Tools Supporting CMMI High Maturity for Small Organizations

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Agenda

Why This Workshop?

Reminder of CMMI Process Performance Models and Baselines

Key Usage of Models and Baselines

Contrasting Large vs Small Organizational Settings:

- Origination of Models
- Staffing Model Development
- Method to Build Models
- Accessing Enough Data
- Data Collection and Storage
- Analytical Tool Choices by Topic
- Interpreting and Documenting Results
- Use in CAR Process Area
- Use in OID Process Area
- Importance of the DAR Process Area

Next Steps

Why This Workshop?

CMMI High Maturity Practices using process performance models and baselines have generally had more practice in large organizations and large projects

However, there are appropriate and business-value added uses and approaches in small settings that should be discussed

This workshop will provide the necessary insight to apply these CMMI High Maturity models and baselines including brief discussion on tools and techniques

Caveat

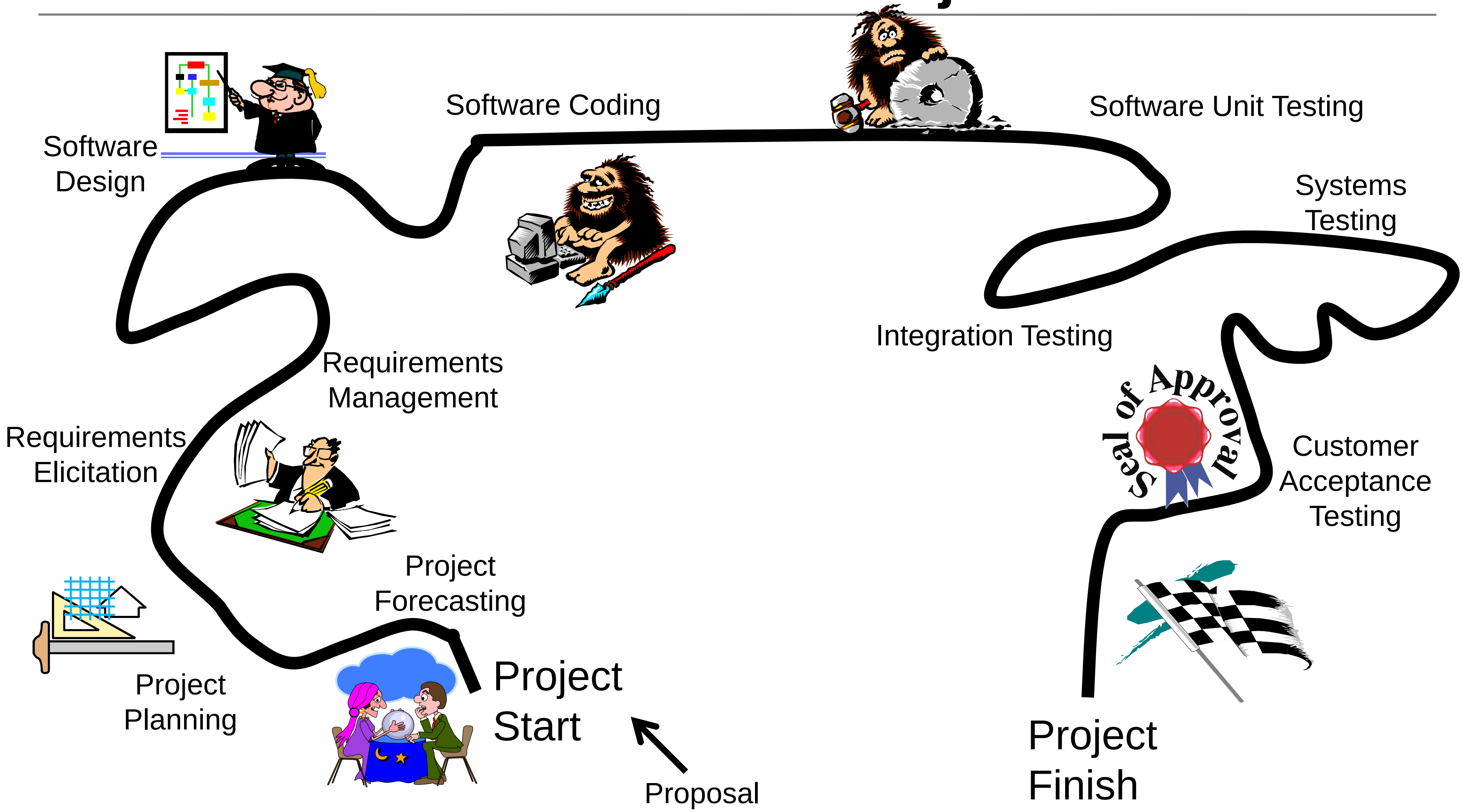
The noted contrasts in this workshop are noted in general terms and are not absolute.

In fact, many of these contrasts may not exist for a given comparison of a large and small setting.

A small setting in this workshop refers to a project of 3-9 months and of 3-10 staff.

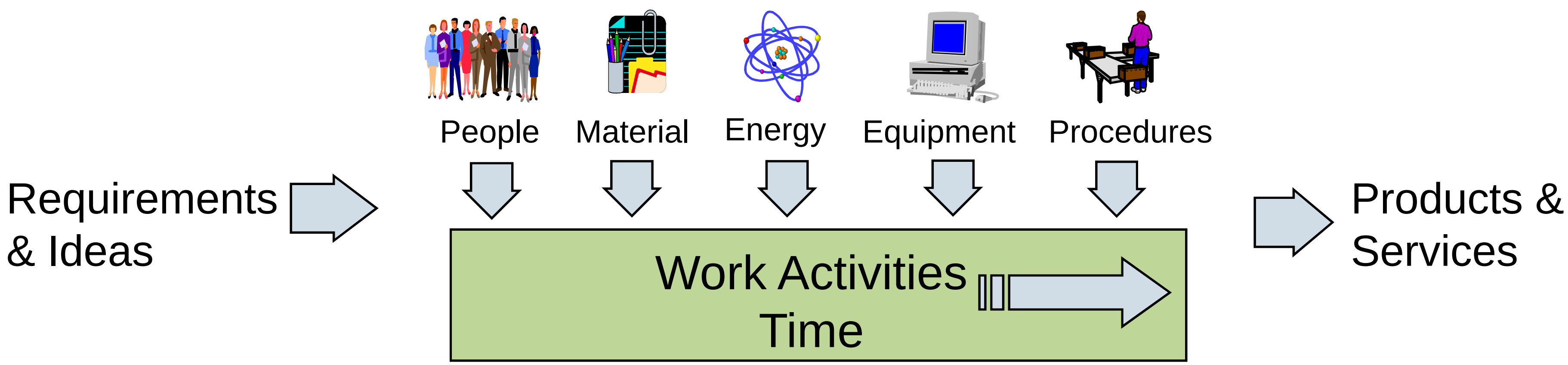
REMINDER OF CMMI PROCESS PERFORMANCE MODELS AND BASELINES

When and Why Do We Need Process Performance Models at the Project Level?



