High Maturity: How Do We Know?

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nderstanding

Central themes

- Baselines
- Control Charts
- Statistical management of subprocesses

Central themes

- Process Performance Models
- Understanding and use of variation

Supporting themes

- Baselines
- Control Charts
- Statistical management of subprocesses

s Presentation

A "BAD" INTERPRETATION

Text in yellow boxes is an example description of implementing the practice consistent with the glossary, using the standard English meaning of words instead of the statistical meaning, and without using the informative material. For example, interpreting variation to mean the difference between two items.

A "GOOD" INTERPRETATION

Text in green boxes is an example description of implementing the practice consistent with the glossary, the statistical meaning of words, and accounting for the informative material. For example, interpreting variation (in the level 4 & 5 practices) to mean central tendency and dispersion.

Selected practices are illustrated.

… Informative Material and Subpractices -1

The MDD states on page I-20

- "Appraisal teams compare the objective evidence collected against the corresponding practices in the appraisal reference model. In making inferences about the extent to which practices are or are not implemented, appraisal teams draw on the entire model document to understand the intent of the model, and use it as the basis for their decisions. This comparison includes the required and expected model components (i.e., generic and specific goals, generic and specific practices) as well as informative material, such as model front matter, introductory text, glossary definitions, and subpractices."

Informative Material and Subpractices -2

Additionally on page I-24 in discussing direct artifacts for PIIs

- "The tangible outputs resulting directly from implementation of a specific or generic practice. An integral part of verifying practice implementation. May be explicitly stated or implied by the practice statement or associated informative material."

And from page II-110

- "The use of informative material in the appraisal reference model to form a checklist is explicitly discouraged."

And from page III-50 the glossary definition for direct artifact

- ñThe tangible outputs resulting directly from implementation of a specific or generic practice. An integral part of verifying practice implementation. May be explicitly stated or implied by the practice statement or associated informative material. "

lect Processes

Select the processes or subprocesses in the organizationôs set of standard processes that are to be included in the organizationôs process-performance analyses.

Pick a few processes from the OSSP for which we have measures.

Select processes/subprocesses that will help us understand our ability to meet the objectives of the organization and projects, and the need to understand quality and process performance. These subprocesses will typically be the major contributors and/or their measures will be the leading indicators.

…rocesses that Support Prediction and Statistical Management

Goals from SP 1.3

Process Step	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6	Goal 7
Req'ts Elicitation	X			X			
Prototype		X					
Architecture Modification							
High level Design			X				
Low level Design			X				
Coding							
Unit Test							
Integration Test							
System Test	X			X			
Alpha Test							
Beta Test		X					

Each **X** in this Goal Decomposition Matrix receives a S.M.A.R.T. objective statement and is a candidate for statistical management. Each Goal will potentially have a process performance model with some of these controllable x factors.

tablish Process-Performance Measures

Establish and maintain definitions of the measures that are to be included in the organization's process-performance analyses.

Provide definitions for the measures and update as necessary.

Select measures, analyses, and procedures that provide insight into the organization's ability to meet its objectives and into the organization's quality and process performance. Create/update clear unambiguous operational definitions for the selected measures. Revise and update the set of measures, analyses, and procedures as warranted. In usage, be sensitive to measurement error. The set of measures may provide coverage of the entire lifecycle and be controllable.

