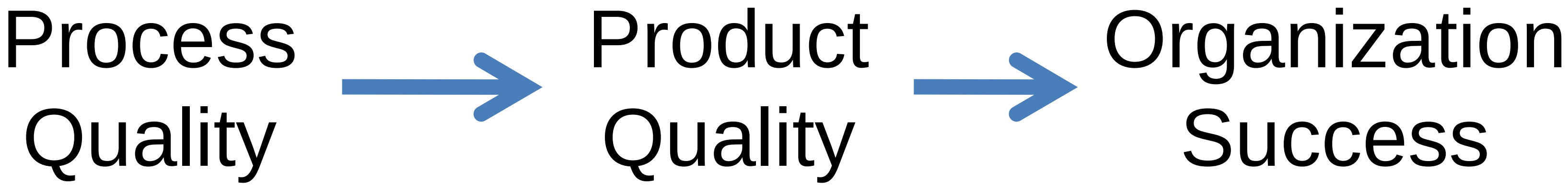
Software Process and Product Quality

Conclusions

Course Summary

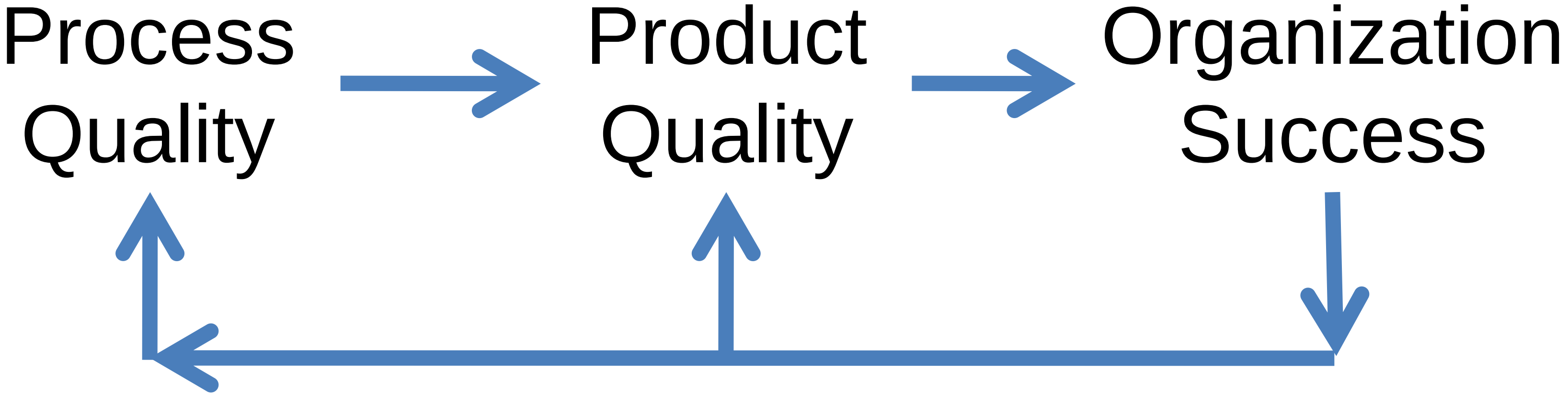
- Quality engineering concepts and principles
  - Quality engineering activities
  - Measurement fundamentals
  - Seven basic quality tools
- Focus on product quality
  - Defects as a quality indicator
  - Other quality attributes
  - Customer perspectives
- Focus on process quality
  - Project-level and activity-level
  - Process capability assessment and improvement
    - Quality system frameworks