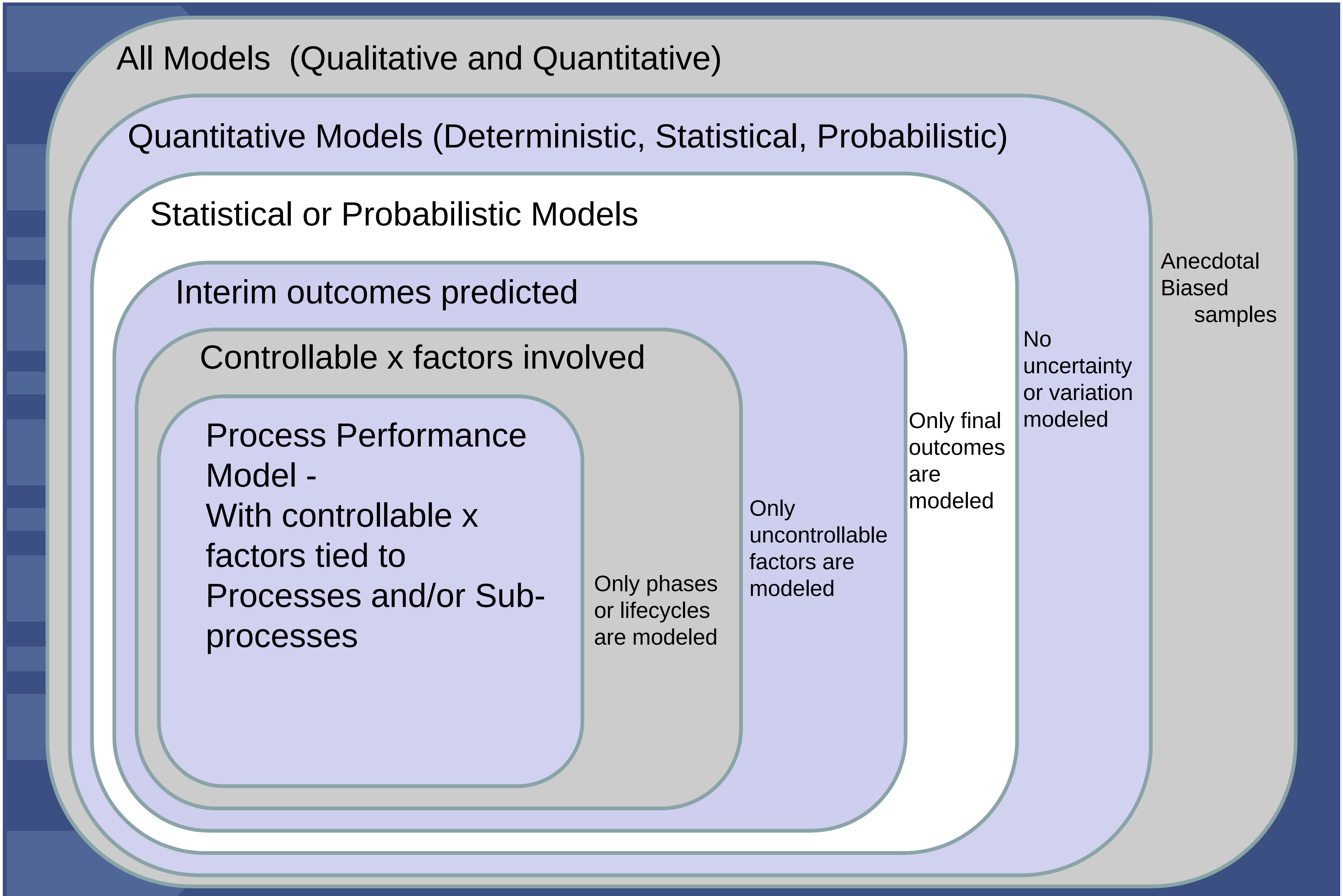
Process Performance Models View Processes Holistically

Processes may be thought of holistically as a system that includes the people, materials, energy, equipment, and procedures necessary to produce a product or service.



Healthy Ingredients of CMMI Process Performance Models

1. Statistical, probabilistic or simulation in nature
2. Predict interim and/or final project outcomes
3. Use controllable factors tied to sub-processes to conduct the prediction
4. Model the variation of factors and understand the predicted range or variation of the outcomes
5. Enable "what-if" analysis for project planning, dynamic re-planning and problem resolution during project execution
6. Connect "upstream" activity with "downstream" activity
7. Enable projects to achieve mid-course corrections to ensure project success


All Models (Qualitative and Quantitative)
Quantitative Models (Deterministic, Statistical, Probabilistic)
Statistical or Probabilistic Models
Interim outcomes predicted
Controllable x factors involved
Process Performance Model - With controllable x factors tied to Processes and/or Sub-processes
Only phases or lifecycles are modeled
Only uncontrollable factors are modeled
Only final outcomes are modeled
No uncertainty or variation modeled
Anecdotal Biased samples

KEY USAGE OF MODELS AND BASELINES

A Non-Exhaustive List of Model Uses

To predict outcomes during project planning and replanning

To predict outcomes during real-time project execution similar to a "what-if" mode

To predict outcomes related to a potential process improvement as an aid in deciding what improvement to make

To predict an expected outcome to be used to evaluate the effect of an implemented change

To screen improvement ideas without the need to pilot every idea in your setting before deciding to further pursue

To enable project managers to make mid-course corrections of projects headed for trouble

To statistically manage processes using prediction intervals from models

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

ORIGINATION OF MODELS

Origination of Models

Large Settings

- Inspiration for models comes primarily from Strategic Planning and annual Business Goal Setting
- Engineering Process Groups may also initiate models as needed
- Senior Technologists may initiate models to address product risk

Small Settings

- Inspiration for models derived from direct customer interactions and needs, and real-time business risks
- Generally a bottom-up approach with team review and usage
- Individuals may create personal models for their own use

Group Exercise #1 (10 minutes)

Within your group, share ideas on **what events would trigger** your small organization/project to build a process performance model

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

STAFFING MODEL DEVELOPMENT

Staffing Model Development

Large Settings

- Dedicated individuals, if not entire teams, resourced to build models at request of Senior and Middle Managers
- Staff generally trained in model development via internal training curriculum
- Some experienced model builders hired externally

Small Settings

- Several or many members of project knowledgeable in basic modeling
- Generally, a bottom-up approach with team review and usage
- Staff receive training externally
- Occasionally, a temporary contractor may be hired

Group Exercise #2 (10 minutes)

Within your group, share ideas on **staffing approaches** that your small organization/project would most likely use to build a process performance model

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

METHOD TO BUILD MODELS

Core Steps of Model Development

1. Identify business need or risk that demands a process performance model
2. Identify model build team
3. Identify performance outcome "y"
4. Identify the initial set of plausible "x" factors that influence the outcome "y" using basic root cause analysis
5. Collect historical or real-time samples of data
6. Ensure data quality and acceptably low measurement error
7. Construct performance baselines for all "y's" and "x's"
8. Determine data types and select proper analytical methods
9. Develop a regression equation, probabilistic model or simulation
10. Sanity test the model
11. Develop predictions and act!
12. Update models as needed

Method to Build Models

Large Settings

- Generally, process improvement teams follow a structured process, similar to Six Sigma DMAIC, to develop the models
- Model development passes thru management review gates to ensure a successful model

Small Settings

- A streamlined process for model development is followed
- The process may be quite informal and executed by a single person
- Generally takes less time
- Generally, possesses less documentation as the author is the only user

Group Exercise #3 (10 minutes)

Within your group, share experiences that you have in **building prediction models** in your small organizational/project settings. Briefly share your approach disregarding how informal it might have been.

