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ABCs of Process Performance Models

November 18, 2009

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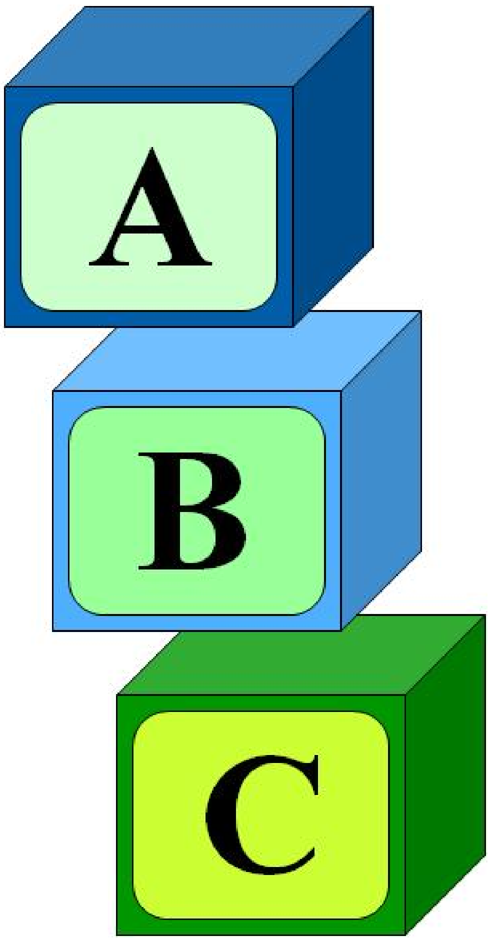

