

HOW TO MEASURE ANYTHING

FINDING THE VALUE OF “INTANGIBLES” IN BUSINESS

BY DOUGLAS W. HUBBARD

Exhibit 4.1
IT Security for the Department of Veterans Affairs

| Security Systems | Events Averted or Reduced | Costs Averted |
|---|--|--|
| Public Key Infrastructure (key encryption/decryption etc.) | Pandemic virus attacks Unauthorized system access: external (hackers) or internal (employees) | Productivity losses Fraud losses Legal liability/ improper disclosure |
| Biometric/single sign-on (fingerprint readers, security card readers, etc.) | | |
| Intrusion-detection systems | Unauthorized physical access to facilities or property | Interference with mission (for the VA, this mission is the care of veterans) |
| Security-compliance certification program for new systems | Other disasters: fire, flood, tornado, etc. | |
| New antivirus software | | |
| Security incident reporting system | | |
| Additional security training | | |

Exhibit 4.2
Department of Veterans Affairs Estimates for the Effects of Virus Attacks

| Uncertain Variable | The value is 90% likely to fall between or be equal to these points: | |
|--|--|------------|
| Agency-wide virus attacks per year (for the next 5 years) | 2 | 4 |
| Average number of people affected | 25,000 | 65,000 |
| Percentage productivity loss | 15% | 60% |
| Average duration of productivity loss | 4 hours | 12 hours |
| Loaded annual cost per person (most affected staff would be in the lower pay scales) | \$ 50,000 | \$ 100,000 |

Exhibit 5.1

Sample Calibration Test

| # | Question | 90% Confidence Interval | |
|----|--|-------------------------|-------------|
| | | Lower Bound | Upper Bound |
| 1 | In 1938 a British steam locomotive set a new speed record by going how fast (mph)? | | |
| 2 | In what year did Sir Isaac Newton publish the Universal Laws of Gravitation? | | |
| 3 | How many inches long is a typical business card? | | |
| 4 | The Internet (then called “Arpanet”) was established as a military communications system in what year? | | |
| 5 | In what year was William Shakespeare born? | | |
| 6 | What is the air distance between New York and Los Angeles (miles)? | | |
| 7 | What percentage of a square could be covered by a circle of the same width? | | |
| 8 | How old was Charlie Chaplin when he died? | | |
| 9 | How many pounds did the first edition of this book weigh? | | |
| 10 | The TV show <i>Gilligan's Island</i> first aired on what date? | | |

Exhibit 5.1, continued

Sample Calibration Test

| # | Statement | Answer (True/False) | Confidence that you are correct (Circle one) |
|----|--|------------------------|---|
| 1 | The ancient Romans were conquered by the ancient Greeks. | | 50% 60% 70% 80% 90% 100% |
| 2 | There is no species of three-humped camels. | | 50% 60% 70% 80% 90% 100% |
| 3 | A gallon of oil weighs less than a gallon of water. | | 50% 60% 70% 80% 90% 100% |
| 4 | Mars is always farther away from Earth than Venus. | | 50% 60% 70% 80% 90% 100% |
| 5 | The Boston Red Sox won the first World Series. | | 50% 60% 70% 80% 90% 100% |
| 6 | Napoleon was born on the island of Corsica. | | 50% 60% 70% 80% 90% 100% |
| 7 | "M" is one of the three most commonly used letters. | | 50% 60% 70% 80% 90% 100% |
| 8 | In 2002 the price of the average new desktop computer purchased was under \$1,500. | | 50% 60% 70% 80% 90% 100% |
| 9 | Lyndon B. Johnson was a governor before becoming vice president. | | 50% 60% 70% 80% 90% 100% |
| 10 | A kilogram is more than a pound. | | 50% 60% 70% 80% 90% 100% |

Answers to Sample Calibration Test

| # | Question | Answer |
|----|--|----------------|
| 1 | In 1938 a British steam locomotive set a new speed record by going how fast (mph)? | 126 |
| 2 | In what year did Newton publish the universal laws of gravitation? | 1685 |
| 3 | How many inches long is a typical business card? | 3.5 |
| 4 | The Internet (then called “Arpanet”) was established as a military communications system in what year? | 1969 |
| 5 | What year was William Shakespeare born? | 1564 |
| 6 | What is the air distance between New York and Los Angeles in miles? | 2,451 |
| 7 | What percentage of a square could be covered by a circle of the same width? | 78.5% |
| 8 | How old was Charlie Chaplin when he died? | 88 |
| 9 | How many pounds did the first edition of this book weigh? | 1.23 |
| 10 | The TV show <i>Gilligan's Island</i> first aired on what date? | Sept. 26, 1964 |
| # | Statement | Answer |
| 1 | The ancient Romans were conquered by the ancient Greeks. | FALSE |
| 2 | There is no species of three-humped camels. | TRUE |
| 3 | A gallon of oil weighs less than a gallon of water. | TRUE |
| 4 | Mars is always farther away from Earth than Venus. | FALSE |
| 5 | The Boston Red Sox won the first World Series. | TRUE |
| 6 | Napoleon was born on the island of Corsica. | TRUE |
| 7 | “M” is one of the three most commonly used letters. | FALSE |
| 8 | In 2002 the price of the average new desktop computer purchased was under \$1,500. | TRUE |
| 9 | Lyndon B. Johnson was a governor before becoming vice president. | FALSE |
| 10 | A kilogram is more than a pound. | TRUE |

Exhibit 5.2a
Aggregate Group Performance

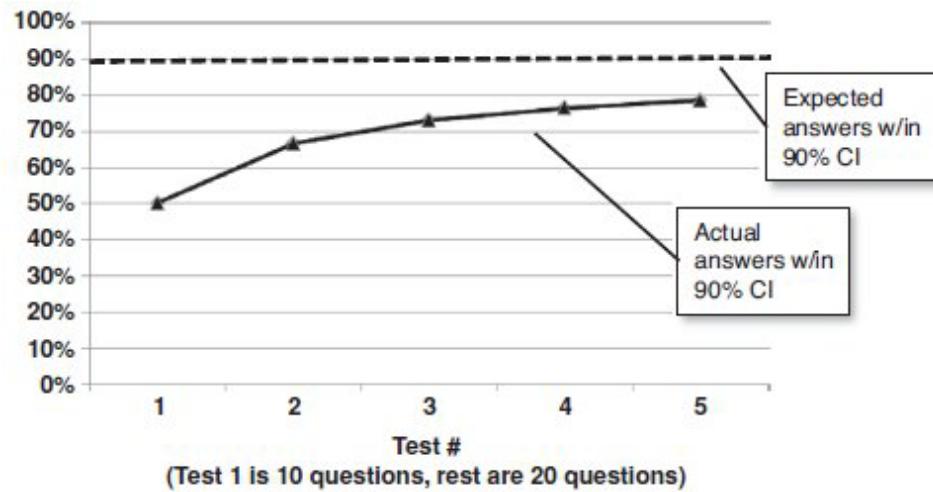


Exhibit 5.2b
Extremes of Performance

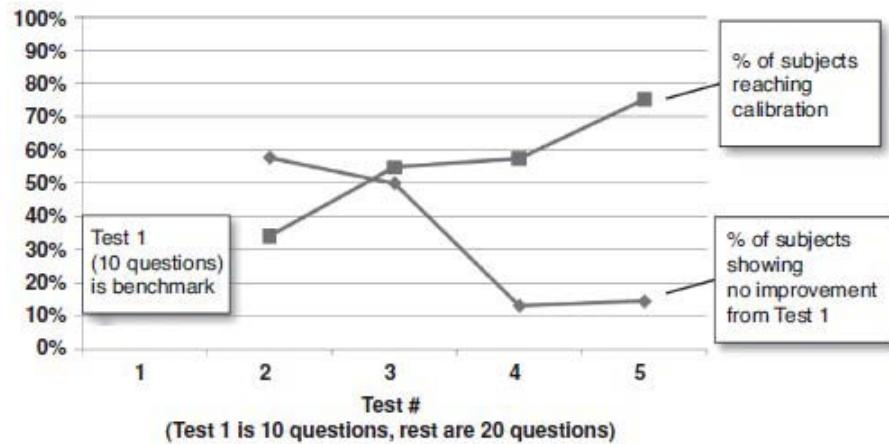


Exhibit 5.3
Calibration Experiment Results for 20 IT Industry Predictions in 1997

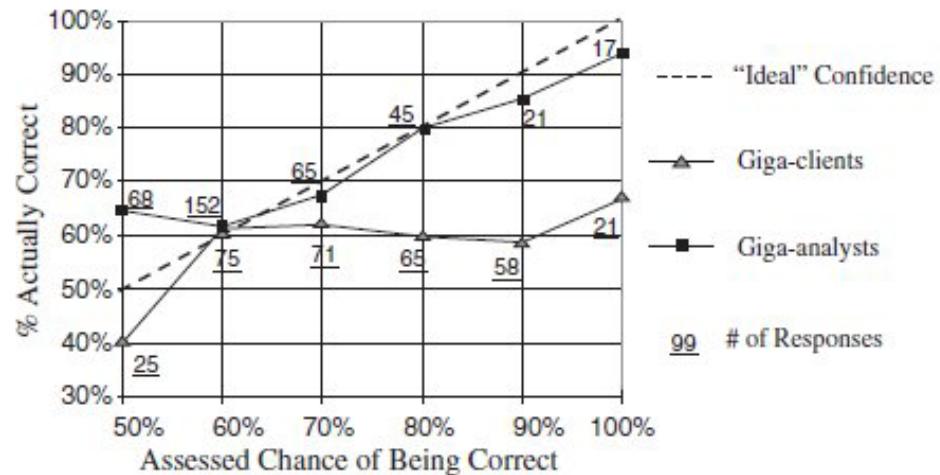
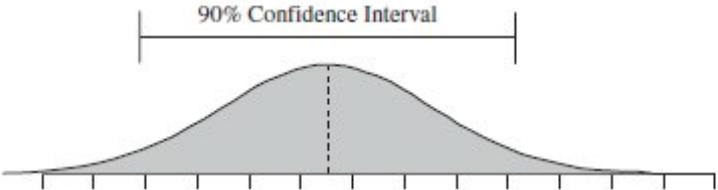


Exhibit 6.1

Normal Distribution

The Normal Distribution

What a normal distribution looks like:



Characteristics:

- Values near the middle are more likely than values farther away.
- The distribution is symmetrical, not lopsided—the mean is exactly halfway between the upper and lower bounds of a 90% CI.
- The ends trail off indefinitely to ever more unlikely values, but there is no “hard stop”; a value far outside of a 90% CI is possible but not likely.

