Making Decisions Under Subsurface Uncertainty

How Difficult Can It Be?

VERY!!!

Outline

- ## Definition of Problem

  – How, when and why these cognitive errors impact our decisions

- ## Industry Evidence to Support Hypothesis

  – Impact upon the E&P Industry leading to poor outcomes

- ## Cognitive Bias

  – Contribution to our poor assessment of uncertainty

Question to Consider:

How do you make decisions, judgments and interpretations when faced with a bewildering array of choices, data, alternatives and incomplete information?

Risk vs. Uncertainty

Risk: threat of a chosen action or event leading to a loss or unwanted outcome, expressed as a probability

Uncertainty: having limited knowledge, expressed as a range of possible outcomes

We are much better at understanding risk than we are at understanding uncertainty

Poor Estimation Skills

- Decision making, by its nature, <u>incorporates uncertainty</u>

- Universal tendency is to <u>understate uncertainty</u>

- This happens because most people are…

    - <u>Too sure </u>of themselves and judgments

    - <u>Too attached</u> to their analysis

    - <u>Too certain</u> they have narrowed the range of possible outcomes

    - <u>Not open</u> to considering contrary information and opinions
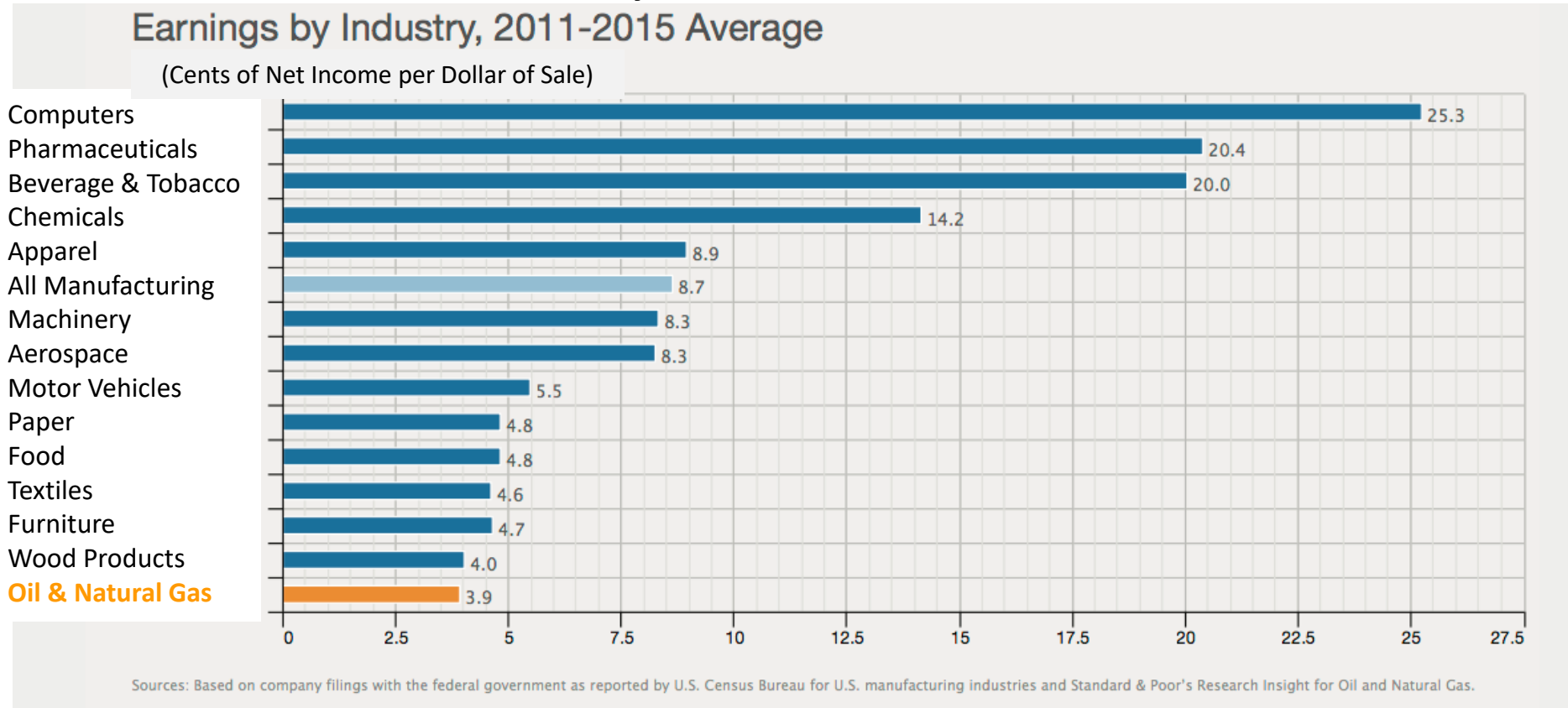
E&P Industry Relevance

- E&P projects have multiple and varied challenges

  - High complexity and uncertainty

  - Large amounts of money are at risk

  - Data and time are limited

- We take shortcuts to act quickly by…

  - Applying intuition, emotion and experience

  - Failing to fully quantify risks and uncertainties

- Projects may fail by not realizing predicted outcome

- Our biases and not applying learnings erode value!

We are collectively making similar errors

Industry Performance
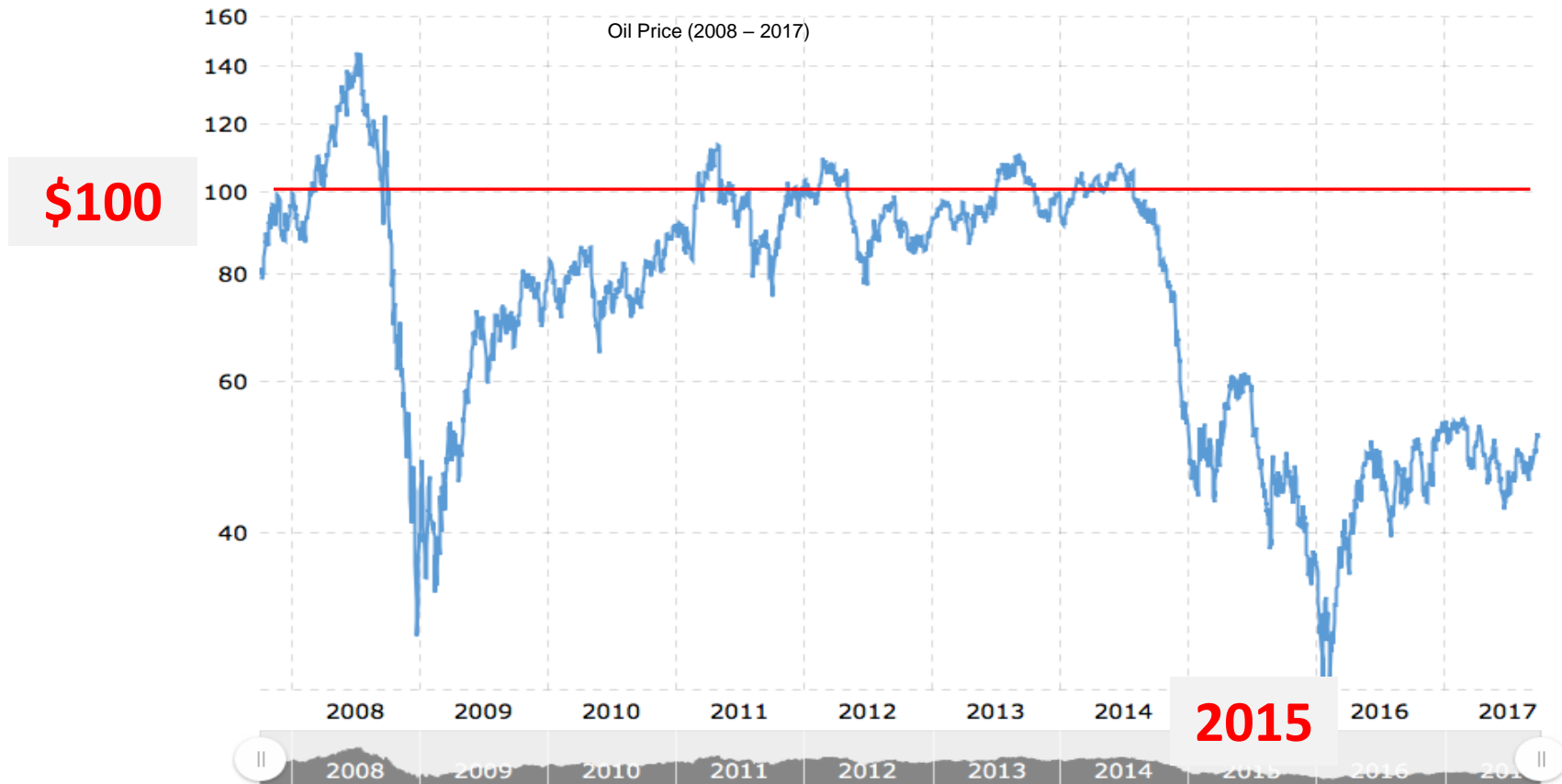
As an industry, we are not performing well
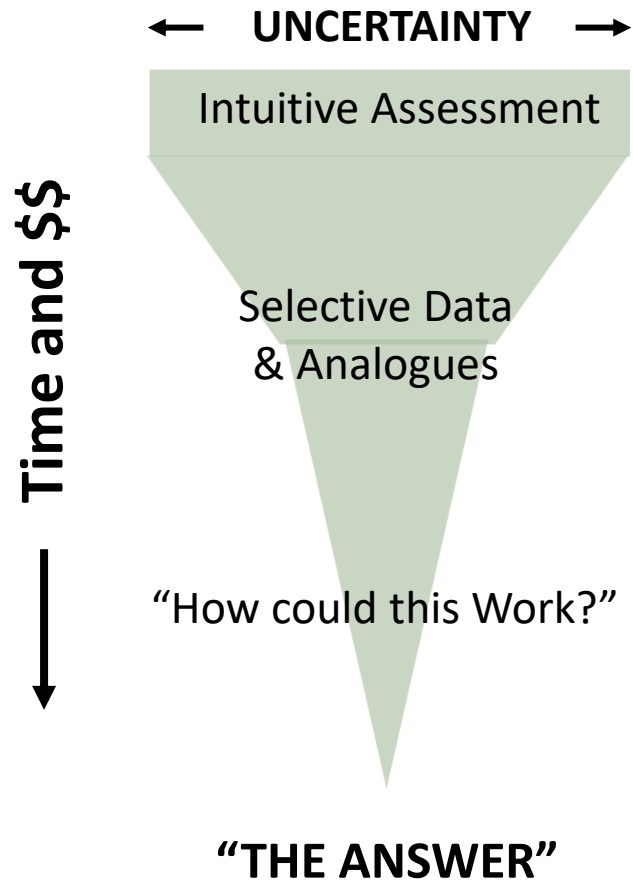
EARNINGS BY INDUSTRY, 2011-2015 AVERAGE

