



**Carnegie Mellon
Software Engineering Institute**

Pittsburgh, PA 15213-3890

Trading Places: Measurement and Analysis in the Eyes of the Acquirer and the Supplier

Wolf Goethert

Jeannine Sivi

Robert Ferguson

Software Engineering Measurement & Analysis Initiative

Sponsored by the U.S. Department of Defense

© 2003 by Carnegie Mellon University

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE MAR 2004		2. REPORT TYPE		3. DATES COVERED 00-00-2004 to 00-00-2004	
4. TITLE AND SUBTITLE Trading Places: Measurement and Analysis in the Eyes of the Acquirer and the Supplier				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Carnegie Mellon University, Software Engineering Institute, Pittsburgh, PA, 15213				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Trademarks and Service Marks

® Capability Maturity Model, Capability Maturity Modeling, Carnegie Mellon, CERT, CERT Coordination Center, CMM, and CMMI are registered in the U.S. Patent and Trademark Office by Carnegie Mellon University.

SM Architecture Tradeoff Analysis Method; ATAM; CMM Integration; CURE; IDEAL; Interim Profile; OCTAVE; Operationally Critical Threat, Asset, and Vulnerability Evaluation; Personal Software Process; PSP; SCAMPI; SCAMPI Lead Assessor; SCAMPI Lead Appraiser; SCE; SEI; SEPG; Team Software Process; and TSP are service marks of Carnegie Mellon University.



Objectives

Establish a view of the acquirer and supplier/contractor roles and responsibilities.

Show how measurement and analysis skills for internal development can be recast for acquisition and contracting environments.

Address two prevalent questions in the acquisition community:

- How can measurement be used to improve requirements-related processes?
- How can we conduct causal analysis when we no longer control the collection processes and/or data?



Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- measurement & analysis methods

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

Summary



Terms and Usage

We use the terms “acquisition” and “contracting” interchangeably throughout this tutorial.

In addition, the terms “contractor” and “supplier” are used interchangeably. The term “developer,” in the context of this tutorial, is used to describe a contractor.



Trends in Outsourcing ₁

From Gartner Group (2002)

- one out of every 10 jobs with U.S.-based information technology vendors and service providers will be exported
- more than 80 percent of corporate boards of directors will have considered offshore outsourcing
- 40 percent of corporations will have finished an outsourcing pilot program or be actively involved in outsourcing technology services

From Forrester Research

- offshore outsourcing will account for 28% of IT budgets in Europe and the U.S. by 2004
- offshore IT workers will go from 360,000 (in 2002) to more than 1 million in 2005

[www.rosourcing.com], [robb 02], [diana 03]



Trends in Outsourcing ₂

From Michael F. Corbett & Associates:

- Offshore outsourcing is just one small part of a (US)\$5 trillion global outsourcing market.
- This market is growing by more than 15 percent per year, and the offshore component is certainly among the fastest growing
- For U.S. IT professionals, this probably means that their future success will come from moving up the IT value chain

From Ovum research

- The outlook for the future is more offshore outsourcing, but not at the levels predicted by other analysts in this area



Why Do Organizations Outsource?

Top 10 Reasons from The Outsourcing Institute:

- Reduce and control operating costs
- Improve company focus
- Gain access to world-class capabilities
- Free internal resources for other purposes
- Resources are not available internally
- Accelerate reengineering benefits
- Function difficult to manage/out of control
- Make capital funds available
- Share risks
- Cash infusion



The Supplier Landscape ₁

Contractor dimensions:

- geography
- style
- maturity
- processes

Examples include the following:

- domestic development groups
- offshore development groups
- dedicated offshore development centers
- off the shelf, COTS products
- systems integrators
- open source
- rational
- PSP/TSP



The Supplier Landscape ₂

From Forester Research

- 88% of the firms looking overseas for services claim to get better value for their money off shore.
- 71% said offshore workers did better quality work.



Contracting Challenges ₁

From *Software Magazine* in 2001:

- 23% of software projects are cancelled
- Cost growth averages 45%
- Schedule growth averages 67%
- Average final product will include only 67% of its requirements
- Only 28% of projects finish on schedule and within budget

Cited by a sampling of Army Acquisition Managers

- The majority of problems and risks affecting acquisition problems resides “somewhat” with the following:
 - factors outside the control of acquirers and developers
 - acquisition program policies and processes
 - contracting processes
 - the contractor’s development process



Contracting Challenges ₂

Cited by a sampling of Army Acquisition Managers

- The top problem areas include
 - requirements management (selected by 63%)
 - project management (22%)
 - contractor processes (22%)
 - unstable funding (21%)

From a recent presentation on component technology

- contractor qualifications (*Mitigation: CMMI*)
- requirements definition (*Mitigation: close partnerships*)
- engineering acceptance (*Mitigation: process analysis*)

[ASSIP 03], [Scherlis 03]



Measurement Challenges

From interviews of several acquisition management personnel:

- “Measurement” is not a troublesome issue in itself; however, **getting consistent, meaningful data and understanding how to use data is a high priority and concern.**
- There is a **tremendous need for progress measures** that can be used for timely warning of major program disasters.

[C-M-H 03]



Measures in Practice ₁

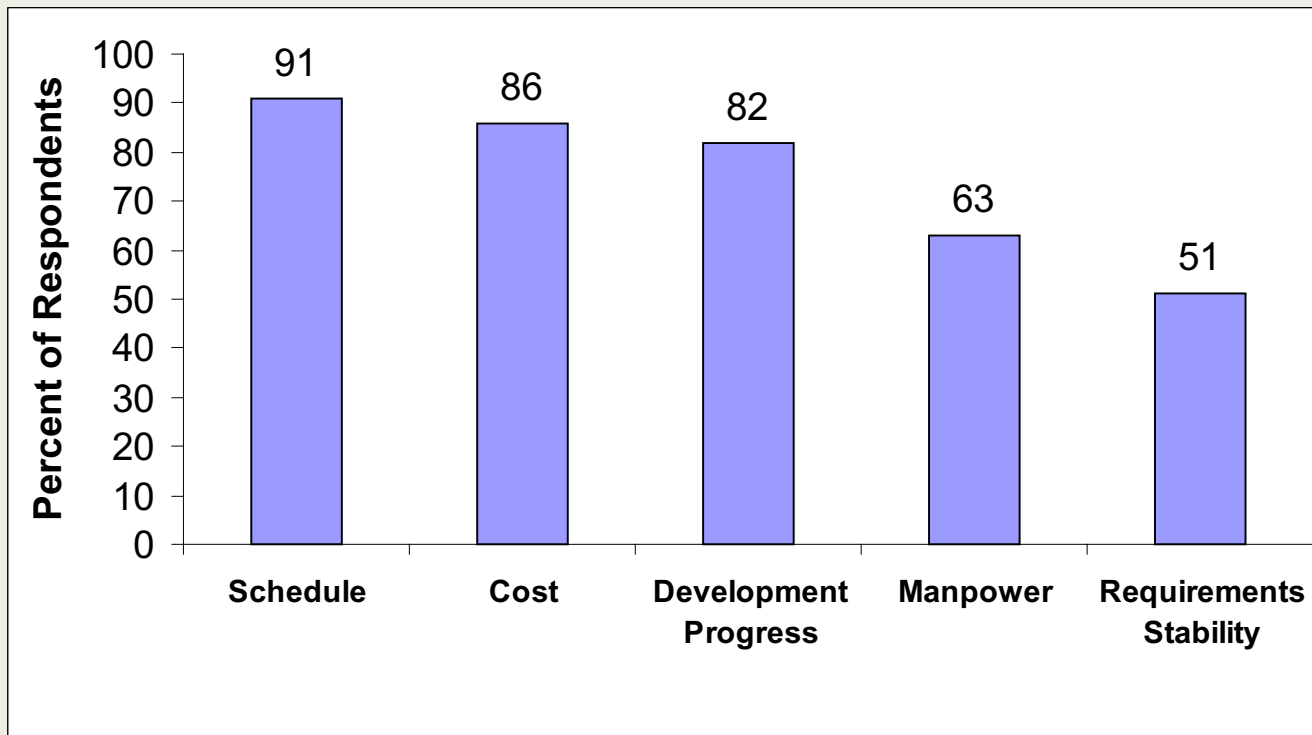
In a recent survey, a sampling of Army Acquisition Managers affirmed the following

- 83% based planning estimates on historical data
- 79% defined quantitative objectives for acquired products and services
- 81% used metrics as an input to decision making
- 75% measured and controlled project cost and schedule
- 50% recorded data in organizational measurement repository
- 78% had sufficient insight into the contractor's software engineering effort to ensure project is managed and controlled and complies with contract requirements
- 78% appraised the quality of the contractor's process, performance, products, and services throughout the contract to identify risks and take appropriate action



Measures in Practice ₂

The surveyed Army Acquisition Managers use these measures to track project status:



[ASSIP 03]



What Does This Mean?

Issues in contracting are complex and multidimensional.

- Requirements management is a problem area that frequently is not well measured.
- Project monitoring and oversight is fairly well measured, but the related analysis may not be mastered.
- Organizations may often measure what they know how to measure, but not necessarily measure all that is needed to be successful.

How does this compare to your experience?



Outline

Context

- state of the community
- changing perspectives

Background

- **roles & responsibilities**
- maturity models
- measurement & analysis methods

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

Summary



Responsibility and Authority

Measuring project and product success is the same whether the project is internal or contracted:

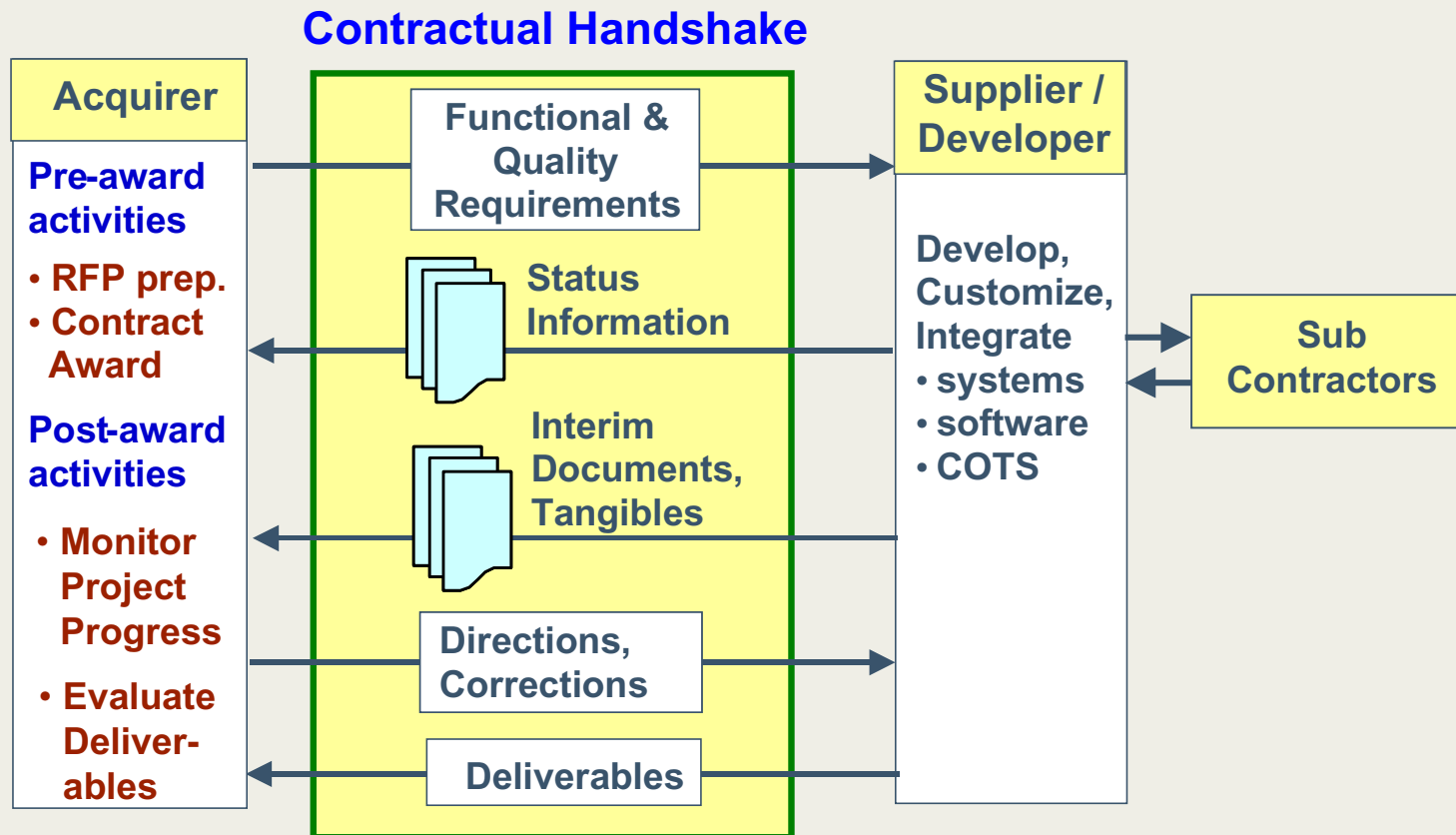
- on schedule
- at cost
- with required functionality
- without defects

The acquiring program manager's "circle of influence" and "circle of control" is different than the development project manager's.

- development project manager addresses the daily details of project execution
- acquisition program manager defines and executes a new set of processes
- acquisition program manager should leverage development knowledge to manage the contract methodically, rationally, and knowledgeably



Roles and Information Exchange





Acquisition Measurement Themes

Project Management

- project execution
- contract relationship

Product Life Cycle & Performance

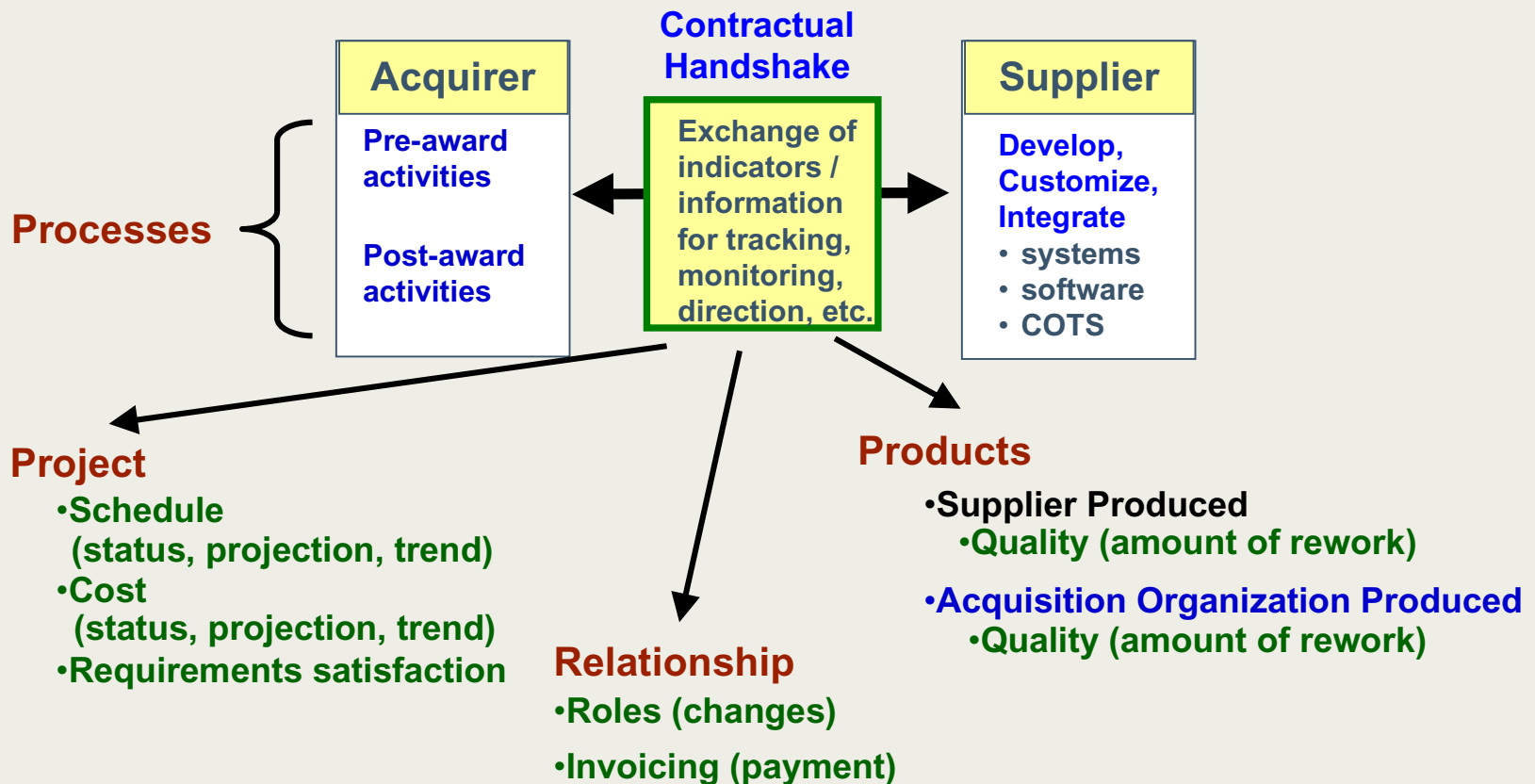
- product planning
- product development
- deployment
- maintenance

