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Pilot and Test Design Framing & Evaluation

Half-day SDP Course

June 17, 2020

Decision Frameworks is a decision quality enablement firm

Decision Consulting	Skill Development	Decision Quality Software
Facilitating Quality Decisions	**Fostering Decision Quality through Practical Training**	**Ensuring Decision Quality with the right Decision Software**

Workshop Objectives

Gain a high-level understanding of the value of information decision framing and evaluation workflow and how to use it to develop robust pilot testing strategies to de-risk projects.

- Understand the fundamentals of valuing information & de-rising projects with pilots or tests.
- Learn a step-wise workflow to frame and evaluate pilot value information decisions.
- Learn to conduct “uncertainty reduction” assessment interviews.
- Become familiar with uncertainty reduction vs. cost plots.
- Use decision trees to value pilot test options considering 100% reliable and imperfect information pilot tests.

Agenda

Time (PDT)	Topic	Detail
08:00	Introductions & Objectives	Discussion: What do we hope to accomplish today?
08:05	Fundamentals of Valuing Information, Workflow & Reliability of Information	Lecture: What are the fundamentals of valuing information and the workflow associated?
09:20	*Break*	
09:30	Pilot Framing Breakouts (separate Zoom rooms)	Breakout: Frame alternative pilot designs
10:45	*Leave breakout – return to video feed*	
10:50	Uncertainty Reduction Forecasting & Confidence Plots	Lecture and Group Exercise: How do we interview teams to forecast uncertainty reduction associated with tests? How do we develop & interpret confidence plots?
11:30	Valuing Alternative Pilot Designs	Under what terms and conditions does the technology have value?
11:50	Wrap-up	What did we learn? Where might we take this in our own companies?
12:00	*Adjourn*	

VOI Fundamentals and Workflow

DECISION FRAMEWORKS APPROACH TO FRAMING & VALUING INFORMATION

Product of a VOI Exercise

A glimpse of the future uncertainty we would face, after acquiring new information.

- Uncertainty reduction
- Test accuracy of interpretation expert interviews

An understanding of the monetary impact on the decisions which would be affected.

- Better choices with more certainty
- Less suboptimal outcomes, or value destruction

Fundamentals of Valuing Information

New information allows us to “update” our view of key risks and uncertainties in our projects.

That in turn, helps us make suboptimal decisions less often – hence, mitigating our project risks through subsequent actions we take as a result of getting new information.

How well information helps us do these two important things depends on how accurate our new interpretation of our project risk or uncertainty will be.

Sometimes we “upgrade” our view of a project uncertainty, once we have new information, and other times, we “downgrade”; but, either way, we are more certain of the actions we are taking on our projects.

Value-of-Information (VOI) Principles

The value of information is equal to the difference between:

- the value of an asset with new information, and
- the value of the same asset prior to acquiring the new information

- VOI = Asset value w/new info – Asset value w/out new info

To be valuable, new information must leave our assets better off then they would be without it.

There must be a future decision, which can change, once new information is acquired, for information to have the potential to add value.

We cannot change our view of an underlying uncertainty unless new information is obtained.

How valuable information will be for your project will depend on the interplay of three important aspects

- Your project uncertainty today
  - The magnitude of the uncertainty today
  - The chance we will make a suboptimal decision without it
- The future decision you may impact
  - The monetary impact (or pain) of a suboptimal future decision
- The quality of the information
  - The accuracy of the new interpretation of the uncertainty, with new information

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Updating Our View of Project Uncertainties with New Information

A Covid-19 Test Example

About this Case Example 1

The following case example was developed to explain the math associated with uncertainty reduction forecasting from new information.

Given the interest in COVID-19 testing, we've developed this case example and used a public article to make reasonable assumptions. All numbers in the case are assumed.

The interesting article which guided our thinking may be found at:

- Title: "COVID-19 tests are far from perfect, but accuracy isn't the biggest problem, here's what all those false positives and negatives really mean," by Maureen Ferran/The Conversation, May 7, 2020, Popular Science. https://www.popsci.com/story/science/covid-test-inaccuracies/

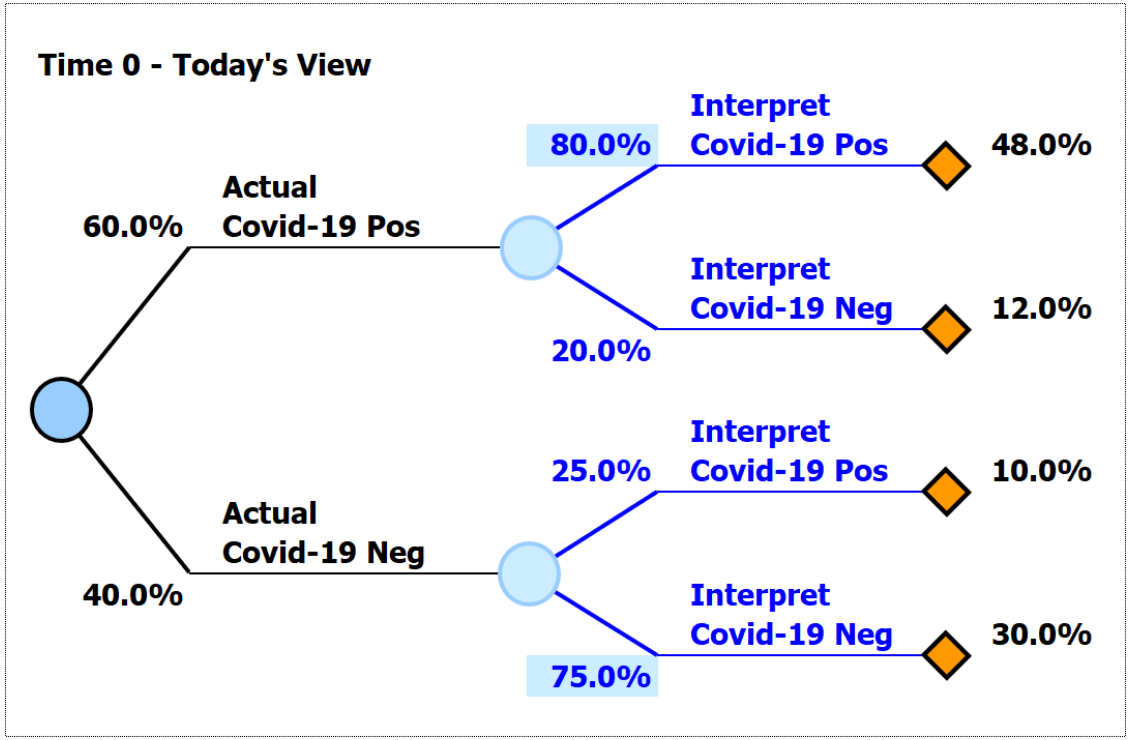
The math intrinsic in forecasting uncertainty reduction finds its roots in Bayesian theory

Ben is experiencing possible COVID-19 symptoms and contacts his doctor who sends him for a COVID-19 RT-PCR swab test.

If Ben is positive for COVID-19, he needs to self isolate, and due to underlying conditions, may be prescribed medications to lessen the effects and or severity of the virus.

For this example, let's assume:

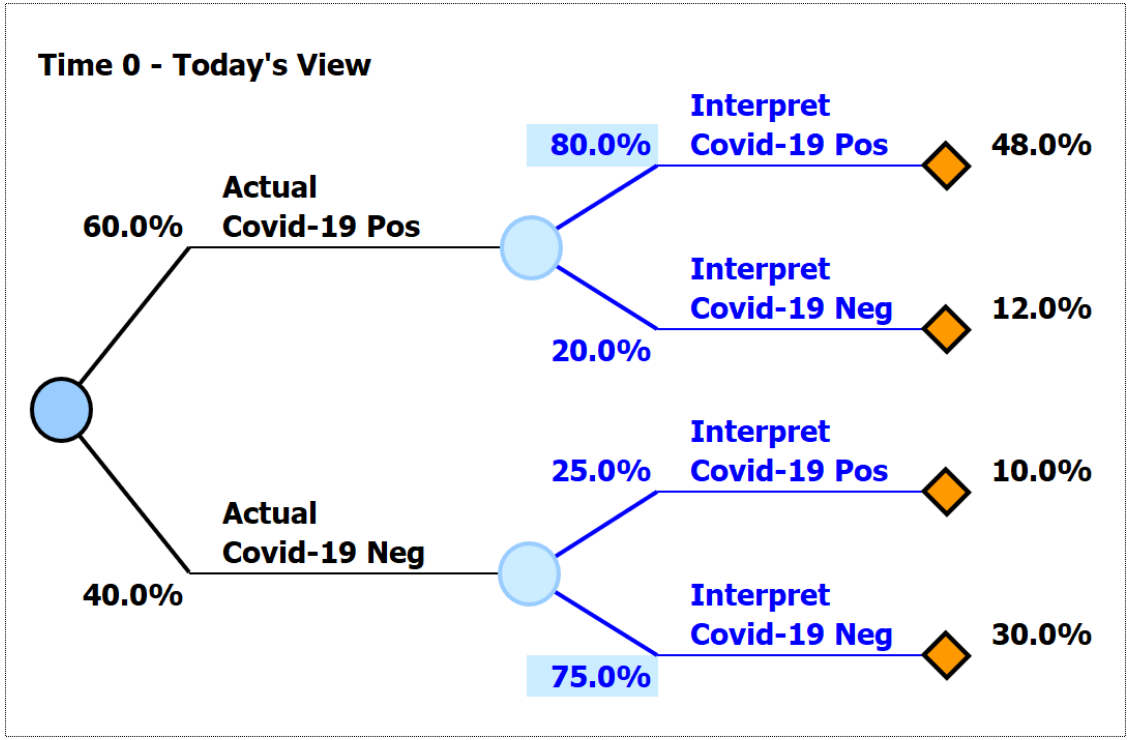
- Ben's doctor believes there is a 60% chance that Ben has COVID-19 (based on his symptoms and the incidence of cases in his location),
- The swab test is estimated to have an 80% clinical accuracy if a person truly has COVID-19, and
- Is estimated to have a 75% clinical accuracy if a person truly does NOT have COVID-19.
- ***Question:*** *If Ben tests negative for COVID-19, what is the probability that he has COVID-19?*



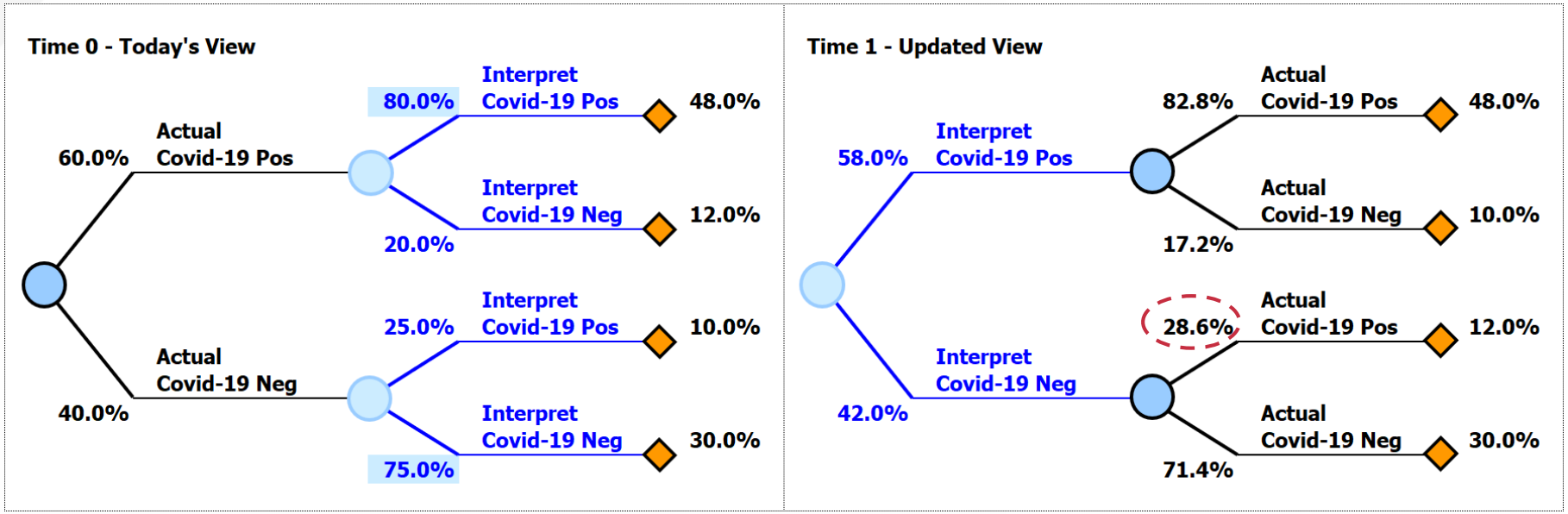
Breaking it down to simple terms illustrates how updated probabilities are calculated

Assume 100 similar patients get tested:

- How many positive COVID-19 patients are there?
  - 60
- How many negative COVID-19 patients are there?
  - 40
- How many positive COVID-19 patients will test negative?
  - 12
- How many negative COVID-19 patients will test negative?
  - 30
- Chance Ben is NEGATIVE for COVID-19 if he tests negative:
  - True COVID-19 negative patients/all who test negative
  - 30/(30 + 12) = 71.4%
- Chance Ben is POSITIVE for COVID-19 if he tests negative
  - 100% - 71.4% = 28.6%



Ben Tests Negative for COVID-19 from the Swab test



If the test indicates Ben is negative for COVID-19, there is only a 71.4% probability that Ben, or any similar patient, actually is negative for COVID-19 - given the numbers assumed in this example! How can this be?

Assume 100 similar patients get tested:

- 40 patients (40%) do not have COVID-19 and the tests identifies 30 of them as negative for COVID (75%), and
- 60 patients (60%) have COVID-19, but 12 of them are falsely flagged by the test as negative for COVID (20%).

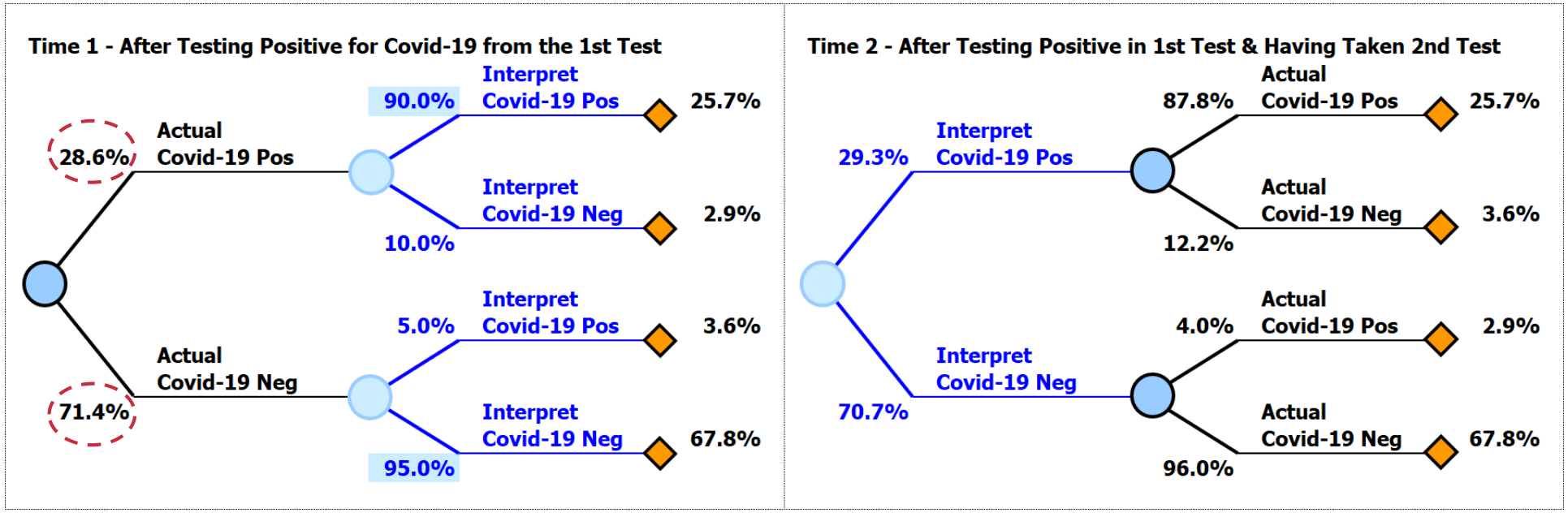
The chance that Ben is negative for COVID-19, when the test indicates he is negative:
= No. of patients who are negative for COVID & test negative / All patients who test negative for COVID (the true negatives + the false negatives)

= 30 /(30 + 12) = 0.714 --- So, if Ben tests negative, there is still a 28.6% chance he has COVID-19.

How can we be more certain that Ben is negative for COVID?

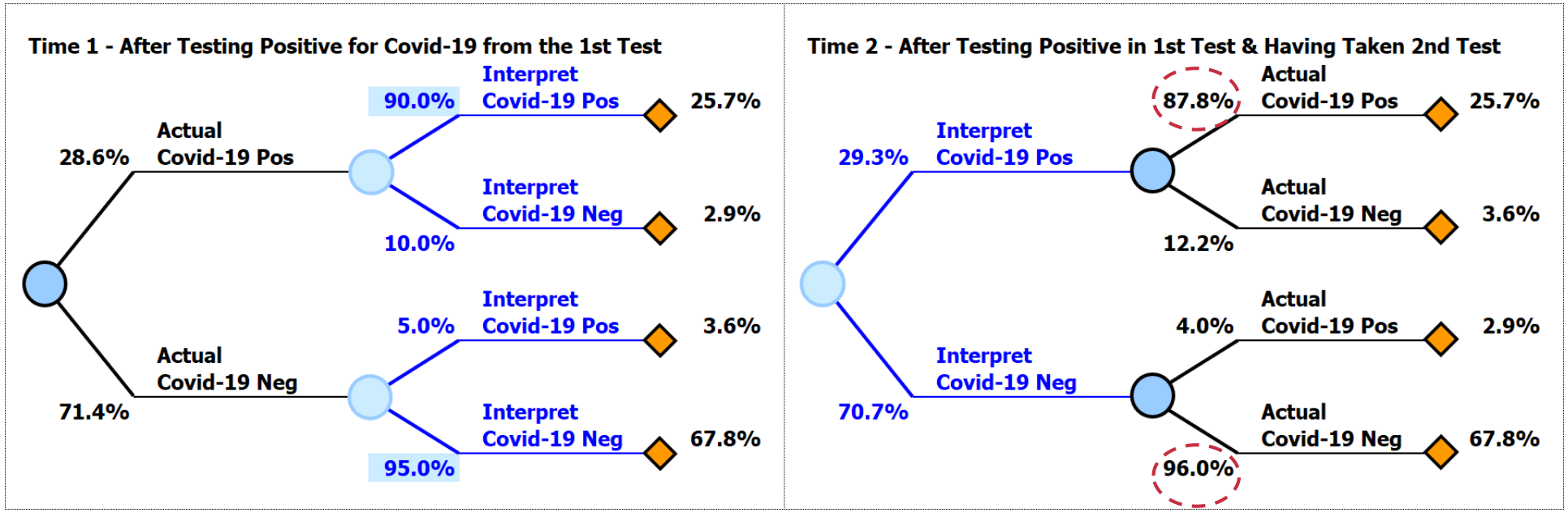
How can we be more certain that Ben actually is negative for COVID-19? Ben could take a second test. He could wait a few days and run the same swab test again as sometimes it won't pick up COVID if it's too early in the virus presentation. Or Ben could take the serological blood draw test right away which detects antibodies fighting the virus. For this example, let's assume Ben takes a serological test and let's assume the test has 90% clinical accuracy for true COVID-19 positive and 95% clinical accuracy for true COVID-19 negative.

Remember that since Ben tested negative once, he now has a different likelihood that he has COVID-19. He has a higher chance of actually being negative for COVID-19. In this example, he now has a 71.4% chance of actually being negative for COVID-19 and 28.6% chance being positive. Remember before the first test, the doctor had estimated a 60% chance that Ben had COVID-19.



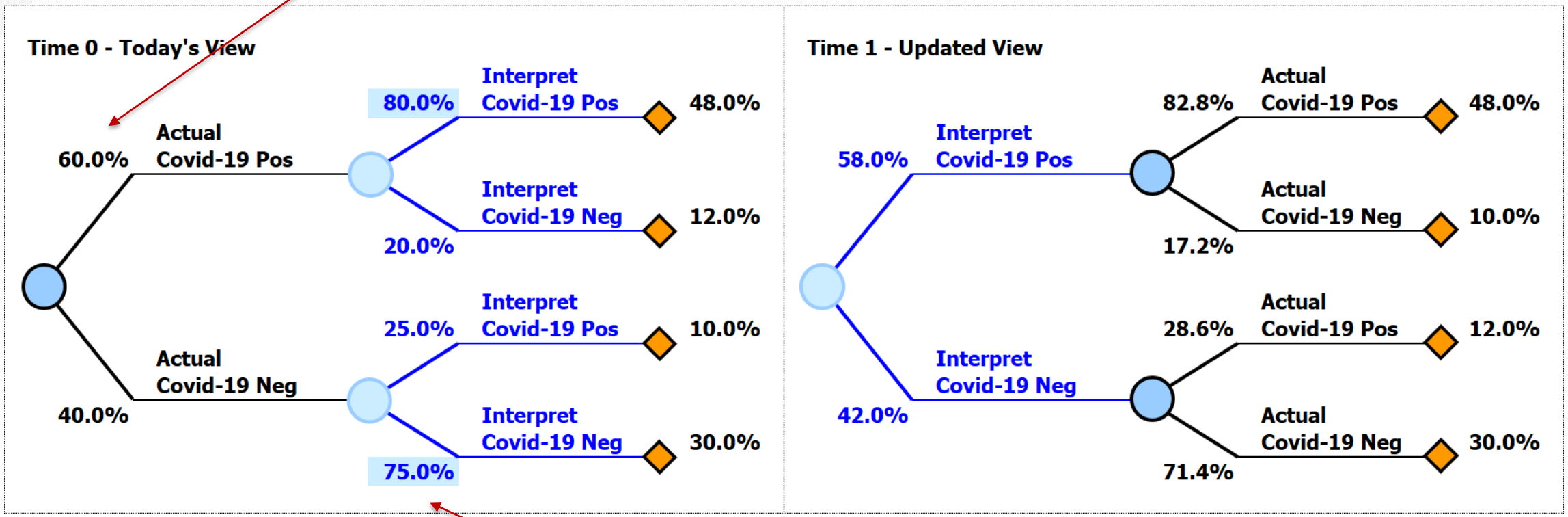
What is the chance Ben is COVID-19 negative if the second test also indicates he is negative?

