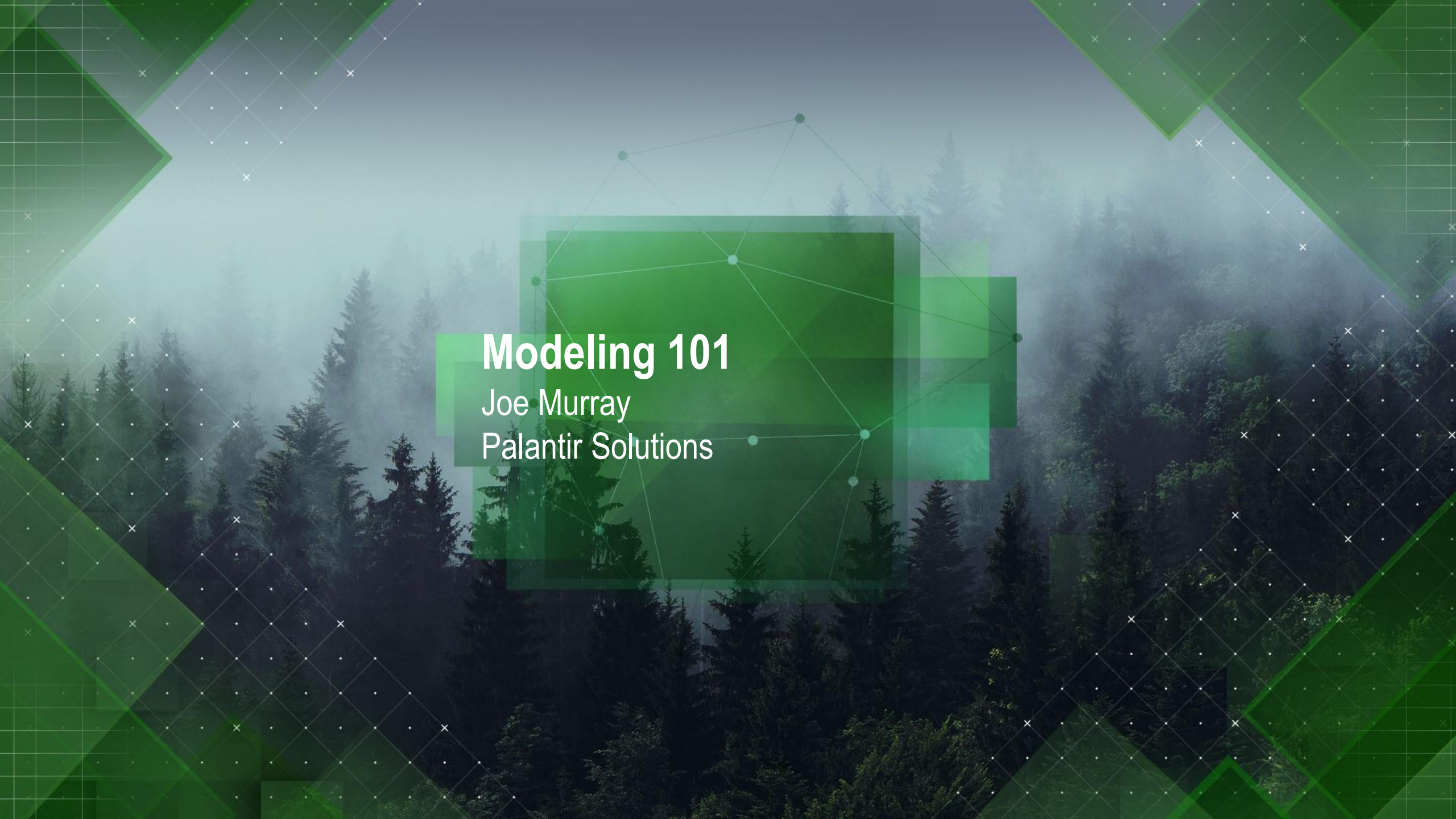

Modeling 101

Joe Murray
Palantir Solutions

Agenda

- Who are Palantir Solutions?
- What is modeling and how does it apply to the E&P industry?
- Modeling risk and uncertainty in fiscal systems
- A real world example

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Who we are

- Palantir Solutions is an independent software & consulting company focused on the upstream oil and gas business.
- We're not the NSA database company. That's Palantir Technologies
- Software offerings
  - Field development planning
  - Economic and financial forecasting
    - Comprehensive worldwide fiscal regime library
  - Reserves booking
  - Portfolio optimization

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Some of our clients

Anadarko Petroleum Corporation

Shell

Apache

MURPHY OIL CORPORATION

HESS

Husky Energy

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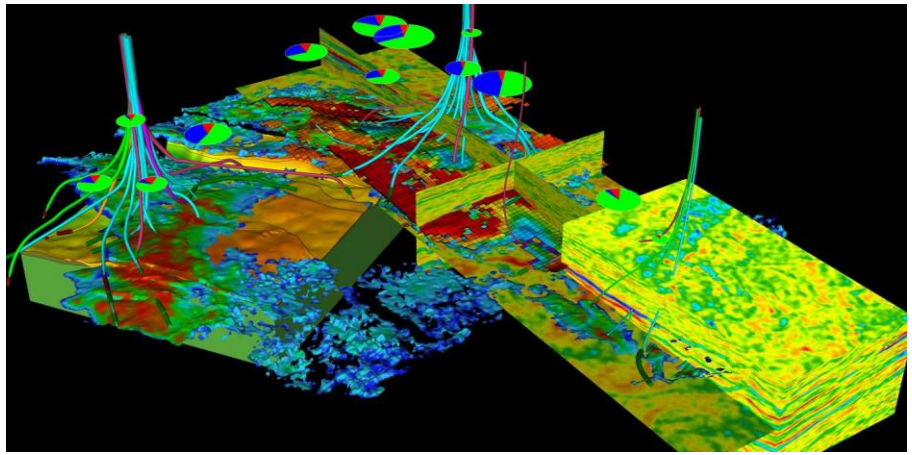
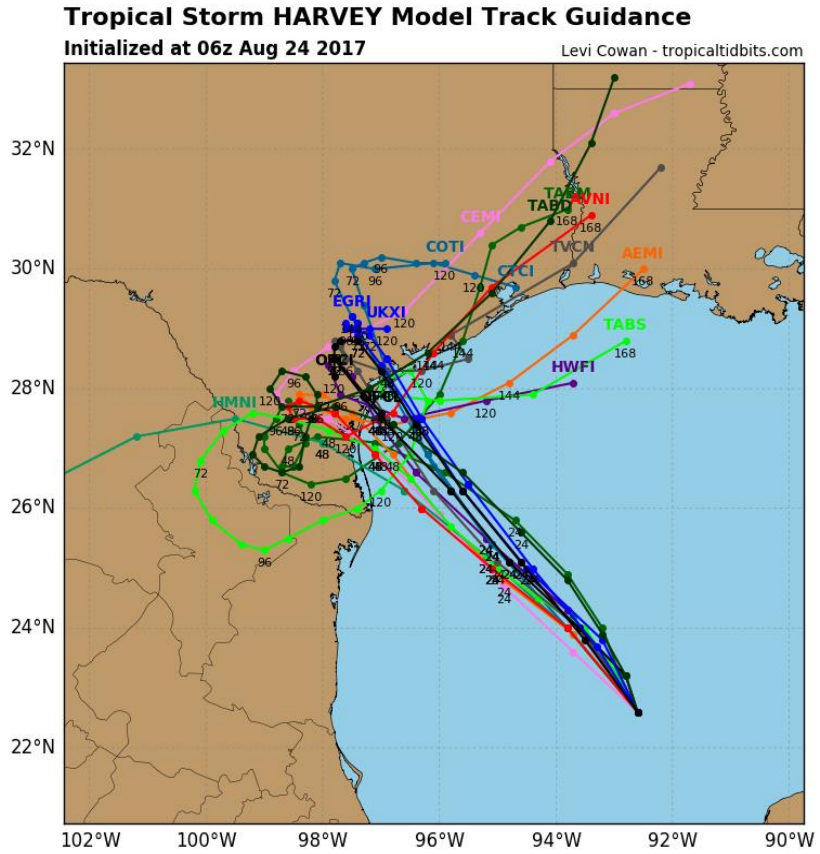
What’s a model?