Earnings by Industry, 2011-2015 Average
(Cents of Net Income per Dollar of Sale)

Industry	Value
Computers	25.3
Pharmaceuticals	20.4
Beverage & Tobacco	20.0
Chemicals	14.2
Apparel	8.9
All Manufacturing	8.7
Machinery	8.3
Aerospace	8.3
Motor Vehicles	5.5
Paper	4.8
Food	4.8
Textiles	4.6
Furniture	4.7
Wood Products	4.0
Oil & Natural Gas	3.9

Sources: Based on company filings with the federal government as reported by U.S. Census Bureau for U.S. manufacturing industries and Standard & Poor's Research Insight for Oil and Natural Gas.

Industry Performance

As an industry, we are not performing well

OIL PRICE, 2008-2017

Oil Price (2008 – 2017)

$100

2015

Managing Uncertainty

Deterministic View

← UNCERTAINTY →

Time and $$

Intuitive Assessment

Selective Data & Analogues

"How could this Work?"

"THE ANSWER"

Probabilistic View

← UNCERTAINTY →

Objective Assessment

Alternative Scenarios, Open to new ideas

"How could this Fail?"

P90 P10

RANGE OF OUTCOMES
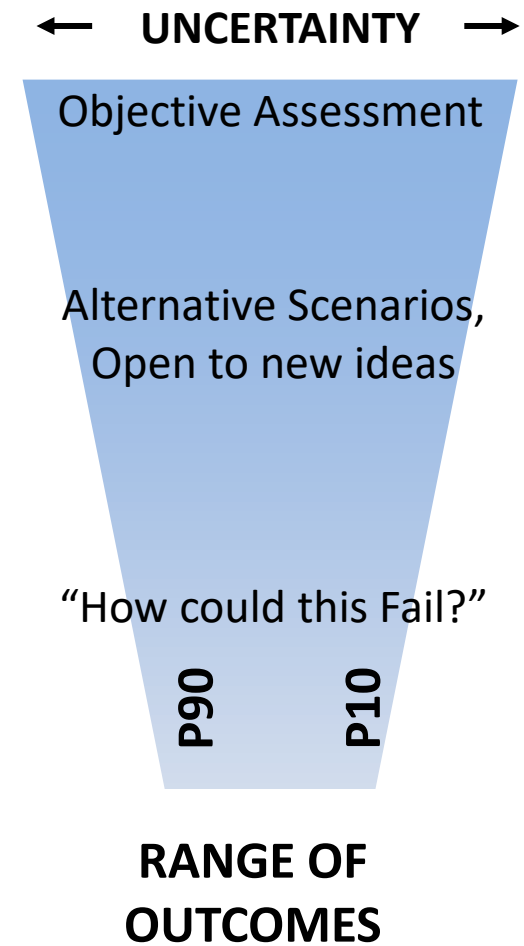
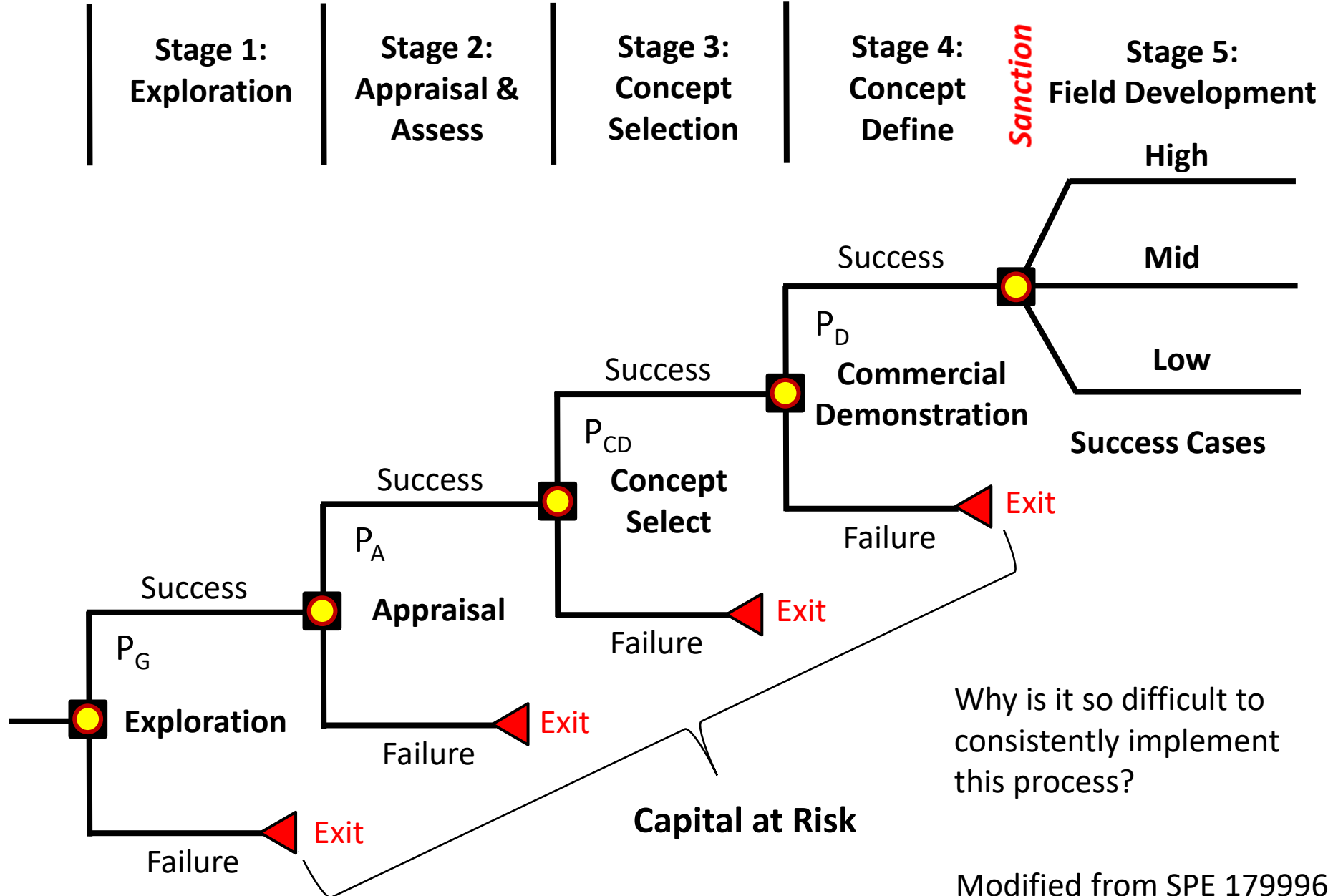*"An unbiased appreciation of uncertainty is a cornerstone of rationality – but it is not what people and organisatons want" D. Kahneman, 2011*