How to make a random distribution with this shape in Excel:

=norminv(rand(),A, B)

A=mean = (90% CI upper bound + 90% CI lower bound)/2 and

B=“standard deviation” =(90% CI upper bound – 90% CI lower bound)/3.29

Exhibit 6.2
Simple Monte Carlo Layout in Excel

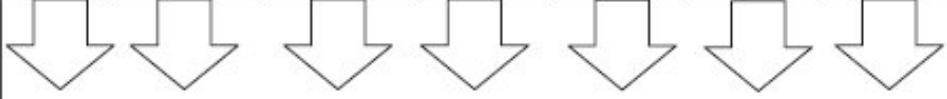
| Scenario # | Maintenance Savings | Labor Savings | Materials Savings | Units Produced | Total Savings | Breakeven Met? |
|--|---------------------|---------------|-------------------|----------------|---------------|----------------|
| 1 | \$ 9.27 | \$ 4.30 | \$ 7.79 | 23,955 | \$511,716 | Yes |
| 2 | \$ 15.92 | \$ 2.64 | \$ 9.02 | 26,263 | \$724,127 | Yes |
| 3 | \$ 17.70 | \$ 4.63 | \$ 8.10 | 20,142 | \$612,739 | Yes |
| 4 | \$ 15.08 | \$ 6.75 | \$ 5.19 | 20,644 | \$557,860 | Yes |
| 5 | \$ 19.42 | \$ 9.28 | \$ 9.68 | 25,795 | \$990,167 | Yes |
| 6 | \$ 11.86 | \$ 3.17 | \$ 5.89 | 17,121 | \$358,166 | No |
| 7 | \$ 15.21 | \$ 0.46 | \$ 4.14 | 29,283 | \$580,167 | Yes |
|  | | | | | | |
| 9,999 | \$ 14.68 | \$ (0.22) | \$ 5.32 | 33,175 | \$655,879 | Yes |
| 10,000 | \$ 7.49 | \$ (0.01) | \$ 8.97 | 24,237 | \$398,658 | No |

Exhibit 6.3

Histogram

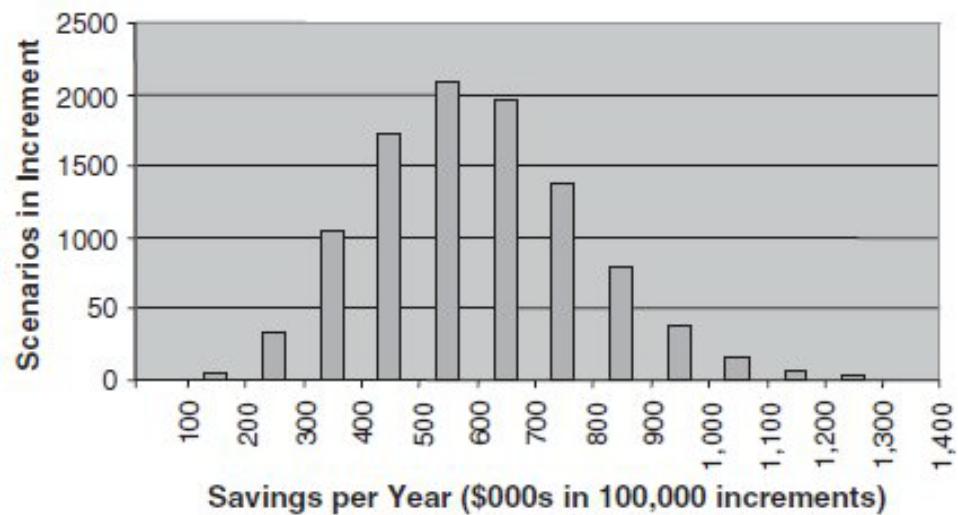


Exhibit 6.4

Binary (a.k.a. Bernoulli) Distribution

The Binary Distribution

What a binary distribution looks like:

A bar chart titled "The Binary Distribution". It has two bars. The first bar, representing value 0, is labeled "40%". The second bar, representing value 1, is labeled "60%".

Characteristics:

- This distribution produces only two possible values.
- There is a single probability that one value will occur (60% in the chart), and the other value occurs the rest of the time.

How to make a random distribution with this shape in Excel:

=if(rand()<P,1,0)

P=probability that a "1" will appear (a "0" appears with 1-P probability)

Exhibit 6.5

Uniform Distribution

The Uniform Distribution

What a uniform distribution looks like:

A diagram titled "The Uniform Distribution". It shows a horizontal line with tick marks. A gray rectangle is drawn below the line, spanning from the first tick mark to the last tick mark. Above the rectangle, the text "100% Confidence Interval" is written.

Characteristics:

- All values between the bounds are equally likely.
- The distribution is symmetrical, not lopsided—the mean is exactly halfway between the upper and lower bounds.
- The bounds are “hard stops” and are, in effect, a “100% CI”—nothing above the upper bound nor below the lower bound is possible.

How to make a random distribution with this shape in Excel:

=rand()*(UB-LB)+LB

UB=Upper bound

LB=Lower bound

Exhibit 6.6

Optional: Additional Monte Carlo Concepts for the More Ambitious Student

| Concept and Its Complexity | Description (All additional examples are on the book's Web site at www.howtomeasureanything.com along with a suggested reading list.) |
|---|---|
| More Distributions (No more complicated than anything else discussed so far) | It's worth having a few more distributions in your tool box to handle a variety of situations because sometimes the wrong distribution can be wrong by a lot. It can be shown that a normal distribution is a very bad approximation for a variety of phenomena including fluctuations of the stock market, the cost of software projects, or the size of an earthquake, plague, or storm. I show more examples of each of these distributions on the book's Web site. |
| Correlations (Still not too much more complicated) | Some of the variables in a model might not be independent of each other. For example, if a union contract affects the hourly rates of both maintenance workers and production workers, they are probably correlated. We can address that by generating correlated random numbers for them or by modeling what they have in common. I show both solutions on the Web site. |
| Markov Simulations (Getting more complicated) | These are simulations where a single scenario is itself separated into a large number of time intervals, each of which is a simulation unto itself and each time interval simulation affects the following time interval. This can apply to complex manufacturing systems, stock prices, the weather, computer networks, and construction projects. Again, see a very simple example on the Web site. |
| Agent-based Models (Getting very complicated) | Just as Markov simulations split up the problem into time intervals, we can also have separate simulations for a large number of individuals acting independently or somewhat in concert. The term <i>agent</i> often implies that each actor follows a set of decision rules. Traffic simulations are an example of models made up of a multitude of agents (vehicles) for a large number of time intervals. A very, <i>very</i> simple example of this is illustrated on the book's Web site. |

Exhibit 6.7

A Few Monte Carlo Tools

| Tool | Made by | Description |
|--------------------|---|---|
| AIE Wizard | Hubbard Decision Research, Glen Ellyn, IL | Excel-based set of macros; also computes value of information and portfolio optimization; emphasizes methodology over the tool and provides consulting for practical implementation issues. |
| Crystal Ball | Oracle (previously Decisioneering, Inc., purchased by Oracle), Denver, CO | Excel based; a wide variety of distributions; a fairly sophisticated tool. Broad user base and technical support. Has adopted Savage's SIPs and SLURPs and Dist utility. |
| @Risk | Palisade Corporation, Ithaca, NY | Another Excel-based tool; main competitor to Crystal Ball. Many users and technical support. |
| XLSim | Stanford U Professor Sam Savage, AnalyCorp | Inexpensive package designed for ease of learning and use. Savage also provides seminars and management protocols for making Monte Carlo methods practical in organizations. |
| Risk Solver Engine | Frontline Systems, Incline Village, NV | Unique Excel-based development platform to perform "interactive" Monte Carlo simulation at unprecedented speed. Supports SIP and SLURP formats for probability management. |
| Analytica | Lumina Decision Systems, Los Gatos, CA | Uses an extremely intuitive graphical interface that allows complex systems to be modeled as a kind of flowchart of interactions; has a significant presence in government and environmental policy analysis. |
| SAS | SAS Corporation, Raleigh, NC | Goes well beyond the Monte Carlo; extremely sophisticated package used by many professional statisticians. |
| SPSS | SPSS Inc., Chicago, IL | Also goes far beyond the Monte Carlo; tends to be more popular among academics. |
| Mathematica | Wolfram Research, Champaign, IL | Another extremely powerful tool that does much more than Monte Carlo; used primarily by scientists and mathematicians but has applications in many fields. |

Exhibit 7.1
Extremely Simple Expected Opportunity Loss Example

| Variable | Campaign Works | Campaign Fails |
|--------------------------------|----------------|----------------|
| Chance of Success | 60% | 40% |
| Impact if Campaign is Approved | +\$40 million | -\$5 million |
| Impact if Campaign is Rejected | \$0 | \$0 |