Record your group experiences on your group flip pad

Prepare to share with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

ACCESSING ENOUGH DATA

Accessing Enough Data

Large Settings

- Large amounts of historical data sitting around possibly not being used
- Requests for new data fields very difficult as organization has a bureacratic process to handle new requests
- The organization is reluctant to change data fields

Small Settings

- Normally very little historical data
- Historical data unique and dependent to individuals
- Normally real-time sampling of data occurs
- Easy to collect new fields with almost no approval
- May need to collect data across projects

Group Exercise #4 (10 minutes)

Within your group, share ideas on **how you have accessed measurement data** in your small organizational/project settings and what you have done when you did not have enough data points from the current project

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

DATA COLLECTION AND STORAGE

Data Collection and Storage

Large Settings

- Data collected from massive workflow automation systems
- Data automatically shared across databases with highly centralized databases accessible to model builders
- Mature data entry screens catching input errors

Small Settings

- Paper records
- Excel spreadsheets, possibly shared on a network drive
- Data manually collected by many, if not most, project members
- Variability in data format, integrity, quality, timeliness

Group Exercise #5
(10 minutes)

Within your group, share experiences you have with **data collection and storage issues** in your small organizational/project setting. Describe the actions you took to prevent or mitigate these issues.

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

ANALYTICAL TOOL CHOICES BY TYPE

Analytical Tool Choices by Type

Large Settings

- Expensive, network shared, possibly enterprise-wide analytical tools
- Purchased on a volume discount sometimes reaching 1% of normal license fees
- Conflict exists as the organization mandates a standard tool to use

Small Settings

- Individual licenses pursued if fit in the budget
- Desire to find freeware if possible
- Excel platform desired
- Single licenses of expensive tools shared among team with default user
- Variety of tools in use

Developing Correlation and Regression Models

X \ Y	Continuous	Discrete
Discrete	ANOVA & Dummy Variable Regression	Chi-Square & Logistic Regression
Continuous	Correlation & Simple Regression	Logistic Regression

Example Tool Choices Follow

The following slides depict example tools by analytical method.

<u>This is not an endorsement by the SEI for any particular tool</u>, but rather is meant to stimulate awareness and investigation into tools that can make these methods practical

A wide variety of commercially-available tools now exist and you should conduct a thorough investigation before deciding on a solution

Recognize that CMMI High Maturity organizations will leverage the concepts of the DAR Process Area to decide on an appropriate solution for their organization

Statistical Package Tools – Examples

Statistics Software on the Internet

Statistical software listed by the American Statistical Association (No endorsements; listings only)

http://www.amstat.org/profession/index.cfm?fuseaction=software

CMU Statlib: data, software and news from the statistics community

http://lib.stat.cmu.edu/lib.stat.cmu.edu/

Free statistical software (no endorsements)

http://statpages.org/javasta2.html

Where to Get Statistics Help on the Internet

Electronic Statistics Textbook

http://www.statsoftinc.com/textbook/stathome.html

WWW Virtual Library of Statistics

http://www.stat.ufl.edu/vlib/statistics.html

Online Introductory Statistics Textbook

http://davidmlane.com/hyperstat/

The Little Handbook of Statistical Practice

http://www.tufts.edu/%7Egdallal/LHSP.HTM

A New View of Statistics

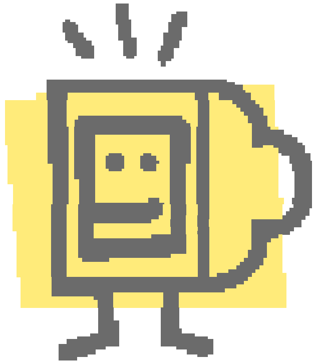
http://www.sportsci.org/resource/stats/index.html

American Statistical Association

http://www.amstat.org/index.cfm?fuseaction=main

NIST/SEMATECH e-Handbook of Statistical Methods

http://www.itl.nist.gov/div898/handbook/



Monte Carlo Simulation Tools – Examples

http://www.palisade.com/trials.asp

@RISK

The world's most powerful risk analysis tool. Take into account all possible scenarios using Monte Carlo simulation. Work directly in Excel, create presentation-quality graphs, use distribution fitting, and more!

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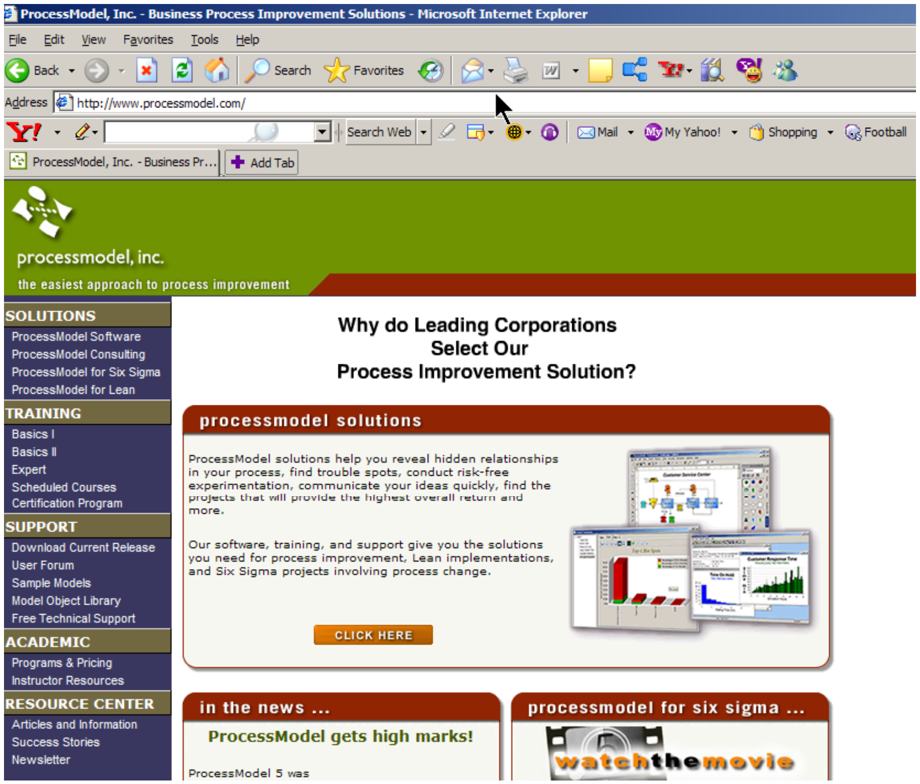
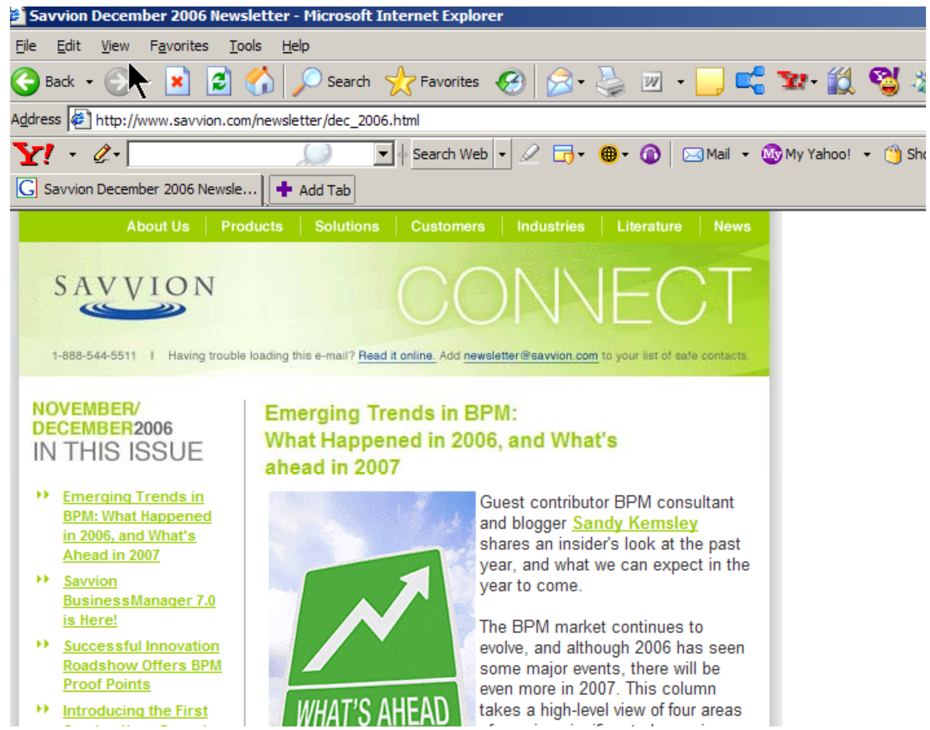
Discrete Event Simulation Tools – Examples

