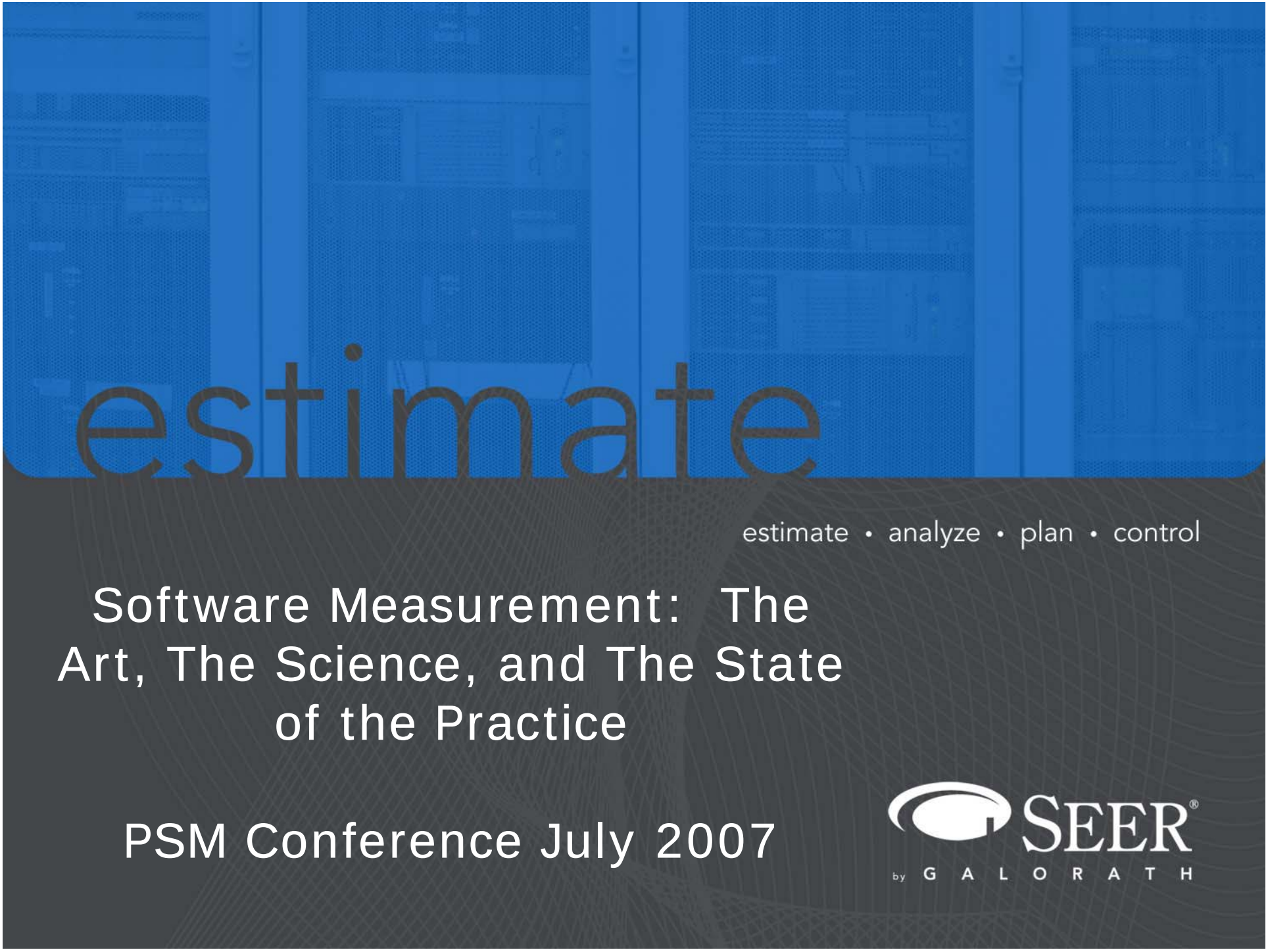


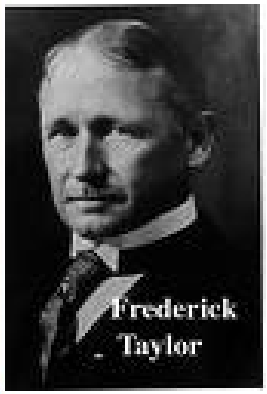
Software Measurement: The Art, The Science, and The State of the Practice

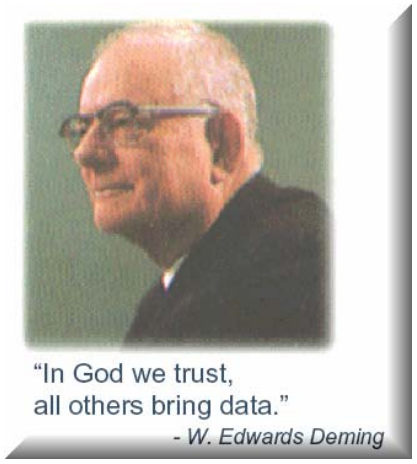
PSM Conference July 2007

SEER® by GALORATH

Some of Dan's Heroes Throughout Time

- Frederick Taylor: The Principals of Scientific Management 1901 "Let data and facts do the talking"
- W. Edwards Demming: "In God We Trust… All Others Bring Data"
- Frederick Brooks: "There is an incremental person when added to a software project that makes it take longer"
- Ed Yourdon: "Avoiding Death Marches in Software Projects"
- Steven Covey: "Sharpen the Saw" Focus on improvement





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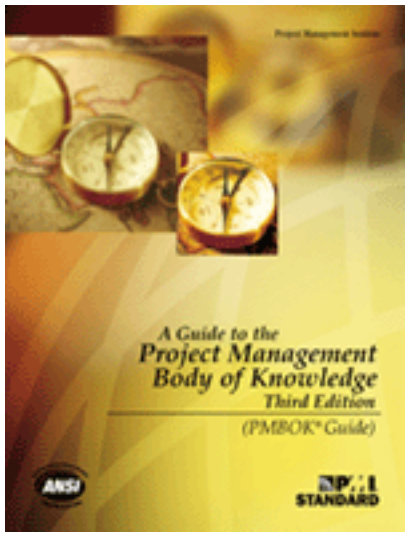
Information Based Project Management

Project Management Defined

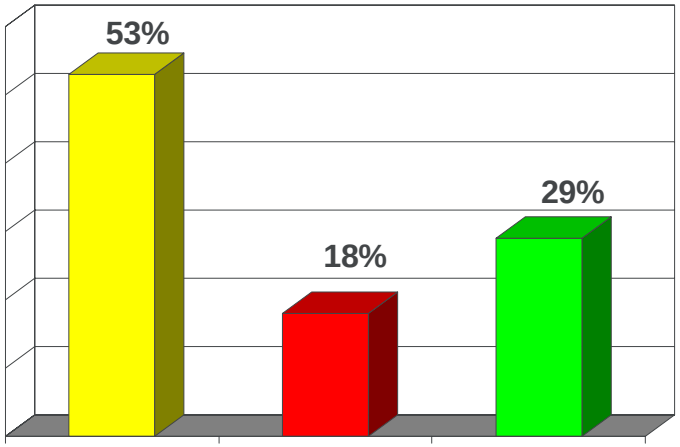
- Application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project
- Management Functions
  - Planning
  - Organizing
  - Staffing
  - Directing
  - Controlling
- All are enhanced by measurement



Top Management Directive "Run IT like a Business"

$255 billion spent on IT projects

- 53% challenged
- 18% failed
- 29% successful



Standish Group, Chaos Report, 2004 Third Quarter findings

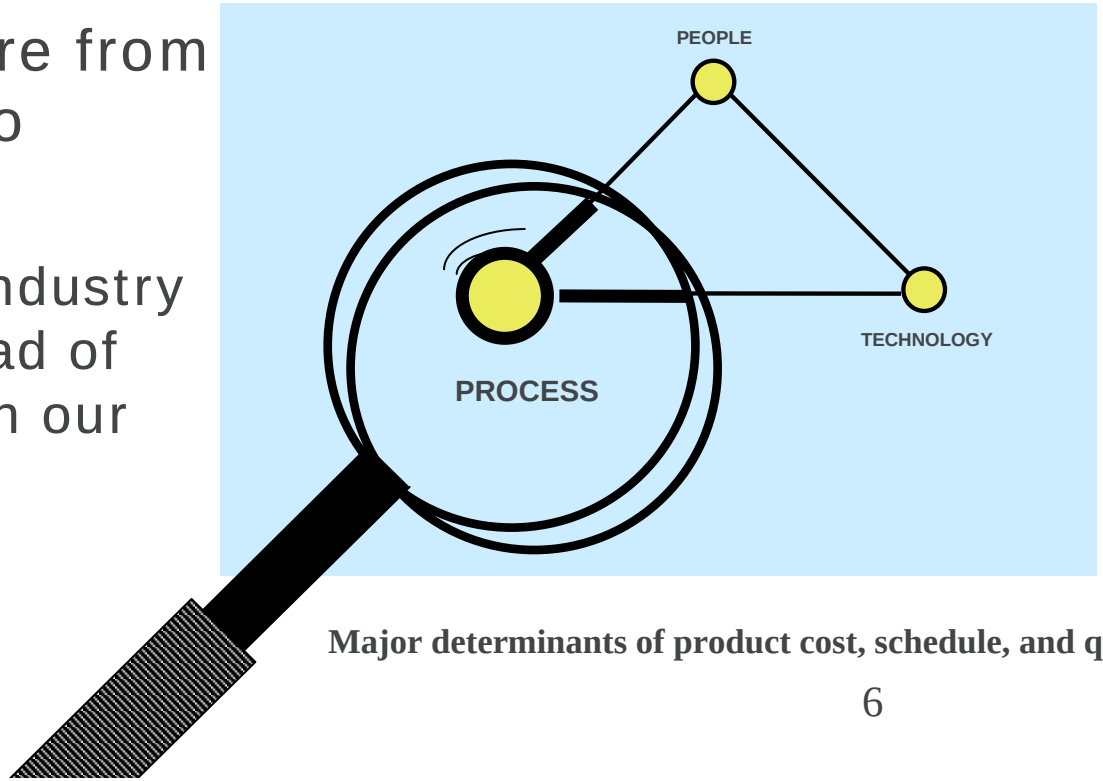
2005 Cutter Consortium software project survey reported:

- 62% overran original schedule by more than 50%
- 64% more than 50% over budget;
- 70% had critical product quality defects after release

$55 billion of U.S. IT budgets wasted annually
Averages 22% of IT organizations budget

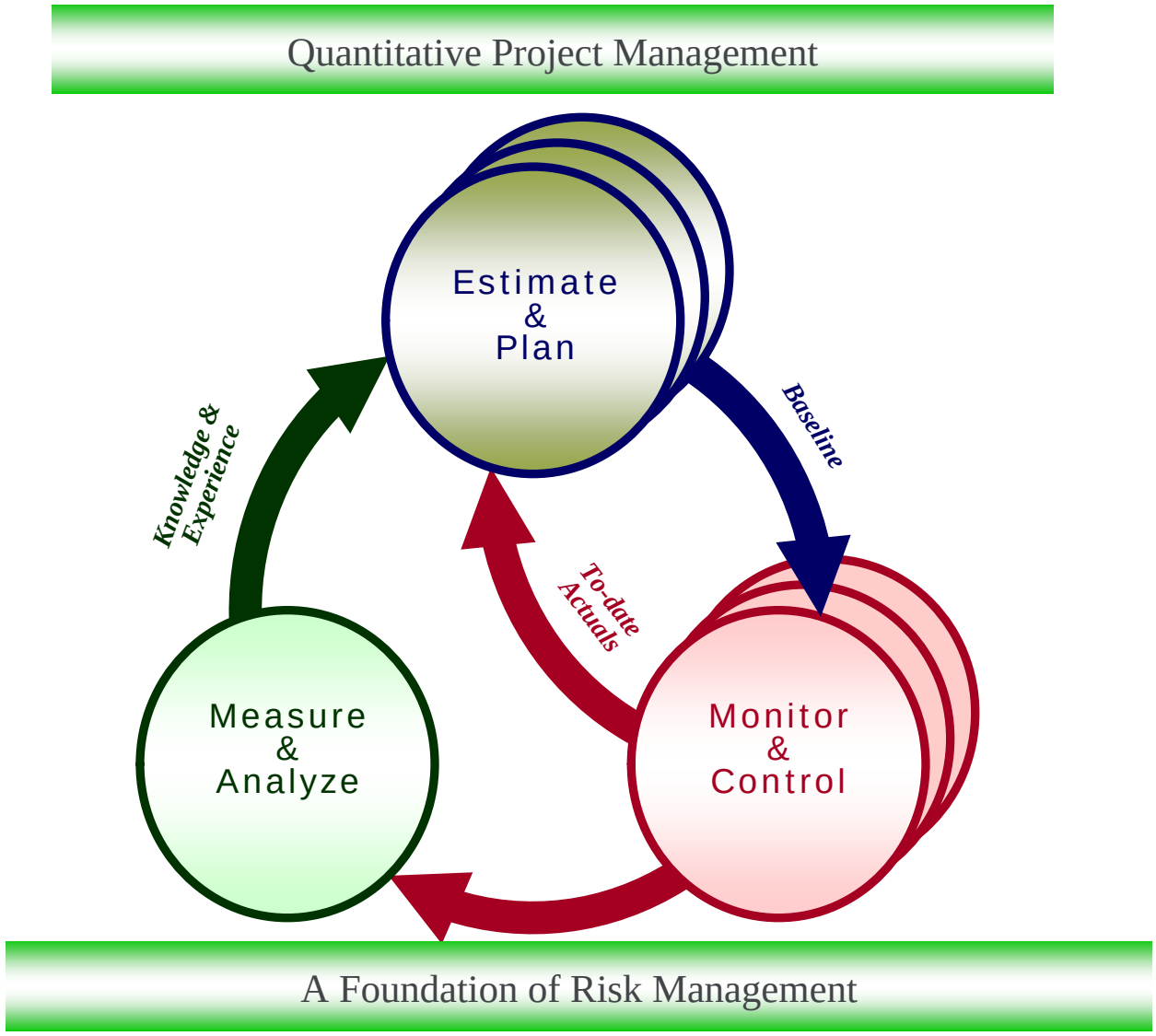
People, Process, Technology Are Keys Source CMMI Tutorial

- Everyone realizes the importance of having a motivated, quality work force but…
- …even our finest people can't perform at their best when the process is not understood or operating "at its best"
- Change software from idiosyncratic to normative
  - We can use industry lessons instead of learning all on our own



Major determinants of product cost, schedule, and quality

CMMI Process Areas Supported By Estimation, Planning & Control



Learning From Lean Manufacturing

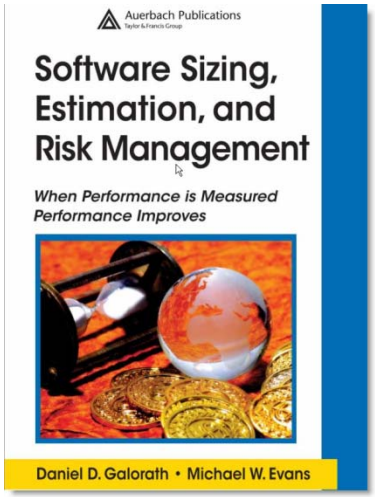
- Craft production: The individual is supreme
- Mass Production: The system is supreme
  - Minimize cost by max resource utilization
  - Principals: Efficiency; repeatability; large infrastructures; Technocentrism
  - Software currently at mass production level
- Lean Production: Integrate System and People
  - Superoptimization, flexibility, maximize value; minimize waste
  - Principals: Value, flow, pull, perfection

Mindset: Product & Stakeholder, Then Process

- “The concentration should be on the product, not just the process”
- Total Quality Management (TQM) advocates claim, process quality determines product quality but…
  - Unless one has a clear definition and expectation for the product, the process is ineffective
  - Analogous to the Chinese proverb…"If you don‘t know where you want to go, a map is useless.“
- Deming's…ideas…being overlooked
  - What is it that we want to accomplish?
  - What are the useful products of the endeavor?
  - How will it benefit the stakeholders?”
- Source: (Baker, Defense Acquisition Univ.; Michel, National Defense Univ.“Education, Information Technology, and the "Software Crisis" ” April 2002)

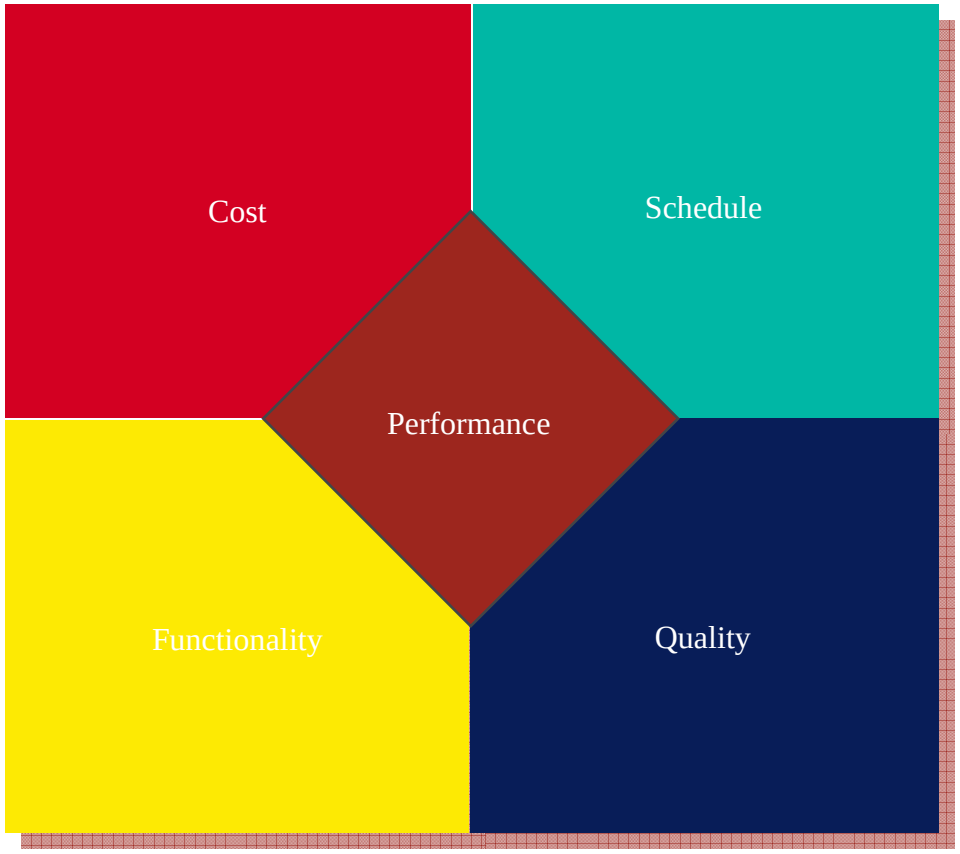
10 Step Software Estimation Process:
Consistent Processes = Reliable Estimates