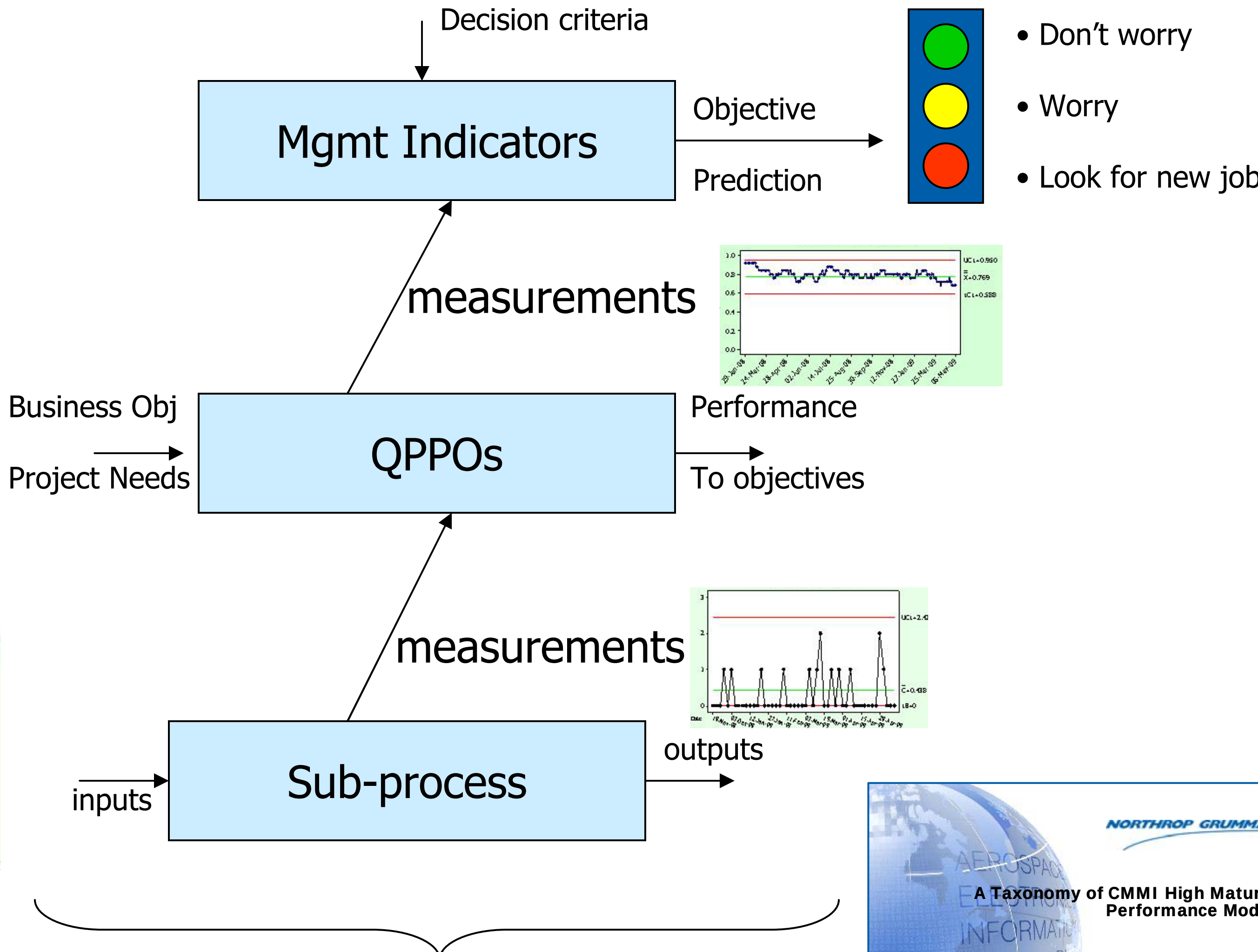

Process Performance Models

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Understanding Fundamentals About Baselines & Models

What the CMMI says . . .

ORGANIZATIONAL PROCESS PERFORMANCE (OPP)

SG 1 Establish Performance Baselines and Models

- SP 1.1 Select Processes
- SP 1.2 Establish Process-Performance Measures
- SP 1.3 Establish Quality and Process-Performance Objectives
- SP 1.4 Establish Process-Performance Baselines
- SP 1.5 Establish Process-Performance Models

What the CMMI says About Baselines . . .

- The organization’s process-performance baselines are a measurement of performance for the organization’s set of standard processes at various levels of detail, as appropriate.
- The processes include the following:
  - Sequence of connected processes
  - Processes that cover the entire life of the project
  - Processes for developing individual work products
  - There may be several process-performance baselines to characterize performance for subgroups of the organization.

What the CMMI says About Models . . .

- Process-performance models are used to estimate or predict the value of a process-performance measure from the values of other process, product, and service measurements. These process-performance models typically use process and product measurements collected throughout the life of the project to estimate progress toward achieving objectives that cannot be measured until later in the project's life.
- The process-performance models are used as follows:
  - The organization uses them for estimating, analyzing, and predicting the process performance associated with the processes in the organization's set of standard processes.
  - The organization uses them to assess the (potential) return on investment for process improvement activities.
  - Projects use them for estimating, analyzing, and predicting the process performance for their defined processes.
  - Projects use them for selecting processes or subprocesses for use.
- These measures and models are defined to provide insight into, and to provide the ability to predict, critical process and product characteristics that are relevant to business value.

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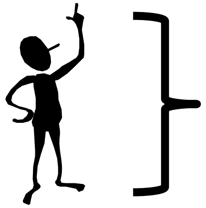
The average practitioner will be in a process induced coma by now . . .

How about a simple example?

Establishing a Baseline

A baseline is the measurement of past and current history



Consider this statement: *The average height of an adult man in the U.S. is 5′ 9″*

This is a ***deterministic*** baseline

How was this determined? Was every man in the US measured? Obviously not!

Data taken from McDowell, Fryar, Ogden, and Flegal, "Anthropometric Reference Data for Children and Adults: United States, 2003–2006," *National Health Statistics Report*, No. 10, October 22, 2008, published by the US Dept. of Health and Human Services, National Center for Health Statistics. We have rounded the data to the nearest 1" and used a normal probability model, in order to simplify our example

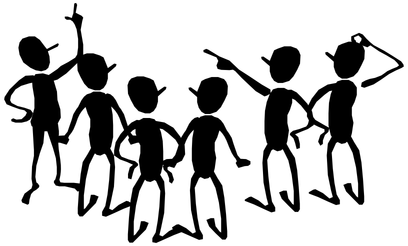
Establishing a Baseline

A Baseline can be established by characterizing a group.