After testing negative for COVID-19 from the first test, Ben's probability that he has COVID-19 dropped from 60%, before the first test, to 28.6% probability after the first test. With the assumed clinical accuracy of the second, serological test below, if the second test indicates Ben is COVID-19 negative, the probability he will actually be COVID-19 negative is 96% (much improved from the 71.4% probability of being COVID negative after the first test indicated that he was negative).



Two uncertainties are involved in forecasting uncertainty reduction

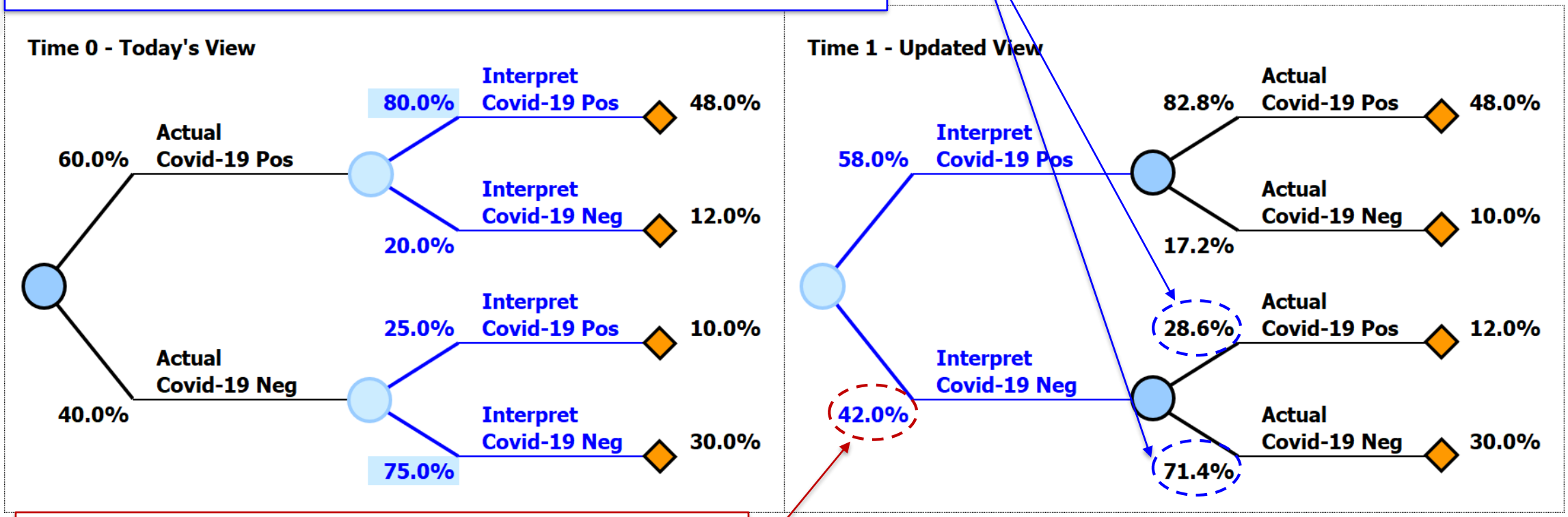
(1) Our view of the underlying uncertainty with today's knowledge (i.e., the doctor's assessment that the patient actually might have COVID-19 based on the patient's symptoms, location and contacts history).



(2) The accuracy of a given test to correctly indicate the true state of nature (i.e., the test manufacturer's purported accuracy of the test given clinical conditions).

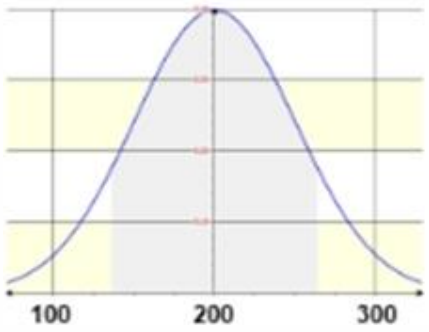
There are two products of an accuracy of information interview assessment (Time 1 view)

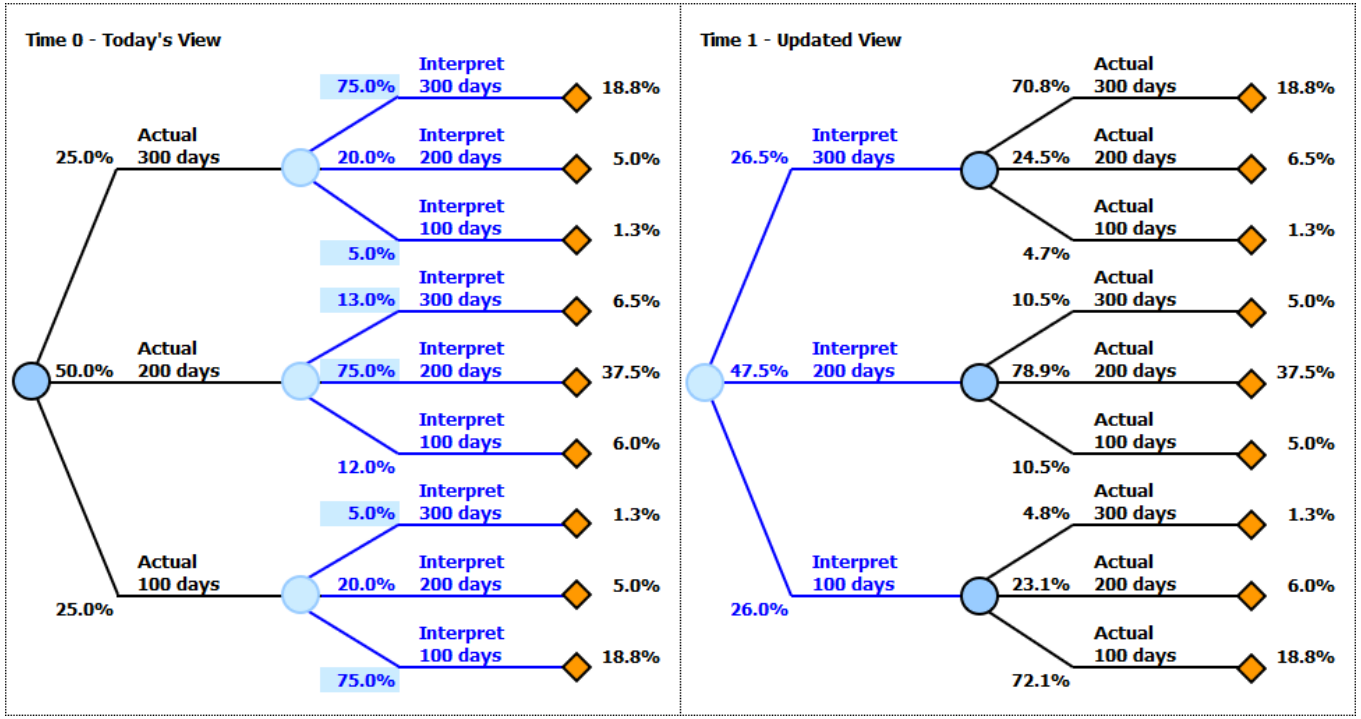
(1) The updated probability of a true state of nature, given the different possible test results (i.e., if the test indicates that the patient does not have COVID-19, there is a 71.4% probability that he does not have COVID: 30%/(30% + 12%) and 28.6% probability that he does have COVID.

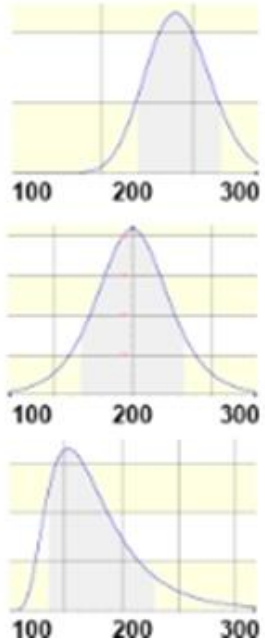


(2) The probability of different possible test results (i.e., there is a 42% probability that the test will indicate the patient is negative for COVID-19 – 30% true negatives and 12% false negatives).

The accuracy of information interview results mathematically demonstrate the de-risking effect of acquiring new information

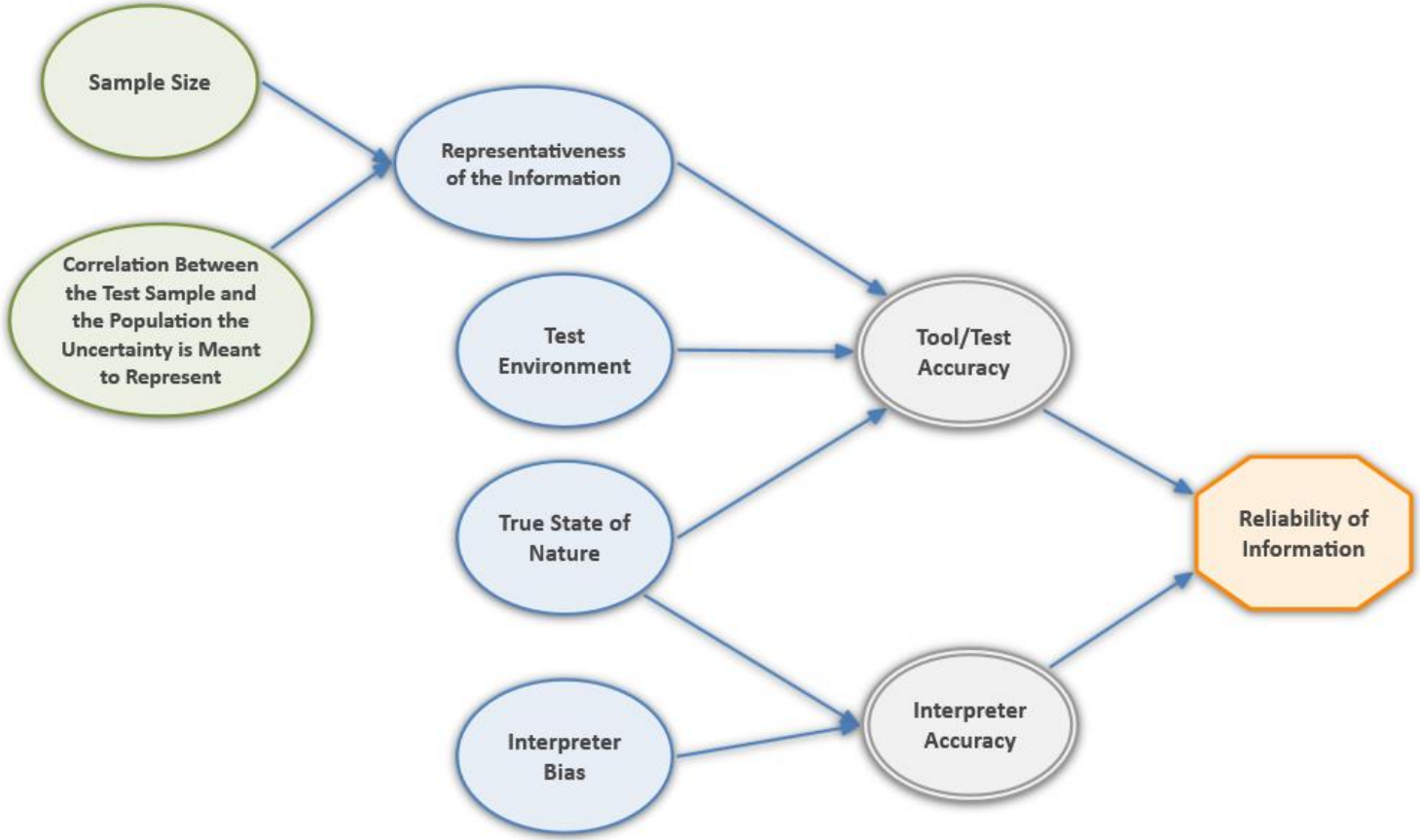






The time 1 view is a glimpse of the future illustrating the distribution narrowing effect of acquiring new information. A three-branch approximation of a continuous distribution uncertainty, coupled with the result of an accuracy interview for a given test, provides a glimpse of three possible test results and associated new uncertainty distributions, given the test information is acquired.

There are many different factors which affect the reliability of information for a given test



These factors form the basis for the reliability or accuracy of information interview questions used to help team's forecast the uncertainty reduction potential of a given test.

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Decision Frameworks Approach to Framing & Evaluating More Complex Information – Pilot Tests or Appraisal Programs

Workflow Overview

There are three key elements of pilot test or appraisal planning

Frame pilot options

- Define the decision problem
- Identify the key uncertainties
- Identify the future decisions they would affect
- Define alternative pilot designs to consider to reduce the key uncertainties

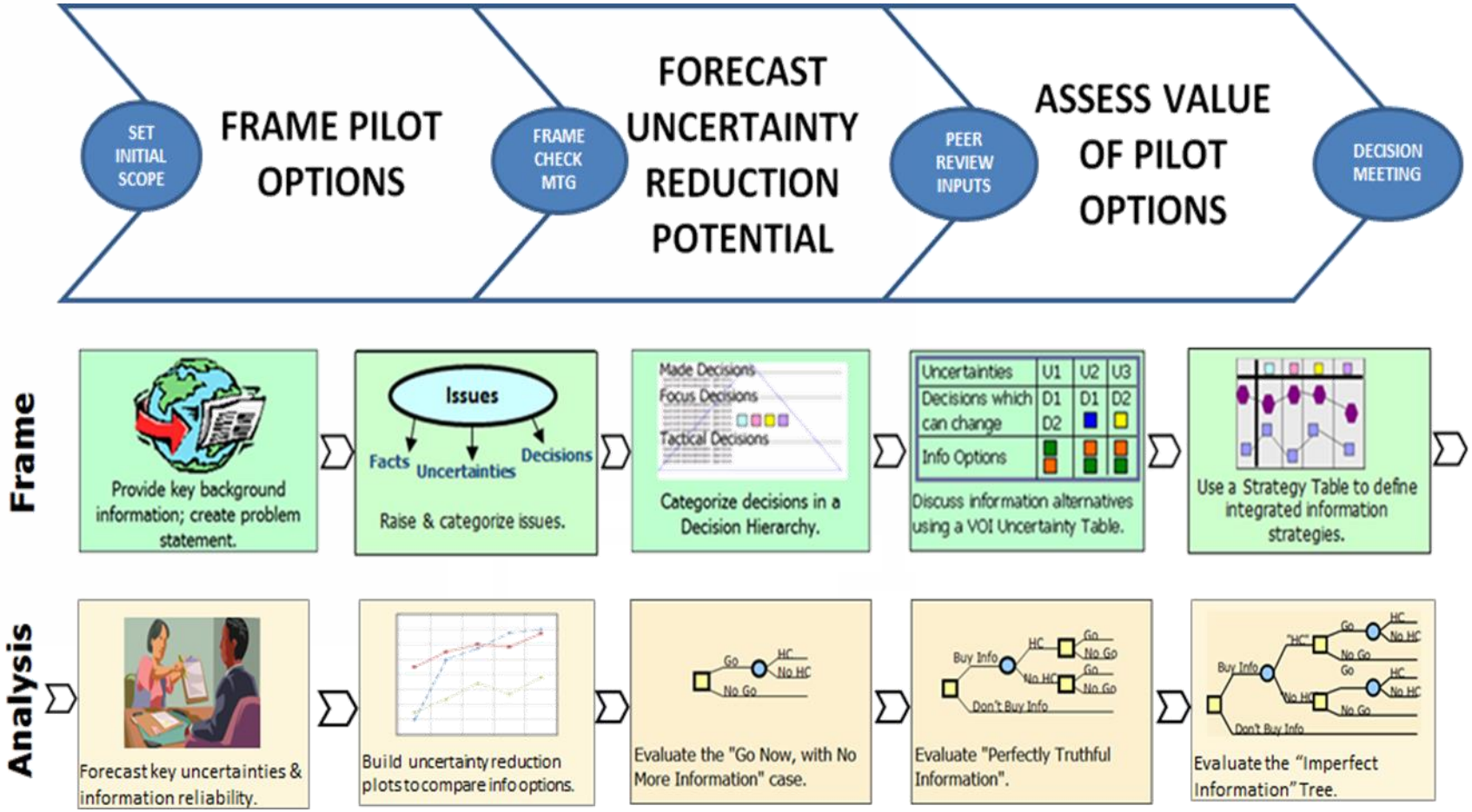
Forecast uncertainty reduction potential

- Perform uncertainty assessments to characterize:
  - The key project uncertainties (which impact go forward decision)
  - The uncertainty reduction potential of different pilot designs
- Compare uncertainty reduction potential vs. cost and or value of different pilot options

Develop the business case, as necessary

- Evaluate the value of the information (w VOI - decision trees):
  - Compare the value of making the go forward decision w/out more information from a pilot to the value of making the go forward decision after more pilot information is acquired

Pilot Framing & Evaluation Workflow



Evaluation of quality decision begins with the decision frame - a group's bounded viewpoint of a decision problem

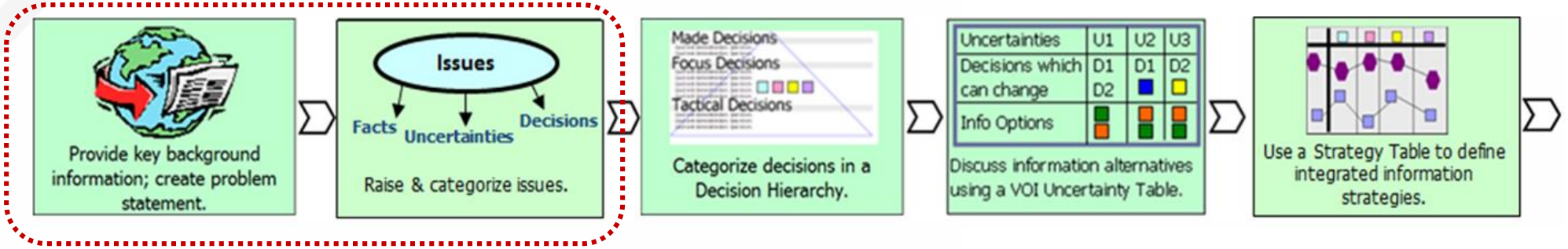
Includes only what is necessary to take a decision

Created by a team

Finalized by the decision makers

Evolves over time

Step 1: Agree the decision problem, brainstorm and categorize the issues



Issues are anything of concern about the decision problem.

Issue Type	Description
Decision Criteria	Partner NPV
Decision Criteria	Partner Profitability (PI)
Decision Criteria	Partner financial breadth
Decision Criteria	Partner scalability
Decision Criteria	Impact of commodity price
Decision Criteria	Environmental footprint
Decision Criteria	Government acceptance of disposal technology
Decision	The lab will partner to pilot and / or commercialize the
Decision	The lab is willing to consider exclusive or nonexclusive
Decision	Linus is a partner on another technology and we are o
Decision	The lab will evaluate conventional technology against n
Decision	A proof of concept is required regardless of the partner chosen for new technology
Decision	Key Assumption: Proof of concept demo will be $ 20 MM with any partner.
Decision	With whom should
Decision	Should we partne
Decision	Should we partne
Decision	Should we partne
Decision	Should we consid
Decision	What is our de-ri
Decision	Should we choos
Decision	Should we choos
Decision	Should we run a
Decision	What should be c
Decision	What should be c
Decision	Should we employ
Decision	Who should we hire to install the new technology?
Uncertainty	How well does our new technology compete with the traditional technology they w
Uncertainty	What are the key drivers for a successful commercialization?
Uncertainty	What are the key risks / uncertainties associated with the new technology?
Uncertainty	What piloting may be valuable to de-risk key uncertainties prior to commercialization?
Fact	The new leaching technology is proven in the lab.