http://www.processmodel.com



http://www.savvion.com



Probabilistic Modeling Tools – Examples

"AGENARISK" http://www.agena.co.uk/

"NETICA" http://www.norsys.com/

"HUGIN" http://www.hugin.com/

Reliability Growth Modeling Tool – Example

http://www.openchannelfoundation.org/projects/CASRE_3.0/

Not Logged In | Secure Login | New User

OPEN CHANNEL FOUNDATION
PUBLISHING SOFTWARE FROM ACADEMIC & RESEARCH INSTITUTIONS

Quick Application Search:

Search

CASRE 3.0

Foundation :: Reliability Analysis :: CASRE 3.0

Get this title!
- Get CASRE 3.0
- Monitor new releases

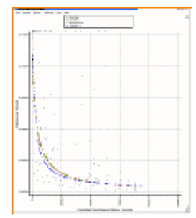
Basic information
- CASRE 3.0 Forum
- Contributors
- History
- Support

Additional resources
- Sample output
- System requirements and installation instructions

CASRE 3.0 GET IT!

Computer Aided Software, Version 3

Total downloads from Open Channel to date: 737



Moderators:
Allen Nikora

CASRE (Computer Aided Software Reliability Estimation) was developed as a software reliability measurement tool that is easier for nonspecialists in software reliability engineering to use than many other currently-available tools. CASRE incorporates the mathematical modeling capabilities of the public domain tool SMERFS (Statistical Modeling and Estimation of Reliability Functions for Software), and runs in a Microsoft Windows environment.

The command interface is menu driven; enabling and disabling of menu options guides users through the selection of a set of failure data, execution of a model, and analysis of model results. Input to the models is simultaneously displayed as text and as a high-resolution display that can be controlled to let users view the data in several different ways (e.g., time between successive failures, cumulative number of failures). Model predictions and statistical evaluations of a model's applicability (e.g., prequential likelihood ratio, model bias, bias trend) may be superimposed on the plot of the data used as input to the model. CASRE also incorporates earlier findings - that prediction accuracy may be increased by combining the results of several models in a linear fashion. Users can define their own model combinations, store them as part of the tool's configuration, and execute them in the same way as any other model.

Group Exercise #6 (10 minutes)

Within your group, share notes on **what analytical tools are used or would most likely be used** in your small organizational/project setting

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

INTERPRETING AND DOCUMENTING RESULTS

One Comparison

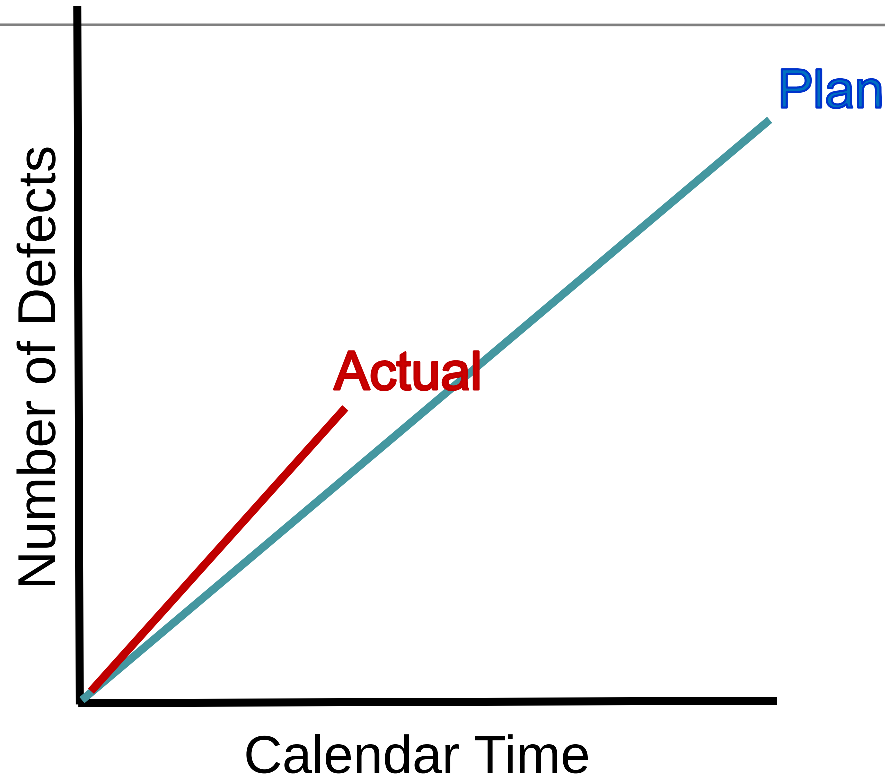
Measures	Score
Cost Variance	
Schedule Variance	
Milestones	
Cumulative Defect Density from Inspections	
Cumulative Defect Density from Testing	

Having only these lagging Indicators is less effective than…

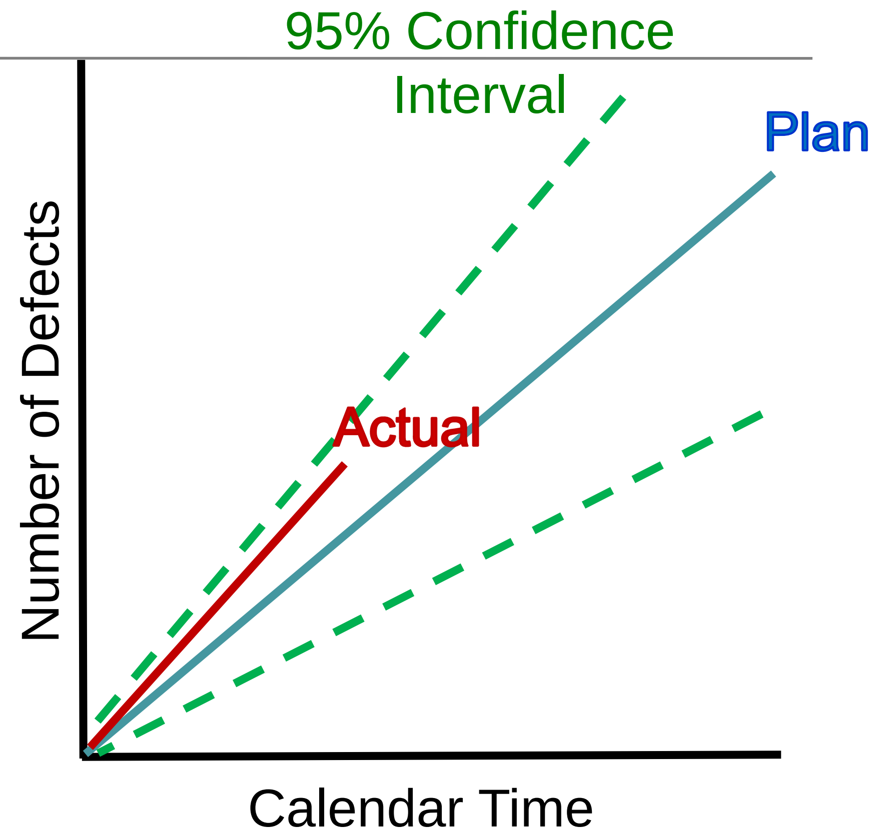
Measures	Score
Resolution Time of Technical Inquiries	
Requirements Volatility	
Staff Turnover	
Average Domain Experience of team	
Complexity Values of the Architecture	
Instability of key interfaces	
Code Coupling and Cohesion	
Degree of Testable Requirements	
Stability of Test Environment	
Brittleness of Software	

Having these additional leading Indicators!

