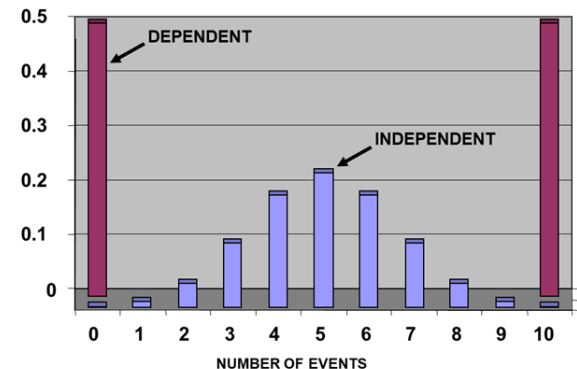
# Partitioning of Risk Components

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Most of industry uses a “split risking” process that considers dependent (shared) and independent components

Why does this matter?

- For a play or portfolio of prospects, split risking is required in order to represent the success case (prospects tend to succeed or fail in groups)
- Play success can derisk (or partially derisk) remaining dependent prospects
- Play failure can invalidate remaining dependent prospect inventory
- The initial wildcat is burdened with the play risk – after success, subsequent dependent prospects are not
- Determining play success or failure as quickly as possible has significant value to the business





# Usage – The Risk Matrix

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	HIGH	MODERATE	LOW
0 - .3		X	.9 - 1.0
.1 - .4		.4 - .7	.7 - .9
.2 - .5		.5 - .6	.6 - .7

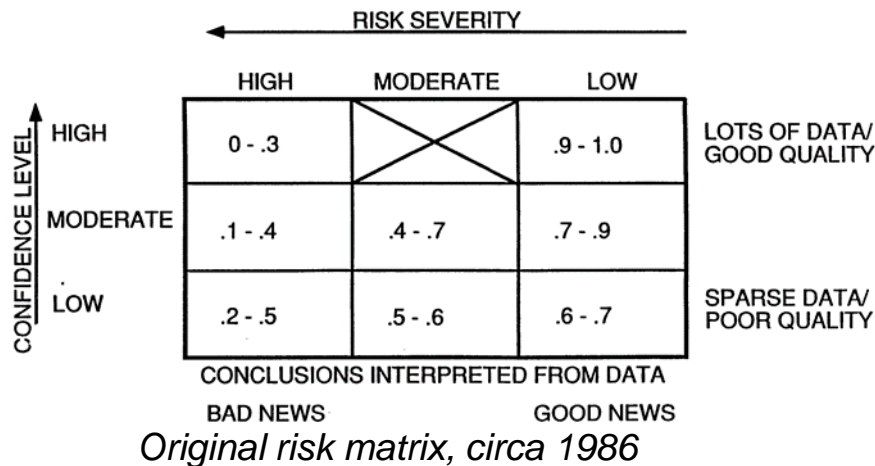
CONCLUSIONS INTERPRETED FROM DATA

Explicit separation of the geologic characterization from the confidence level is critical

- With low confidence (limited data constraints), you can neither strongly support nor condemn an opportunity
    - ❖ *It is better to know something is good than to think it might be good*
    - ❖ *It is worse to know something is bad than to think it might be bad*
  - With high confidence, you cannot sit on the fence [must be close to 0 (failure) or 1 (success)]
- While this concept is a very powerful, our implementation provided room for improvement

# History of the Risk Matrix

## Risk Matrices utilized at ExxonMobil



LEVEL OF GEOLOGIC UNDERSTANDING	VIABILITY OF MECHANISM			EXAMPLE:
	BAD NEWS	NEUTRAL	GOOD NEWS	
HIGH	<b>0-.2</b>	n/a	<b>.8-1</b>	GOOD QUALITY, DEFINITIVE DATASETS
MEDIUM	<b>.2-.4</b>	<b>.4-.6</b>	<b>.6-.8</b>	
LOW	<b>.4-.5</b>	<b>.5</b>	<b>.5-.6</b>	POOR QUALITY, NON-DEFINITIVE DATASETS
EXAMPLE:	NEGATIVE INDICATIONS PREDOMINATE		POSITIVE INDICATIONS PREDOMINATE	

*Modified risk matrix, circa 2000*

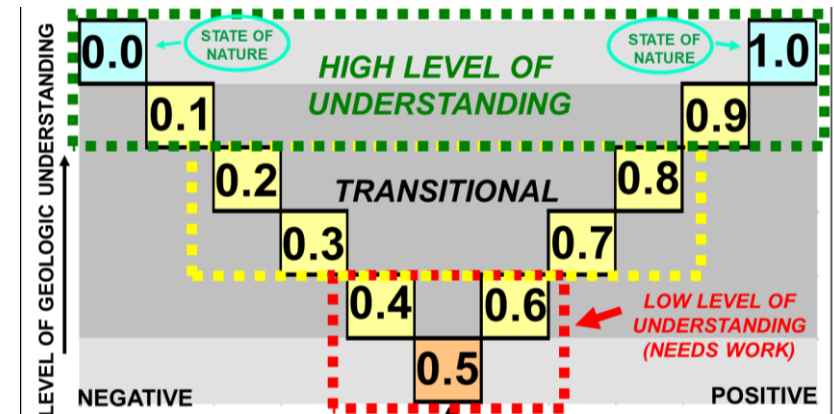
*Proposed modified risk matrix, circa 1995*

0.0	1.0
0.1	0.9
0.2	0.8
0.3	0.7
0.4	0.6
0.5	

*Proposed risk matrix modified for Base Rate, circa 2009*

0.00 - 0.04	X	0.64 - 1.00
0.04 - 0.16	0.16 - 0.36	0.36 - 0.64
0.16 - 0.25	0.25	0.25 - 0.36

**ExxonMobil**



*Initial Referenced V, circa 2000  
"Referenced to Base Rate"*

# Integrating Lines of Evidence (LOEs)

LOE - Independent observation pertaining to success or failure for a particular risk element

## Integrating Lines of Evidence with the Risk Matrix

- Evaluated process of plotting observations (LOEs) on Risk Matrix
- Useful documentation, but challenge combining conflicting observations (e.g., how do 2 Medium Positives compare to 1 High Negative?)