Facts
Issues outside of your control, the outcomes of which are known or will be known within the decision time frame

Uncertainties
Issues outside of your control, the outcomes of which will not be known in the decision time frame

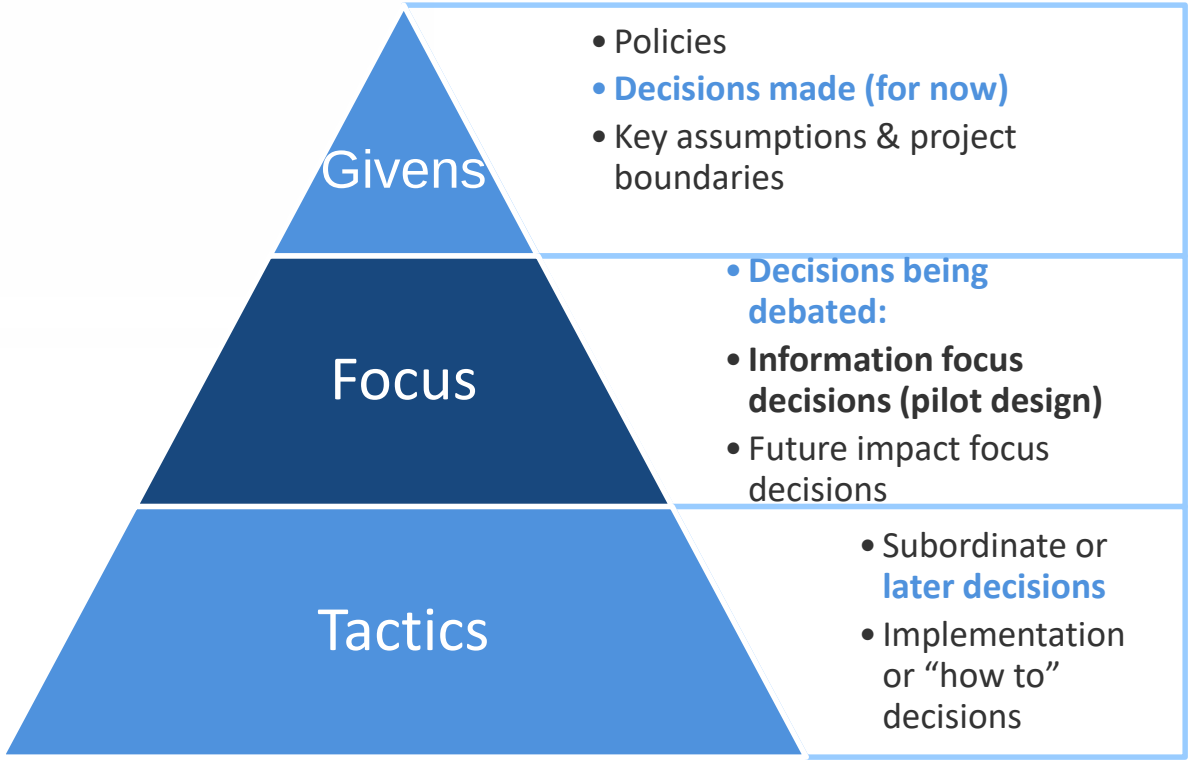
Decisions
Actions within your control (choices, options, alternatives)

Values / Objectives
Issues that describe your values
Decision criteria & other considerations upon which the decision will be made

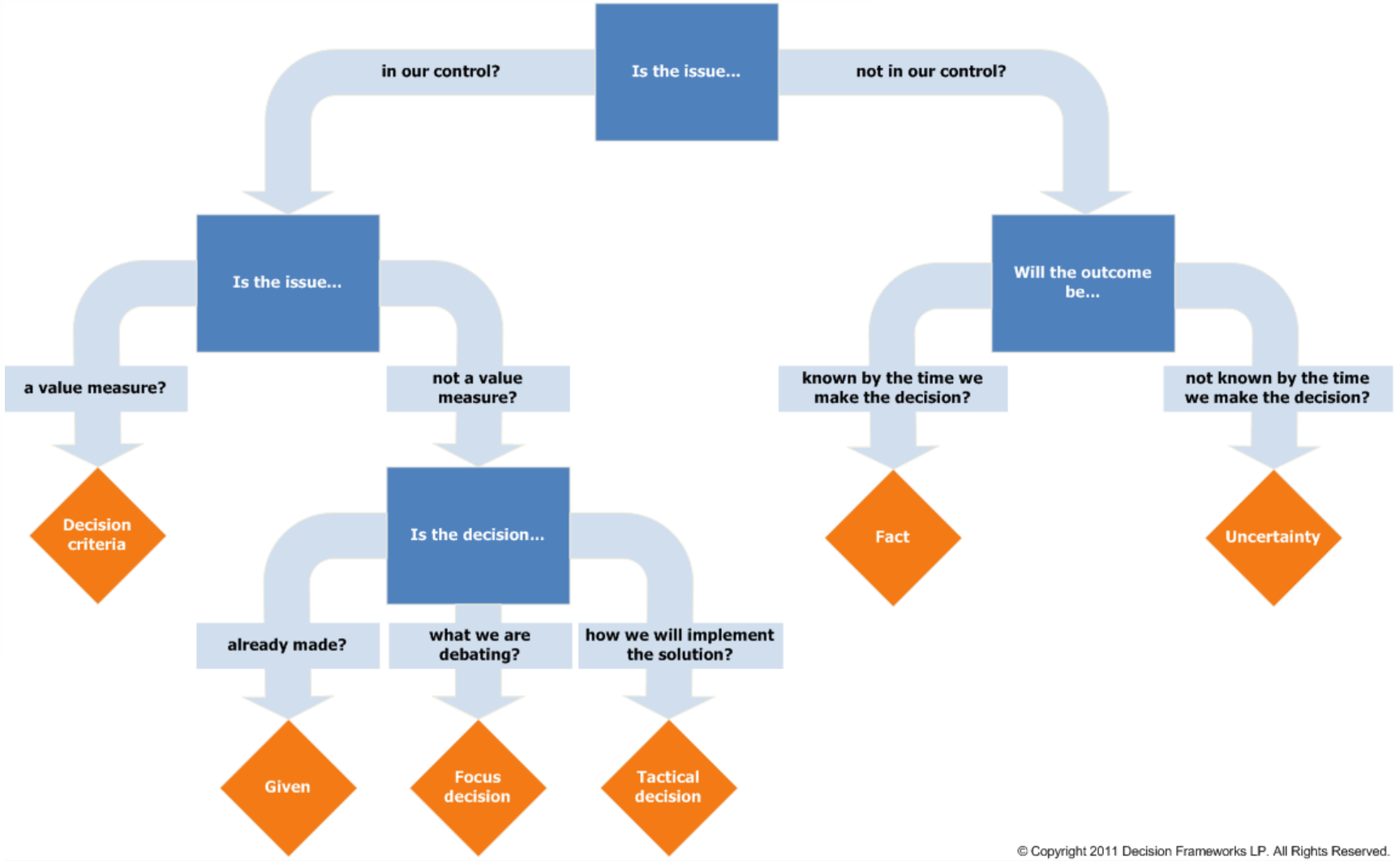
Decision Problem

Step 2: Define the problem focus by categorizing the decisions

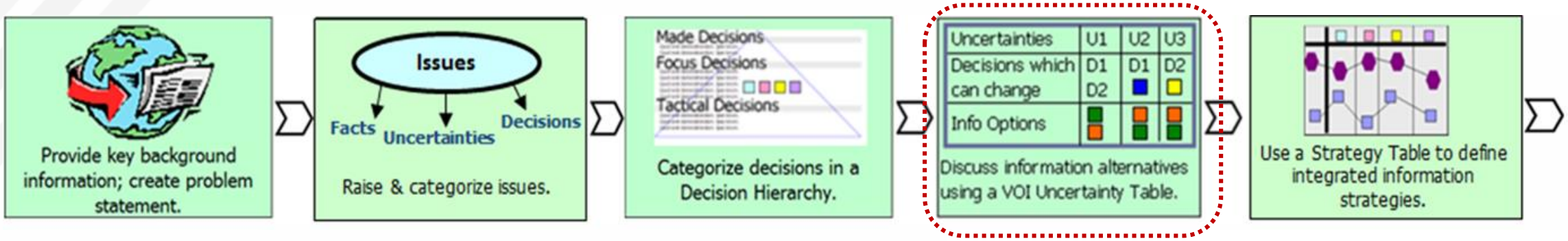
*The **Decision Hierarchy** contains only decisions… all the levers which could be pulled and have been pulled.*



Issue Categorization Flow Chart



Step 3: Develop the Uncertainty Table

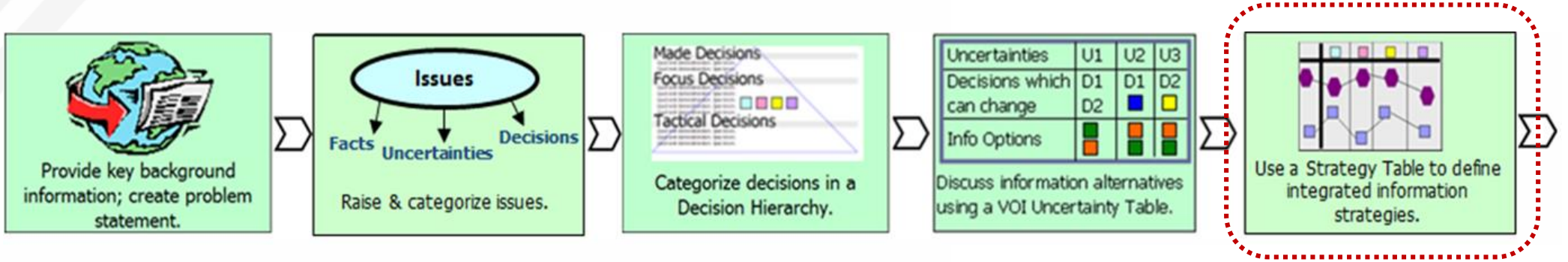


The Uncertainty Table is a key Pilot and VOI framing and project management tool. It includes:

- A list of the key go forward project uncertainties listed as column headings,
- The future project decisions that each key uncertainty would impact, and
- The different pilot or information options which could be used to resolve, or reduce, each key project uncertainty.

Key uncertainties inherent in the asset	Technology Performance	Operating Costs
Future decisions which could change	Commercialize the technology or not	Commrcialize the technology or not
Information sources to consider	Field test technology (pilot)	Uptime computer models
	Simulation	Field test (pilot)
	Lab tests	

Step 4: Define alternative pilot designs using a Strategy Table



Strategy	Pilot Size	Pilot Duration	Data Collection	Objective	Rationale
Lean & Mean Pilot	Small field trial facility	1 year	Pilot performance data	Maximize understanding of commercial product	Can optimize operations if/when commerialize
	Small pilot plant	2 years	Lab simulation based on collected pilot data		
	Medium plant (phase 1 of commercial plant)	3 years	Extensive lab tests of pilot samples		

Build the Strategy Table menu of options from the focus decisions

Givens/Made Decisions

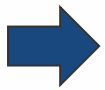
We will host a going away party for our best friends.
Final decisions will be made by my wife
The party will have to be on Friday night.

Focus

Starter?
Chips and dip?
Crab Cakes?
Main Course?
Grilled steaks?
Lasagna?
Dessert?
Cherry pie?
"Do it your self" ice cream sundaes?

Tactics

How much and when to cook some of the dishes ahead of time?
Whether to buy some dishes "ready made"?



Focus Decisions			
Starter	Main	Dessert	Wine
Chips and Dip	Grilled Steaks	Do it Yourself Ice Cream Sundays	Sauvignon Blanc
Crab Cakes	Lasgna	Cherry Pie	Malbec
Gumbo Soup	Hamburgers	Bread Pudding	Chardonney
Salad	None	Baked Alaska	Pinot Noir
None		None	Merlot
			Bring Your Own
			None

Group the focus decisions to identify the main categories of decisions (strategic decisions)

Name the categories & label column headings. List the choices under each column (strategic alternatives)

Develop strategies around strategic themes or approaches to solve the problem

Strategy Name	Objective	Rationale
Cheap & Easy	Host party with little effort and expense	Important to spend time together & not make a big fuss
Little Touches Mean a Lot	Make all their favorite dishes	We want our best friends to know how special they are

- Discuss specific goals around which strategies could be built, for example:
  - Fastest to first revenue
  - Partner-friendly
  - Cheapest
  - Best for project
- Goal are DIVAS: **D**iverse, **I**nteresting, **V**iable, **A**lternative **S**trategies

To define each strategy alternative, agree the name, objective and rationale, then select the menu options

Strategy Name	Approach Objective	Rationale
Cheap & Easy	Host party with little effort and expense	Most important to spend time with friends, not make a big deal of food

Starter	Main	Dessert	Wine
Chips and Dip	Grilled Steaks	Do it Yourself Ice Cream Sundays	Sauvignon Blanc
Crab Cakes	Lasgna	Cherry Pie	Malbeck
Gumbo Soup	Hamburgers	Bread Pudding	Chardonney
Salad	None	Baked Alaska	Pinot Noir
None		None	Merlot
			Bring Your Own
			None

1. **Agree strategy theme**
   - Name = short, creative description
   - Objective = main goal or approach to that strategy
   - Rationale = why the strategy might be viable and should be considered
2. **Select menu options to define the strategy**

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Advanced Biofuel Production Technology Pilot

A Value of Information Case Study

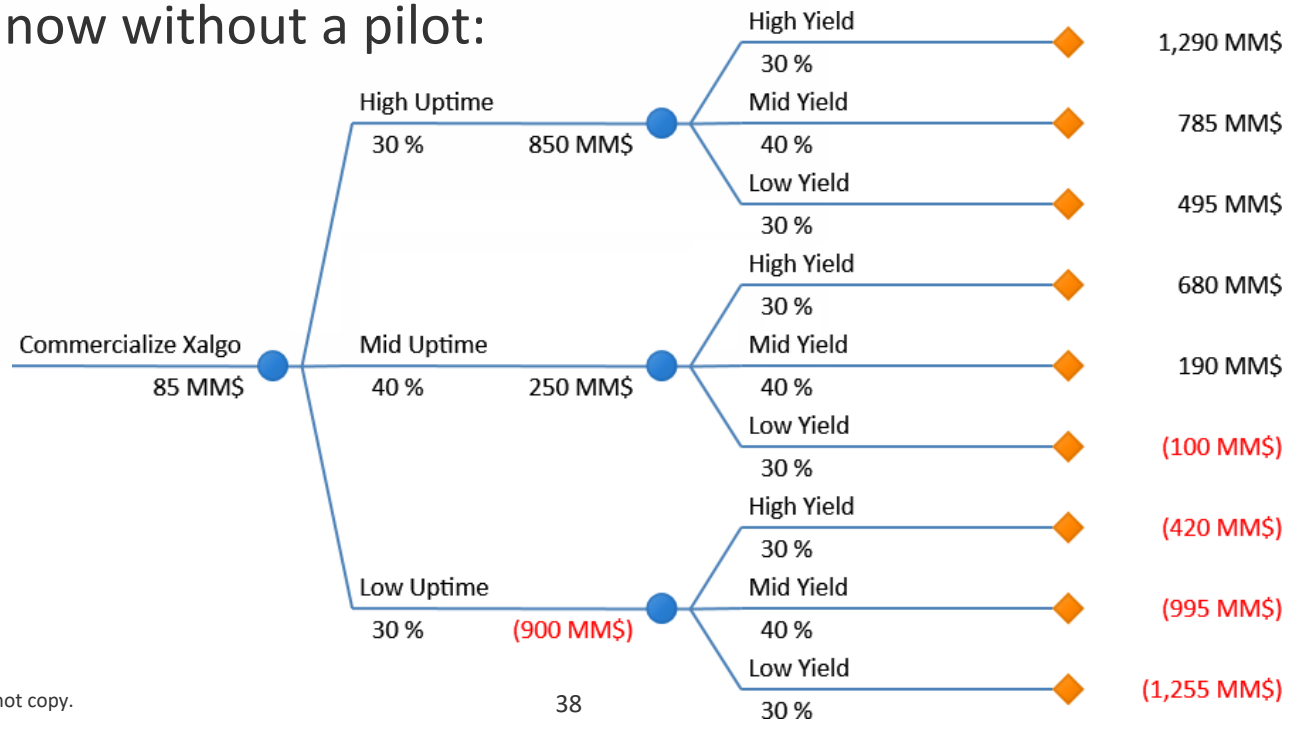
Advanced Biofuel Production Technology Pilot

BACKGROUND PART A

Background A1

Utilizing government grants, Sunny Industries has spent considerable resources developing their new biofuel production technology, Xalgo, which is used to convert algo bio-oil into green diesel. It has progressed as far as it can in the lab and, as such, Sunny is now faced with a decision to either pilot Xalgo, commercialize it or abandon it. If Sunny decides not to commercialize, they must pay a non-compliance penalty of 350 MM$ to the government.

Two key uncertainties drive the decision, the uptime associated with Xalgo and yield of algal oil to green diesel. The team has provided the following estimates if Sunny were to commercialize Xalgo now without a pilot:



Background A2

The team is debating different pilot design options. Some believe a medium pilot plant of 50 Mgal/year would deliver sufficient information on both plant uptime and yield. Others who are more concerned with uptime than yield are pushing for a larger pilot plant of 100 Mgal/year, whereas their counterparts suggest a smaller 30 Mgal/year pilot plant may do the trick.

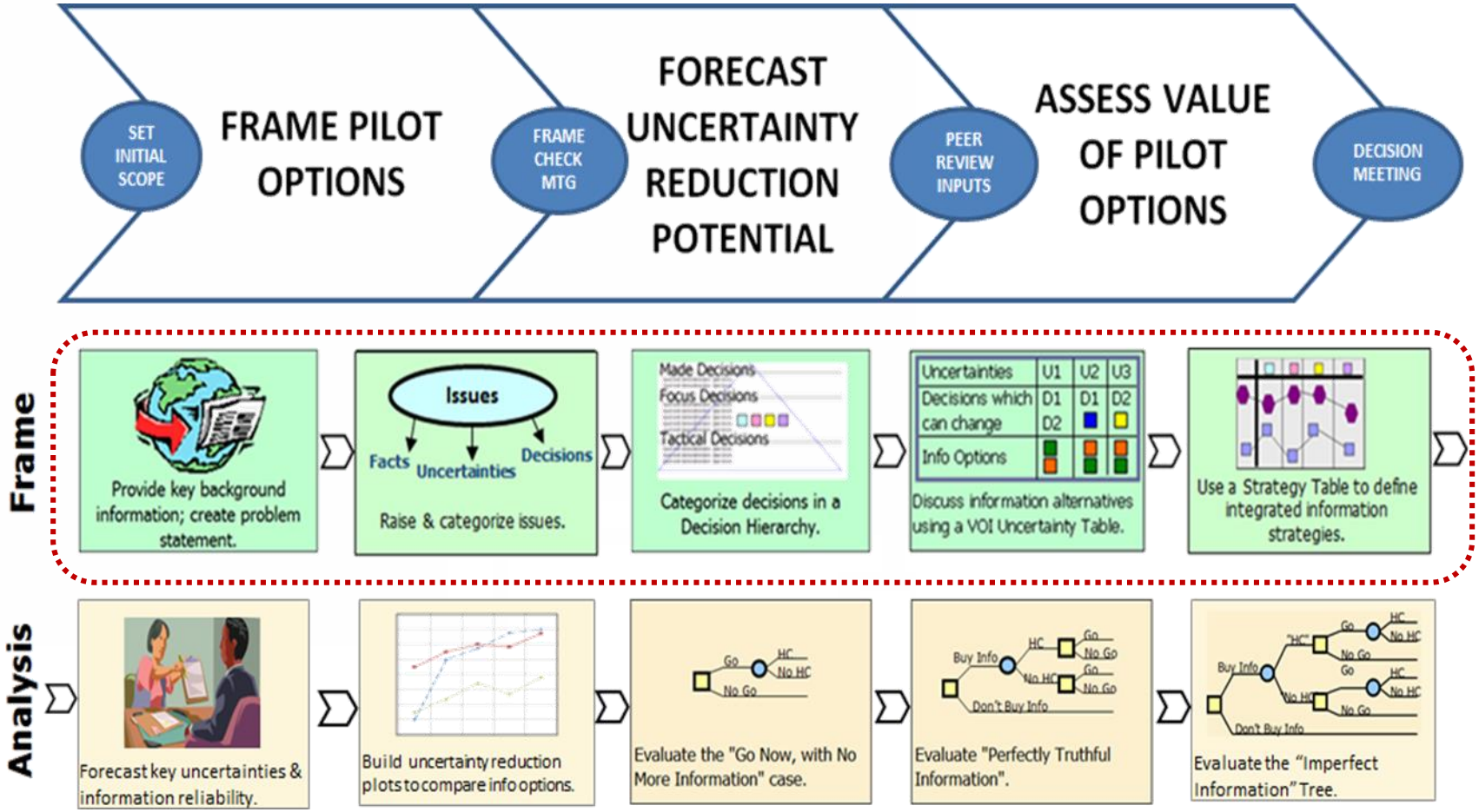
Duration of the pilot is another key decision being discussed. Some argue that de-risking sustained uptime requires at least 24 months of production—if not 36 months. Others believe with heavy data monitoring and simulation, a shorter pilot of 12 months can provide sufficient uptime information.

Furthermore, there is debate pertaining to the amount of data acquisition required for a successful pilot program. Some prefer a full monitoring, testing and simulation program to fully understand yield at the commercialization level. Others argue that a larger pilot plant and a longer pilot duration would necessitate only collecting critical data during the pilot. Others are in favor of a select monitoring and critical testing program.

Advanced Biofuel Production Technology Pilot

VOI PROBLEM FRAME

Pilot Framing & Evaluation Workflow



What problem are we trying to solve? (Problem Definition)

What is the optimum pilot strategy for Sunny Industries to pursue with respect to their goal to commercialize a green diesel technology?

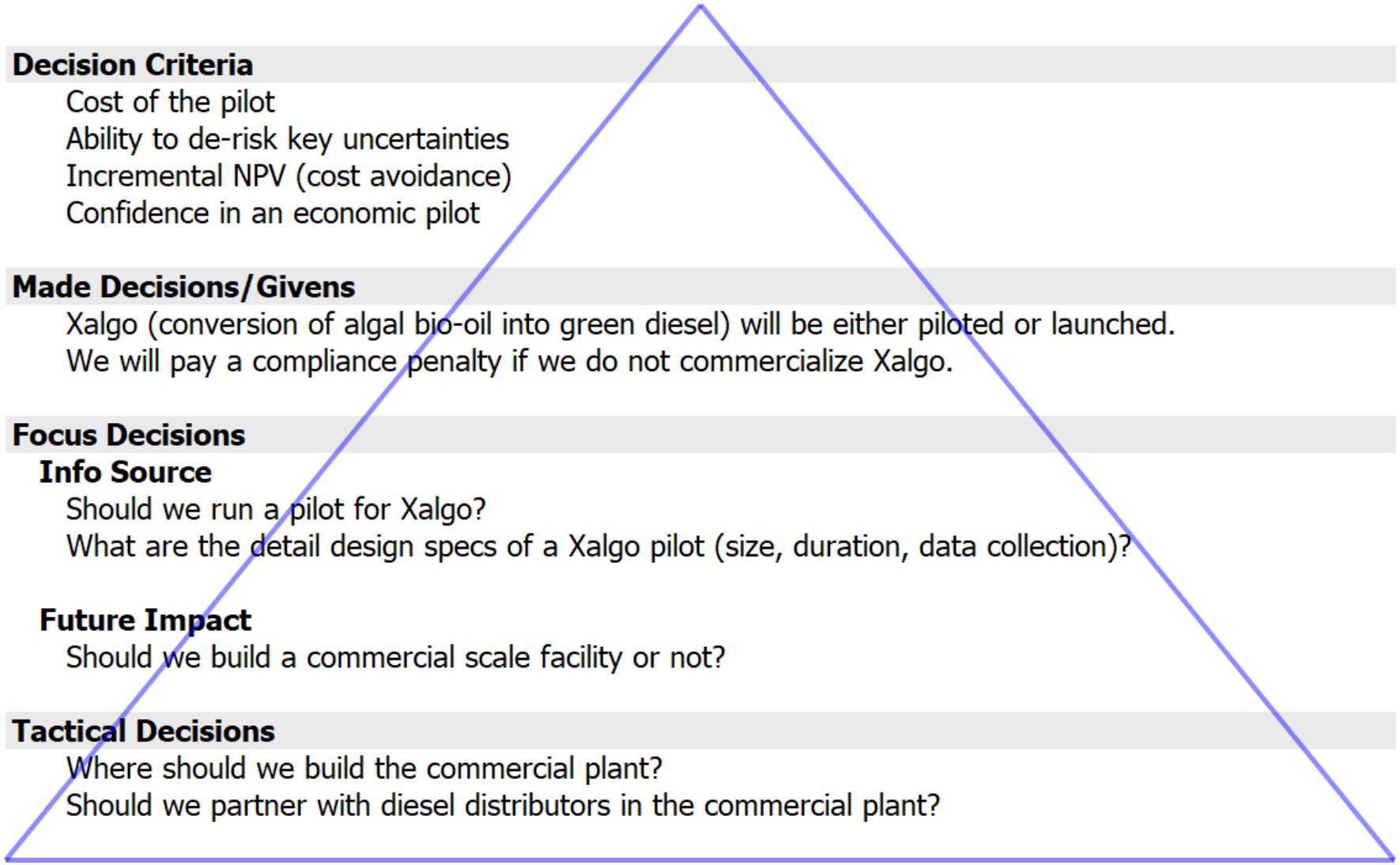
Key Questions the framing and evaluation need to answer:

- Should Xalgo be piloted or launched without piloting?
- Which pilot, if any, should be recommended?