Process & Organizational Infrastructure

- process definition and execution
- relationship management



Measuring Project, Product, Process





Responsibilities Prior to Contract Award

Scope definition

Vendor selection

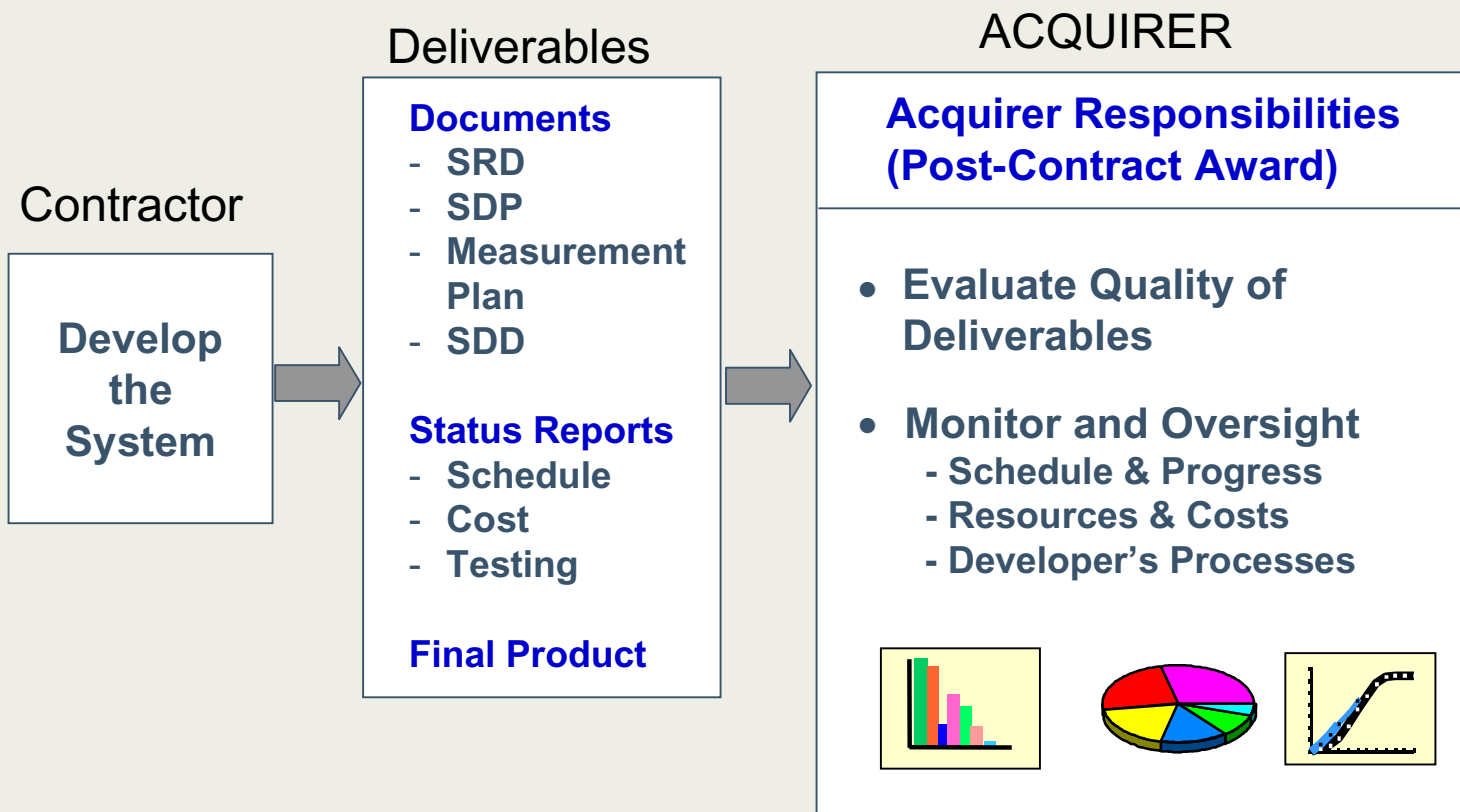
- technical capabilities
 - proposed scope
- process capabilities
 - predictable, productive performance
 - ability to deal with change
- financial capabilities

Contract negotiation

- quality management metrics
- change management
- managing & monitoring the relationship

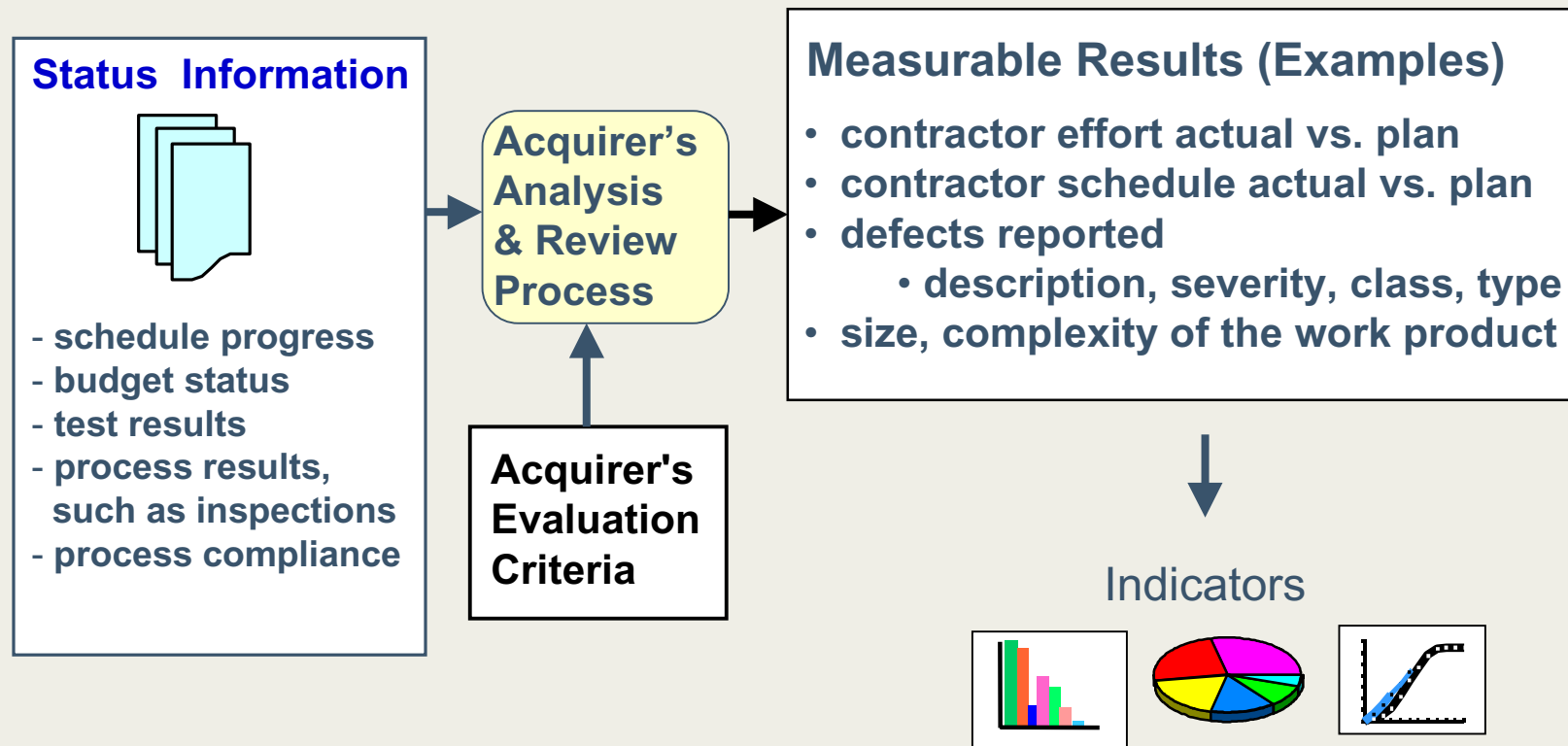


Responsibilities After Contract Award



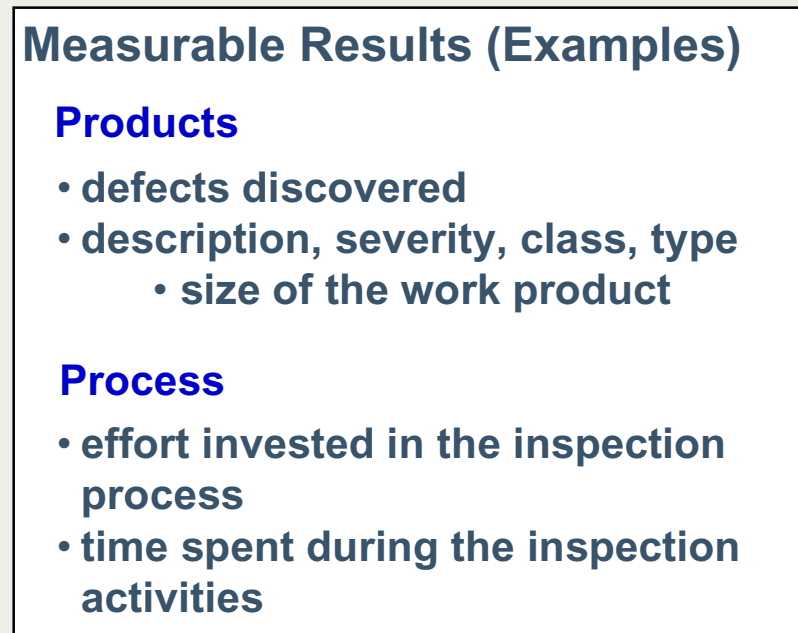
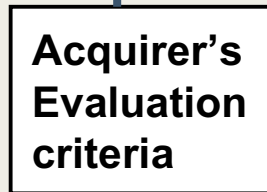
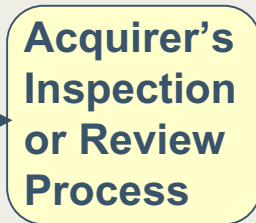
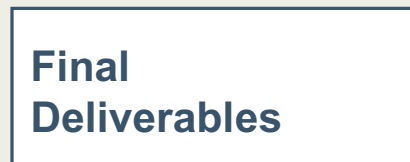
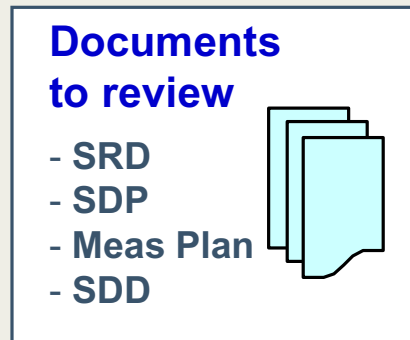


Monitor & Oversight

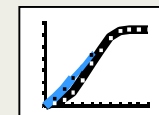
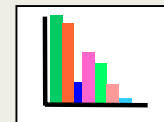




Evaluate Quality of Deliverables



Indicators





Success Factors

To make this work you need:

- technical capabilities
 - integration, validation, deployment
- process capabilities
 - project management, QA, change control
- domain knowledge
 - product uses, stakeholders, quality goals
- relationship management
 - contracting, change management, roles, payment, relationship reviews.....

And measurement to see that these things are working well.



Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- **maturity models**
- measurement & analysis methods

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

Summary



Adapting CMMI for Acquisition

In addition to establishing these Process Areas (PAs)

- Supplier Agreement Management
- Integrated Supplier Management

You may also need to use these PAs for your acquisition processes and extend them to include your supplier:

- Requirements Management, Development
- Integrated Teaming
- Decision Analysis and Resolution
- Organizational Environment for Integration
- Organizational Process Performance
- Quantitative Project Management
- Causal Analysis and Resolution
- Risk Management
- Project Monitoring and Control
- Verification & Validation
- Configuration Management
- Measurement and Analysis

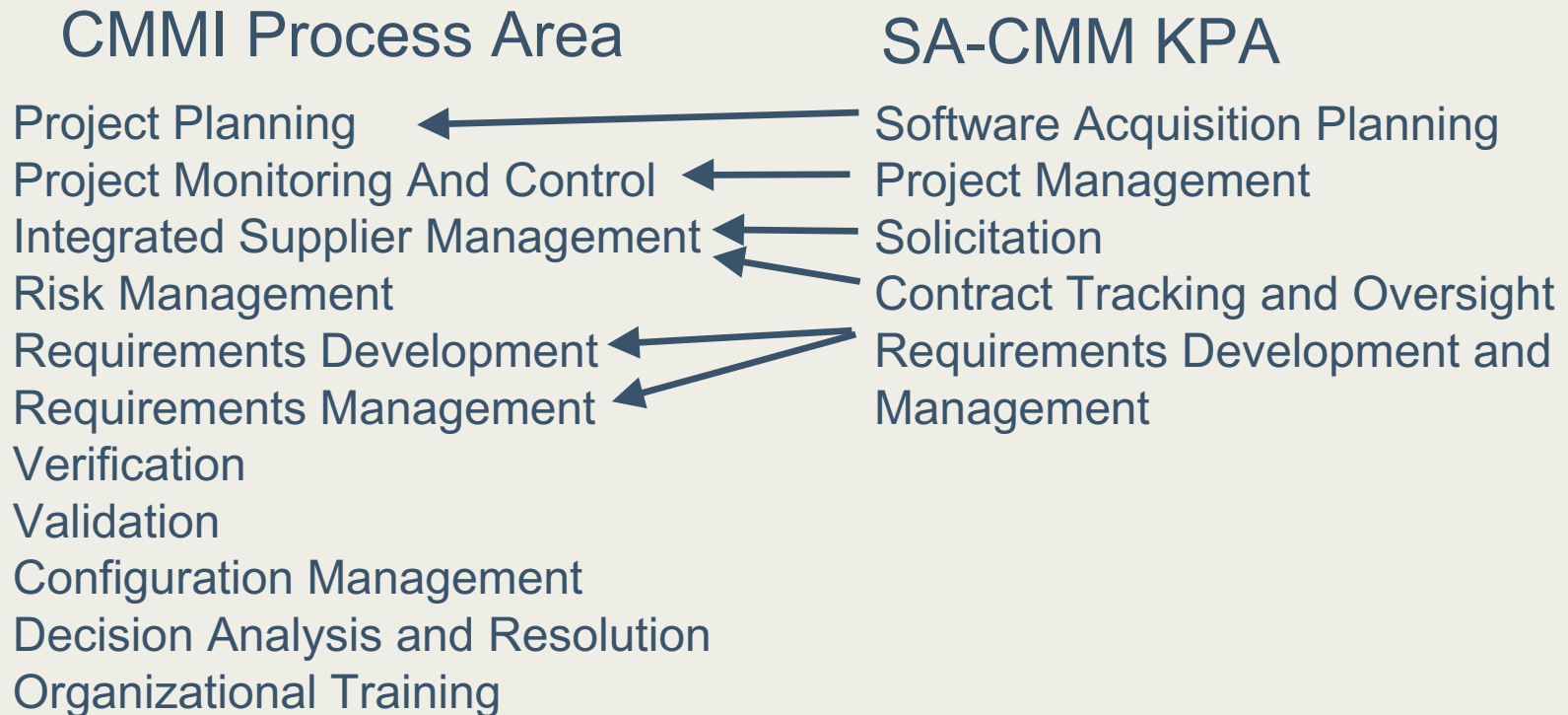


SA-CMM Key Process Areas

Level	Focus	Key Process Areas	
5 Optimizing	<i>Continuous process improvement</i>	Acquisition Innovation Management Continuous Process Improvement	Higher Quality Productivity Lower Risk
4 Quantitative	<i>Quantitative management</i>	Quantitative Acquisition Management Quantitative Process Management	
3 Defined	<i>Process standardization</i>	Training Program Management Acquisition Risk Management Contract Performance Management Project Performance Management User requirements Process Definition and Maintenance	
2 Repeatable	<i>Basic project management</i>	Transition to Support Evaluation Contract Tracking and Oversight Project Management Requirements Development and Mgt. Solicitation Software Acquisition Planning	Higher Risk Rework
1 Initial	<i>Competent people and heroics</i>		