Premise of a Quality Focus



Process Quality → Product Quality → Organization Success

Measure and Improve



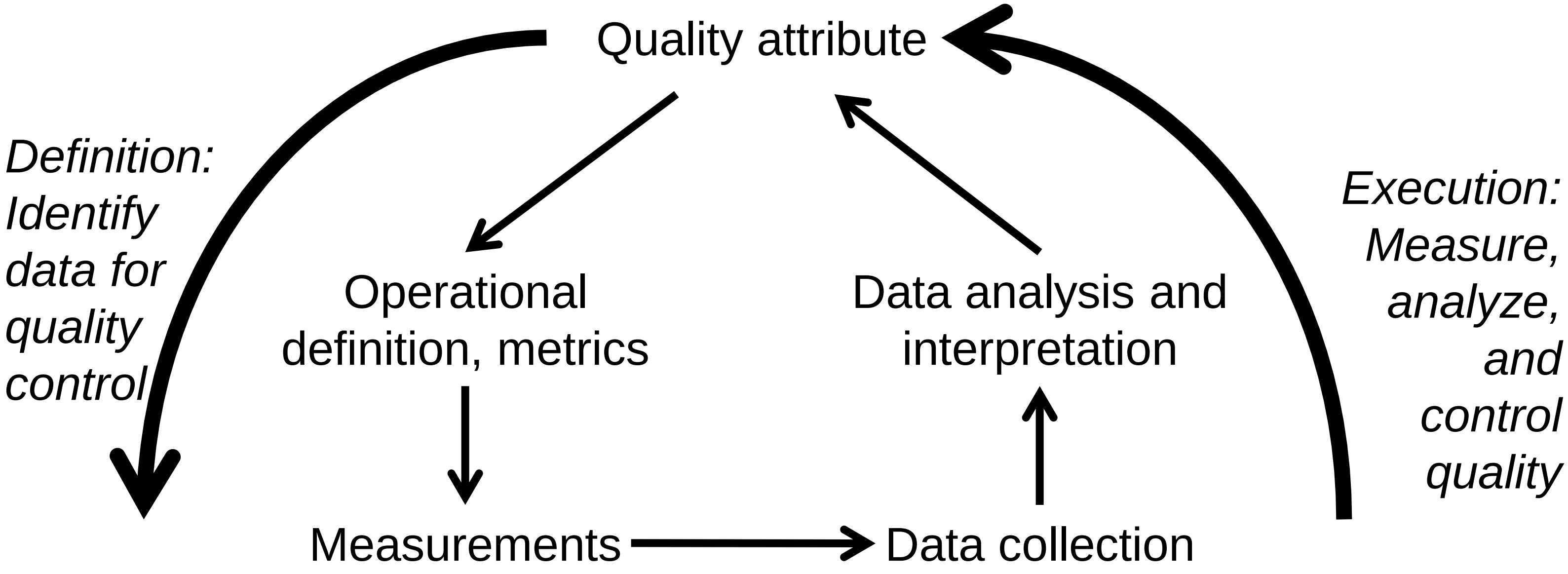
Process Quality

Product Quality

Organization Success

Measure quality, analyze results, and identify improvements

Implementing a Quality Improvement System



Quality attribute

Operational definition, metrics

Measurements

Data collection

Data analysis and interpretation

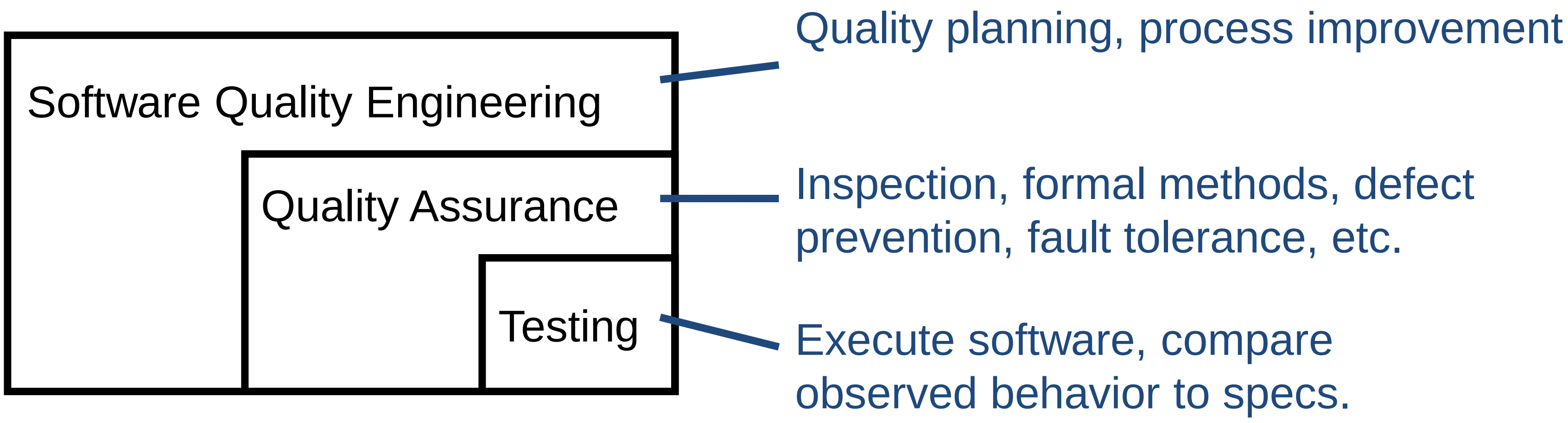
Definition: Identify data for quality control

Execution: Measure, analyze, and control quality

Quality Engineering

- Balance cost of quality with cost of poor quality in the context of business objectives
- The ultimate measure of quality is customer satisfaction
- Quality systems and frameworks (principles and practices) guide quality activities, but they cannot guarantee quality
  - Only people can deliver excellence

Scope of Software Quality Engineering



Software Quality Engineering

Quality Assurance

Testing

Quality planning, process improvement

Inspection, formal methods, defect prevention, fault tolerance, etc.

Execute software, compare observed behavior to specs.