Brainstorm the key issues (Issues List)

Issue Type	Issue
Decision	Should we build a commercial scale facility or not?
Decision	Should we run a pilot for Xalgo?
Decision	What are the detail design specs of a Xalgo pilot (size, duration, data collection)?
Decision	Xalgo (conversion of algal bio-oil into green diesel) will be either piloted or launched.
Decision	We will pay a compliance penalty if we do not commercialize Xalgo.
Decision	Where should we build the commercial plant?
Decision	Should we partner with diesel distributors in the commercial plant?
Decision Criterion	Cost of the pilot
Decision Criterion	Ability to de-risk key uncertainties
Decision Criterion	Incremental NPV (cost avoidance)
Decision Criterion	Confidence in an economic pilot
Uncertainty	What is the CapEx of a pilot?
Uncertainty	What will be the yield (algal oil to green diesel) associated with Xalgo?
Uncertainty	How representative is a pilot of commercial production?
Uncertainty	What will be the uptime associated with Xalgo?
Uncertainty	What is the scalability of Xalgo with or without a pilot?

Prioritize the decisions (Decision Hierarchy)



Decision Criteria

Cost of the pilot
Ability to de-risk key uncertainties
Incremental NPV (cost avoidance)
Confidence in an economic pilot

Made Decisions/Givens

Xalgo (conversion of algal bio-oil into green diesel) will be either piloted or launched.
We will pay a compliance penalty if we do not commercialize Xalgo.

Focus Decisions

Info Source

Should we run a pilot for Xalgo?
What are the detail design specs of a Xalgo pilot (size, duration, data collection)?

Future Impact

Should we build a commercial scale facility or not?

Tactical Decisions

Where should we build the commercial plant?
Should we partner with diesel distributors in the commercial plant?

What are the key uncertainties that could change future decisions? (Uncertainty Table)

Key uncertainties inherent in the asset	Xalgo Uptime	Xalgo Yield (algal oil to green diesel)
Future decisions which could change	Build commercial scale Xalgo facility or not?	Build commercial scale Xalgo facility or not?
Information sources to consider	Pilot plant (30, 50 or 100 Mgal/year)	Pilot plant (30, 50 or 100 Mgal/year)
	Pilot duration (12, 24 or 36 months)	Production flow test
	Shut-in diagnostics	Simulation
	Trials of solutions	

Frame pilot design options

Decision Criteria
- Cost of the pilot
- Ability to de-risk key uncertainties
- Incremental NPV (cost avoidance)
- Confidence in an economic pilot

Made Decisions/Givens
- Xalgo (conversion of algal bio-oil into green diesel) will be either piloted or launched.
- We will pay a compliance penalty if we do not commercialize Xalgo.

Focus Decisions

Info Source
- Should we run a pilot for Xalgo?
- What are the detail design specs of a Xalgo pilot (size, duration, data collection)?

Future Impact
- Should we build a commercial scale facility or not?

Tactical Decisions
- Where should we build the commercial plant?
- Should we partner with diesel distributors in the commercial plant?

The focus decisions determine whether a strategy table will be helpful in defining information options. When a team is debating multiple aspects of a pilot or test, a strategy table may be helpful.

Strategy	Pilot Size	Data Acquisition	Pilot Duration
	30 Mgal/yr	Collect critical data only	12 months on production
	50 Mgal/yr	Select monitoring and critical testing	24 months on production
	100 Mgal/yr	Full monitoring, testing & simulation program	36 months on production

Develop alternative pilot strategies

Strategy	Pilot Size	Data Acquisition	Pilot Duration	Objective	Rationale
Yield Pilot	30 Mgal/yr	Collect critical data only	12 months on production	Maximize understanding of yield at the lowest cost	Poor yield is a showstopper
	50 Mgal/yr	Select monitoring and critical testing	24 months on production		
	100 Mgal/yr	Full monitoring, testing & simulation program	36 months on production		

Strategy	Pilot Size	Data Acquisition	Pilot Duration	Objective	Rationale
Yield Pilot	30 Mgal/yr	Collect critical data only	12 months on production	Maximize understanding of yield at the lowest cost	Poor yield is a showstopper
Uptime Pilot	50 Mgal/yr	Select monitoring and critical testing	24 months on production	Maximize understanding of plant uptime	With insufficient uptime, we can't produce enough to be economic
Balanced Pilot	100 Mgal/yr	Full monitoring, testing & simulation program	36 months on production	Understand minimal acceptable yield and uptime	We can optimize performance in the commercialization phase

Compare the final pilot strategy designs

Strategy	Pilot Size	Data Acquisition	Pilot Duration	Objective	Rationale
Yield Pilot	30 Mgal/yr	Full monitoring, testing & simulation program	12 months on production	Maximize understanding of yield at the lowest cost	Poor yield is a showstopper
Uptime Pilot	100 Mgal/yr	Collect critical data only	24 months on production	Maximize understanding of plant uptime	With insufficient uptime, we can't produce enough to be economic
Balanced Pilot	50 Mgal/yr	Select monitoring and critical testing	12 months on production	Understand minimal acceptable yield and uptime	We can optimize performance in the commercialization phase

The next step for the team is to assess the cost of each pilot design and the accuracy of each pilot design for each of the key uncertainties, uptime and yield.

Initial costs for each pilot are estimated as:

- Yield Pilot = 10 MM$
- Uptime Pilot = 50 MM$
- Balanced Pilot = 25 MM$

For pilots, update the uncertainty table to reflect the alternative pilot designs

Key uncertainties inherent in the asset	Xalgo Uptime	Xalgo Yield (algal oil to green diesel)
Future decisions which could change	Build commercial scale Xalgo facility or not?	Build commercial scale Xalgo facility or not?
Information sources to consider	Yield Pilot	Yield Pilot
	Uptime Pilot	Uptime Pilot
	Balanced Pilot	Balanced Pilot

Note: There is potential value of each pilot to reduce each uncertainty and affect the commercialization decision.

The VOIs for reducing each uncertainty with a given pilot can be additive.

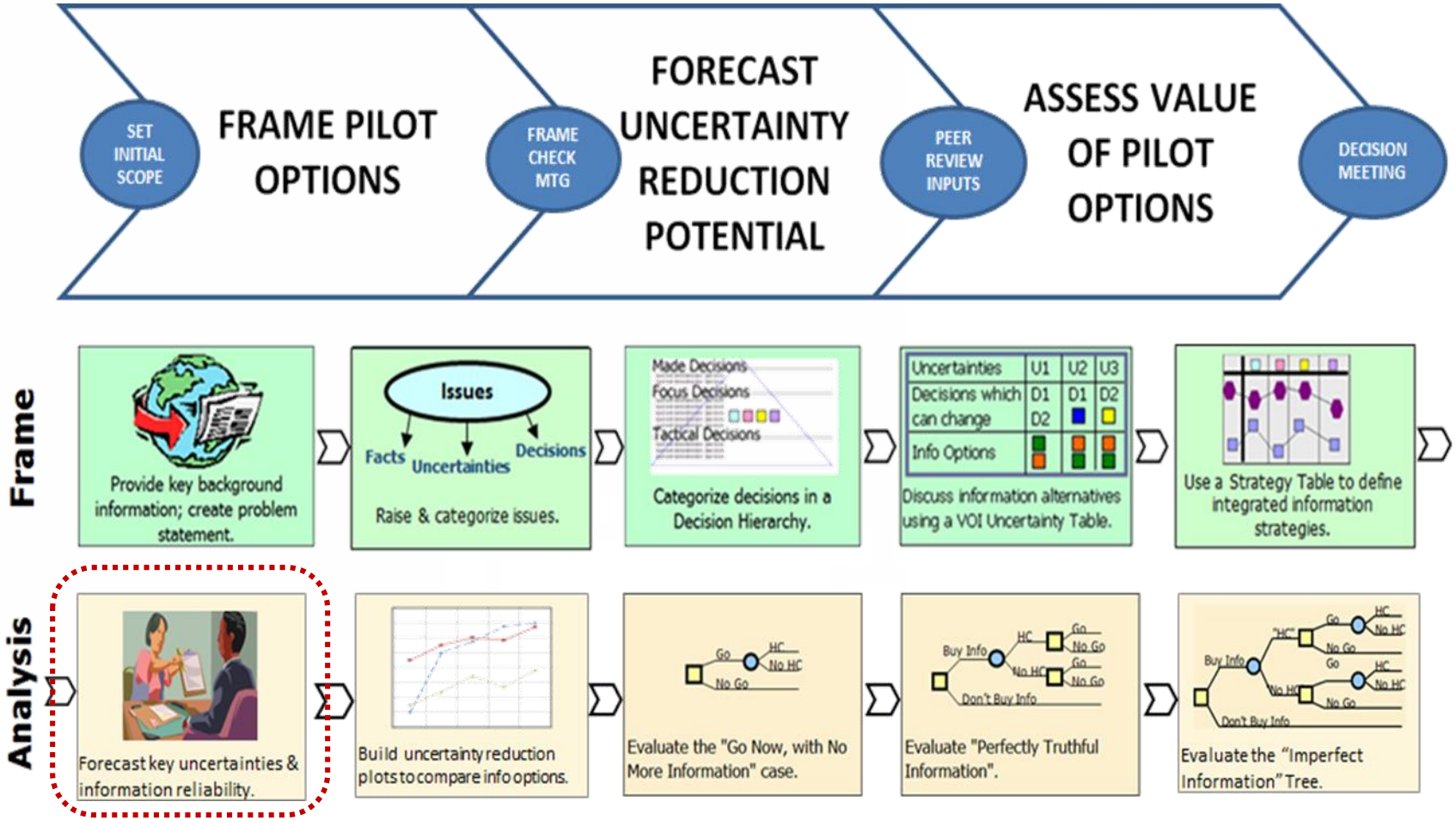
decision | FRAMEWORKS

REAL PEOPLE • REAL INSIGHTS • REAL DECISIONS

Reliability of Interpretation Expert Interviews & Confidence Plots

Forecasting Uncertainty Reduction Potential from Different Tests

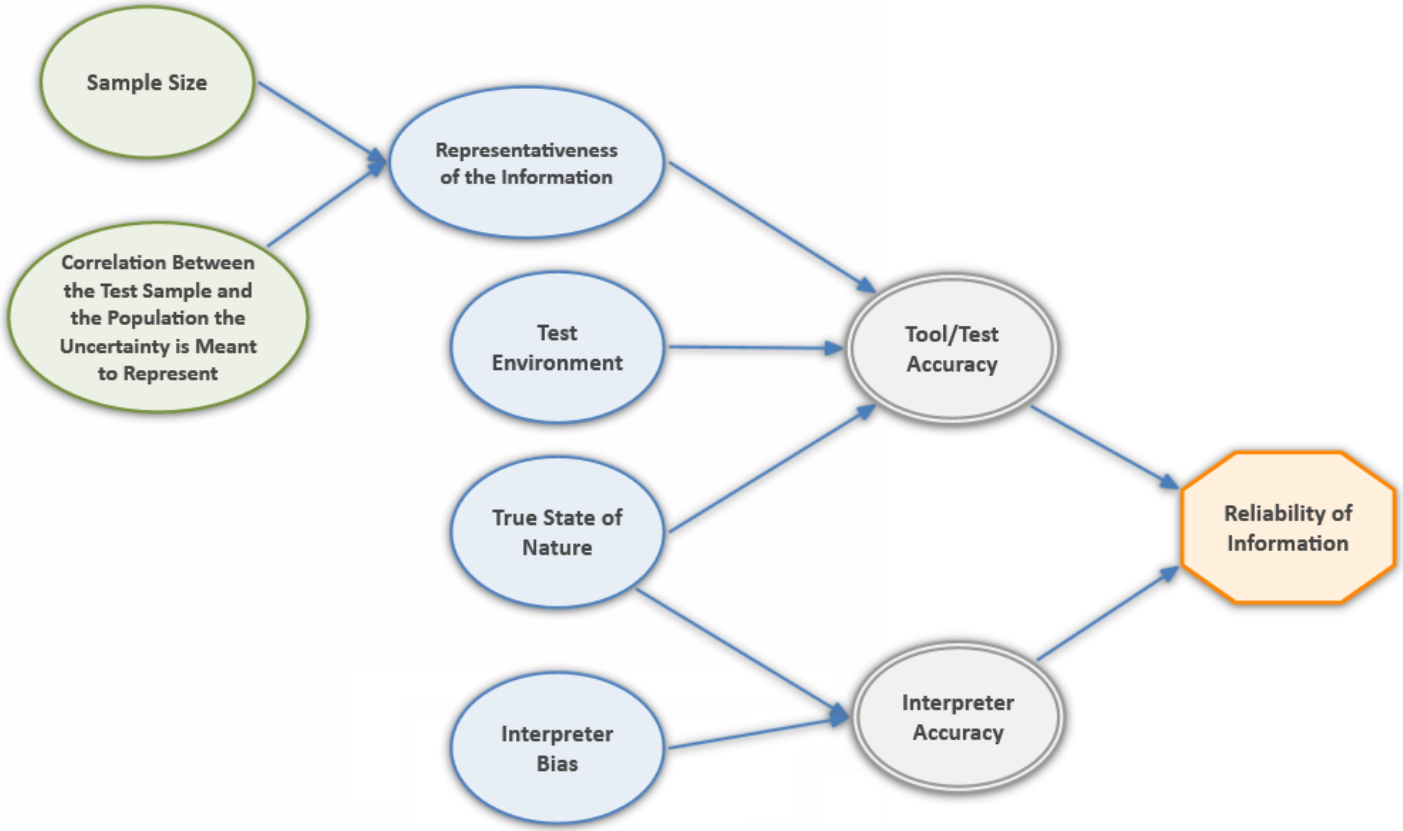
Pilot Framing & Evaluation Workflow



Forecasting uncertainty reduction potential is imperative to de-risking project decision making

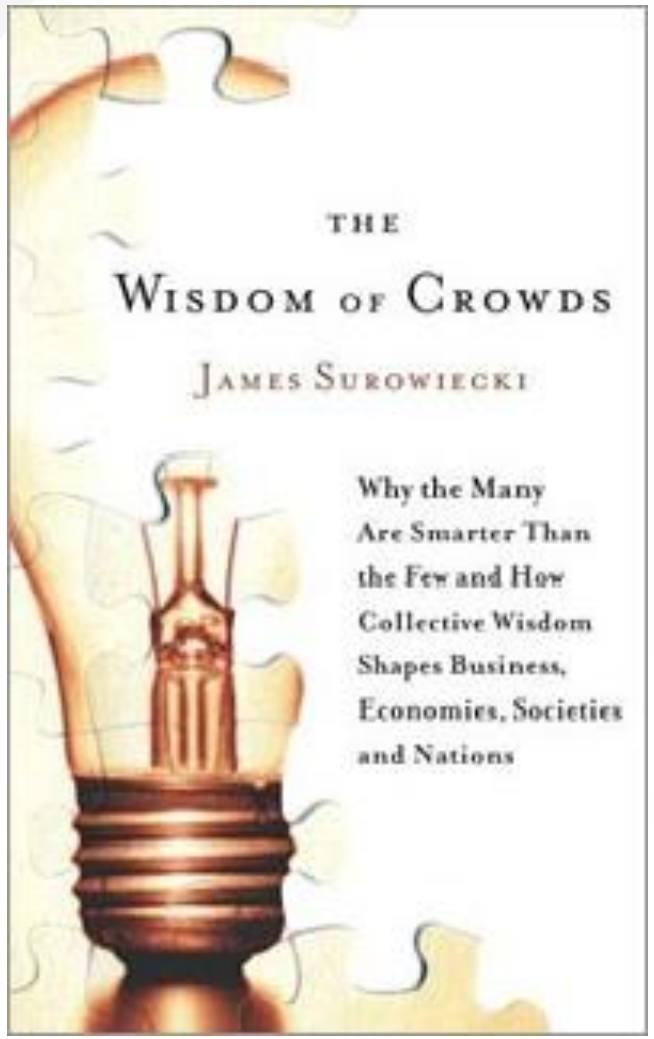
- Reliability of information interviewing with a knowledgeable group helps de-bias the assessments and develop robust test accuracy forecasts.
- The result is a set of useful uncertainty reduction plots which helps teams and their management gain insight on their information options and understand which pilot designs add the most value.

There are many different factors which affect the reliability of information for a given test or appraisal program



These factors form the basis for the reliability of information interview questions used to help team's forecast the uncertainty reduction potential of a given test.

Use a modified "Wisdom of Crowds" approach to conduct the reliability of information assessment interviews

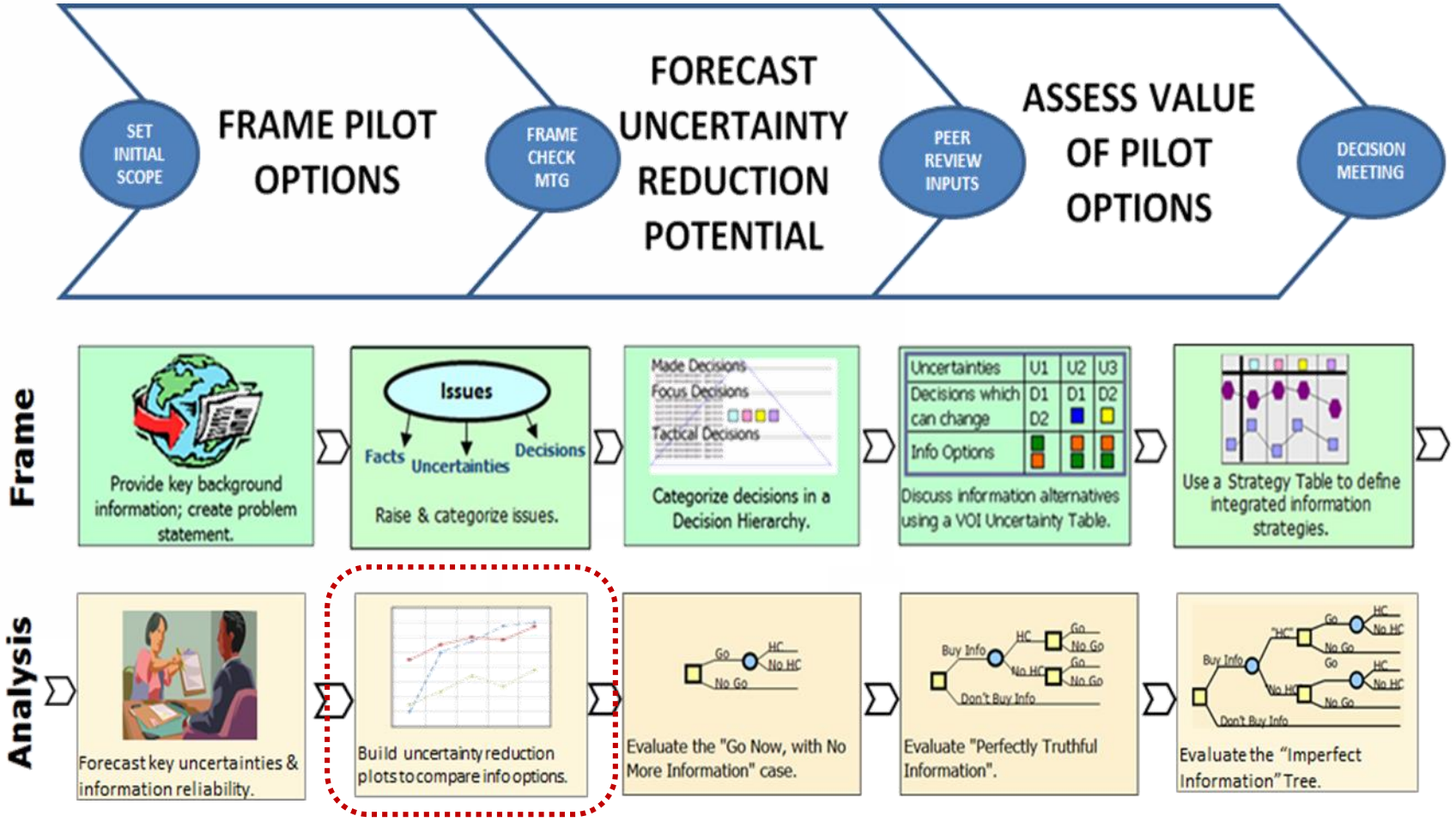


- When trying to forecast very difficult uncertainties, it may be better to use the views of many with some relevant knowledge rather than depend on the view of one "expert".
- Involves gathering a group of people with different, relevant knowledge to assess the reliability of different information programs to help them correctly interpret the true state of nature of a key project uncertainty.
- The group is asked a series of questions relating to the drivers of information reliability and discusses the answers.
- Each person's estimates are recorded and compared. The group then decides which values to use.
- This creates buy-in for the values used, as well as provides a range to sensitize across, representing the diverse opinions of the individuals.

Advanced Biofuel Production Technology Pilot

CASE BACKGROUND PART B

Pilot Framing & Evaluation Workflow



Background B1

Strategy	Pilot Size	Data Acquisition	Pilot Duration	Objective	Rationale
Yield Pilot	30 Mgal/yr	Full monitoring, testing & simulation program	12 months on production	Maximize understanding of yield at the lowest cost	Poor yield is a showstopper
Uptime Pilot	100 Mgal/yr	Collect critical data only	24 months on production	Maximize understanding of plant uptime	With insufficient uptime, we can't produce enough to be economic
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The next step for the team is to assess the cost of each pilot design and the accuracy of each pilot design for each of the key uncertainties, uptime and yield.