The Staged Approach for Managing Risk

Stage 1: Exploration | Stage 2: Appraisal & Assess | Stage 3: Concept Selection | Stage 4: Concept Define | *Sanction* | Stage 5: Field Development

P_G Exploration

P_A Appraisal

P_{CD} Concept Select

P_D Commercial Demonstration

Success — Success — Success — Success

High / Mid / Low

Success Cases

Failure — Exit

Capital at Risk

Why is it so difficult to consistently implement this process?

Modified from SPE 179996

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E&P Industry Relevance

- Examples Where Cognitive Pitfalls Impact in E&P Industry
  - Exploration Play Potential
  - Resource Estimation
  - Chance of Success
  - Appraisal Programme
  - Production Forecasting
  - Development Concept
  - Project Planning (e.g., costs, time, resources)
  - Portfolio Predictions
  - Company or Project Valuation

E&P Industry Relevance

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For Example: Exploration Volumes Bias
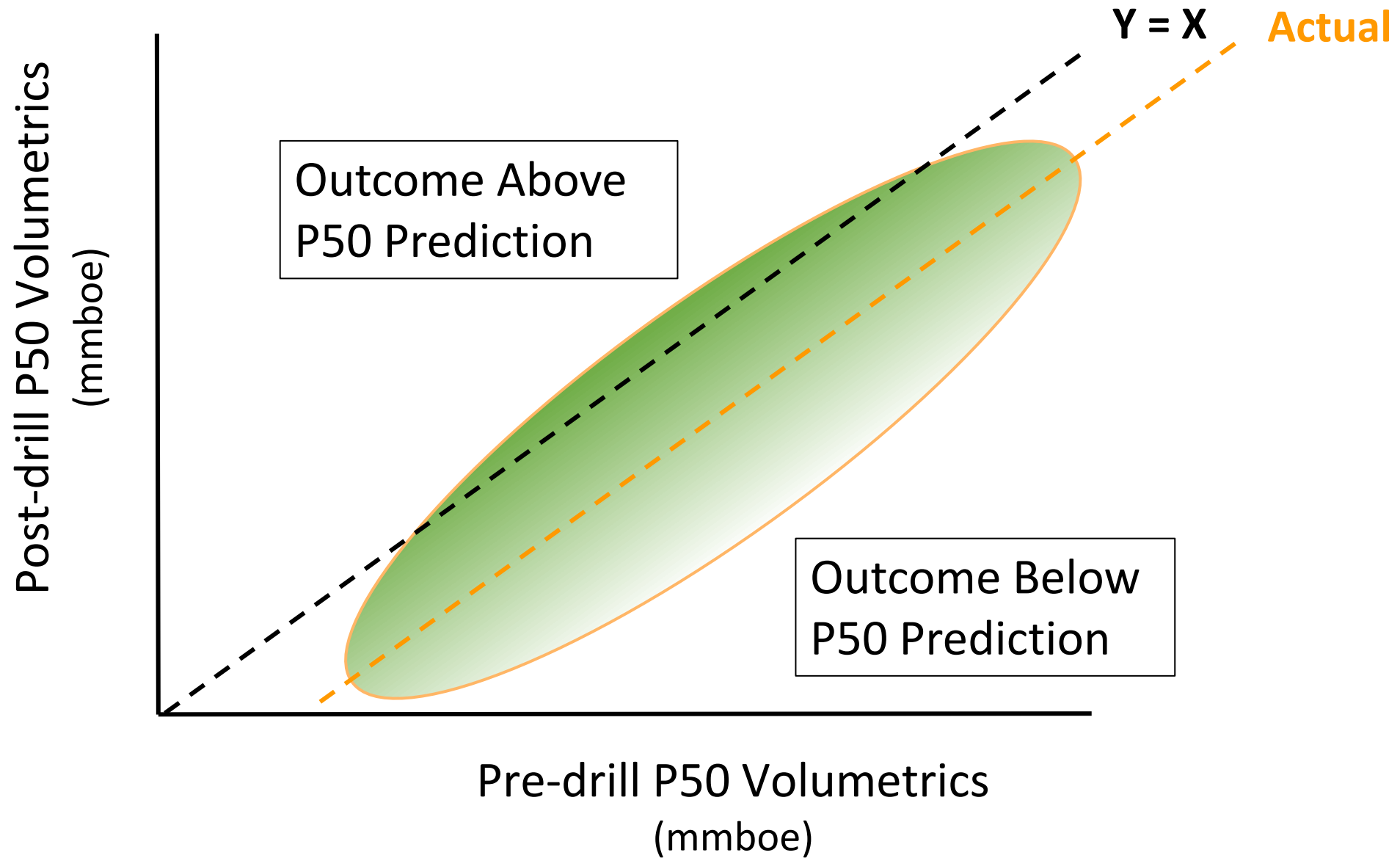
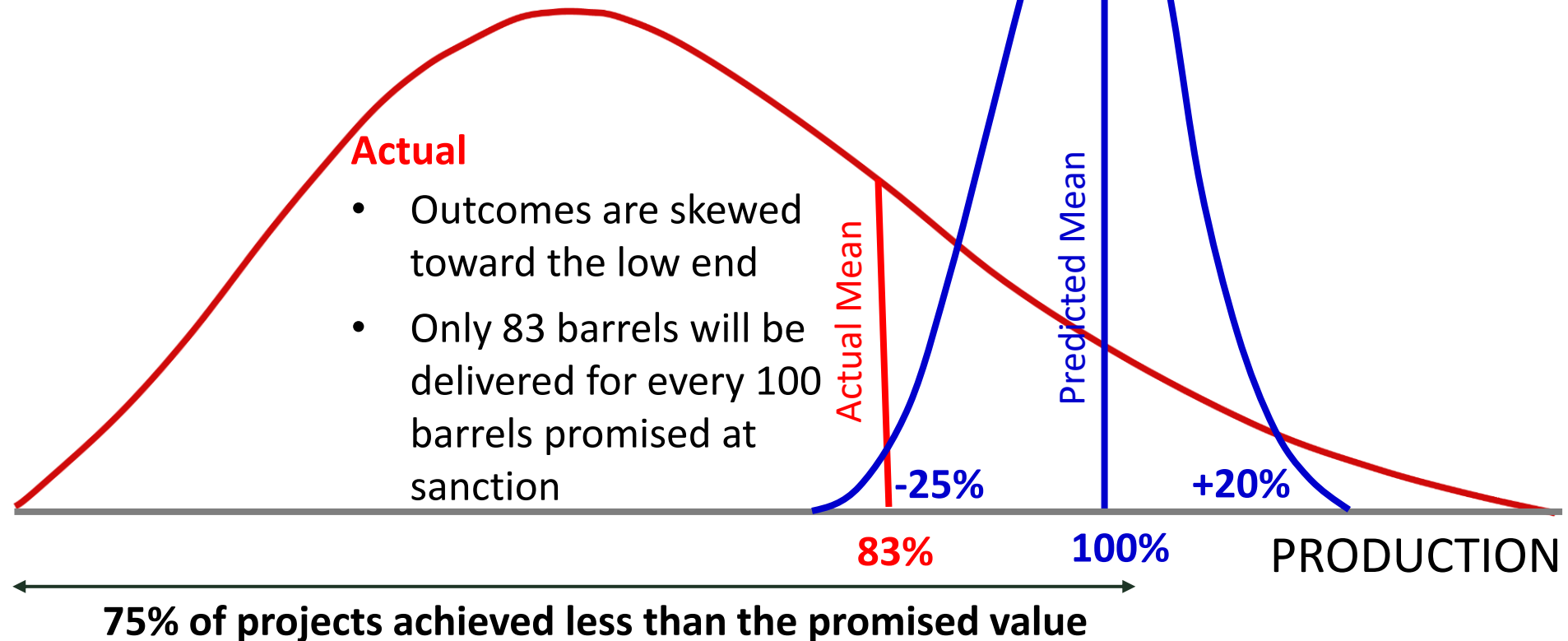# For Example: Production Attainment Bias