What is a model?





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What is a model?

Oxford Dictionary:

model / mod·el /ˈmädl/

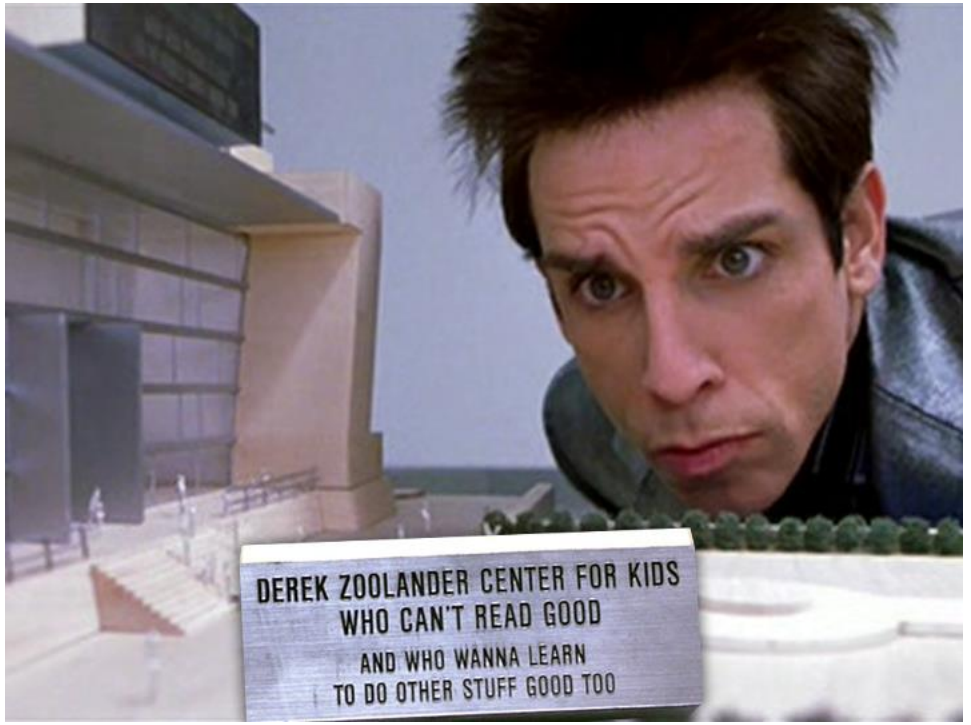
noun

1. a three-dimensional representation of a person or thing or of a proposed structure, typically on a smaller scale than the original.

"a model of St. Paul's Cathedral"

2. A thing used as an example to follow or imitate.

"*the project became a model for other schemes*"



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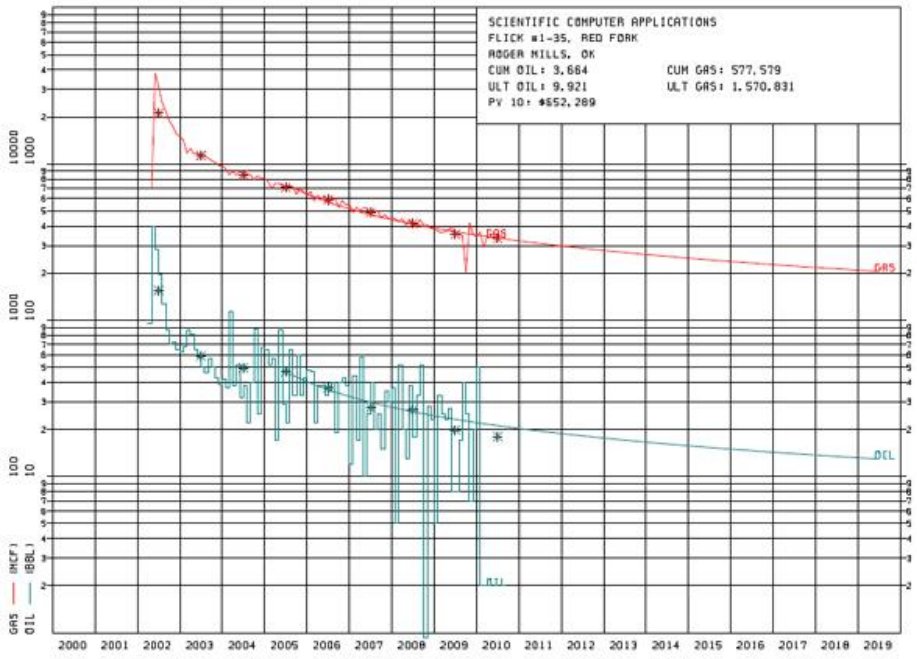
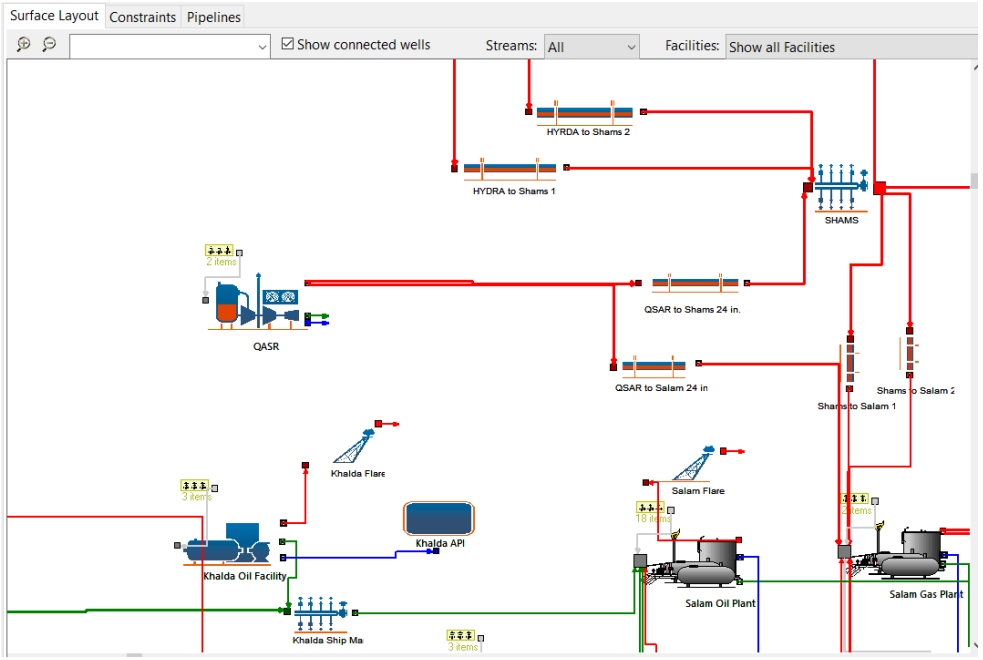
What is a model?

3. A simplified description, especially a mathematical one, of a system or process, to assist calculations and predictions.