A Second Comparison

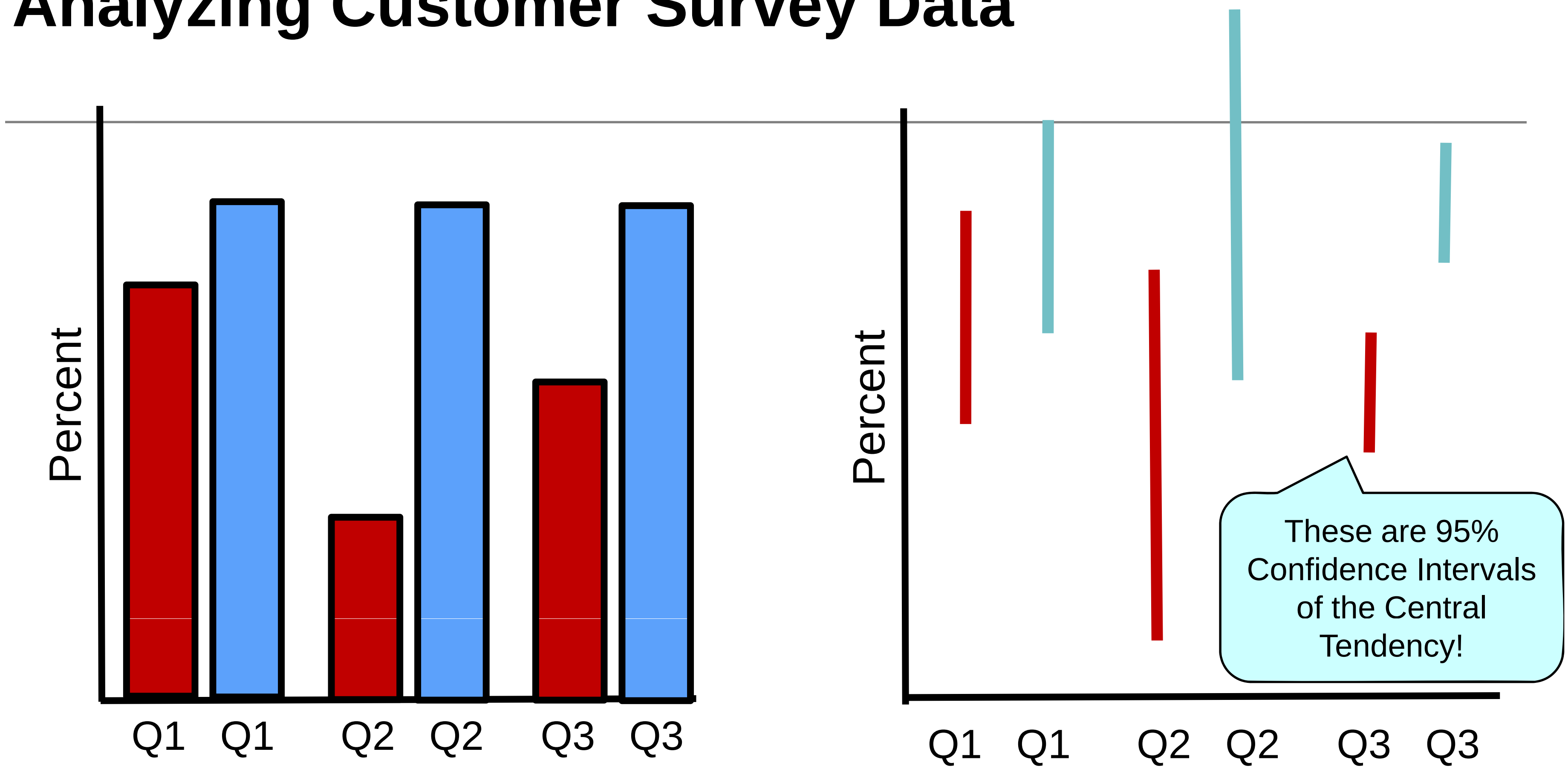


Traditional management review would conclude that corrective action is needed…



while management in High Maturity organizations understand that corrective action is not needed!

Analyzing Customer Survey Data



Traditional analysis reacts to any perceived differences in average percentage results…

while management in High Maturity organizations understands that only statistically significant differences matter!

Details of the Requirements Phase PPM

The outcome, Y, is the predicted number of Requirements defects for a given feature team

The x factors used to predict the Requirements defects are:

x1: Req’ts Volatility (continuous data)

x2: Risk of Incomplete Req’ts (nominal data)

x3: Risk of Ambiguous Req’ts (nominal data)

x4: Risk of Non-Testable Req’ts (nominal data)

x5: Risk of Late Req’ts (nominal data)

Development of the Req'ts Phase PPM

Prediction Expression

$$
\begin{aligned}
&7.5937439072846 \\
&+32.8600305113136 * \text{Volatility} \\
&+\text{Match}\left(\text{RiskofIncompleteness}\right)\begin{pmatrix} \text{"0"} \Rightarrow -0.2406507338728 \\ \text{"1"} \Rightarrow 0.24065073387281 \\ \text{else} \Rightarrow . \end{pmatrix} \\
&+\text{Match}\left(\text{RiskofAmbiguity}\right)\begin{pmatrix} \text{"0"} \Rightarrow -0.0312842155195 \\ \text{"1"} \Rightarrow 0.03128421551947 \\ \text{else} \Rightarrow . \end{pmatrix} \\
&+\text{Match}\left(\text{RiskofNonTestability}\right)\begin{pmatrix} \text{"0"} \Rightarrow 0.00179694498247 \\ \text{"1"} \Rightarrow -0.0017969449825 \\ \text{else} \Rightarrow . \end{pmatrix} \\
&+\text{Match}\left(\text{RiskofLateReqts}\right)\begin{pmatrix} \text{"0"} \Rightarrow -0.107577311748 \\ \text{"1"} \Rightarrow 0.10757731174804 \\ \text{else} \Rightarrow . \end{pmatrix} \\
&+\text{Match}\left(\text{RiskofUnsafeReqts}\right)\begin{pmatrix} \text{"0"} \Rightarrow 0.16470472563596 \\ \text{"1"} \Rightarrow -0.164704725636 \\ \text{else} \Rightarrow . \end{pmatrix}
\end{aligned}
$$

Details of the Software Brittleness PPM

The outcome, Y, is the measure of software brittleness, measured on an arbitrary scale of 0 (low) to 100 (high), which will be treated as continuous data

The x factors used in this prediction example are the following:

- Unit path complexity
- Unit data complexity
- Number of times the unit code files have been changed
- Number of unit code changes not represented in Design document updates