Exhibit 7.2
EOL “Slices” for Range Estimates

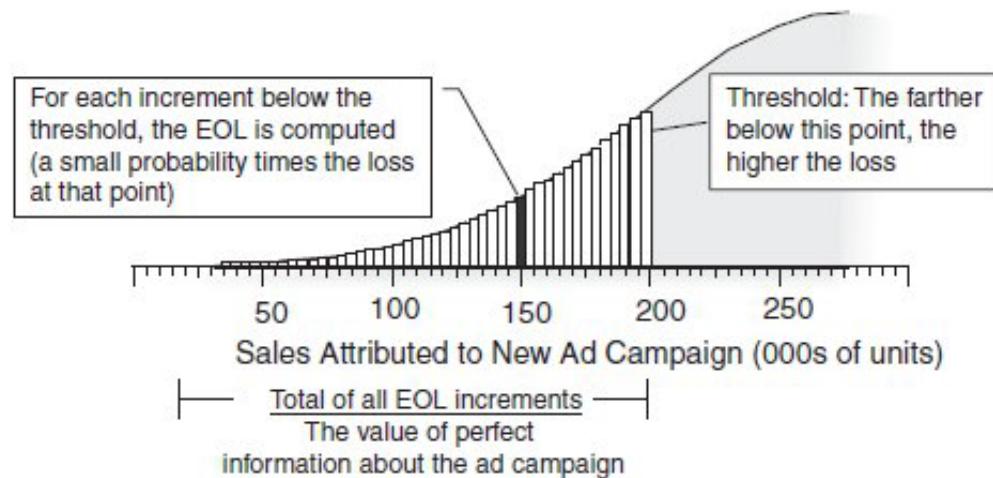


Exhibit 7.3
Example of the Relative Threshold

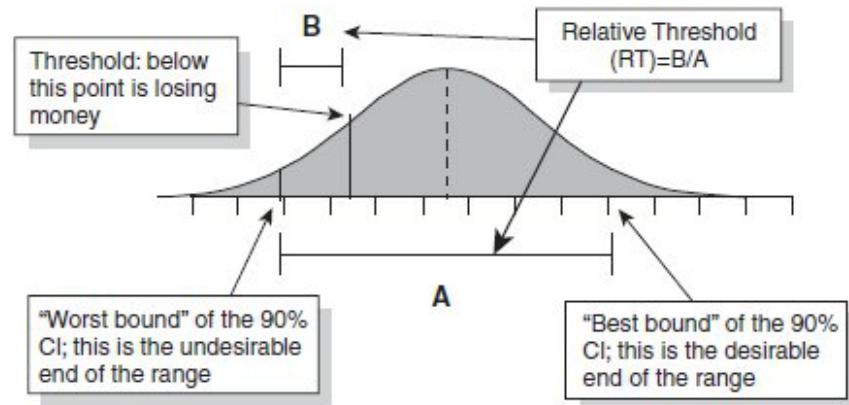
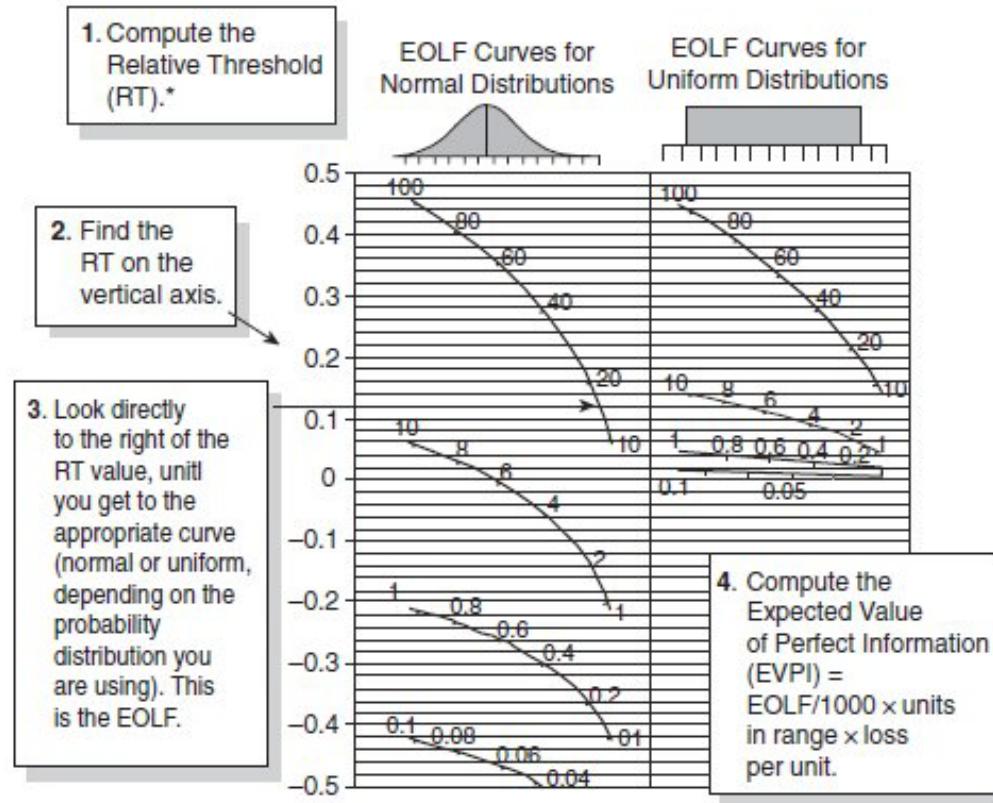


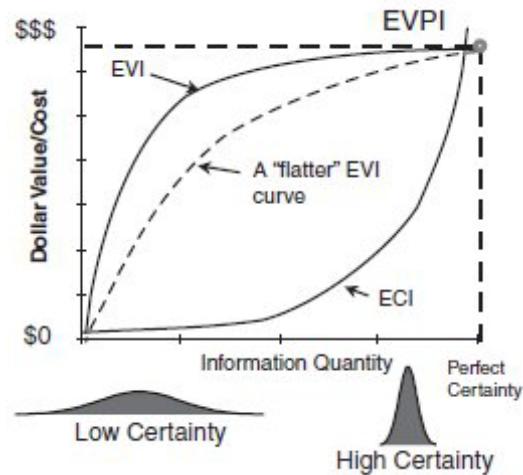
Exhibit 7.4
Expected Opportunity Loss Factor Chart



*RT (Threshold – Worst Bound) / (Best Bound – Worst Bound);

see Exhibit 7.2 for more detail.

Exhibit 7.5
Expected Value of Information Curve



EVPI: Expected Value of Perfect Information

ECI: Expected Cost of Information

EVI: Expected Value of Information

Exhibit 7.6

Measurement Inversion

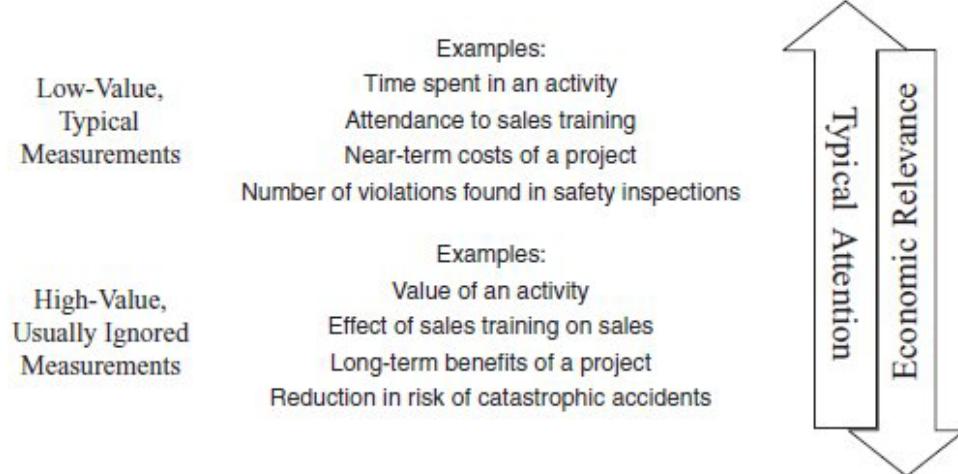


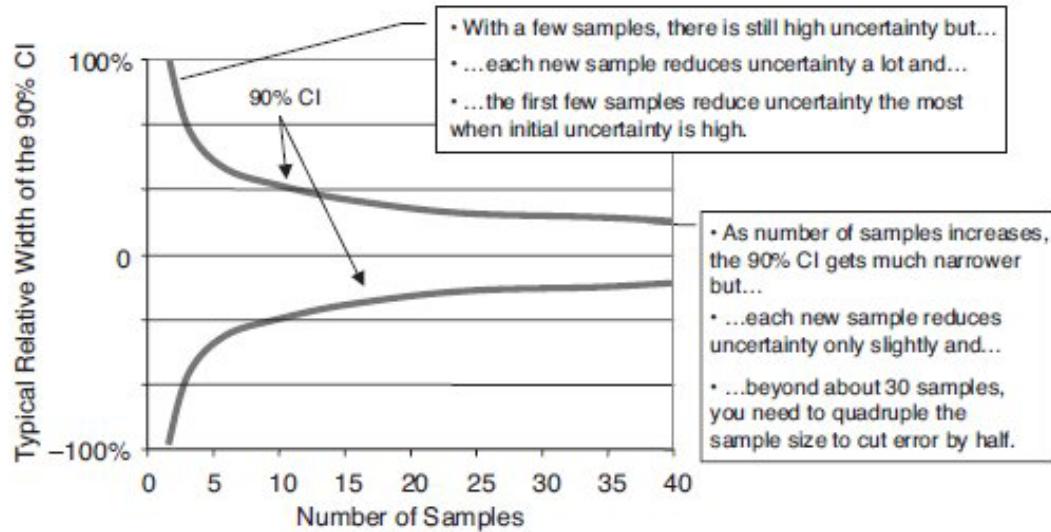
Exhibit 9.1
Simplified t-Statistic

| Sample Size | t-Score |
|----------------|-----------------|
| 2 | 6.31 |
| 3 | 2.92 |
| 4 | 2.35 |
| 5 | 2.13 |
| 6 | 2.02 |
| 8 | 1.89 |
| 12 | 1.80 |
| 16 | 1.75 |
| 28 | 1.70 |
| Larger samples | (z-score) 1.645 |

Pick the nearest sample size (or interpolate if you prefer more precision).

Exhibit 9.2

How Uncertainty Changes with Sample Size



Uncertainty reduces much faster on the first few observations than you might think.

Exhibit 9.3

Varying Rates of Convergence for the Estimate of the Mean

| One Sample | ← Parametric → ← Nonparametric → | | |
|--|---|--|---|
| (Useful sample sizes probably smaller on the left, larger on the right) | | | |
| Convergence | Very quickly converging (Relatively homogeneous things) | Usually quickly converging (Any fairly symmetrical population, extremes are not many times larger than the average) | Might be slowly converging (Outliers are very large compared to most) |
| Examples | <ul style="list-style-type: none"> • Cholesterol level of your blood • Purity of a public water supply • Weight of Jelly beans | <ul style="list-style-type: none"> • Percentage of customers who like the new product • Failure loads of bricks • Age of your customers • How much time staff spend commuting • How many movies a year people see | <ul style="list-style-type: none"> • Cost overruns of software projects • Downtime of a factory due to an accident • Market fluctuations • Income levels of individuals • Casualties of wars • Size of volcanic eruptions • Market value of corporations |

Exhibit 9.4
Mathless 90% CI for the Median of Population

| Sample Size | Lower bound: <i>n</i> th smallest | Upper bound: <i>n</i> th largest | Actual Confidence |
|-------------|-----------------------------------|----------------------------------|-------------------|
| | <i>n</i> th Largest and Smallest | | |
| 5 | 1st | | 93.8% |
| 8 | 2nd | | 93.0% |
| 11 | 3rd | | 93.5% |
| 13 | 4th | | 90.8% |
| 16 | 5th | | 92.3% |
| 18 | 6th | | 90.4% |
| 21 | 7th | | 92.2% |
| 23 | 8th | | 90.7% |
| 26 | 9th | | 92.4% |
| 28 | 10th | | 91.3% |
| 30 | 11th | | 90.1% |

