

Use of Measurement & Analytical Techniques in High Maturity Organizations & Those Who'd Like to Get There – Insights from Six Sigma & Elsewhere

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13th Annual PSM Users' Group Conference
Orlando, Florida – 23 June 2009



Software Engineering Institute

Carnegie Mellon

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Agenda



A summary of analytical techniques ... Commonly used & otherwise

- *Frequency of use in high maturity organizations*
- *Some useful ones to consider*
- *Interspersed with ...*

Your experience & expertise

- With these & other techniques & approaches
- What else **you** want / need to do in your own work
- Implementation Issues

Next steps

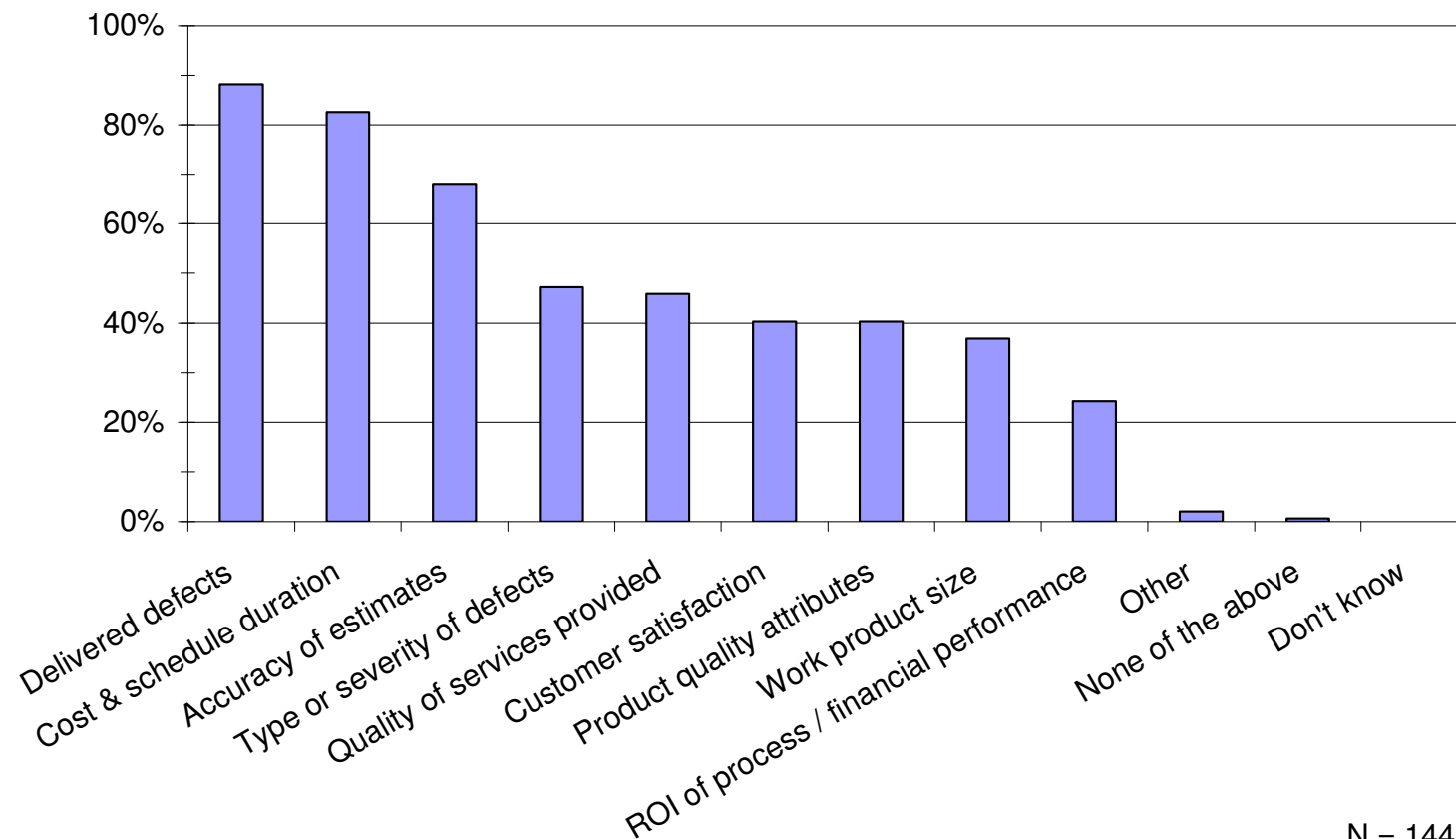


What's Commonly Modeled?



Diversity of Process Performance Models: Product Quality & Project Performance

Which of the following product quality and project performance outcomes are routinely predicted with process performance models in your organization?

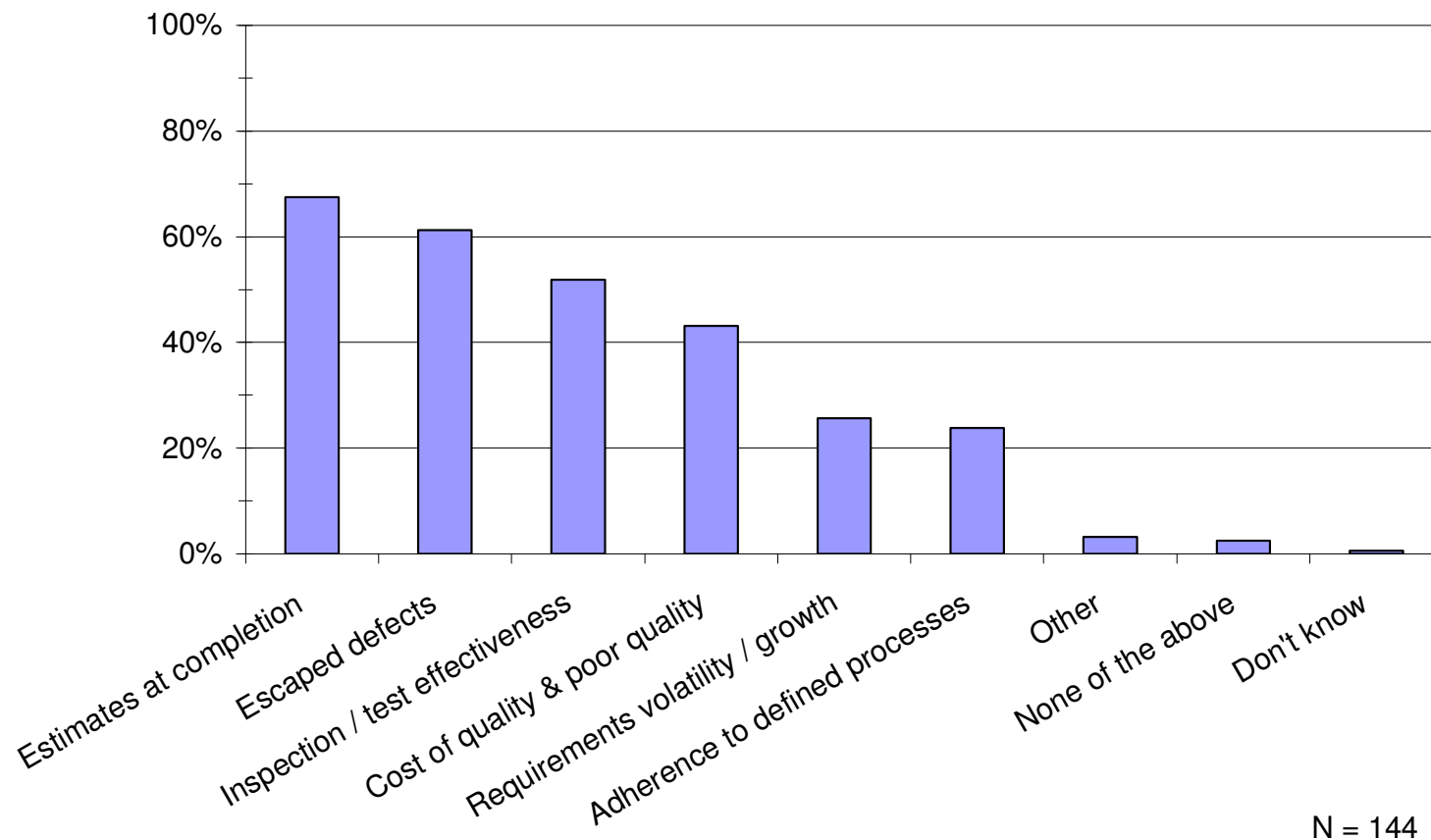


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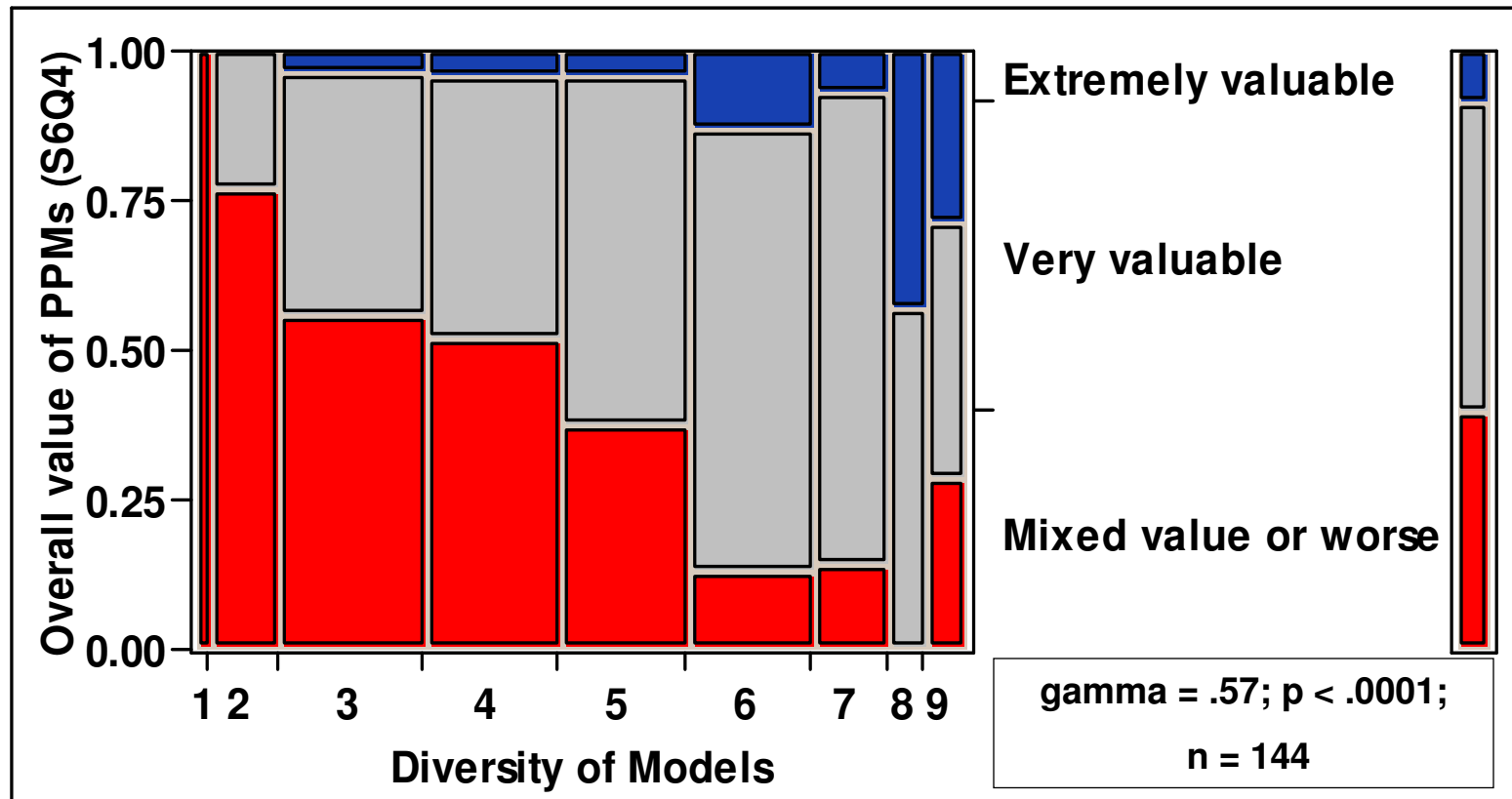