SEER by GALORATH



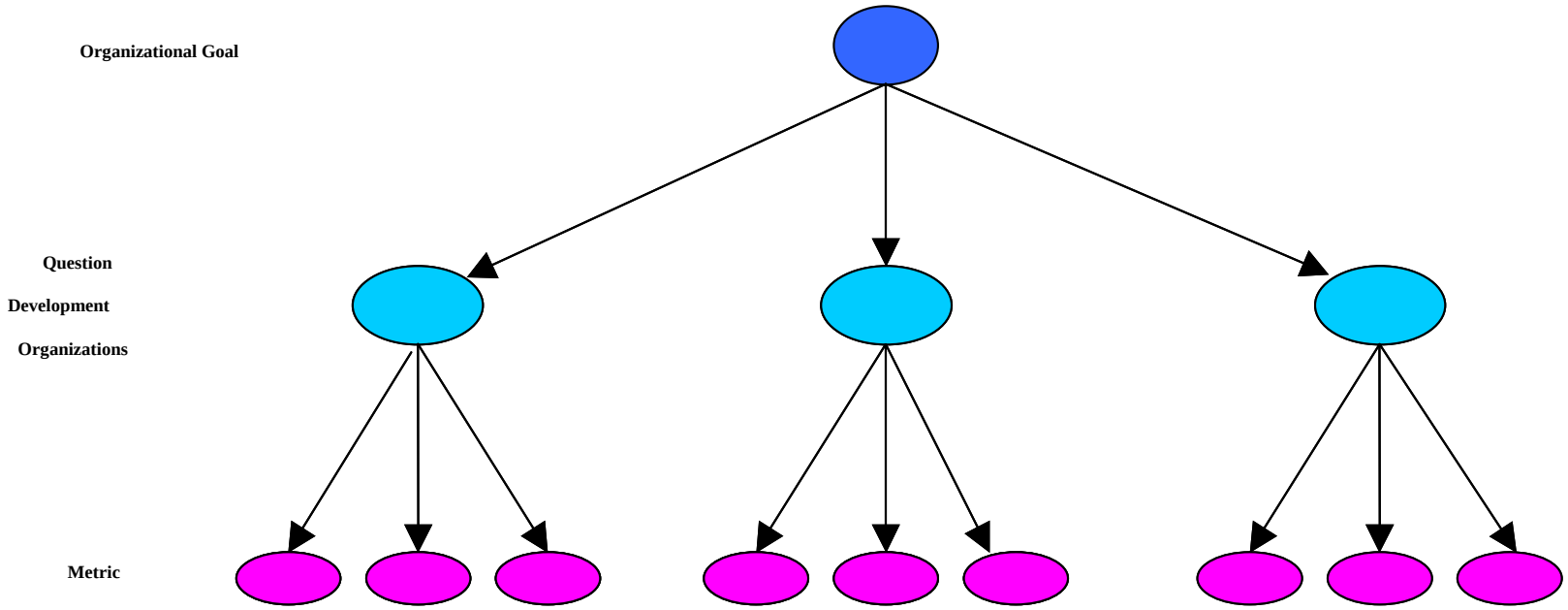
1. Establish Estimate Scope
2. Establish Technical Baseline, Ground Rules, Assumptions
3. Collect Data
4. Estimate and Validate Software Size
5. Prepare Baseline Estimates
6. Review, Verify and Validate Estimate
7. Quantify Risks and Risk Analysis
8. Generate a Project Plan
9. Document Estimate and Lessons Learned
10. Track Project Throughout Development

PSM Integrated Software Management 1998



Measurement & Data Collection

Goal Question Metric Approach



- Combine goal-orientation bottoms up, decision-support & other operational management techniques
  - www.weather.com to decide to bring an umbrella is decision support

Reasons Many Don't Want To Provide Data

- They could be proven wrong
- It could be used against them
- Data often doesn't exist
  - Even if processes dictate data requirements
- If it exists it may not be clean
- It may give away corporate productivity & bid strategy

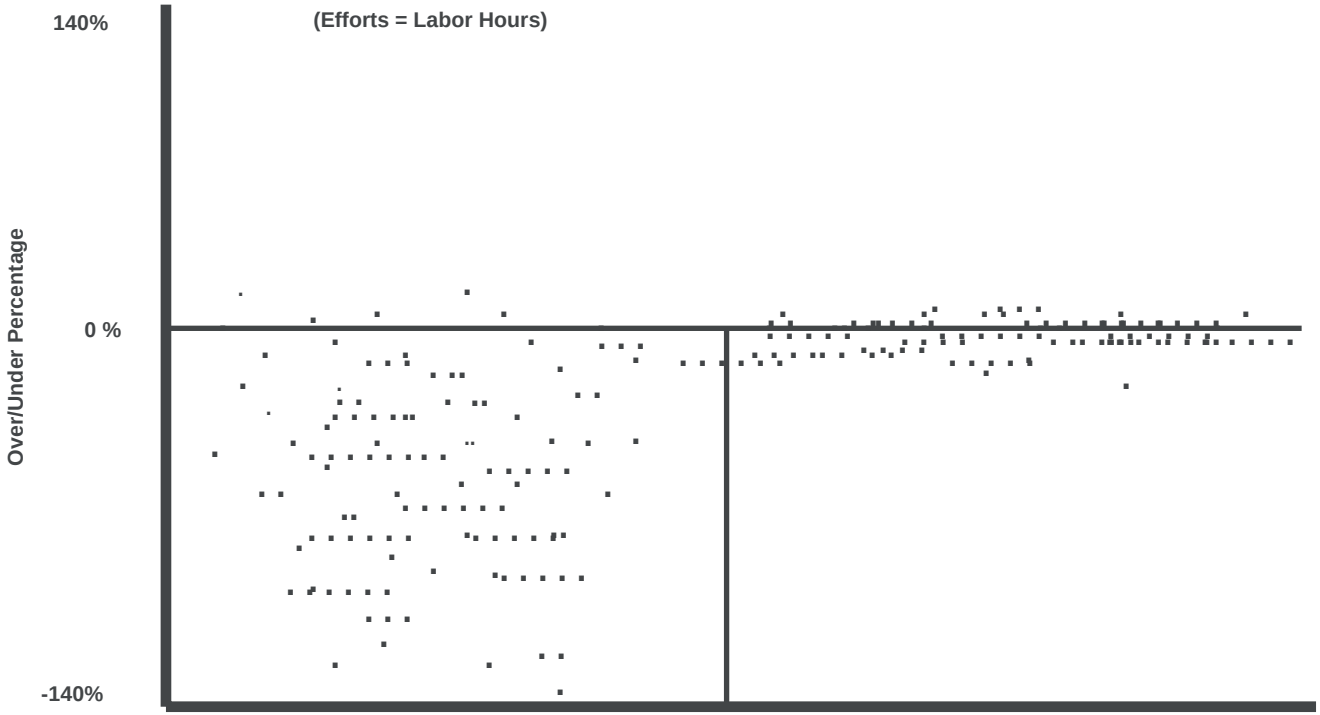
Data Must Be Used With Caution

- Run sanity checks on data
  - A million lines of code can't be developed in 3 months
- Ongoing issue between our statisticians and engineers
- Some Statisticians claim.. "That is what the data says so it must be right"
  - Sometimes even if it is obviously wrong

Josiah Stamp Observation On Data & Statistics

- “The government [is] extremely fond of amassing great quantities of statistics. These are raised to the nth degree, the cube roots are extracted, and the results are arranged into elaborate and impressive displays.
- What must be kept ever in mind, however, is that in every case, the figures are first put down by a village watchman, and he puts down anything he d..m well pleases.
- Attributed to Sir Josiah Stamp, 1840-1941, H.M. collector of inland revenue.