E.g., sampling from a population – i.e., selecting some men to measure from the population of all men

Moving from a *deterministic* to a *probabilistic* baseline

- We typically characterize variation by a second number called standard deviation.
- The standard deviation is included in the baseline description which comprises the pair of numbers: average and standard deviation
- The average height of a man is 5′ 9″ with a standard deviation of 3″
- This is a ***statistical*** or ***probabilistic*** baseline



The average height is 5′ 9″
The standard deviation about the mean is $\pm$ 3″

Using a Model with a Baseline

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Question: Using the **deterministic baseline** what is the expected height of the next man you meet?

Answer: 5′ 9″ because the data provides only one value

The corresponding ***deterministic model*** predicts that all men are 5′ 9″

Follow-up Question: How much confidence do you have that this answer is correct?

How much money would you bet that the next man you meet is 5′ 9″?

A model is a tool used to predict the future

A Better Model?

New Question: Using the statistical or probabilistic baseline what is the expected height of the next man you meet?

Answer: somewhere between 5′ 3″ and 6′ 3″

- The corresponding ***probabilistic model*** predicts that most men (95%) are within 2 standard deviations of the mean (5′ 9″ $\pm$ 6″)
- How much confidence do you have that this answer is correct? Are you more confident that the next man you meet will be between 5′ 3″ and 6′ 3″ than exactly 5′ 9″?
- Will this model reliably predict the height of the next woman you meet?
  - Can the same model be used to accurately predict this, or is a different model needed?
  - This raises a supplementary question: Is the baseline part of the model?

What are some common project models?

- Earned value equations that forecast cost and schedule at project completion
- Estimation tools used during proposals (e.g., SEER-SEM, which is a probabilistic model)

A Simple "Project"

- Objective: Design a minimum height doorway for a house that will accommodate most people.
- Constraints:
  - Assume there is no long-established history or height requirements
  - Also assume a fixed 3" margin for shoes and hair styles, and add another 1" to bound the round-off error in the data
- Question: *What height should your doorway be?*

Note that we no longer care about the prediction interval for the height of the "next man." Now we want a not-to-exceed figure. This is what statisticians call a one-tailed problem, rather than the previous two-tailed problem. At the same 95% probability/confidence level used before, this will be 1.645 standard deviations higher than the average.

A Simple "Project"

- A deterministic solution
  - Using the deterministic model you would presume that a doorway with a height of 6′ 1″ – this assumes that every man is 5′ 9″, and allows for 4″ of margin

- A statistical or probabilistic solution
  - Using the statistical or probabilistic model at the 95th percentile, you would design the doorway to be at least 6′ 6″ high
    - Average height is 5′ 9″
    - Adjustment for random variation is 5″. This is figured as 1.645*3″ as we explained in the note on the previous slide
    - Adjustment for shoes and 'dos and round-off error is fixed at our 4″ margin
  - If you needed to accommodate more people, you could increase the door height. For example, 6′ 10″ would accommodate 99.9% of the population
    - This is the upper 3-sigma value. It also is the door height in the authors' houses

Models and baselines are used to make predictions about meeting project objectives with certain levels of confidence

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If one model is good, then more models are better . . .