Diversity of Process Performance Models: Process Performance

Which of the following (often interim) process performance outcomes are routinely predicted with process performance models in your organization?

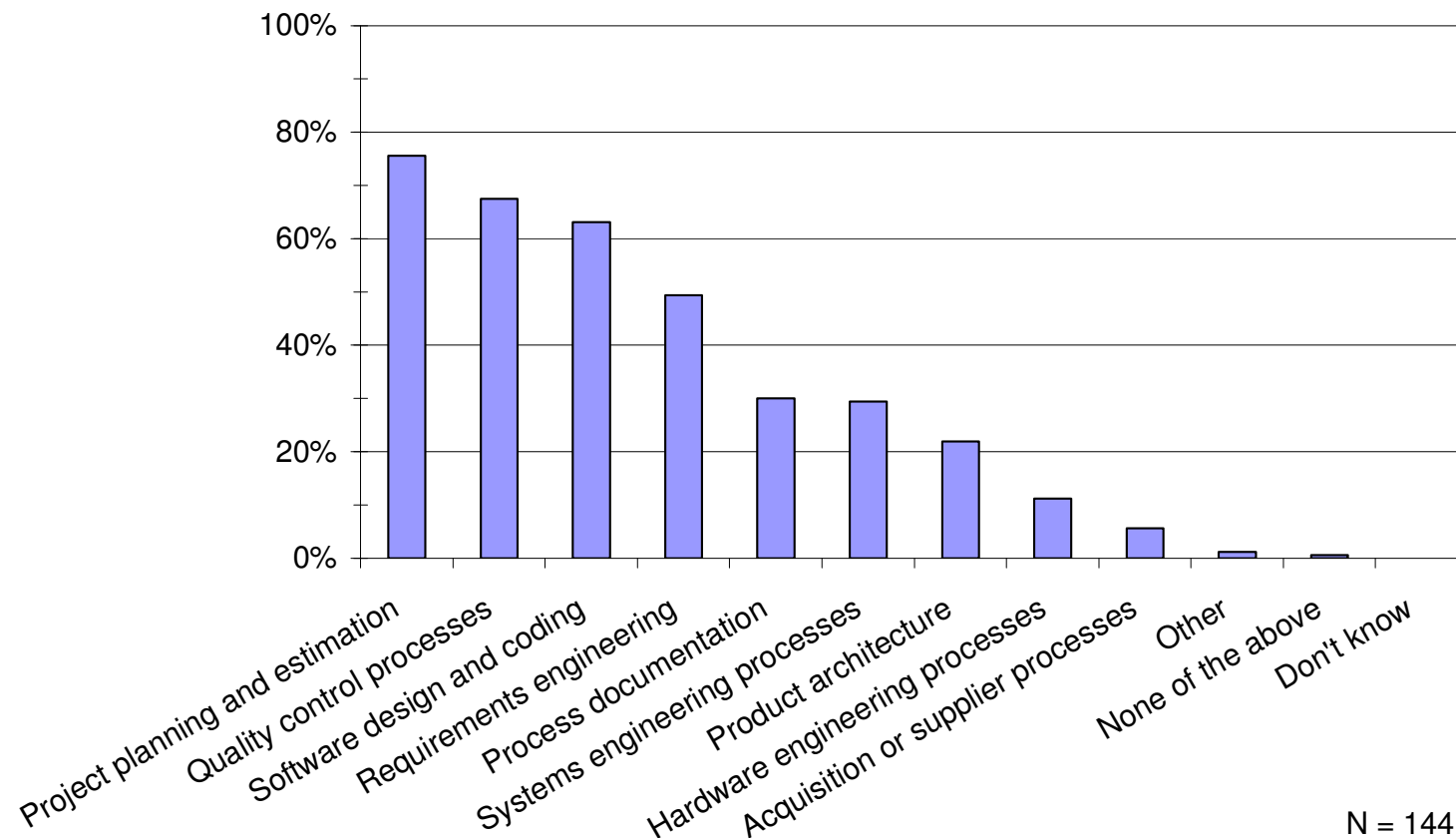


Relationship Between Diversity of Models Used & Overall Value Attributed to PPMs



Routinely Modeled Processes & Activities

Which of the following processes and activities are routinely modeled in your organization?



Commonly Used Methods

Regression, correlation, scatter plots

ANOVA & it's variants

Box plots

A little about SPC

- It **can** be useful
 - Especially for managing stable processes
 - & identifying problems
 - that may require exploratory data analysis & collection
- But there's often over-aggregation & confusion over time ordering
- & causal analysis is confounded
 - Even when the data are filtered / stratified properly



Further Background

Commonly used analytical techniques often require interval / ratio data

- But much of our data is discrete & poorly distributed

Methods for analyzing discrete data exist

- To predict the likelihood of successful technical & business outcomes
- & enable insightful classification, better advice & guidance for decision making

An aside: What do you do in the absence of good data?

- Expert judgment
- Data archeology
- Collapse categories to reduce noise and cope with small Ns



A Focus on Discrete Methods

A full complement of descriptive & inferential statistics

- Useful for performance modeling & exploratory data analysis

Examples

- Particularly useful for exploration, narrowing focus & establishing baselines
 - Cross tabulation , e.g., chi-square, Gamma, etc.
 - Rank order correlations, e.g. Spearman's rho
- Logistic regression & log linear variants
 - For multiple variable analysis
 - (iterative to remove insignificant factors)
 - That can combine both continuous (x) & discrete (y) data
 - Interpreted based on odds of occurrence as opposed to case counts