		VIABILITY OF MECHANISM		
		BAD NEWS	NEUTRAL	GOOD NEWS
CONFIDENCE	HIGH	0 - <b>3</b>	n/a	.8 - 1
	MEDIUM	.2 - .4	.4 - .6	<b>2</b> - <b>1</b>
	LOW	.4 - .5	.5	.5 - .6

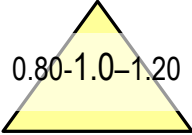
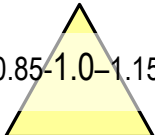
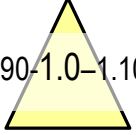

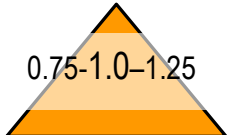
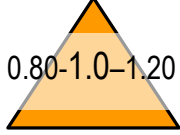
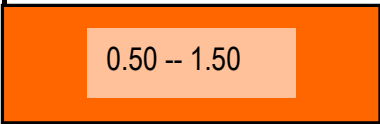
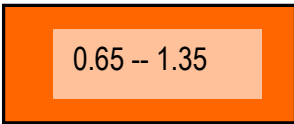
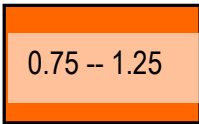
*Image captured for documentation*

- 1** Medium Positive Geologic Observation #1
- 2** Medium Positive Geologic Observation #2
- 3** High Negative Geologic Observation #3

# Risk Matrix Limitations

Concept only applicable if state of nature is 0 or 1

- Does not apply to Success Ratio for a family of prospects
- High-confidence estimates could be any value between 0 and 1
- Confidence level informs the range the applied to the estimate

CONFIDENCE LEVEL	RISK SEVERITY		
	HIGH <0.10	MEDIUM 0.10 - 0.20	LOW >0.20
HIGH	0.80-1.0-1.20 	0.85-1.0-1.15 	0.90-1.0-1.10 
MEDIUM	0.70-1.0-1.30 	0.75-1.0-1.25 	0.80-1.0-1.20 
LOW	0.50 -- 1.50 	0.65 -- 1.35 	0.75 -- 1.25 

Future Success Ratio Uncertainty Multiplier

# Risk Matrix – the Neutral Value (0.5)

LEVEL OF GEOLOGIC UNDERSTANDING	VIABILITY OF MECHANISM			EXAMPLE:
	BAD NEWS	NEUTRAL	GOOD NEWS	
HIGH	0-.2	n/a	.8-1	GOOD QUALITY, DEFINITIVE DATASETS
MEDIUM	.2-.4	.4-.6	.6-.8	
LOW	.4-.5	.5	.5-.6	POOR QUALITY, NON-DEFINITIVE DATASETS
EXAMPLE:	NEGATIVE INDICATIONS PREDOMINATE		POSITIVE INDICATIONS PREDOMINATE	

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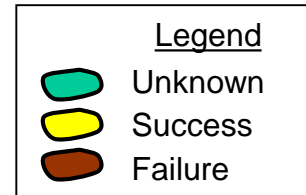
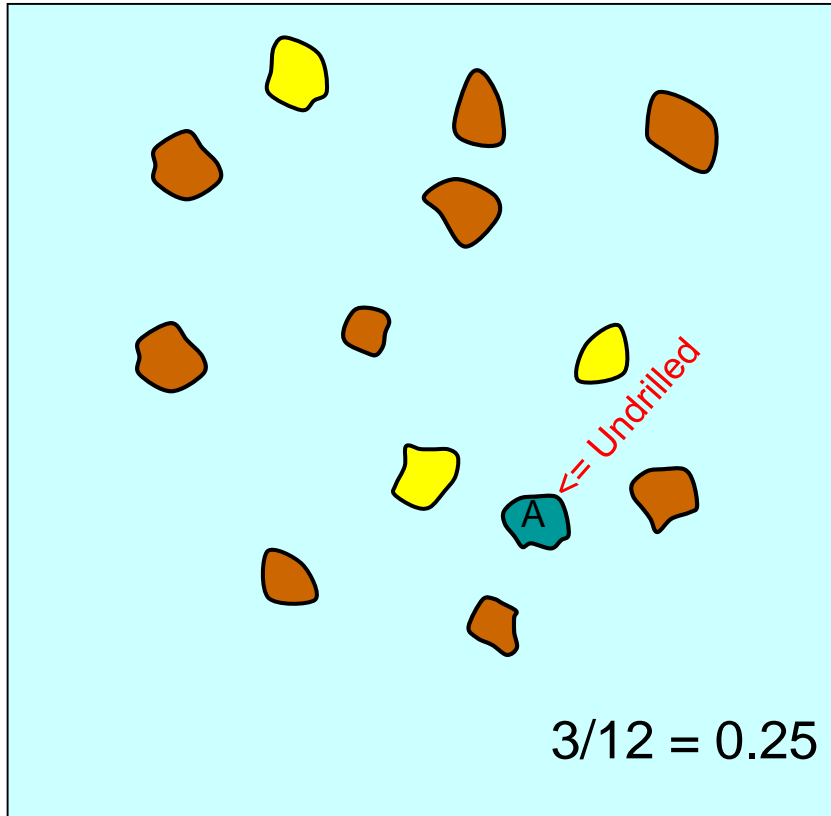
## Why do we assume geology is like a coin?