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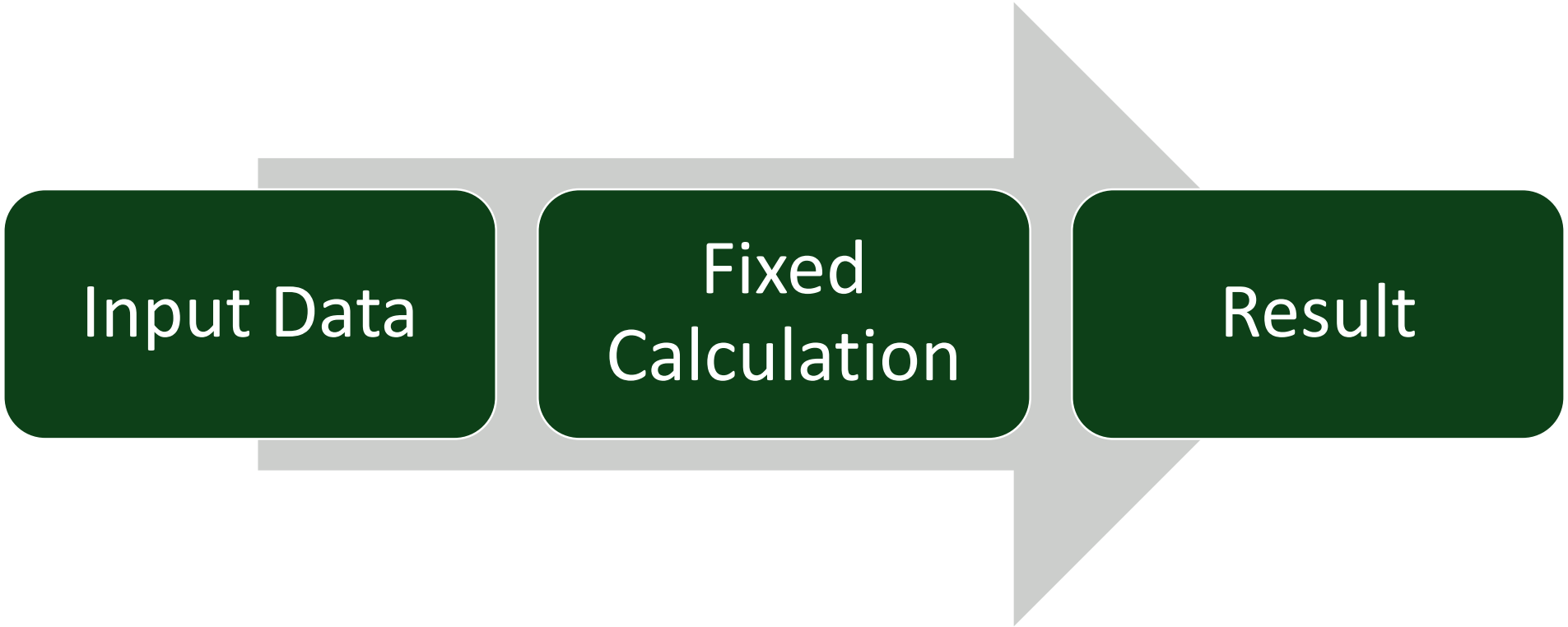
What is a model?



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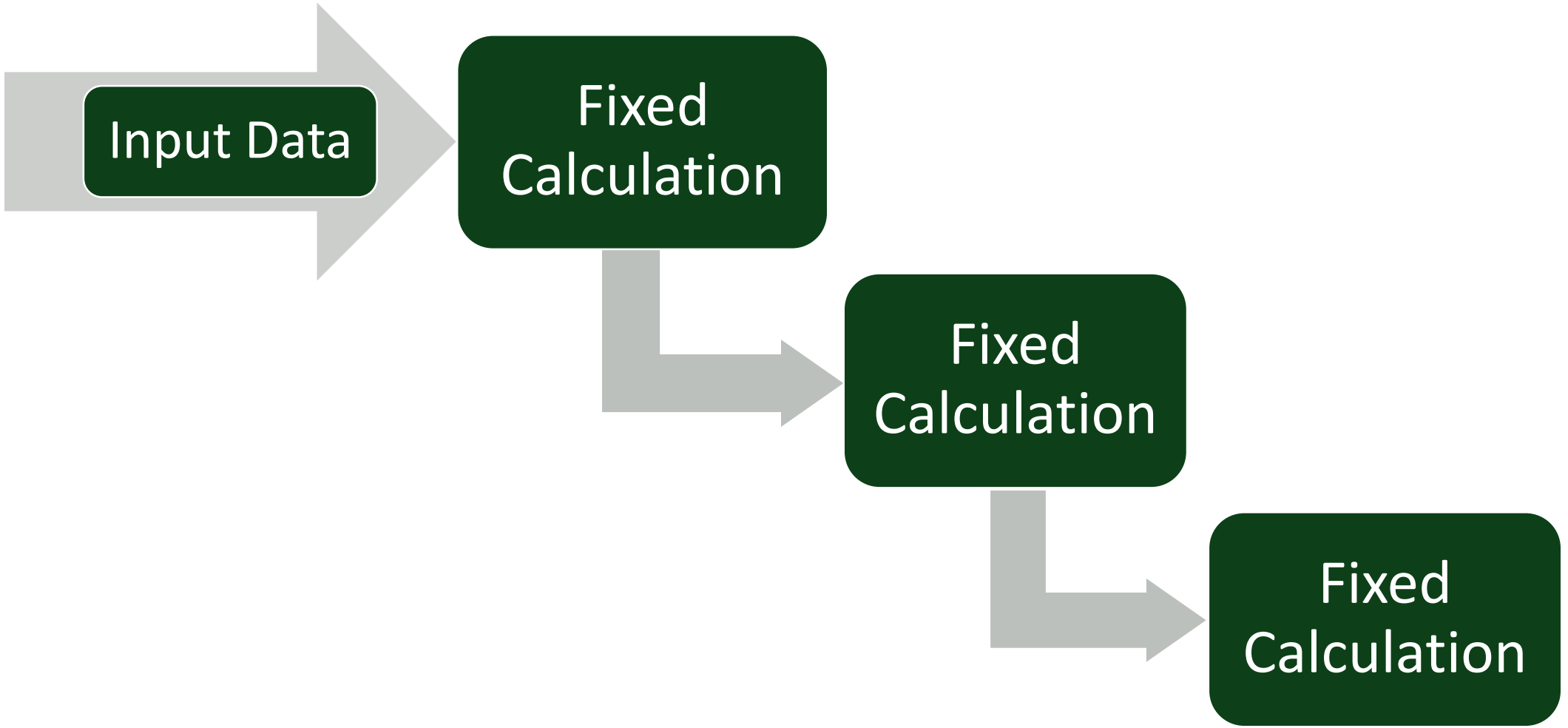
What is a model?



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E&P Modeling

- E&P companies use models all the time to forecast business performance
  - Reservoir simulators
  - Decline curve analysis
  - Field development planning
  - Decision Analysis models
  - Economic and financial forecasting
  - Portfolio analysis

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Fiscal System Modeling

- A fiscal system is a deterministic algorithm
  - Given a certain input, this model type will always produce the same output.
  - 100 Barrels of oil x $50/barrel = $5000 revenue
  - Revenue is calculated the same way every time.
- Inherent variability exists in an E&P project inputs
  - How much oil do I really have?
  - What is the price of oil going to be?

E&P Megaprojects

Megafailures

Chevron Wheatstone LNG Cost Blowout To $34 Billion Hits Woodside

Chevron blamed the delay in module deliveries to Wheatstone mainly on "poor performance" at one of the fabricating yards it originally chose, which led it to redirect work to other yards.

The cost jump comes on top of a $17 billion blowout Chevron suffered on the bigger Gorgon LNG project off Australia's west coast, where two out of three production units, are now up and running.

Real returns from Gorgon project likely to be half official projections

The massive Gorgon LNG plant, under construction on Barrow Island on Australia's North West Shelf, saw costs escalate from $37 billion in 2009 to more than $54 billion last year because of higher material and labor costs, according to the report. Workforce shortages have also forced the project to push back the start date of its first phase from 2014 to late 2015, according to the Oxford report.

Megafailures

BloombergMarkets

Chevron Calls End of LNG Mega Project After $88 Billion Spree

By **Perry Williams** and **Rebecca Keenan**
March 20, 2017, 11:37 PM CDT

- Greenfield gas export facilities in Western Australia unlikely
- Gorgon, Wheatstone expansions off table amid focus on returns

Chevron Corp. has signaled the end of major new LNG projects in Western Australia and is unlikely to sanction an expansion of its Gorgon and Wheatstone export developments as it focuses on boosting returns from $88 billion of investment.

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What happened?