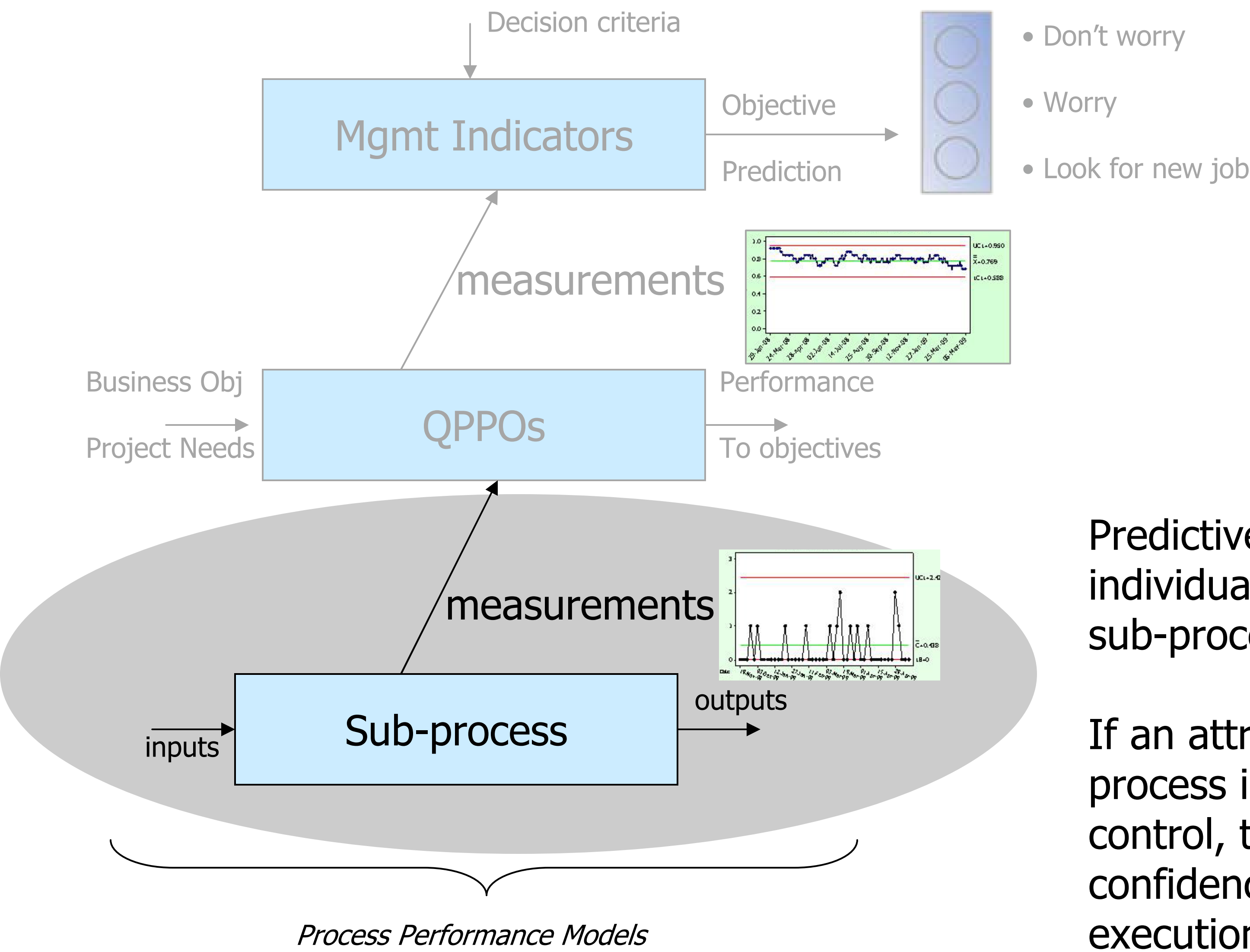
Models During Proposals

- During Proposal phase, the project's defined process is composed from the organization's standard processes
  - Basis of Estimates (BOEs) that use historical metrics represent a type of cost model.
  - If the BOE provides a standard deviation, which can be adjusted to account for varying levels of expected risk identified by the customer, then the BOE represents a statistical probabilistic model
  - Organizational processes that are identified as critical to the project may also have associated statistical sub-process baselines that statistically control some critical attribute like cost, quality, or schedule
  - At contract award the project objectives and the critical processes related to achieving those objectives are clearly understood

Models During Execution

- During project execution, project managers coordinate the activities of the Integrated Product Teams
- IPTs execute those critical processes to ensure meeting project objectives
- Monitoring the performance of processes or sub-processes under statistical control ensure continued stability within established limits
- This provides a high degree of confidence in meeting project objectives