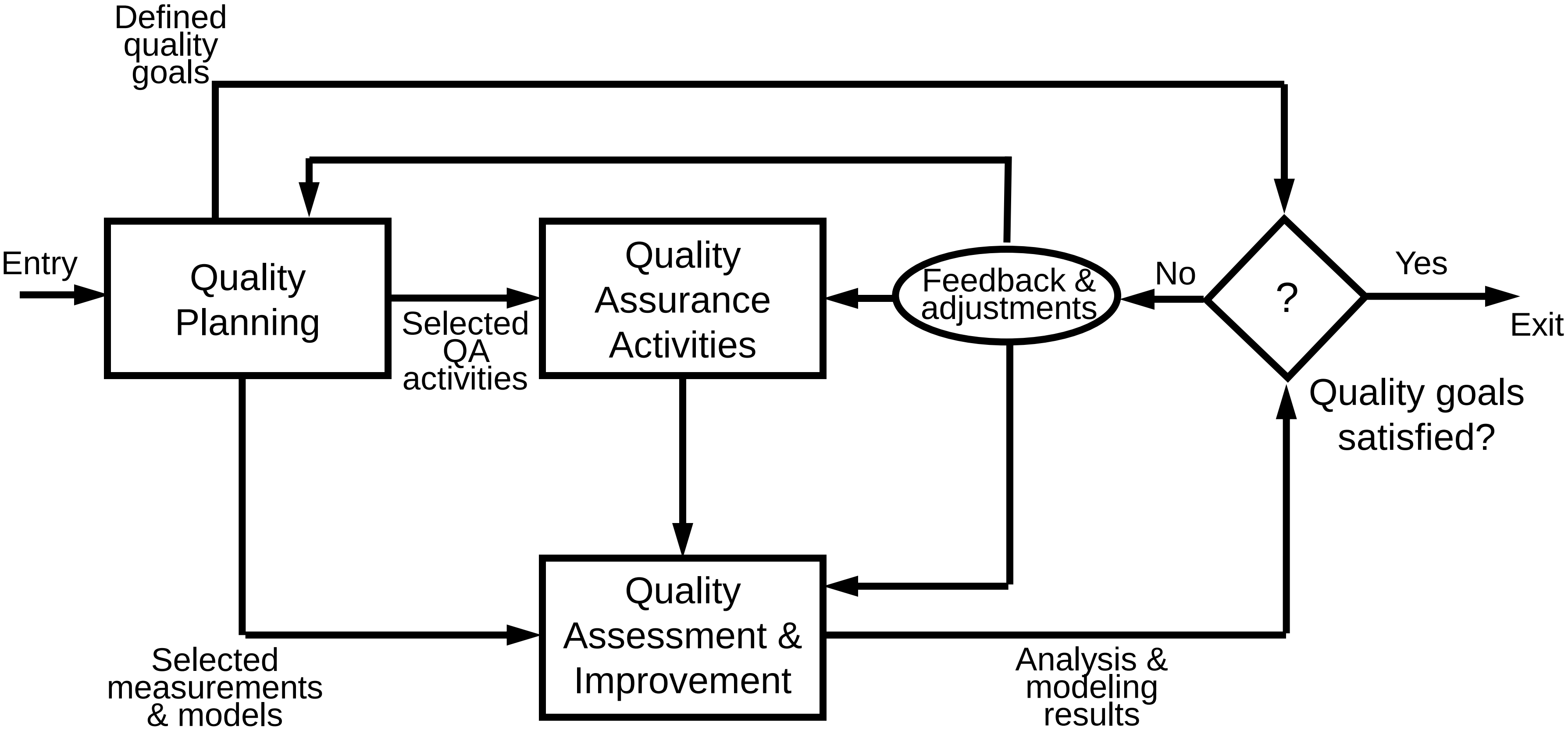
Cost of Quality, Cost of Poor Quality

- The cost of getting “it” right is high
- The cost of getting “it” wrong and having to fix may be higher
- Murphy: “There is never enough time to do it right, but there is always enough time to do it over”

- But, up front, can you anticipate where it might be wrong?
  - The cost of focusing on the wrong things might be higher than the cost of fixing it when it is wrong
    - Especially schedule impact costs
  - Software is easy to fix
    - Embrace change

- As an engineer (and business-person), balance the cost of getting it wrong with the cost of wasted effort

Quality Engineering Process



Quality Planning Activities

- Set quality goals by balancing customer expectations with project economics (cost, schedule, scope, risk)
  - Identify customer quality views and attributes
    - Including customer balance of their cost of quality
  - Select direct measures of the quality attributes
  - Set achievable and acceptable goal values of the quality measures
- For the stated quality goals ...
  - Select specific QA activities to achieve quality goals
    - Balance the cost and benefit of the QA activities against the quality goals
  - Select direct and indirect product and process quality measurements and quality models for quality assessment and analysis

Quality Assurance Activities

- Defect prevention
  - Remove (human) error sources
  - Block defects from being injected into software artifacts
- Defect reduction
  - Detect defects
    - Inspection
    - Testing
  - Remove defects
    - “Debugging”—iterate on the software engineering activity
      - Rework requirements, design, code, etc.
- Defect containment
  - Fault tolerance
  - Fault containment