- Oil and gas prices dropped significantly
- Numerous new gas field discoveries around the world raised global supply
- Massive unexpected cost overruns
- **Uncertainty**

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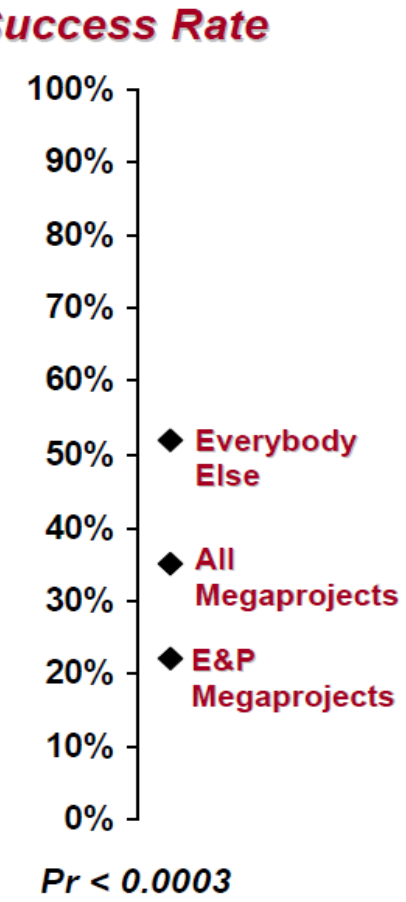
Megafailures

Megaproject Success and Failure

We deem a project to be a failure if one or more of the following occurred:

Costs Grew	25% +
Overspent (Absolute Measure)	25% +
Schedule Slipped	25% +
Schedule vs. Industry Average	50% +
Severe and Continuing Production Problems *(First Two Years)*	Yes



* Ed Merrow, *Upstream Megaprojects Revisited – What's The Problem?* UIBC 2010

Failures closer to home

"I would like to know the assumptions used to develop the probabilities that resulted in discounts of production from new fields, and also request the same information for the legacy fields." - Sen. Hollis French

"In reviewing the last ten annual production forecasts of Alaska North Slope oil production (available on the tax division website) the department found that prior forecasts have erred by 33.4% to 63.1% when forecasting greater than 5 years into the future." – Department of Revenue Commissioner Bryan Butcher

- This is not unique to Alaska.

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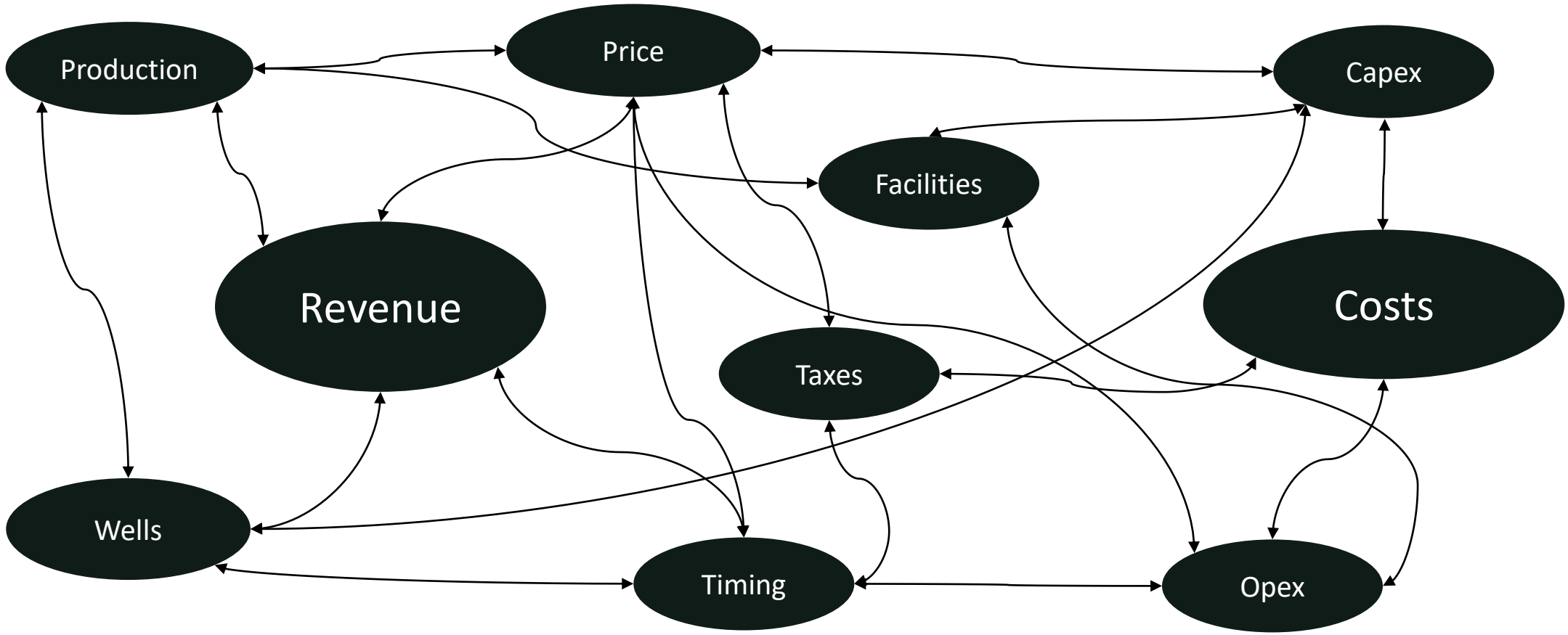
Managing Risk and Uncertainty

Influence Diagram of Fiscal System Variables



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How do we estimate inputs?

- Production
  - Reservoir simulations, field development models, decline analysis
- Capital Investment
  - Internal cost databases, External databases (Questor)
- Operating Costs
  - Internal & external cost databases.
- Price
  - Miss Cleo

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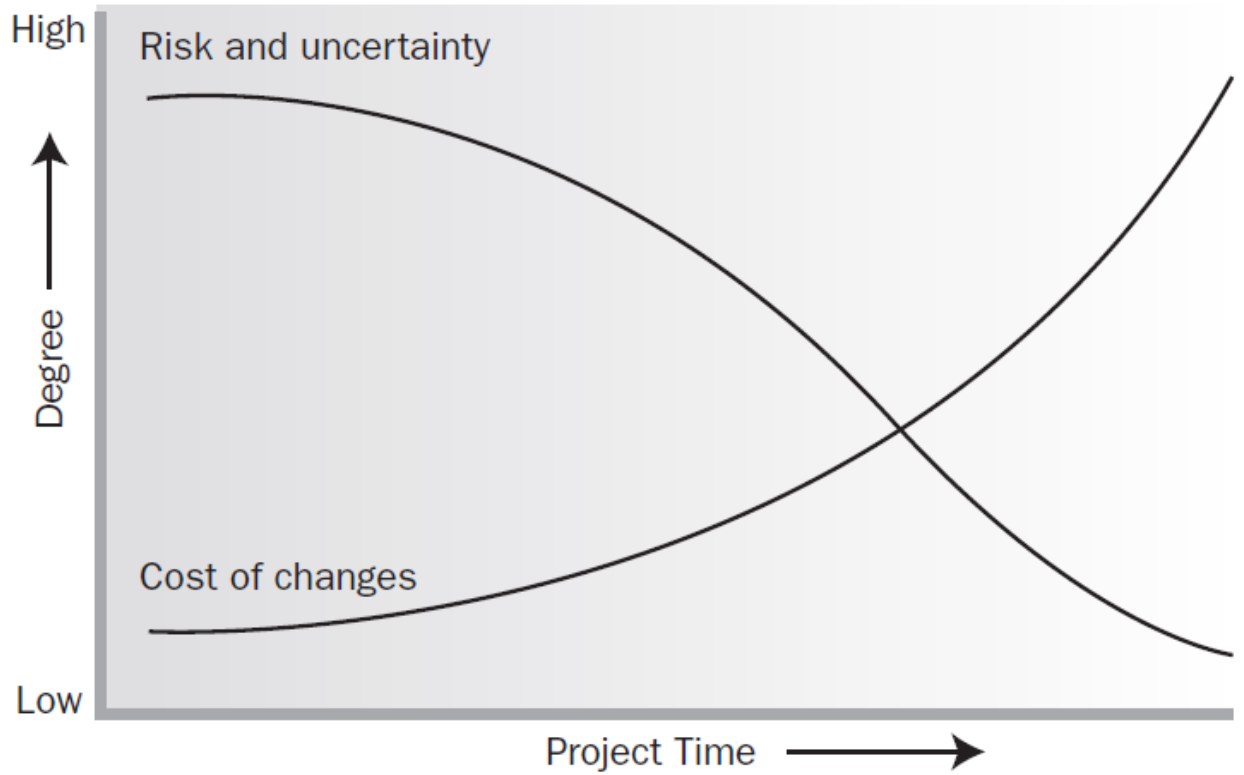
Risking Input Data

- Project management teaches us risk and uncertainty is highest early in the project.
- As the project matures, the risk decreases but the cost to make changes increases.