Exhibit 9.5
Population Proportion 90% CI for Small Samples

| Number of "hits" in Sample | Sample Size | | | | | | | | | |
|----------------------------|-------------|-----------|----------|-----------|-----------|----------|-----------|----------|----------|----------|
| | 1 | 2 | 3 | 4 | 6 | 8 | 10 | 15 | 20 | 30 |
| 0 | 2.5-78 | 1.7-63 | 1.3-53 | 01.0-45 | 0.7-35 | 0.6-28.3 | 0.5-23.9 | 0.3-17.1 | 0.2-13.3 | 0.2-9.2 |
| 1 | 22.4-97.5 | 13.5-87 | 9.8-75.2 | 07.6-65.8 | 05.3-52.1 | 4.1-42.9 | 3.3-36.5 | 2.3-26.4 | 1.7-20.7 | 1.2-14.4 |
| 2 | | 36.8-98.3 | 25-90.3 | 18.9-81 | 12.9-65.9 | 9.8-55 | 07.9-47.0 | 5.3-34.4 | 4.0-27.1 | 2.7-18.9 |
| 3 | | | 47-98.7 | 34.3-92.4 | 22.5-78 | 16.9-66 | 13.5-57 | 9.0-42 | 6.8-33 | 4.5-23 |
| 4 | | | | 55-99.0 | 34.1-87 | 25.1-75 | 20-65 | 13-48 | 9.9-38 | 6.6-27 |
| 5 | | | | | 48-94.7 | 34.5-83 | 27-73 | 17.8-55 | 13.2-44 | 8.8-31 |
| 6 | | | | | | 65-99.3 | 45-90 | 35-80 | 22.7-61 | 16.8-49 |
| 7 | | | | | | | 57-95.9 | 44-87 | 28-67 | 21-54 |
| 8 | | | | | | | | 72-99.5 | 53-92 | 33-72 |
| 9 | | | | | | | | | 64-96.7 | 39-77 |
| 10 | | | | | | | | | | 29-63 |
| | | | | | | | | | | 19-45 |
| | | | | | | | | | | 21-49 |

Exhibit 9.6

Example Distributions for Estimates of Population Proportion from Small Samples

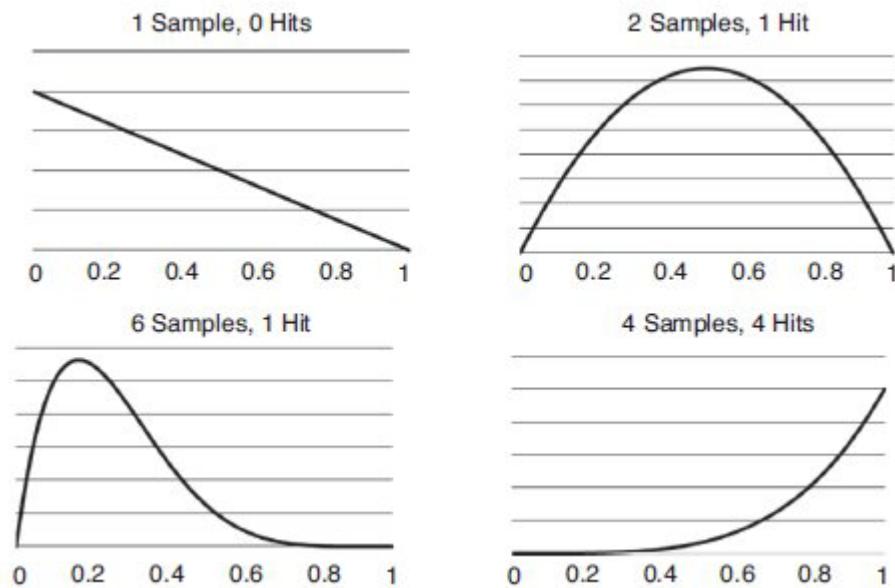


Exhibit 9.7

Comparison of World War II German Mark V Tank Production Estimates

| Month of Production | Intelligence Estimate | Statistical Estimate | Actual (based on captured documents after the war) |
|---------------------|-----------------------|----------------------|--|
| June 1940 | 1,000 | 169 | 122 |
| June 1941 | 1,550 | 244 | 271 |
| August 1942 | 1,550 | 327 | 342 |

Source: Leo A. Goodman, "Serial Number Analysis,"
Journal of the American Statistical Association 47 (1952): 622–634.