Quality Assessment and Improvement Activities

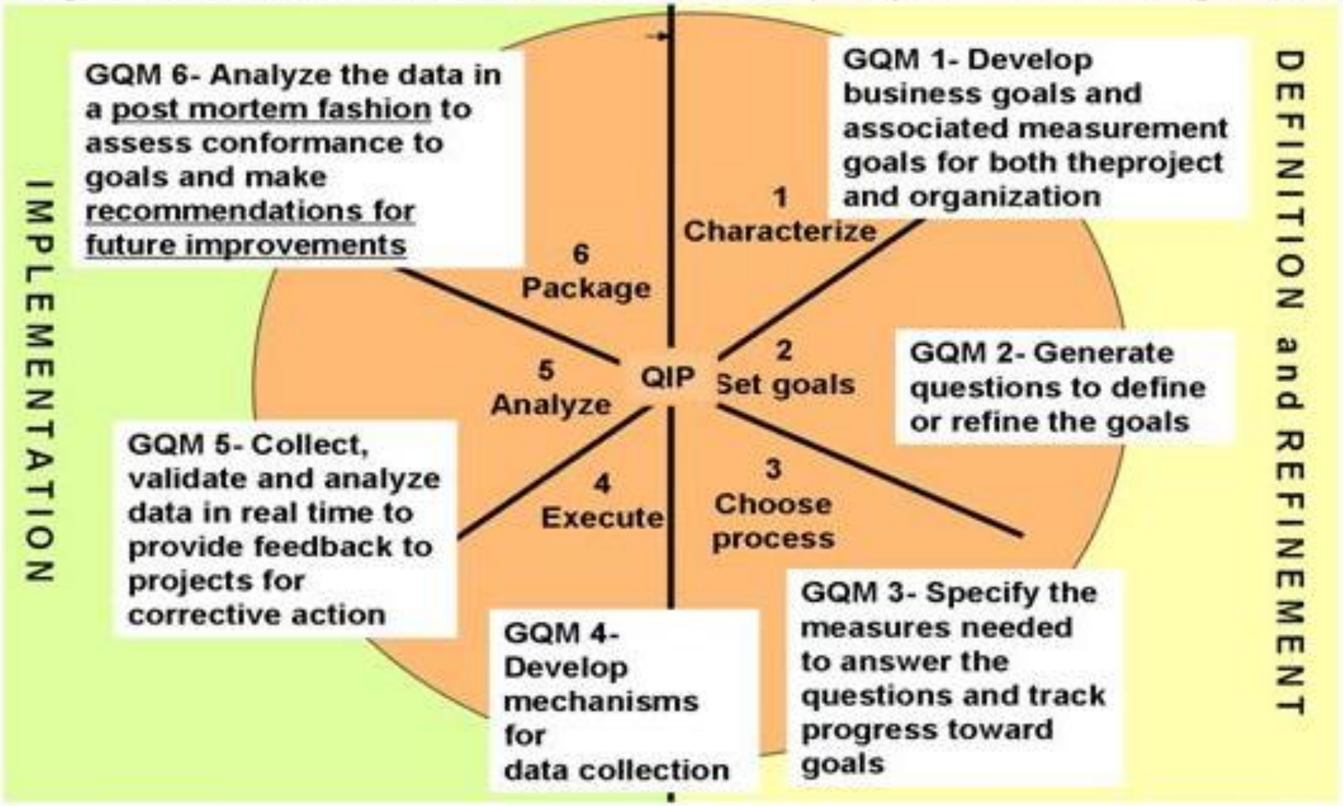
- Measurement
  - Defect and other product quality measurements
  - Process measurements
- Quality analysis and modeling
  - Analyze measurement data
  - Fit data to analytical models of quality
    - Estimate current and future quality (quality trends)
    - Identify problematic software components or process activities
- Feedback for immediate process improvement
  - Adjust quality goals, project plan, QA plan
  - Adjust quality models
- Feedback for organizational process improvement
  - Improve techniques for quality assurance, quality engineering, and overall software engineering process

Implementing a Quality Improvement System – GQM Approach

The following is based on Goal-Question-Metric Software Acquisition Gold Practice at the DACS Gold Practices Web Site

(https://www.goldpractices.com/practices/gqm/)

Integration of GQM Process within the Quality Improvement Paradigm (QIP)



GQM 1- Develop business goals and associated measurement goals for both theproject and organization

GQM 2- Generate questions to define or refine the goals

GQM 3- Specify the measures needed to answer the questions and track progress toward goals

GQM 4- Develop mechanisms for data collection

GQM 5- Collect, validate and analyze data in real time to provide feedback to projects for corrective action

GQM 6- Analyze the data in a post mortem fashion to assess conformance to goals and make recommendations for future improvements

Based on: Basili, "Using Measurement to Build Core Competencies in Software", DACS Course, 2005