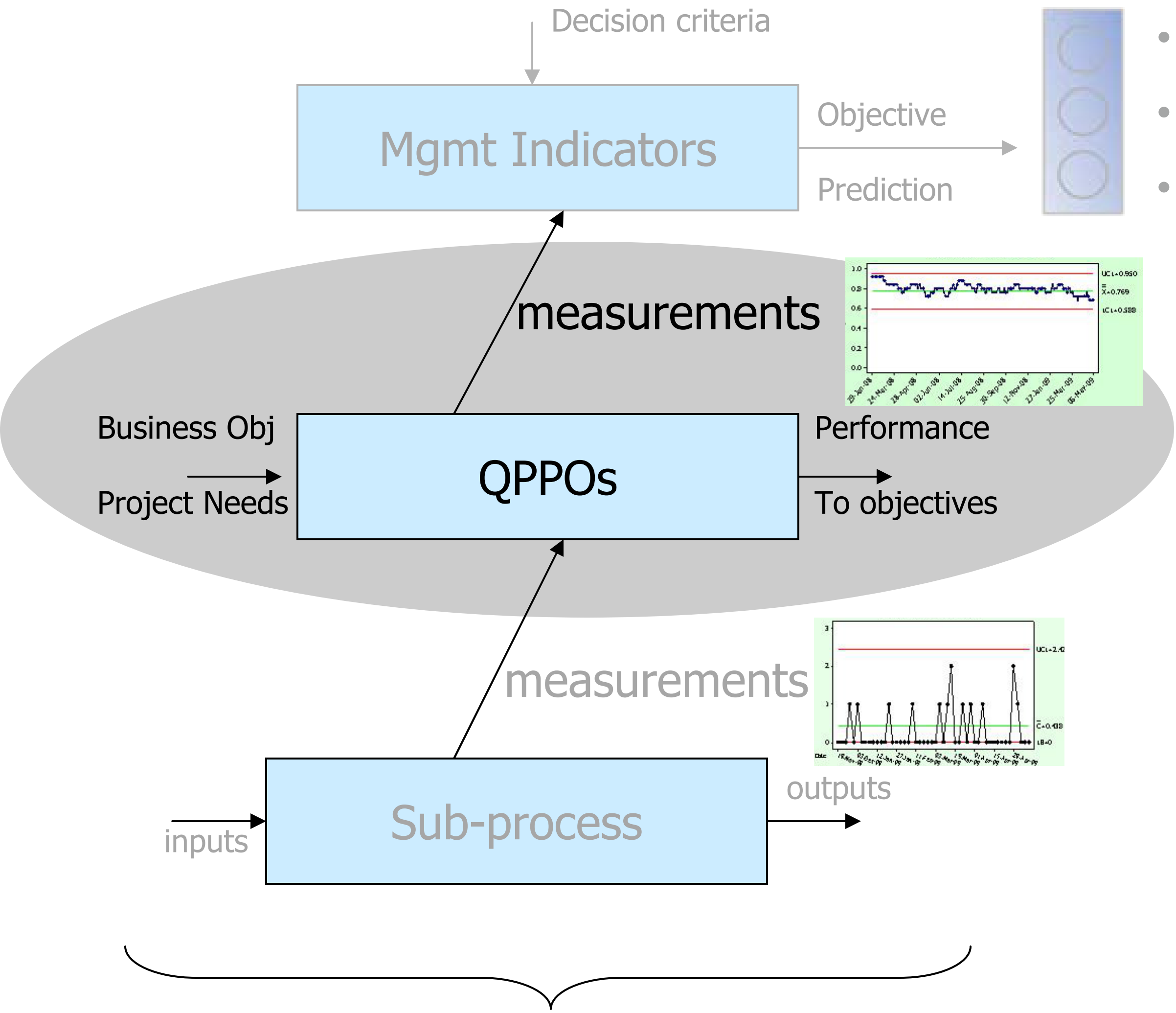
Sub-process Performance Model



Predictive model for individual executions of a sub-process.

If an attribute of the sub-process is under statistical control, then there is high confidence that the next execution will be within the upper & lower control limits.