- A coin has exactly two outcomes of equal probability
- Just because we don't know what the outcome will be does not mean the outcomes are equally likely
- We can use drilling results or geologic insights to inform the probability of success (Prior, or Base Rate)
- Knowing nothing else, revert to the Base Rate (generally not 0.5)

Realization – Risk Matrix concept more powerful when applied to COV

# Base Rate – Simple Example (Patchy)

## Reservoir Facies Presence Adequacy

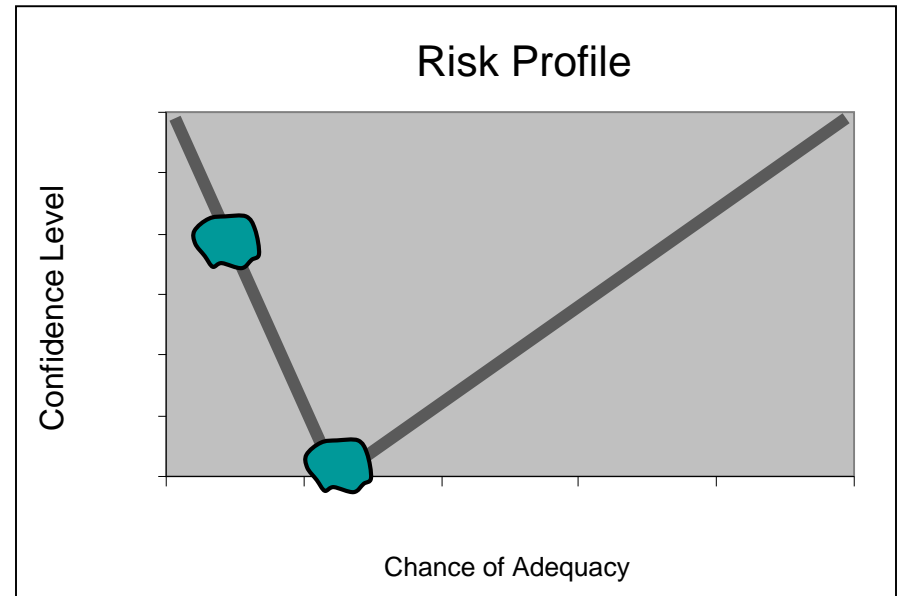
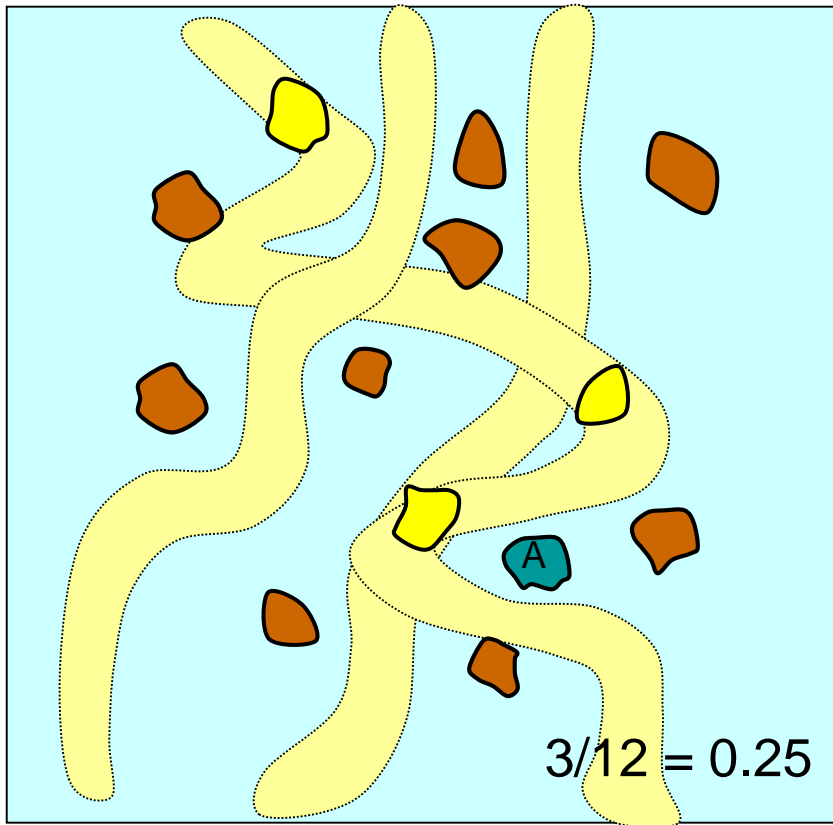


Consider set of 12 prospects tested for Reservoir Presence

What is the chance that undrilled prospect "A" has Reservoir?