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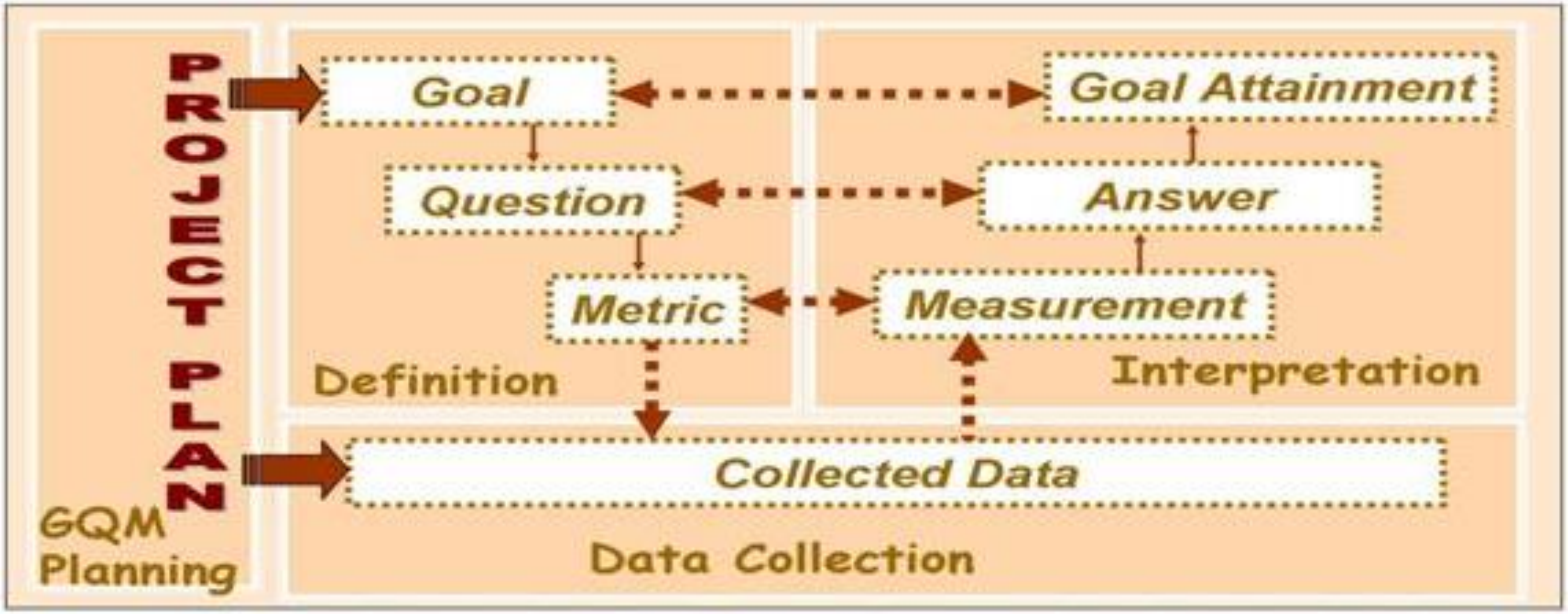
Phases of GQM Implementation



Source: Solingen, "Experiences in Using the Goal/Question/Metric Paradigm" , 1998

Six Steps of GQM

- Steps 1-3: Definition
  - Use business goals to drive identification of the right metrics
- Steps 4-6: Data Collection and Interpretation
  - Gather the measurement data and make effective use of the measurement results to drive decision making and improvements

Six Steps of GQM

Steps 1-3: Definition

Use business goals to drive identification of the right metrics

1. **Develop** a set of corporate, division and project **business goals and associated measurement goals** for productivity and quality
2. **Generate questions** (based on models) that define those goals as completely as possible in a quantifiable way
3. **Specify** the **measures** needed to be collected to answer those questions and track process and product conformance to the goals

Six Steps of GQM

Steps 4-6: Data Collection and Interpretation

Gather the measurement data and make effective use of the measurement results to drive decision making and improvements

4. **Develop mechanisms** for data collection
5. **Collect, validate** and **analyze** the **data in real time** to provide feedback to projects for corrective action
6. **Analyze** the **data** in a **postmortem** fashion to assess conformance to the goals and to make recommendations for future improvements

Key Practices of GQM (p. 1 of 3)

- ***Get the right people involved in the GQM process***
- ***Set explicit measurement goals and state them explicitly***
- ***Don’t create false measurement goals*** (for example, matching metrics you already have or are easy to get)
- ***Acquire implicit quality models from the people involved***

Key Practices of GQM (p. 2 of 3)

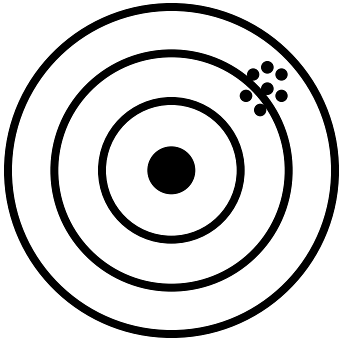
- ***Consider context***
- ***Derive appropriate metrics***
- ***Stay focused on goals when analyzing data***
- ***Let the data be interpreted by the people involved***
- ***Integrate the measurement activities with regular project activities***