Process Performance Model

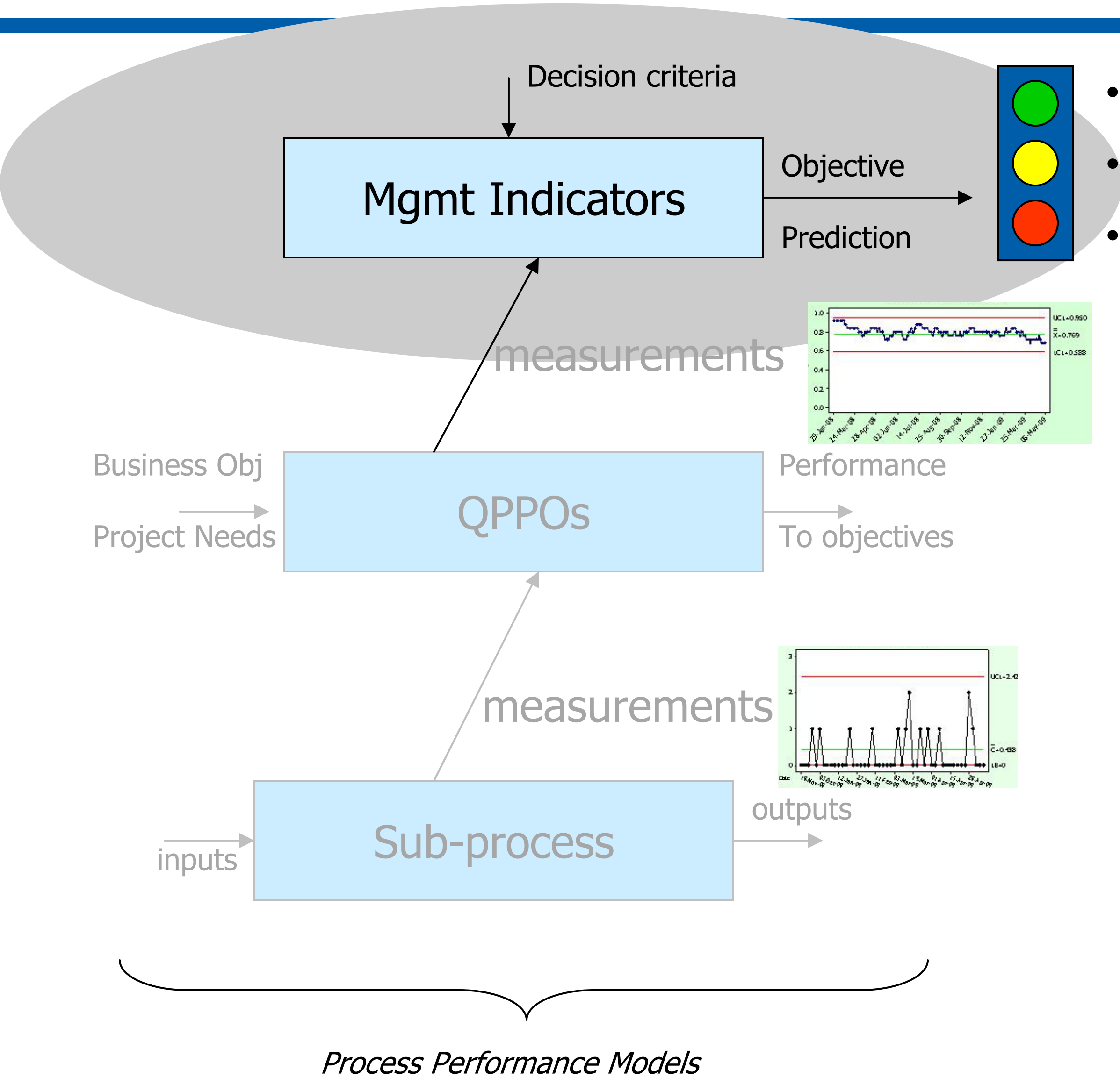


Process Performance Models

Predictive model of achieving the objectives of process (e.g., collection of sub-processes or multiple executions of a single sub-process).

If the objective function is under statistical control, then there is high confidence that the next execution will be within the upper & lower control limits.