Predicted
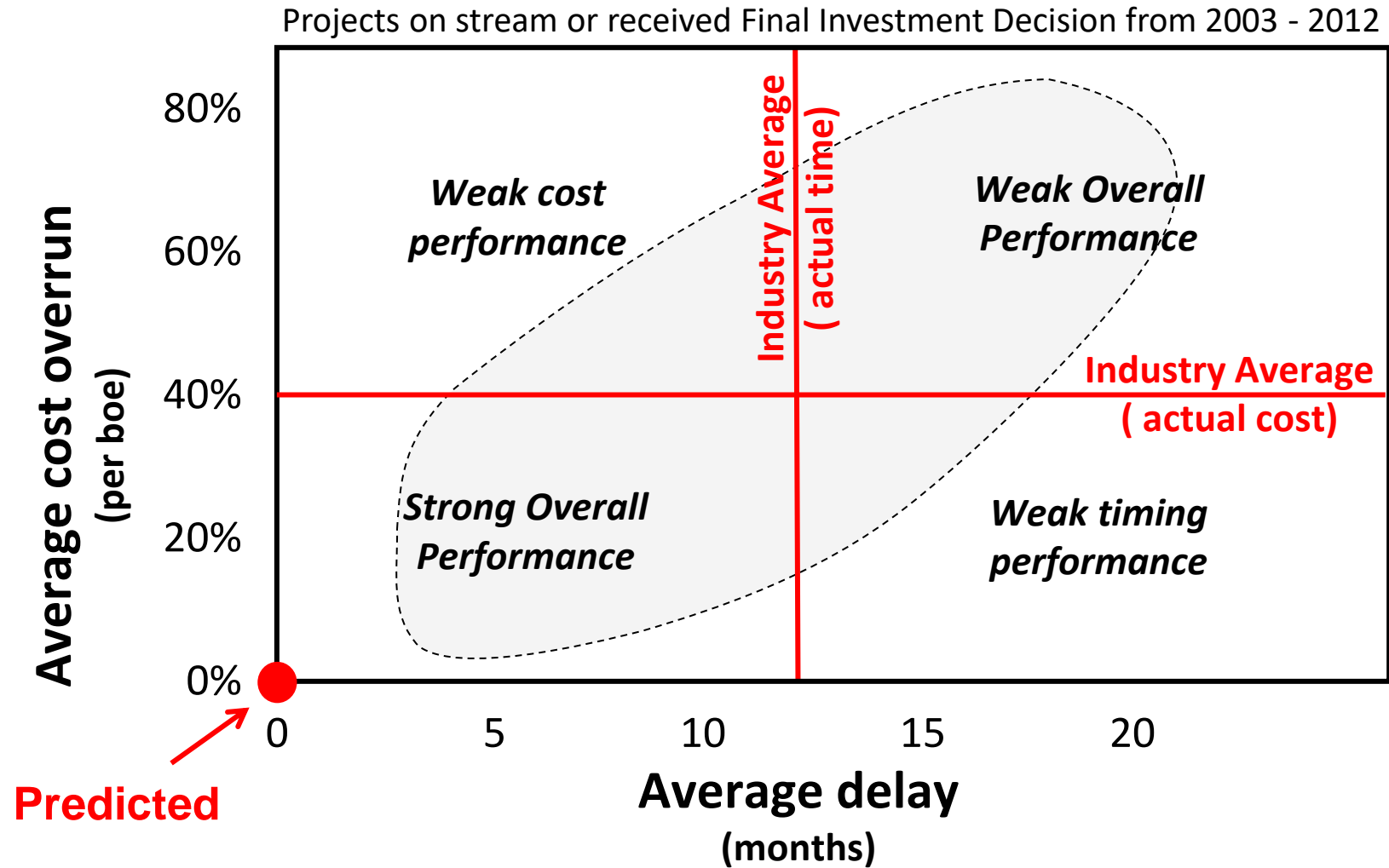- Target will be met with a narrow uncertainty of -25% to +20%

Overconfidence
(predicted range is too narrow)
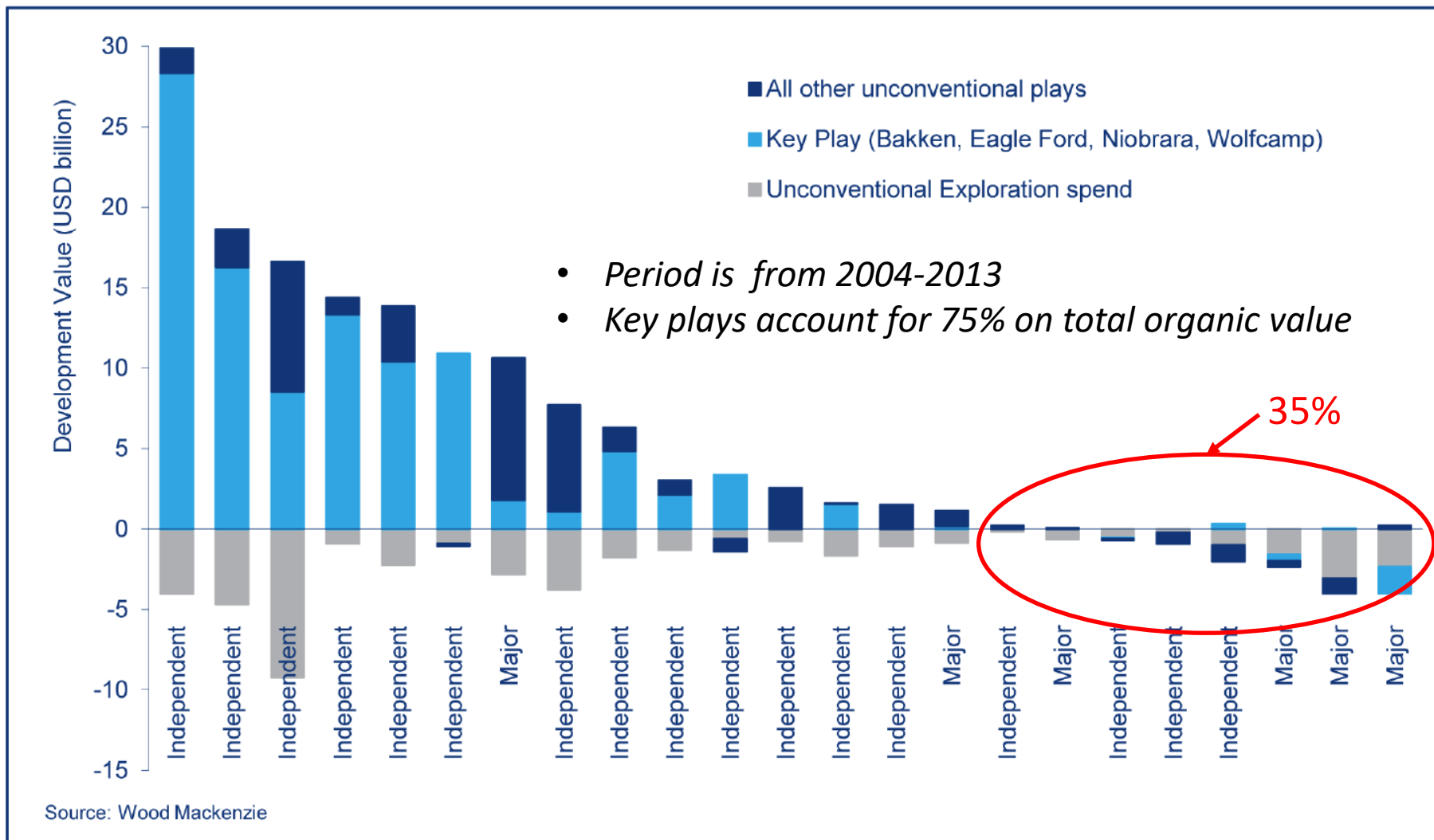
Overoptimism
(predicted mean value is too high)