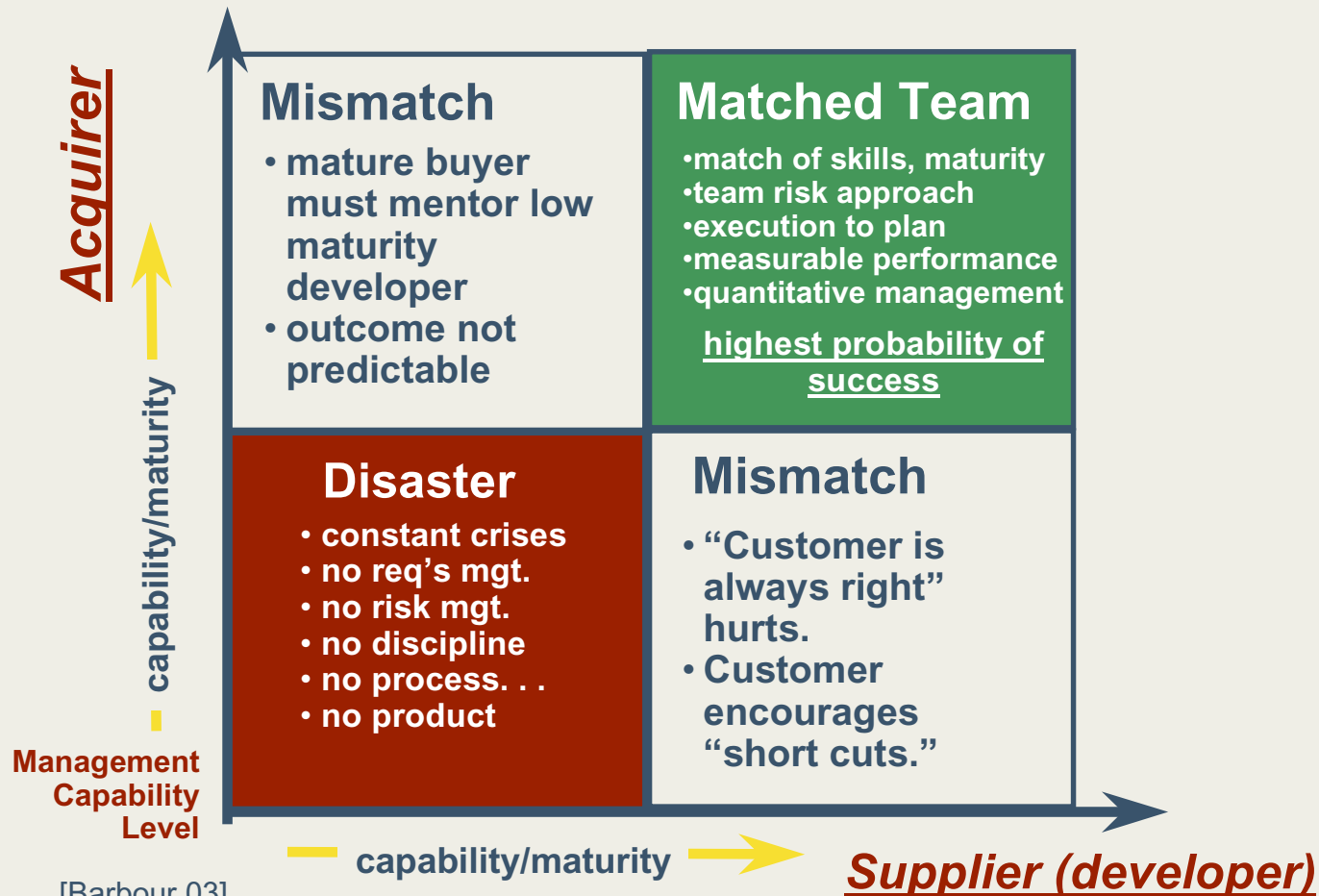


Relation to CMMI PAs





Maturity Matching Considerations



[Barbour 03]



Focusing In

Key points:

- trends in contracting
- common problems and issues faced when contracting
- common view of the roles and responsibilities of an acquirer
- role of reference models

What's in sight:

- measurement and analysis techniques

In the distance:

- an illustration of these techniques at work





Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- **measurement & analysis methods**

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

Summary



Benefits of Using Measures

Measurement by itself does not control or improve; it gives insight for objectively planning, managing, and communicating.

- historical data help us **predict and plan**
- actual versus plan data help us **determine progress and support decision making**
- analyzing trends helps us **identify and focus on problem areas**
- project data provide a basis for **objective communication**



Measurement in CMMI Process Areas

Project Management

- Project Planning, Project Monitoring and Control, Software Acquisition Management
- Integrated Project Management, Risk Management, Integrated Supplier Management
- Quantitative Project Management

Process Management

- Organization Process Focus, Organization Process Definition
- Organization Process Performance
- Organization Innovation and Deployment

Engineering -- All

Support

- Measurement and Analysis, Process and Product Quality Assurance
- Decision Analysis and Resolution
- Causal Analysis and Resolution



Measurement in CMMI Generic Practices

“Monitor and control the process against the plan and take appropriate corrective action.” (GP2.8)

“Collect work products, measures, measurement results, and improvement information derived from planning and performing the process to support the future use and improvement of the organization’s processes and process assets.” (GP3.2)

Two uses of measurement:

- project management
- process improvement

As the organization matures, the sophistication and uses of measurement increase.



Measurement in SA-CMM

Maturity Levels 2-5

- **status** of
 - processes
 - products

Maturity Levels 4-5

- **effectiveness** of
 - processes
 - products



Acquisition Enterprise Measurement

Execution of a contracted project also involves

- legal processes
- financial processes

While this tutorial does not explore these aspects of contracting, each aspect is measurable and can be quantitatively managed.



Sources for Measures

Goal-Driven (Software) Measurement (GDM)

Goals → Questions → Indicators → Measures (GQIM)

USER DEFINES INDICATORS & MEASURES

Based On:

- what's needed to manage the User's goals
- decisions and decision criteria related to managing the user's goals

Practical Software & Systems Measurement

Common Issue Area → Measurement Category → Measures

PREDEFINED

PREDEFINED

PREDEFINED



Goal-Driven Measurement (GDM)

When using goal-driven measurement, the primary question is **NOT**:

“What metrics should I use?”

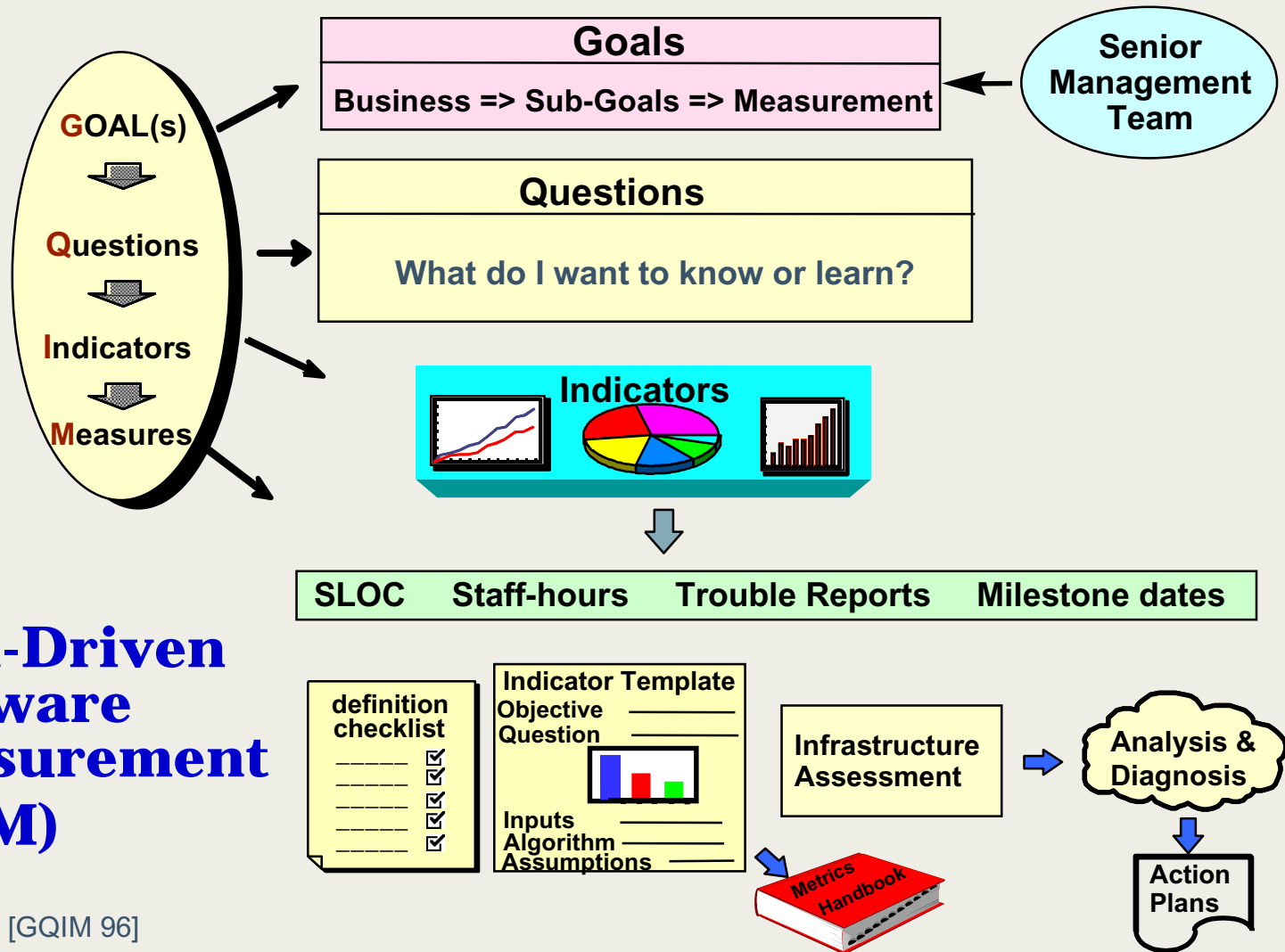
rather, it is:

“What do I want to know or learn?”

“What decision do I want to make?”

Goal-driven measurement is **NOT** based on a predefined set of metrics.

[GQIM 96]



Goal-Driven Software Measurement (GDM)

[GQIM 96]



Practical Software & Systems Measurement (PSM)

This measurement process is funded by the DoD and is freely available at <http://www.psmc.com>.

PSM process identifies project-specific issues:

- issues grouped into common software issue areas
- measurement categories correspond to issue areas
- each measurement category has a candidate set of proven measures

Measures are selected based on availability, environment, and other factors.



PSM Common Software Issues – Measurement Categories

Schedule and Progress

- Milestones Performance
- Work Unit Progress
- Incremental Capability

Product Size and Stability

- Product Size and Stability
- Functional Size and Stability

Process Performance

- Process Compliance
- Process Efficiency
- Process Effectiveness

Customer Satisfaction

- Customer Feedback
- Customer Support

Resources and Cost

- Personnel
- Financial Performance
- Environment Availability

Product Quality

- Functional Correctness
- Supportability - Maintainability
- Efficiency
- Portability
- Usability
- Dependability - Reliability

Technical Effectiveness

- Technology Suitability
- Impact
- Technology Volatility

[PSM 00]

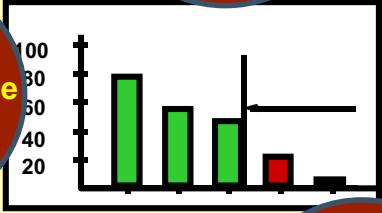
Modified Indicator Template

Indicator Name/Title _____ Date _____

Objective _____

Questions _____

Visual Display _____



Establish Measurement Objectives

Communicate Results

Perspective

Input(s) _____

Data Elements _____

Definitions _____

Data Collection _____

How _____

When/How Often _____

By Whom _____

Form(s) _____

Data Reporting _____

Responsibility for Reporting _____

By/To Whom _____

How Often _____

Specify Measures

Specify Data Collection Procedures

Collect Data

Assumptions _____

Algorithm _____

Interpretation _____

Probing Questions _____

Analysis _____

Evolution _____

Feedback Guidelines _____

X-reference _____

Specify Analysis Procedures

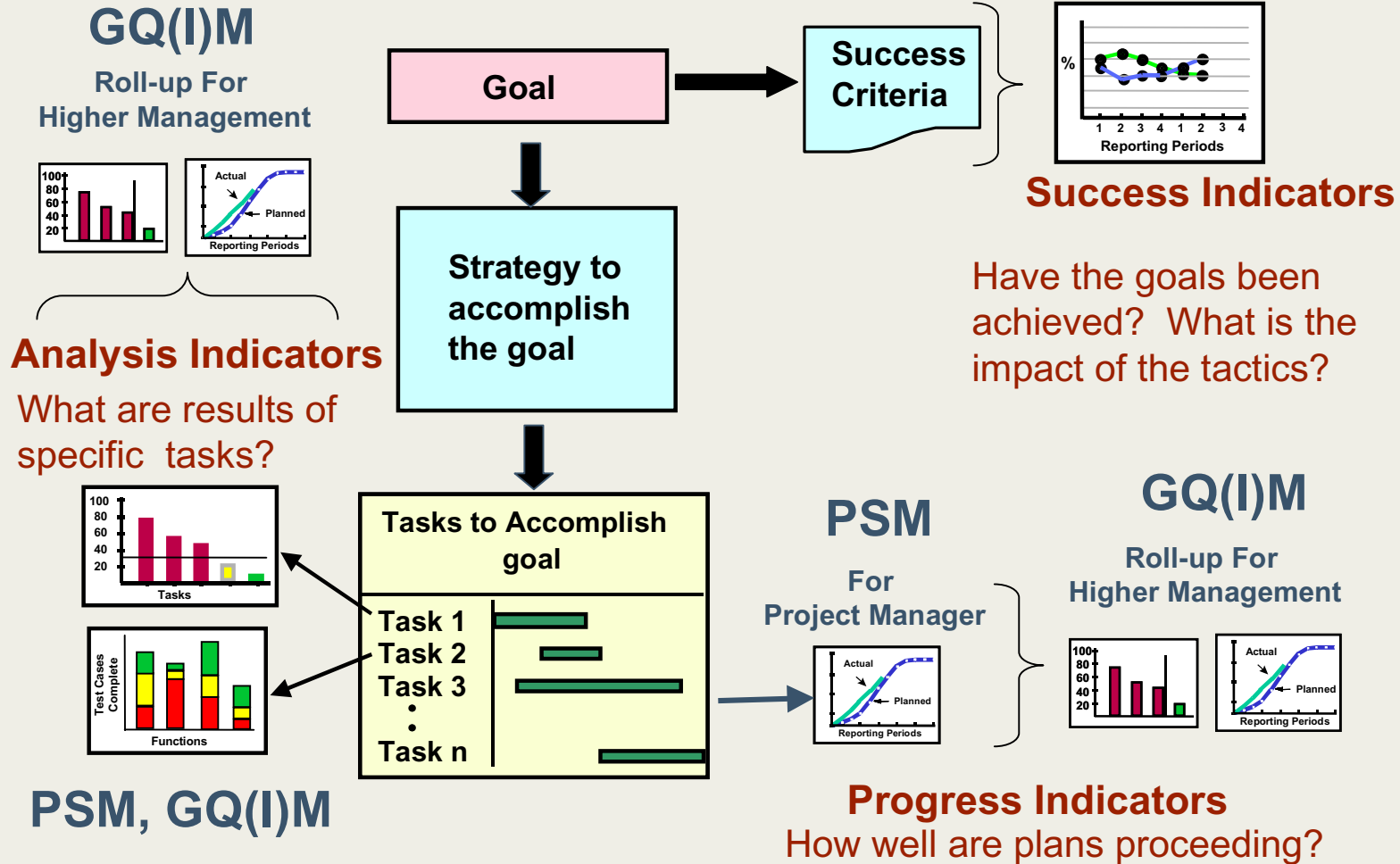
Analyze Data

Additional Modifications by clients

- streamlined data collection & reporting sections using “swimlane” diagrams
- Addition of “corrective action guidelines”
- Subprocess selection (for CMMI)



Indicator Classifications





Data Analysis Dynamics

Getting Started

- Identify the goals
- Black box process view
- Is the data right?
- Do I have the right data?

Decision point:

- If the data is not perfect, do I move forward or obtain better data?

Initial Evaluation

- What should the data look like?
- What does the data look like?
- Can I characterize the process, product, problem?

Decision point:

- Can I address my goals right now?
- Or is additional analysis necessary? at the same or deeper level of detail?
- Can I move forward?