# Base Rate – Simple Example (Patchy)

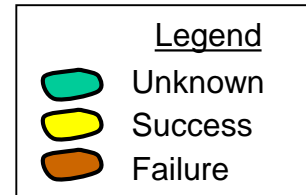
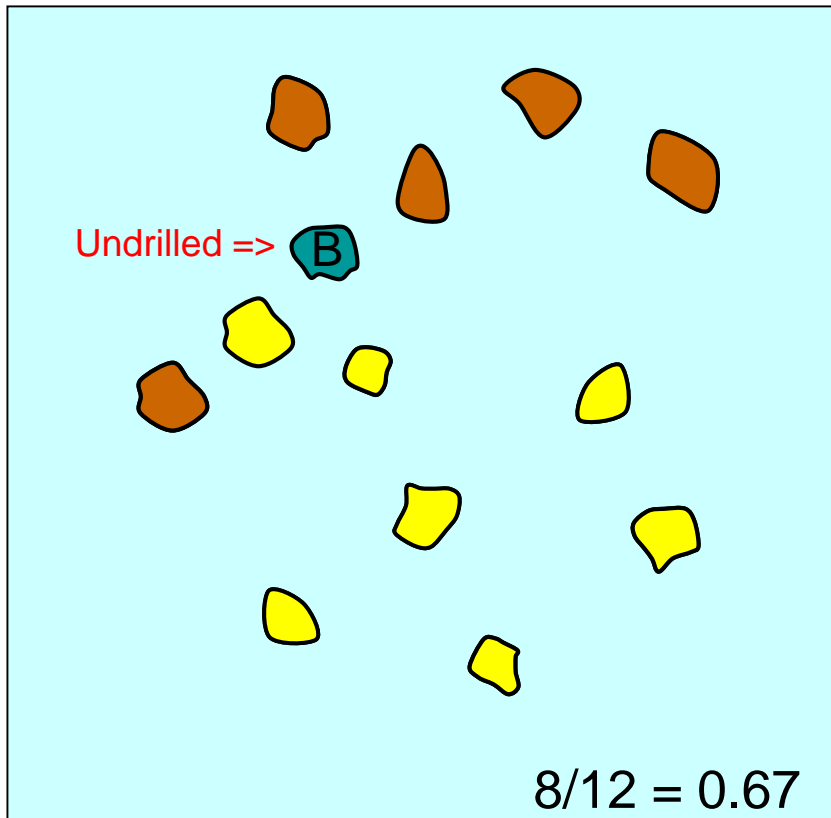
## Reservoir Facies Presence Adequacy



Referenced V – Patchy Reservoir

# Base Rate – Simple Example (Distributed)

## Reservoir Facies Presence Adequacy

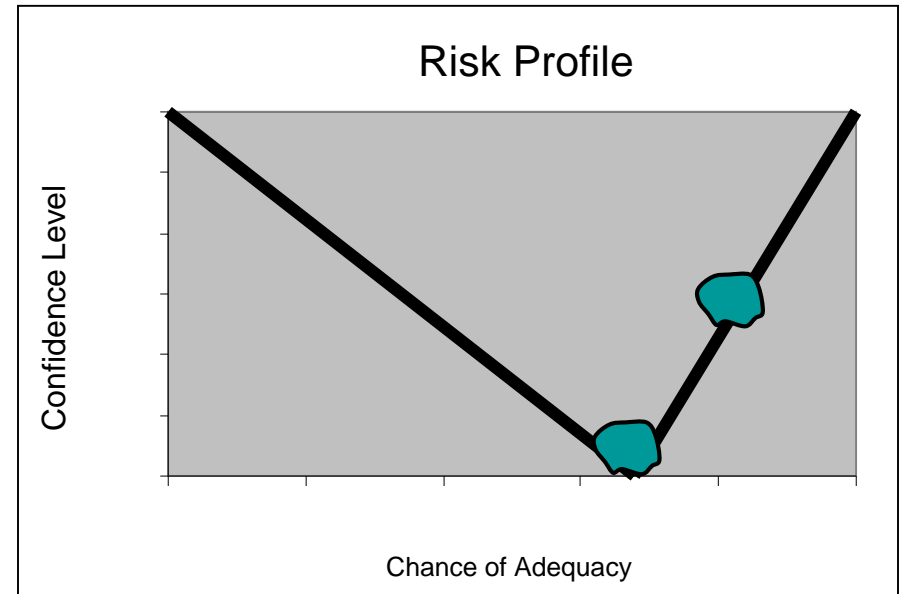
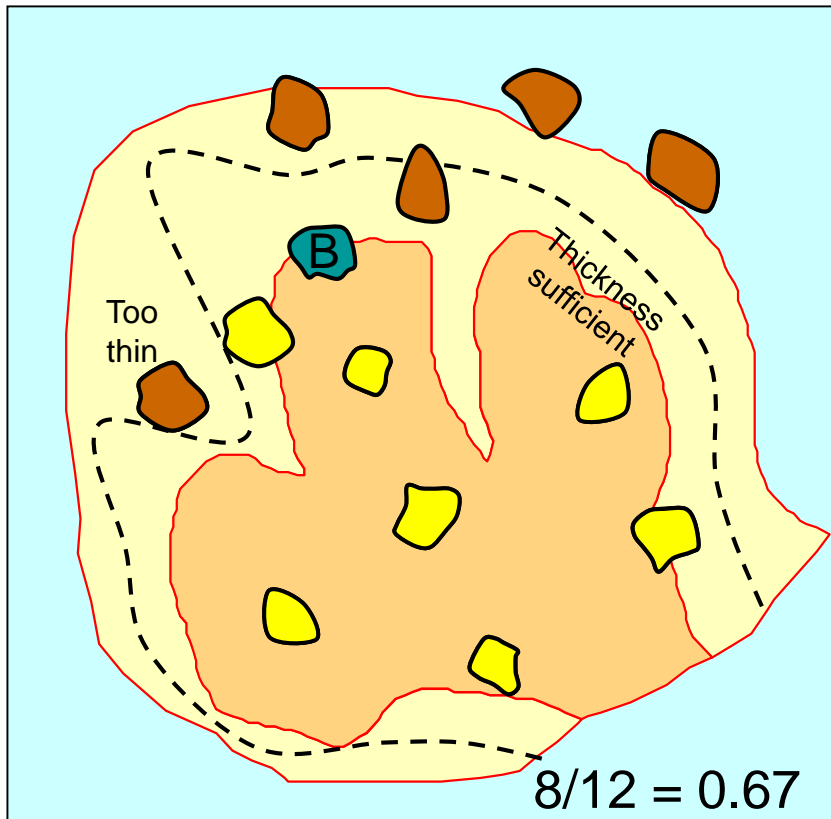


Consider set of 12 prospects tested for Reservoir Presence

What is the chance that undrilled prospect "B" has Reservoir?