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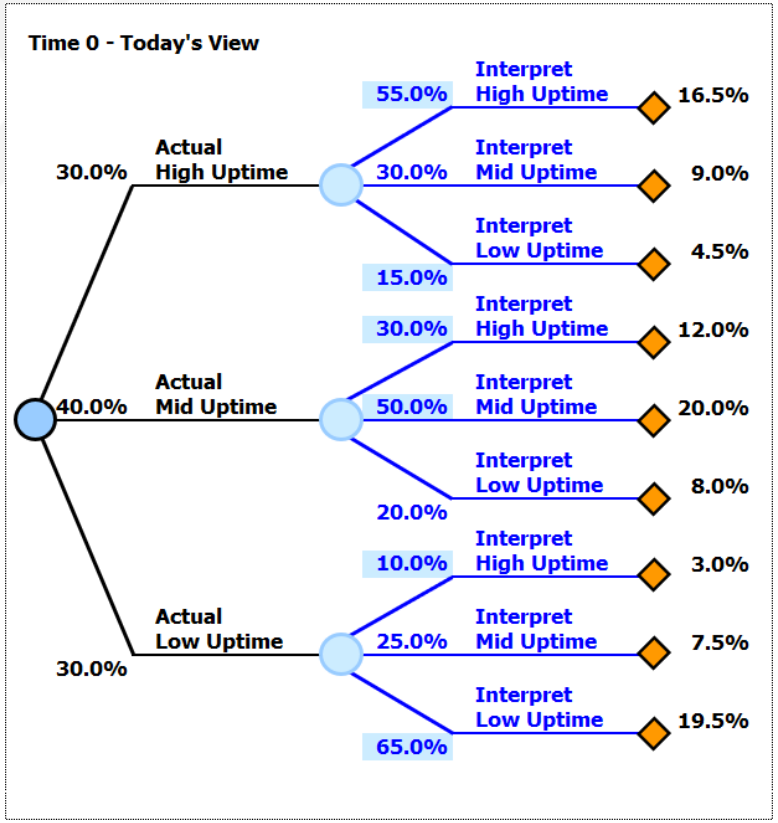
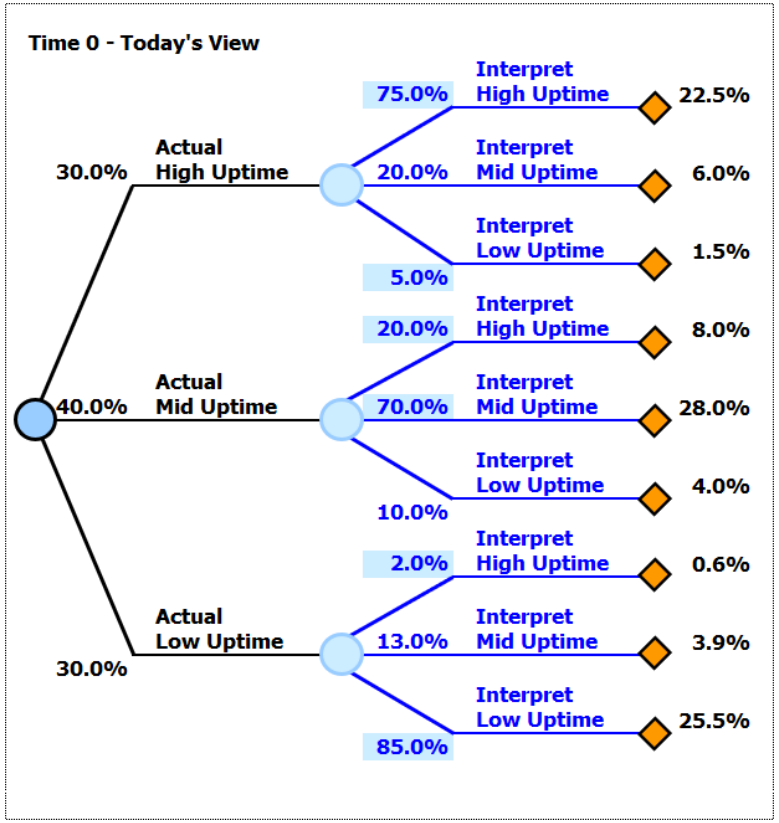
- Uptime Pilot = 50 MM$
- Balanced Pilot = 25 MM$

Background B2 – Uptime Accuracy

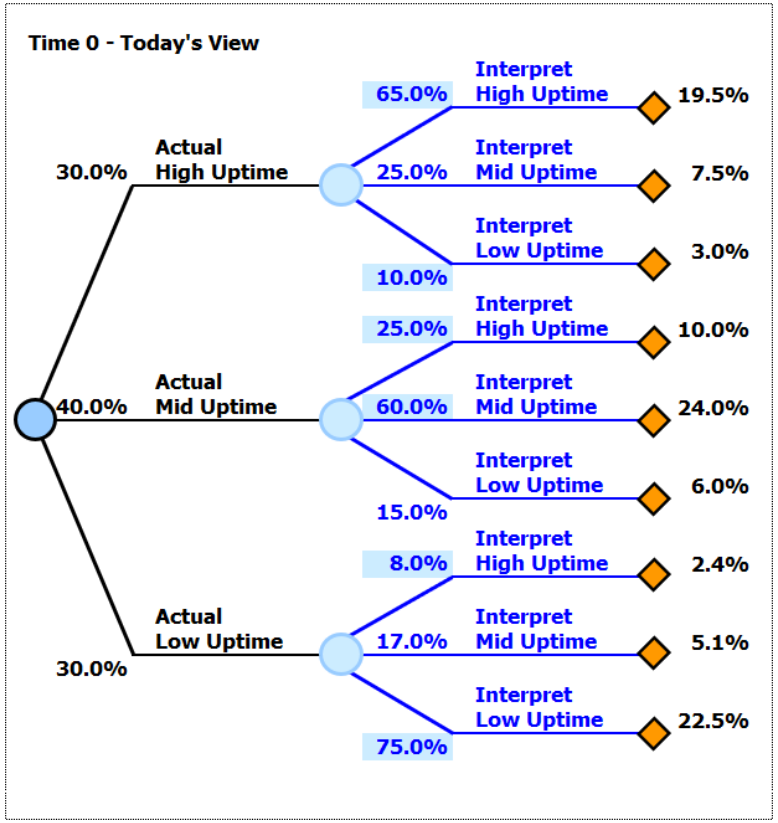
Yield Pilot



Uptime Pilot

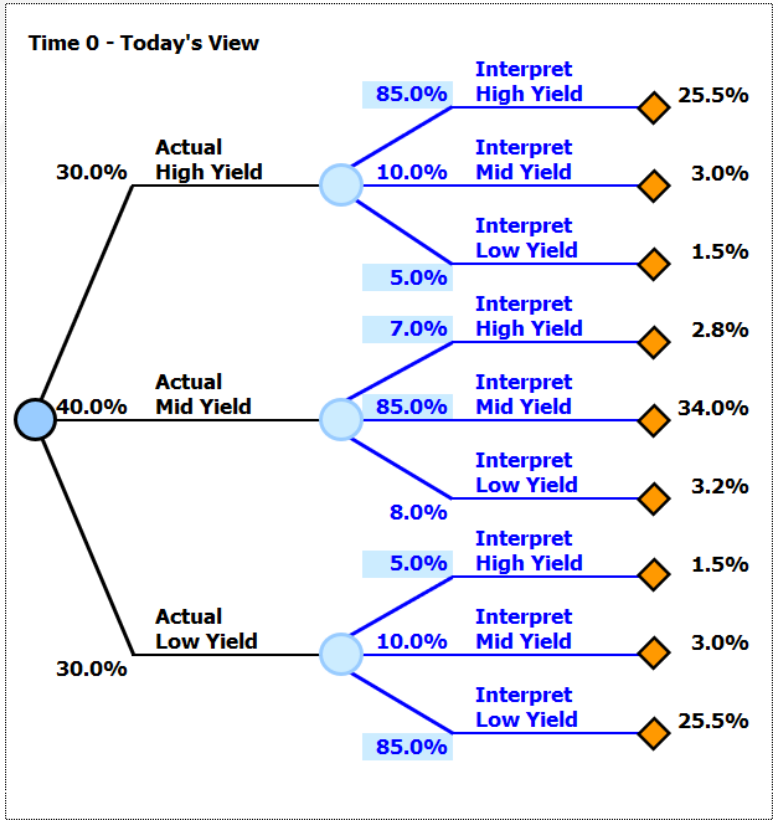


Balanced Pilot

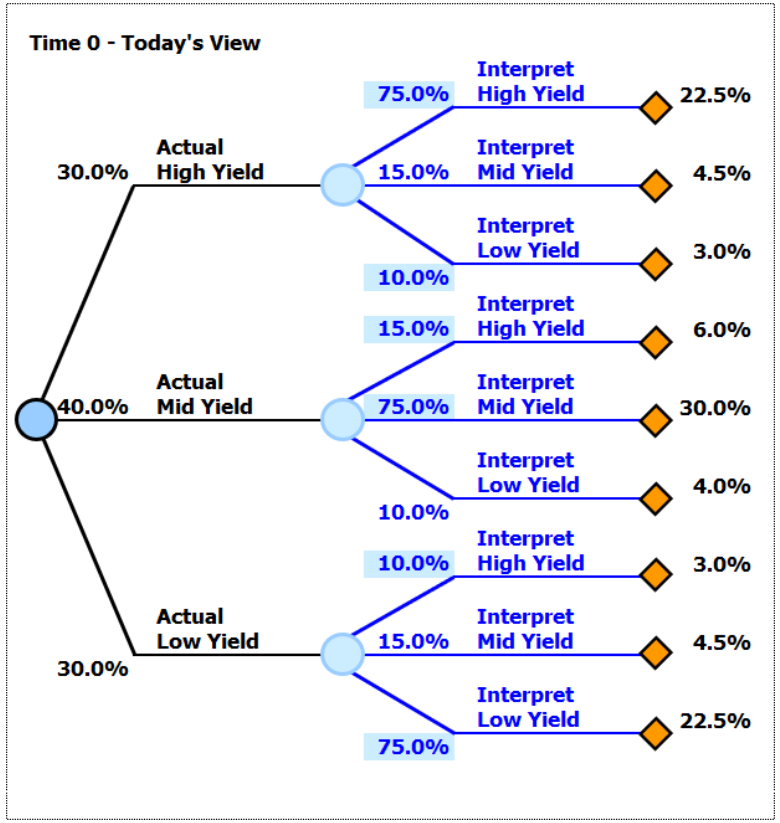


Background B3 – Yield Accuracy

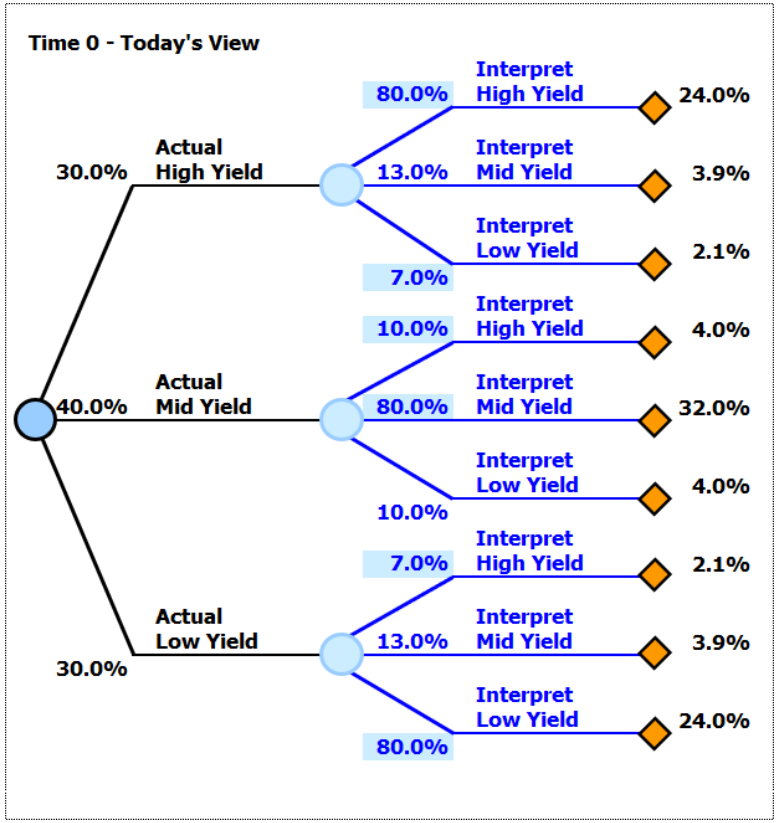
Yield Pilot



Uptime Pilot



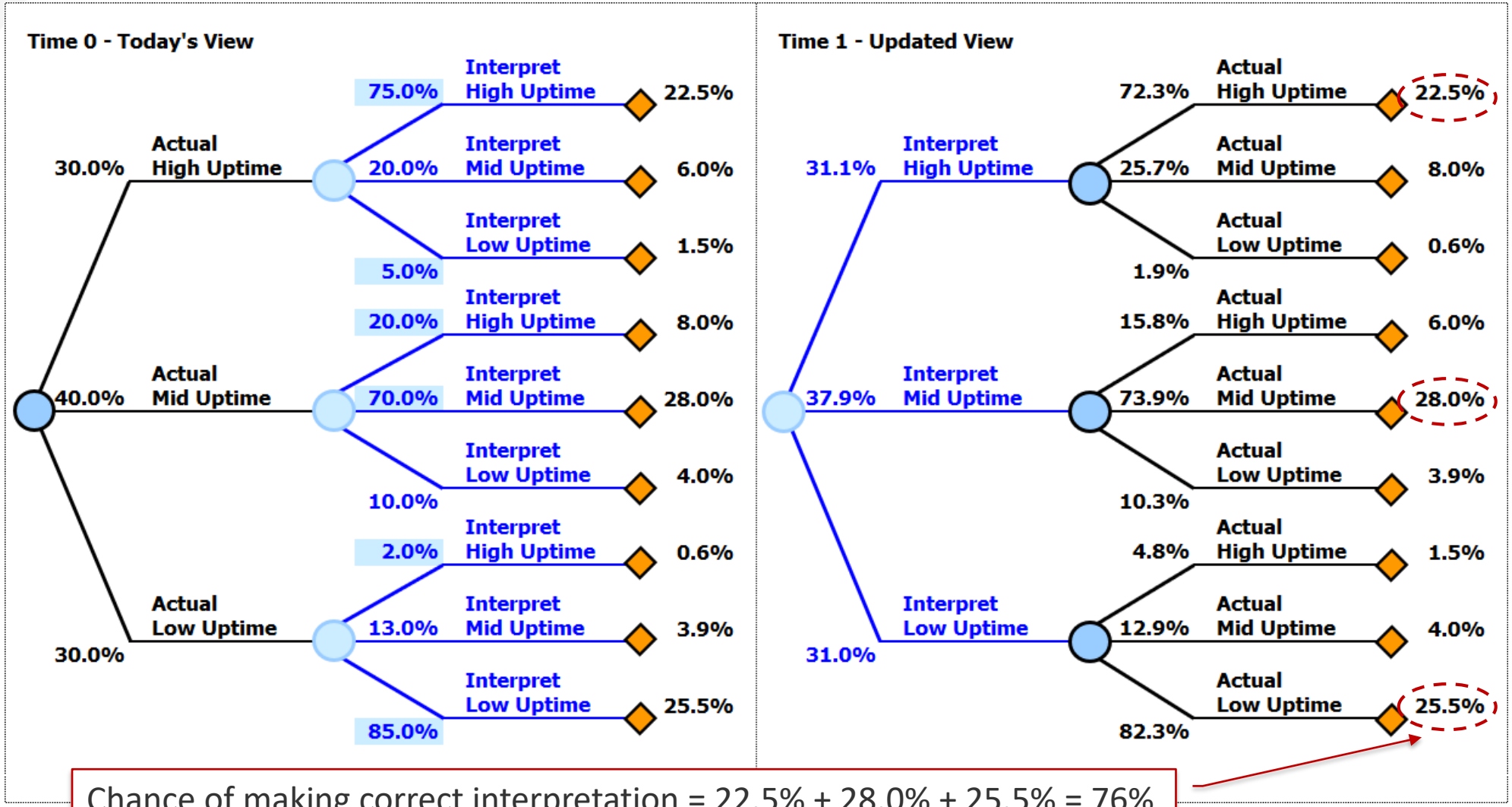
Balanced Pilot



Advanced Biofuel Production Technology Pilot

FORECAST UNCERTAINTY REDUCTION POTENTIAL

Assess the confidence of a correct interpretation from the reliability interview results of a given pilot



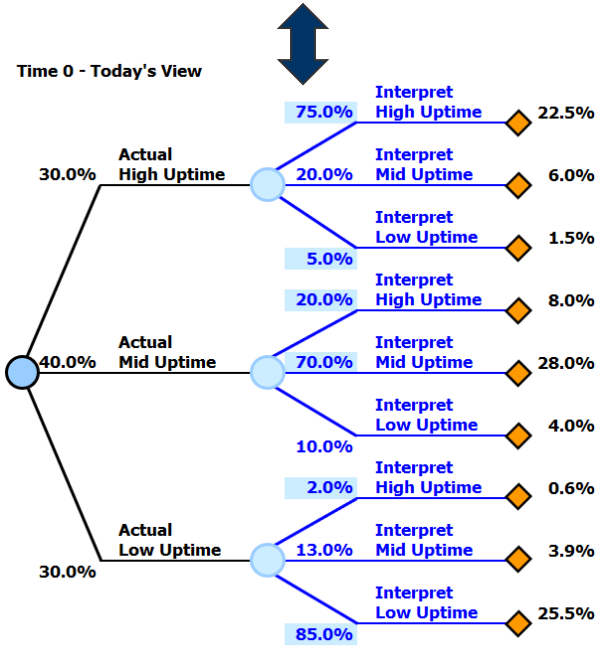
Chance of making correct interpretation = 22.5% + 28.0% + 25.5% = 76%

Compare pilot accuracy differences between the pilot options

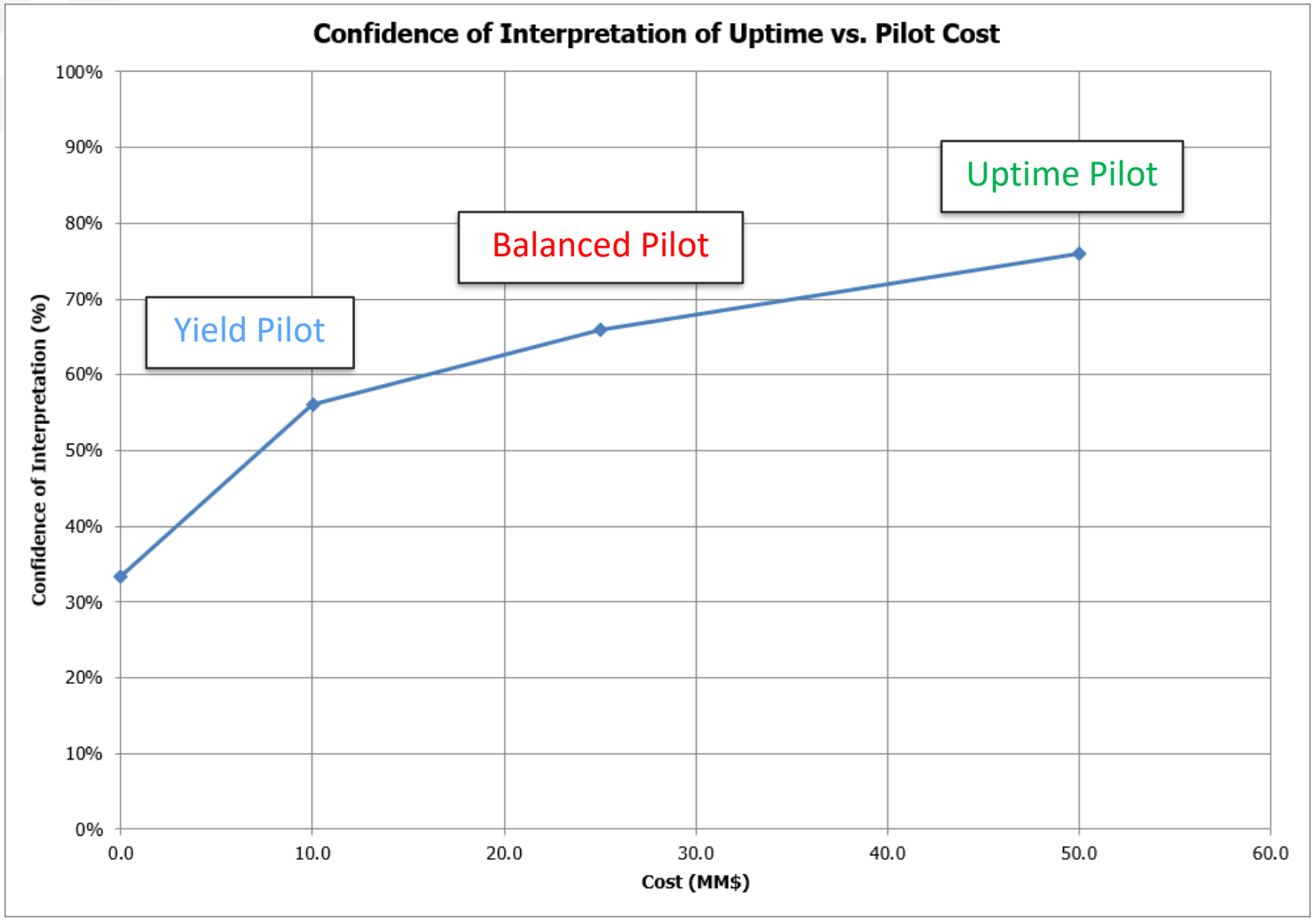
		Information Reliability			
Actual	Interpretation	Today	Yield Pilot	Balanced Pilot	Uptime Pilot
High Uptime	**High Uptime**	33%	55%	65%	75%
	Mid Uptime	33%	30%	25%	20%
	Low Uptime	33%	15%	10%	5%
Mid Uptime	High Uptime	33%	30%	25%	20%
	Mid Uptime	33%	50%	60%	70%
	Low Uptime	33%	20%	15%	10%
Low Uptime	High Uptime	33%	10%	8%	2%
	Mid Uptime	33%	25%	17%	13%
	Low Uptime	33%	65%	75%	85%