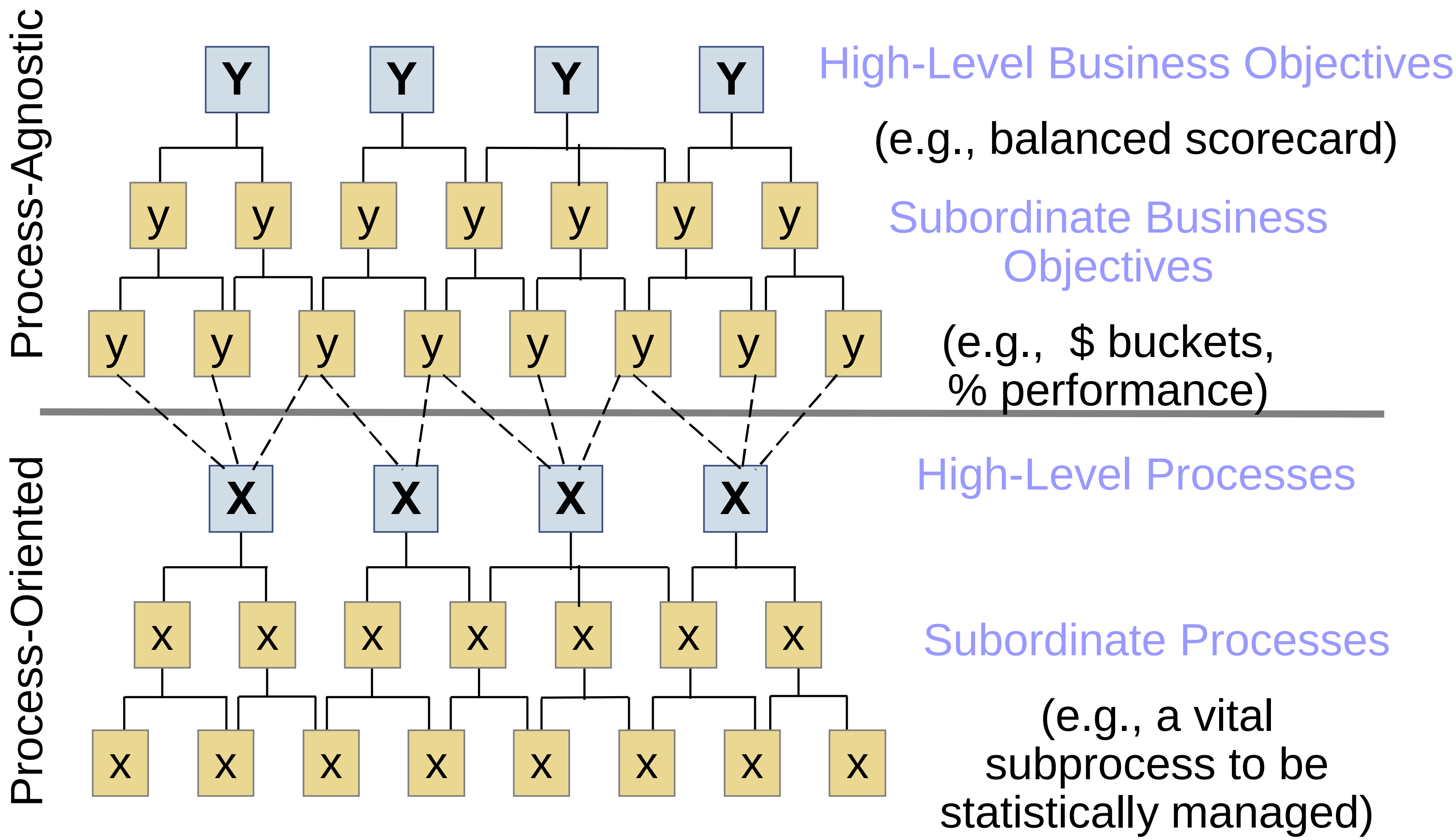
…tablish Quality and Process-Performance Objectives

Establish and maintain quantitative objectives for quality and process performance for the organization.

Write down quality and process performance objectives such as improve cycle time, quality, and the percent of improvement we want.

These objectives will be derived from the organizationõs business objectives and will typically be specific to the organization, group, or function. These objectives will take into account what is realistically achievable based upon a quantitative understanding (knowledge of variation) of the organizationõs historic quality and process performance. Typically they will be SMART and revised as needed.

Objectives


Process-Agnostic
Process-Oriented
Y
Y
Y
Y
y
x
X
High-Level Business Objectives
(e.g., balanced scorecard)
Subordinate Business Objectives
(e.g., $ buckets, % performance)
High-Level Processes
Subordinate Processes
(e.g., a vital subprocess to be statistically managed)

…tablish Process-Performance Baselines

Establish and maintain the organization's process-performance baselines.