# Base Rate – Simple Example (Distributed)

## Reservoir Facies Presence Adequacy



Referenced V – Distributed Reservoir

# Applying New Insights – The Risking V

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Enhancement: Use Risk Matrix concept to represent test accuracy (COV) within an upgraded Risking V process

- Historically, applied most commonly as updated COA

Implementing Risking V concept in conjunction with:

- Base Rates and Benchmarks
- Explicit Lines of Evidence (visualized using a COV Matrix)
- COV (Chance of Validity) Modifiers

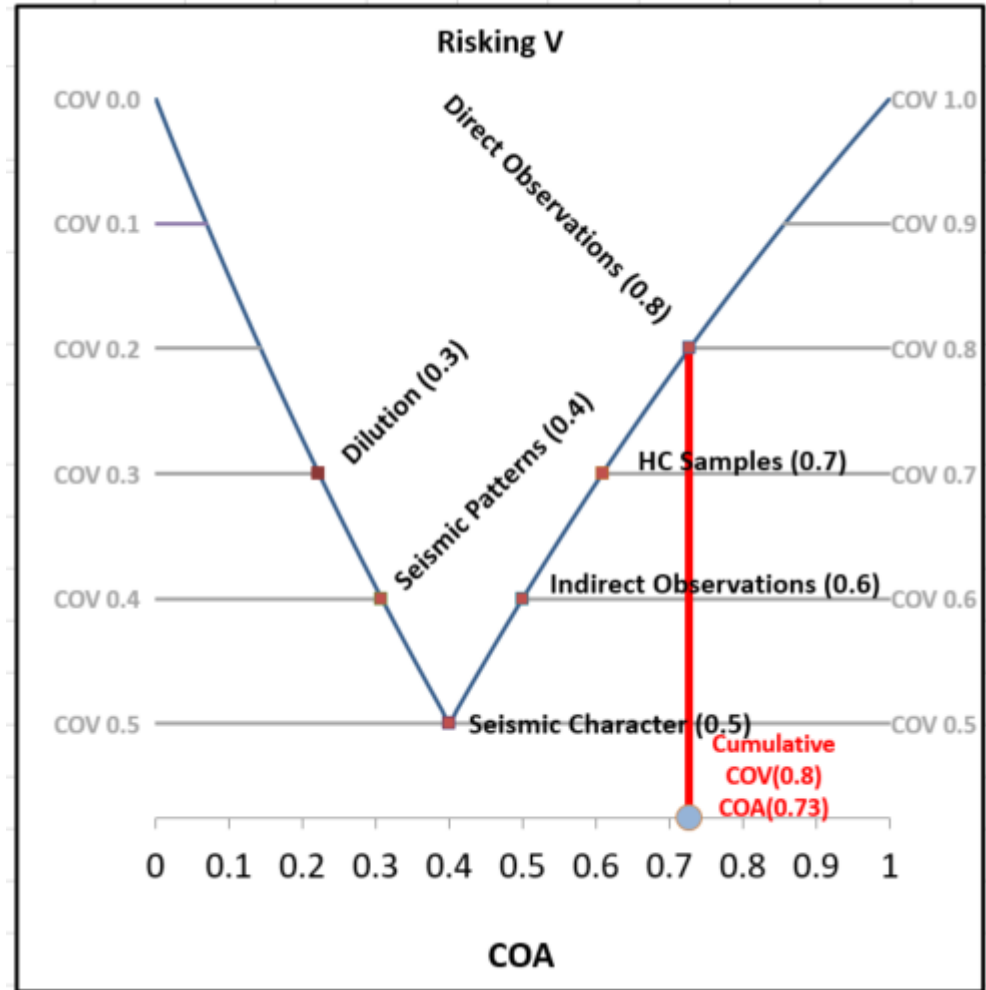
...to derive a final Chance of Adequacy (risk) value

This approach will provide an enhanced framework in which to track results and calibrate inputs

- Delivering better support for business decisions while facilitating learning

# The Risking V

Base Rate/COV Integrator		
Risk Element	Source	
Asset		
	Base Rate Description	
Base Rate	0.4	
Line of Evidence (LOE) Name	LOE COV	LOE Description
Dilution	0.3	
Seismic Patterns	0.4	
Seismic Character	0.5	
Indirect Observat	0.6	
HC Samples	0.7	
Direct Observatio	0.8	
Cumulative COV	0.80	
Adjusted COA	0.73	



The Risking V integrates Base Rate with Lines of Evidence with appropriate Chance of Validity

# Risking V Implementation

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Single Risking V created for each of the 9 geologic play elements

- Represent total risk – results partitioned into shared and independent components

Each Risking V created by team of subject experts, considering:

- Consistent Lines of Evidence (LOEs)
- Chance of Validity (COV) – criteria and bumpers
- Global Base Rates (guidance for local Base Rates – preferred)

Flexibility for incorporating unique local considerations

- With appropriate documentation

Working to track lines of evidence and COVs in Assessment Tracking Database (ATDB)