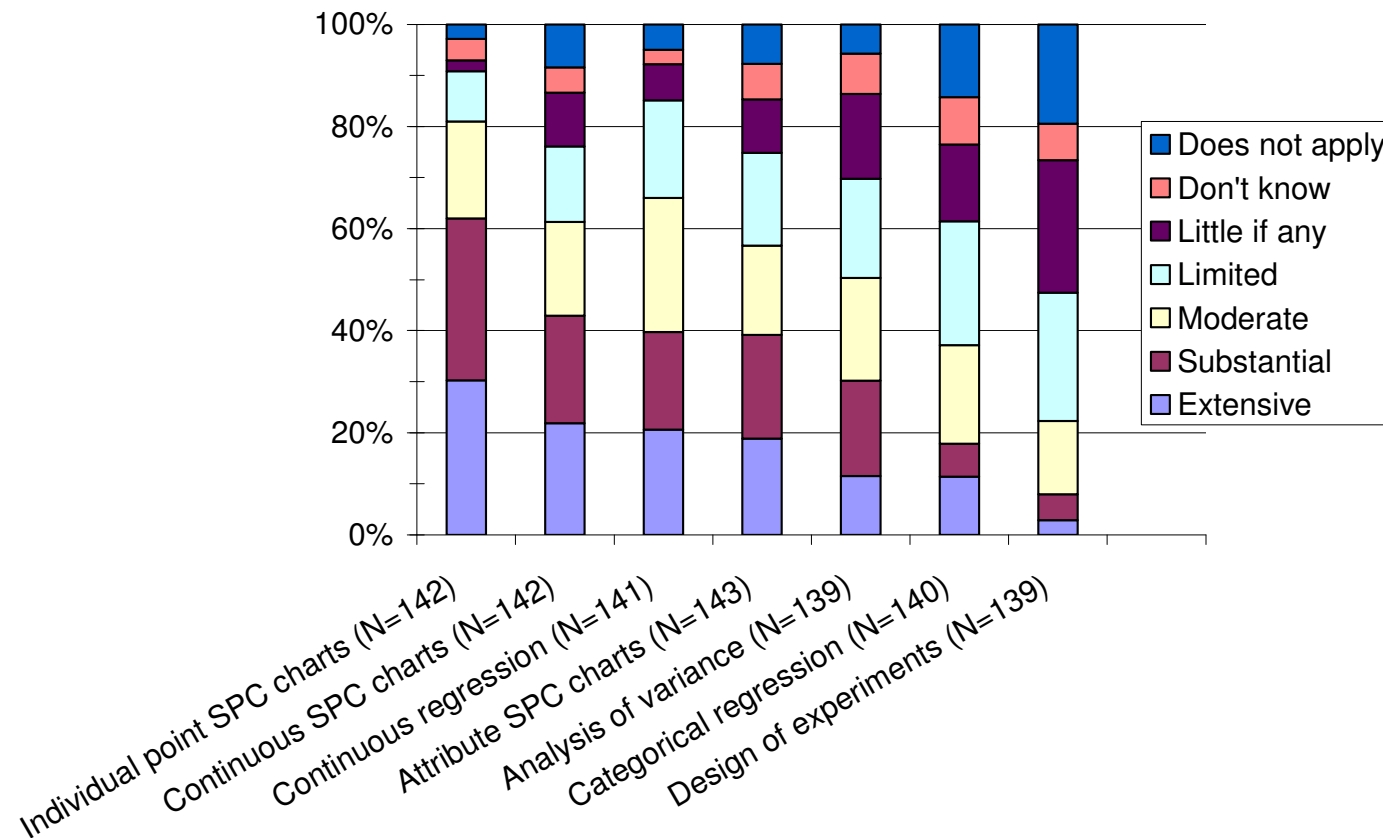


More on Techniques Used

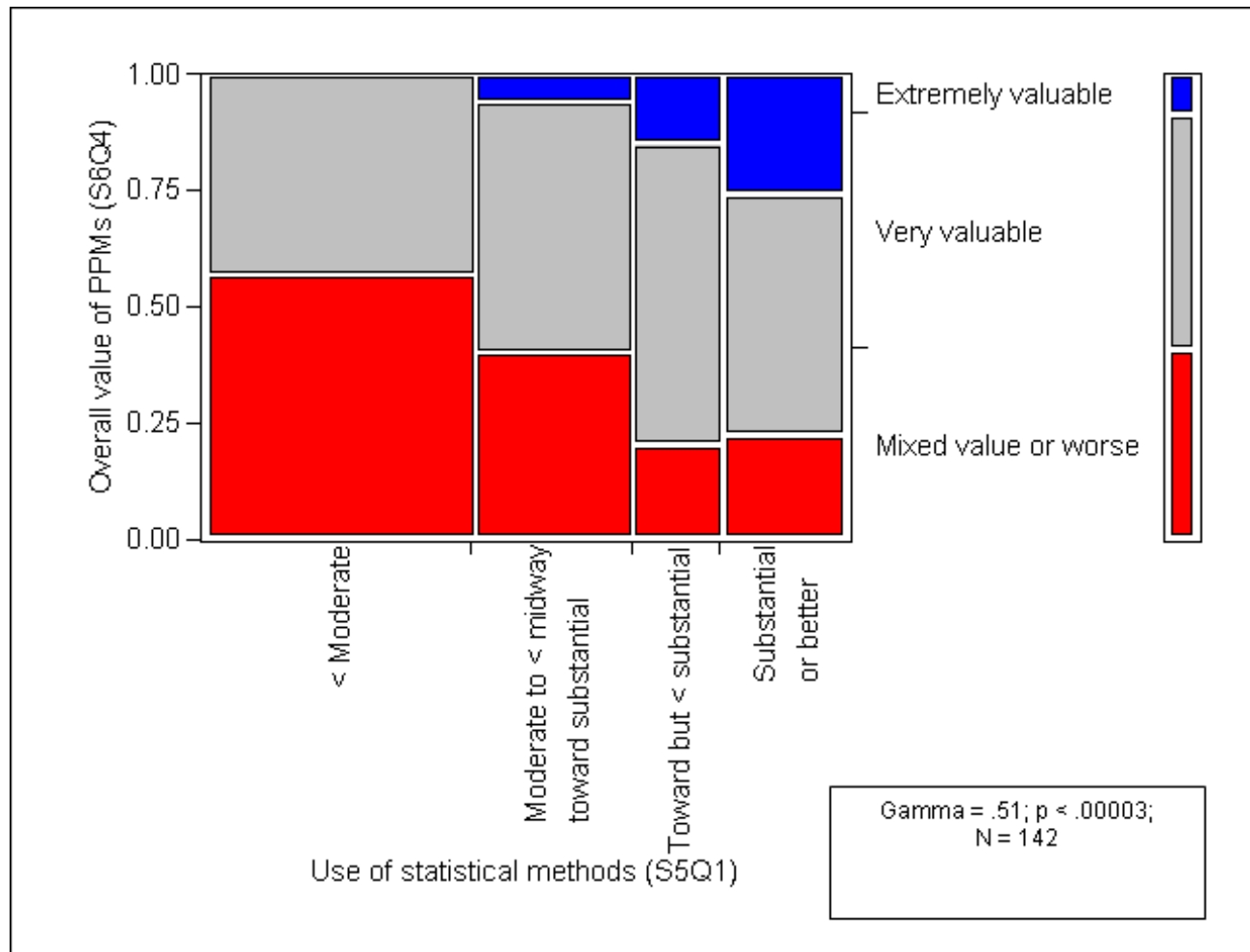


Use of Diverse Statistical Methods

To what extent are the following statistical methods used in your organization's process performance modeling?



Relationship Between Use of Statistical Methods & Overall Value Attributed to PPMs



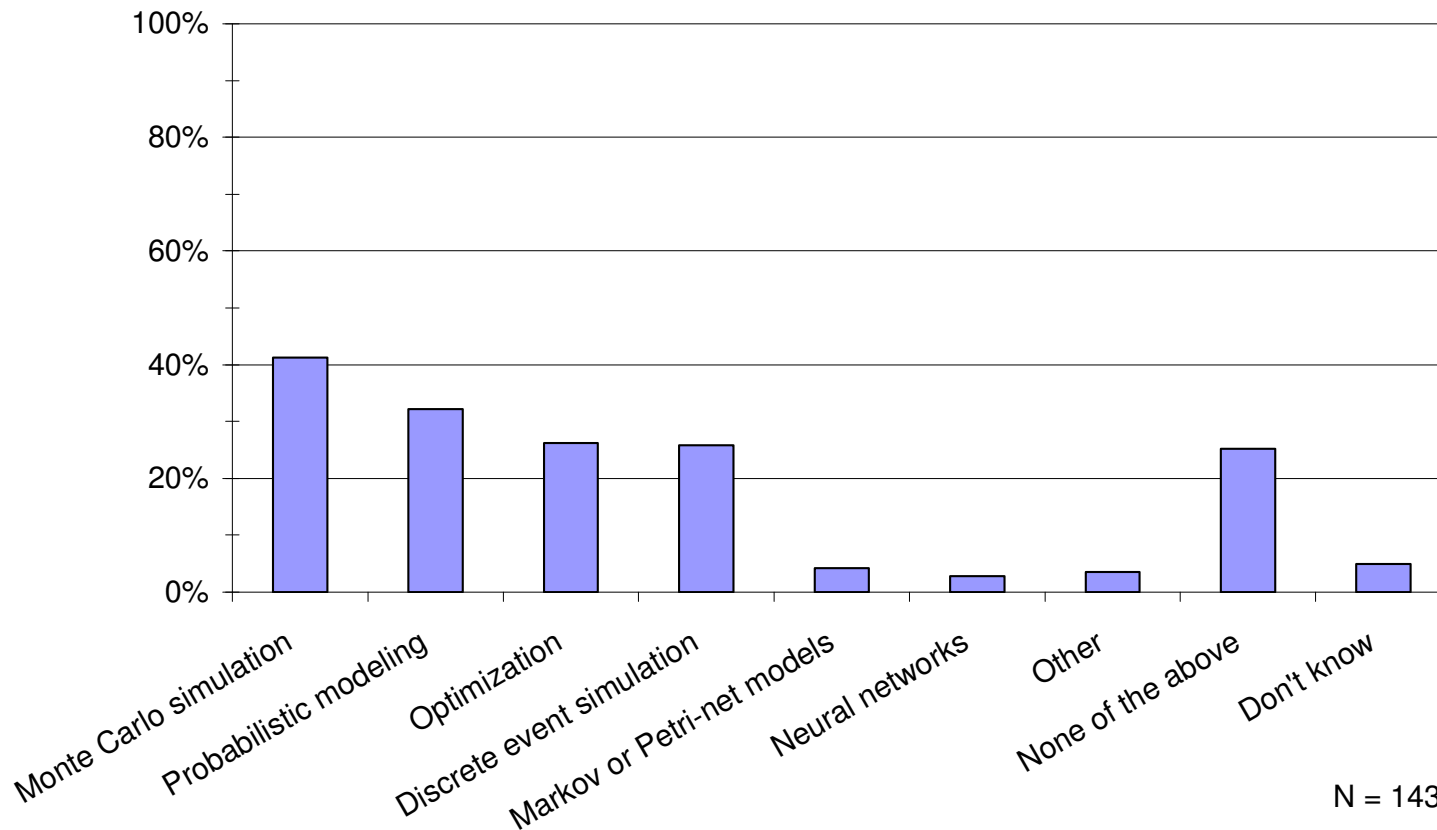
There's room for improvement here too

Regression & ANOVA are the best individual discriminators

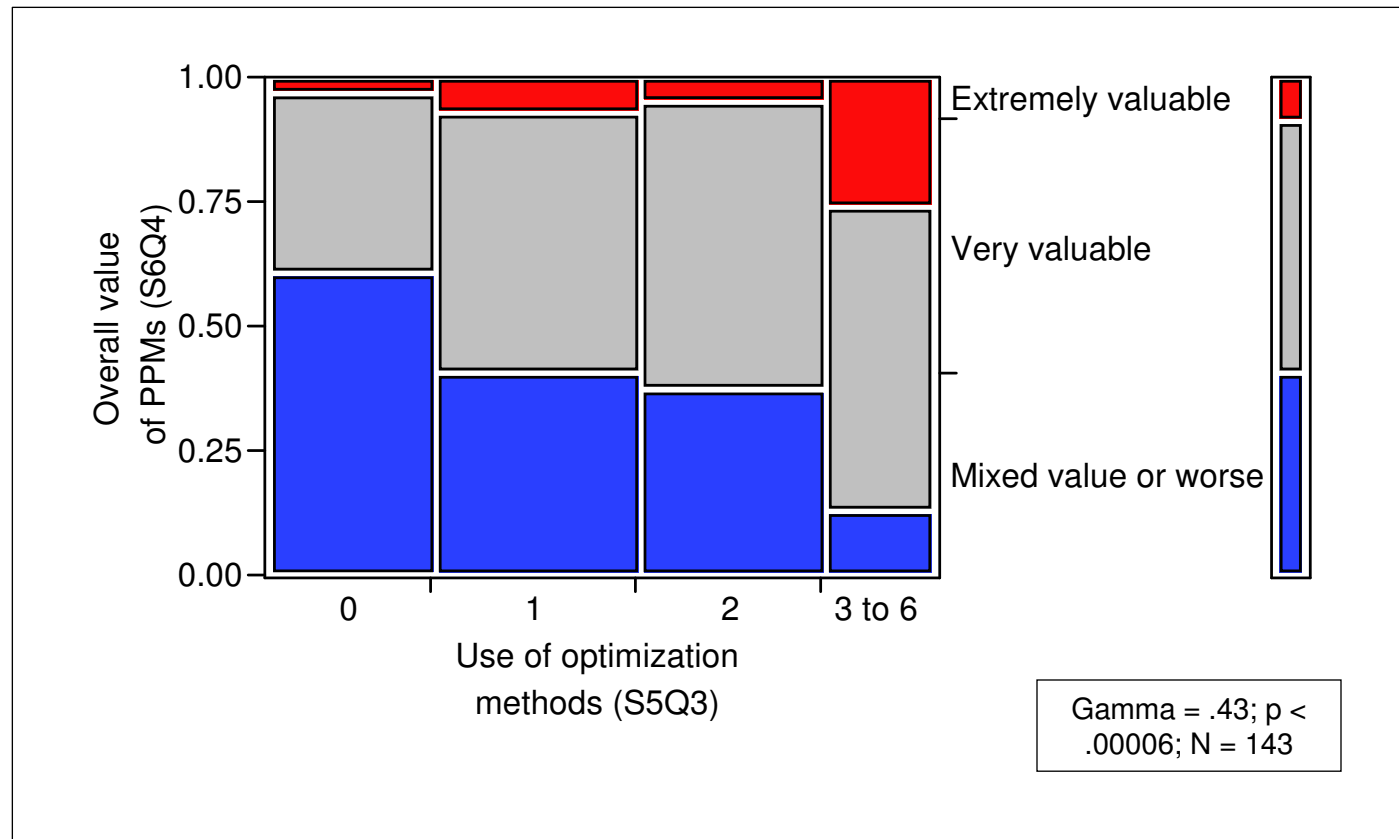


Use of Optimization Techniques

Which of the following other optimization approaches are used in your organization's process performance modeling?