Store measures in our spreadsheet repository on a periodic basis indicating the end date of the period they represent and baseline them in our CM system.

Baselines will be established by analyzing the distribution of the data to establish the central tendency and dispersion that characterize the expected performance and variation for the selected process/subprocess. These baselines may be established for single processes, for a sequence of processes, etc. When baselines are created based on data from unstable processes, it should be clearly documented so the consumers of the data will have insight into the risk of using the baseline. Tailoring may affect comparability between baselines.

tablish Process-Performance Models

Establish and maintain the process-performance models for the organization's set of standard processes.

We have historical productivity and defect injection/detection rates by phase which we update periodically and include in reports.

Rather than just a point estimate, PPMs will address variation in the prediction. PPMs will model the interrelationships between subprocesses including controllable/uncontrollable factors. They enable predicting the effects on downstream processes based on current results. They enable modeling of a PDP to predict if the project can meet its objectives and evaluate various alternative PDP compositions. They can predict the effects of corrective actions and process changes. They can also be used to evaluate the effects of new processes and technologies/innovations in the OSSP.

...s that Predict Future Outcomes[1]

Enrich the detailed process maps from CMMI ML3 to include executable process models developed from PPBs that summarize cycle times, processing times, available resources, sub-process costs, and quality.

Identify key process handoffs during project execution in which exit and entrance criteria are important.

At these handoffs, establish process performance models (PPMs) that predict interim outcomes. They govern process handoffs and provide leading indicators of problems with outcomes.

ls that Predict Future Outcomes[2]

Next, identify controllable factors tied to upstream subprocesses that may be predictive of one or more of the outcomes (interim and final) to be predicted.

Decide what type of data the outcome (Y) is and what type of data the factors (xôs) are.

Using the data types, begin to identify the statistical methods to help with our process modeling. (See next slide)

(Other forms of process modeling are certainly possible.)

ls that Predict Future Outcomes[3]

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

ls that Predict Future Outcomes[4]

ANOVA, Dummy Variable Regression

Using these controllable factors…	To predict this outcome
Type of Reviews Conducted; Type of Design Method; Language Chosen; Types of Testing	Delivered Defect Density
High-Medium-Low Domain Experience; Architecture Layer; Feature; Team; Lifecycle model; Primary communication method	Productivity
Estimation method employed; Estimator; Type of Project; High-Medium-Low Staff Turnover; High-Medium-Low Complexity; Customer; Product	Cost and Schedule Variance
Team; Product; High-Medium-Low Maturity of Platform; Maturity or Capability Level of Process; Decision-making level in organization; Release	Cycle Time or Time-to-Market
Iterations on Req’ts; Yes/No Prototype; Method of Req’ts Elicitation; Yes/No Beta Test; Yes/No On-Time; High-Medium-Low Customer Relationship	Customer Satisfaction (as a percentile result)

s that Predict Future Outcomes[5]

Regression

Using these controllable factors…	To predict this outcome
Reqâs Volatility; Design and Code Complexity; Test Coverage; Escaped Defect Rates	Delivered Defect Density
Staff Turnover %; Years of Domain Experience; Employee Morale Survey %; Volume of Interruptions or Task Switching	Productivity
Availability of Test Equipment %; Reqâs Volatility; Complexity; Staff Turnover Rates	Cost and Schedule Variance
Individual task durations in hrs; Staff availability %; Percentage of specs undefined; Defect arrival rates during inspections or testing	Cycle Time or Time-to-Market
Resolution time of customer inquiries; Resolution time of customer fixes; Percent of features delivered on-time; Face time per week	Customer Satisfaction (as a percentile result)

...s that Predict Future Outcomes[6]

Chi-Square, Logistic Regression

Using these controllable factors…	To predict this outcome
Programming Language; High-Medium-Low Schedule compression; Reqts method; Design method; Coding method; Peer Review method	Types of Defects
Predicted Types of Defects; High-Medium-Low Schedule compression; Types of Features Implemented; Parts of Architecture Modified	Types of Testing Most Needed
Architecture Layers or components to be modified; Type of Product; Development Environment chosen; Types of Features	Types of Skills Needed
Types of Customer engagements; Type of Customer; Product involved; Culture; Region	Results of Multiple Choice Customer Surveys
Product; Lifecycle Model Chosen; High-Medium-Low Schedule compression; Previous High Risk Categories	Risk Categories of Highest Concern

s that Predict Future Outcomes[7]