Key Practices of GQM (p. 3 of 3)

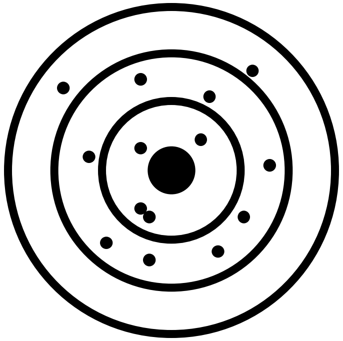
- ***Do not use measurements for other purposes (such as to assess team member productivity)***
- ***Secure management commitment to support measurement results***
- ***Establish an infrastructure to support the measurement program***
- ***Ensure that measurement is viewed as a tool, not the end goal***
- ***Get training in GQM before going forward***

Measurement Fundamentals

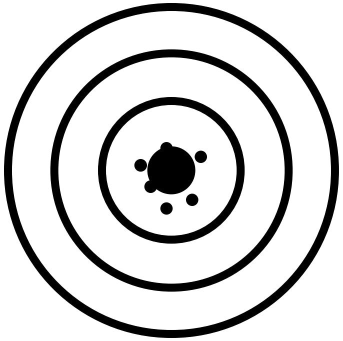
- Tie measurements to the concept of interest
  - Indicators
  - Measurements vs. Metrics
- Measurement scales (nominal, ordinal, interval, ratio) and proper use of measures
- Correlation and Causation
- Reliability and Validity; Systematic and Random Error