Relationship Between Use of Optimization Methods & Overall Value Attributed to PPMs



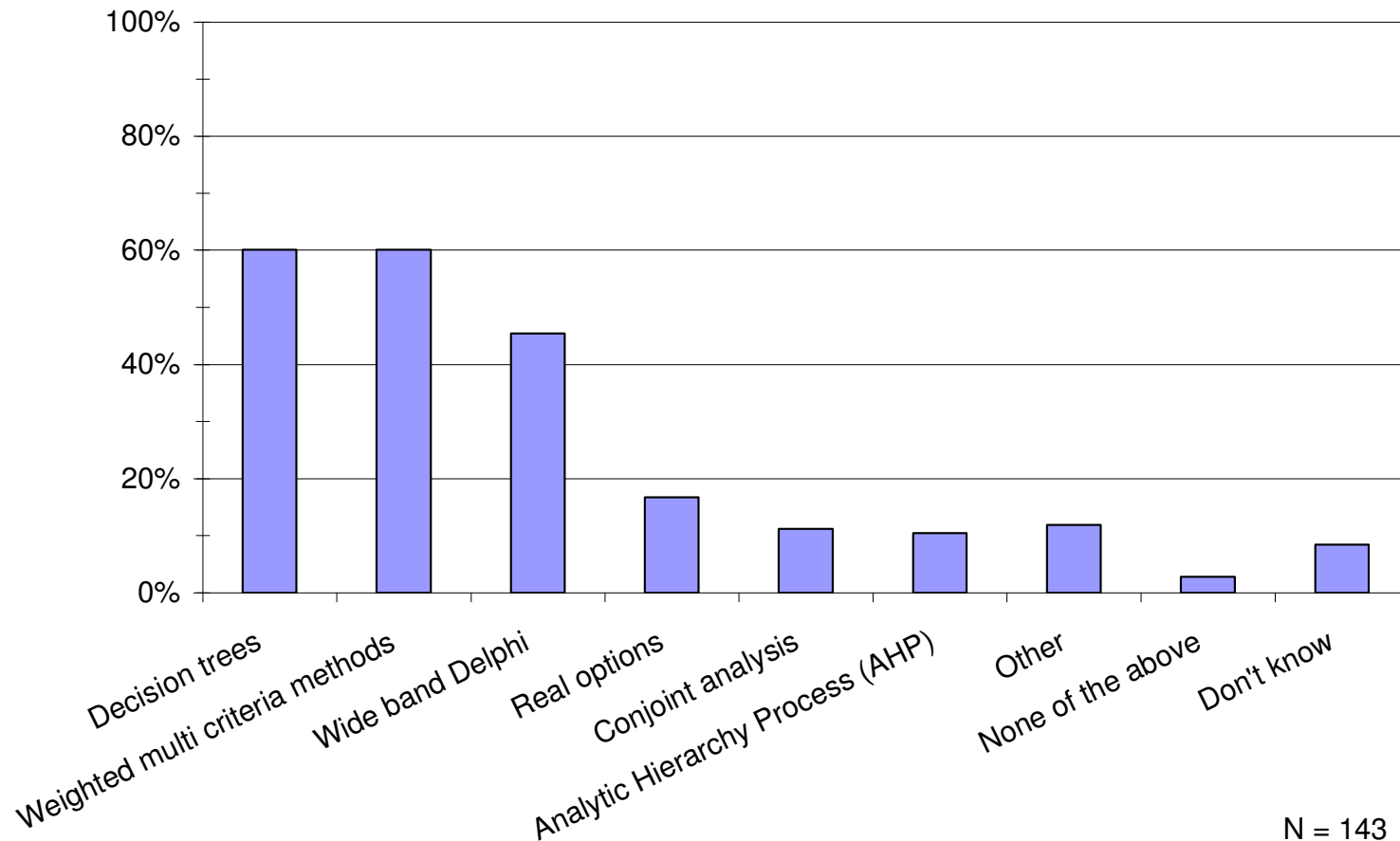
Methods still used less often

But the value that can be added seems to be considerable



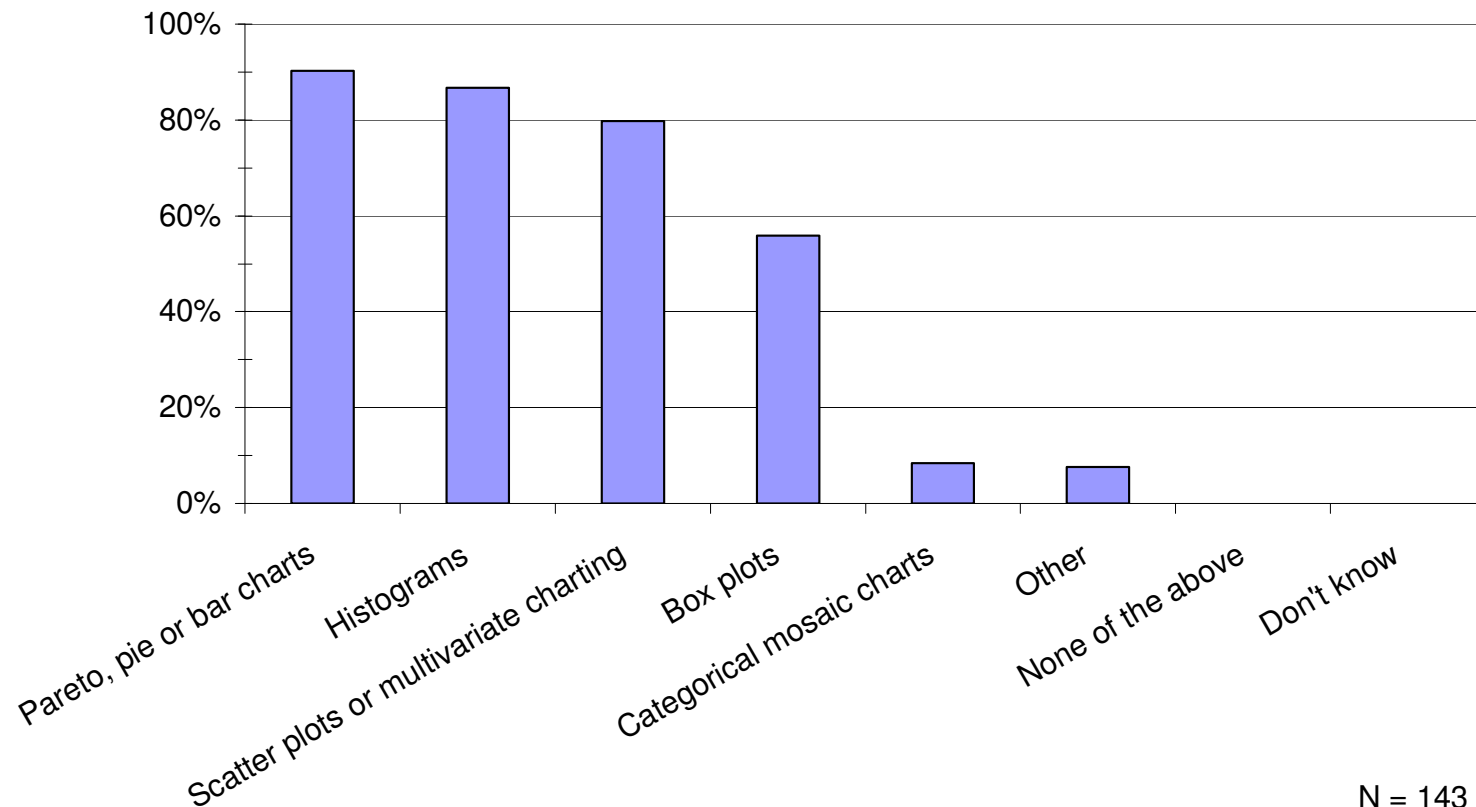
Use of Decision Techniques

Which of these decision techniques are used in your organization?



Use of Visual Display Techniques

Which of the following visual display techniques are used to communicate the results of your organization's analyses of process performance baselines?