Exhibit 9.8
Serial Number Sampling

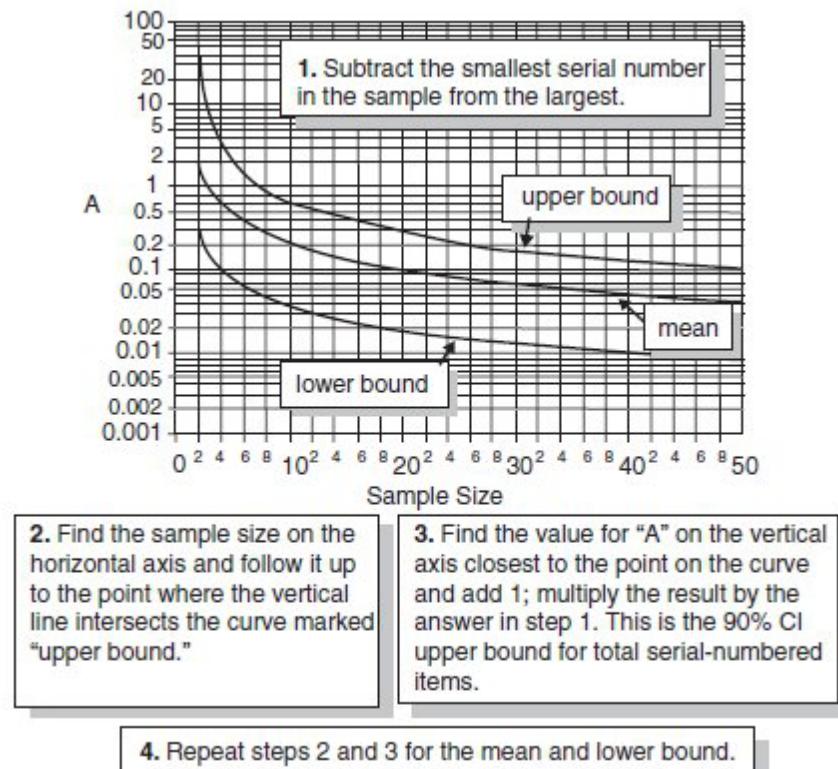


Exhibit 9.9
Threshold Probability Calculator

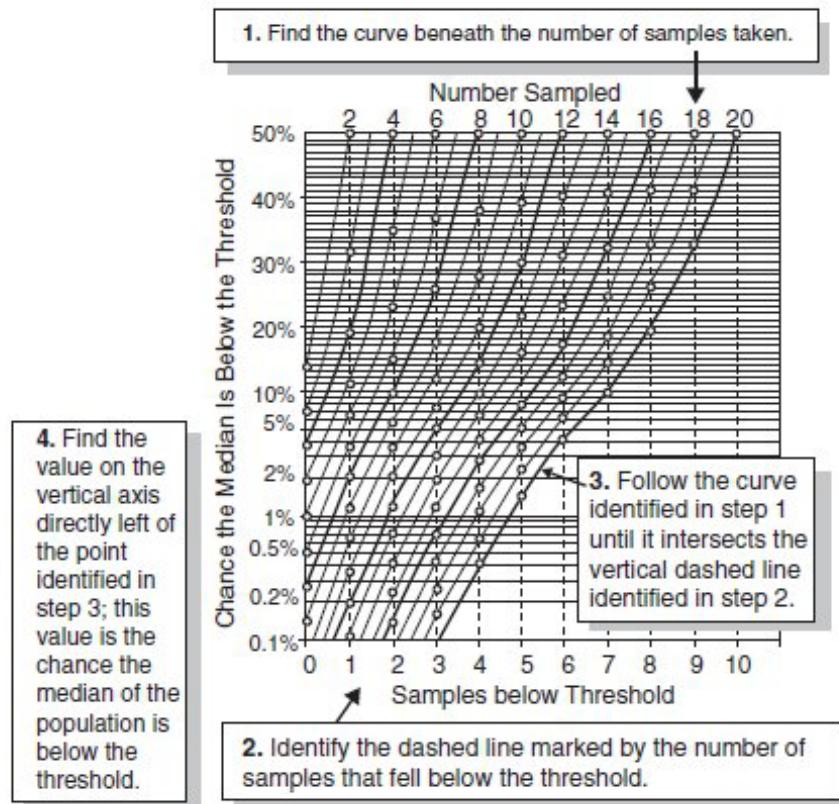


Exhibit 9.10
Examples of Correlated Data

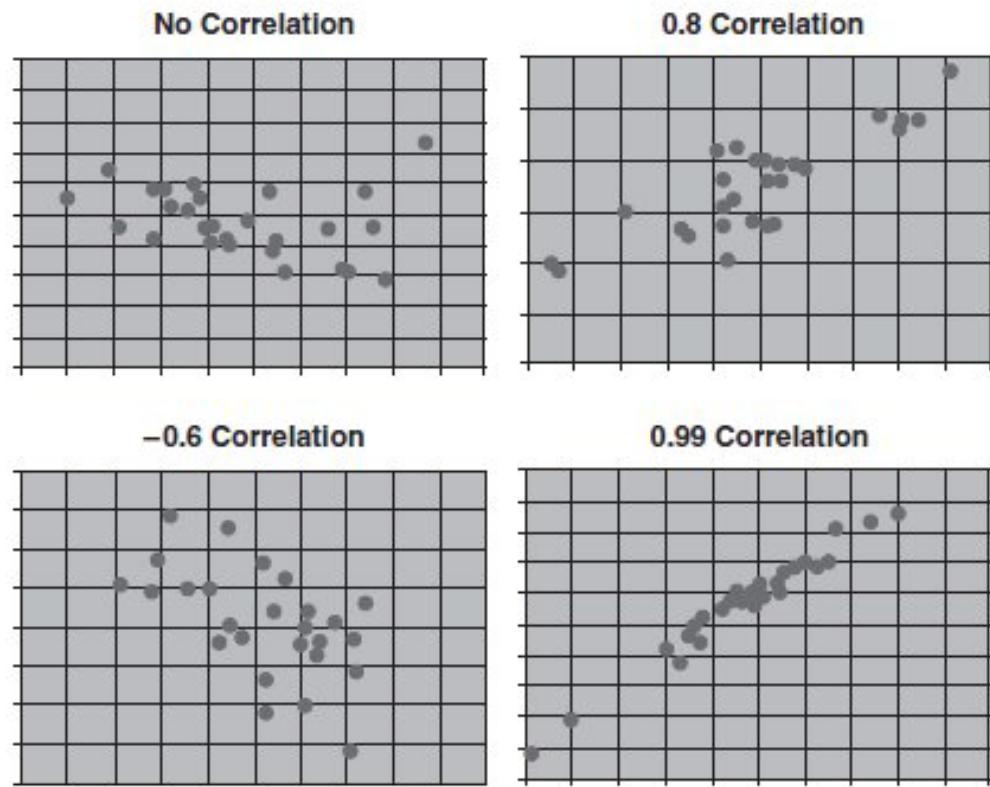


Exhibit 9.11
Promotion Period versus Ratings Points for a Cable Network

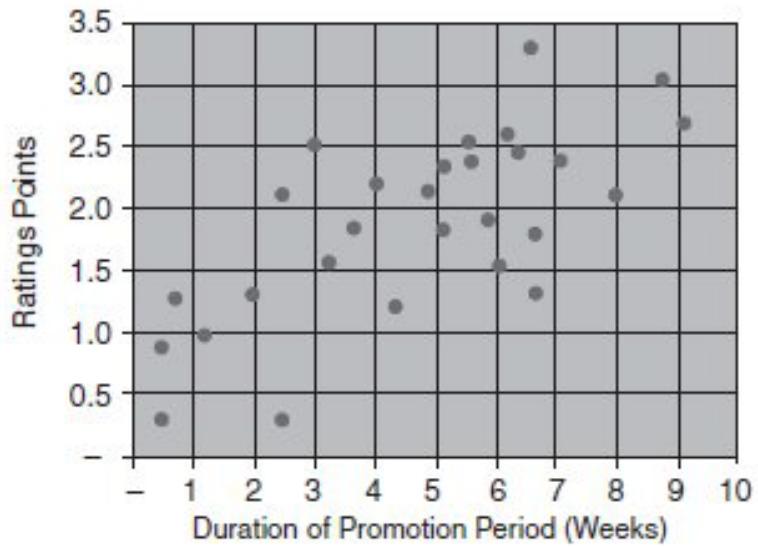


Exhibit 9.12

Selected Items from Excel's Regression Tool "Summary Output" Table

| Variable Name | What It Means |
|---------------|---|
| Multiple R | Correlation of one or more variables to the "dependent" variable (e.g., ratings points): 0.7 in this example. |
| R square | Square of the multiple R. This can be interpreted as the amount of variance in ratings points explained by promotion weeks. |
| Intercept | Ratings point if promotion weeks were set to zero. This is where the best-fit line would intersect the vertical axis. |
| X variable 1 | Coefficient (i.e., weight) for promotion weeks. |
| P-Value | If there really were no correlation, the probability that this correlation or higher could still be seen by chance. Generally, the convention is that P-value should be below .05, but, as discussed already, even a higher P-value can qualify as a legitimate measurement if it reduced your previous state of uncertainty. |

Exhibit 9.13

Promotion Time versus Ratings Chart with the “Best-Fit” Regression Line Added

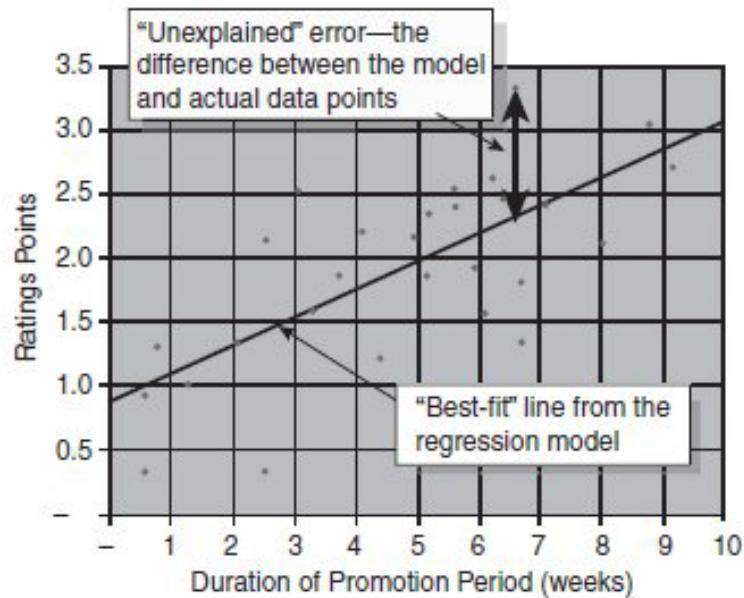


Exhibit 10.1

Bayes' Theorem

$$P(A|B) = P(A) \times P(B|A) / P(B)$$

where:

$P(A|B)$ = Conditional probability of A given B

$P(A)$ = Probability of A

$P(B)$ = Probability of B

$P(B|A)$ = Conditional probability of B given A

Exhibit 10.2

Calibrated Subjective Probabilities versus Bayesian

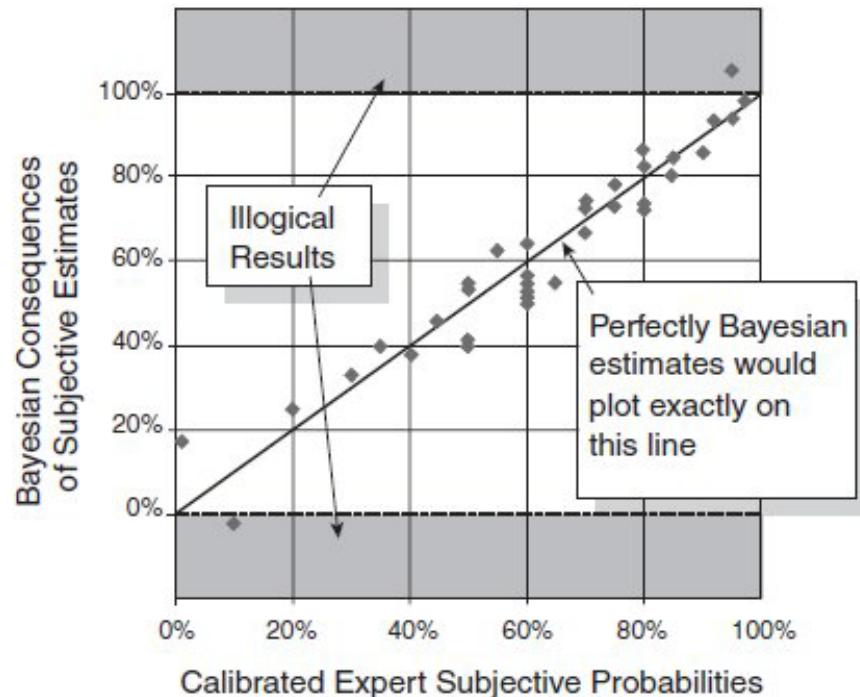


Exhibit 10.3
Confidence versus Information Emphasis

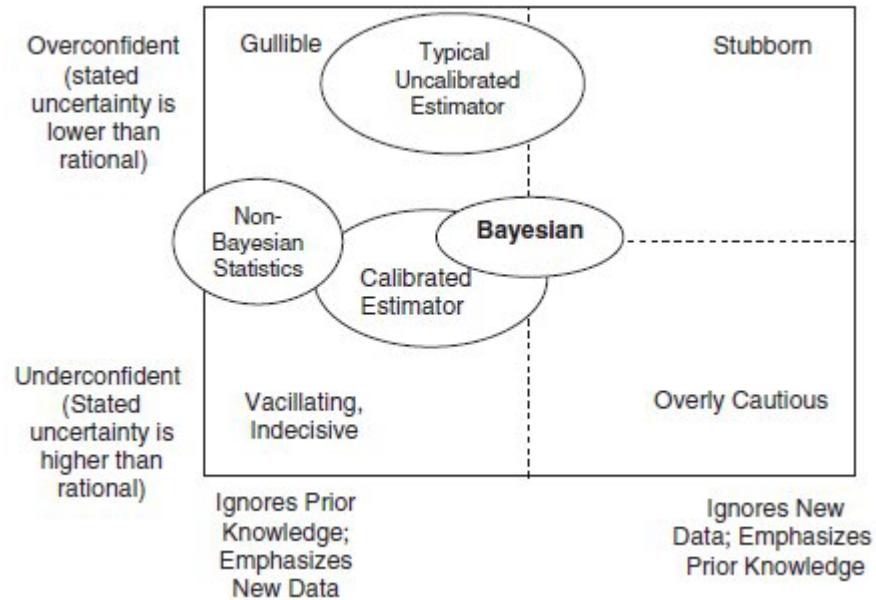
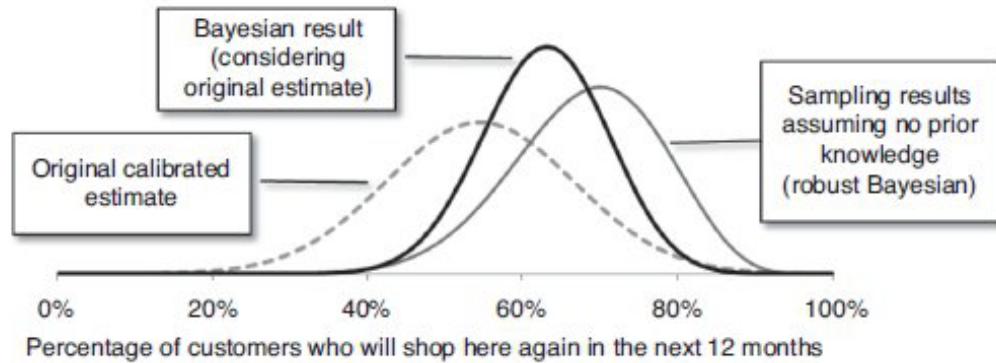


Exhibit 10.4

Customer Retention Example



Comparison of Prior Knowledge, Sampling without Prior Knowledge,
and Sampling with Prior Knowledge (Bayesian Analysis).