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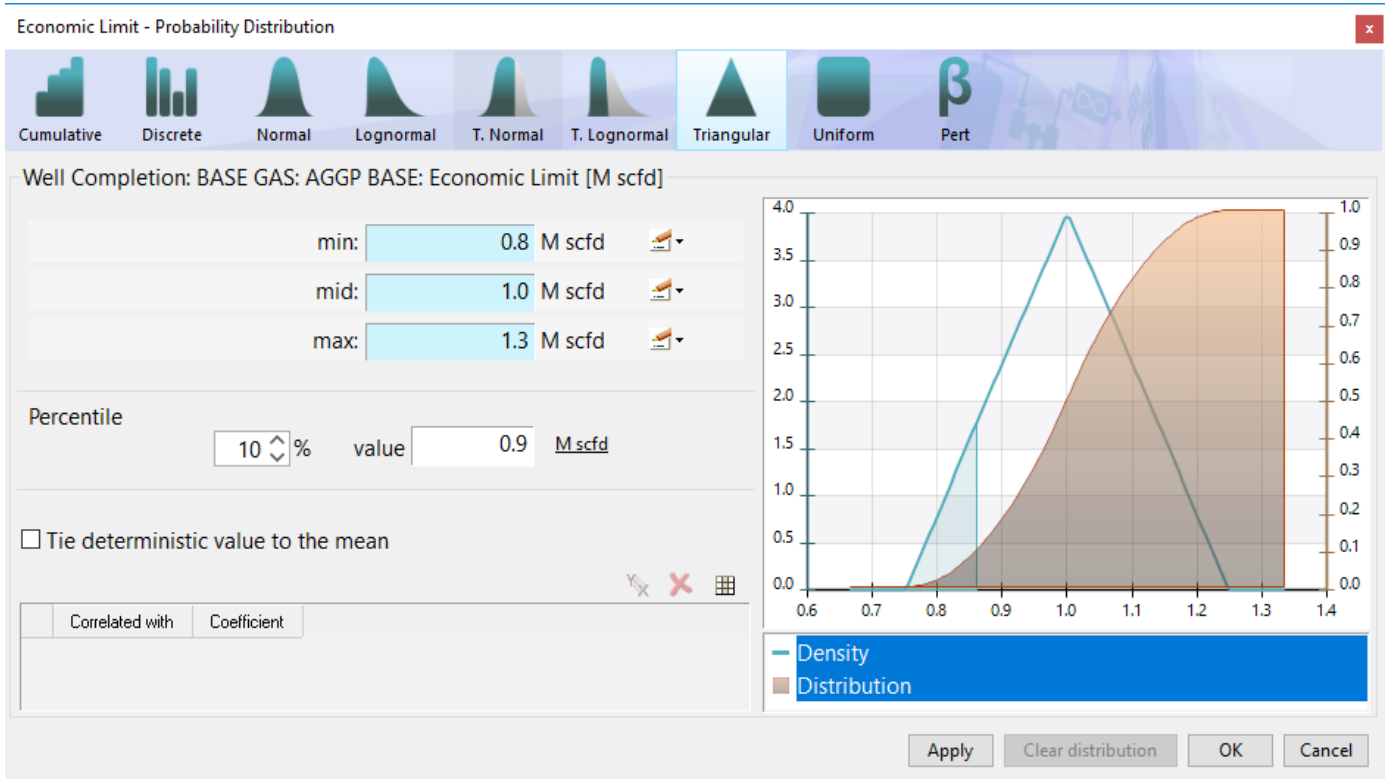
Risking Input Data

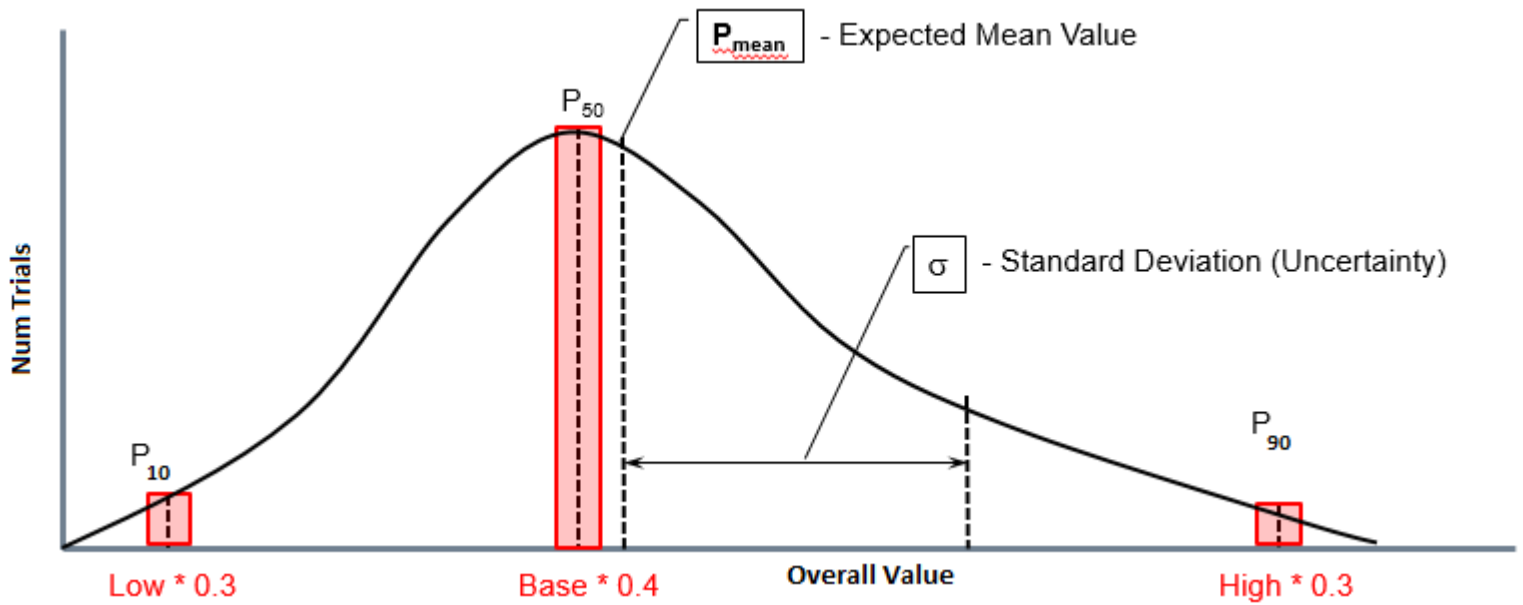
- Apply a probability distribution to input variables.
- Random values are selected in a predefined range and the full field development simulation is run
- Calculate ~50 trials to get a solution space to work with. More trials yield diminishing returns.