Moving Forward

- Further evaluation
- Decompose data, process

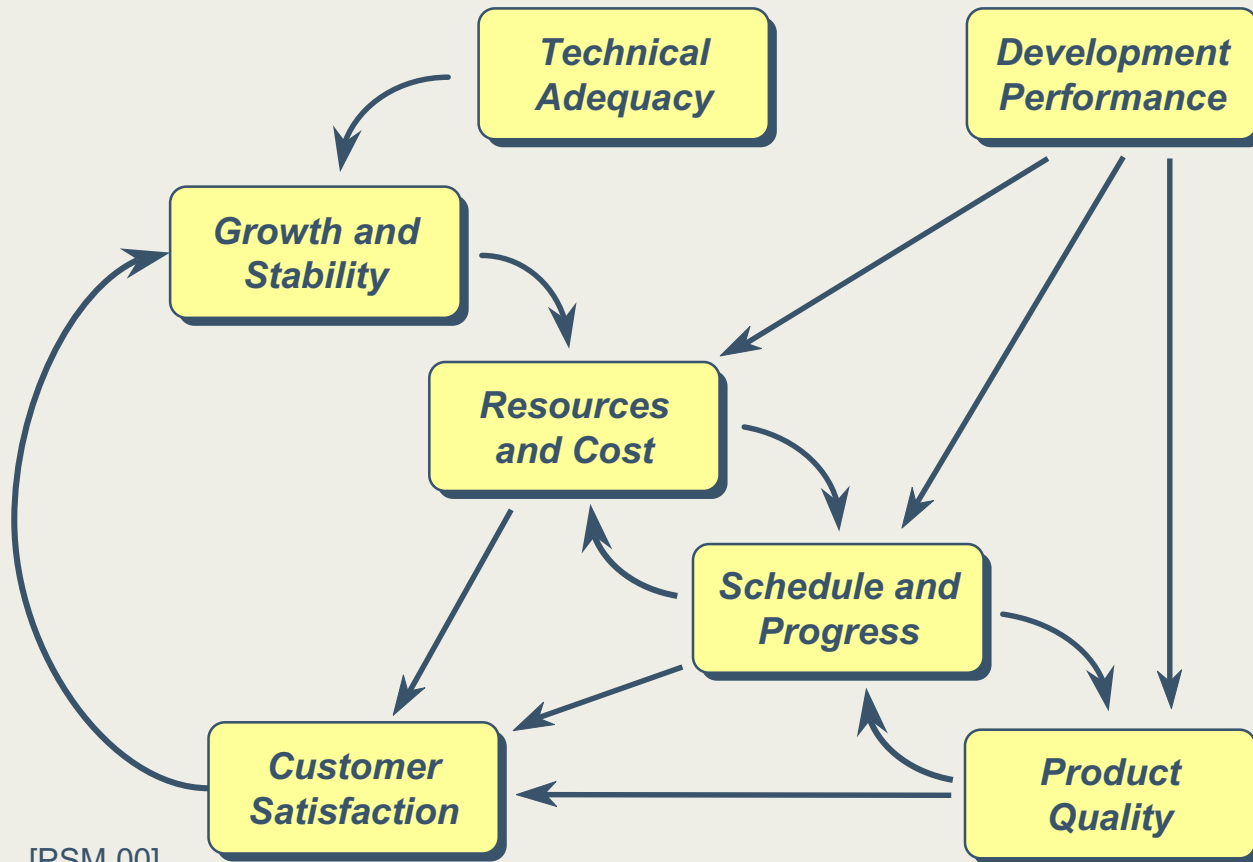
Decision point:

- Do I take action?
- What action do I take?

Repeat until root cause found, at target with desired variation



Performance Analysis Model



[PSM 00]



Performance Analysis Checklist ₁

Single indicator issues:

- Do actual trends correspond to planned trends, such as progress, growth, and expenditures? How big is the variance?
- Does the variance appear to be gradually growing each month?
- Are actual values exceeding planned limits, such as open defects, changes, and resource utilization?
- Are outliers or other anomalies affecting the results?

[PSM 00]



Performance Analysis Checklist ₂

Integrated indicator issues:

- Is the source of the problem evident?
 - Change in functionality, unplanned rework, etc.
- Are growing problems in one area a leading indicator of other problems later in the project?
 - Requirements creep impact on schedule
- Do multiple indicators lead to similar conclusions?
 - Lack of progress correlates with low staffing
- Does other project information contradict performance results?
 - Milestones being met but open defect counts are increasing

[PSM 00]



Focusing In

Earlier:

- trends, roles, models

Key Points:

- measurement in maturity models
- three indicator types: success, progress, analysis
- comparing PSM and GQIM
- Performance Analysis Model

What's in sight:

- an illustration of these methods at work





Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- measurement & analysis methods

Illustration

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

Summary



Composite Illustration*

This illustration is based on an organization that is

- maintaining an existing product, a blend of COTS, and internally developed code
- pursuing the acquisition of a replacement product

Their acquisition includes two contracts:

- requirements development
- product design, code, and test

This illustration will focus on

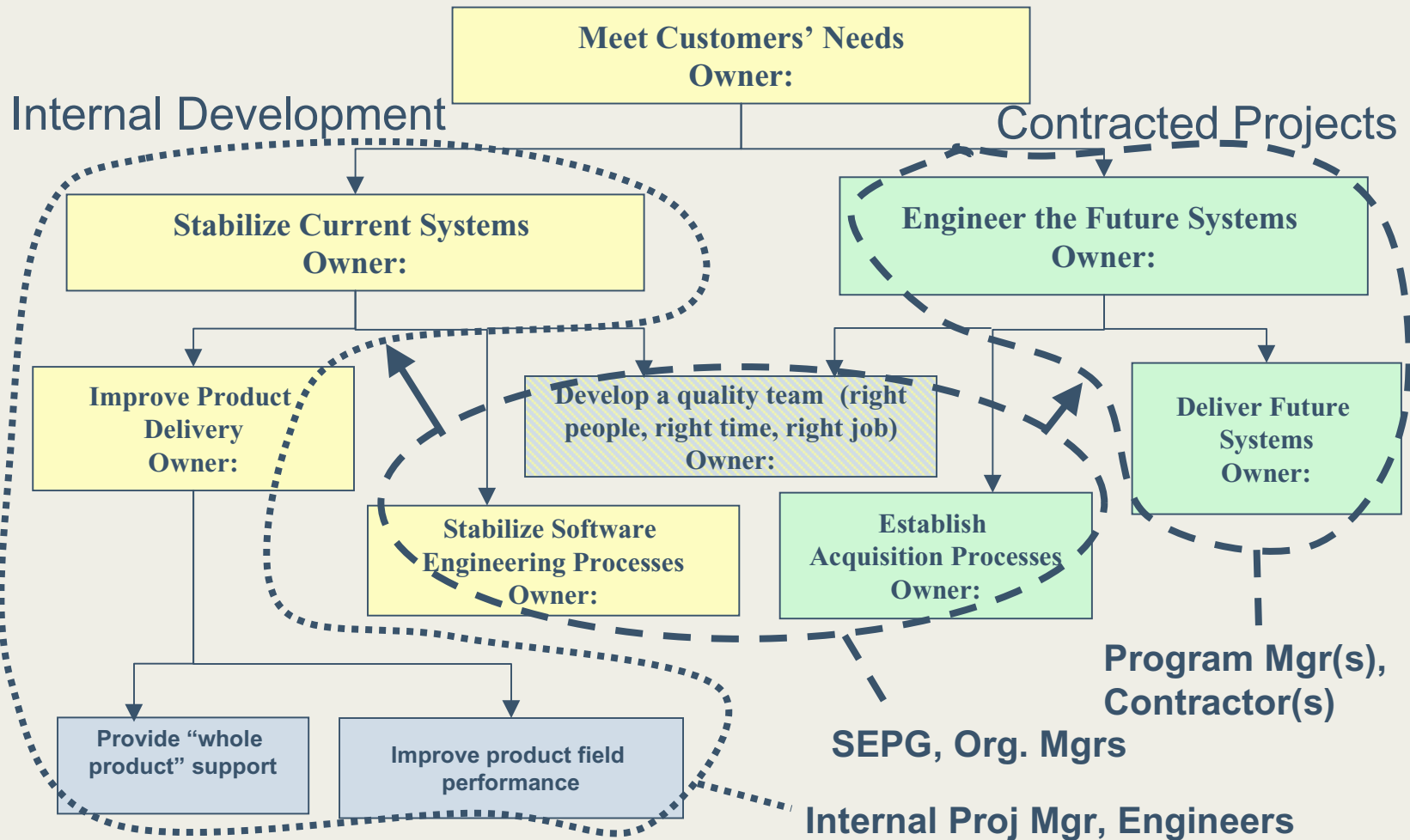
- evaluating requirements document quality (contract 1)
- analyzing project execution data (contract 2)

It will briefly highlight other aspects of acquisition measurement.

*This illustration is a composite of two projects. Aspects from other projects have been interwoven for demonstration purposes.



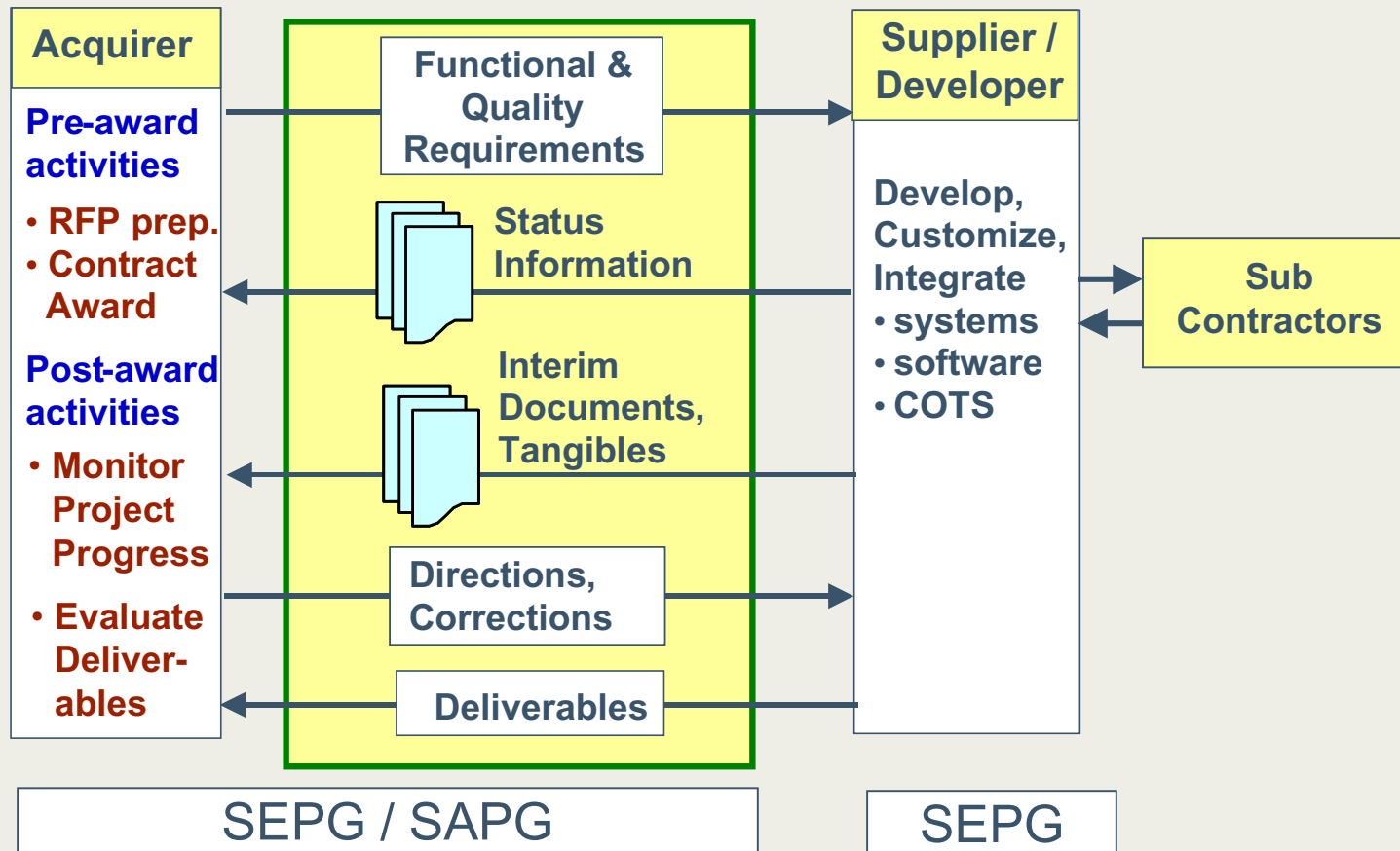
Illustration: Goal Structure





Roles and Information Exchange

Contractual Handshake

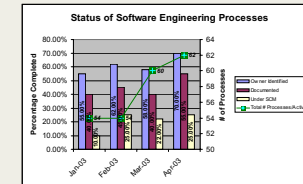




Goal:
Establish Acquisition Processes

Success Criteria

Sr. Mgmt scorecard ; Middle Mgmt dashboard



Sr. Mgmt dashboard

- quality trends
- selected project EV data

Middle Mgmt dashboard

- system documentation and testing

Strategy to accomplish goal

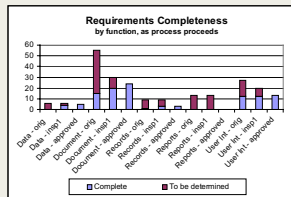
- Reference models: CMMI, SA CMM, IEEE/ISO 12207
- Leverage CMMI capabilities built in engineering: MA, REQM, RD, CAR
- Aim for CMMI capability in selected PAs: SAM, DAR, RSK, PP/PMC, CM, PPQA
- Reference all SA-CMM Level 2 kPAs, noting overlaps with CMMI

Success Indicators

process owners, training, CM, and documentation (future: procedural adherence)

Middle Mgmt Dashboard

- selected SPI plan EV data



Analysis Indicators

Reqts completeness – original, at inspection, approved (for contract 1)

Tasks to Accomplish goal

- Implement requirements management process
- Tailor existing project monitoring processes for acquisition managers
-

TODAY = 29 JULY						
	Plan Start	Plan Finish	Actual Start	Actual Finish	Days	Days
Start # number of inspection process	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Original inspection process per (SOP)2207	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Document #	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Review and update of new inspection process	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Establish configuration mgmt, change mgmt procedures for new inspection process	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Implement new inspection process	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Establish process for routine monitoring of procedural adherence	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Create data storage mechanisms to hold inspection data	15-Jul	15-Jul	15-Jul	15-Jul	0	0
Create data storage mechanisms to hold inspection data	15-Jul	15-Jul	15-Jul	15-Jul	0	0

For this example:
 Days late = actual finish - plan finish if task completed
 Days late = actual start - plan start if task in progress

Progress Indicators

start, finish dates with progress noted (move toward EV)



Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- measurement & analysis methods

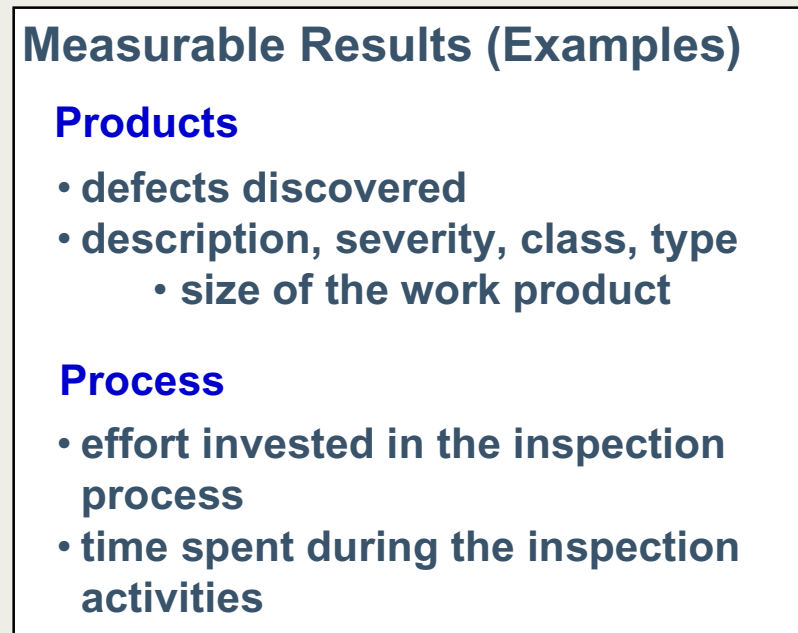
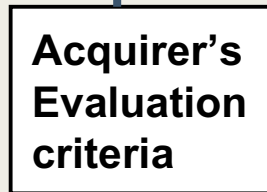
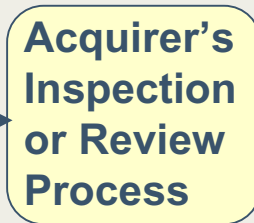
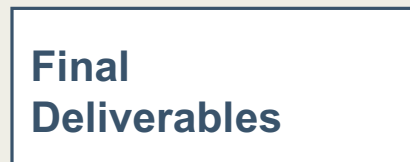
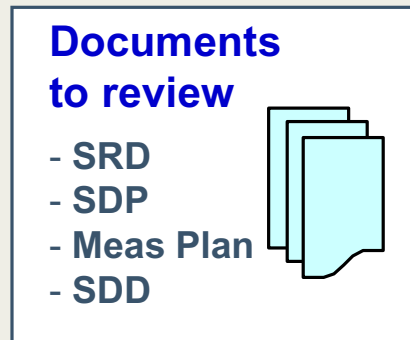
Scenario

- goal-setting and success, progress, analysis indicators
- **inspecting the quality of deliverables: requirements**
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

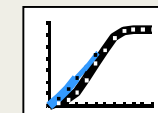
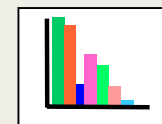
Summary



Evaluate Quality of Deliverables



Indicators





Requirements Development & Management (SA-CMM RDM)

Purpose:

To establish a common understanding of the software requirements by the acquisition project team, the end user, and the contractor.