List each pilot's reliability side-by-side:

- Compare & adjust difference between pilots
- Set end points for highest and lowest reliability
- Challenge team to discuss information which would maximize reliability



Assess confidence of interpretation of uptime vs. pilot designs

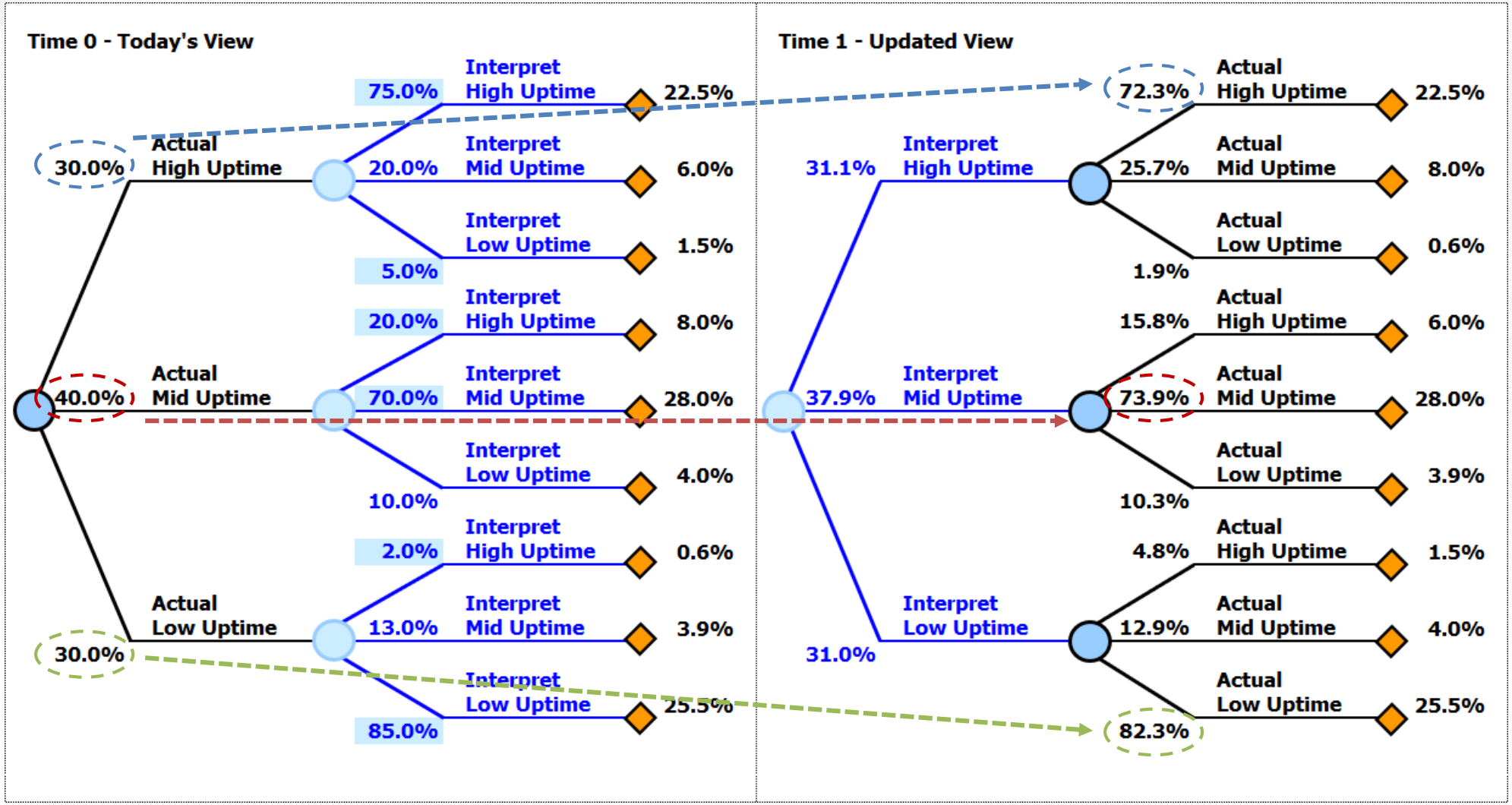


The Uptime Pilot provides little extra confidence in commercialization uptime for a fairly significant additional cost:

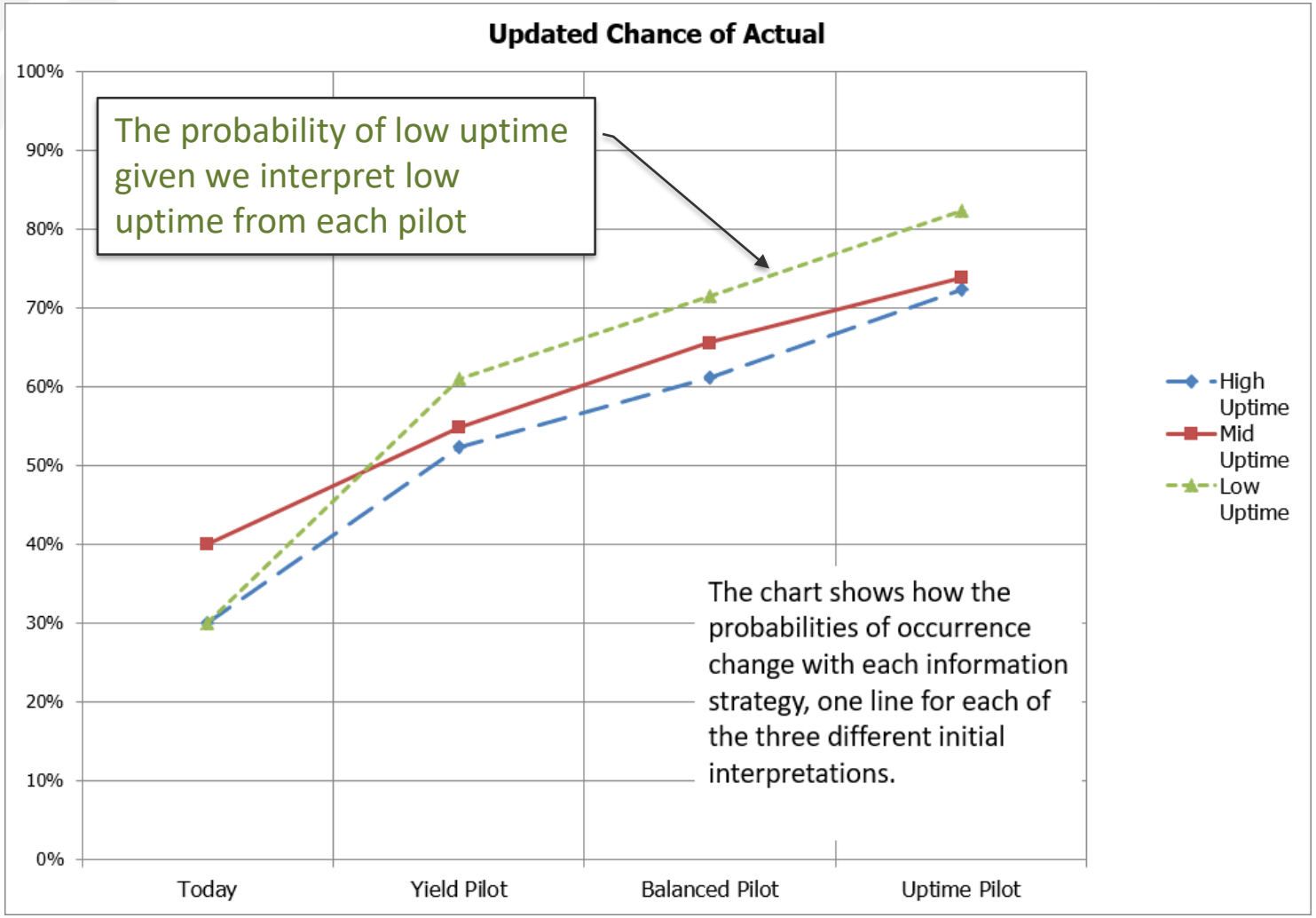
Uptime Pilot – 76% total confidence for 50 $mm

Balanced Pilot – 66% total confidence in uptime for 25 $mm

Assess how the probability of each state of nature changes from the reliability interview results of a given pilot

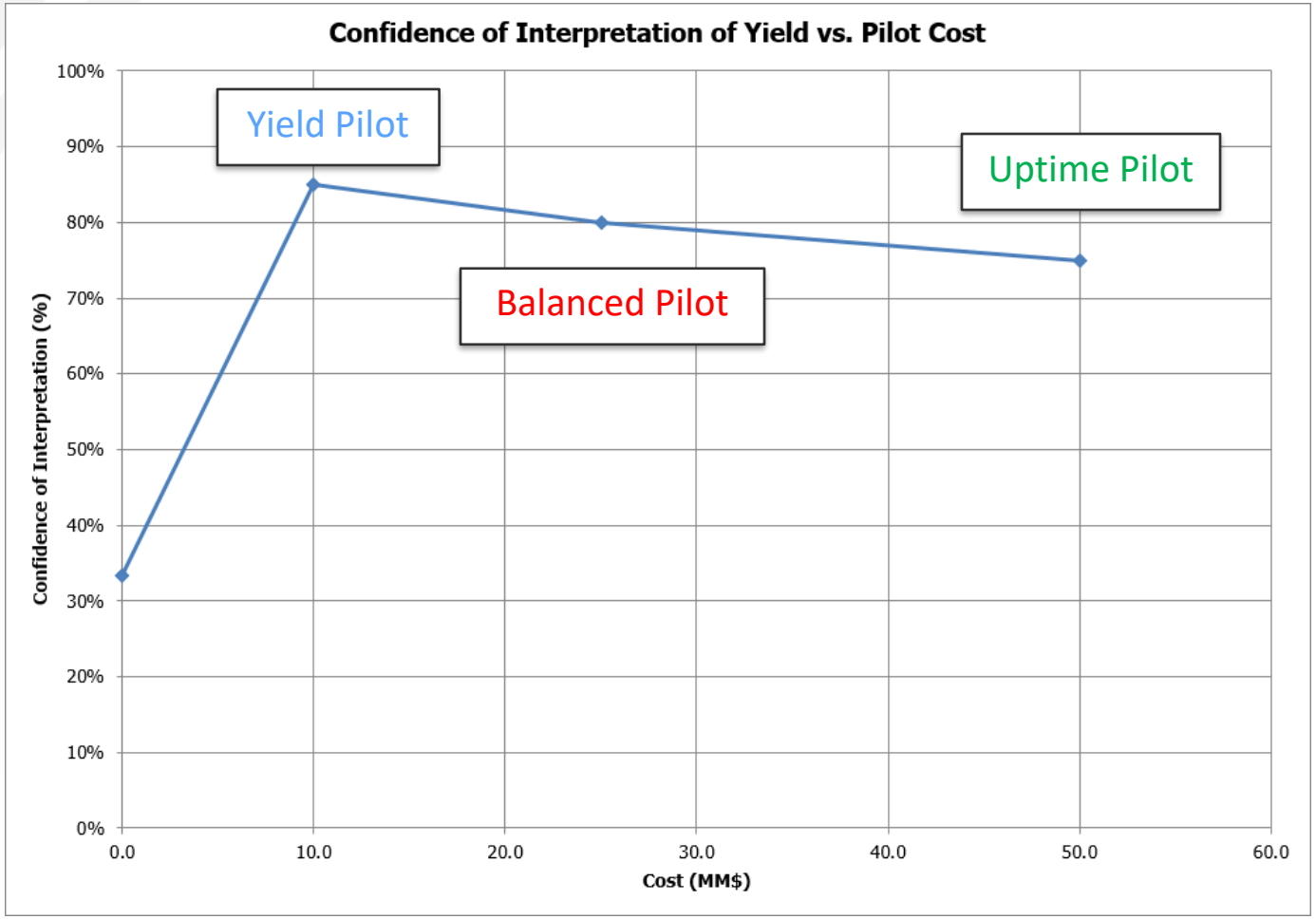


Evaluate probability of uptime given different pilot interpretations of uptime



Probability of low uptime is a critical metric to go to commercialization. If the team needs 70% or greater confidence that commercialization would be low before they could walk from the project, then Balance Pilot or Uptime Pilot will be required.

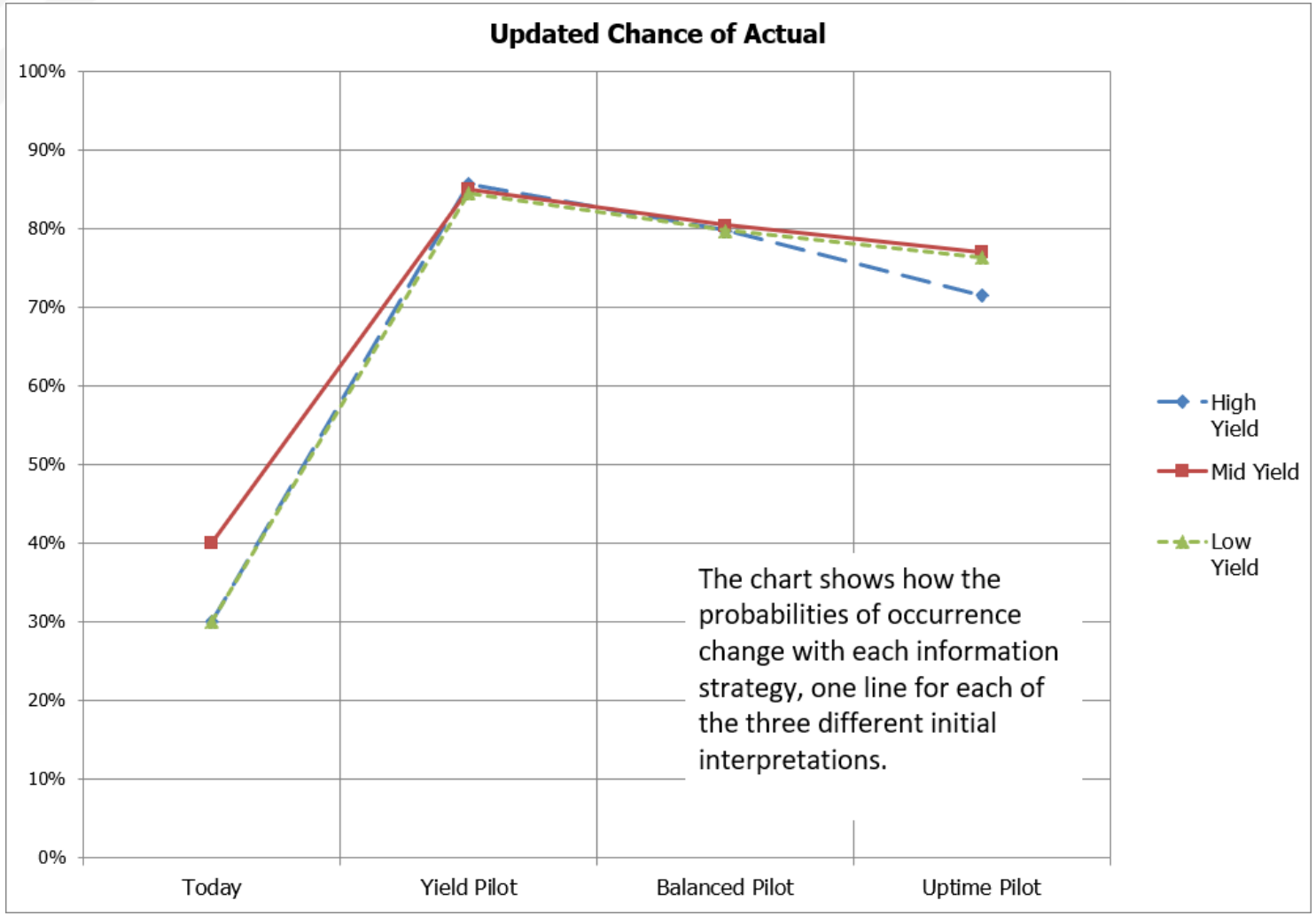
Assess confidence of interpretation of yield vs. pilot design



The Yield Pilot provides the highest total confidence in yield and is the least expensive pilot.

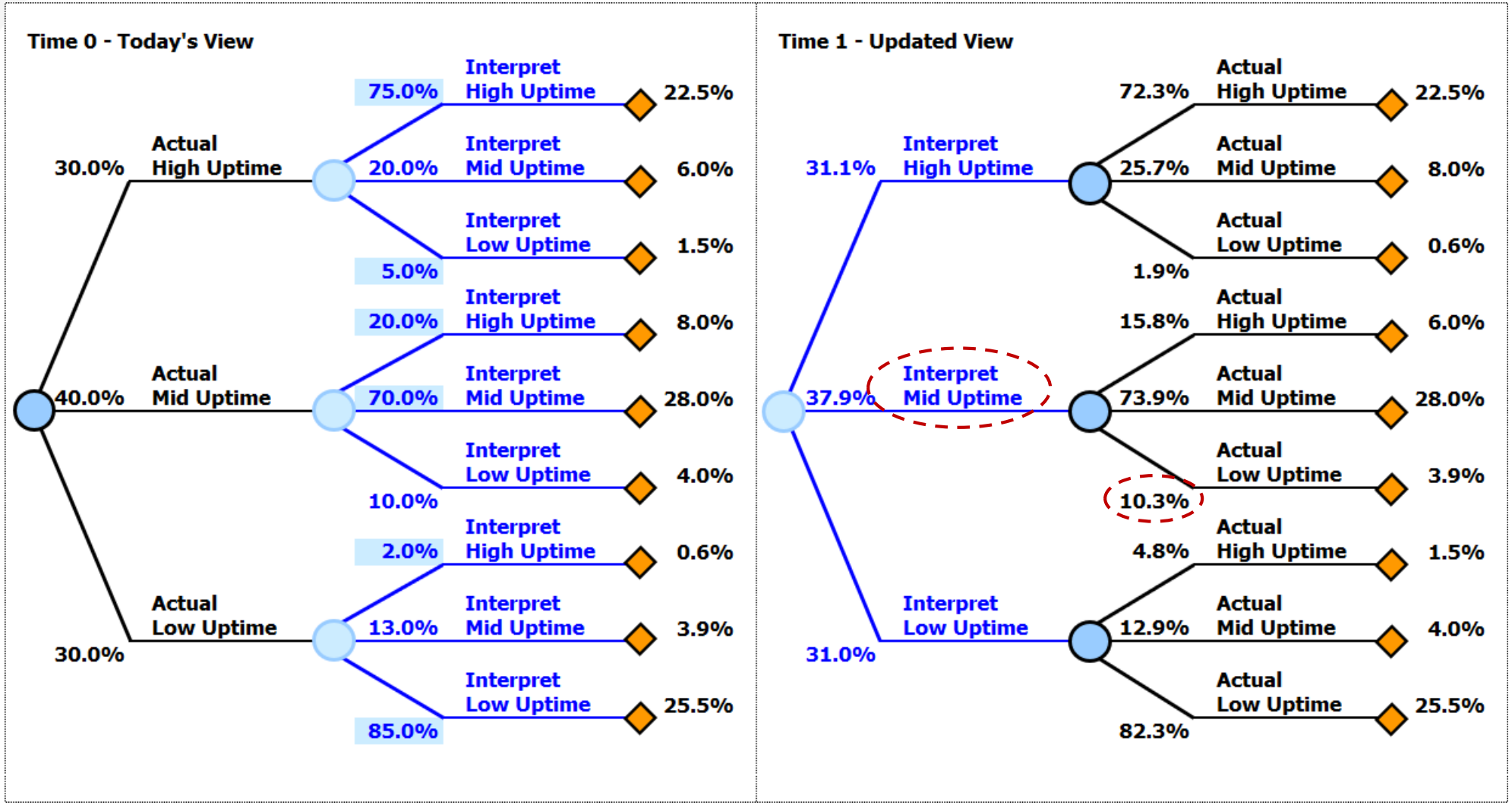
Hence, pilot design will be driven by realizing the desired total confidence in uptime rather than yield, as all pilots provide good total confidence in yield.

Evaluate probability of yield given different pilot interpretations of yield

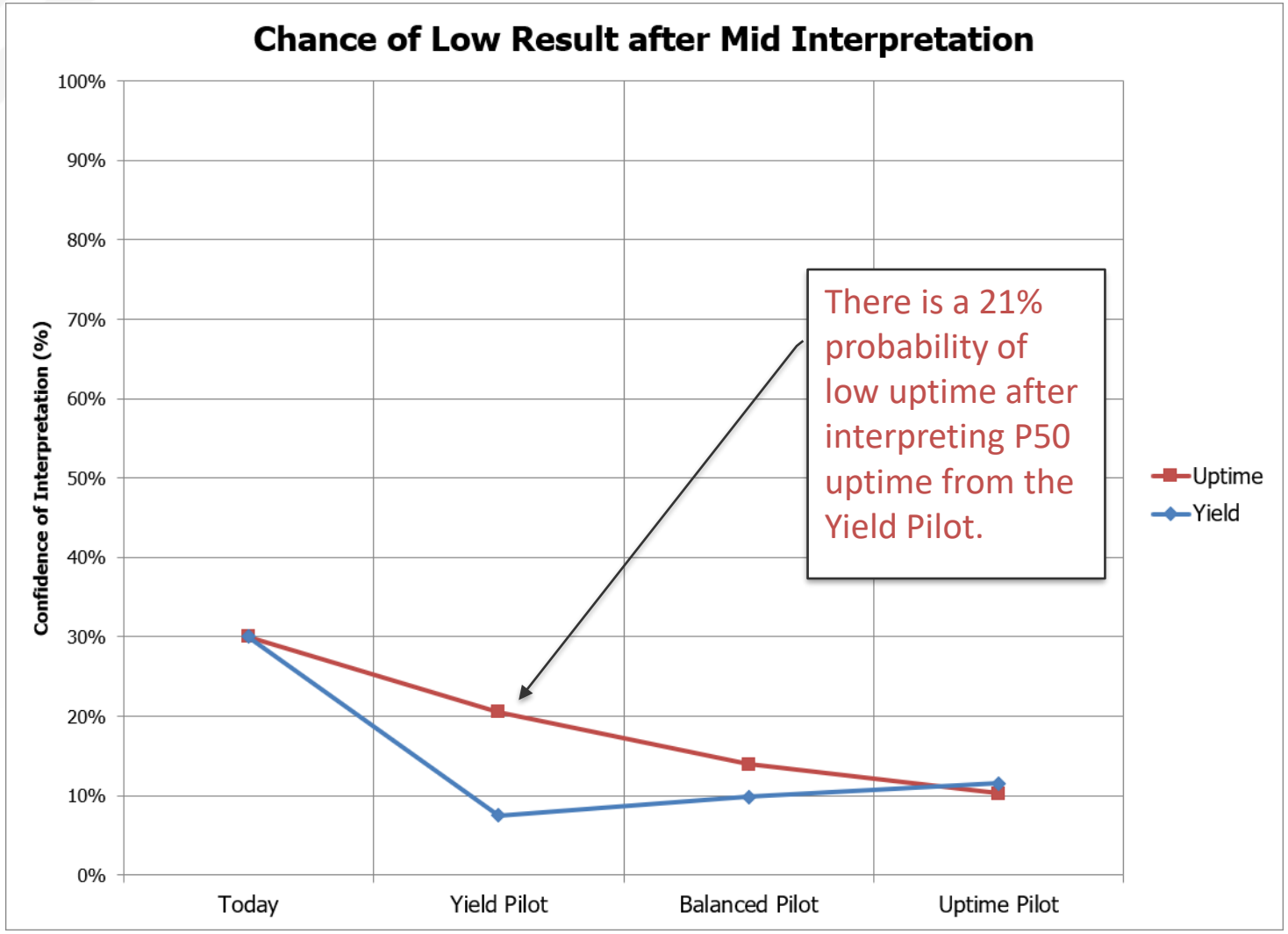


The Yield Pilot provides the highest confidence in yield commercialization for all three possible states of nature (low, mid and high yield) and is the cheapest pilot.