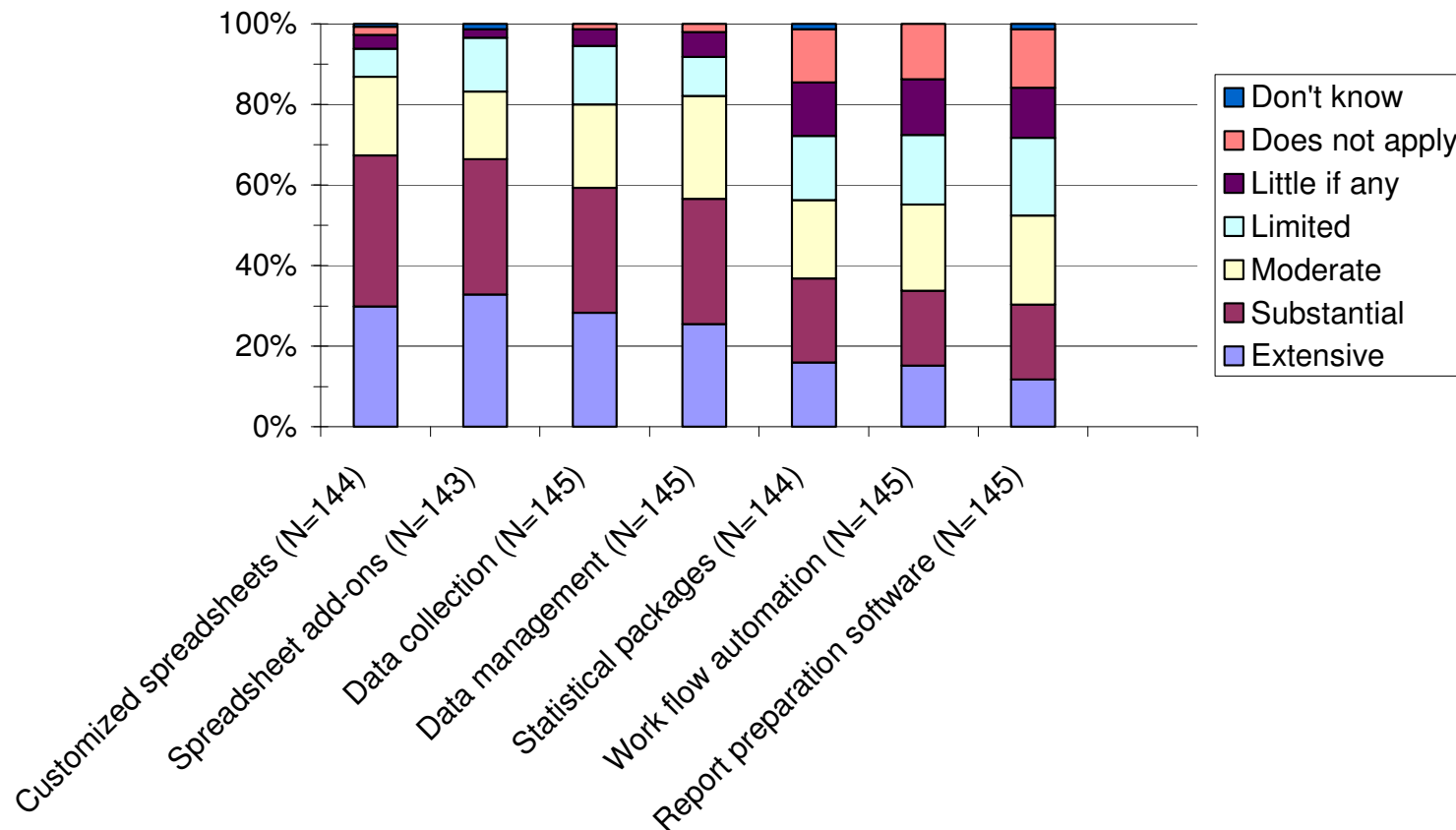


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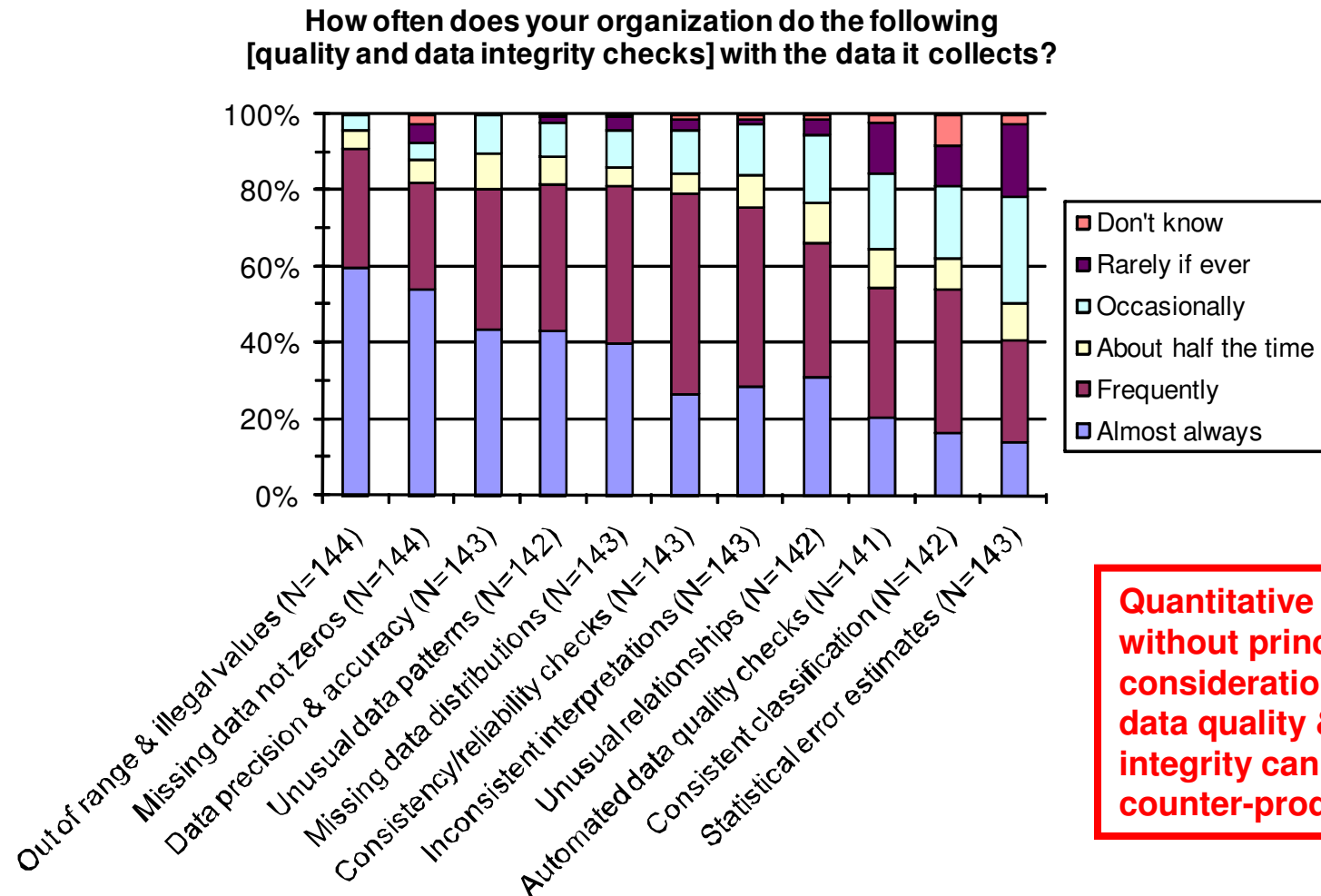


Use of Automated Support for Measurement & Analysis Activities

How much automated support is available for measurement related activities in your organization?



Use of Methods to Ensure Data Quality & Integrity



Root Cause & Hypothesis Testing



Diagnosing Root Cause



Key steps

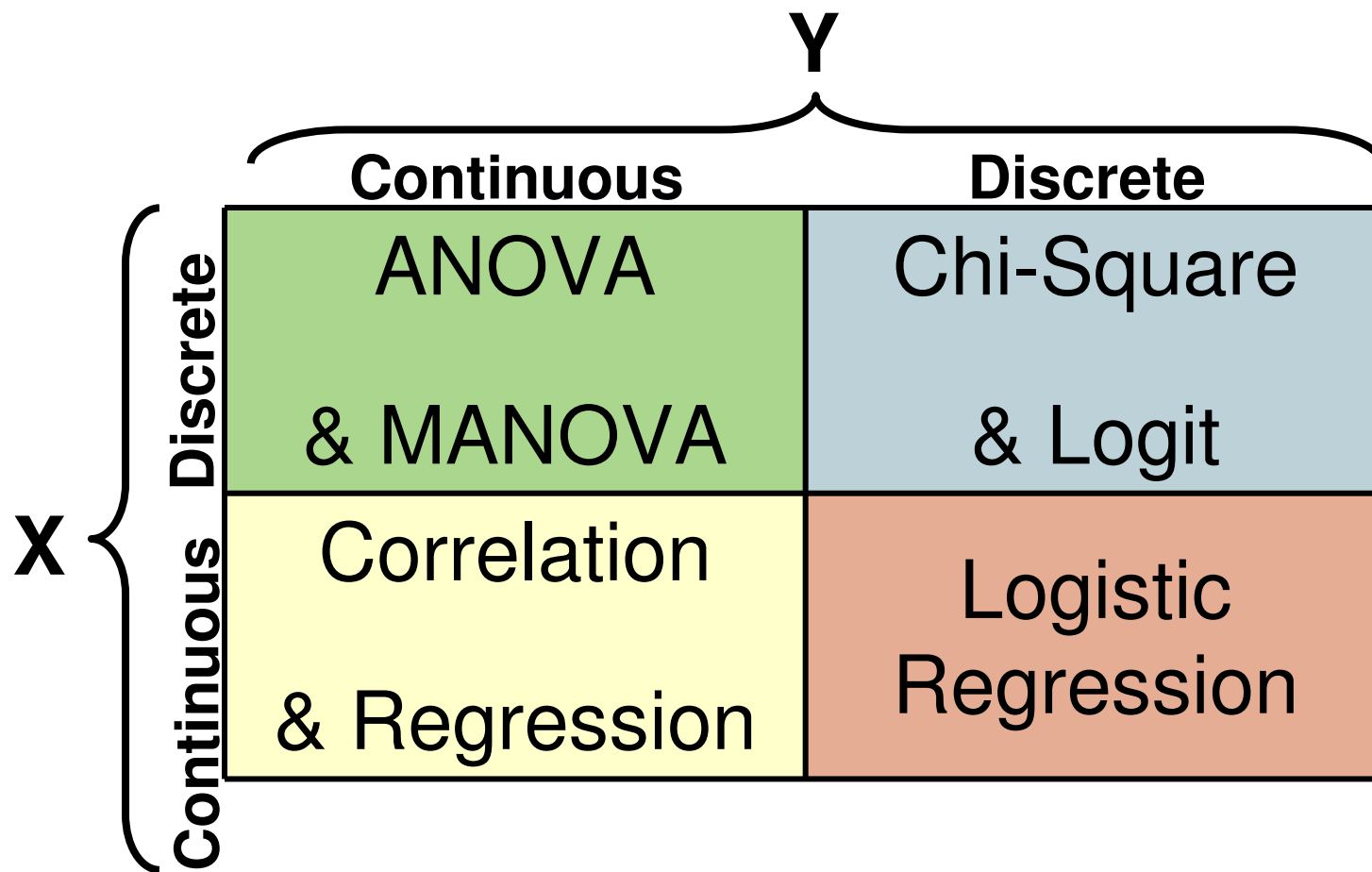
- Generate and organize hypotheses
 - additional data exploration, characterization as needed
- Select hypotheses to test
- Test and evaluate