- includes both technical and non-technical requirements
- involves development of the requirements and management of any changes
- starts with description of an operational need and ends with transfer of responsibility to the maintainer



RDM - Measurement Opportunities

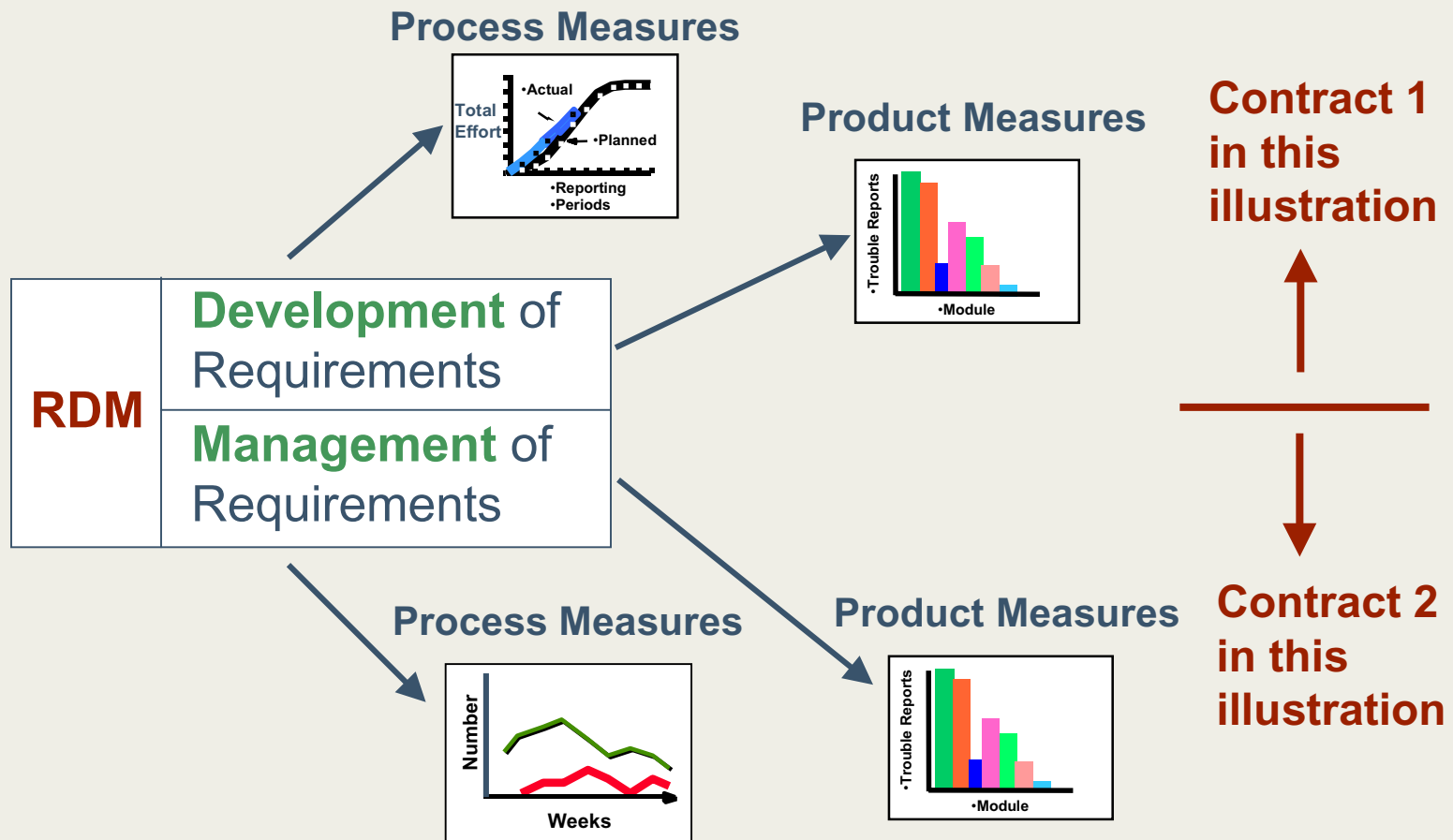
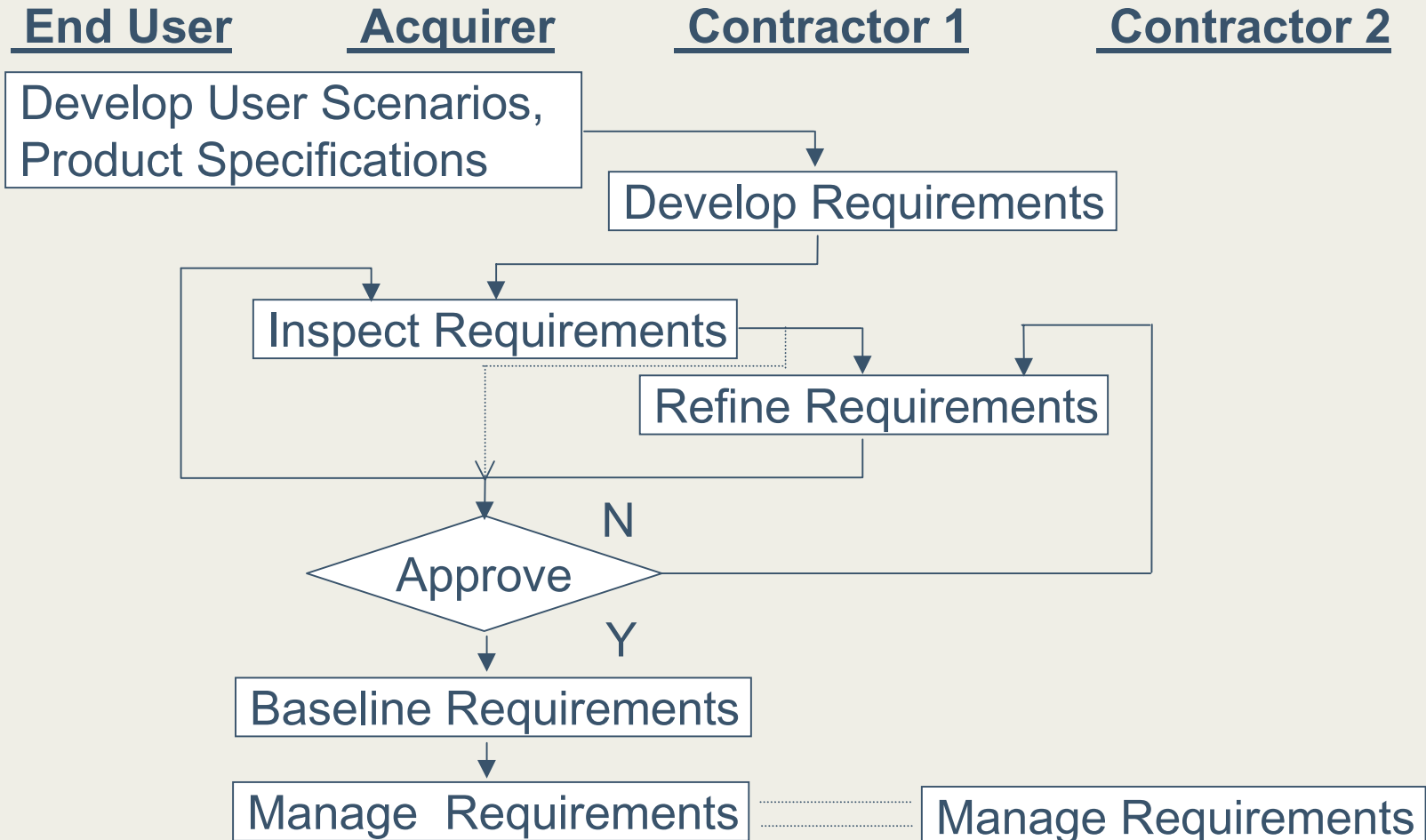




Illustration: Reqts Process Flow





Requirements Process Measures

Process Measures

- effort expended
- funds expended
- progress toward completion
- completion of milestones
- number of change requests processed (post-development)

For the contractor, these are measures of development process.

For the acquirer, these are measures of the inspection process.



Requirements Document Measures and Evaluation Criteria

“Inch” or “thickness” Criterion

- Document is at least three inches thick

“Drop it” or “Thud” Criterion

- Related to inch criterion
- Specific level of sound before it is accepted

Format

- Pretty pictures
- In color





Requirements Document Effective Evaluation Criteria

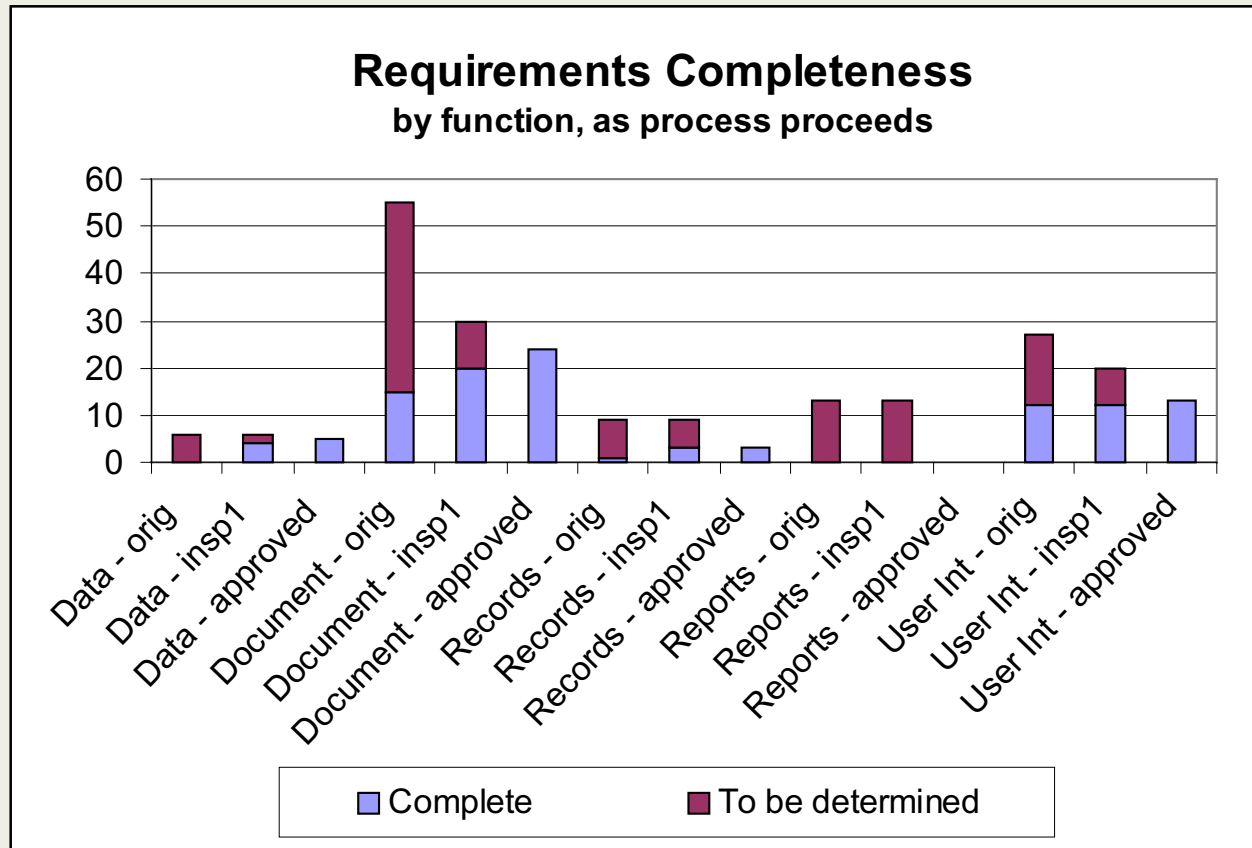
Examples of measurements for evaluation criteria

- completeness:
 - “TBD” requirements;
 - product performance measures included
- consistency:
 - no conflicts across document sections
- clarity:
 - growth in issues,
 - presence of ambiguous language or words with many meanings.
- conformity:
 - meets stated criteria, constraints
- correctness:
 - all data fields in valid ranges

Contract should contain evaluation criteria.



Illustration: Requirements Indicator





Practical Issues

The organization or program/project office may have several barriers to effective document inspection, such as

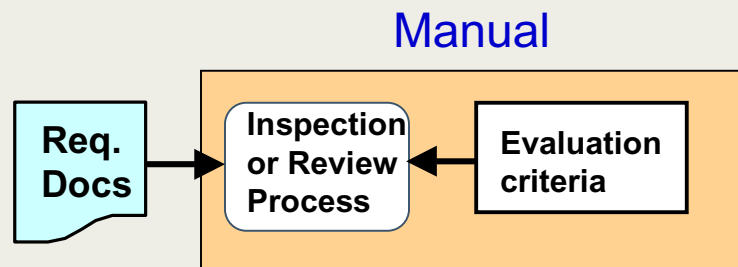
- insufficient quantity/availability of personnel
- insufficient technical or domain knowledge
- schedule constraints

Example:

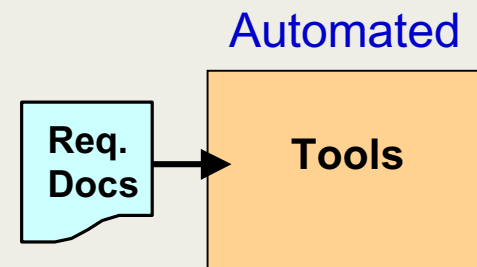
- If you have a 300 page requirements document and typically inspect at a rate of 2 hrs/page, are there resources available to invest 600 hours to inspect that document?



Advancing the State of Requirements Product Measures



Lengthy, labor intensive process



Reduce cycle time and effort
while producing better results
than possible with tedious
manual review

Examples of Tools:

- **Quality Analyzer for Requirements Specifications (QuARS)**
 - Lexical, syntactic and semantic analyses of requirements
- **Automated Requirements Measurement (ARM)**



Quality Analyzer for Requirements Specification

How does it work?

- natural language analysis of requirements text
- lexical: vague, weak, optional, subjective, other terms
- syntactic: multiple, implicit, under specified statements
- semantic:
 - allows screening for consistency, completeness, etc.
 - arbitrary combinations of domains, components, functionality, product quality attributes, and so on



Automated Requirements Measurement (ARM)

Checks for desirable requirements characteristics such as:

- complete: precisely define all real world situations
- consistent: no conflict between individual requirements
- correct
- modifiable
- ranked
- traceable
- unambiguous: can only be interpreted one way
- understandable: meaning of each of its statements is easily grasped by all of its readers
- verifiable
- validatable: by individuals and organizations having vested interest
- testable



Focusing In

Earlier:

- trends, roles, models
- measurement methods

Key Points:

- quality of deliverables
- effective evaluation criteria
- measuring requirements development (contract 1)
- tools for analyzing requirements

What's in sight:

- monitoring and oversight: evaluating a schedule slip (contract 2)
- What would YOU include in the contract?





Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- measurement & analysis methods

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- **monitoring and oversight: progress analysis**
- measurement in the contract
- communicating with integrated measures

Summary



Monitoring & Oversight

Contract #2 has been awarded.

- supplier is developing the product in two builds

The contractor has just notified you that the project has both cost and schedule slippage.