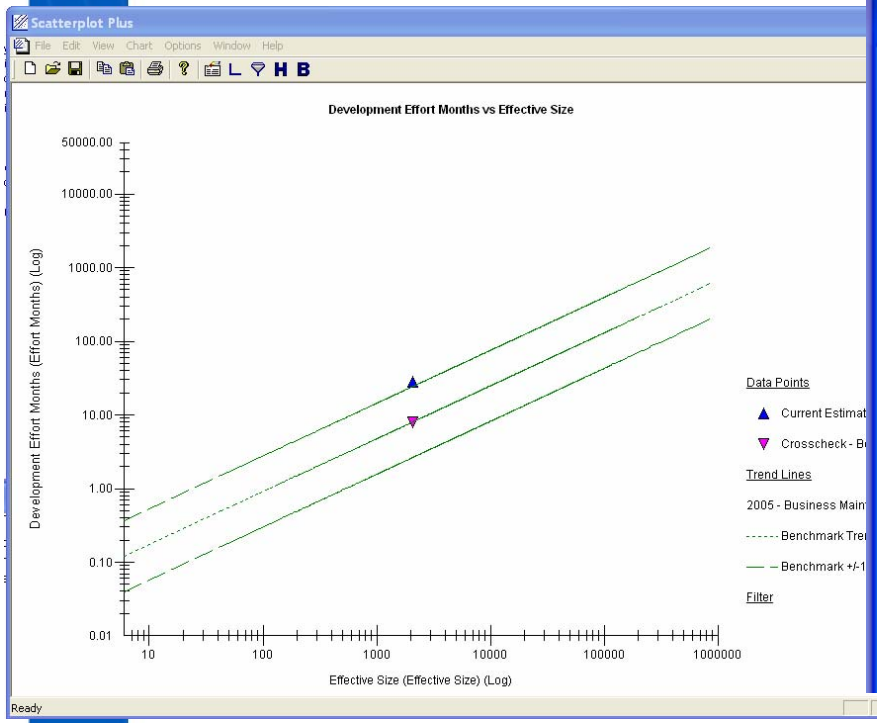
Data Improves Estimates For New Programs Source: John Vu, Boeing SEPG 1997

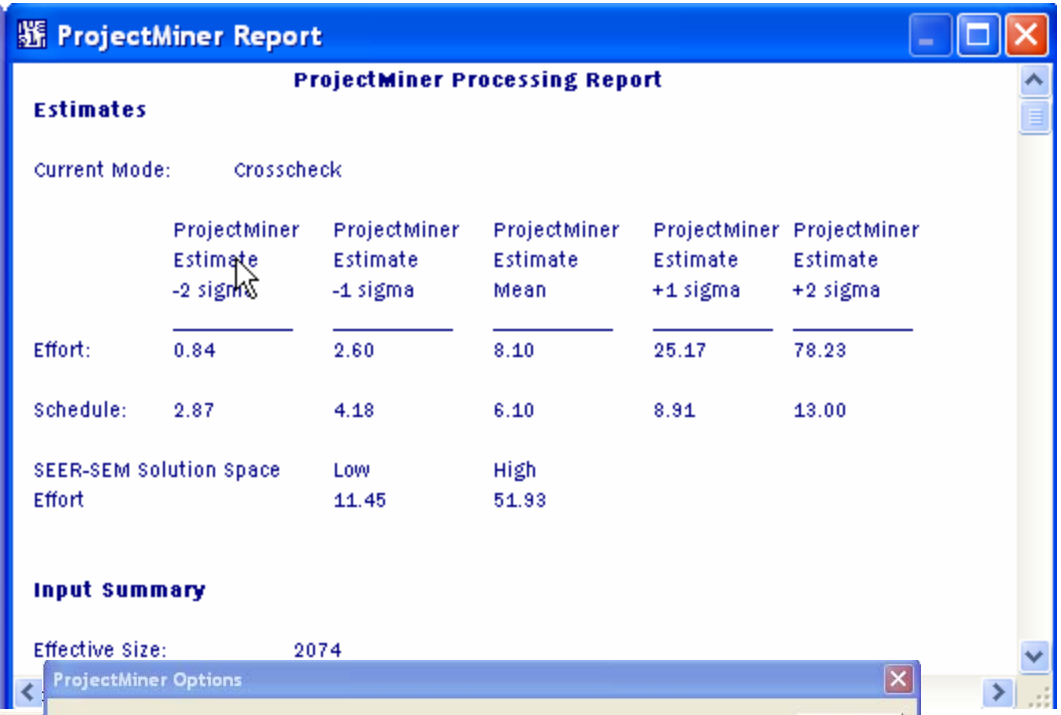


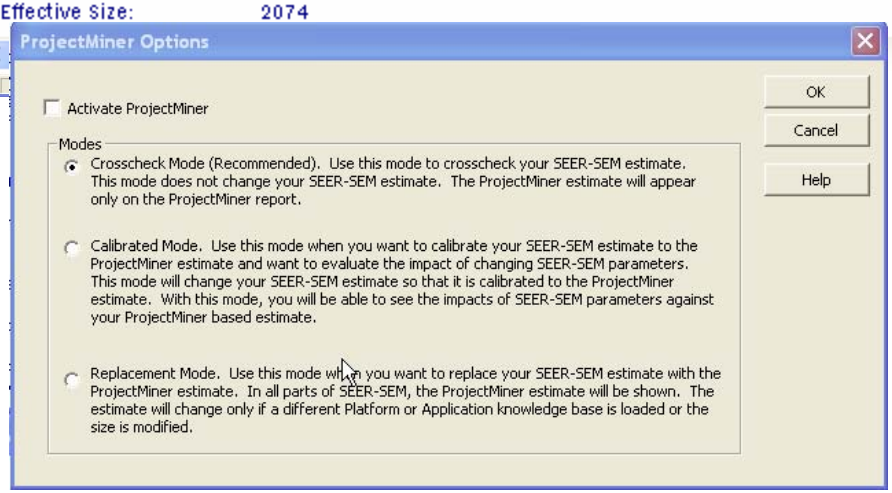
John Vu, Boeing, keynote talk at SEPG '97,
"Software Process Improvement Journey (From Level 1 to Level 5)"

(Based on 120 projects in
Boeing Information Systems)

Historical Data Can Substantiate Parametrics and/or Provide Calibration







Data Collection Lessons Learned (Summarized)

1. Motivate potential data providers to participate
2. Avoid nondisclosure agreements containing clauses requiring exclusivity or destruction of data if you can
3. Provide data collection forms and instructions beforehand, in both hard copy and electronic formats
4. Provide clear definitions but recognize providers may not read them
5. Identify which data are *required*, *highly desirable* or *desirable*
6. During the face-to-face interview confirm data is realistic and valid
7. Grade to indicate confidence
8. Normalize data via well-documented process & keep both the raw and normalized data

Cost Management... 1998 Cost Conference Dan Keynote Air Force Aeronautical Systems Center REDUX

Who Cares About Costs??!! REDUX

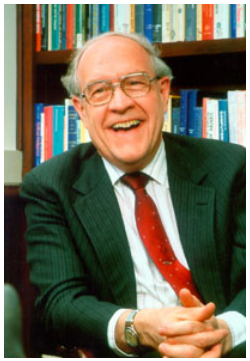
- "Affordability Driving New Weapon System Designs" *Aviation Week* 9/7/98
- "Operators Push For Cuts In Cost Of Composites Use" *Aviation Week* 9/7/98
- "Cost of New Space Station 3.6 Billion Over Budget", *Los Angeles Times* 1998
- "A Day Late and (Many) A Dollar Short" *The Hackett Group*
- "For Every 100 Application Development Projects There Are 94 Restarts", *Computerworld Magazine*
- "Behind Oxfords Billing Nightmare" Business Week 11/17/97
- "Feds Year 2000 Costs On Rise" *Computerworld Magazine* 9/7/98
- …And On And On

Since Costs Are Constantly Talked About Why Aren't They Understood and Managed?

- Don’t Know How
  - How To Produce Credible Estimates
  - How To Scope The Problem
  - How To Factor In Risk
- Engineers Sometimes Don’t Care
  - Make It “Best”... At Any Cost
  - Since They Can’t Quantify Cost They Often Ignore Cost
- Government Sometimes Monitors Rather Than Manages
- Over Optimism
- Sometimes People Don’t Want To Know The Cost

Frederick Brooks Classic Paper "No Silver Bullets"

- "There is no single development, in either technology or management technique, which by itself promises even one order-of magnitude improvement within a decade in productivity, in reliability, in simplicity."
- -- Fred Brooks, 1986
- i.e. There is no magical cure for the "software crisis"
  - Not software measurement
  - Not better tools
  - Not ---- (fill in the blank… the current great hope)