Exhibit 10.5

Summary of Results of the Three Distributions versus Thresholds

| Source of Distribution | Confidence in Deferred Expansion (Retention <73%) | Confidence in Changing Location (Retention <50%) |
|---|--|---|
| Based on initial calibrated estimate (35% to 75%) | 93% | 34% |
| Based on sample alone (14 of 20 surveyed will stay) | 69% | 4.3% |
| Bayesian analysis using both initial estimate and sample data | 91% | 6.5% |

Exhibit 11.1
An Investment Boundary Example

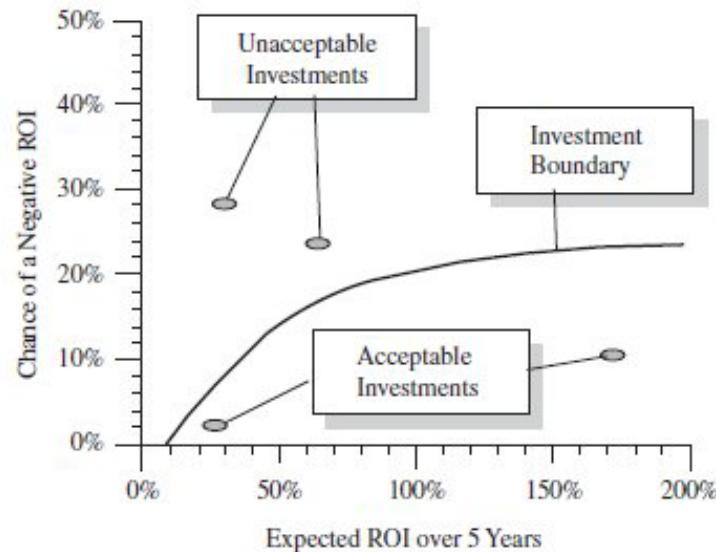


Exhibit 11.2
Hypothetical “Utility Curves”

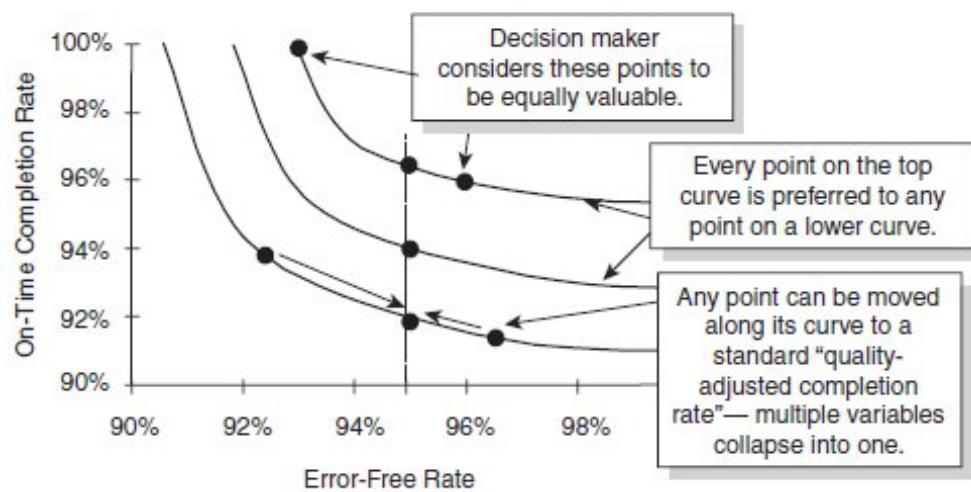


Exhibit 12.1
Asch Conformity Experiment

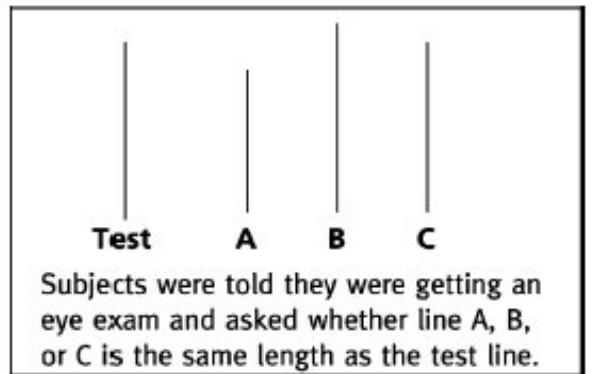


Exhibit 12.2
Effects of Lens Model on Improving Various Types of Decision

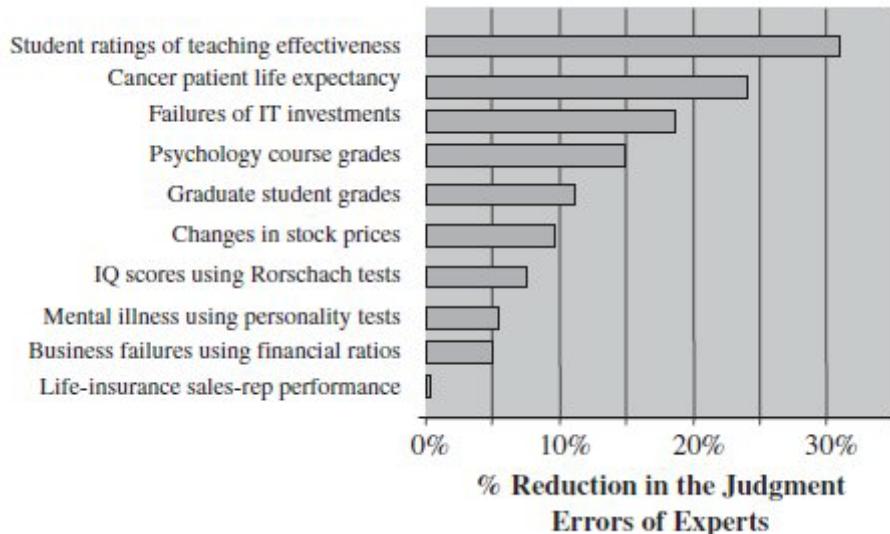


Exhibit 12.3

Lens Model Process

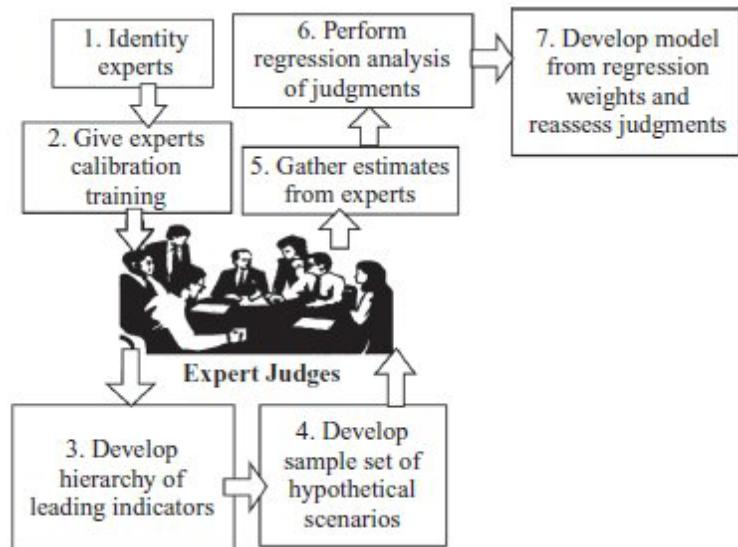


Exhibit 12.4

Nonlinear Example of a Lens Model Variable

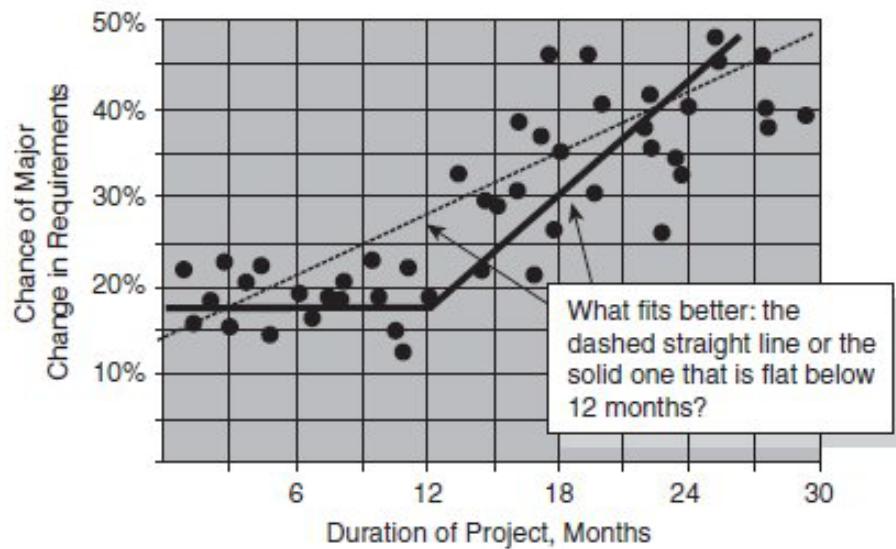


Exhibit 12.5

Relative Value of Estimation Methods for Groups of Similar Problems

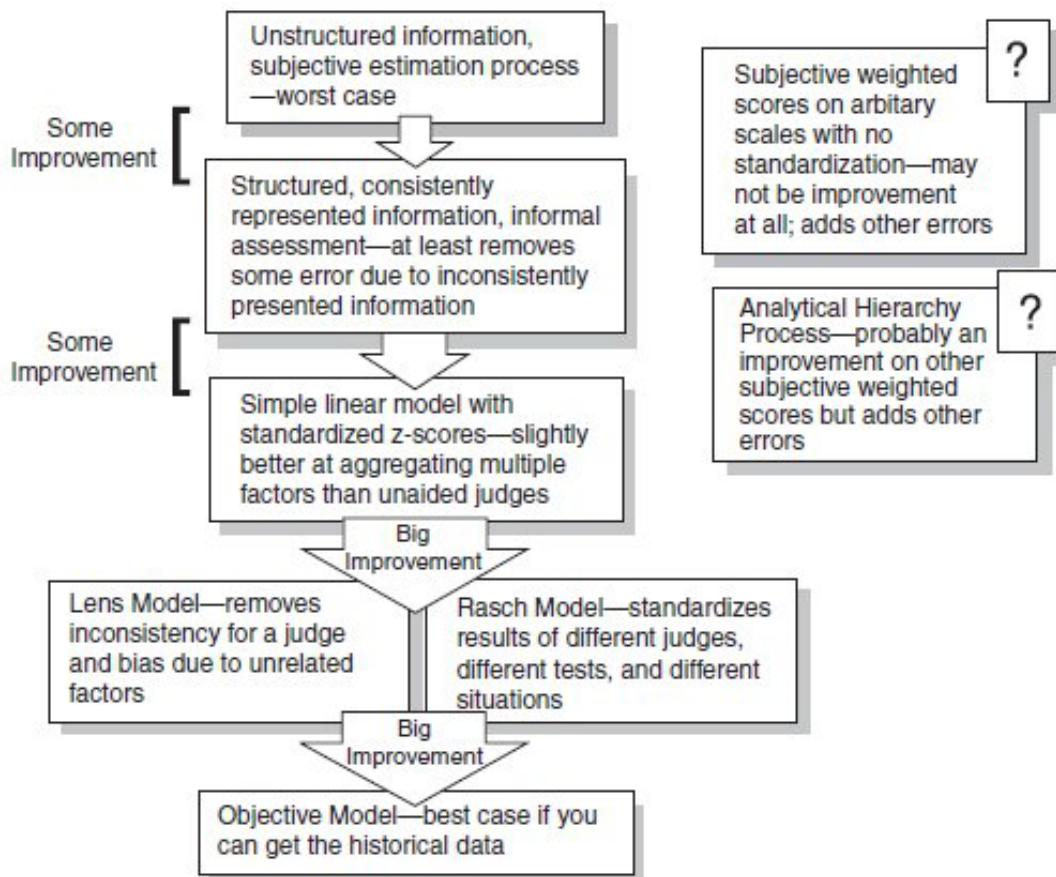


Exhibit 13.1

Summary of Available Prediction Markets

| | |
|---|--|
| Consensus Point www.consensuspoint.com | A service for businesses that want to set up prediction markets for internal use. Developed by some of the same people who created Foresight Exchange, the business has a lot of flexibility in how to set up and create reward systems for good forecasters, including monetary incentives. |
| Foresight Exchange www.ideosphere.com | A free Web site available to the public and one of the earliest experiments on the concept of prediction markets. All bets are "play money." Claims are proposed by the public and reviewed by volunteers. It is an active market with a large number of players, and a good way to get introduced to prediction markets. |
| NewsFutures www.newsfutures.com | A direct competitor for Consensus Point, it offers businesses services to set up prediction markets. |
| Intrade www.intrade.com | Began as www.tradesports.com , a type of sports betting Web site that expanded into politics, economics, world events, and other areas. These are now separate sites. Anyone can create an account but real money is at stake. Anyone can propose a claim but that also requires money. |