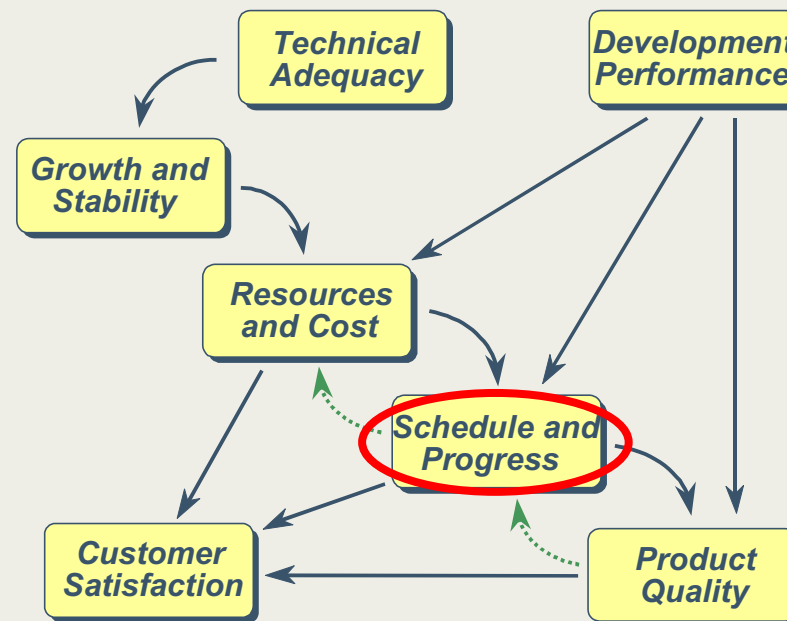
What do you do?



Performance Analysis Model

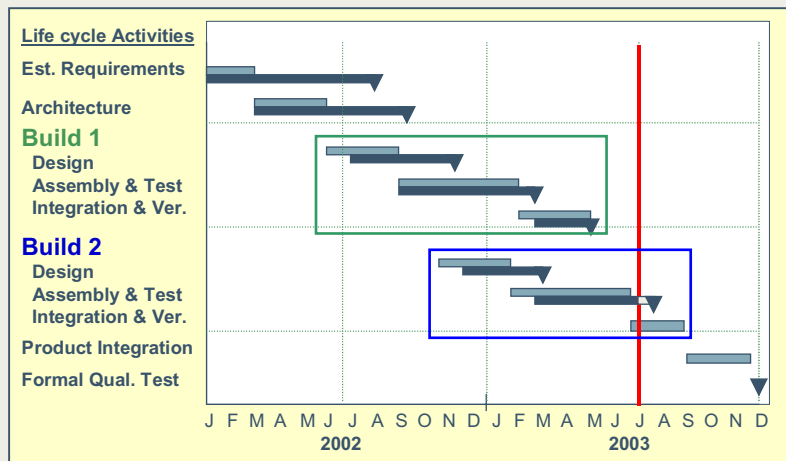
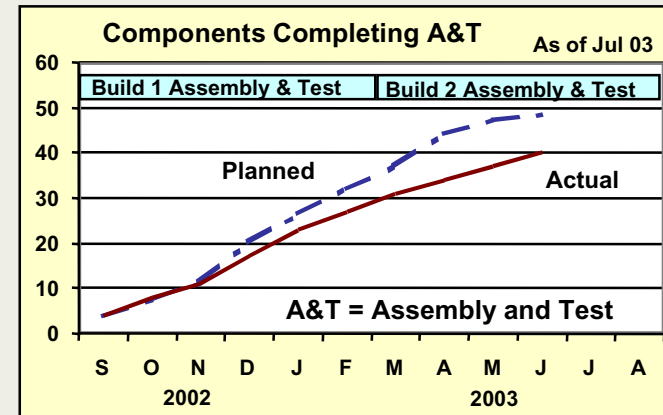
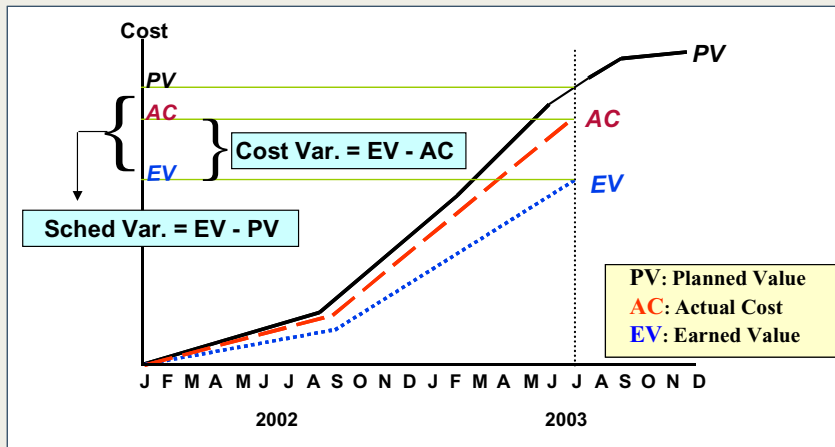
Use model to guide analysis.

- Step 1: Confirm Problem (Cost & Schedule Slippage)





Schedule & Progress Indicators



Tool tips:

The top two charts were made in Excel and manually manipulated.

The Gantt chart can be generated using any scheduling software.



What We Learned

From Schedule and Progress indicators

- cost and schedule slippage -- *EV chart*
- activities taking longer than planned -- *Gantt chart*
- assembly and test behind schedule -- *components completion chart*

What does this mean?

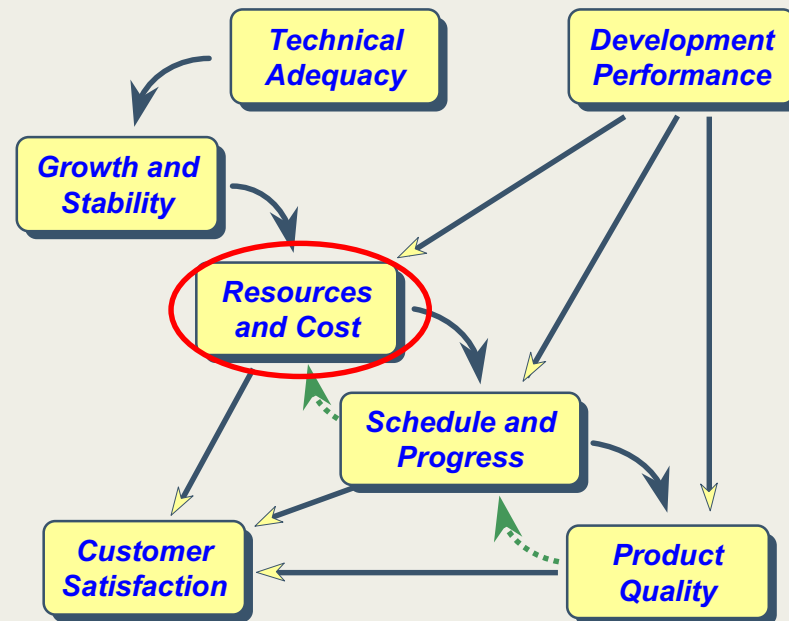
- confirms we have a problem



Resources and Cost Indicators

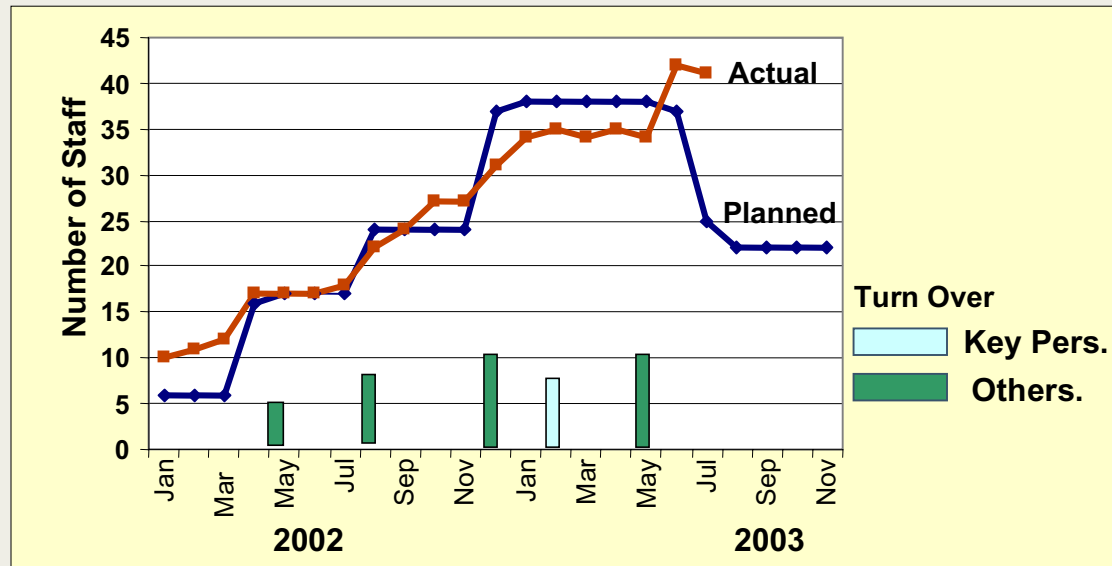
Analysis/Probing Questions

- Is the staff allocation contributing to the problem (too many, too few, wrong time frame)?
- What is rate of staff turnover?
- How does actual staff compare to planned staff allocation?





Resources and Cost Indicators



Prg	Plan	2	3	3	3	9	9	11	12	22	23	23	22	22	22	22	15	
	Actual	3	3	4	5	5	6	9	9	11	11	15	18	19	19	20	20	30
Tester	Plan				1	1	1	3	3	2	2	5	5	7	8	8	8	5
	Actual	3	3	3	3	3	3	3	5	5	5	5	5	5	5	5	5	5

Tool tip: This chart was made in Excel and manually manipulated.



What We Learned

From Resources and Cost Indicators

- staffing did not follow planned level
 - too many at beginning of project
 - testers and programmers used to fill in for analysts and designers => high re-training costs
 - high turnover rate => training & getting up-to-speed costs

What does this mean?

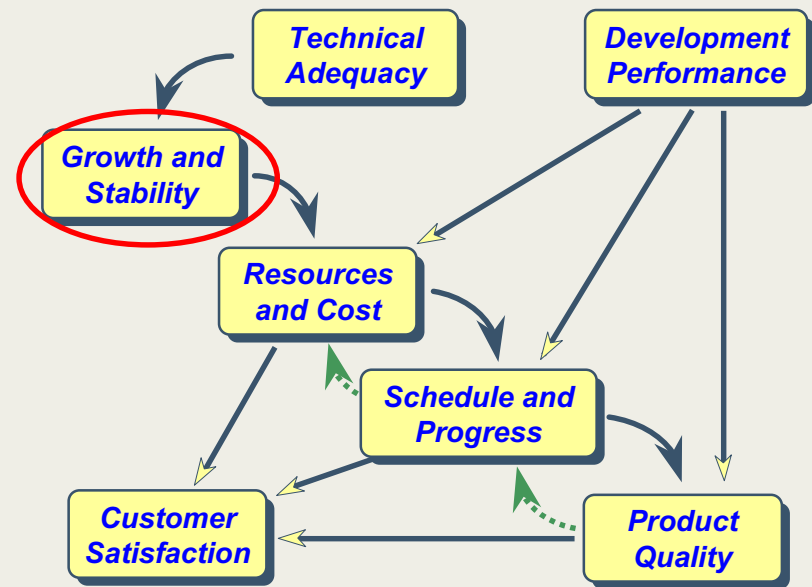
- cost overrun due partly to staffing problems



Growth and Stability Indicators

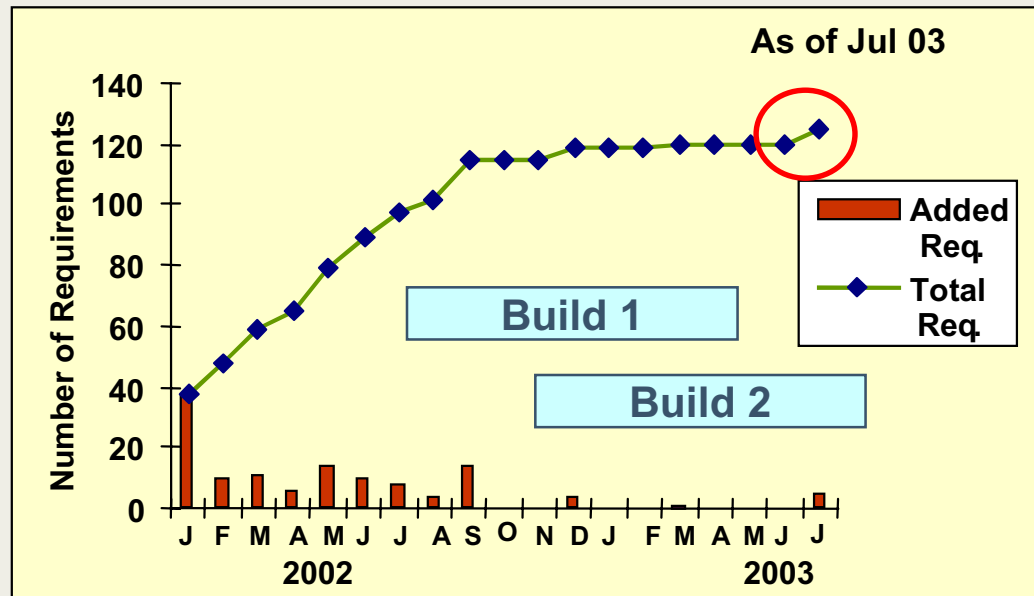
Analysis/Probing Questions

- Are the requirements stable?
- What is the code growth?
- Is functionality being transferred from build 1 to build 2? If so, how does this effect the delivery date?





Requirement Changes Information



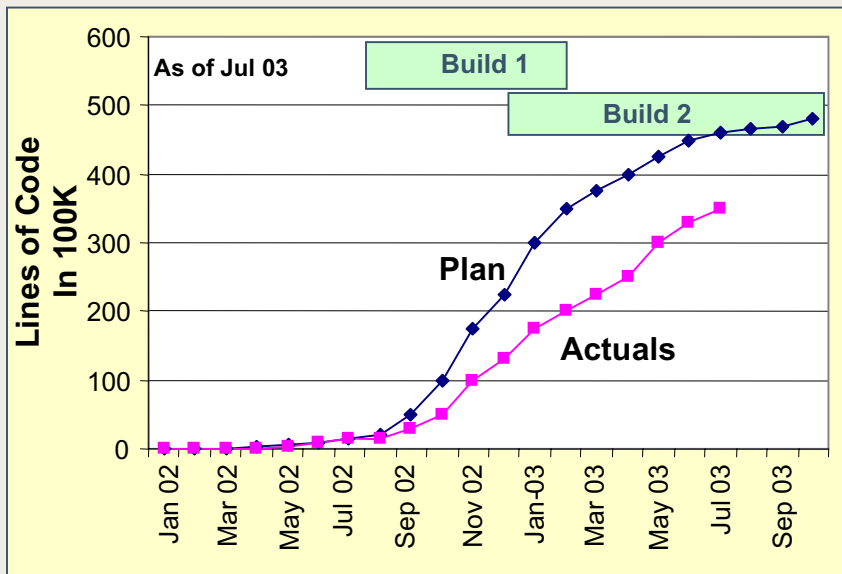
Tool tip: This chart can be generated in Excel followed by manual editing using the drawing toolbar

	2002								2003		
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Dec	Mar	Jul
Req Changes	10	11	6	14	10	8	4	14	4	1	5
Complexity	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Resources (staff-days)	4	5	3	2	4	2	3	3	2	1	2

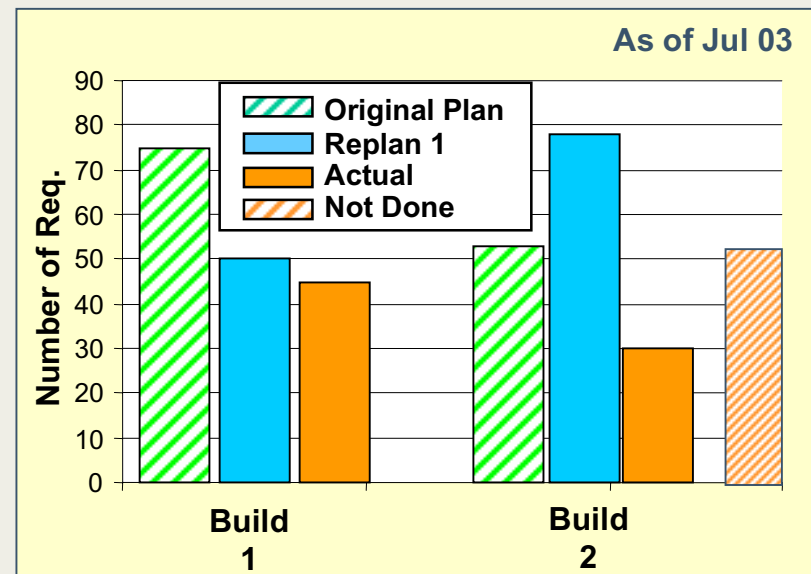


Growth and Stability Indicators

Size Growth



Requirements per Build



Tool tip: This chart was made in Excel and manually manipulated.