Reliable but not valid



Valid but not reliable



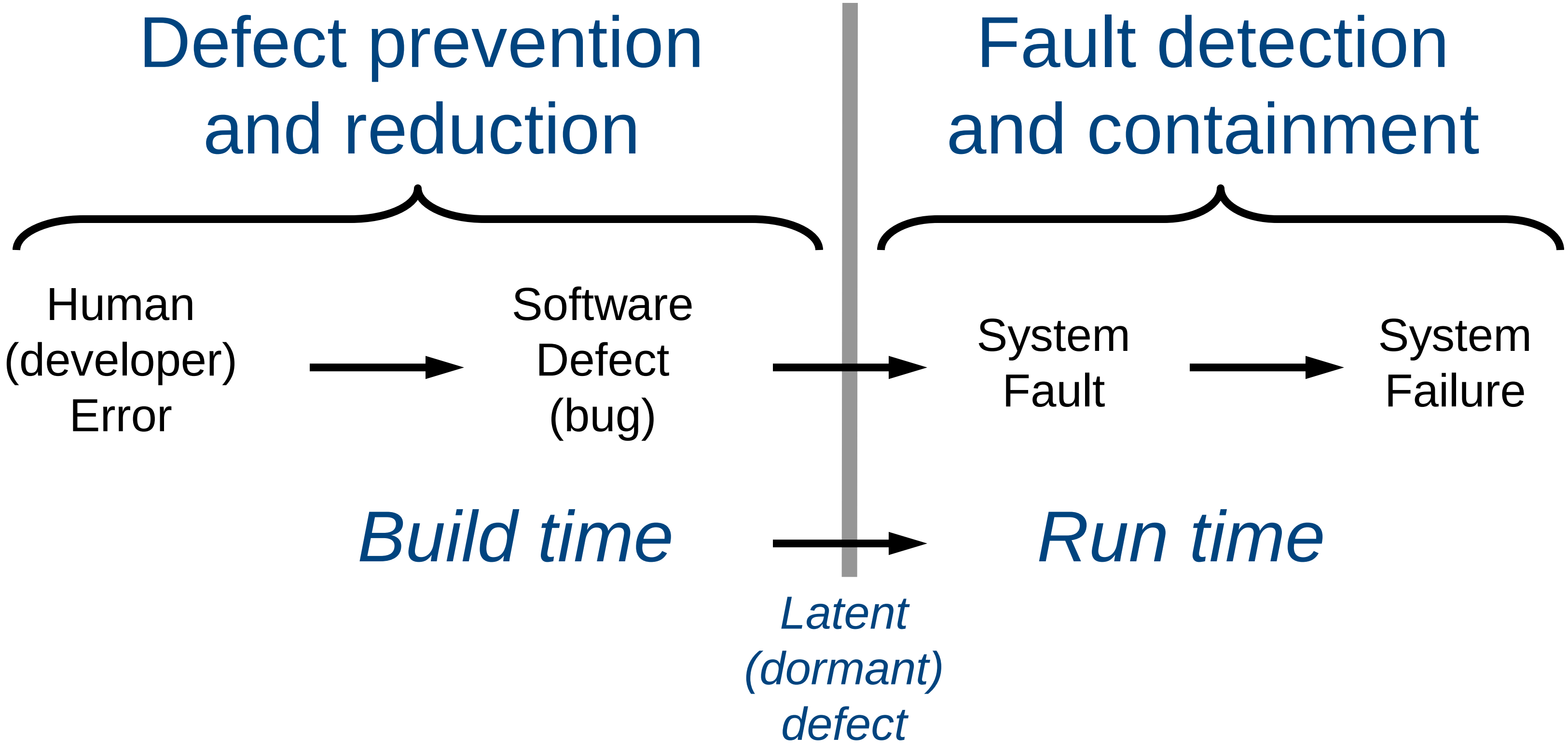
Valid *and* reliable

The Seven Basic Quality Tools

- Checklists (Checksheets)
- Pareto Diagrams
- Histograms
- Run Charts
- Scatter Diagrams (Scatter Plots)
- Control Charts
- Cause-and-Effect (Fishbone) Diagrams

Product Quality

Defects and Failures



Defect prevention and reduction

Fault detection and containment

Human (developer) Error → Software Defect (bug) → System Fault → System Failure

Build time → *Run time*

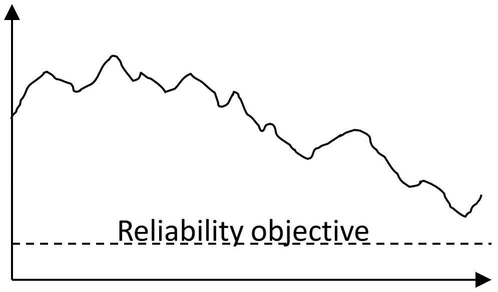
Latent (dormant) defect

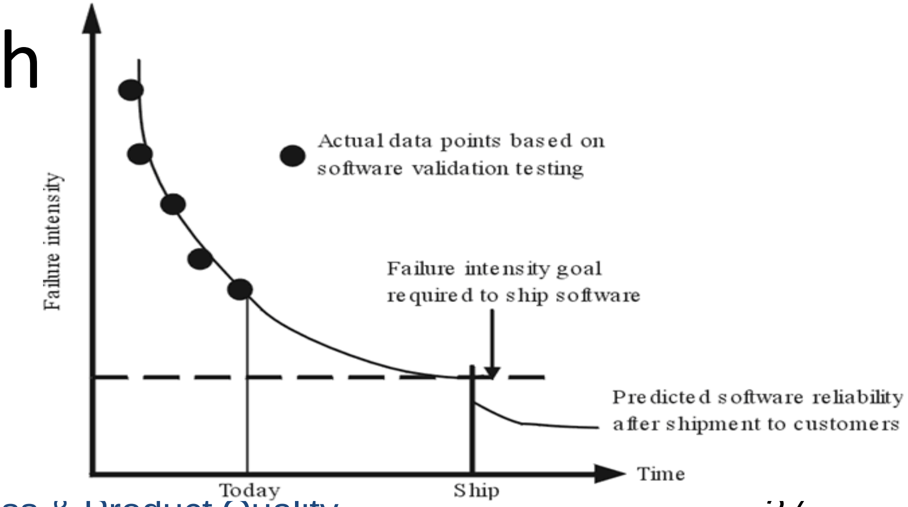
Defects

- Defect measures and metrics
  - Size and defect counts → various "density" metrics
  - Defect type classifications
- Multiple stages of defect removal
  - Inspections at all stages (requirements, design, implementation)
  - Multiple stages of testing (unit, integration, system)
  - Defect removal/containment effectiveness

Software Reliability Engineering

- Customer perspective (failures) vs. developer perspective (defects)
- Operational profiles
  - Identify the most frequently used product features
  - Focus design and testing on the frequently used features
    - And the “important” features (high cost if getting it wrong)
- Predict reliability growth





Product Quality: Big Q vs. little q

- Quality includes many more attributes than just absence of defects

Reliability
Maturity
Fault-tolerance
Recoverability

Portability
Adaptability
Installability
Conformance
Replaceability

Functionality
Suitability
Accurateness
Interoperability
Compliance
Security

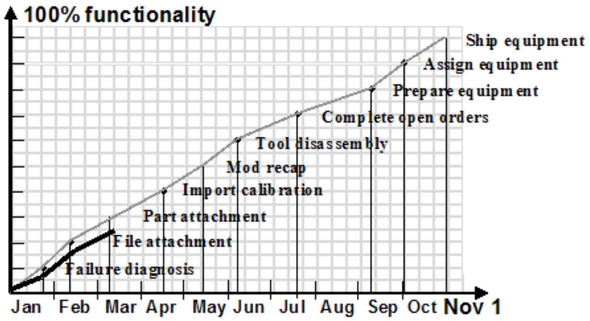
Efficiency
Time behavior
Resource behavior