Assess the probability of a poor outcome after interpreting a mid outcome

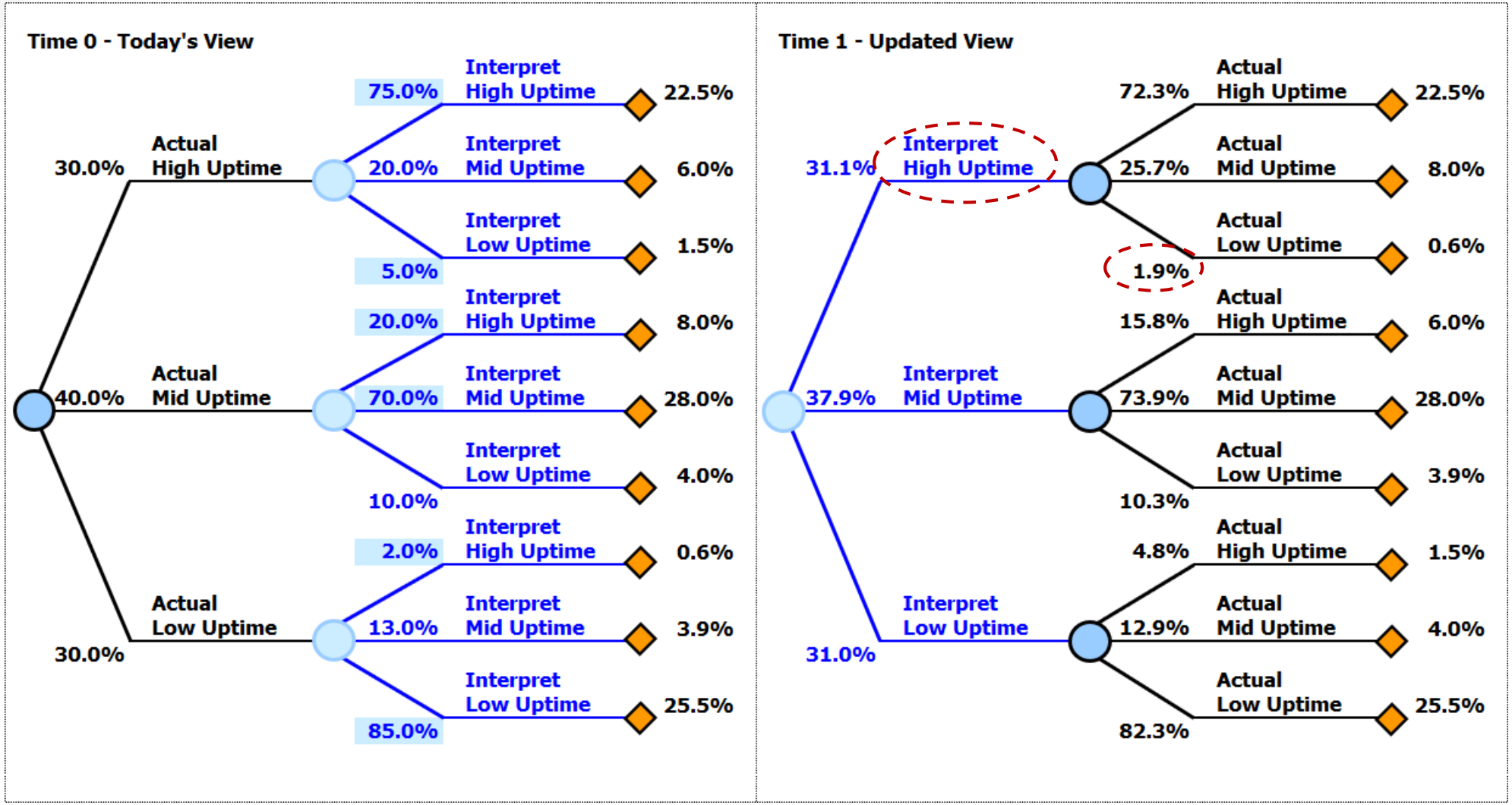


Evaluate how much risk we are buying down with each pilot after interpreting mid

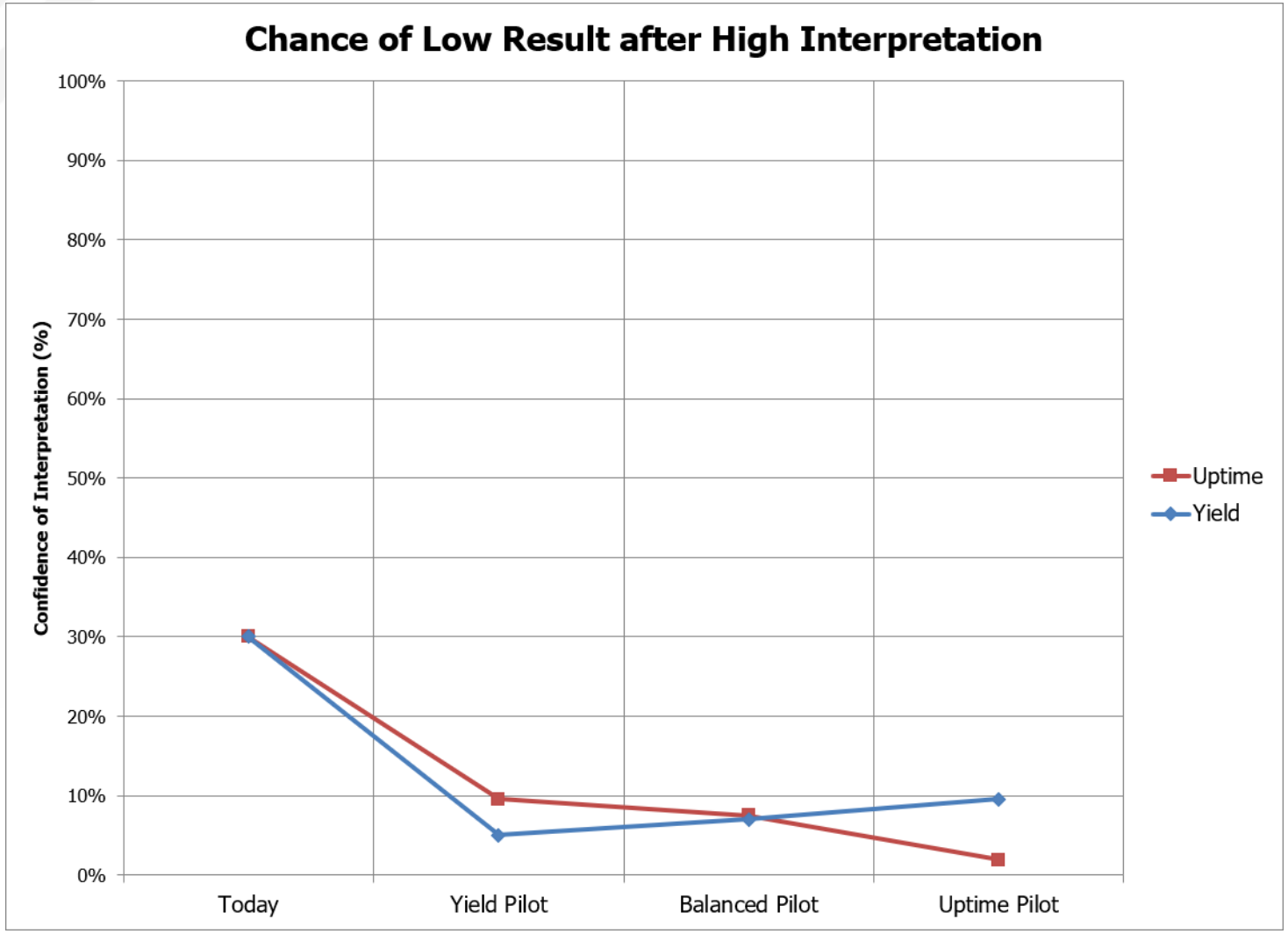


The Balanced Pilot buys down the risk of poor plant uptime in commercialization (14% probability) much better than the Yield Pilot which may be adequate over the much more expensive Uptime Pilot.

Assess the probability of a poor outcome after interpreting a high outcome



Evaluate how much risk we are buying down with each pilot after interpreting high



All pilots buy down the risk of a poor outcome for both uncertainties, given the interpretation from the pilot is high. This suggests the risk after interpreting the mid combined with pilot cost will likely drive the pilot decision.

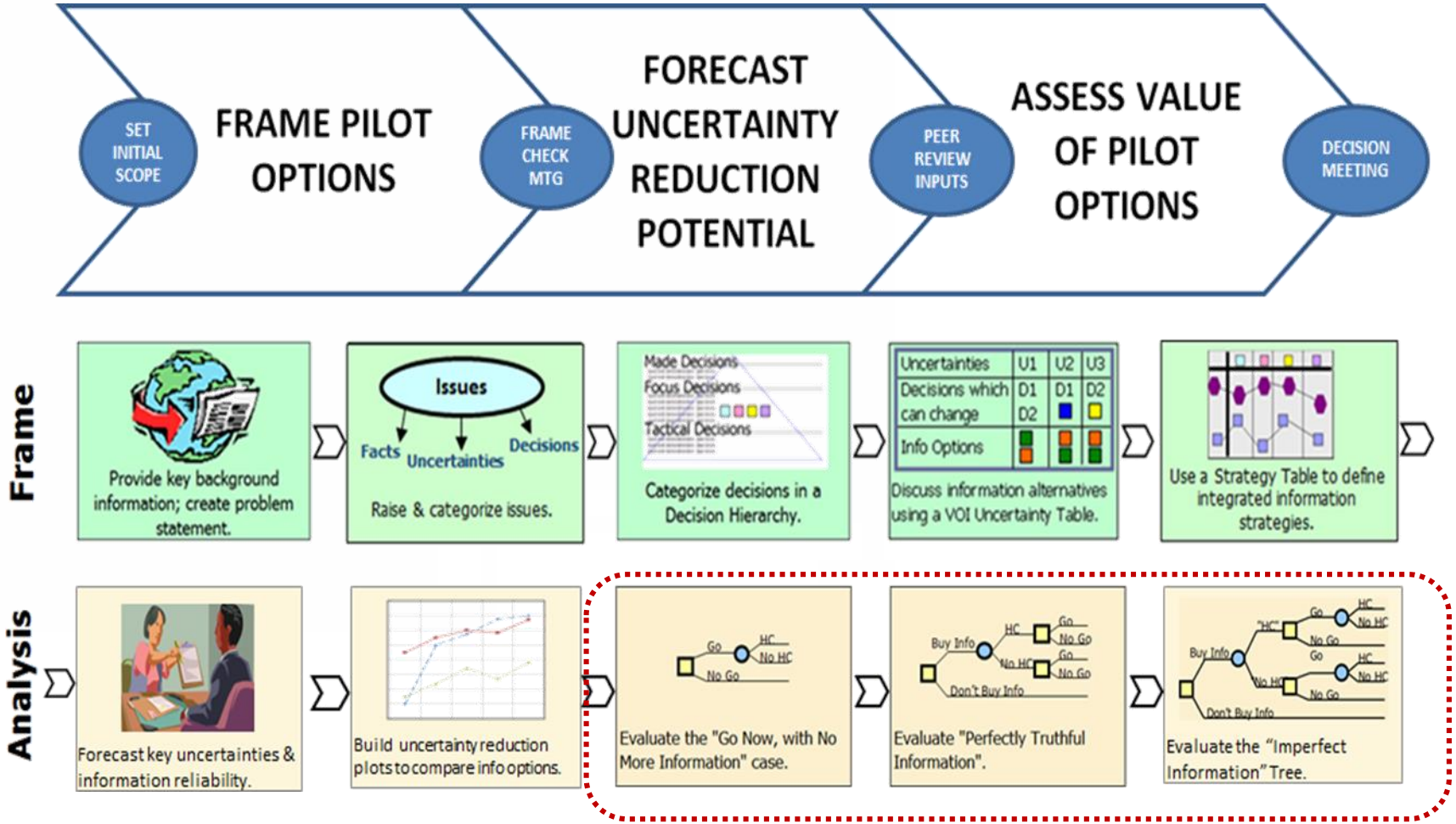
Insights from the confidence plots drive which business case VOI evaluations might be useful

- Reducing uncertainty of uptime will drive the pilot design decision because all pilots provide adequate accuracy in interpreting yield.
- The Balanced Pilot and Uptime Pilot are going to be the focus because they provide sufficient confidence in uptime, but the Uptime Pilot is twice as expensive.
- Confirming the accuracy of each pilot to interpret uptime commercialization is important prior to running the business case.
- Confirming costs and considering a Hybrid Uptime Pilot, which has higher confidence for less cost than the Uptime Pilot, may be useful before final business case VOI evaluation.

Advanced Biofuel Production Technology Pilot

BUSINESS CASE PILOT VALUE OF INFORMATION ANALYSIS

Pilot Framing & Evaluation Workflow



Select which VOI evaluations are necessary to provide clarity for the pilot decision

Key uncertainties inherent in the asset	Xalgo Uptime	Xalgo Yield (algal oil to green diesel)
Future decisions which could change	Build commercial scale Xalgo facility or not?	Build commercial scale Xalgo facility or not?
Information sources to consider	Yield Pilot	Yield Pilot
	Uptime Pilot	Uptime Pilot
	Balanced Pilot	Balanced Pilot

Based on insights from the confidence plots, the VOI evaluation will focus only on the Uptime Pilot and the Balanced Pilot and their value potential to de-risk uptime in commercialization.

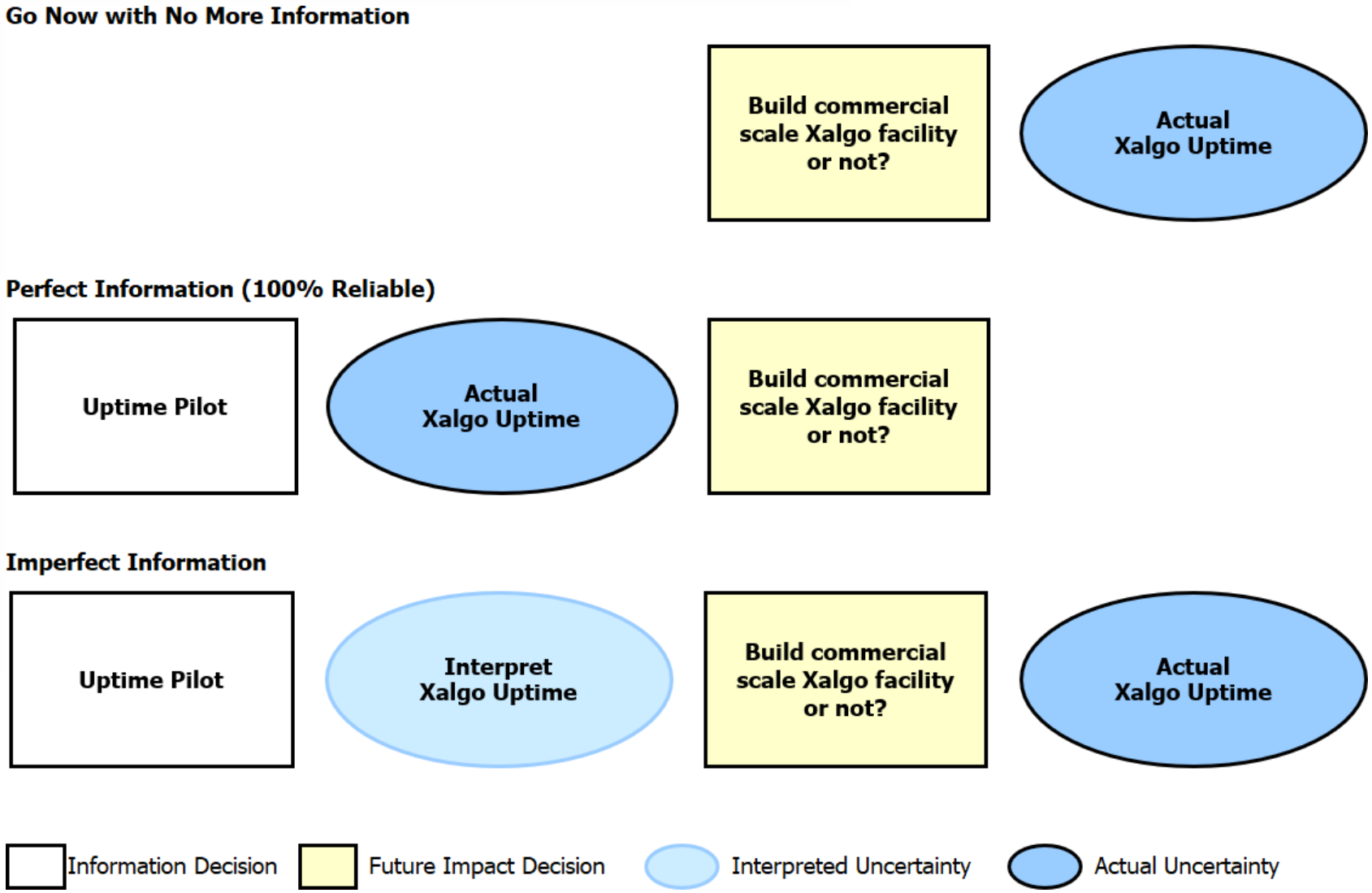
Choose the evaluation focus

Evaluate getting information on:

- One uncertainty, from
- One information source, to potentially change
- One decision at a time.
- Do this for each pilot design to understand the potential value.