Management Indicator Model



- Don't worry
- Worry
- Look for new job

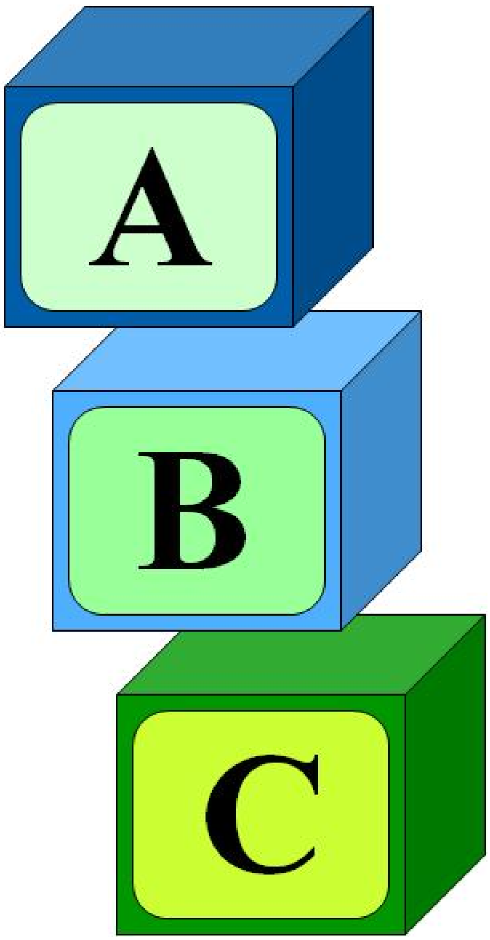
Predictive model of continued achievement of program objectives.

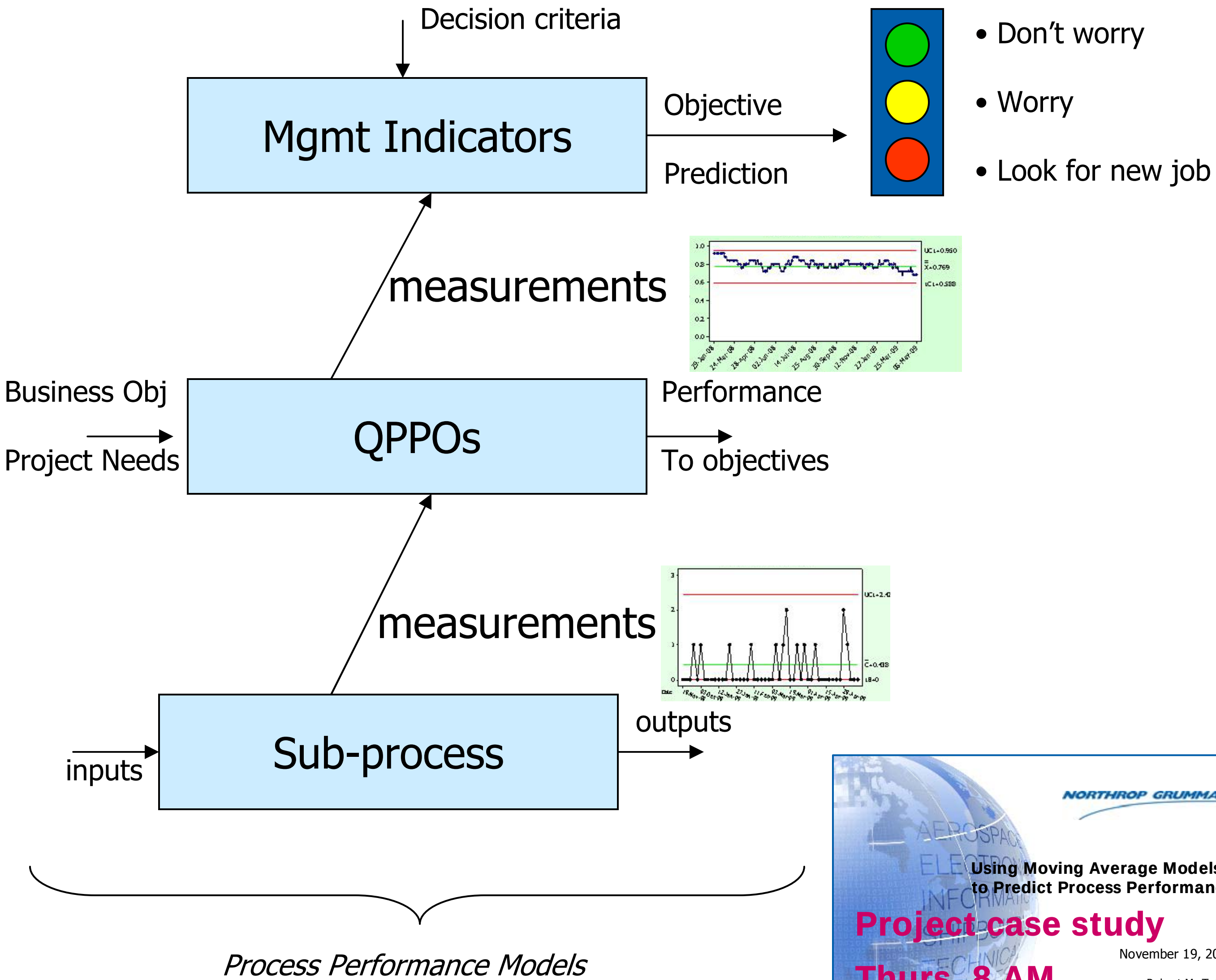
Green = Very high likelihood of achieving objectives, without process intervention.