Actual
- Outcomes are skewed toward the low end
- Only 83 barrels will be delivered for every 100 barrels promised at sanction

Actual Mean

Predicted Mean

-25%   +20%

83%   **100%**   PRODUCTION

75% of projects achieved less than the promised value

Based on 147 projects sanctioned from 2002-2008   Modified from SPE 145437

For Example: Project Schedule and Cost Bias

Projects on stream or received Final Investment Decision from 2003 - 2012

"Project efficiency has been so terrible, so absolutely dismal, that things are unlikely to get any worse"—Wood Mackenzie, Sept. 2016

From Wood Mackenzie, 2013

For Example: Opportunity Value Bias

- Period is from 2004-2013
- Key plays account for 75% on total organic value

35%

Chart legend:
- All other unconventional plays
- Key Play (Bakken, Eagle Ford, Niobrara, Wolfcamp)
- Unconventional Exploration spend

Y-axis: Development Value (USD billion)

Source: Wood Mackenzie

- The 23 companies shown here acquired acreage in 30+ North American plays
- Only 15 of these companies delivered positive development value

SPE 174925

Thought Processes at Work*

ANN APPROACHED THE BANK

What visual image comes to mind?

What questions might you ask?

*Thinking, Fast and Slow, Kahneman 2012

Thought Processes at Work*

ANN APPROACHED THE BANK

Did you consider that Ann might be in a boat?

*Thinking, Fast and Slow, Kahneman 2012

Two Primary Decision-Making Processes

- Reflexive: operates automatically and quickly, with little or no effort (*"Thinking Fast"*)

  – Relies on instinct, intuition, emotion and often unconscious and automatic action; default option and receives information first

  – Uses heuristics – simple and rapid shortcuts that allow us to make decisions quickly and easily, and hence more prone to bias

- Reflective: uses controlled and conscious reasoning (*"Thinking Slow"*)

  – Later part of our brain development to solve problems Reflexive unable to

  – Invokes critical, deductive, rational and logical thinking; less prone to bias

  – Requires deliberate effort and time, and can be tiring

Management Quote

"We have only two problems: We are finding **half the volumes** we say we would and taking **twice as many wells** to recover the hydrocarbons we say we will. Other than that, we are doing fine."

Summary

- Our tendency is to understate uncertainty and risk

  - We rely too heavily on our reflexive, instead of reflective, thought processes

  - Our cognitive errors exacerbate these tendencies contributing to poor decision making

- As a result, we fail to realise our predicted outcomes, which erode value

So what's going on?

Cognitive Bias

- Cognitive Bias
  - A <u>predictable</u>, <u>consistent</u> and <u>repeatable</u> mental error in thinking and processing of information that can lead to illogical judgments or decisions
    - ➢ Separate concept from a specific mistake
    - ➢ Cannot unequivocally ascribe bias to a poor decision
    - ➢ Can be made consciously or unconsciously
    - ➢ Often occur when heuristics lead to incorrect results
    - ➢ Common in all humans, with an evolutionary basis
    - ➢ Awareness alone does not mitigate their influence
    - ➢ Related, but different, to Motivational Bias

http://en.wikipedia.org/wiki/List_of_cognitive_biases

Most Commonly Reported Biases Encountered*

#1   Anchoring (77%)

#2   Motivational (48%)

#3   Confirmation (44%)

#4   Overconfidence (41%)

#11 Information** (14%)

*As identified post-*Mitigating Bias, Illusion and Blindness in E&P Decision Making* course
        Sample size 124
**Identified as #1 by company undertaking Post-Appraisal bias analysis
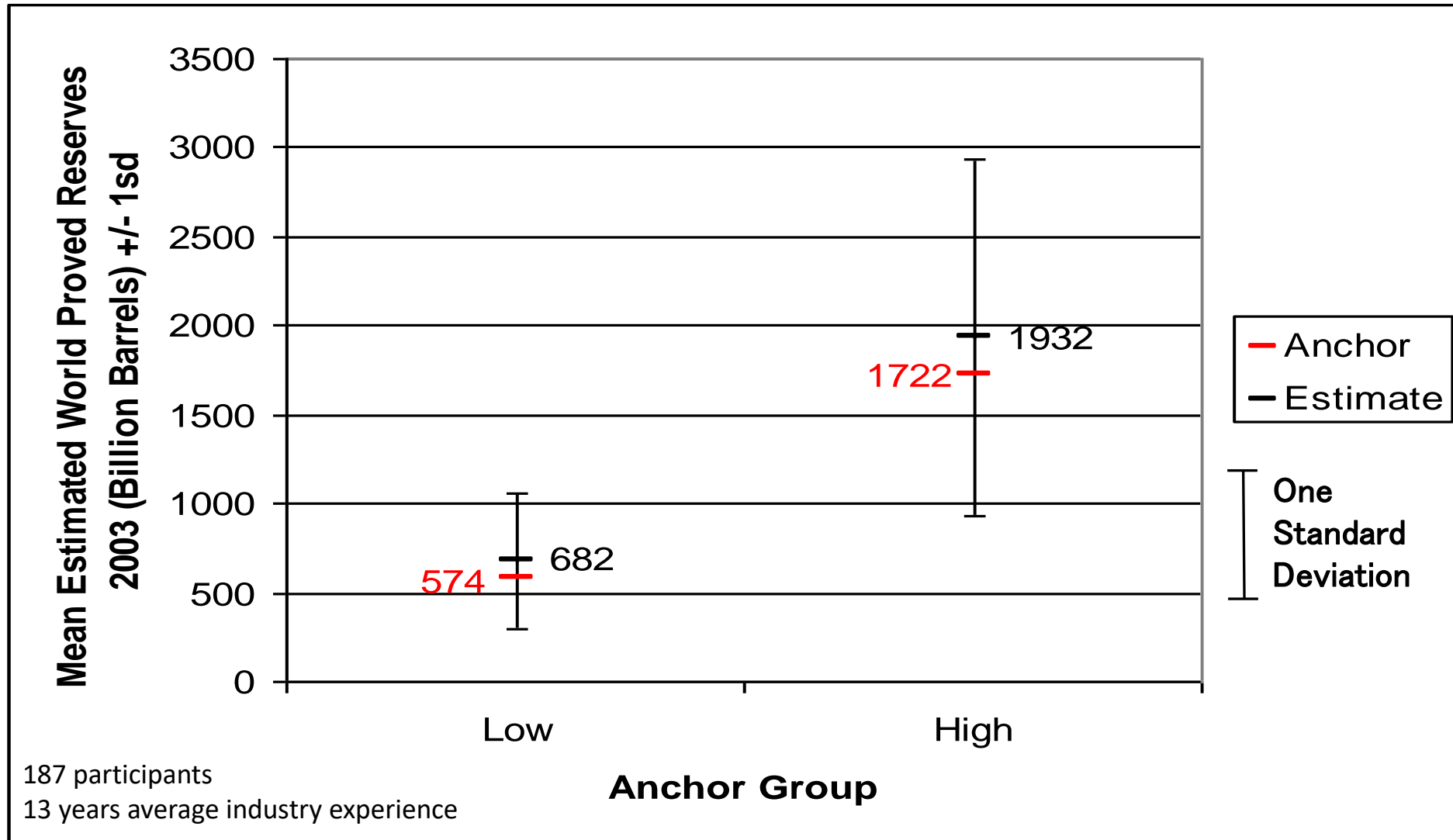   Sample Size 72 (All the above in their Top 5)