Exhibit 13.2
Share Price for “Apple Computer Dies by 2005” on Foresight Exchange

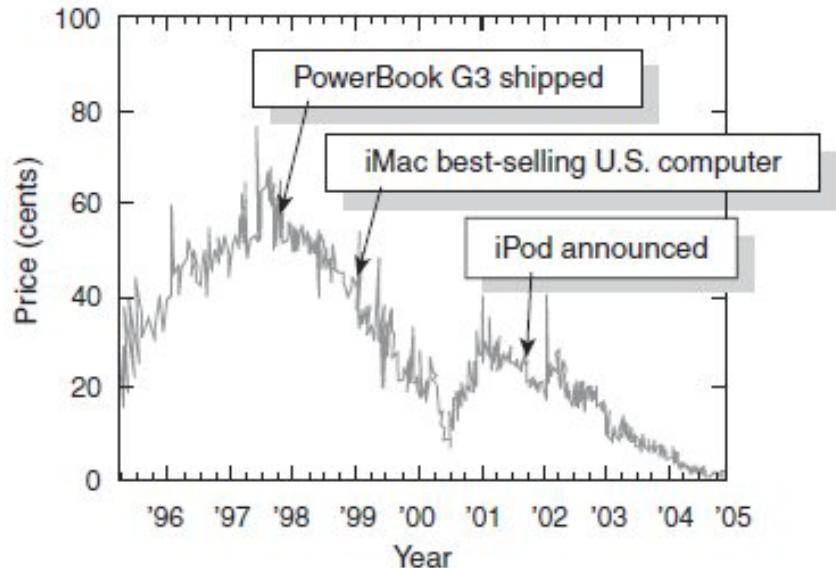


Exhibit 13.3
Performance of Prediction Markets: Price versus Reality

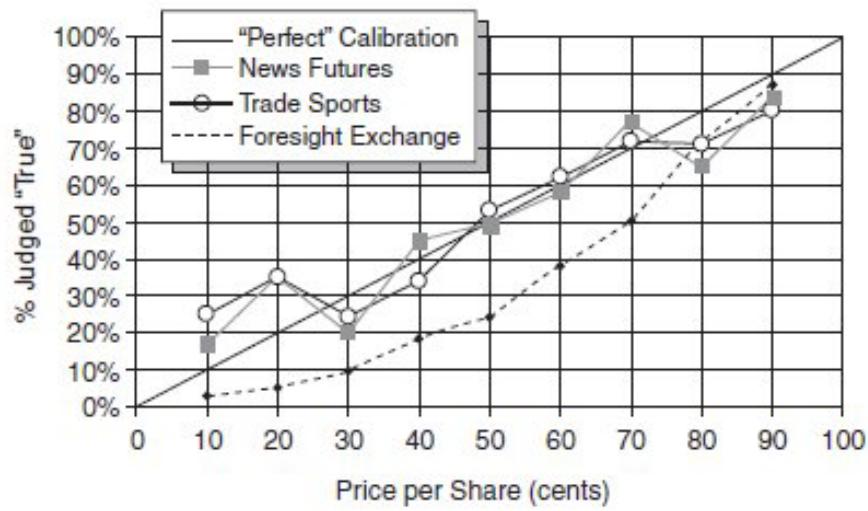


Exhibit 14.1

Summary of the AIE Process: The Universal Measurement Approach

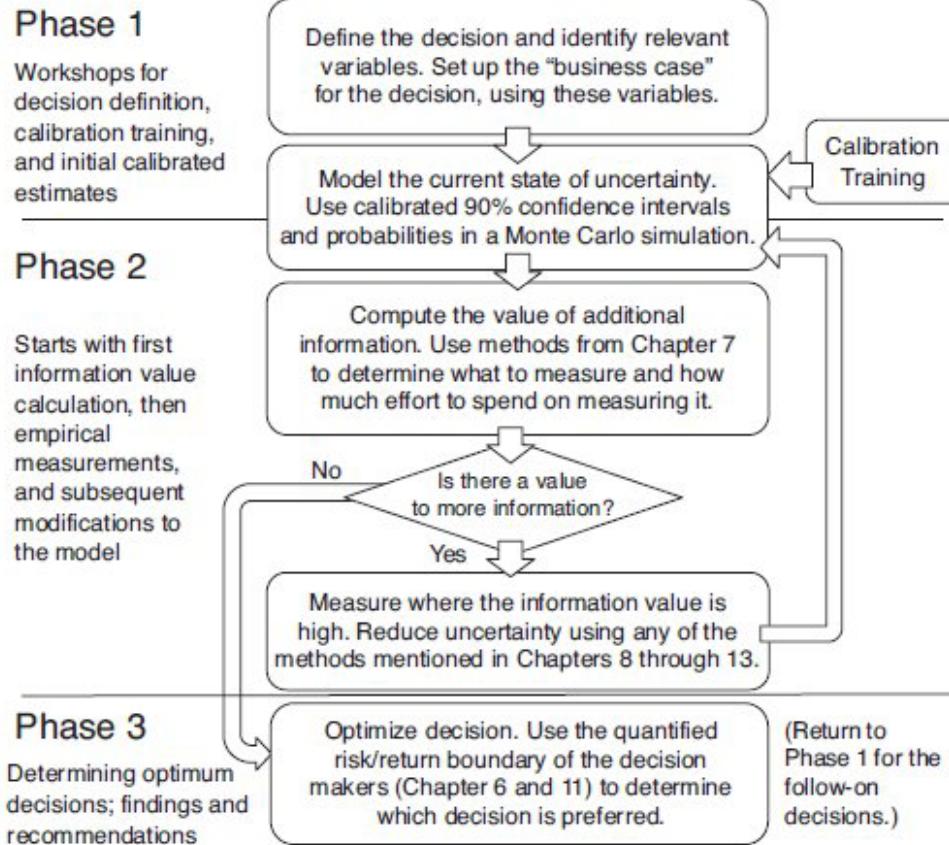


Exhibit 14.2

Overview of the Spreadsheet Model for the Benefits of SDWIS Modification

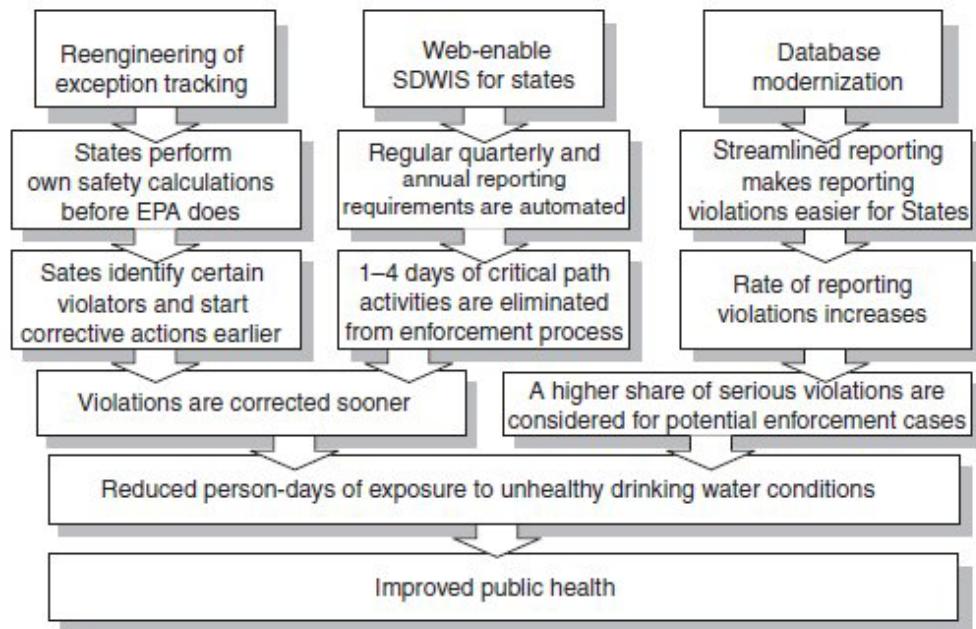


Exhibit 14.3

Summary of Average Effects of Changing Supply Route Variables for a Marine Expeditionary Force (MEF)

| Change | Change in Gallons/Days |
|------------------------------|------------------------|
| Gravel versus Paved | 10,303 |
| +5-mph average speed | 4,685 |
| +10-meter climb | 6,422 |
| +100-meter average altitude | 751 |
| +10-degree temperature | 1,075 |
| +10 miles of route | 8,320 |
| Additional stop on the route | 1,980 |

Additional Calibration Tests

Calibration Survey for Ranges: A

| # | Question | Lower Bound (95% chance value is higher) | Upper Bound (95% chance value is lower) |
|----|--|--|---|
| 1 | How many feet tall is the Hoover Dam? | | |
| 2 | How many inches long is a 20-dollar bill? | | |
| 3 | What percentage of aluminum is recycled in the United States? | | |
| 4 | When was Elvis Presley born? | | |
| 5 | What percentage of the atmosphere is oxygen by weight? | | |
| 6 | What is the latitude of New Orleans? Hint: Latitude is 0 degrees at the equator and 90 at the North Pole. | | |
| 7 | In 1913, the U.S. military owned how many airplanes? | | |
| 8 | The first European printing press was invented in what year? | | |
| 9 | What percentage of all electricity consumed in U.S. households was used by kitchen appliances in 2001? | | |
| 10 | How many miles tall is Mount Everest? | | |
| 11 | How long is Iraq's border with Iran in kilometers? | | |
| 12 | How many miles long is the Nile? | | |
| 13 | In what year was Harvard founded? | | |
| 14 | What is the wingspan (in feet) of a Boeing 747 jumbo jet? | | |
| 15 | How many soldiers were in a Roman legion? | | |
| 16 | What is the average temperature of the abyssal zone (where the oceans are more than 6,500 feet deep) in degrees F? | | |
| 17 | How many feet long is the Space Shuttle Orbiter (excluding the external tank)? | | |
| 18 | In what year did Jules Verne publish <i>20,000 Leagues Under the Sea</i> ? | | |
| 19 | How wide is the goal in field hockey (feet)? | | |
| 20 | The Roman Coliseum held how many spectators? | | |

Answers on page 45.