Logistic Regression

Using these controllable factors…	To predict this outcome
Inspection Preparation Rates; Inspection Review Rates; Test Case Coverage %; Staff Turnover Rates; Previous Escape Defect Rates	Types of Defects
Escape Defect Rates; Predicted Defect Density entering test; Available Test Staff Hours; Test Equipment or Test Software Availability	Types of Testing Most Needed
Defect Rates in the Field; Defect rates in previous release or product; Turnover Rates; Complexity of Issues Expected or Actual	Types of Skills Needed
Time (in Hours) spent with Customers; Defect rates of products or releases; Response times	Results of Multiple Choice Customer Surveys
Defect densities during inspections and test; Time to execute tasks normalized to work product size	Risk Categories of Highest Concern

s that Predict Future Outcomes[8]

An example:

A regression analysis was conducted to develop a statistically-based process performance model **predicting Defect Density**.

As will be seen on the next slide, the regression model provides rich information about the role of the **controllable x factors (Req'ts Volatility and Experience)** in predicting the **Y outcome (Defect Density).**

In turn, this will provide management with rich information on how to be **pro-active** in changing predicted high levels of Defect Density to acceptable lower levels!

...s that Predict Future Outcomes[9]

Regression Analysis: Defect Densi versus ReqtsVolatil, YearsDomainE

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The regression equation is
Defect Density = 0.484 + 0.480 ReqtsVolatility - 0.0242 YearsDomainExperience


Predictor                    Coef     SE Coef       T      P
Constant                  0.48367     0.03957   12.22  0.000
ReqtsVolatility           0.47963     0.09511    5.04  0.000
YearsDomainExperience   -0.024215    0.001941  -12.48  0.000