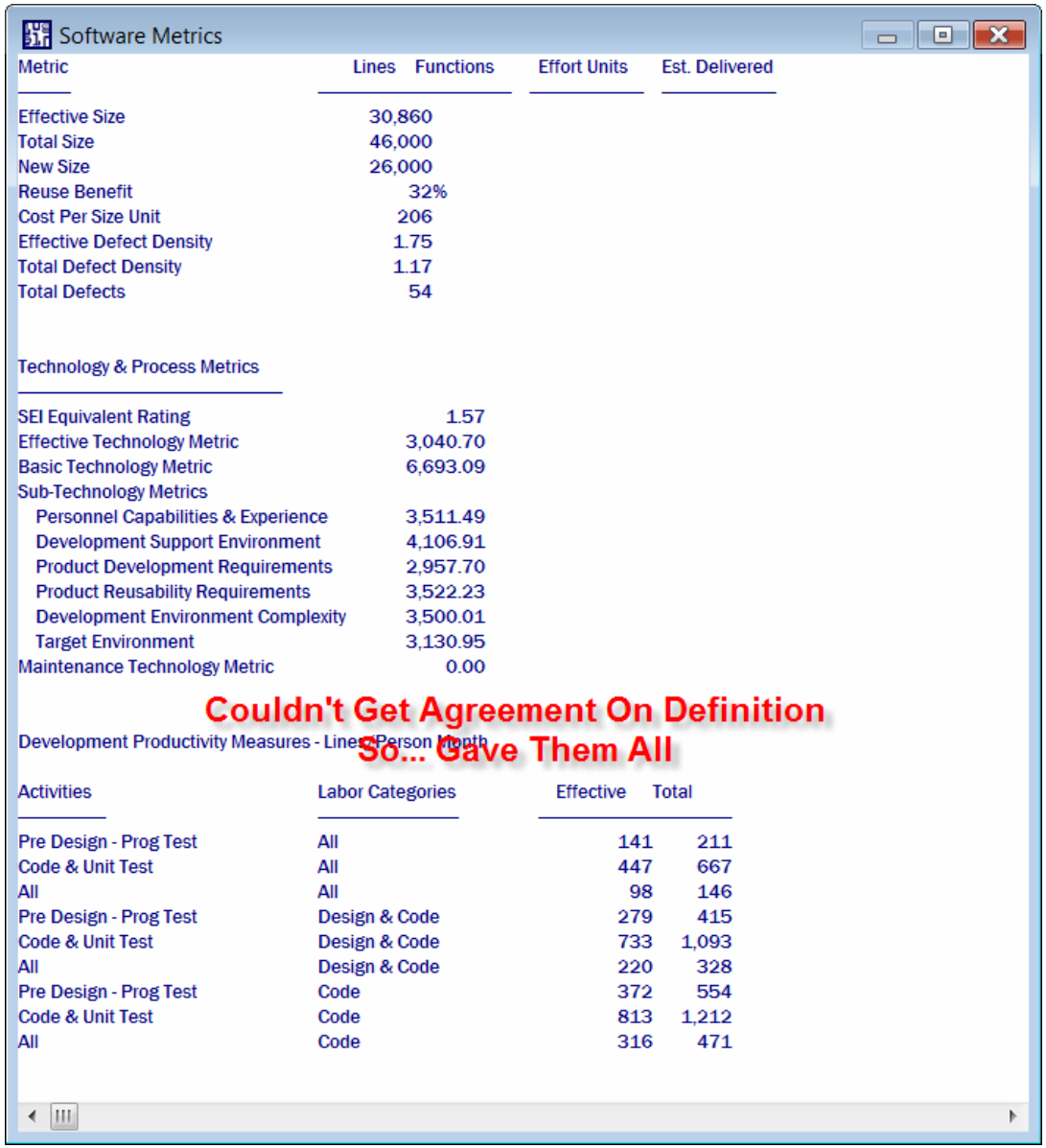
Evolution of Size Metrics as an Example

Evolution of Size Measures

- Where lines of code was once the king
  - In many domains other measures are gaining overtaking them
  - Where code used to be hand generated and easily counted with counters..
    - Much code is autogenerated
    - And many systems are primarily legacy
    - Or package installation

Even With Standards Many Use Their Unique Definitions

- Tried to establish single definition for productivity
- Unsuccessful so we gave all possible definitions
- Advantage: all are there
- Disadvantage: Even ones you don't need/ want are there



Size Mis-Estimation Then and Now

- Where size has often been miscounted or misestimated
- Function based sizing methods have the same issues
  - “Physical Function Points” Versus IFPUG
  - COSMIC Versus …
  - Full Function Points Versus…
- The problem of definition

Projects have been killed because the program office was not happy with the count.. Compared to another system’s count with different version of function points

Industry Databases

The Good

- databases are available e.g:
  - ISBGS
  - NASA SEL
  - SSCAG
  - New efforts with SEI and others
  - Others

The Bad

- Data is as good as the recorder
- Data may not be normalized
- Some data is structured to impress
- Some are trying to just consolidate.. Buyer be ware

Thoughts On Measurement
Source: J. Rothman

- Measurement Is Observation
- Measure what makes sense
- Measure what you want more of
- DeMarco: Effort moves to what is measured
- Measure in the aggregate
- Be careful measuring individuals

Measurement Is One Key To Controlling Chaos Projects

- Identify the “meatballs in the spaghetti”.. What we will measure
- Capture & document these units of software
- Clarify subdivisions of work & definitions of “complete”
  - Include reviews as part of complete
- Quickly train team on these processes
- Invoke peer reviews to reduce errors and increase reliability
- Measure and track progress vs effort
- Spend management time where measurement shows issues

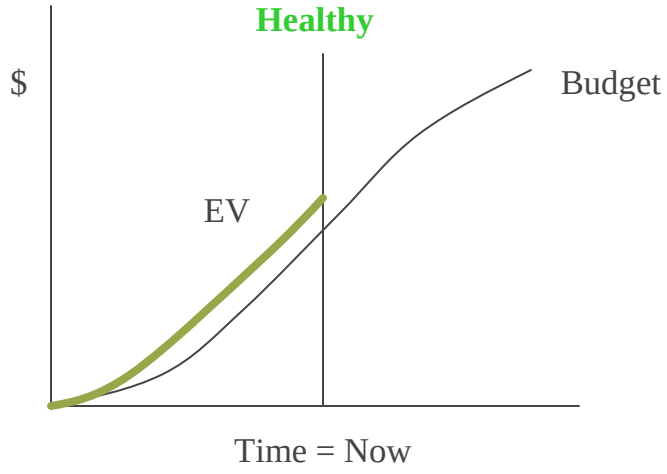
Functional Focus Example: Ladies Purse

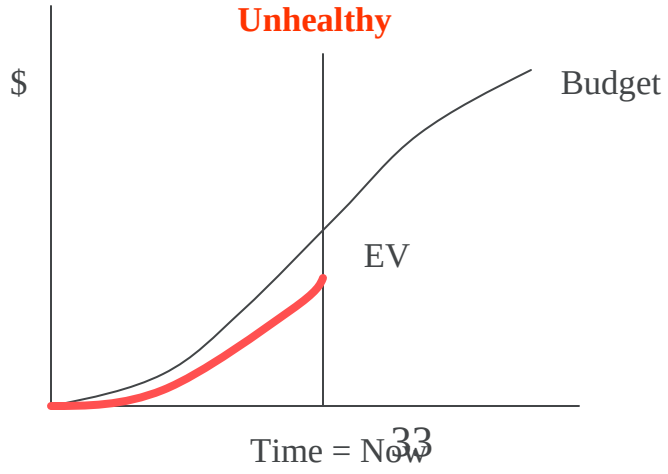
- Function ..... Hold stuff
- Cost..... $400 at Nordstrom
- What else will perform the function?.....Paper bag - cost = $0.05
- Go to plastic bag for more durability.....Cost = $0.10
- Add color.....Cost = $0.15
- Add strap.....Cost = $0.25

Earned Value

Use Earned Value TO Quantify Progress Versus Effort

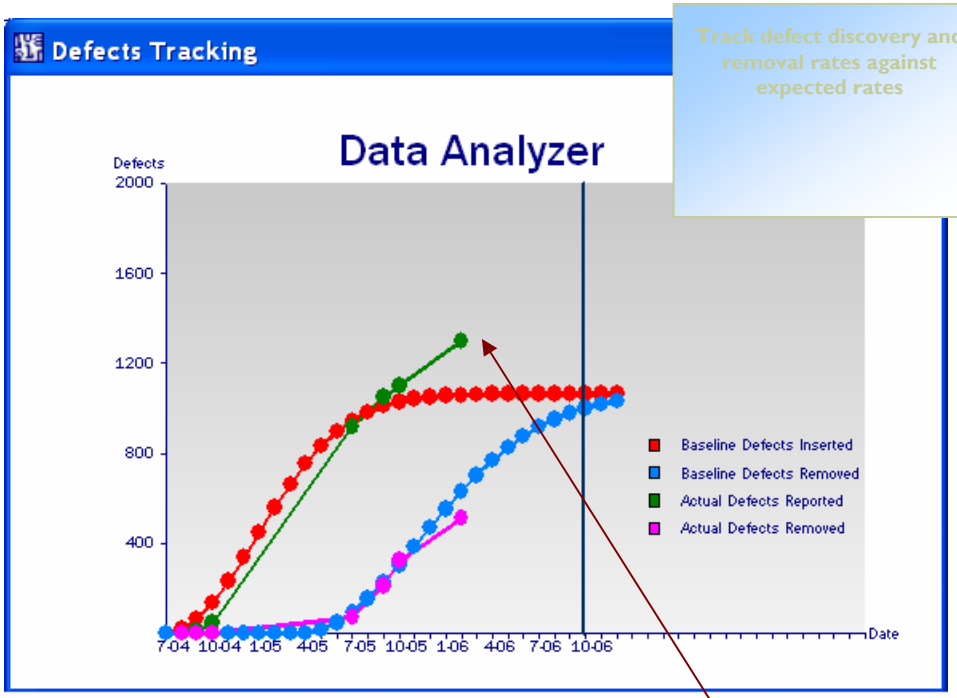
- Main concern of EVM: what has been accomplished in a given time and budget, versus what was planned for the same time and budget
  - A project is generally healthy if what has been accomplished is what was planned, or more
  - Project unhealthy if accomplishment lags expectations
- Definition: Earned value = budgeted value for the work accomplished (what you got for what it cost you)