Anchoring Bias Definition

Tendency to <u>"anchor" evaluation on a reference value</u> or piece of information/data

Example

Base decision of whether or not to sell an Equity based more on your purchase price rather than the perceived value of company

Anchoring Bias Example

From Welsh, Bratvold & Begg, 2005

Anchoring Bias Example

Nearby Field — Lower Devonian Stratigraphy — New Field

Dlm
Dh
Di
Dsr
Sg/St
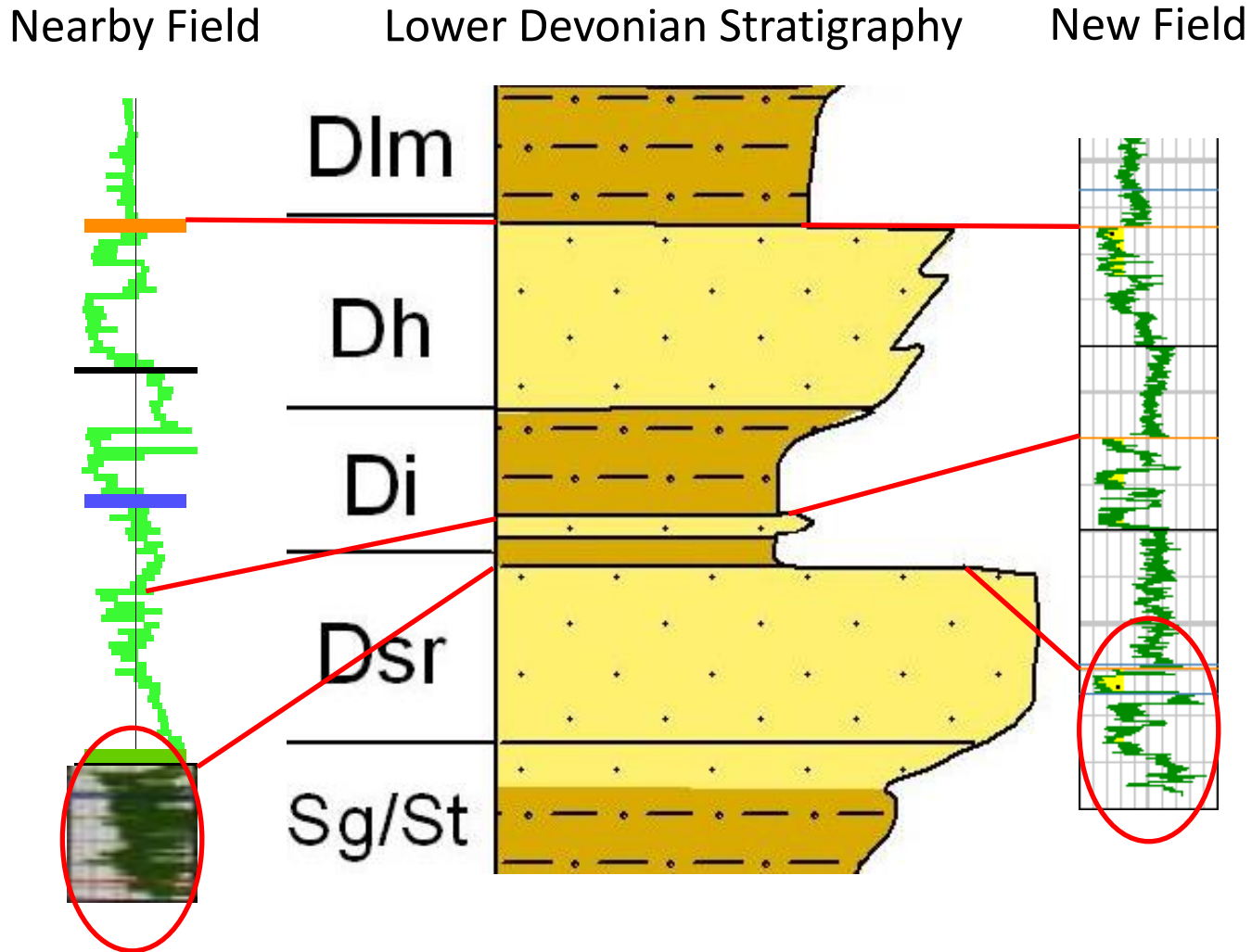
Devonian Reservoir Model
- Lower Devonian stratigraphy
  - 3 sands
- Well has 3 gas-filled sands in new Field
- Operator has significant, long-term experience in basin
- Nearby Field (Operator partner)
  - All 3 sands productive
- Conclusion: Well represents full sequence of Lower Devonian with the 3 sands
- Work by Partner shows all repeated 1st sands brought on by well and seismic observations
  - Seismic
  - Biostratigraphy
 - Field work

E&P Industry Examples of Anchoring Bias

- Parameter inputs into Resource estimation

- Chance of Success estimation

- Considering only one geologic model or analogue

- Preparing only one seismic interpretation and structure map

- Project Planning and forecasting

- Focus on 'Sunk Cost'

- Reliance on a single interpretation or opinion

Anchoring is one of the most robust of the Cognitive Biases – So Beware!

Exercise

Each card below has a <u>letter</u> on one side and a <u>number</u> on the other side. Given the rule **"If a card below has a vowel on one side, then it has an even number on the other side"**, which <u>two</u> cards would you turn over to allow you to determine if the rule is <u>potentially</u> true or not?

| A | K | 2 | 7 |
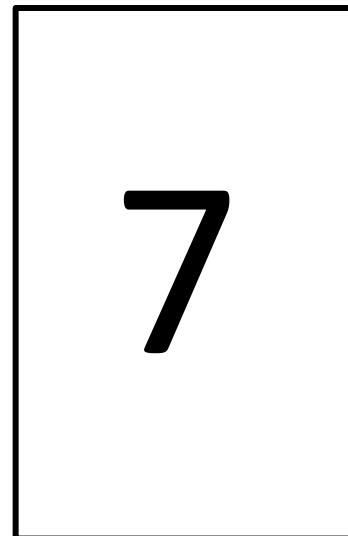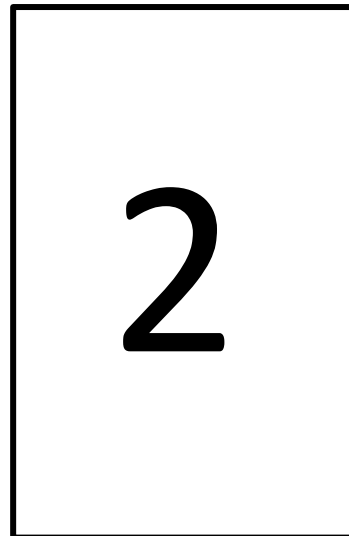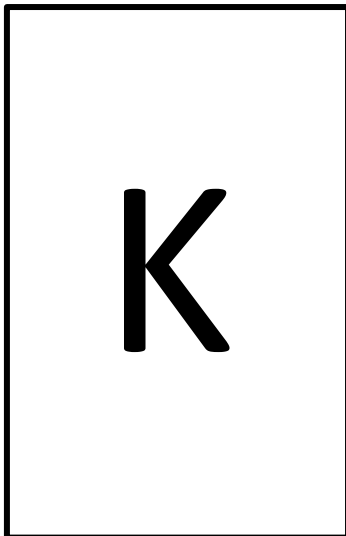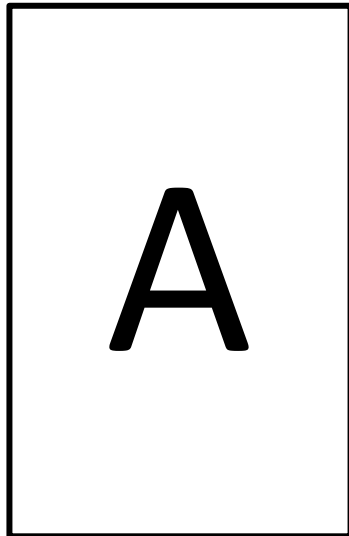
Confirmation Bias Definition

Tendency to search for, favour or interpret data or information in a way that <u>confirms one's</u> <u>preconceptions, interpretations or beliefs</u>

- And corollary: ignore, dismiss, or underweight data or information that contradicts or conflicts with what we expect

Example

Seeking out news sources that are aligned with ones current point of view, and ignoring or disregarding any information that contradicts

Confirmation Bias Example

Based on 2D seismic and well data, you have interpreted a NW-SE trending channel system in an area of N-S structural faulting.