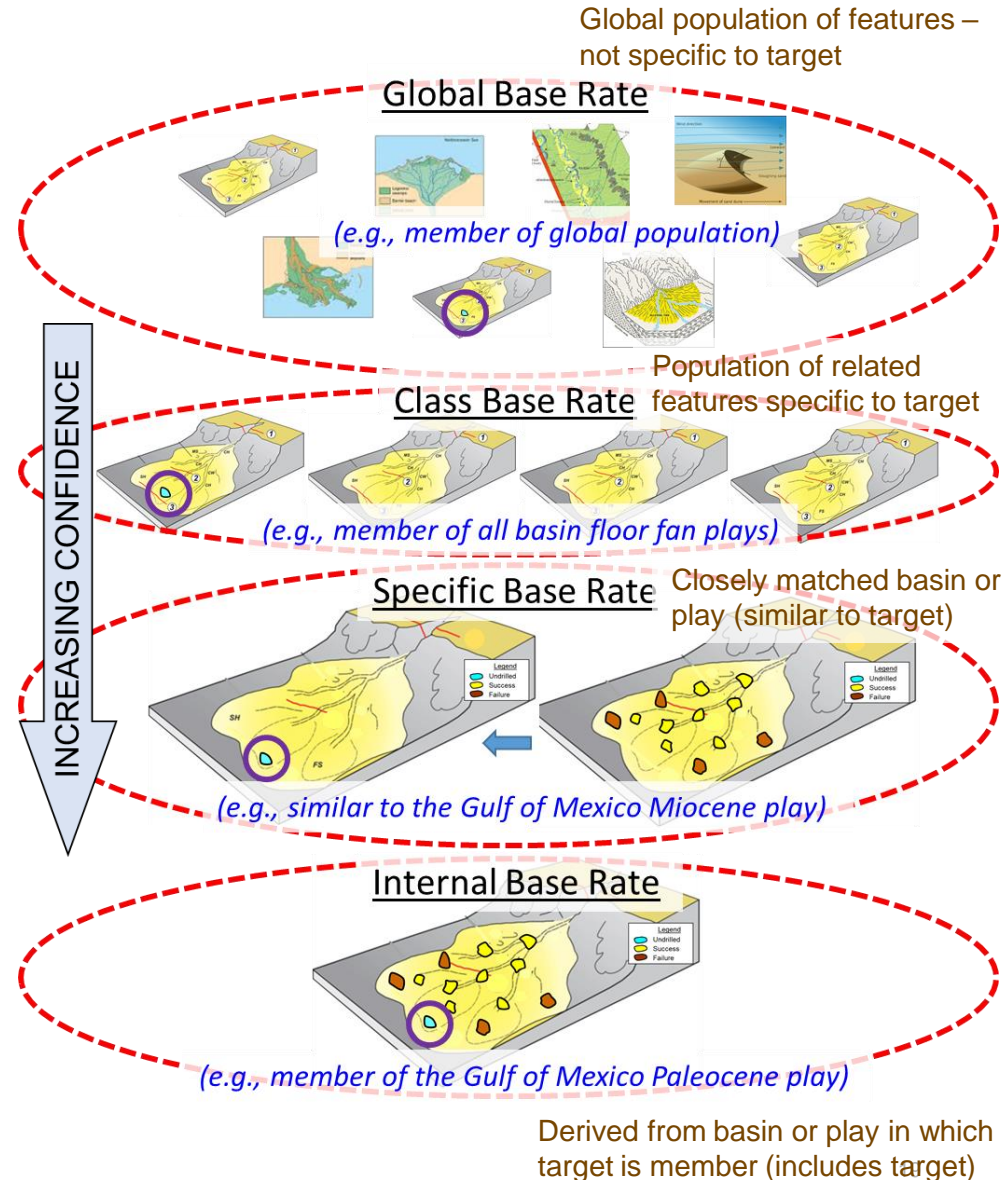
# Definitions: Base Rate & Lines of Evidence

## Base Rate

- Initial assumption about the Chance of Success
- Based on historical drilling results or geologic concepts
- Determined at different levels of granularity

## Line of Evidence (LOE)

- Information that can be used to update the Chance of Success
- Quantified to support Bayesian updating (Chance of Validity)
- Standard LOE's by play element
- Can be modified locally as necessary (with documentation)