Development of the Brittleness PPM

Regression Analysis: Brittleness versus PathComplexi, NumOfFileCha, ...

```
The regression equation is
Brittleness = 6.62 + 0.793 PathComplexity + 0.743 NumOfFileChanges
               + 5.04 NumChangesNotDocumented
```

Predictor	Coef	SE Coef	T	P
Constant	6.6168	0.4192	15.78	0.000
PathComplexity	0.79281	0.01173	67.58	0.000
NumOfFileChanges	0.74298	0.01197	62.07	0.000
NumChangesNotDocumented	5.04283	0.04320	116.75	0.000

```
S = 2.99998   R-Sq = 69.0%   R-Sq(adj) = 69.0%
```

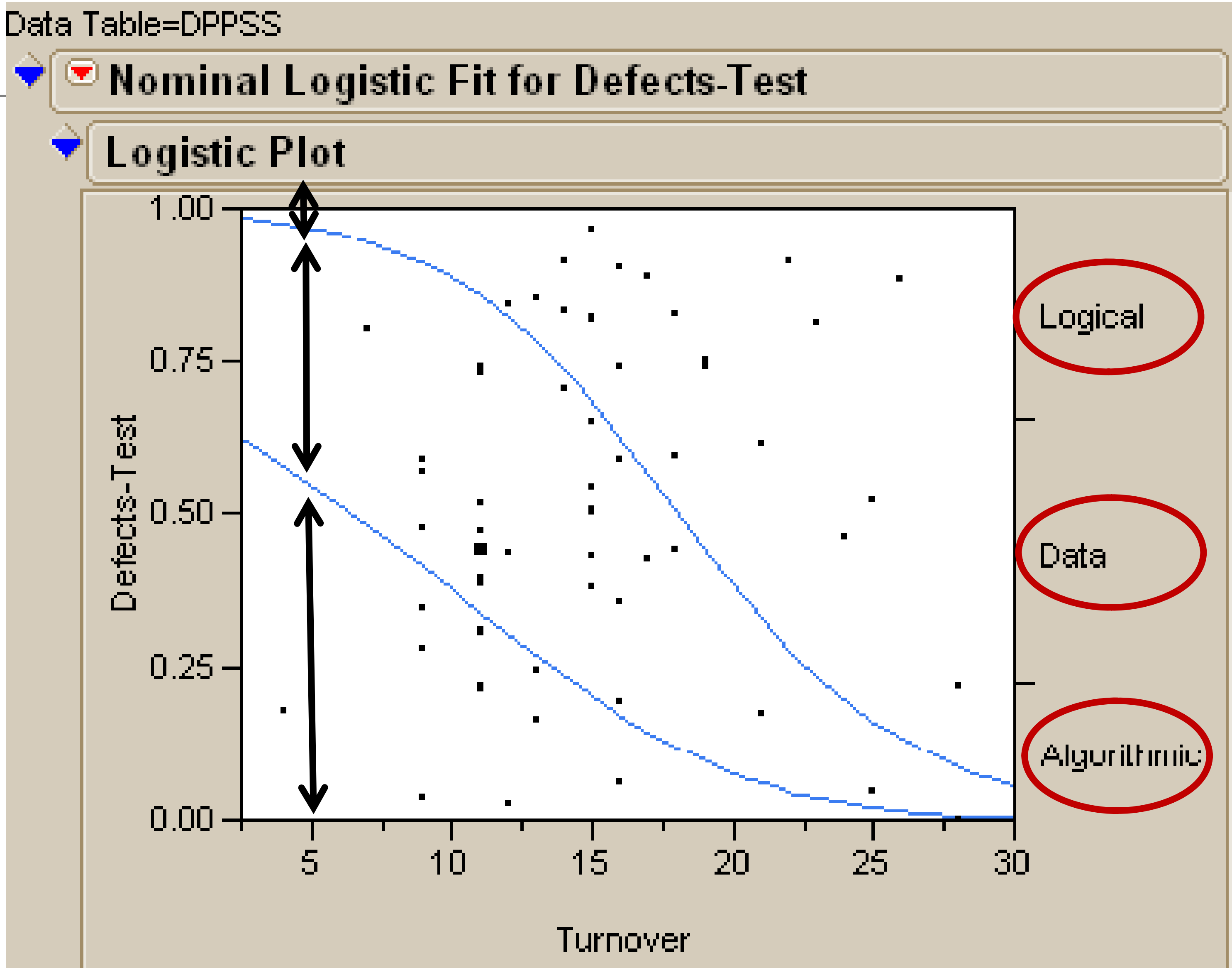
Details of the System Testing PPM

The outcome, Y, is the relative likelihood of occurrence of the different standard defect types (e.g. nominal categories such as: logical, data, and algorithmic)

The x factor used in this prediction example is a measure of staff turnover of the feature development team prior to System Test (e.g. continuous data as a percentage)

This x factor was chosen because it historically surfaced as a significant factor in explaining types of defects found in System Test.