Key uncertainties inherent in the asset	**Xalgo Uptime**
Future decisions which could change	**Build commercial scale Xalgo facility or not?**
Information sources to consider	**Uptime Pilot**

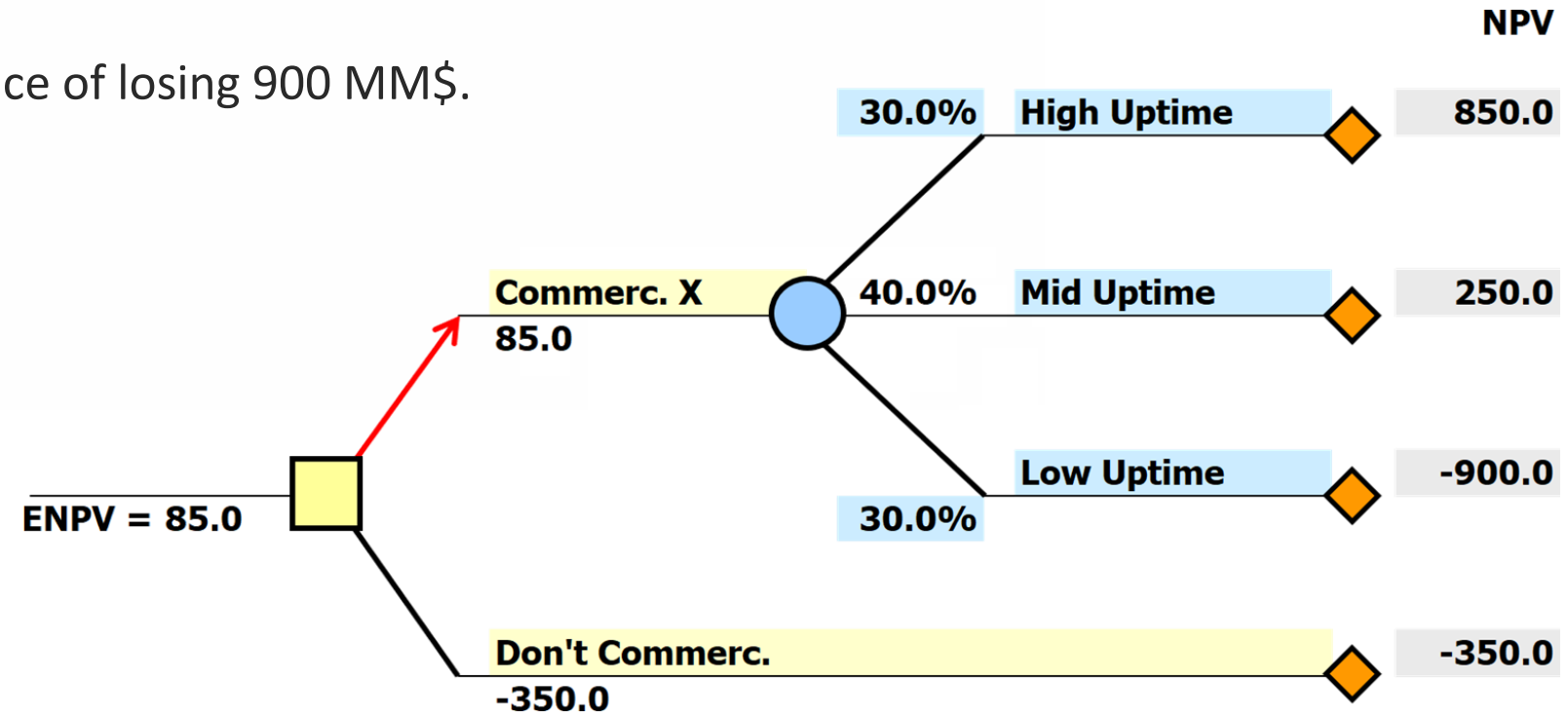
Develop the Decision and Risk Timelines for each VOI tree



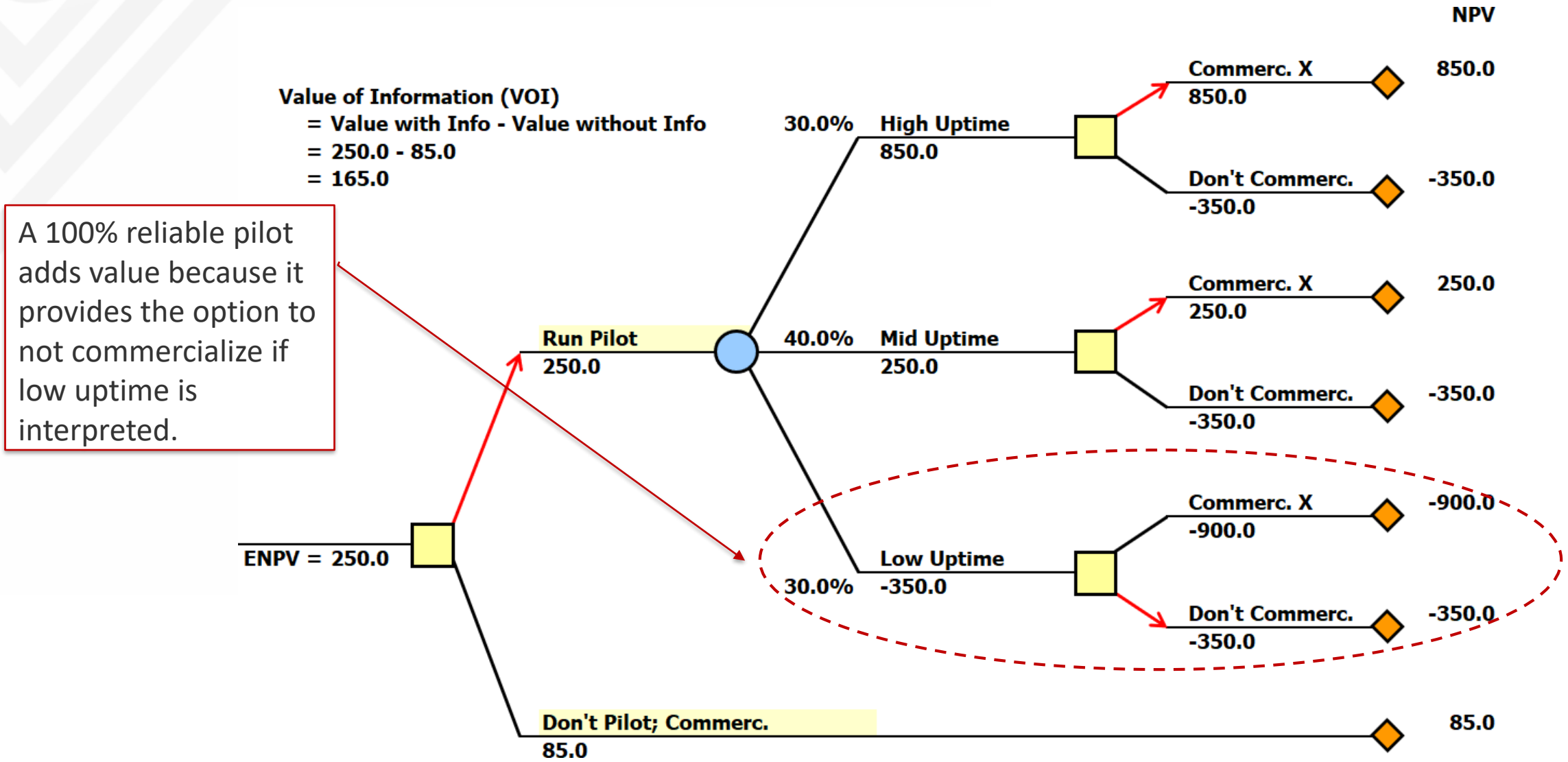
Evaluate the commercialize now case

If Sunny does not run a pilot, they have the choice to commercialize Xalgo or take a non-compliance penalty. Given the input values assessed below:

- Sunny would choose to commercialize Xalgo with an
- Expected value of 85 MM$, but with a
- 30% chance of losing 900 MM$.

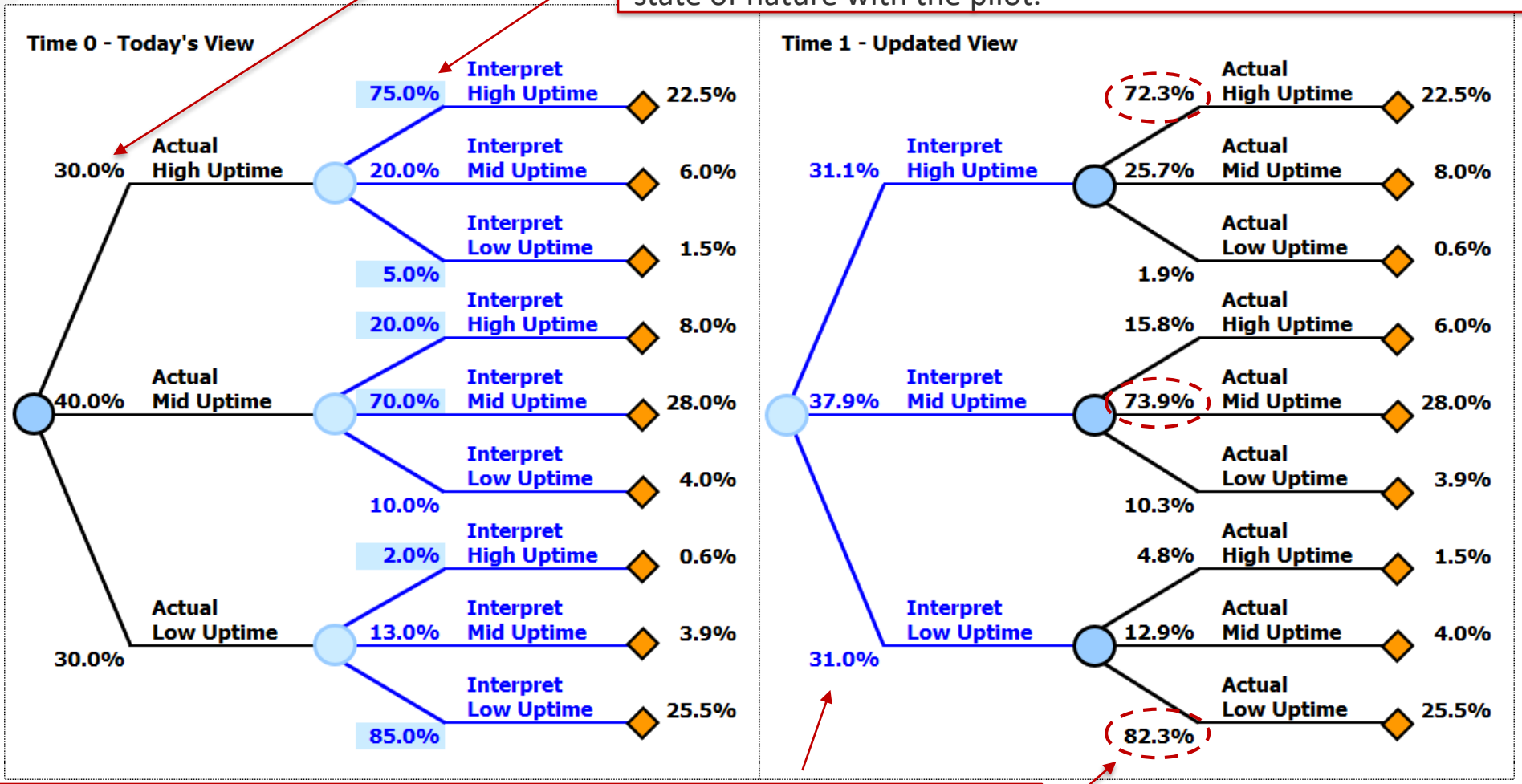


Assess the value of a 100% reliable pilot without the cost



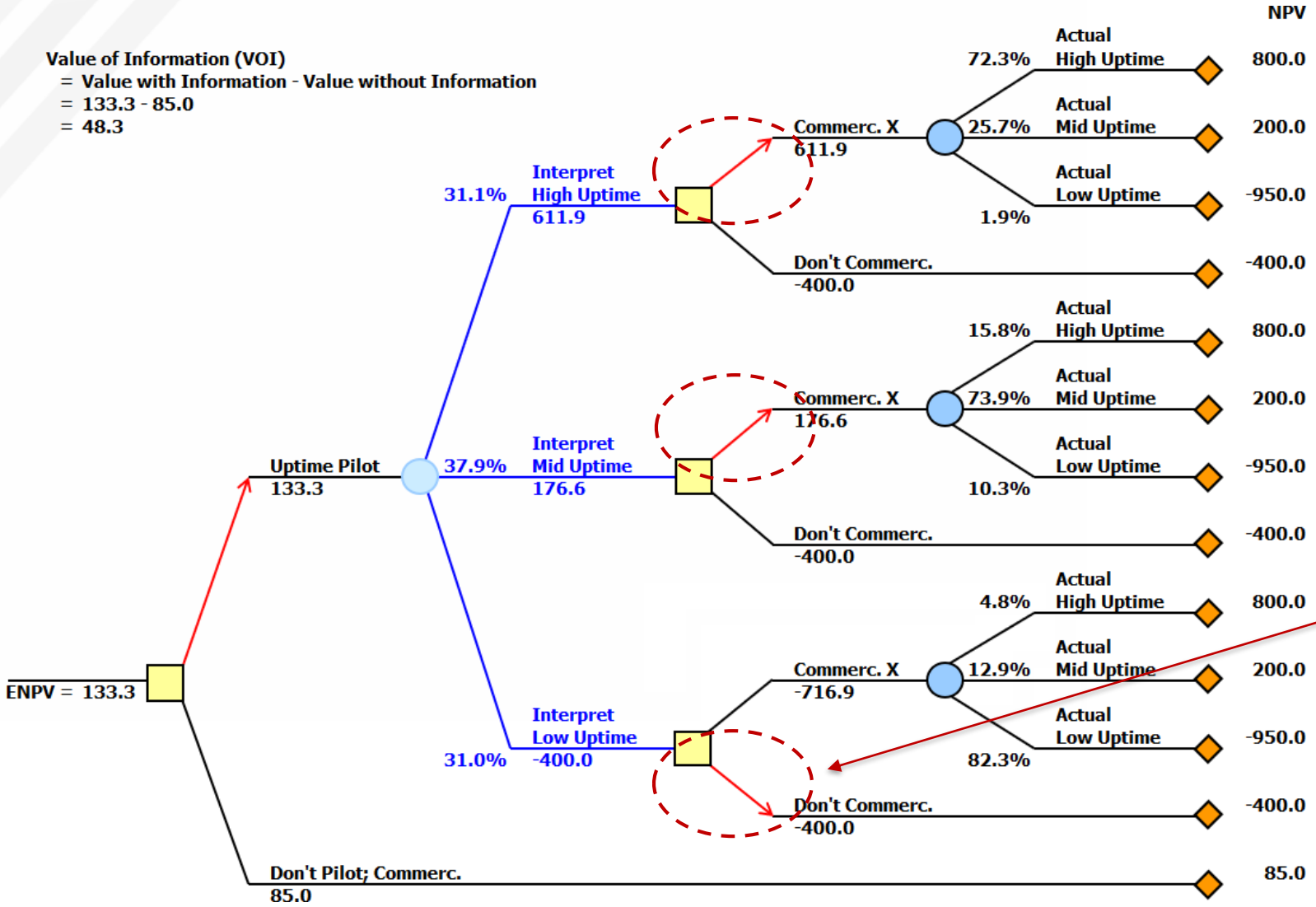
Assess reliability of interpretation for the Uptime Pilot

Our uncertainty today and ability to interpret each possible true state of nature with the pilot.



Two new possible interpretations of our uncertainty after the pilot and the chance of each interpretation being the true state of nature

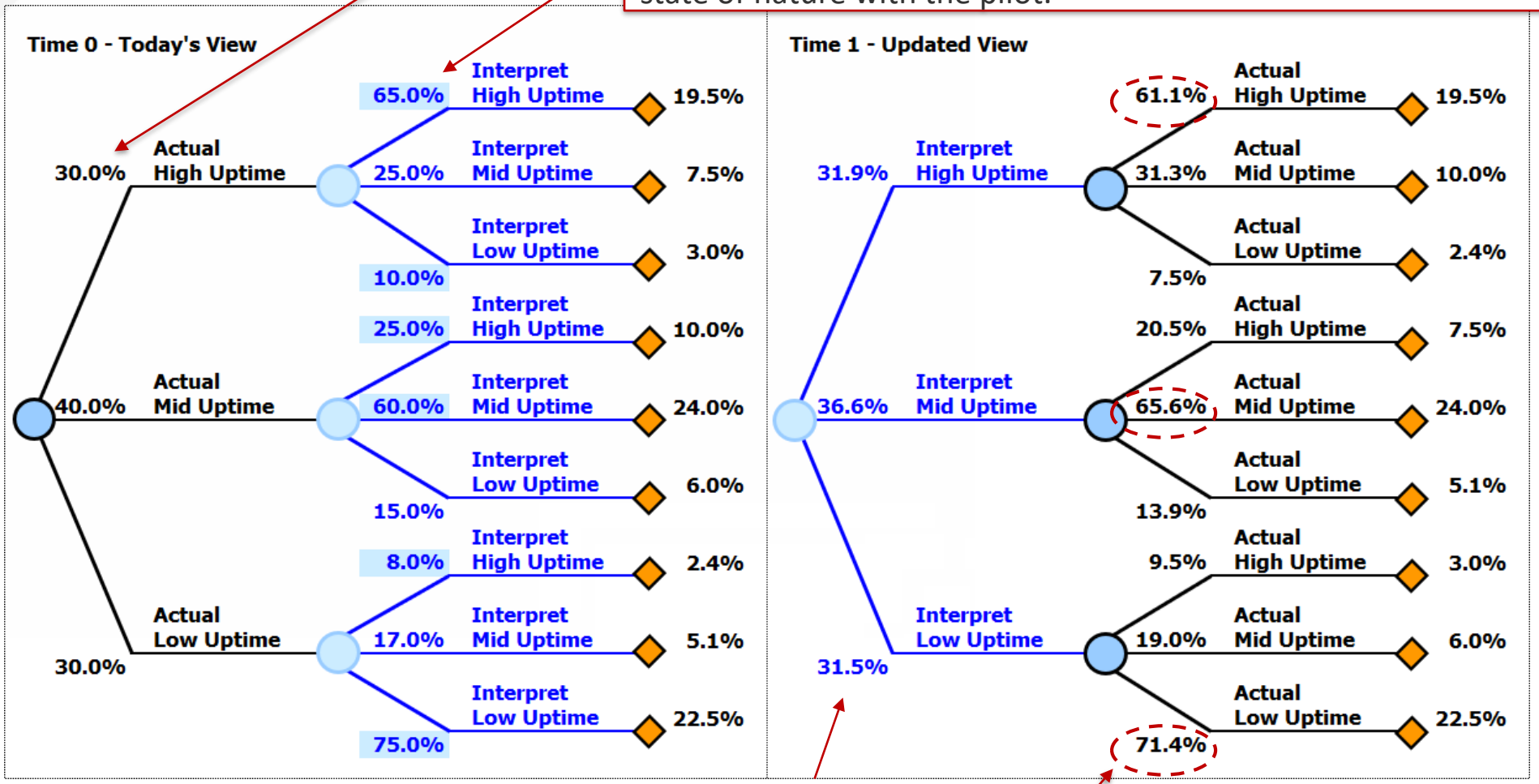
Assess the value of the Uptime Pilot



The Uptime Pilot adds value because it changes the commercialization decision if low uptime is interpreted

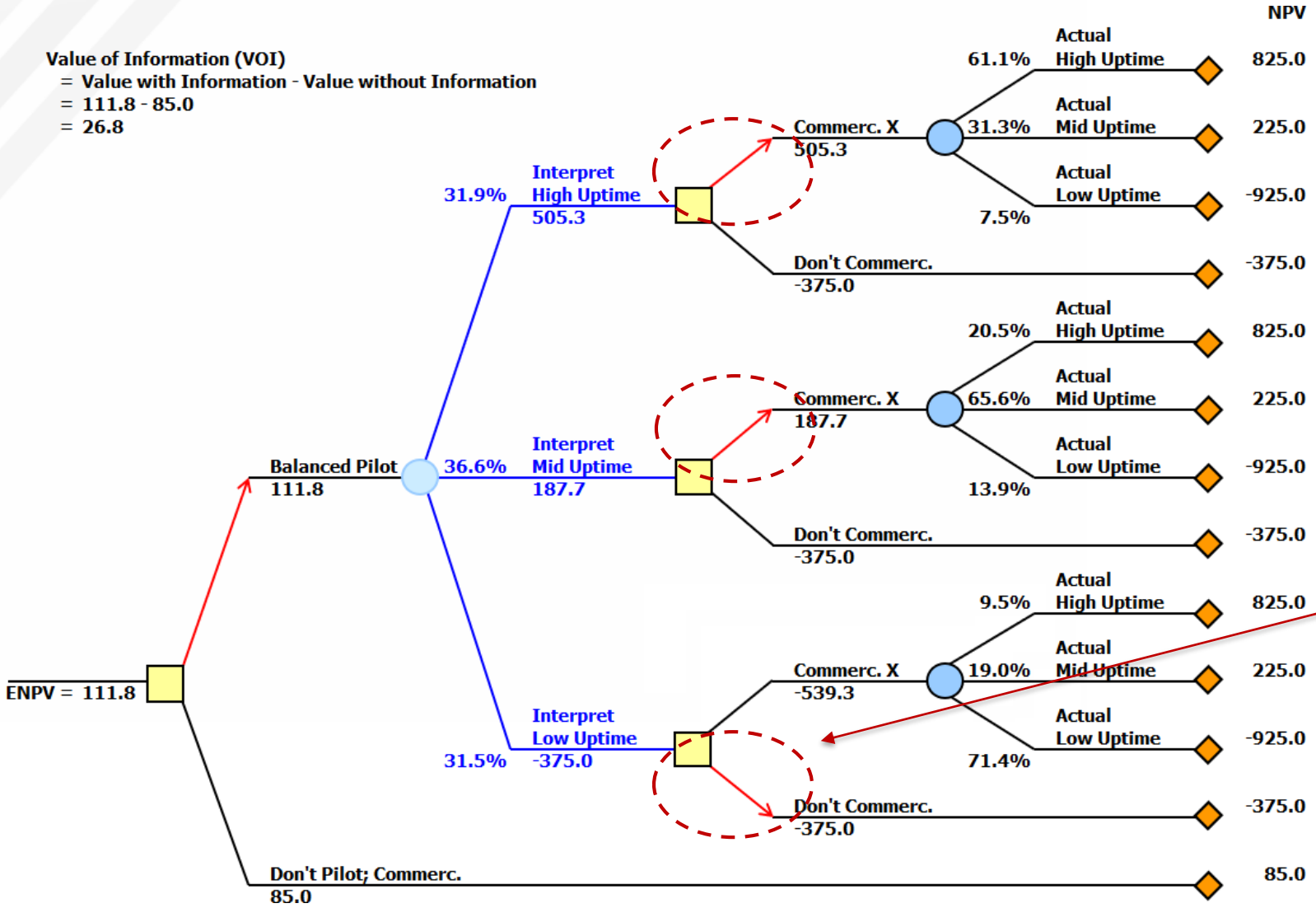
Assess reliability of interpretation for the Balanced Pilot

Our uncertainty today and ability to interpret each possible true state of nature with the pilot.



Two new possible interpretations of our uncertainty after the pilot and the chance of each interpretation being the true state of nature

Assess the value of the Balanced Pilot



The Balanced Pilot adds value because it allows us to change the commercialization decision when we interpret low uptime

Pilot VOI Evaluation Insights

- The Uptime Pilot is significantly more valuable than the Balanced Pilot. It provides more confidence and results in similar profitability.
- A trade-offs discussion of the two pilots with decision makers will result in a quality decision discussing the added value of the Uptime Pilot for twice the cost of the Balanced Pilot.

Pilot	Gross VOI (MM$)	Pilot Cost (MM$)	Net VOI (MM$)	PI (VOI/Cost)	Total Confidence in Interpretation (%)	Chance of Low Uptime After P50 Interpretation (%)
Uptime Pilot	98.2	50	48.3	0.97	76	10
Balanced Pilot	51.7	25	26.8	1.07	66	14

decision | FRAMEWORKS

REAL PEOPLE • REAL INSIGHTS • REAL DECISIONS

Pilot and Test Design Framing & Evaluation Course Takeaways

Half-day SDP Course

June 17, 2020

There are three key elements of pilot test or appraisal planning

Frame pilot options

- Define the decision problem
- Identify the key uncertainties
- Identify the future decisions they would affect
- Define alternative pilot designs to consider to reduce the key uncertainties

Forecast uncertainty reduction potential

- Perform uncertainty assessments to characterize:
  - The key project uncertainties (which impact go forward decision)
  - The uncertainty reduction potential of different pilot designs
- Compare uncertainty reduction potential vs. cost and or value of different pilot options

Develop the business case, as necessary

- Evaluate the value of the information (w VOI - decision trees):
  - Compare the value of making the go forward decision w/out more information from a pilot to the value of making the go forward decision after more pilot information is acquired

Pilot Framing and Evaluation Takeaways

- Framing alternative pilot designs using an uncertainty table is essential.
- It is important to characterize two types of uncertainties for pilots:
  - The set of commercialization uncertainties (what is making it difficult to commercialize today)
  - The accuracy of each pilot to interpret each commercialization uncertainty (via a reliability of information interview)
- Confidence plots provide significant insight to focus necessary business case value of information analysis.
- Value of information decision tree analysis completes pilot evaluation decision making.