Additional Calibration Tests

Calibration Survey for Ranges: B

| # | Question | <i>Lower Bound (95% chance value is higher)</i> | <i>Upper Bound (95% chance value is lower)</i> |
|----|--|---|--|
| 1 | The first probe to land on Mars, Viking 1, landed there in what year? | | |
| 2 | How old was the youngest person to fly into space? | | |
| 3 | How many meters tall is the Sears Tower? | | |
| 4 | What was the maximum altitude of the Breitling Orbiter 3, the first balloon to circumnavigate the globe, in miles? | | |
| 5 | On average, what percentage of the total software development project effort is spent in design? | | |
| 6 | How many people were permanently evacuated after the Chernobyl nuclear power plant accident? | | |
| 7 | How many feet long were the largest airships? | | |
| 8 | How many miles is the flying distance from San Francisco to Honolulu? | | |
| 9 | The fastest bird, the falcon, can fly at a speed of how many miles per hour in a dive? | | |
| 10 | In what year was the double helix structure of DNA discovered? | | |
| 11 | How many yards wide is a football field? | | |
| 12 | What was the percentage growth in Internet hosts from 1996 to 1997? | | |
| 13 | How many calories are in 8 ounces of orange juice? | | |
| 14 | How fast would you have to travel at sea level to break the sound barrier (mph)? | | |
| 15 | How many years was Nelson Mandela in prison? | | |
| 16 | What is the average daily calorie intake in developed countries? | | |
| 17 | In 1994, how many nations were members of the United Nations? | | |
| 18 | The Audubon Society was formed in the United States in what year? | | |
| 19 | How many feet high is the world's highest waterfall (Angel Falls, Venezuela)? | | |
| 20 | How deep beneath the sea was the <i>Titanic</i> found (miles)? | | |

Answers on page 46.

Additional Calibration Tests

Calibration Survey for Binary: A

| | <i>Statement</i> | <i>Answer True/False</i> | <i>Confidence that you are correct (Circle one)</i> |
|----|---|------------------------------|---|
| 1 | The Lincoln Highway was the first paved road in the United States, and it ran from Chicago to San Francisco. | | 50% 60% 70% 80% 90% 100% |
| 2 | Iron is denser than gold. | | 50% 60% 70% 80% 90% 100% |
| 3 | More American homes have microwaves than telephones. | | 50% 60% 70% 80% 90% 100% |
| 4 | “Doric” is an architectural term for a shape of a roof. | | 50% 60% 70% 80% 90% 100% |
| 5 | The World Tourism Organization predicts that Europe will still be the most popular tourist destination in 2020. | | 50% 60% 70% 80% 90% 100% |
| 6 | Germany was the second country to develop atomic weapons. | | 50% 60% 70% 80% 90% 100% |
| 7 | A hockey puck will fit in a golf hole. | | 50% 60% 70% 80% 90% 100% |
| 8 | The Sioux were one of the “Plains” Indian tribes. | | 50% 60% 70% 80% 90% 100% |
| 9 | To a physicist, “plasma” is a type of rock. | | 50% 60% 70% 80% 90% 100% |
| 10 | The Hundred Years’ War was actually over a century long. | | 50% 60% 70% 80% 90% 100% |
| 11 | Most of the fresh water on Earth is in the polar ice caps. | | 50% 60% 70% 80% 90% 100% |
| 12 | The Academy Awards (Oscars) began over a century ago. | | 50% 60% 70% 80% 90% 100% |
| 13 | There are fewer than 200 billionaires in the world. | | 50% 60% 70% 80% 90% 100% |
| 14 | In Excel, a “^” means “take to the power of.” | | 50% 60% 70% 80% 90% 100% |
| 15 | The average annual salary of airline captains is over \$150,000. | | 50% 60% 70% 80% 90% 100% |
| 16 | By 1997, Bill Gates was worth more than \$10 billion. | | 50% 60% 70% 80% 90% 100% |
| 17 | Cannons were used in European warfare by the eleventh century. | | 50% 60% 70% 80% 90% 100% |
| 18 | Anchorage is the capital of Alaska. | | 50% 60% 70% 80% 90% 100% |
| 19 | Washington, Jefferson, Lincoln, and Grant are the four presidents whose heads are sculpted into Mount Rushmore. | | 50% 60% 70% 80% 90% 100% |
| 20 | John Wiley & Sons is not the largest book publisher. | | 50% 60% 70% 80% 90% 100% |

Answers on page 47.

Additional Calibration Tests

Calibration Survey for Binary: B

| | <i>Statement</i> | <i>Answer True/False</i> | <i>Confidence that you are correct (Circle one)</i> |
|----|---|------------------------------|---|
| 1 | Jupiter's "Great Red Spot" is larger than Earth. | | 50% 60% 70% 80% 90% 100% |
| 2 | The Brooklyn Dodgers' name was an abbreviation for "trolley car dodgers." | | 50% 60% 70% 80% 90% 100% |
| 3 | "Hypersonic" is faster than "subsonic." | | 50% 60% 70% 80% 90% 100% |
| 4 | A "polygon" is three dimensional and a polyhedron is two dimensional. | | 50% 60% 70% 80% 90% 100% |
| 5 | A 1-watt electric motor produces 1 horsepower. | | 50% 60% 70% 80% 90% 100% |
| 6 | Chicago is more populous than Boston. | | 50% 60% 70% 80% 90% 100% |
| 7 | In 2005, Wal-Mart sales dropped below \$100 billion. | | 50% 60% 70% 80% 90% 100% |
| 8 | Post-It Notes were invented by 3M. | | 50% 60% 70% 80% 90% 100% |
| 9 | Alfred Nobel, whose fortune endows the Nobel Peace Prize, made his fortune in oil and explosives. | | 50% 60% 70% 80% 90% 100% |
| 10 | A BTU is a measure of heat. | | 50% 60% 70% 80% 90% 100% |
| 11 | The winner of the first Indianapolis 500 clocked an average speed of under 100 mph. | | 50% 60% 70% 80% 90% 100% |
| 12 | Microsoft has more employees than IBM. | | 50% 60% 70% 80% 90% 100% |
| 13 | Romania borders Hungary. | | 50% 60% 70% 80% 90% 100% |
| 14 | Idaho is larger (area) than Iraq. | | 50% 60% 70% 80% 90% 100% |
| 15 | Casablanca is on the African continent. | | 50% 60% 70% 80% 90% 100% |
| 16 | The first man-made plastic was invented in the nineteenth century. | | 50% 60% 70% 80% 90% 100% |
| 17 | A chamois is an alpine animal. | | 50% 60% 70% 80% 90% 100% |
| 18 | The base of a pyramid is in the shape of a square. | | 50% 60% 70% 80% 90% 100% |
| 19 | Stonehenge is located on the main British island. | | 50% 60% 70% 80% 90% 100% |
| 20 | Computer processors double in power every three months or less. | | 50% 60% 70% 80% 90% 100% |

Answers on page 48.

Answers to Additional Calibration Tests

Calibration Survey for Ranges: A

| <i>#</i> | <i>Answers</i> |
|----------|--------------------|
| 1 | 738 |
| 2 | 6 3/16ths (6.1875) |
| 3 | 45% |
| 4 | 1935 |
| 5 | 21% |
| 6 | 31 |
| 7 | 23 |
| 8 | 1450 |
| 9 | 26.7% |
| 10 | 5.5 |
| 11 | 1458 |
| 12 | 4,160 |
| 13 | 1636 |
| 14 | 196 |
| 15 | 6000 |
| 16 | 39° F |
| 17 | 122 |
| 18 | 1870 |
| 19 | 12 |
| 20 | 50,000 |

Answers to Additional Calibration Tests

Calibration Survey for Ranges: B

| <i>#</i> | <i>Answers</i> |
|----------|----------------|
| 1 | 1976 |
| 2 | 26 |
| 3 | 443 |
| 4 | 6.9 |
| 5 | 20% |
| 6 | 135,000 |
| 7 | 803 |
| 8 | 2394 |
| 9 | 150 |
| 10 | 1953 |
| 11 | 53.3 |
| 12 | 70% |
| 13 | 120 |
| 14 | 760 |
| 15 | 26 |
| 16 | 3,300 |
| 17 | 184 |
| 18 | 1905 |
| 19 | 3212 |
| 20 | 2.5 miles |

Answers to Additional Calibration Tests

Calibration Survey for Binary: A

| # | <i>Answers</i> |
|----|----------------|
| 1 | FALSE |
| 2 | FALSE |
| 3 | FALSE |
| 4 | FALSE |
| 5 | TRUE |
| 6 | FALSE |
| 7 | TRUE |
| 8 | TRUE |
| 9 | FALSE |
| 10 | TRUE |
| 11 | TRUE |
| 12 | FALSE |
| 13 | FALSE |
| 14 | TRUE |
| 15 | FALSE |
| 16 | TRUE |
| 17 | FALSE |
| 18 | FALSE |
| 19 | FALSE |
| 20 | TRUE |

Answers to Additional Calibration Tests

Calibration Survey for Binary: B

| <i>#</i> | <i>Answers</i> |
|----------|----------------|
| 1 | TRUE |
| 2 | TRUE |
| 3 | TRUE |
| 4 | FALSE |
| 5 | FALSE |
| 6 | TRUE |
| 7 | FALSE |
| 8 | TRUE |
| 9 | TRUE |
| 10 | TRUE |
| 11 | TRUE |
| 12 | FALSE |
| 13 | TRUE |
| 14 | FALSE |
| 15 | TRUE |
| 16 | TRUE |
| 17 | TRUE |
| 18 | TRUE |
| 19 | TRUE |
| 20 | FALSE |