Generating and organizing lists of hypotheses

- 5 whys (just what it says: keep asking “why”)
- Brainstorming
- PSM Performance Analysis Model
- Diagrams: cause & effect, affinity, tree, interrelationship



Quantifying Relationships



Types of Hypothesis Tests

<i>Data Type</i> →		Interval or Ratio (Parametric Tests)		Ordinal (Non-Parametric Tests)		Nominal	Proportion
		Mean	Variance	Median	Variance/Fit	Similarity	Similarity
<i># Samples (Data Groups)</i> ↓ 1 Sample		1 sample t test	1 sample Chi-Square test	1 sample Wilcoxon Signed Ranks test	Kolmogorov-Smirnov Goodness of Fit test	>2 cells Chi-Square Binomial Sign Test =2 cells	1 Proportions test
	2 Samples	<u>Independent</u> 2 sample t test paired t test <u>Paired</u>	<u>Normal</u> F test Levene test <u>Not Normal</u>	<u>Independent</u> Mann Whitney U test Wilcoxon matched <u>Paired</u>	<u>= Medians</u> Siegel-Tukey test Moses test <u>≠ Medians</u>	Fisher Exact test (1 way ANOVA); Chi-Square test	2 Proportions test
	3+ Samples	ANOVA (1 & 2 way ANOVA; Balanced ANOVA; GLM) MANOVA (General & Balanced)	<u>Normal</u> Bartlett test Levene test <u>Not Normal</u>	<u>Independent</u> Kruskal-Wallis 1 way ANOVA Friedman 2 way ANOVA <u>Paired</u>	Van der Waerden Normal scores test	Chi-Square test	ANOM (Analysis of Means)



Segmentation vs. Stratification



SIX SIGMA ADVANTAGE
The Third Wave™



**What are
some
examples?**

Segmentation (nominal data) –

- grouping the data according to one of the data elements (e.g., day of week, call type, region, etc.)
- gives discrete categories
- in general we focus on the largest, most expensive, best/worst – guides “where to look”

**What are
some
examples?**

Stratification (ordinal data) –

- grouping the data according to the value range of one of the data elements (e.g., all records for days with “high” volume vs. all records with “low” volume days)
- choice of ranges is a matter of judgment
- enables comparison of attributes associated with “high” and “low” groups – what’s different about these groups?
- guides diagnosis



Explaining Alpha Error – 1

		and your decision is to...	
If the null hypothesis is really...		Accept the null	Reject the null
TRUE	TRUE	Correct decision with probability of $1 - \alpha$	Incorrect decision with probability of α Type I error
		Incorrect decision with probability of β Type II error	Correct decision with probability of $1 - \beta = \text{Power}$

Your perspective determines which error type is of the most concern (Type I or Type II error).



Explaining Alpha Error – 2

In court, if the
defendant
is really...

and your decision from hearing the evidence is to...

CONCLUDE INNOCENCE

CONCLUDE GUILT

INNOCENT

Correct decision with
probability of $1 - \alpha$

Incorrect decision
with probability of α

Type I error

GUILTY

Incorrect decision with
probability of β

Correct decision with
probability of $1 - \beta =$
(Power)

Type II error

As the defendant, which error type is more tolerable?
As the prosecutor?

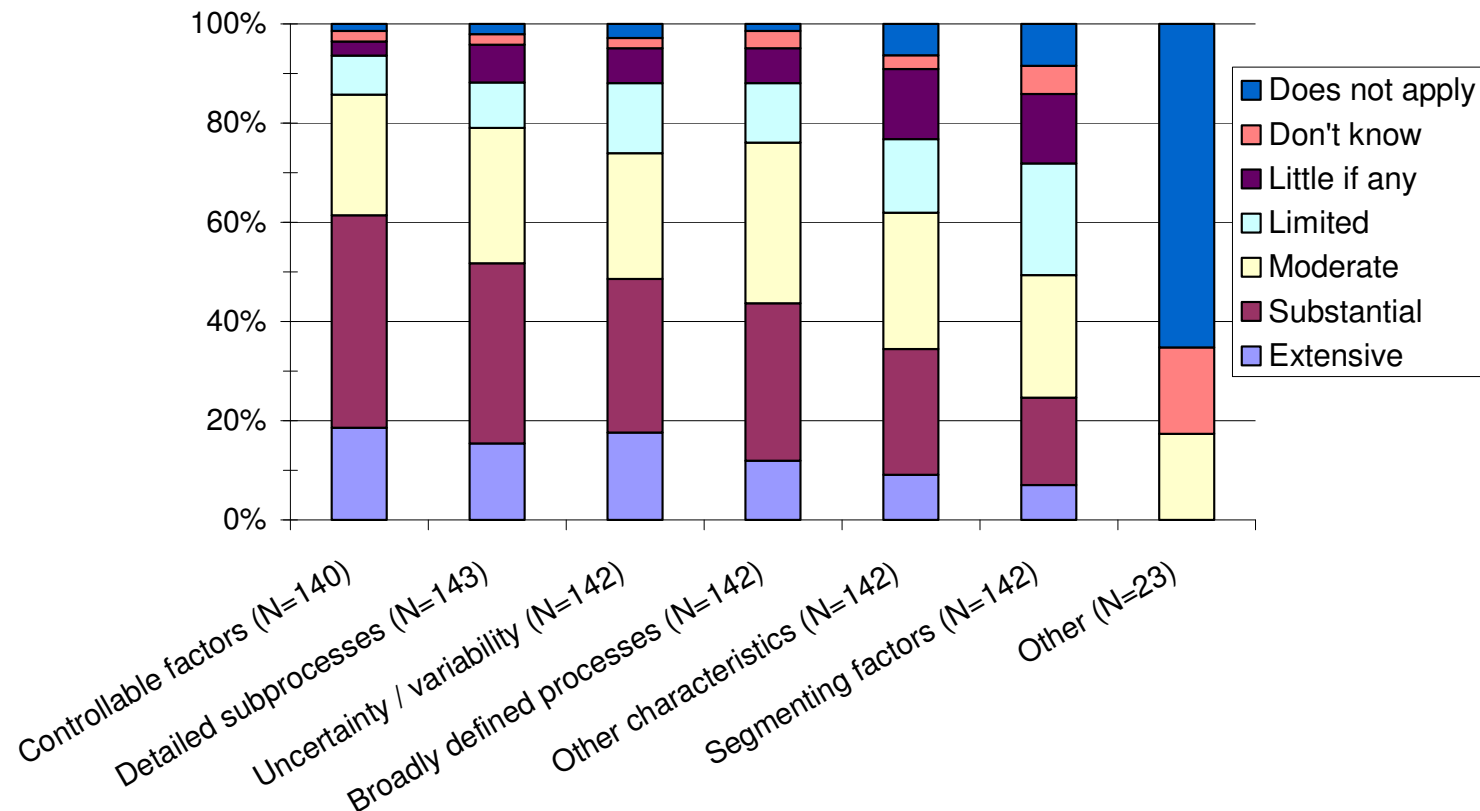


Modeling Approaches



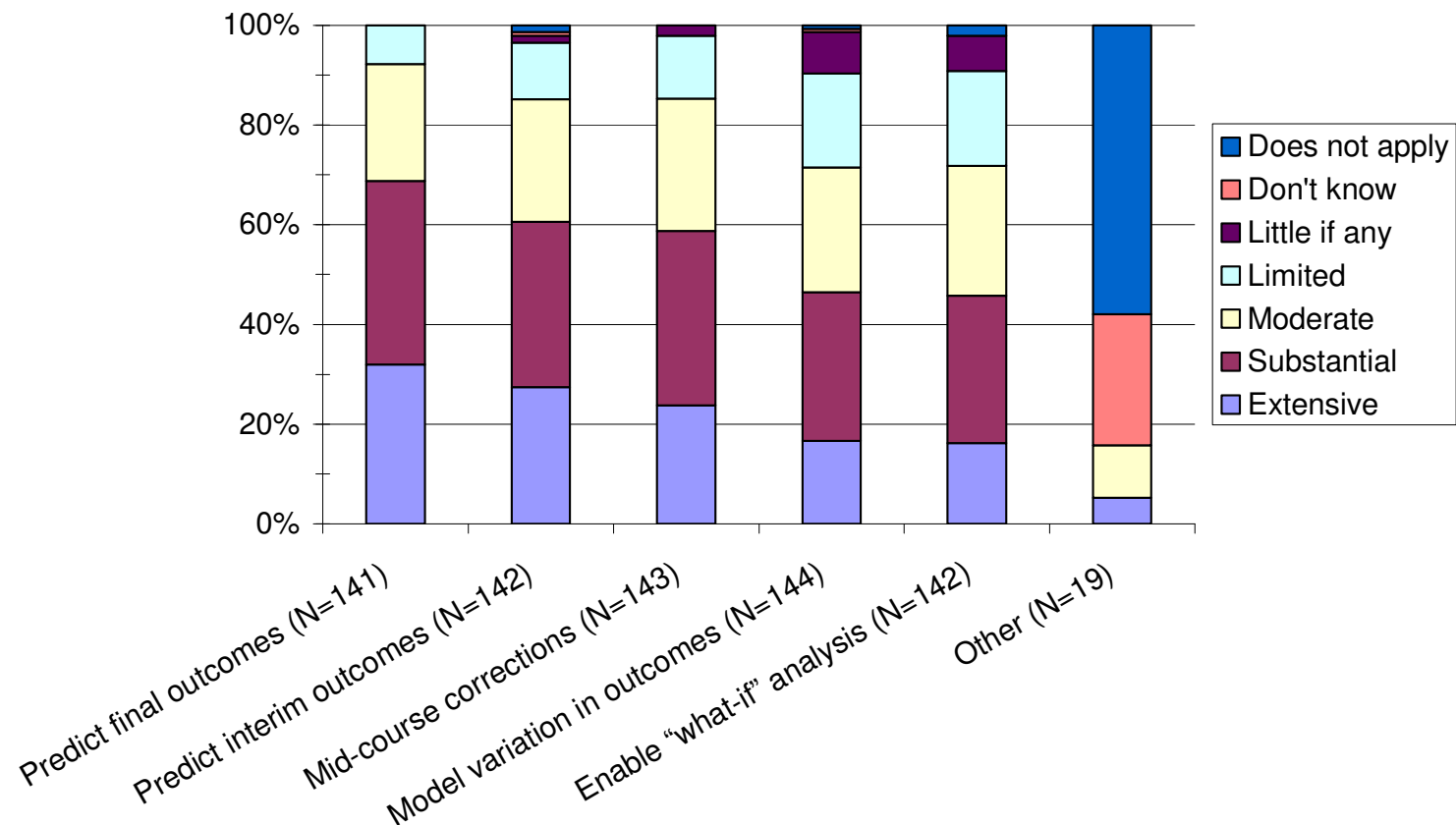
Emphasis on “Healthy” Process Performance Model Ingredients

How much emphasis does your organization place upon the following in its process performance modeling?