Analyzing Risked Projects

Consider 100 simulations performed. Select 3 representative scenarios

- Low scenario (P10)
- High scenario (P90)
- Middle scenario (P50)
- Swanson's Mean (weighted average) of the 3 scenarios yields an Expected Value



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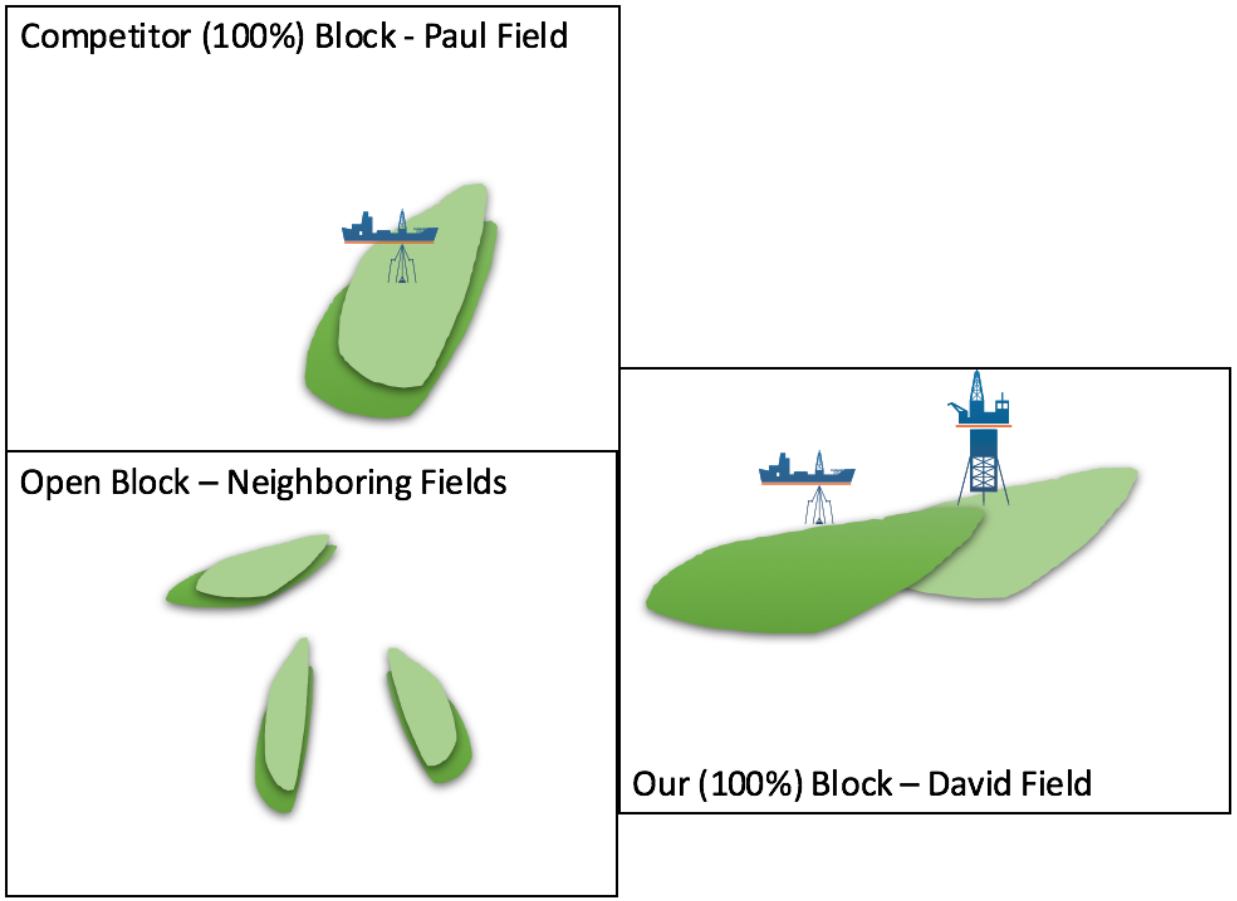
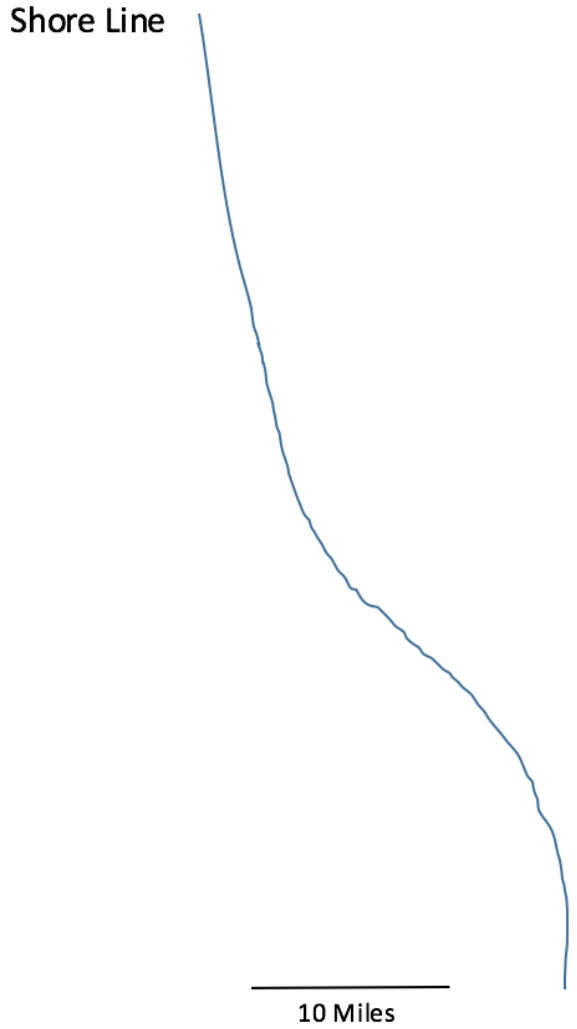
Modeling Asset Development Strategies

Deepwater Opportunity





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David Reservoirs

West Reservoir

- High Quality
- Wells have more predictable performance
- 700 MMBBL in place
- Higher expected recovery factor

East Reservoir

- Poor quality, compartmentalized
- Deeper, higher temperature and pressure
- Wells have very heterogeneous performance
- 1,700 MMBBL in place
- Lower recovery factor

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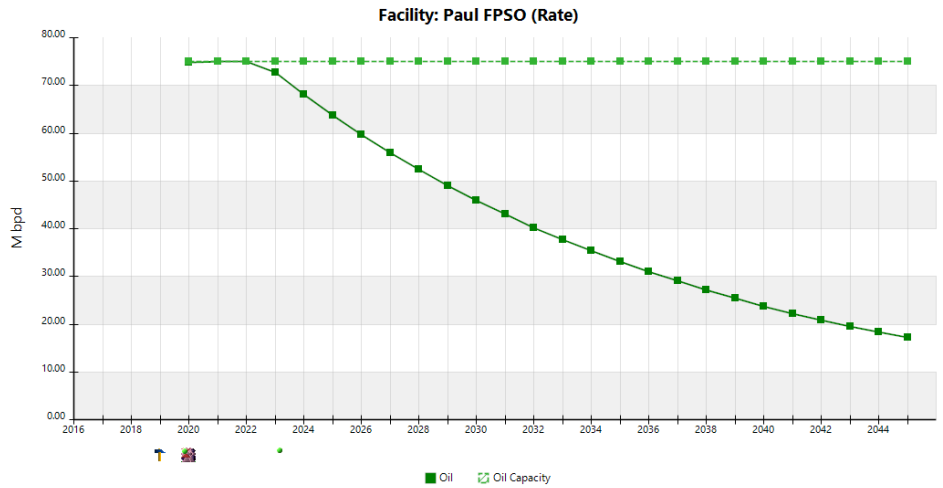
Paul Field

- Already in development
- Paul Field FPSO has capacity of 75 MBOPD; field decline opens ullage in the future.