# Line of Evidence Guidance

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## For each Play Element

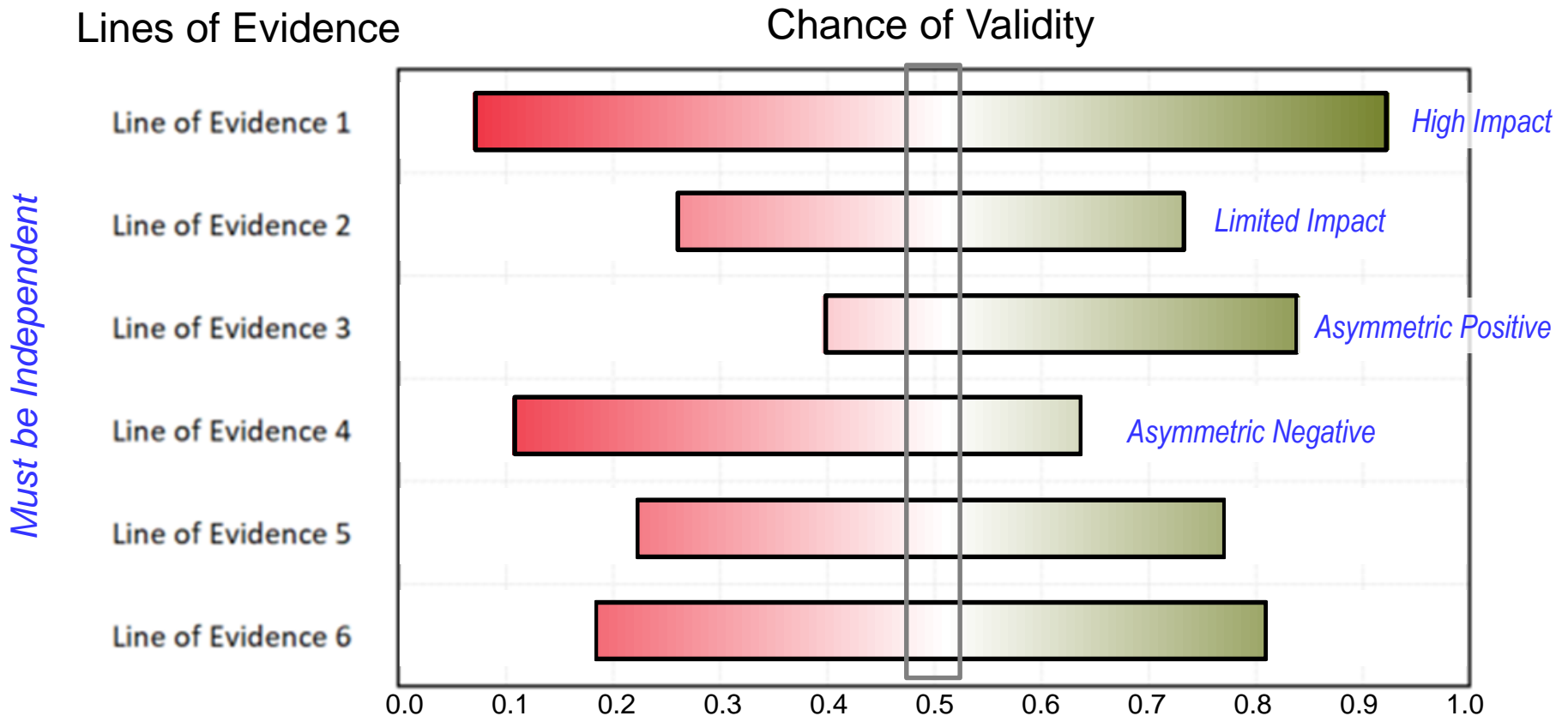
- Guidance is provided for each Line of Evidence (LOE) to facilitate consistency in assigning Chance of Validity (CoV) values

Example Removed

Line of Evidence #1

Line of Evidence #2

# Lines of Evidence & Chance of Validity

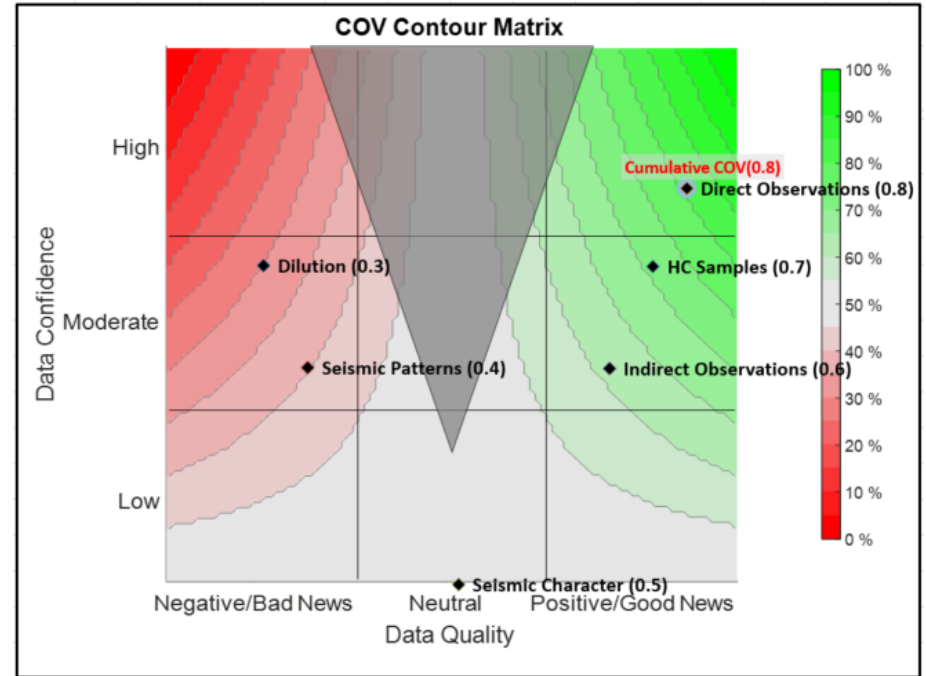
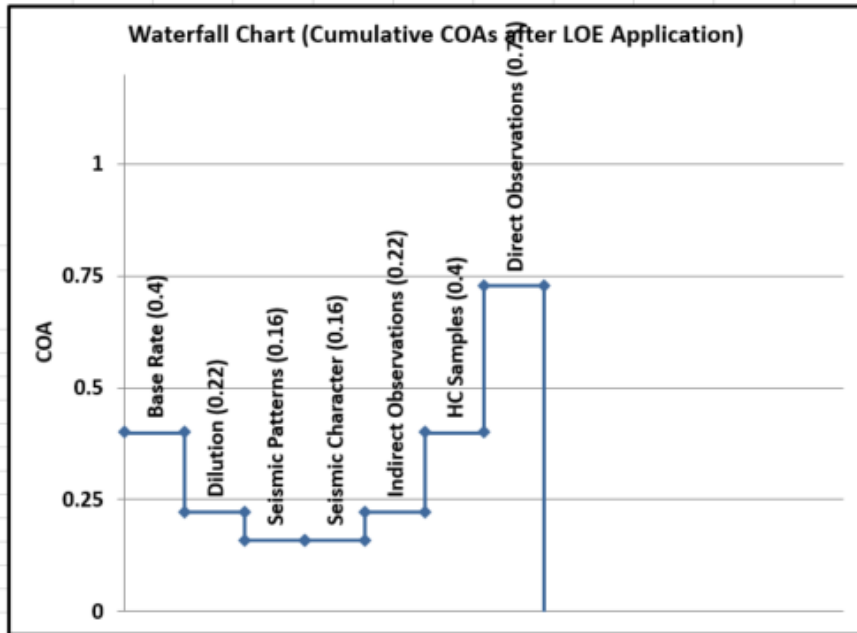