S = 0.00893207   R-Sq = 85.9%   R-Sq(adj) = 84.8%


Analysis of Variance

Source            DF          SS          MS       F      P
Regression   [illegible]  [illegible]  [illegible]063038   79.01  0.000
Residual Erro[illegible]
Total
```

Prediction equation for defect density

p values below 0.05 indicate the predictors to keep in the model

Percentage of total variation in defect density explained by the model

p value below 0.05 indicates the model is significant

blish Performance Baselines and Models

Baselines and models, which characterize the expected process performance of the organization's set of standard processes, are established and maintained.

The aforementioned data and models characterize OSSP performance.

Central tendency and variation are the cornerstones of our implementation. Our baselines and models incorporate our understanding of these, allow us to understand risks in our organizations and its projects, and allow us to create and execute effective strategies to mitigate and manage risks.

tablish the Project’s Objectives

Establish and maintain the projectôs quality and process-performance objectives.

Project Manager documents project objectives such as îProduce the system better, cheaper, fasterò in the project plan.

These objectives will be based on the organizationôs quality and process performance objectives and any additional customer and relevant stakeholder needs and objectives. These objectives will be realistic (based upon analysis of historical quality and process performance) and will cover interim, supplier, and end-state objectives. Conflicts between objectives (i.e., trade-offs between cost, quality, and time-to-market) will be resolved with relevant stakeholders. Typically they will be SMART, traceable to their source, and revised as needed.

mpose the Defined Process

Select the subprocesses that compose the projectÕs defined process based on historical stability and capability data.

Look at our data spreadsheets to select the subprocesses that have the highest performance, best quality, and most stability -- the ones that have changed the least.

The PDP is composed by:

- selecting subprocesses
- adjusting/trading-off the level and depth of intensity of application of the subprocess(es) and/or resources

to best meet the quality and process performance objectives. This can be accomplished by modeling/simulating the candidate PDP(s) to predict if they will achieve the objectives, and the confidence level of (or risk of not) achieving the objective.

Defined Process

Analyze organizational goals and customer requirements to determine the desired outcomes in cost, schedule, and quality.

Identify alternative process compositions.

Evaluate these alternatives with respect to the desired outcomes in cost, schedule, and quality by:

- Calibrating PPMs with distributional data from PPBs for key subprocesses
- Applying the calibrated PPMs to evaluate alternatives

Select/Establish the appropriate process composition for the project.

The next two slides illustrate this with an application of Monte Carlo simulation and optimization. The simulation and optimization help to confirm which choices we should make.

PBs (First Phases Shown Only)

		Option 1			Option 2			Option 3			Option 4		
Requirements Development		Traditional			KJ Analysis & QFD			Prototyping					
		LL	Avg	UL	LL	Avg	UL	LL	Avg	UL			
	Effort	25	35	45	35	45	55	65	80	95			
	Cycle Time	15	20	25	30	35	40	50	60	70			
	Quality	35	45	55	27	30	33	22	25	28			
Reqts Review		Email Routing			Walkthrough			Inspections			Sampling Inspections		
		LL	Avg	UL	LL	Avg	UL	LL	Avg	UL	LL	Avg	UL
	Effort	1	4	7	7	10	13	18	20	22	8	10	12
	Cycle Time	1	2	3	1	4	7	1	5	9	2	3	4
	Quality	25.00%	40.00%	55.00%	50.00%	55.00%	60.00%	80.00%	85.00%	90.00%	65.00%	70.00%	75.00%
Design		SA/SD			OOD								
		LL	Avg	UL	LL	Avg	UL						
	Effort	50	60	70	65	75	85						
	Cycle Time	40	45	50	50	55	60						