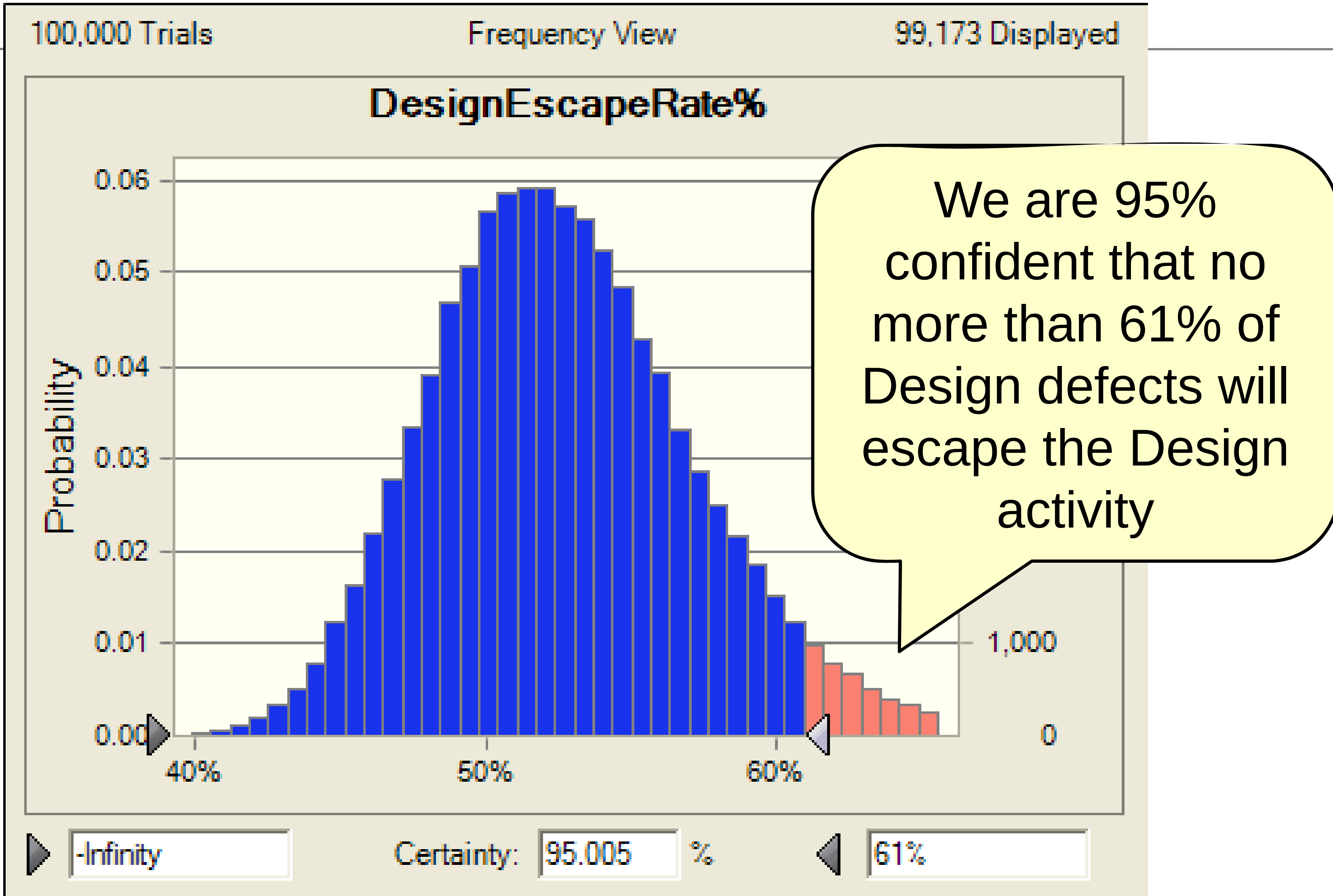
Development of the System Test PPM



Escaped Defect Analysis Matrix

	All numbers per 1MSLOC	Phase Found: Reqts Activity	Design Activity	Code Activity	Integration Test	System Test	User Test	Total Injection Rate by	Escape Rate by Activity	Escape Rate by All Activities	Activity Injection Rate by	Escape Rate by Activity %	Escape Rate by All Activities %
Phase Injected	Reqts Activity	500	80	10	60	150	30	830	330	330	7%	40%	40%
	Design Activity		2000	300	1200	600	100	4200	2200	2450	36%	52%	54%
	Code Activity			3800	2000	400	140	6340	2540	4680	54%	40%	53%
	Integration				300	50	5	355	55	1475	3%	15%	29%
	System Test					100	0	100	0	275	1%	0%	17%
	User Test						5	5	0	0	0%	0%	0%
	Phase Containment Rate	500	2080	4110	3560	1300	280	11830	5125	9210	100%	43%	Of all defects escaped at least one phase
	Screening Rate	500	2000	3800	300	100	5			1.8	For defects not caught in phase originally injected, this is the average number of times they escaped a phase		
	Phase Containment Rate %	60%	46%	47%	71%	83%	100%						
	Screening Rate %	60%	48%	60%	85%	100%	100%						

Escaped Defect Analysis Monte Carlo Simulation



Predicting Customer Satisfaction

Y = Customer Satisfaction Scores

Possible x factors that may be used in Multiple Regression to predict Y:

Attributes of Customer including power user vs casual user

Degree of “delighters” vs “satisfiers” vs “must-be” product features

Timeliness in reaching the market window

Price

Time for competitors to catch up

Economy

Product return policy

Customer service record

Recruiting Critical Resources

Y = Probability of Hiring a Critical Resource

Possible x factors that may be used in Multiple Regression to predict Y:

Availability of Critical Expertise in the local area

Salary willing to offer candidates

Other benefits including signing bonus

Career path available to new hires

Amount of professional development provided to employees

Retirement package

Profit sharing package

Vacation available to new employees

Retaining Critical Resources

Y = Probability of Retaining a Critical Resource

<u>Possible x factors that may be used in Multiple Regression to predict Y:</u>

Salary increases available to employees

Career path available to employees

Amount of professional development provided to employees

Retirement package

Profit sharing package

Vacation available to new employees

Mobility within the organization

Degree of agile teaming employed vs bureaucracy of organization

Predicting Uncertain Schedules with Confidence - 1

Process	Durations		
Step		Expected	
1		30	
2		50	
3		80	
4		50	
5		90	
6		25	
7		35	
8		45	
9		70	
10		25	
		500	

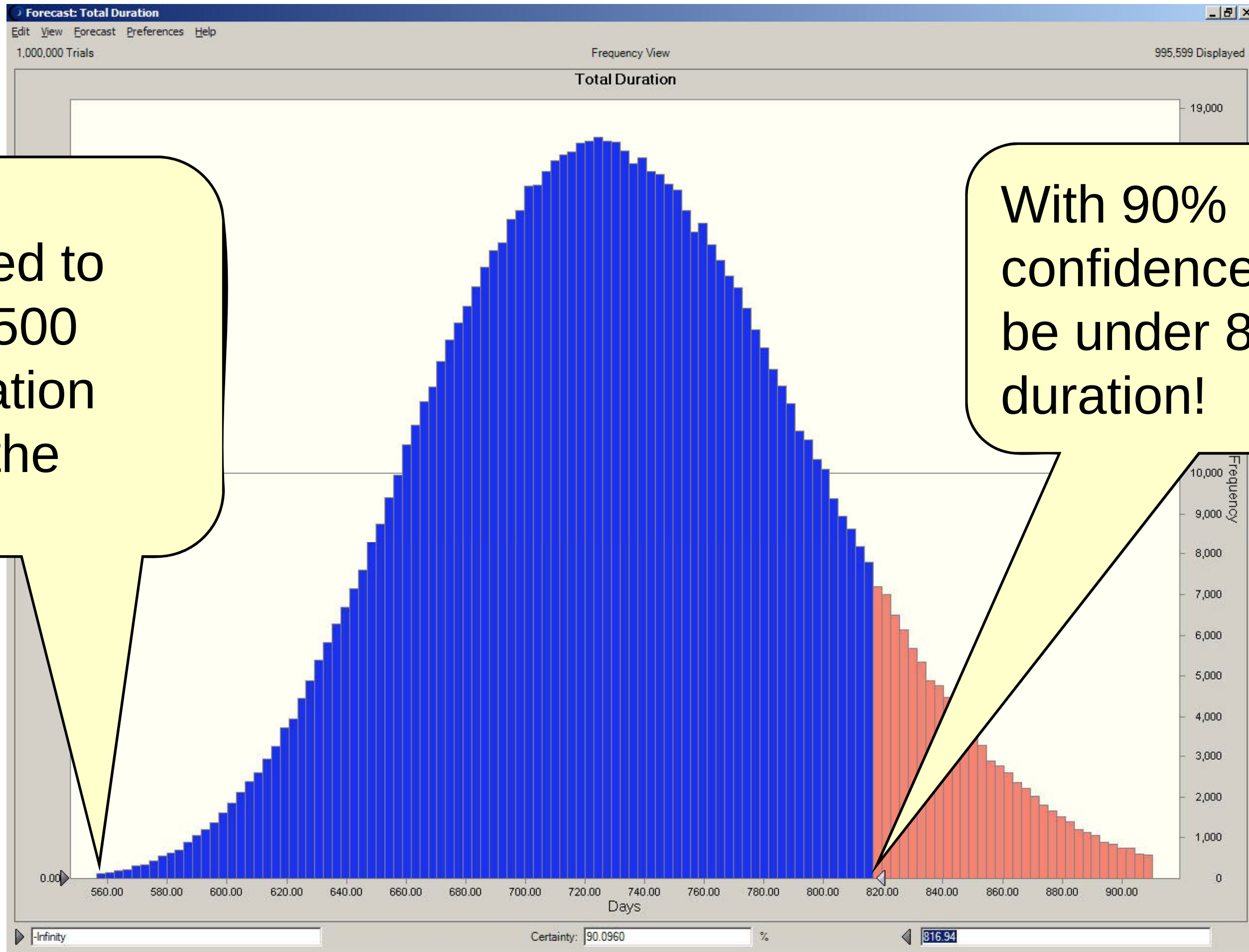
What would you forecast the schedule duration to be?