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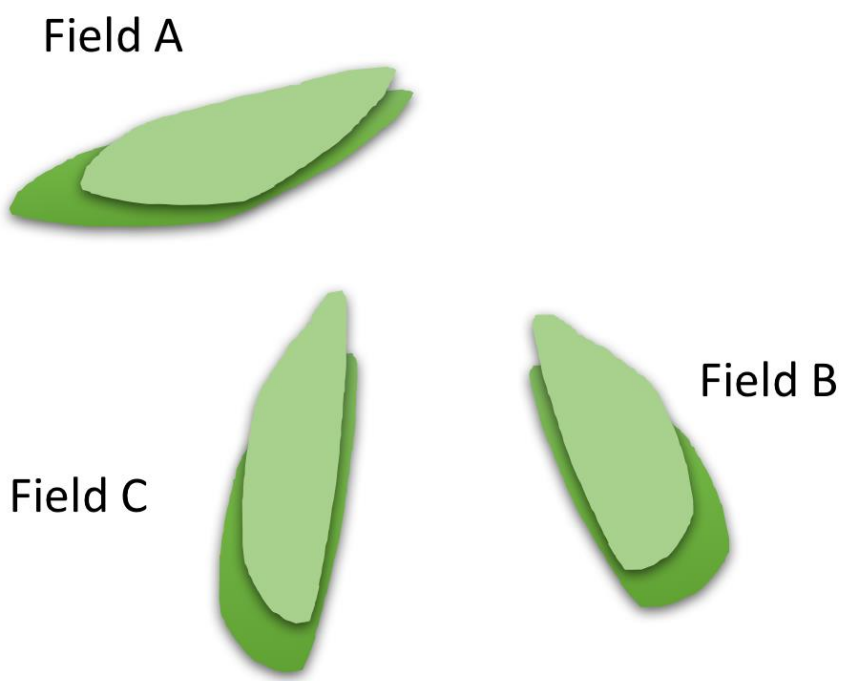
Neighboring Field Cluster



- 75 MMBL recoverable not enough to stand alone
  - 35 in A
  - 20 in B
  - 20 in C
- Decent Quality
  - 4 wells in A
  - 3 wells in B
  - 3 wells in C
  - All wells are similar

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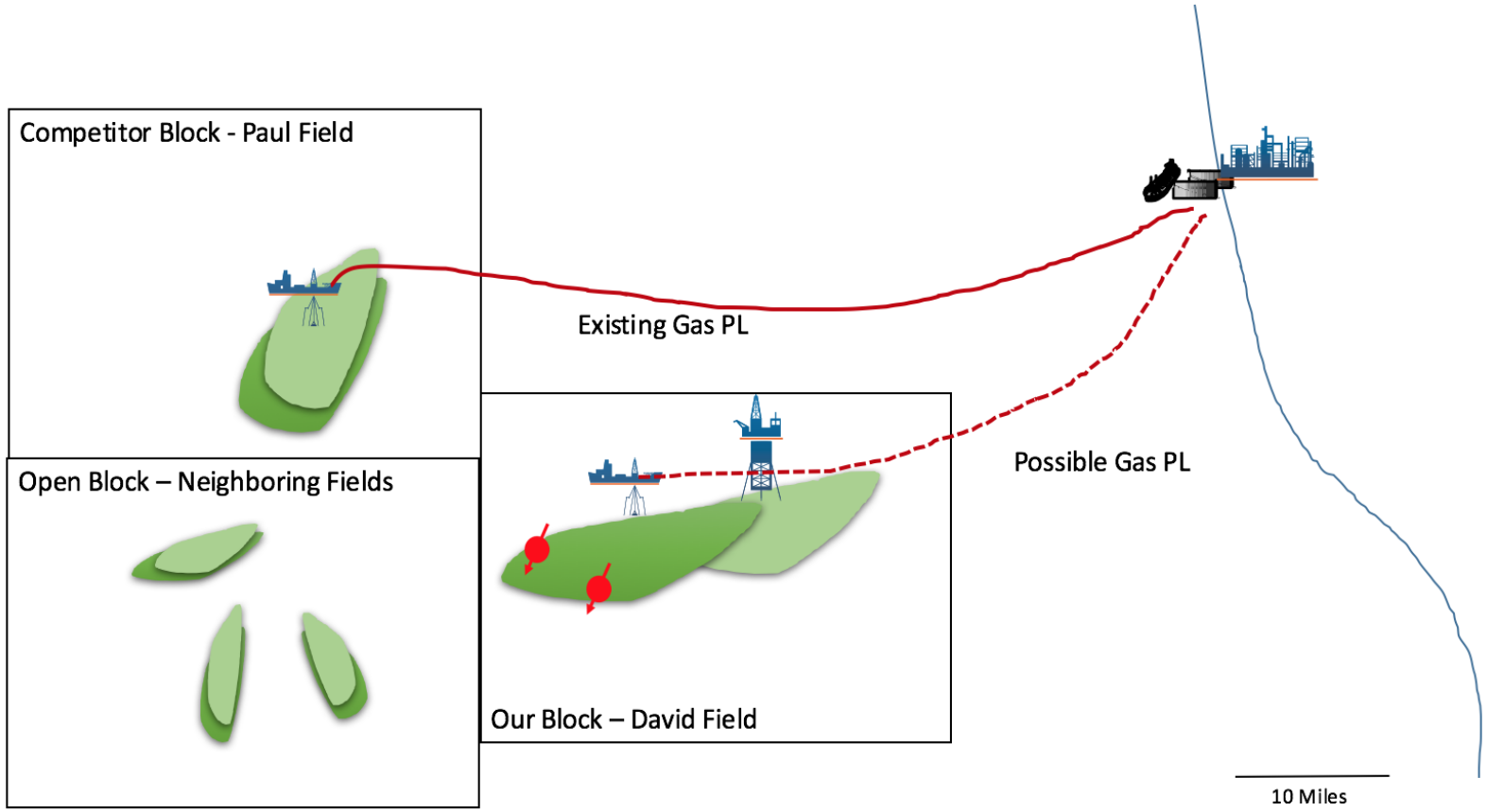
Gas Issues



- No Flaring after 2020
- LNG plant onshore
  - LNG plant gets all gas for free
  - Need pipeline to shore
  - Paul already has a gas pipeline with spare capacity
  - Plant has significant uptime issues
- Can re-inject gas in our West reservoir

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Asset-Level Goals

- We want best possible NPV_{10} from the David Field
- We would like to produce the most barrels we can
- We like to have control – uncomfortable when our results depend on the decisions or malfunctions of other parties
- We hope to minimize risk
  - Risk means variability of NPV_{10}
- Our CEO just promised Wall Street 30 MBOPD by 2021….don't want to re-set expectations
- We also promised Wall Street that we are lowering our Capex and Opex per barrel – we need to see these for each strategy
- A write-down of value (i.e. expected value below zero) would be very irritating
- Our management team does not know what they want most