There are data from four additional wells that could indicate the presence or absence of reservoir quality rock.

However, you only have the funds to purchase the data from two of these wells. Which two wells would you recommend to purchase?
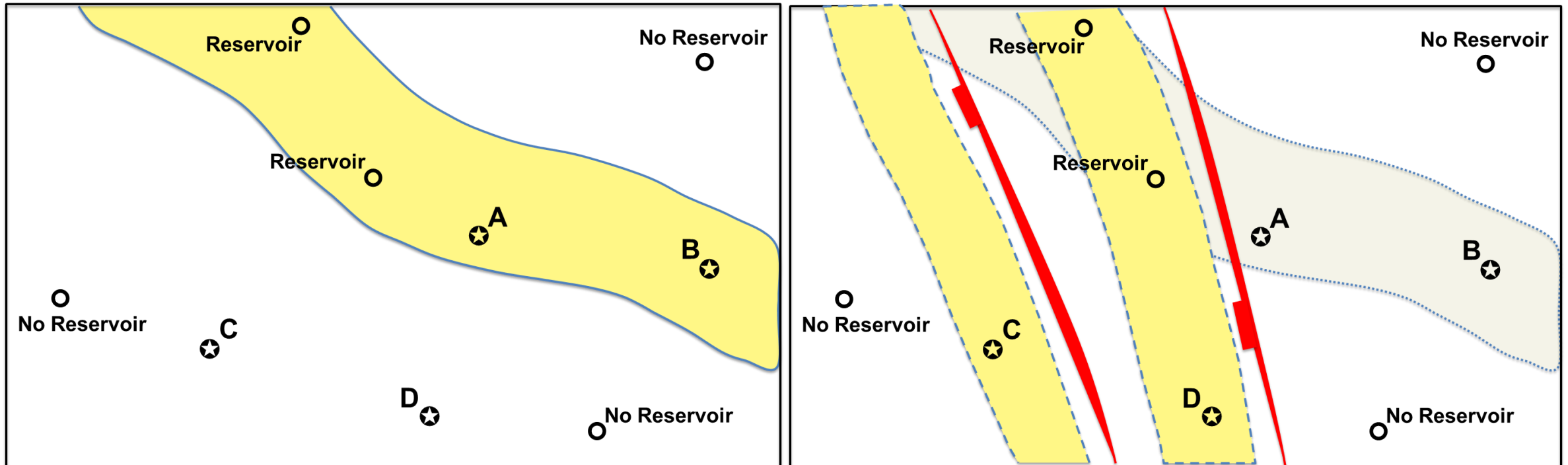
Confirmation Bias Example

The wells available to purchase are shown by the Stars on the map below (A, B, C, D).

Model
NW-SE trending Channel
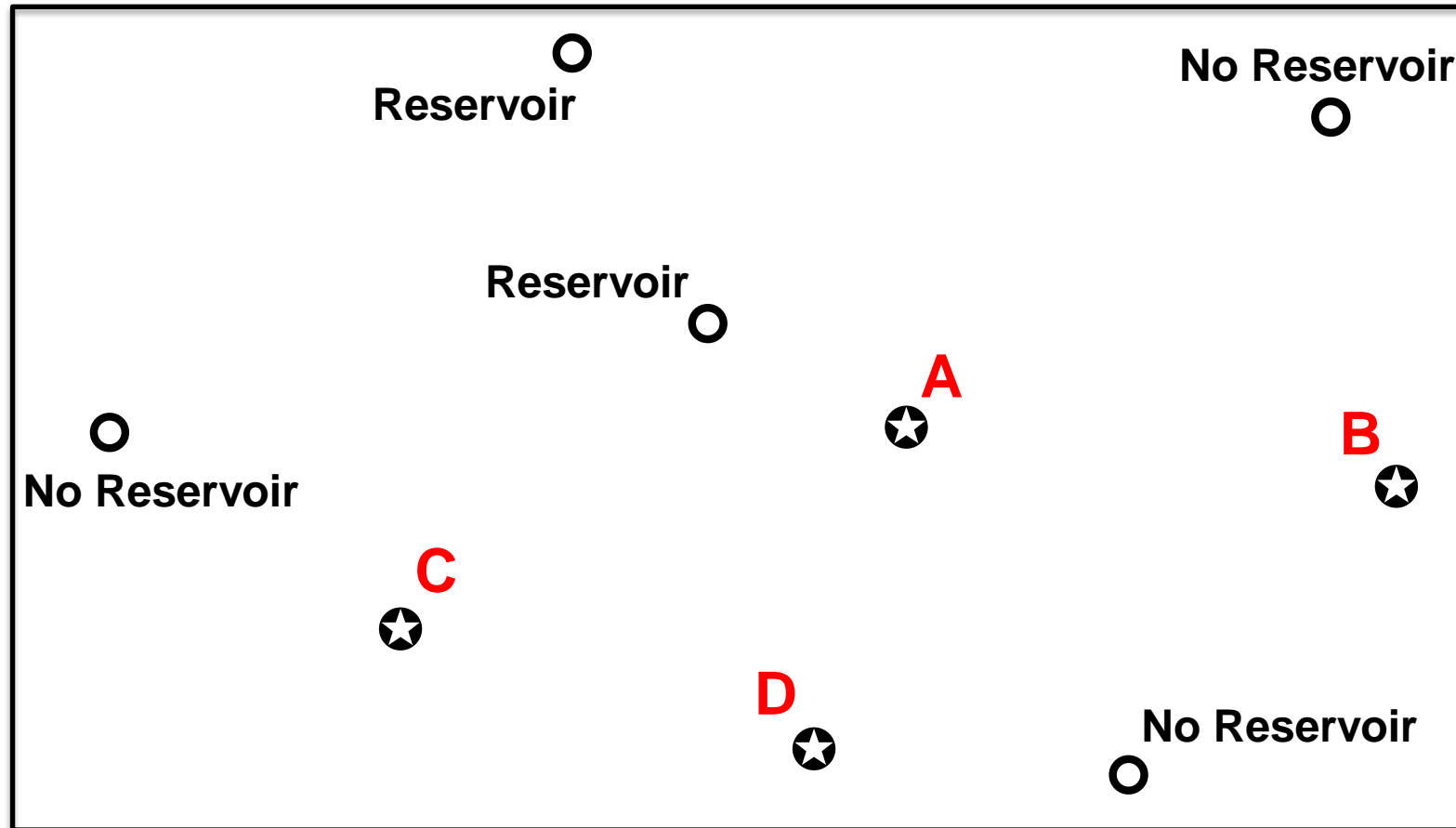
Reservoir

No Reservoir

Reservoir

A

No Reservoir

B

C

D

No Reservoir

Confirmation Bias Example

The wells available to purchase are shown by the Stars on the map below (A, B, C, D).

E&P Industry Examples of Confirmation Bias

- Seeking evidence or preferentially acquiring data that confirm your hypothesis or interpretation

- Ignoring, dismissing or downgrading relevance of data that does not support decision or conflicts with interpretation

- "Cherry-picking" data or information that supports your view

- Not considering other models or interpretations that the existing data might support

- Extending interpretation of prospective areas to areas where little data exists

Exercise

John is a male living in the USA. He wears glasses and has no interest in fashion. He is an introvert and tends to be quiet. He is good at math, likes reading science fiction, and his favourite museum is the Smithsonian National Air & Space Museum in Washington D.C.

What is more likely? John is a **lawyer** or a **physicist**?

Information Bias Definition

Tendency to have a <u>distorted perception</u> of information and its significance

Example

Gamblers lost millions betting <u>against</u> black after the roulette ball had fell on black 26 times in a row

Representative Heuristic

- Judgments based on how similar (i.e., representative) something is perceived to be to something else, often ignoring statistical evidence

- In a flip of a 'fair' coin, which is the more likely sequence to obtain, a or b:

    (a) HHTHTTTHTH
    (b) HHHHHHHHHH

- And the more representative expectation, a or b?