Contractor's Explanation:

- Functions deferred to later build because of unanticipated complexity



What We Learned

From Growth and Stability Indicators

- requirement changes are of low complexity but will have some ripple effect
- code production below planned value
- functionality being deferred from build 1 to build 2 attributed by contractor to unanticipated complexity

What does this mean?

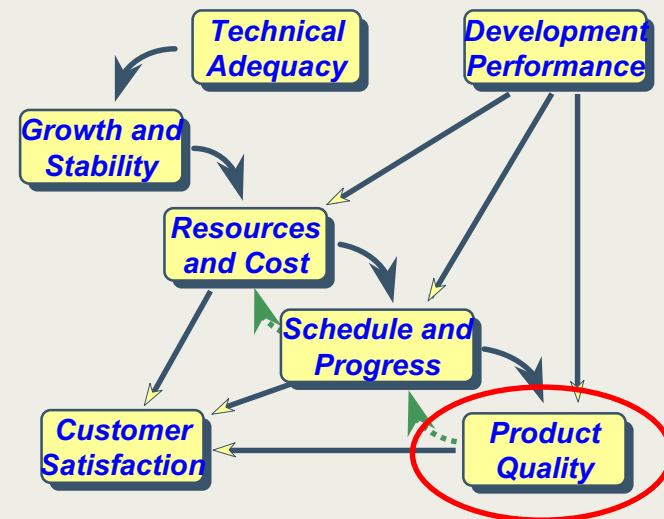
- expect further cost and schedule growth due to low code production and increased number of functions to be implemented in Build 2
- expect an impact on completion date due to functions deferred to Build 2
- expect the possibility of a “Build 3” proposal



Product Quality Indicators

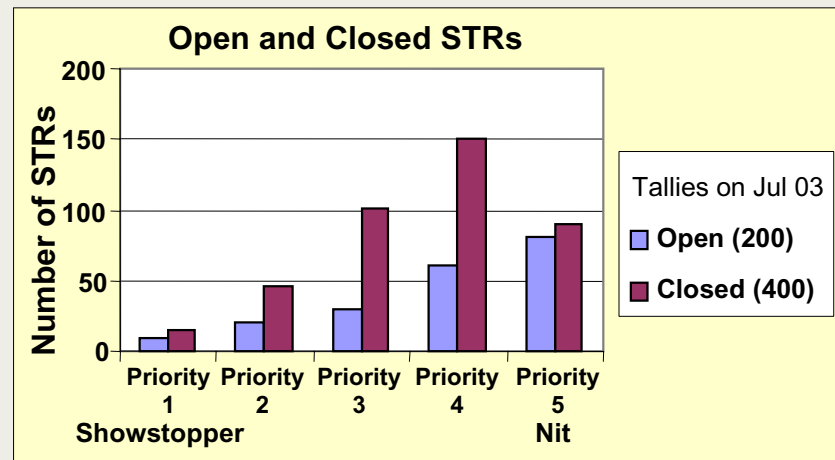
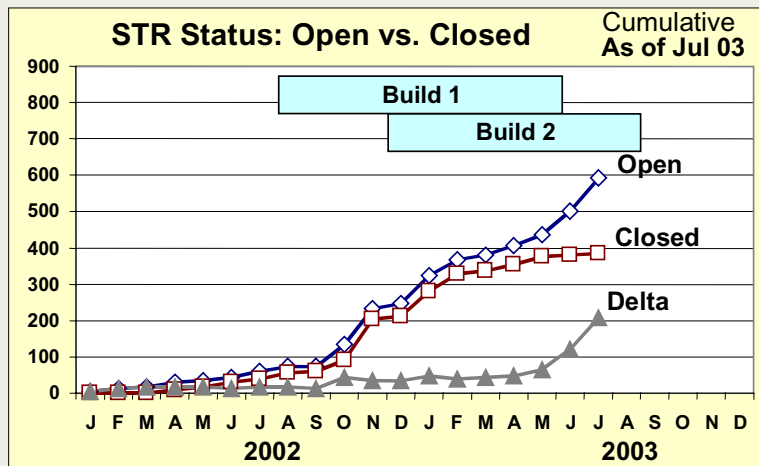
Analysis/Probing Questions

- Are the defined processes being followed?
- What is the rate of closure for trouble reports?
- What type of trouble reports are being detected? In what phase?





Product Quality Indicators

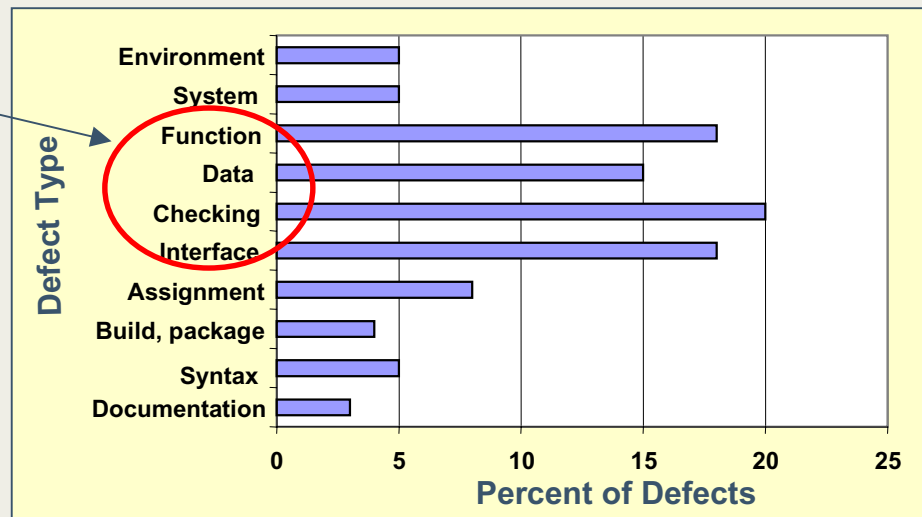


Tool tip: This chart was made in Excel and manually manipulated.



Classifying Trouble Report Defects

Types that code inspections would have been expected to catch





What We Learned

From Product Quality Indicators

- STRs being opened faster than they're being closed
- Code inspections should have found defect types

What does this mean?

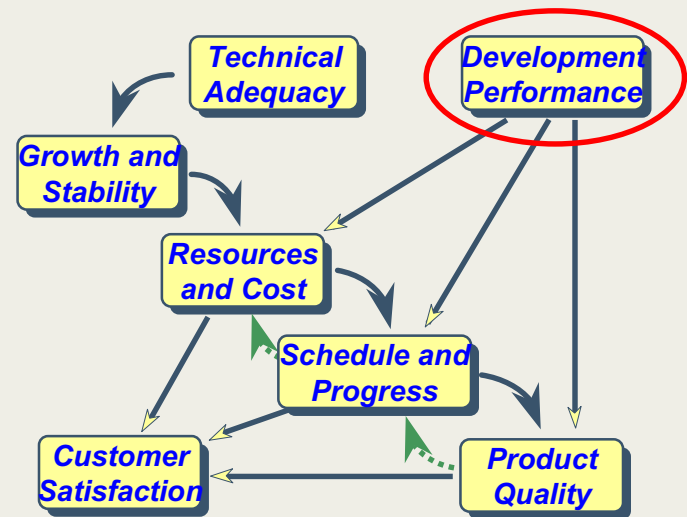
- Code inspection process allowed large number of defects to slip through.



Development Performance Indicators

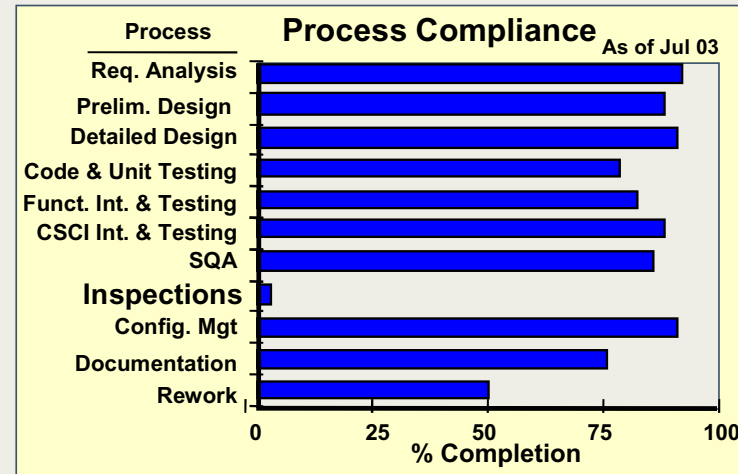
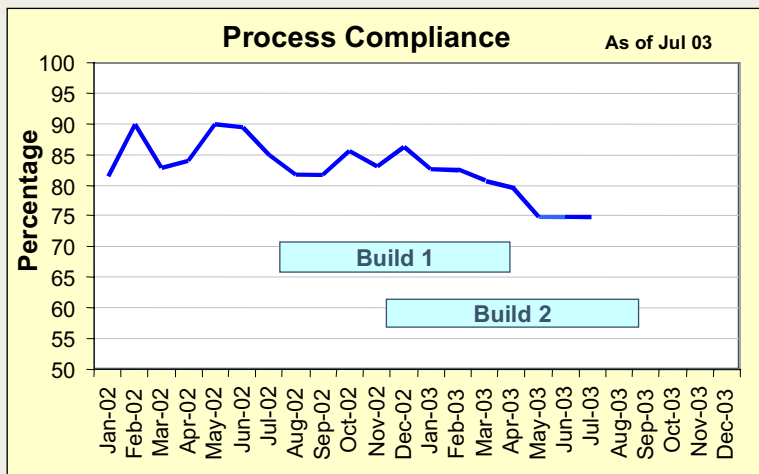
Analysis/Probing Questions

- Are the defined processes being followed?
- Are any defined processes being skipped?





Development Performance Indicators



Tool tip: This chart was made in Excel and manually manipulated.



What We Learned

From Development Performance Indicators

- adherence to defined process decreased over time
- stopped doing inspections

What does this mean?

- defects usually detected during code inspections allowed to slip through
- impact on cost and schedule due to rework



Reasons for Slippage

Staffing problems:

- too many at beginning of project
- below planned level during most of development
 - noting that productivity increased dramatically
- high turnover rate

Process compliance:

- stopped doing inspections
- allowed errors to leak to later phases

Requirements changes after Build 2 code and unit test

Conclusion:

- expect further cost and schedule growth due to low code production and increased number of functions to be implemented in Build 2



Possible Actions

Developer Actions

- replan based on current performance
- get staffing under control
 - verify the skills balance of resources
 - do not decrease staffing to conform to “planned” staffing, particularly if that would decrease the number of programmers
- restart inspections
 - code
 - test cases

Acquirer Decision Options

- use contract labor (additional costs)
- deliver smaller size - less functionality
- accept schedule slip



Focusing In

Earlier:

- trends, roles, models
- measurement methods
- evaluating deliverables

Key Points:

- use the Performance Analysis Model as a causal analysis navigation aid
- always use multiple indicators
- couple data analysis with knowledge of your and your contractor's processes

What's in sight:

- What would YOU include in the contract?
- How to communicate using your measures





Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- measurement & analysis methods

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- **measurement in the contract**
- communicating with integrated measures

Summary



Writing Your Contract

Performance-based contracting

- contractors are paid based on how they meet predefined metrics

General tips:

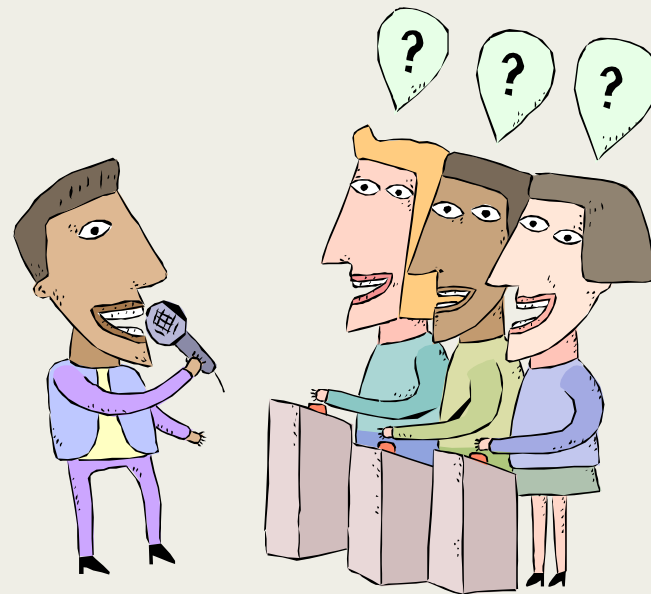
- Consider project, product, process measures
- Specify frequency of reporting
- Specify target performance where known
 - the “SMART” approach applies: specific, measurable, attainable, realistic, timely



Discussion: Write Your Contracts!

For the two-contract illustration just reviewed, what measures would YOU request in the contracts?

Which measures do you think would be readily available (or not)?





Outline

Context

- state of the community
- changing perspectives

Background

- roles & responsibilities
- maturity models
- measurement & analysis methods

Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- **communicating with integrated measures**

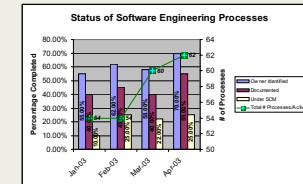
Summary



**Goal:
Establish Acquisition
Processes**

**Success
Criteria**

**Sr. Mgmt scorecard ;
Middle Mgmt dashboard**



Sr. Mgmt dashboard

- quality trends
- selected project EV data

Middle Mgmt dashboard

- system documentation and testing

Strategy to accomplish goal

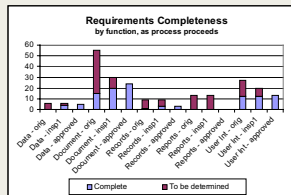
- Reference models: CMMI, SA CMM, IEEE/ISO 12207
- Leverage CMMI capabilities built in engineering: MA, REQM, RD, CAR
- Aim for CMMI capability in selected PAs: SAM, DAR, RSK, PP/PMC, CM, PPQA
- Reference all SA-CMM Level 2 kPAs, noting overlaps with CMMI

Success Indicators

process owners, training, CM, and documentation (future: procedural adherence)

Middle Mgmt Dashboard

- selected SPI plan EV data



Analysis Indicators

Reqts completeness – original, at inspection, approved (for contract 1)

Tasks to Accomplish goal

- Implement requirements management process
- Tailor existing project monitoring processes for acquisition managers
-

Item #	Plan Start	Plan Finish	Actual Start	Actual Finish	Days
Number of inspection process	15-May	15-May			0
Organize inspection process per (SOP)2207	15-May	15-May			0
Document #	15-May	15-May			0
Review and update of new inspection process	15-May	15-May			0
Establish configuration mgmt, change mgmt procedures for new inspection process	15-May	15-May			0
Implement process for routine monitoring of procedural adherence	15-May	15-May			0
Create data storage mechanisms to hold inspection results	15-May	15-May			0
Create data storage mechanisms to hold inspection data	15-May	15-May			0

For this example:
Days late = actual finish - plan finish if task completed
Days late = actual start - plan start if task in progress

Progress Indicators

start, finish dates with progress noted (move toward EV)