	Quality	35	45	55	16	20	24						
Design Review		Email Routing			Walkthrough			Inspections			Sampling Inspections		
		LL	Avg	UL	LL	Avg	UL	LL	Avg	UL	LL	Avg	UL
	Effort	5	12	19	15	20	25	25	35	45	5	7	9
	Cycle Time	1	2	3	1	4	7	1	5	9	2	3	4
	Quality	25.00%	40.00%	55.00%	50.00%	55.00%	60.00%	80.00%	85.00%	90.00%	65.00%	70.00%	75.00%
Code		Manual w/No Reuse			Manual w/Reuse			Code Generation w/No Reuse			Code Generation w/Reuse		
		LL	Avg	UL	LL	Avg	UL	LL	Avg	UL	LL	Avg	UL
	Effort	150	300	450	220	250	280	100	125	150	90	100	110
	Cycle Time	50	65	80	45	55	65	35	40	45	25	30	35
	Quality	200	250	300	100	200	220	90	110	130	85	90	95

cess Simulation & Optimization

Subprocesses	Optimize for	
	Cycle Time	Quality
Requirements Development	Traditional	Traditional
Requirements Review	Email Routing	Sampling Inspections
Design	SA/SD	OOD
Design Review	Email Routing	Sampling Inspections
Code	Code Generation with Reuse	Code Generation with Reuse
Code Review	Email Routing	Walkthrough
Unit Test	Ad Hoc	Ad Hoc
Integration Test	Hybrid	Hybrid
System Test	Production Hardware	Production Hardware
Acceptance Test	Low Intensity	Low Intensity
Results (95% confidence results will not exceed)		
Cycle Time	171	185
Quality Rework Costs	$487,000	$354,000
Overall Costs	$7,935,000	$841,000

lect the Subprocesses that Will Be Statistically Managed

Select the subprocesses of the project's defined process that will be statistically managed.

Select the subprocesses that we must already measure.

Subprocesses that are the major contributors to or predictors of the accomplishment of the projectôs interim or end-state objectives will be selected. Additionally, these need to be suitable for statistical management. Statistically managing the selected subprocesses provides valuable insight into performance by helping the project identify when corrective action is needed to achieve its objectives. Select the attributes that will measured and controlled.

nage Project Performance

Monitor the project to determine whether the projectôs objectives for quality and process performance will be satisfied, and identify corrective action as appropriate.

Compare the actual versus estimated and corresponding actual trend versus estimated trend. If weôre not meeting our objectives or based on the actual trend it looks like we wonôt achieve our objectives in the future, document what we might do to fix the shortcoming/potential shortcoming.

Monitor the project

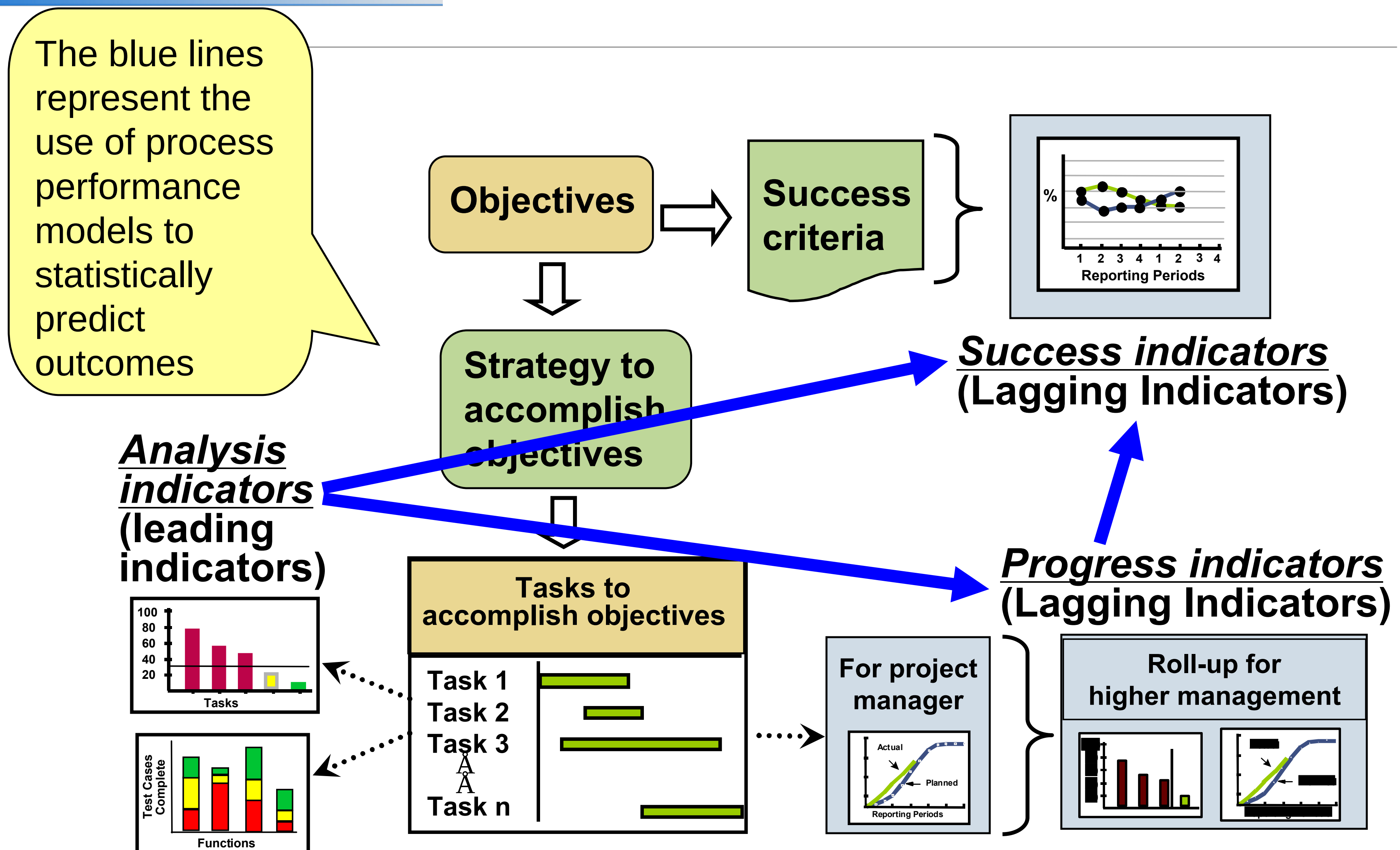
Å Manage stability and capability of selected subprocesses.
Å Track quality and process performance data including suppliersô
Å Update/calibrate PPMs and predictions based on results to date.
Å Identify deficiencies/risks to achieving objectives (e.g., where current performance is outside tolerance intervals, or prediction/confidence intervals are not contained within specification limits).

ect Performance[1]

Management reviews dashboards that include not only outcomes but leading indicators such as the controllable x factors identified in OPP and earlier in QPM.

There are typically 3-5 leading indicators for each outcome (or lagging indicator) that may be used in a process performance model.

...ect Performance²



ect Performance[3]

Management typically now only spends a fraction (20%) of **<u>each management review looking at the lagging indictors</u>** (e.g. the outcomes of cost, schedule and quality)

Most of their time (80%) is instead spent **<u>reviewing the statistical management of controllable x factors and the predicted outcomes</u>** based on the x factors.

Inherently, the discussion focuses on management **<u>pro-actively taking action based on performance models and control charts of controllable x factors.</u>**

ntitatively Manage the Project

The project is quantitatively managed using quality and process-performance objectives.

Project processes are managed against objectives using the standard data and statistical management spreadsheets*.