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Possible Asset Decisions

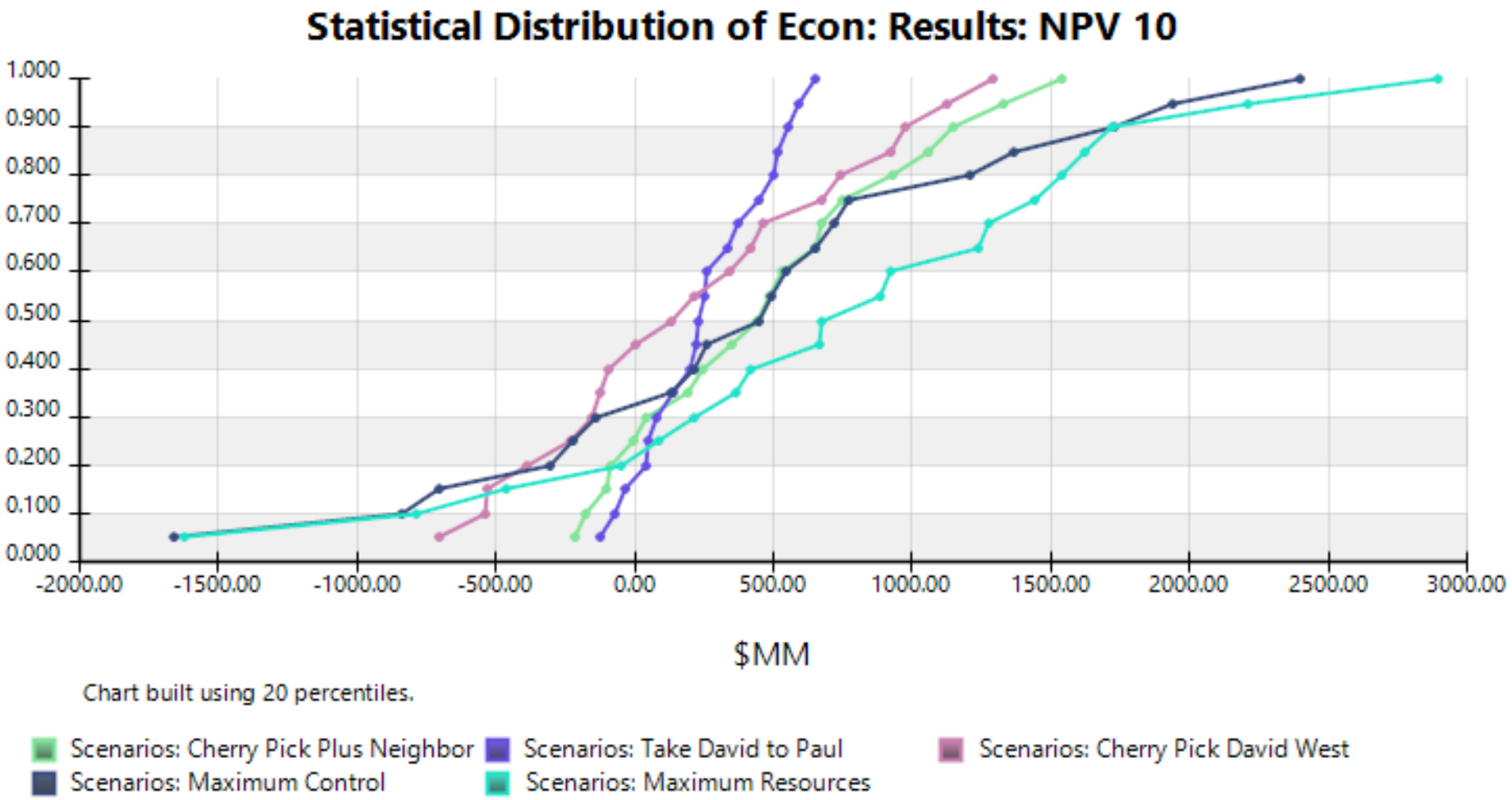
- Should we utilize an FPSO or do a subsea tie-back to a neighboring field?
  - If we tie back we lose control
- How big should our FPSO be?
- Should we use dry tree unit (DTU) (on a spar/floating system) or wet tree (subsea) wells?
  - Reach from DTU is costly + DTU required; SS wells are costly upfront; interventions are costly on SS
  - How many well slots on a DTU should I design for?
- How much of the field should we develop?
- Can we add value developing the other fields as subsea tie backs?
- Are there things we can do to manage risk?
- Can I pay to make risk go away or transfer to someone else?
- What do we do about gas?

Possible Strategies to Test

- Divergent and “Do-able” scenarios

Strategic Themes	Level of Control	Which Reservoir to Develop	Type of Well Drilling	Size of DTU	Where to Process Oil	Pay a Premium to Paul for Processing Priority	FPSO Sizing, MBOPD	Gas Solution	Tie-In Neighbor Fields
Maximum Control	Complete	Both	Dry Trees	40 Slot	David FPSO	NA	100	Inject	Bring them to David
Cherry Pick David West	Complete	West	Wet Trees	NA	David FPSO	No	60	Take to LNG	Let Paul take them
Target Maximum Resources	Complete	Both	Combination	20 Slot	David FPSO	NA	100	Inject	Bring them to David
Take David to Paul	Give to Paul	Both	Wet Trees	NA	Paul Field	Yes	NA	Take to Paul	Let Paul take them
Cherry Pick plus Neighbor Fields	Complete	West	Wet Trees	NA	David FPSO	No	60	Take to LNG	Bring them to David

Evaluate Tradeoffs



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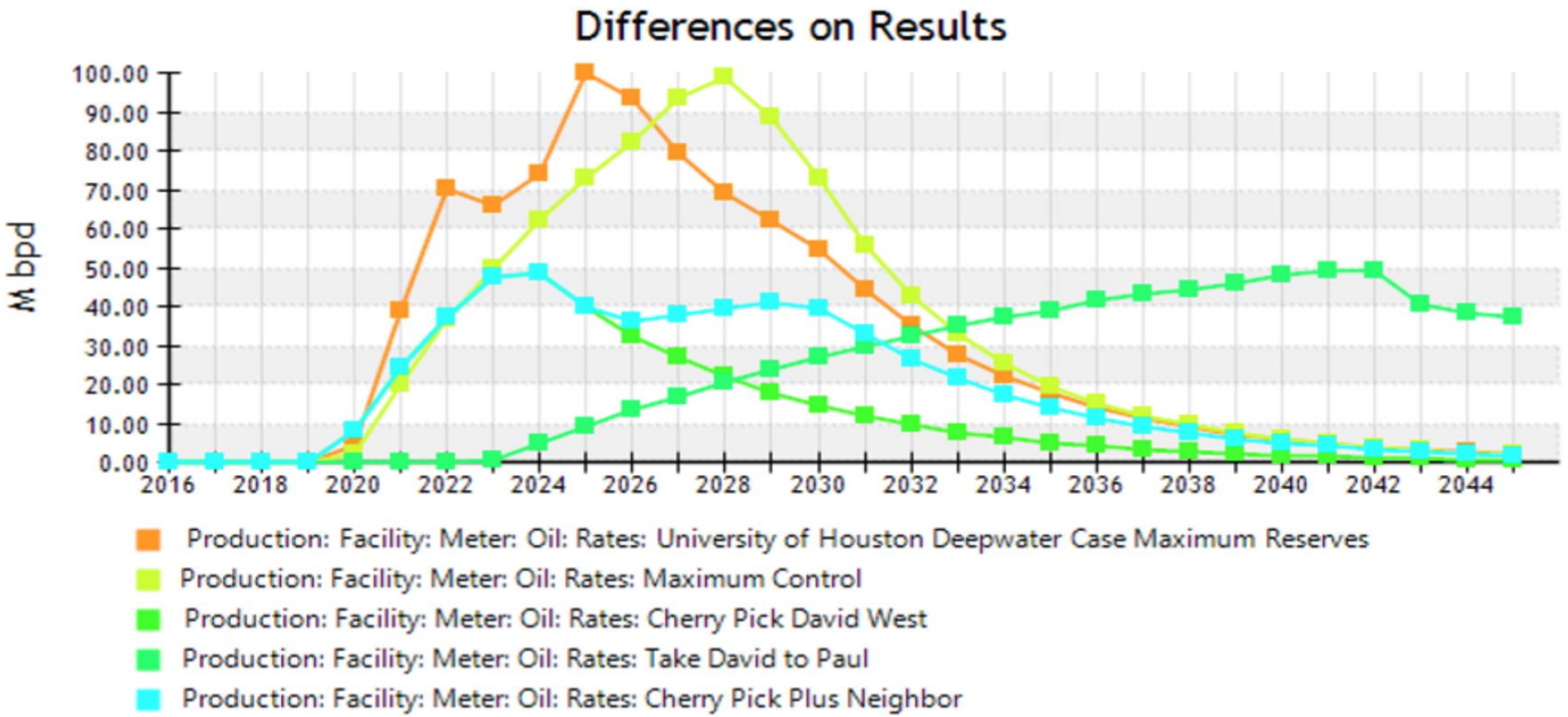
Evaluate Tradeoffs



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Scenario Values From PetroVR Sent to Corporate

Net Present Value, 10%, $MM	P-10	P-50	P-90
Maximum Control	(840)	449	1730
Cherry Pick David West	(536)	130	973
Target Maximum Resources	(789)	677	1720
Take David to Paul	(74)	229	553
Cherry Pick plus Neighbor Fields	(180)	443	1146

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Summary

- Fiscal system models are merely a calculator.
- Largest uncertainty lies in production and price forecasting.
- Risking inputs and applying them to realistic field development scenarios is critical to accurate modeling.