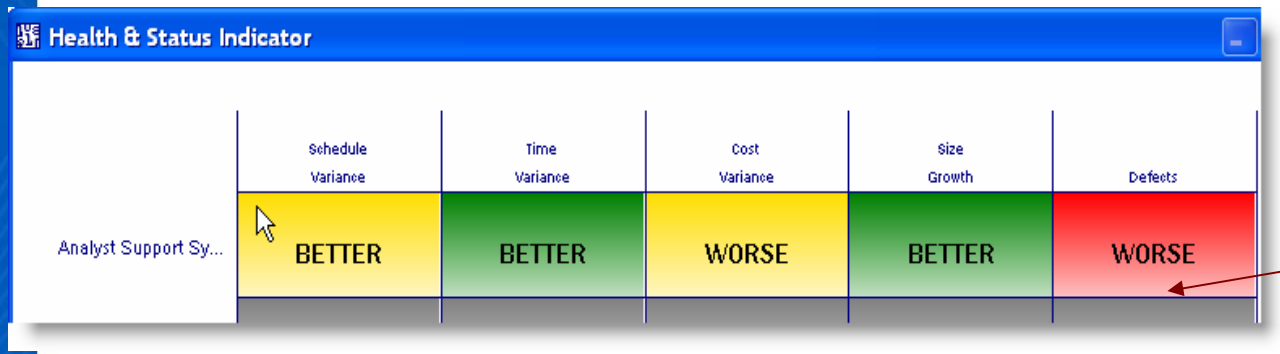
Defects and Growth Impact Software Process

Track defect discovery and removal rates against expected rates



Heath and Status Indicator shows status and trends from the previous snapshot

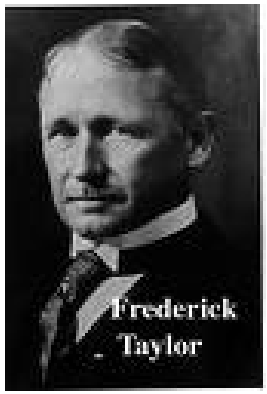
Thresholds are user definable



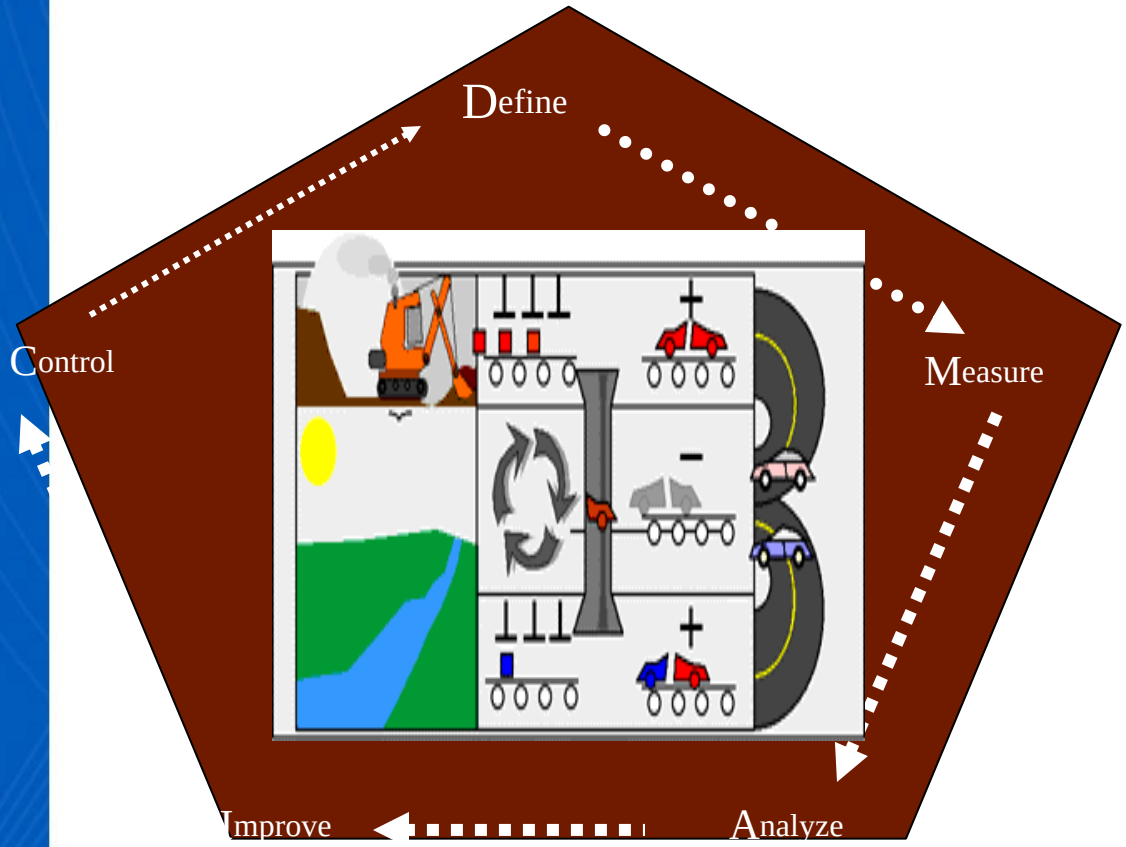
Increased defect reporting rate shows a worsening trend

The Hawthorne Effect: People Respond To Being Measured

- Goal: Find optimum for productivity 1924 to 1927
- **Increase, No Control Group**; Three departments; all showed an increase of productivity, whether illumination increased or decreased.
- **Increase, Control group** =change in lighting; experimental group got sequence of increasing light. Both groups substantially increased production, no difference between groups
- **Decrease, Control group got stable lights**; other sequence of decreasing levels. Both groups steadily increased production until the light in experimental group got so low they protested and production fell off
- All back to original: Productivity went up



Six Sigma Lessons For Measurement (Source DR. RICK EDGEMAN)



Define the problem and customer requirements.

Measure defect rates and document the process in its current incarnation.

Analyze process data and determine the capability of the process.

Improve the process and remove defect causes.

Control process performance and ensure that defects do not recur.

Six Sigma Can Be A Model For Measurement

highly structured strategy for acquiring, assessing, and applying customer, competitor, and enterprise intelligence for the purposes of product, system or enterprise innovation and design

Innovation Algorithm

DMAIC (Define-Measure-Analyze-Improve-Control)

Design for Six Sigma Algorithm

DMADV (Define-Measure-Analyze-Design-Verify)

- Applies strategies & tools from Statistics, Quality, Business, Engineering and other disciplines

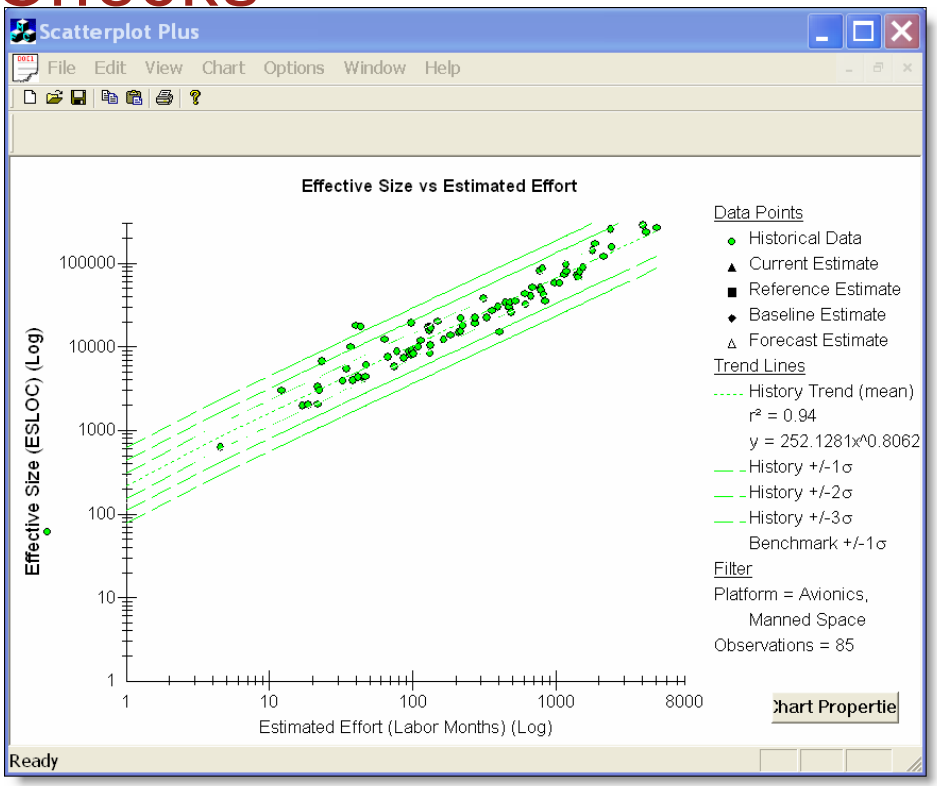
Six Sigma application
can improve both estimates and estimate process