Representative Heuristic

- Common pitfalls that can lead to incorrectly estimating the probability of occurrence of an uncertain event
  - Base Rate
    - Tendency to focus on specific information, ignoring what is generally true
  - Conjunction Fallacy
    - Belief that a combination of specific or unique conditions are more probable than a single general one
  - Sample Size
    - Belief that a sample population can be characterised with a selective or small number of data points (size + bias fallacies)

SPE-AIME Experiment

- 10 general knowledge questions, with a confidence range around each answer (98/90/80/50/30%)

- Result
  - Poor accuracy (c. 20 – 40% correct)
  - Struggled to differentiate between confidence ranges
  - Experts performed just as poorly
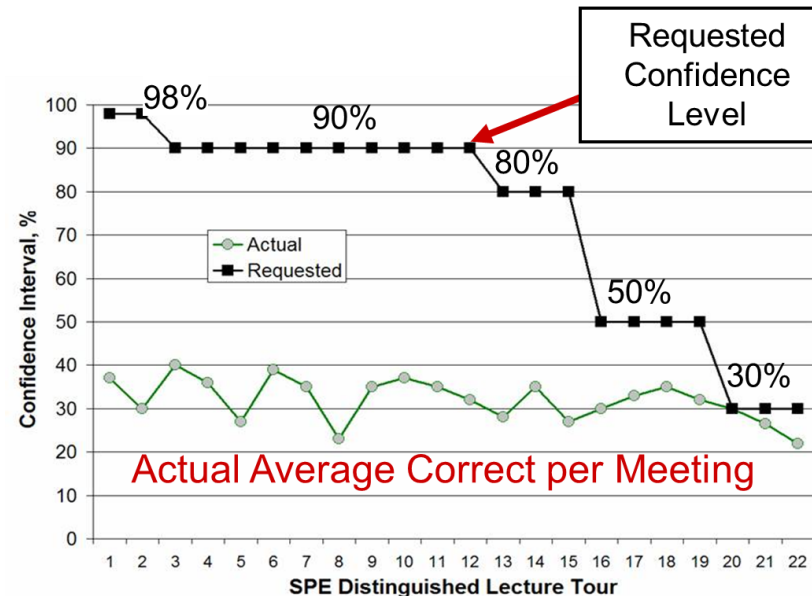
From: E. Capen, 1976

Overconfidence Bias Definition

Tendency to <u>overestimate the accuracy</u> of one's own interpretation, judgement or ability

- Exhibits itself by too narrow a range of possible outcomes

Example

Several studies have consistently showed that a large majority (64-93%) of people believe they are Above Average Drivers

E&P Industry Examples of Overconfidence Bias

- Optimistic data interpretation and failing to consider downsides

- Resource estimation (particularly Minimum) too high, with a narrow range

- Chance of Geologic or Commercial Success estimation too high

- Justification for data interpretation too confident

- Inflated project planning (e.g., underestimate costs and time for completion)

- Predicted portfolio outcomes overconfident

- Production targets too high

- Exaggerated Opinion of prospect or opportunity

- Discounting or dismissing negative scenarios

Endemic Bias in our Industry– So Beware!

Motivational Bias Definition

Tendency to take actions, judgements and decisions based on a <u>desire for a particular outcome</u>, often <u>motivated by one's own self-interest</u>

- In general,

  o Motivational Bias: tends to be a <u>conscious</u> bias influenced by <u>external</u> factors

  o Cognitive Bias: tends to be an <u>unconscious</u> bias and related to <u>internal</u> aspects on how we process information

  o Tends to be "top-down" whereas cognitive bias is "bottom-up"

Exercise

- You are an auto salesperson

- Upon completion of a sale, you advise the customer that the manufacturer will send them a survey to rate your performance

- You are aware that if you receive a 'perfect' 10 mark on all of the questions, you will receive a bonus

- Do you inform the customer of this condition when you tell them about the survey?

Motivational Bias – the non-Cognitive Bias

- Although not a Cognitive Bias, Motivational Bias is related and can trigger or accentuate one

- Often can have unintended consequences

- Often is unwritten, and the response by the individual is what they think is desired

- Bias can be overestimation and optimism, or underestimation and conservatism

- Often leads to assessments and decisions that are poor and counter-productive

Outcome vs. Process

- Natural tendency is to focus and judge a decision on the eventual outcome, rather than the decision-making process
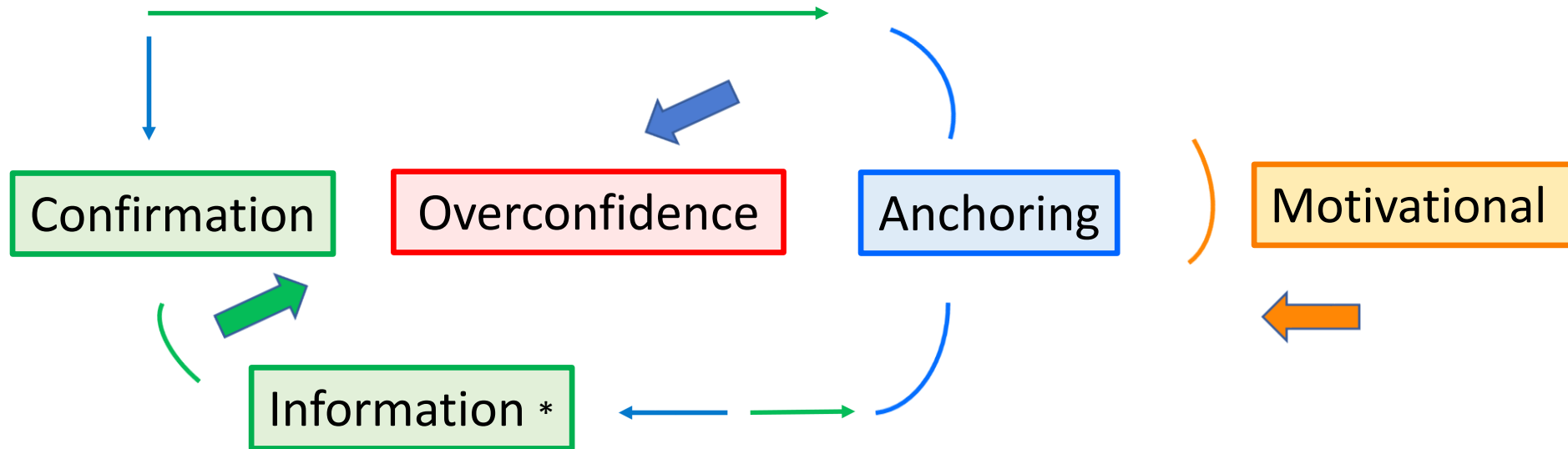
Some Bias Mitigations

Specific Biases

- Anchoring – work with multiple or counter 'anchors'

- Confirmation - engage in 'disconfirmation' bias; try to falsify your model

- Information – become familiar with statistics and probability

- Overconfidence – widen ranges

- Motivational – focus on evaluation and decision-making process

Some Bias Mitigations

General 'Toolkit'

- Embrace uncertainty!

- Be aware of bias in yourself and others

- Require estimates to have a range of outcomes and level of confidence

- Undertake a Bias 'pre-mortem'; consider what could go wrong and why

- Encourage questions and be open to discussion; listen!

- Seek independent guidance (i.e., Assurance)

- Use performance tracking to better calibrate estimations and decisions

- Consider alternative scenarios and interpretations, employing multiple working hypotheses

Alternative Scenarios

Whilst consideration of alternative scenarios is a key bias mitigation, there are several pitfalls which make it challenging:

- Anchoring – attachment to one particular scenario or analogue

- Confirmation – so focused on preferred model that you search for data to support and dismiss data that suggests an alternative

- Information – tendency to incorrectly assess impact of information on model

- Overconfidence – believe you understand model (i.e., we think we know more than we do!)

- Motivational – personal investment into developing model

If I had one wish, it is to see organizations dedicating some effort to study their own decision processes and their own mistakes, and keep track so as to learn from those mistakes."

Daniel Kahneman – "Thought Leader" by Michael Scrage

QUESTIONS?