Use of “Healthy” Process Performance Model Ingredients

To what degree are your organization's process performance models used for the following purposes?



Use of Exemplary Modeling Approaches

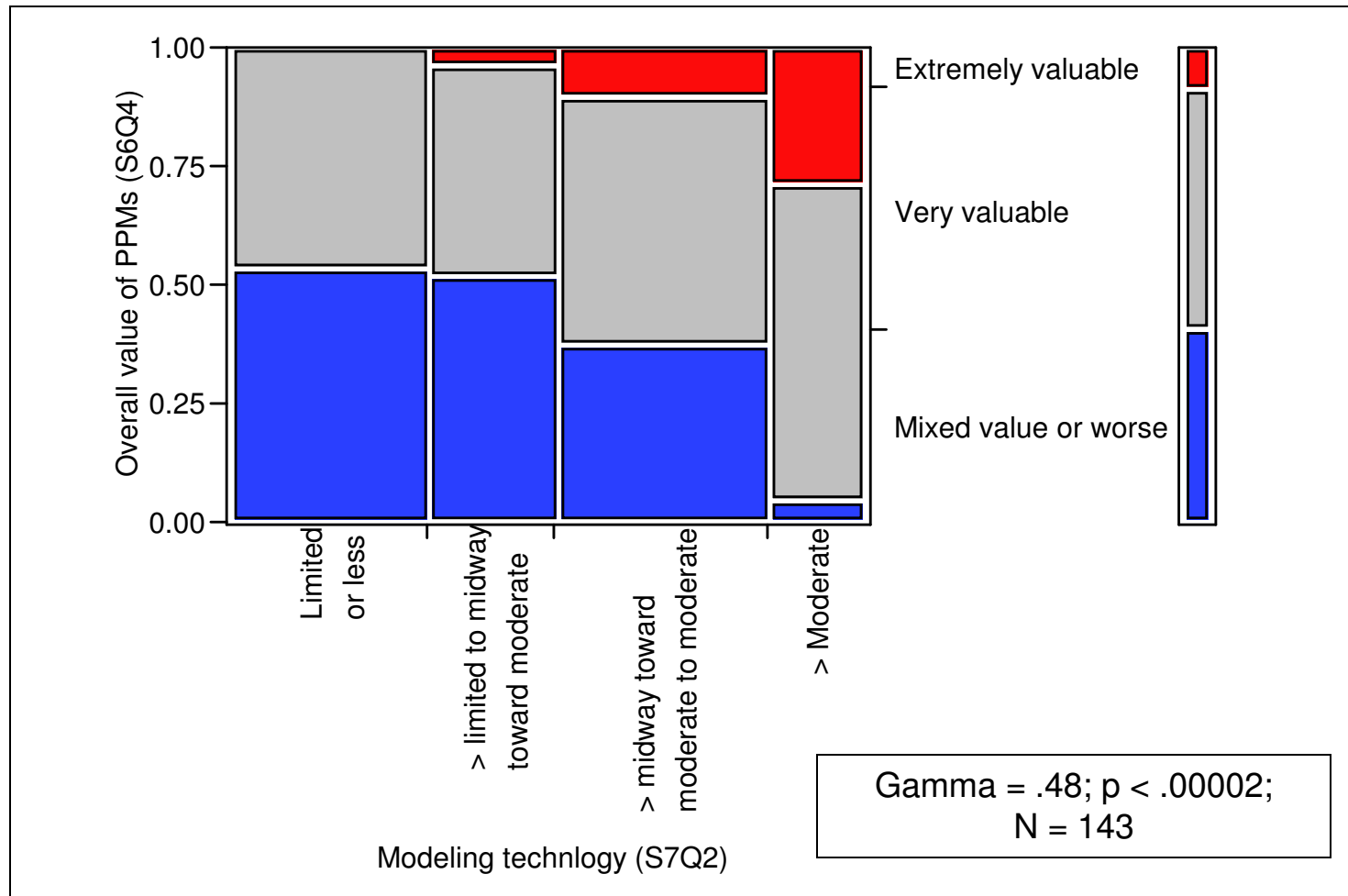
Including:

- We have trouble doing process performance modeling because it takes too long to accumulate enough historical data.
- We thought we knew what was driving process performance, but process performance modeling has taught us otherwise.
- We use data mining when similar but not identical electronic records exist.
- We do real time sampling of current processes when historical data are not available.
- We create our baselines from paper records for previously unmeasured attributes.

Relatively little use, but apparent payoff when used – Gamma = .48



Use of Exemplary Modeling Approaches & Overall Value Attributed to Process Performance Models



More Examples



Estimation Using Monte Carlo Simulation

What is Monte Carlo simulation?

Monte Carlo uses random numbers and probability statistics to execute a simulation model repeatedly.

- used, e.g., to assess project management risks related to schedule and quality

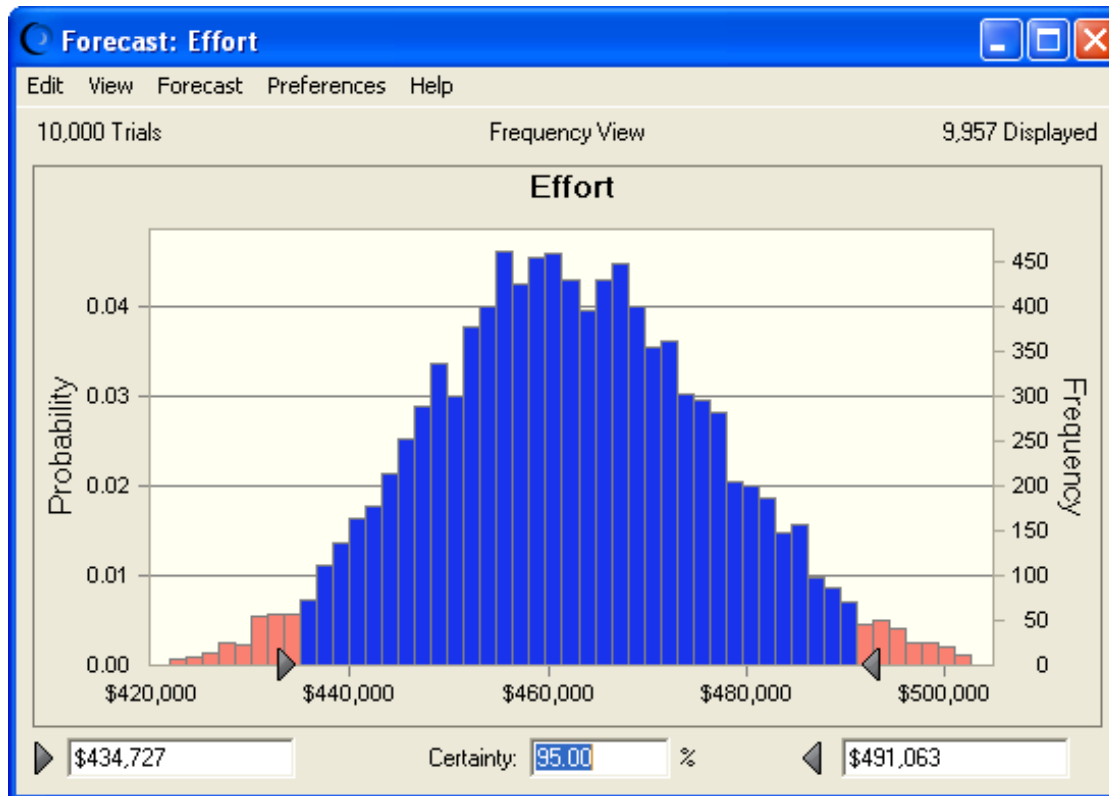
Benefits

Monte Carlo simulation

- allows modeling of variables that are uncertain (The user can enter a range of values instead of a single value.)
- enables more accurate sensitivity analysis
- analyzes simultaneous effects of many different uncertain variables, creating a more realistic analysis
- eases audience buy-in and acceptance of modeling because values for the uncertain variables are included in the analysis
- establishes confidence levels for outcomes, which supports risk management



Determining Certainty Levels Using Crystal Ball



95% of the trials
centered around
the median of
the entire range

Example from SEI's DPPSS course: printed there with permission of Oracle; Crystal Ball 11.1.1 (Build 11.1.63.0) used to capture the screenshot.

See <http://www.oracle.com/crystalball/index.html>



Discrete Event Simulation

What is it?

- uses a model set of processes and subprocesses to evaluate a process's behavior
- mimics the process's behavior over time. The mathematical and logical relationships of the process constitute the model.
- is based on process descriptions, data, and parameters gathered by studying and/or measuring aspects of the real subprocesses

Used, e.g., to model a proposed process to judge whether an aggressive schedule can be met with specified staffing



Benefits of Using Discrete Event Simulation – 1

Discrete Event Simulation

- provides insight into the nature of a process and its subprocesses, showing
 - complex interactions within or among subprocesses
 - bottlenecks, flows, routing, cycle times
- helps identify characteristics of a process
- helps develop options for process improvement
- can be used to test new concepts prior to implementation, averting many cost and cycle time problems
- provides information to improve the effectiveness of a process
- provides an “insurance policy” for process performance by
 - assisting with risk management
 - helping to identify unusual events and impacts



Benefits of Discrete Event Simulation – 2

- provides the ability to test ideas for improvement or to test a new design using “what-if” scenarios. Specifically,
 - key metrics can be viewed
 - changes can be quantified prior to implementation
 - substantial ROI can be achieved
 - design alternatives can be evaluated inexpensively
- is a powerful tool for communication and presentation that
 - enables animation and graphical reporting of key metrics
 - uses real-world data for arrival patterns, processing times, and resource availabilities
 - allows users to see what they would often miss by employing time compression and dilation



Objects Used to Build a Process Model

Entities – the items or people being processed (e.g., products, documents, customers)

Resources – the agents used to perform activities and move entities (e.g., service personnel, operators, or equipment)

Activities – the tasks performed on entities (e.g., assembly, document approval, customer checkout)