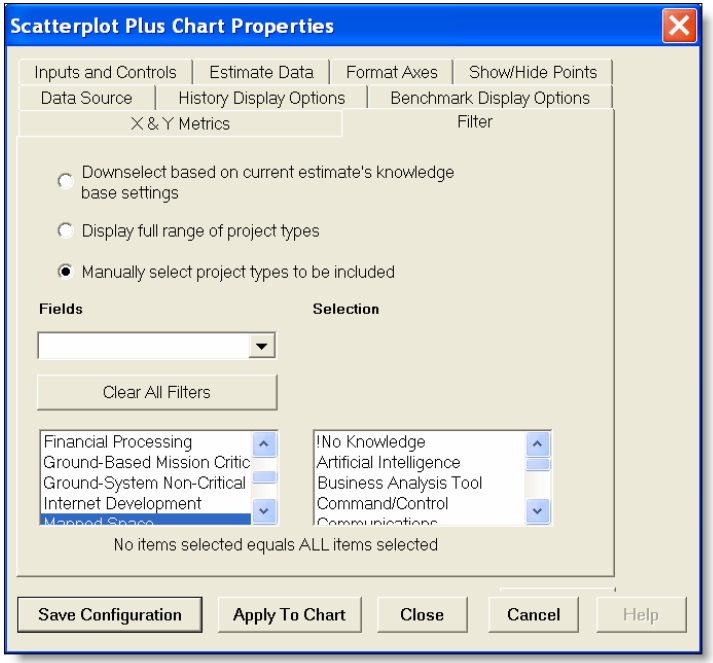
Fundamental Metrics For Estimation, Planning & Control

- Size
  - AKA Volume, Mass
  - Units: Source Lines of Code (SLOC); Function Points (FP) Use Cases
  - New versus rework
  - COTS & Packages
- Effective Technology
  - AKA Productivity Potential, Efficiency
  - Units: none
- Time
  - AKA Duration, Schedule
  - Units: Calendar Months, Calendar Weeks
- Effort
  - AKA Work, Labor
  - Units: Staff Months, Staff Hours
- Cost
  - AKA Budget, Money
  - Units: $, other currencies
- Staffing
  - AKA Manpower Loading
  - Units: FTE People
- Defects
  - AKA Reliability, Quality
  - Units: Defect Count

Compare Parametrics With Metrics and Sanity Checks

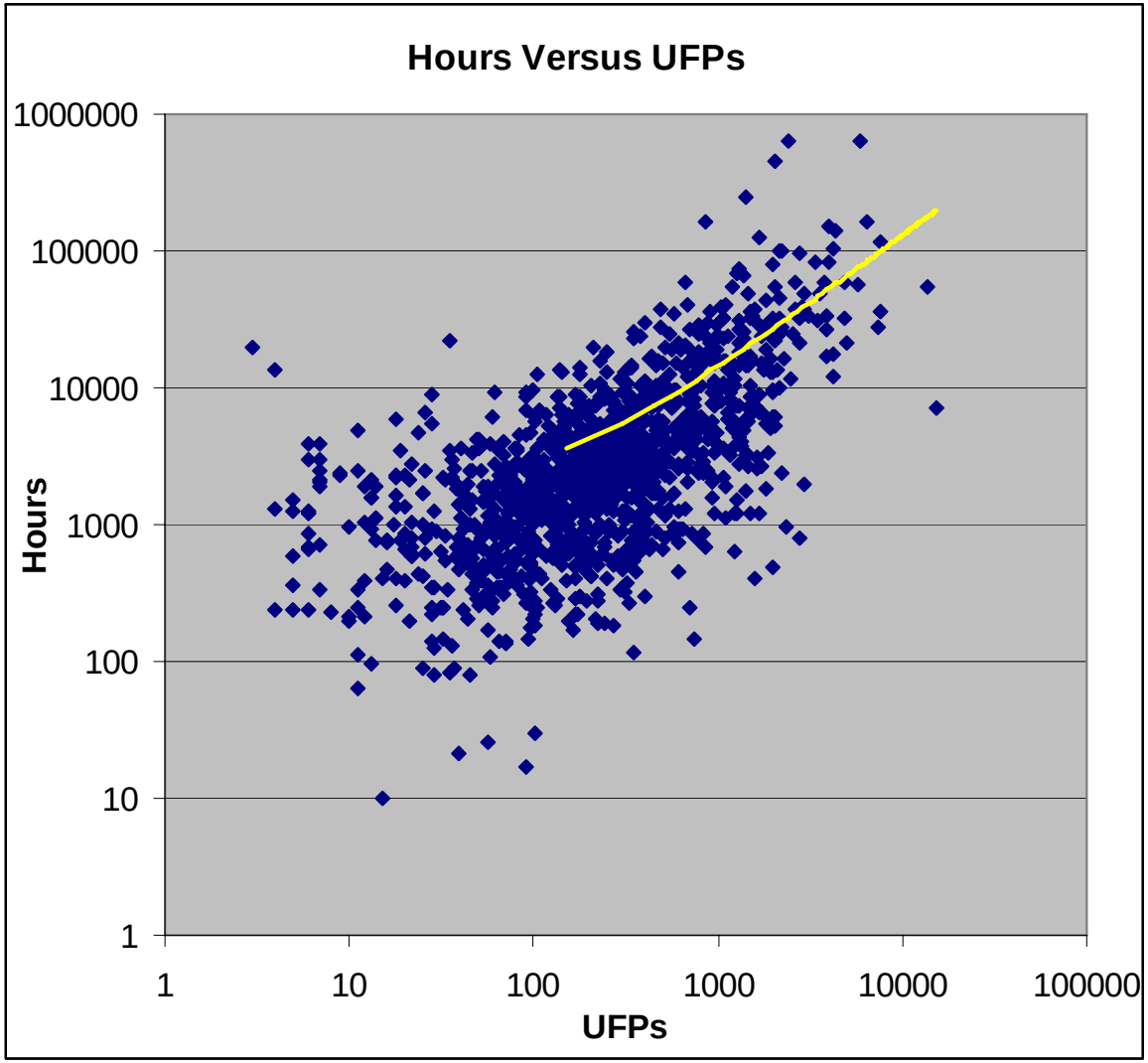
- Works with common repository
- Shows actual data, ranges, and correlations
- Plots SEER-SEM estimates and contrasts with data





"In God we trust,
all others bring data."
- W. Edwards Deming

Just the Top Level Data Isn't Sufficient For Estimation



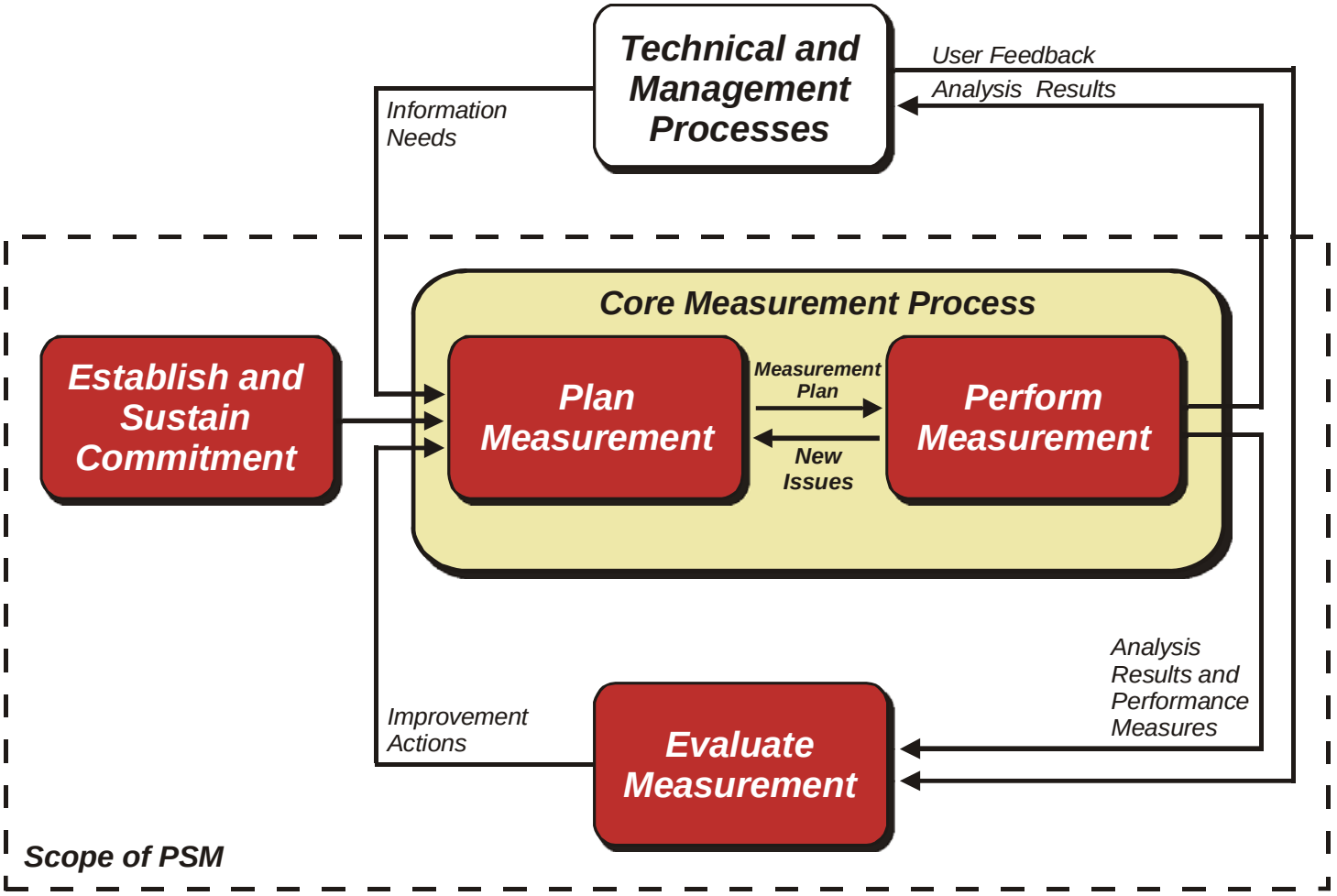
The 7 Habits Of Highly Effective Measurement Adapted From: Covey