* Explained in QPM goal 2

Projects are managed through the use of:
Åmeasuring and controlling quality and process performance attributes.
Åstatistical techniques to ensure stable and capable subprocesses
ÅPPMs to predict if objectives will be met based on current performance
Åspec limits to indicate when the performance of current processes will adversely affect the projectôs ability to meet its objectives

...lect Measures and Analytic Techniques

Select the measures and analytic techniques to be used in statistically managing the selected subprocesses.

Select effort, size, and defects (estimated and actual for each) and use trend charts to analyze them and investigate spikes that appear to be unusually large as special causes.

Identify the measures that will provide insight into the performance of the subprocesses selected for statistical management and the statistical techniques that will be used for analysis. These measures can be for both controllable and uncontrollable factors. Operational definitions will be created/updated for these measures. Where appropriate (i.e., they are critical to meeting downstream objectives), spec limits will be established for the measures.

…ply Statistical Methods to Understand Variation

Establish and maintain an understanding of the variation of the selected subprocesses using the selected measures and analytic techniques.

For each subprocess measure, compare the actual to the estimated (using trends) to understand how much variation there is between what we expected and what we are actually getting.

Selected measures for the subprocesses will be statistically controlled to identify, remove, and prevent reoccurrence of special causes of variation, or in other words, stabilize the process. When control limits are too wide, sources of variation are easily masked and further investigation is warranted.

…onitor Performance of the Selected Subprocesses

Monitor the performance of the selected subprocesses to determine their capability to satisfy their quality and process-performance objectives, and identify corrective action as necessary.

Compare the actual versus estimated and corresponding actual trend versus estimated trend. If weôe not meeting our objectives or based on the actual trend it looks like we wonô achieve our objectives in the future, document what we might do to fix the shortcoming/potential shortcoming.

For a stable subprocess, determine if the control limits (natural bounds) are within the specification limits which indicates a capable subprocess. If it is not, document corrective actions that address the capability deficiencies.

cord Statistical Management Data

Record statistical and quality management data in the organization's measurement repository.

Put the data in our statistical management spreadsheet.

Record the data along with sufficient information to understand the context for the data and thus make the data usable by the organization and other projects.

istically Manage Subprocess Performance

The performance of selected subprocesses within the project's defined process is statistically managed.

Systemization of our process is achieved through planning and execution of the plans.

Selected subprocesses are statistically managed to ensure stability and capability (i.e., special causes of variation are identified, removed, and prevented from recurring and the control limits of the subprocess are kept within the specification limits).

SOME FINAL THOUGHTS

it for the number?

That can be a valid business objective

But, it is in all of our best interest to ensure that the number means something

- Å That means paying attention to the informative
- Å The richness of the model is in the informative
- Å The ideas/concepts that add value are in the informative

Without the informative material Levels 4 and 5 add little of even the minimum we all believe they are.

If it is not value added, change it!