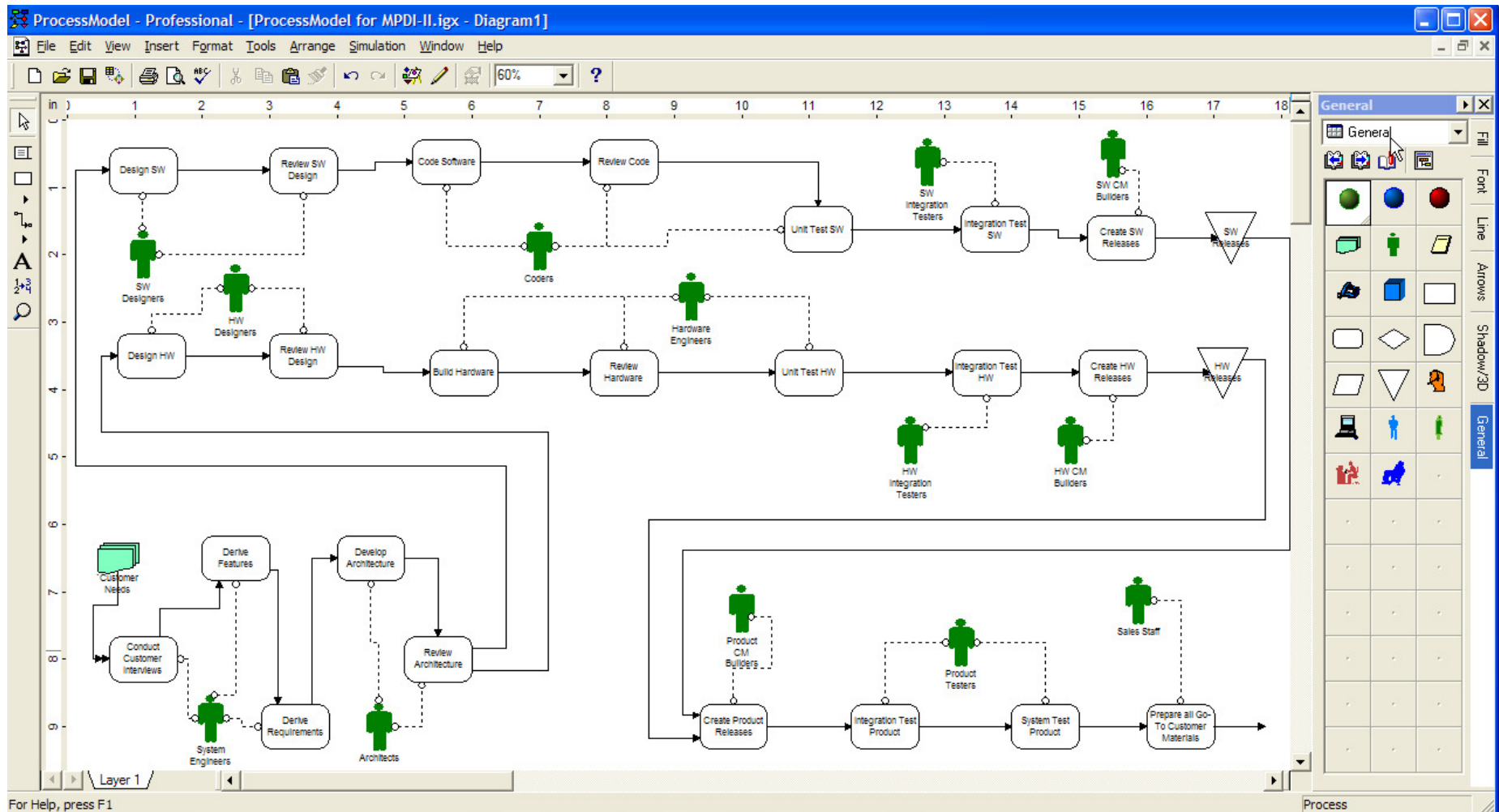
Connections – the lines connecting the graphic shapes

Storages – locations where entities can wait or be held until further processing (e.g., waiting areas, stock places)



Project Process Model

Screenshot from *ProcessModel*, Version 5.3; <http://www.processmodel.com>
Approved for use in SEI DPPSS course by
Scott Baird, President, ProcessModel, Inc.



For Help, press F1

Process



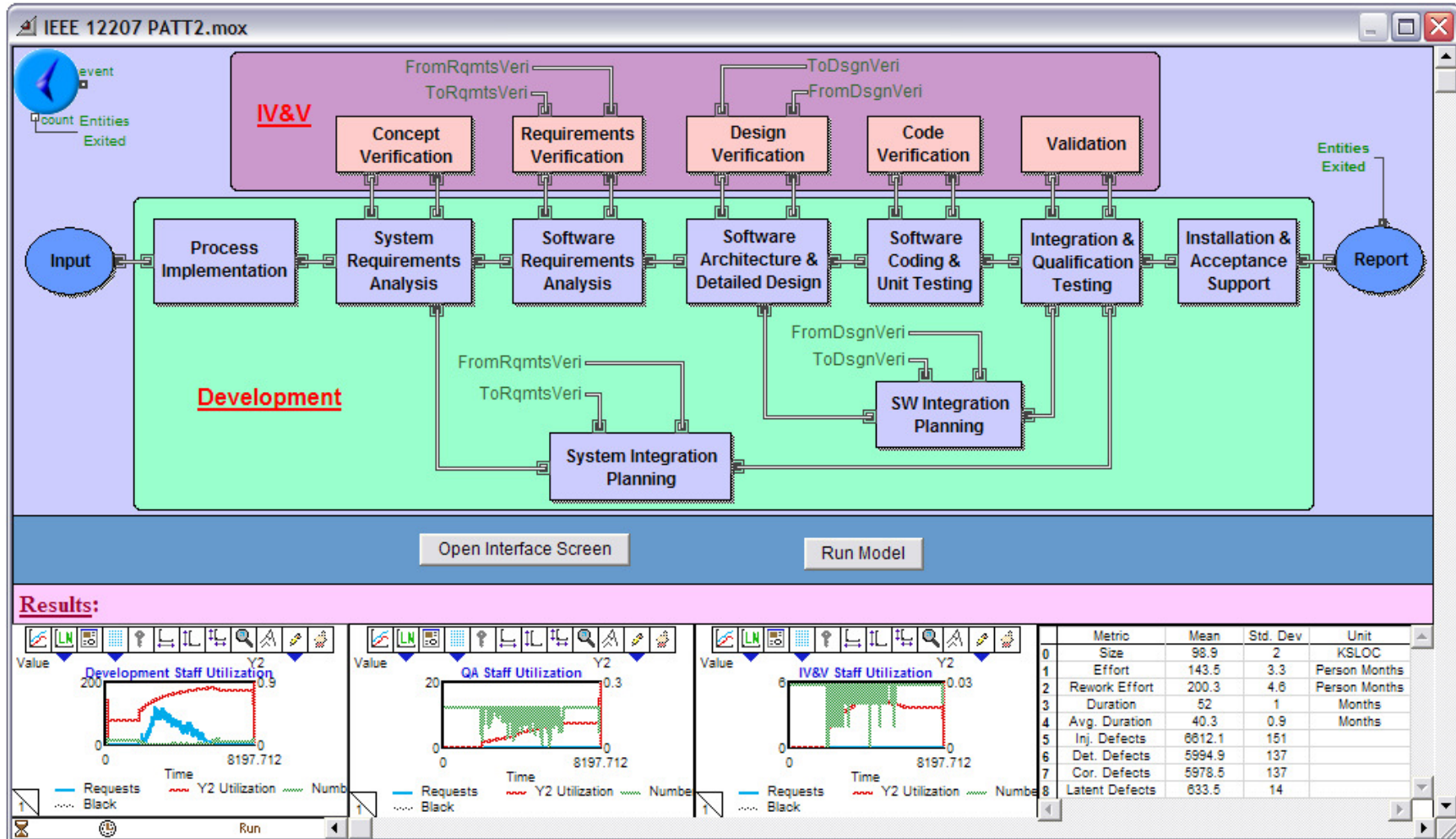
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23 June 2009
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NASA Model – IEEE 12207 Software Development Lifecycle



Reference for Advanced Modeling Tool with Inventory of Pre-Populated Subprocesses

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SEI Technical Report published in 2007 by David Raffo, *Moving Up the CMMI Capability and Maturity Levels Using Simulation*, CMU/SEI-2008-TR-002, <http://www.sei.cmu.edu/publications/documents/08.reports/08tr002.html>



Using Design of Experiments

Design of experiments (DOE) can be used in many ways, including notably to:

- enable confident piloting prior to fuller deployment
- identify and collect a sample of data (x factors and a y outcome), enabling the determination of a quantified, predictive relationship between the x factors and the y outcome.

In particular, “fractional factorial” experimental designs can be used to identify predictive relationships with a very small set of data.

- efficiently using only a subset of the combinations of the various factors

Designed experiments are most commonly used for product design

- but they also can be used to develop process performance models

DOE (& Response Surface Methodology) can be used by practitioners without the need to fully understand the underlying theory and equations.



Software Reliability Growth Models

Tracking reliability growth allows you to

- know test progress
- estimate and stabilize product quality
- decide whether to accept or reject a product
- decide whether or not to release a product
- estimate maintenance cost of removing remaining failures

See Handbook of Software Reliability Engineering for more detail

- <http://www.cse.cuhk.edu.hk/~lyu/book/reliability/>



Agenda

A summary of analytical techniques ... Commonly used & otherwise

- Frequency of use in high maturity organizations
- Some useful ones to consider
- Interspersed with ...



Your experience & expertise

- ***With these & other techniques & approaches***
- ***What else you want / need to do in your own work***
- ***Implementation Issues***

Next steps



Your Experience & Lessons Learned

What analytical techniques have proven useful?

Your needs now & in the future

- What obstacles have you faced?
- What's been tried and not useful?

What about quantifying Voice of the Customer & other qualitative methods...?



Implementation Issues: Facilitating Adoption & Institutionalization

What does it take to make it happen?

Alignment with business & technical information needs

- Buy-in at all levels
- Avoiding tension between upper management & program goals

Foster management understanding & promote information ownership

- Need senior managers who get it ... & are engaged in the analysis
- With support from measurement experts *who know the domain* (e.g., six sigma master black belts)

What else?



Agenda

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Next steps



What's Next?

1. Respond to our state of the measurement & analysis practice surveys
 - A little self serving, but...
2. Your participation in twice yearly series of SEI high maturity measurement & analysis workshops
3. Presentations at PSM, CMMI Technology, SPEG & other conferences
4. A PSM white paper(s)
5. Other publications
6. Other ideas?



Thank You for Your Attention!

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