- Be Proactive: Identify Targets, Find Ways Of Meeting Conflicting Goals
- Begin With the End In Mind: Understand What the Key Issues Are.. Measure what matters
- Put First Things First: Planning
- Think Win/ Win: Ensure measurement helps those being measured
- Seek First to Understand, Then to be Understood
- Synergize: Combine Knowledge/Resources /data With Models & processes
- Sharpen the Saw: Spend Some Resources To Improve Processes & Tools, Training

PSM 2007

Follows the 7 Habits

Measurement Activities



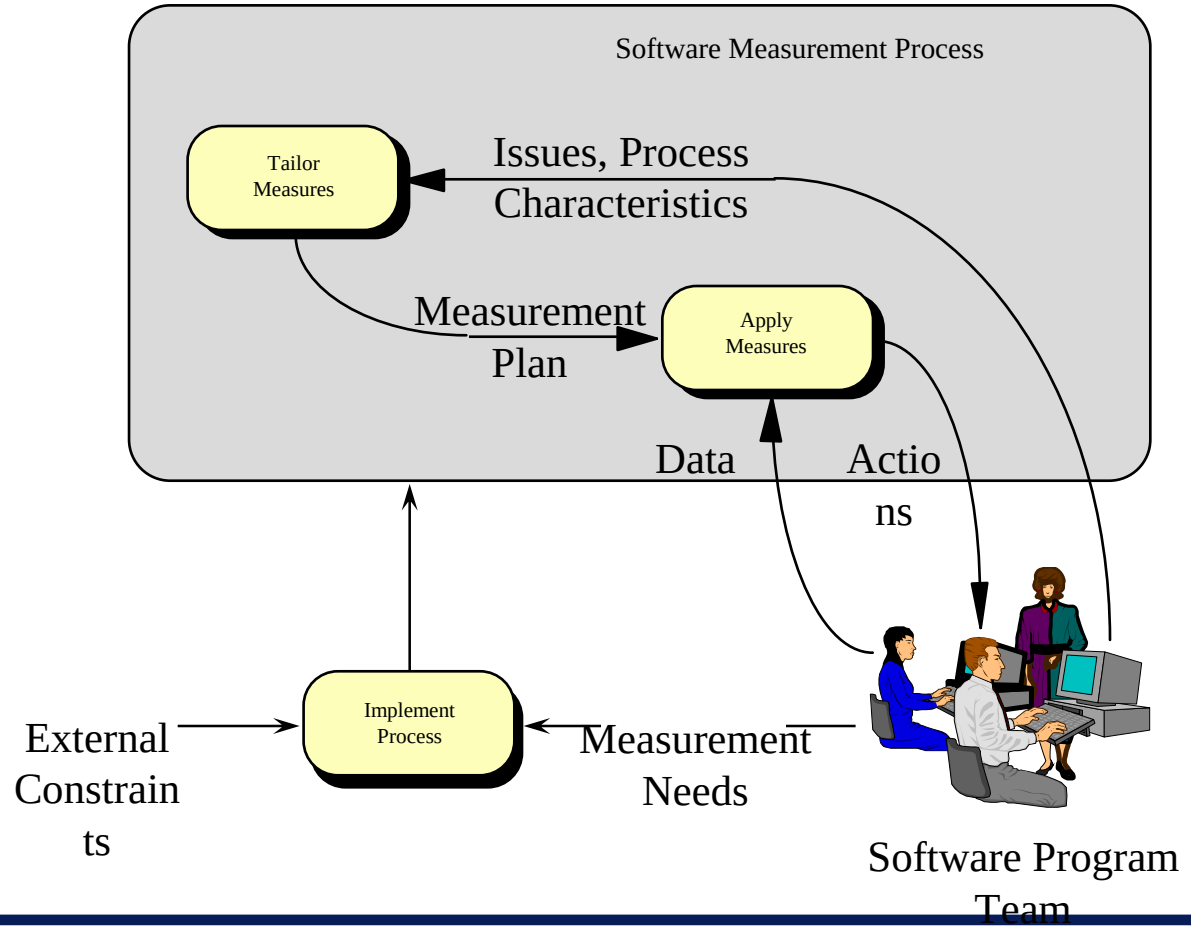
PSM Mapping of Information Categories, Concepts, and Measures

Information Category - Measurable Concept - Measure		
Information Categories	**Measurable Concepts**	**Prospective Measures**
Schedule and Progress	Milestone Completion	Milestone Dates
	Critical Path Performance	Slack Time
	Work Unit Progress	Requirements Traced Requirements Tested Problem Reports Opened Problem Reports Closed Reviews Completed Change Requests Opened Change Requests Resolved Units Designed Units Coded Units Integrated Test Cases Attempted Test Cases Passed Action Items Opened Action Items Completed
	Incremental Capability	Components Integrated Functionality Integrated
Resources and Cost	Personnel Effort	Staff Level Development Effort Experience Level Staff Turnover
	Financial Performance	BCWS, BCWP, ACWP Budget Cost
	Environment and Support Resources	Quantity Needed Quantity Available Time Available Time Used
Product Size and Stability	Physical Size and Stability	Database Size Components Interfaces Lines of Code
	Functional Size and Stability	Requirements Functional Changes Function Points

PSM Mapping of Information Categories, Concepts, and Measures (continued)

Information - Category - Measure Mapping		
Information Categories	**Measurable Concepts**	**Prospective Measures**
Product Quality	Functional Correctness	Defects
		Age of Defects
		Technical Performance Level
	Supportability-Maintainability	Time to Restore
		Cyclomatic Complexity
	Efficiency	Utilization
		Throughput
		Response Time
	Portability	Standards Compliance
	Usability	Operator Errors
	Dependability-Reliability	Mean Time to Failure
Process Performance	Process Compliance	Reference Maturity Rating
		Process Audit Findings
	Process Efficiency	Productivity
		Cycle Time
	Process Effectiveness	Defects Contained
		Defects Escaping
		Rework Effort
		Rework Components
Technology Effectiveness	Technology Suitability	Requirements Coverage
	Technology Volatility	Baseline Changes
Customer Satisfaction	Customer Feedback	Satisfaction Ratings
		Award Fee
	Customer Support	Requests for Support
		Support Time

Software Measurement Activities 1998



PSM Mapping of Issues, Categories, and Measures 1998

Software Issues - Categories - Measures Mapping

Issue	Category	Measure
Schedule and Progress	Milestone Performance	Milestone Dates
	Work Unit Progress	Components Designed
		Components Implemented
		Components Integrated and Tested
		Requirements Allocated
		Requirements Tested
		Test Cases Completed
		Paths Tested
		Problem Reports Resolved
		Reviews Completed
		Changes Implemented
	Schedule Performance	Schedule Variance
	Incremental Capability	Build Content - Component
		Build Content - Function
Resources and Cost	Effort Profile	Effort
	Staff Profile	Staff Level
		Staff Experience
		Staff Turnover
	Cost Performance	Cost Variance
		Cost Profile
	Environment Availability	Resource Availability Dates
		Resource Utilization
Growth and Stability	Product Size and Stability	Lines of Code
		Number of Components
		Words of Memory
		Database Size
	Functional Size and Stability	Requirements
		Function Points
	Target Computer Resource Utilization	CPU Utilization
		CPU Throughout
		I/O Utilization
		I/O Throughput
		Memory Utilization
		Storage Utilization
		Response Time
Product Quality	Defect Profile	Problem Report Trends
		Problem Report Aging
		Defect Density
		Failure Interval
	Complexity	Cyclomatic Complexity
Development Performance	Process Maturity	Capability Maturity Model Level
	Productivity	Product Size/Effort Ratio
		Functional Size/Effort Ratio
	Rework	Rework Size
		Rework Effort
Technical Adequacy	Technology Impacts	Program Defined Measures

The Rule of Inertia

If you always do
what you always do
then
you will always get
what you always get

The Rule of Measurement

When performance is measured
Performance improves…

When performance is measured and reported the rate of improvement accelerates..

Thomas Monson

Conclusions

- Applied measurement is a critical component of software and systems management
- Measure what you want people to focus on
- Continue emphasis on standards and definition
- Data collection is challenging
- Additional emphasis on data validation