Illustration: Goal Structure

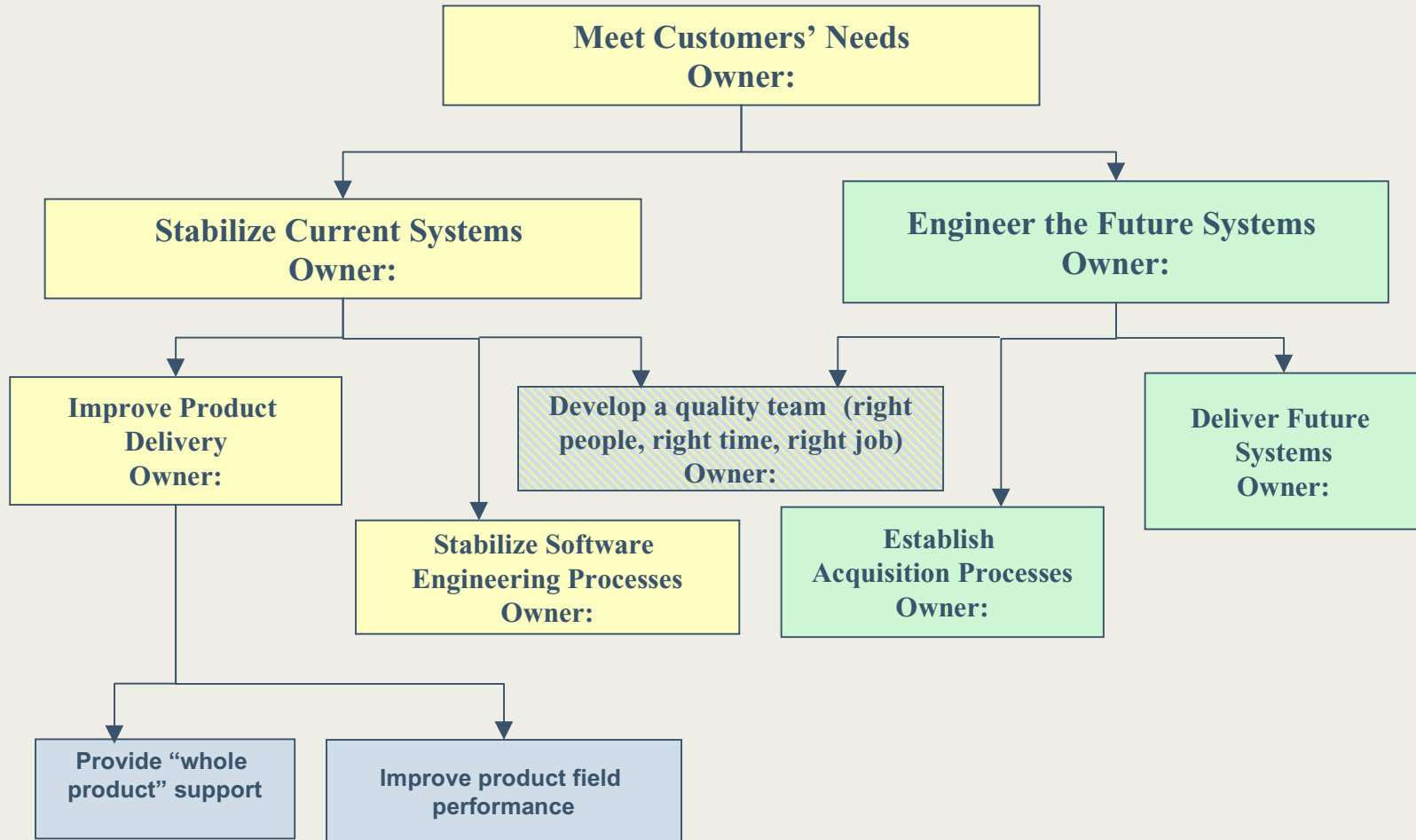
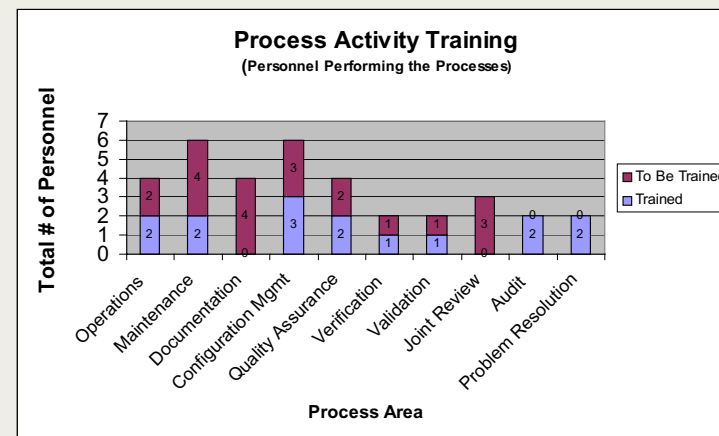
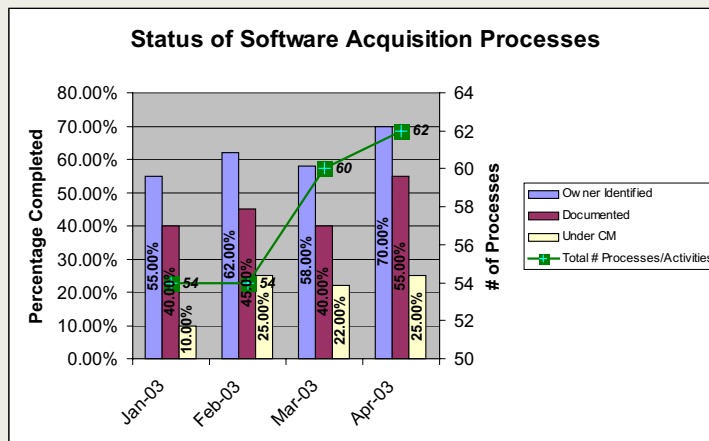




Illustration: Success Indicators Establish Acquisition Processes

Two key success indicators (excerpted from indicator templates)

- status of ownership, training, documentation, configuration management of processes (evolve into procedural adherence)
- status of training, using ISO12207 to group processes



After processes established, monitor sustainment or adherence

- use appraisal and/or audit results



Illustration: Senior Management Reporting

Required contractor metrics reported by all programs

- size growth
- workforce size and qualifications
- selected earned value (EV)
- quality trends
- requirements fulfillment

Required acquirer metrics reported by all programs



Outline

Context

- State of the community
- Changing Perspectives

Background

- Roles & Responsibilities
- Maturity Models
- Measurement & Analysis Methods

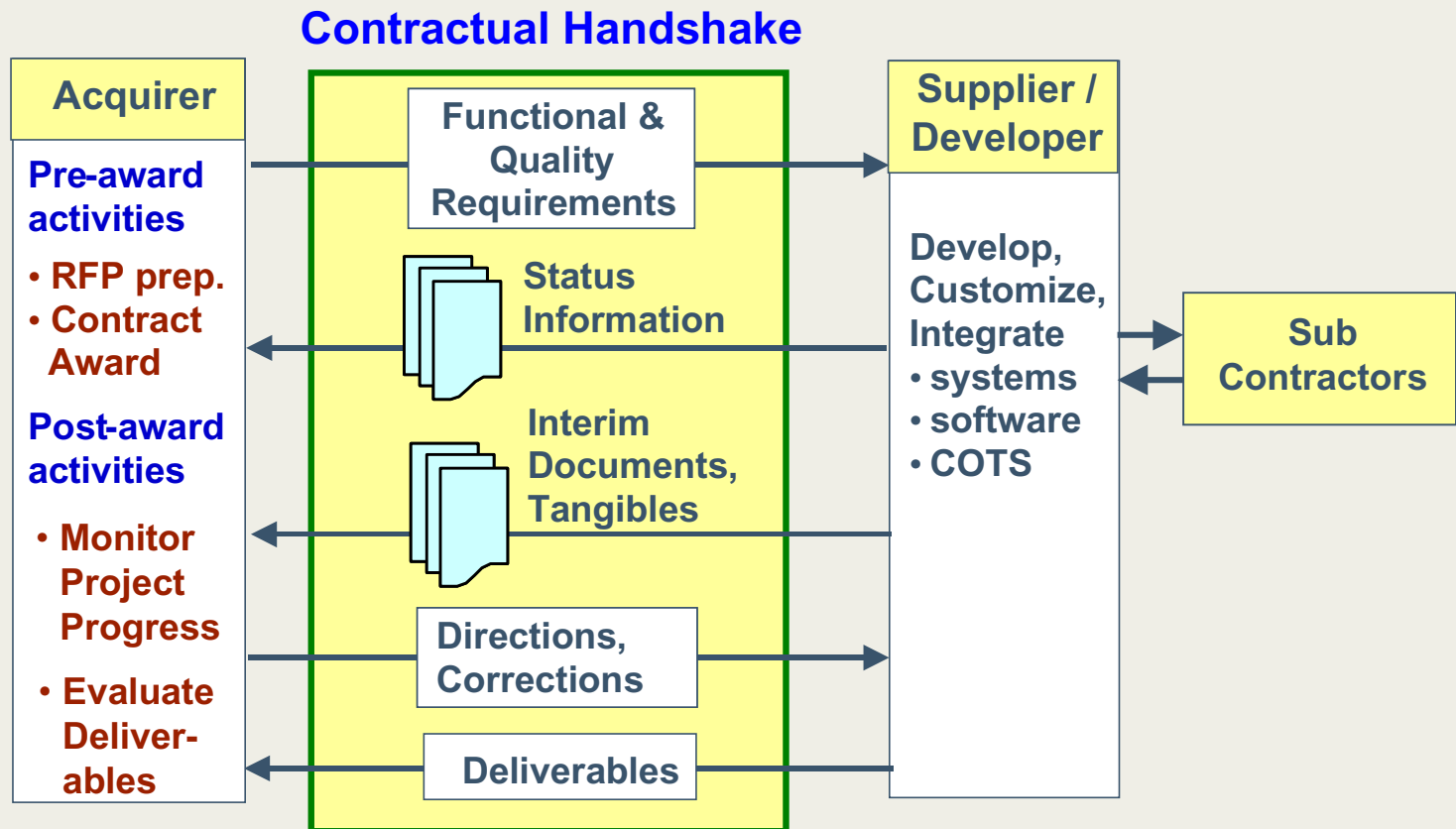
Scenario

- goal-setting and success, progress, analysis indicators
- inspecting the quality of deliverables: requirements
- monitoring and oversight: progress analysis
- measurement in the contract
- communicating with integrated measures

Summary

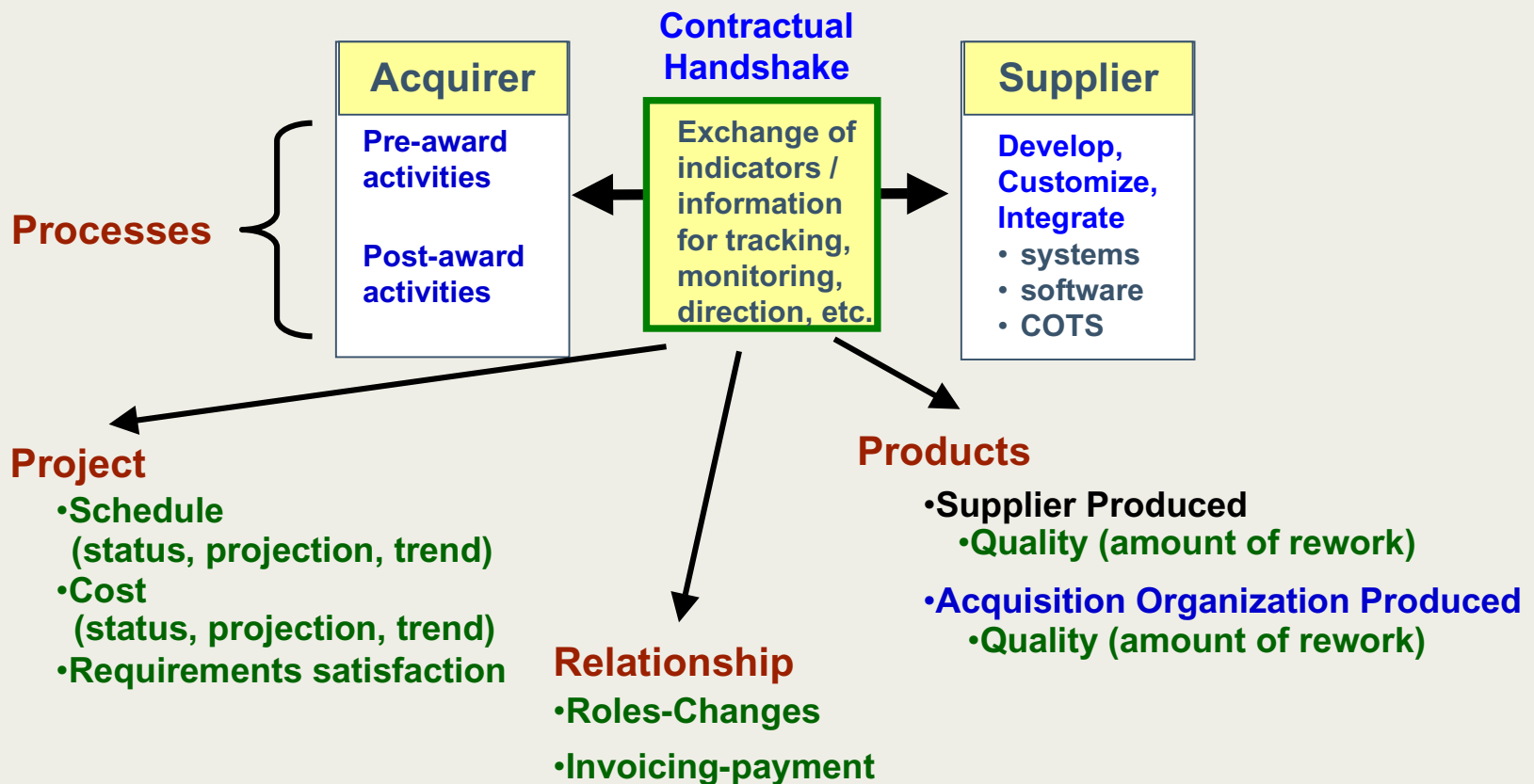


Roles and Information Exchange





Measuring Project, Product, Process





Summary – Focus Points

Key acquisition responsibilities (after contract award):

- monitoring and oversight
- inspecting, reviewing, and understanding documents and other work products

Post-contract award success depends on pre-contract award activities

- building measurement expectations into contracts
- establishing good partnerships and working relationships with contractors

Measure products, processes, projects, relationships

- requirements development, management, products should not be exempt! They are measurable.



Carnegie Mellon
Software Engineering Institute

Contact Information

Wolf Goethert
Software Engineering Institute
Measurement & Analysis Initiative
Email: wbg@sei.cmu.edu
412-268-3889

Jeannine Sivi
Software Engineering Institute
Measurement & Analysis Initiative
Email: jmsivi@sei.cmu.edu
412-268-7994

Robert Ferguson
Software Engineering Institute
Measurement & Analysis Initiative
Email: rwf@sei.cmu.edu
412-268-9750



References

Note: URLs valid as of tutorial delivery date.

- [ASSIP 03] Information from a 2003 Survey of Army Acquisition Program Managers
- [Barbour 03] Taken from a set of workshop slides.
- [C-M-H 03] Carleton, Anita, Robert Mishler and Watts Humphrey, The integrated Software Acquisition Measurement (ISAM) Project, Interim Status Report
- [DAD 03] Sivi, Jeannine and William Florac, Data Analysis Dynamics, Half Day Tutorial Delivered at SEPG 2003, Boston, MA
- [Diana 03] Diana, Alison, Outsourcing by the Numbers,
<http://www.ecommercetimes.com/perl/story/32114.html>
- [DZ 02] Zubrow, David, Putting 'M' in the Model: Measurement and Capability Maturity Model® Integration (CMMISM), ICSQ, 29 October 2003, Ottawa, Canada
- [DZ – P 03] Adapted from [DZ 02] by Mike Phillips for a client workshop
- [Ferguson 03] Ferguson, Jack, Use of CMMI in an Acquisition Context, CMMI Users Group 2003, Denver, CO
- [GQIM 96] Goal-Driven Software Measurement--A Guidebook
<http://www.sei.cmu.edu/publications/documents/96.reports/96.hb.002.html>



References

Note: URLs valid as of tutorial delivery date.

- [Robb 02] Robb, Drew, 5 Top Trends in Offshore Outsourcing,
<http://itmanagement.earthweb.com/erp/article.php/1558431>
- [PSM 00] Practical Software and Systems Measurement A Foundation for Objective Project Management, Guidebook, version 4.0b, Practical Software and Systems Measurement Support Center, U.S. TRACOM-ARDEC, AMSTA-AR-QA-A, Picatinny Arsenal, NJ, Website: www.psmc.com, October 2000
- [SWM 01] Software Magazine, Feb/March, 2001



Reading & Resources ₁

Note: URLs valid as of tutorial delivery date.

Practical Software and Systems Measurement (PSM)

- reference for the Performance Analysis Model
- reference lists of measures to consider
- <http://www.psmc.com>

Goal Driven Measurement (GDM) and Goal-Question-Indicator-Metric (GQIM)

- front end for selecting most relevant PSM measures
- used for developing context-specific indicators, particularly “success indicators”
- “Goal-Driven Software Measurement--A Guidebook”
<http://www.sei.cmu.edu/publications/documents/96.reports/96.hb.002.html>



Reading & Resources ₂

Note: URLs valid as of tutorial delivery date.

Defense Acquisition University (DAU) Deskbook

- <http://deskbook.dau.mil/jsp/default.jsp>
- provides information about regulatory references, mandatory and discretionary references by service branch, and several knowledge repositories

Guidelines for Successful Acquisition and Management of Software-Intensive Systems,

http://www.stsc.hill.af.mil/resources/tech_docs/index.html

Acquisition Centers of Excellence

- Air Force, for instance ESC Hanscom
 - <http://esc.hanscom.af.mil/ESC-BP/>
- Navy
 - <http://www.ace.navy.mil/public/html/>



Reading & Resources ₃

Note: URLs valid as of tutorial delivery date.

Project Management Body of Knowledge (PMBOK®)

- proven, traditional project management practices and innovated, advanced practices with more limited use
- Project Management Institute Guide to the PMBOK contains the generally accepted subset of knowledge and practices that are applicable to most projects most of the time
 - http://www.pmi.org/info/PP_StandardsExcerpts.asp
 - http://www.pmi.org/info/PP_PMBOK2000Excerpts.asp