Bumpers (COV limits) constrain the influence of each Line of Evidence

- As used here, COV is  $P(\text{Observations}|\text{Technical Success})$
- A wide range indicates potential for a substantial impact
- A narrow range indicates a limited impact
- The bumpers can be asymmetric (*e.g., something is helpful if present but not limiting if absent*)

# The Risking V Bayesian Update Process

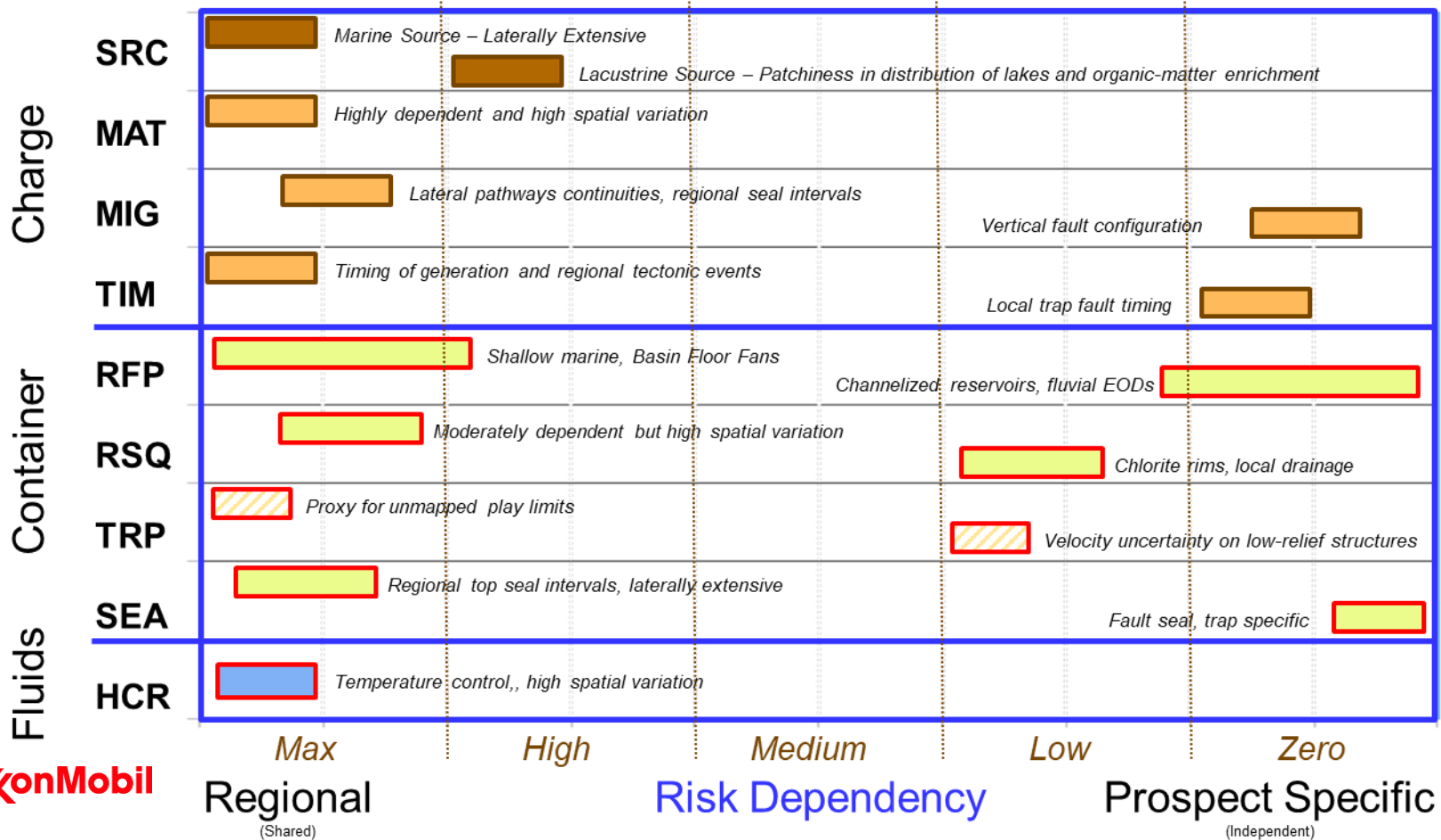
The Risking V uses sequential Bayesian updating to arrive at the modified Chance of Success



# Partitioning Risk Components

Each Risking V represents total risk (one Risking V per element)

- Total Element Risk partitioned into dependent and independent components
- The expected contribution of the two components varies by element



# Conclusions

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ExxonMobil is implementing a Risking V process to provide an improved platform for calibrating and tracking geologic success

Risking V's are implemented by geologic play element

- Dependent and independent components partitioned from the results

Each Risking V includes guidance on defining Base Rates, Lines of Evidence, and Chance of Validity

Sequential Bayesian updating is used to produce the final Chance of Adequacy

Results will be tracked in the Assessment Tracking Database (ATDB) for validation and to facilitate learning



**Thank You!**