Predicting Uncertain Schedules with Confidence - 2

Process	Durations		
Step	Best	Expected	Worst
1	27	30	75
2	45	50	125
3	72	80	200
4	45	50	125
5	81	90	225
6	23	25	63
7	32	35	88
8	41	45	113
9	63	70	175
10	23	25	63
		500	

Would you change your mind in the face of unbalanced risk?

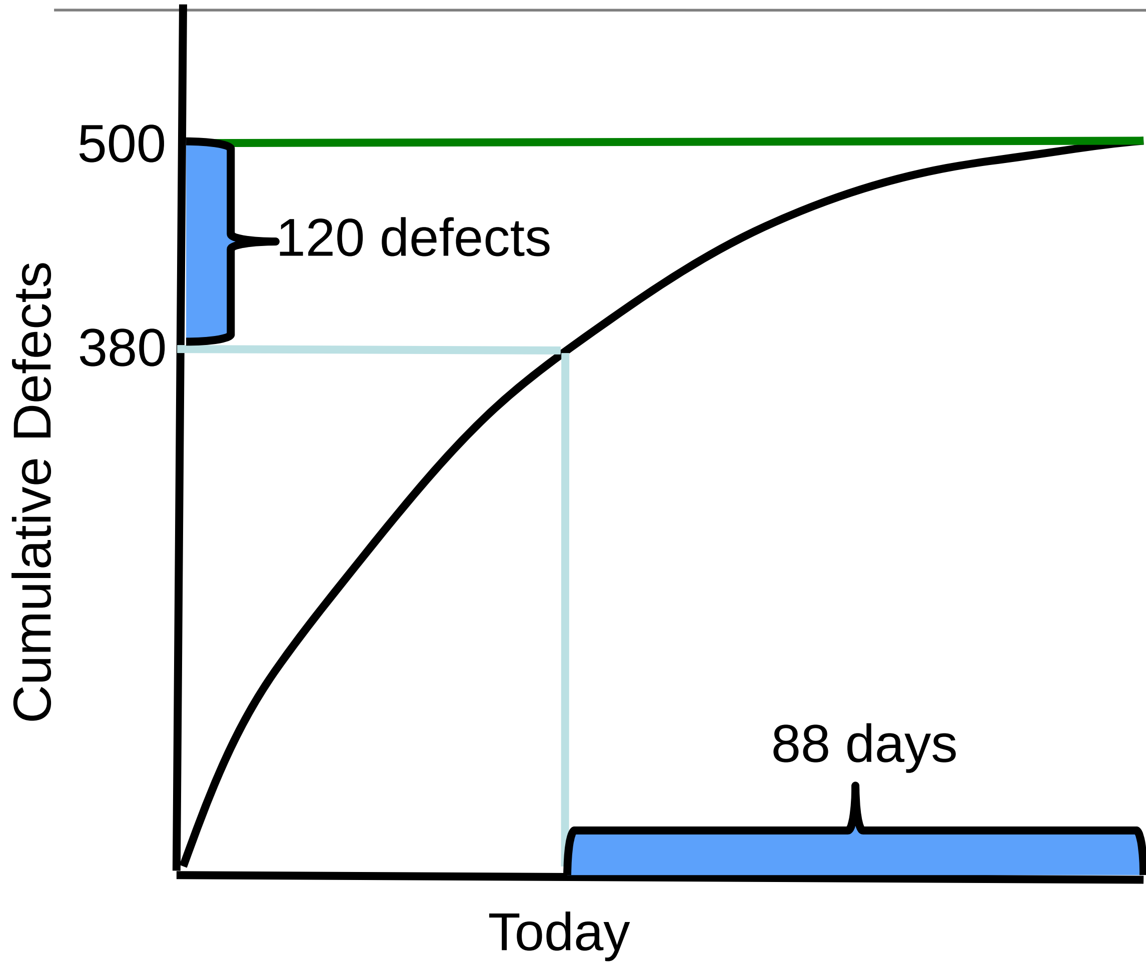
Monte Carlo Simulation enables Confidence in Schedules!



Almost guaranteed to miss the 500 days duration 100% of the time!

With 90% confidence, we will be under 817 days duration!

Reliability Growth Model Output – Example



With this approach, you can conclude the remaining test time required (88 days) and latent defects to be delivered to the customer if you delivered today (120 defects).

Interpreting and Documenting Results

Large Settings

- Dedicated users of models author formal reports on the results and conclusions
- White papers and other internal publications may be used
- Reporting templates are used to ensure stability as different people assume the key user role

Small Settings

- Notes are recorded in the journal or notepad of the statistical package
- Callouts on powerpoint slides summarize the conclusion and action
- Meeting minutes document the interpretation, conclusions and actions
- Individual personal notes

Group Exercise #7 (10 minutes)

Within your group, compare notes on **how interpretation and documentation of results of model usage** would occur in your small organizational/project settings

Record your notes on your group flip pad

Prepare to share 3-5 notes with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

USE IN CAR PROCESS AREA

Use in CAR Process Area

Large Settings

- Predictions are made and if unacceptable, CAR may be initiated by team
- Prediction intervals are established and serve as early warning indicators; if actual performance is outside of the interval, CAR may be initiated by team

Small Settings

- Individuals view the results of their predictions and act immediately
- Some actions may be communicated to rest of team
- Individuals more readily have insight to what is going on when reacting to model results

Group Exercise #8 (10 minutes)

Within your group, share ideas on how you would **envision corrective action being initiated based on the results of process performance models** in your small organizational/project settings. Would individuals be able to act immediately in an empowered fashion?

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

USE IN OID PROCESS AREA

Use in OID Process Area

Large Settings

- Enterprise systems established to collect and analyze innovative improvement ideas
- Standard organizational process performance models used to screen ideas
- Models used to generate ideas for improvement

Small Settings

- Individuals with complete domain knowledge
- Subjective real-time assertions of innovative improvements
- Models primarily serve to add confidence, or to handle completely new situations
- Dynamic models can predict new performance

Group Exercise #9 (10 minutes)

Within your group, share ideas on how **innovative new process or tool technology ideas are surfaced, analyzed and selected** in your small organizational/project setting.

Do you just go by word of mouth recommendation or do you seek some type of analysis before choosing a solution?

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

CONTRASTING LARGE VS SMALL ORGANIZATIONAL SETTINGS:

IMPORTANCE OF THE DAR PROCESS AREA

Importance of the DAR Criteria

Large Settings

- DAR criteria needed to ensure a large number of model builders, analysts, users of statistical management charts and model results are consistent and to avoid confusion
- DAR needed to guide different org segments in choosing models, etc…

Small Settings

- DAR criteria primarily needed to guide individuals on when to use more formal modeling approaches, and when to inform others of the results
- DAR criteria needed also for segmenting projects as they collectively use each other's data fields

Group Exercise #10 (10 minutes)

Within your group, share ideas on how you would need to **segment your projects so that similar groups of projects could share data and modeling results** in your small organizational/project setting

Record your group ideas on your group flip pad

Prepare to share 3-5 ideas with the audience at large

NEXT STEPS

Next Steps from a Tools and Method Standpoint

Identify your business and project goals including key customer drivers

Decide where the greatest risk and uncertainty is in the business

Assess the culture and current background of the project members

Conduct a cost/benefit analysis of which tools addressing which issues

Start small and let internal success and experience motivate wider adoption

Empower individuals to assess what tools they need and can afford to use from a time and learning curve standpoint

Don't let the tools become the end! They are the means to superior performance!

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