Yellow = Process performance analysis is warranted.

Red = Achievement of objectives unlikely, without process intervention.

Different Models for Different Customers





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For the Statistically Inclined, Here Is a Picture of Our Model

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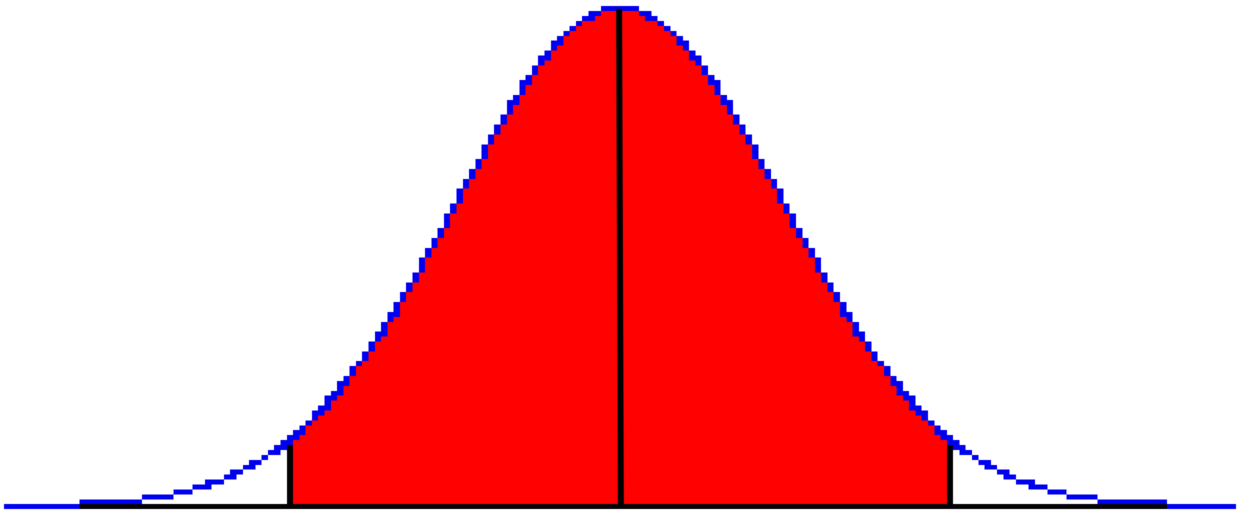

5%	50%	95%
mean - 1.645*sigma	mean	mean + 1.645*sigma
64.4″	69.4″	74.3″

For the Health and Human Service data,

sigma = ([74.3″ – 69.4″]/1.645 + [69.4″ – 64.4″]/1.645)/2 = 3″

Notes: The data represent a sample size of 4,482 adult men 20 years and older, representing all races and ethnicity types. Because of the large sample size, we treat the degrees of freedom as effectively infinite, and use the normal approximation to the *t*-distribution. The error of this approximation and the difference between the sample values and the theoretical population parameters, are well within the measurement precision of these data. The 1″ allowance for round-off error is sufficient to bound these errors.