Usability
Understandability
Learnability
Operability

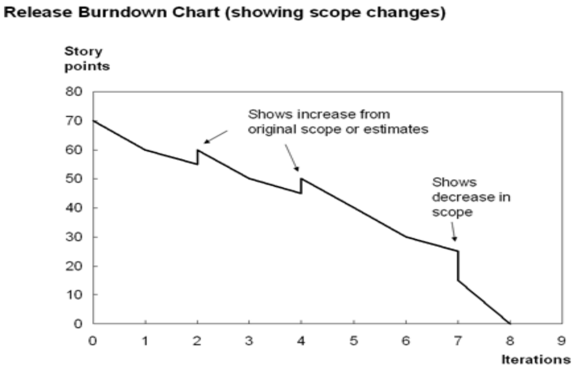
Maintainability
Analyzability
Changeability
Stability
Testability

Process Quality

- Project-level metrics
  - Cycletime, Productivity, Staffing, Requirements volatility, Reuse, Estimation accuracy, Progress



Burn-Up (Earned Value)



Release Burn-Down

- Activity-specific metrics
  - Requirements, Design, Coding, Testing, Maintenance, Configuration Management, Quality Engineering

Process Maturity and CMMI

- Achieving each level...
  - Establishes a different component in the software process
  - Increases the process capability of the organization

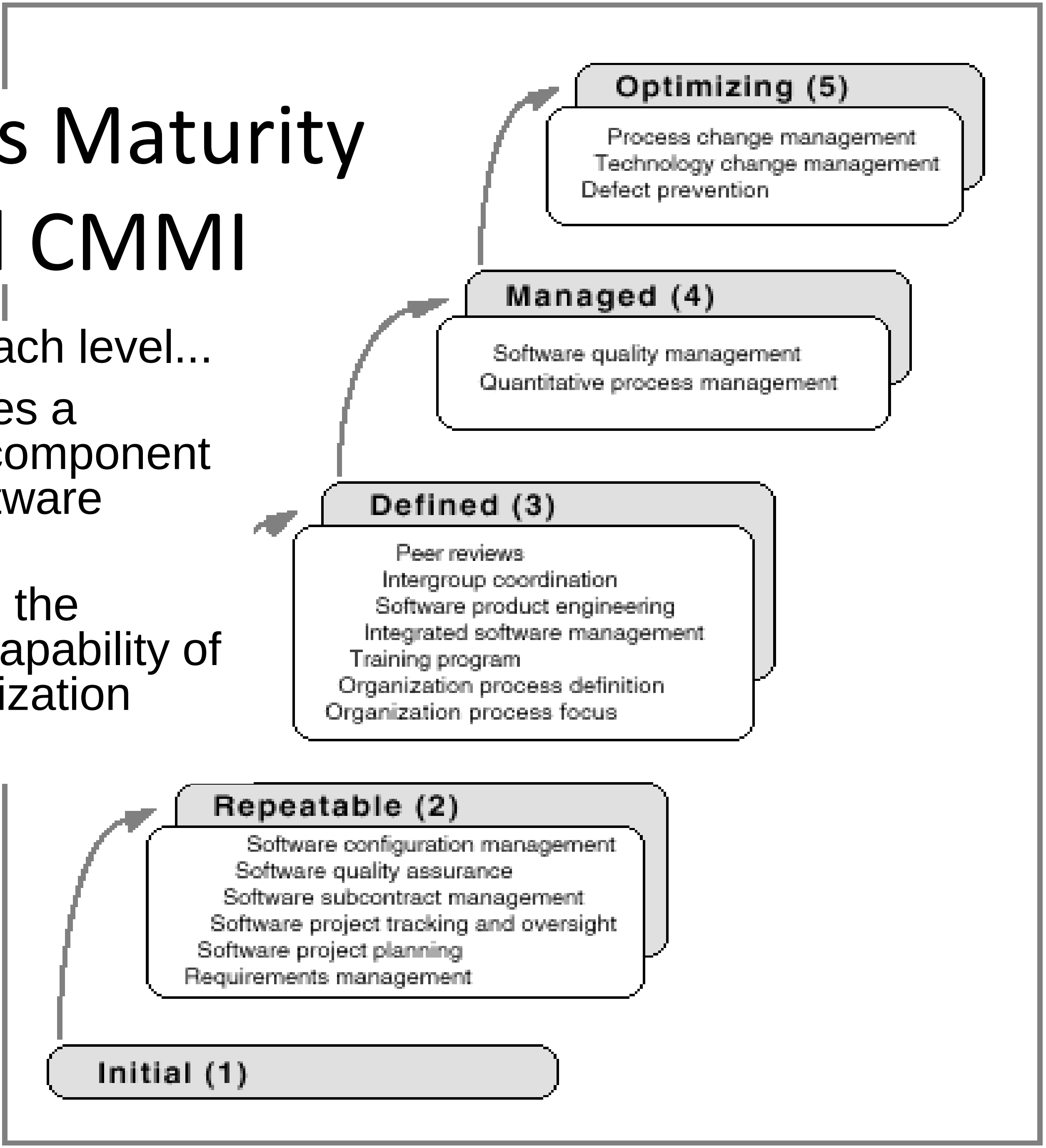
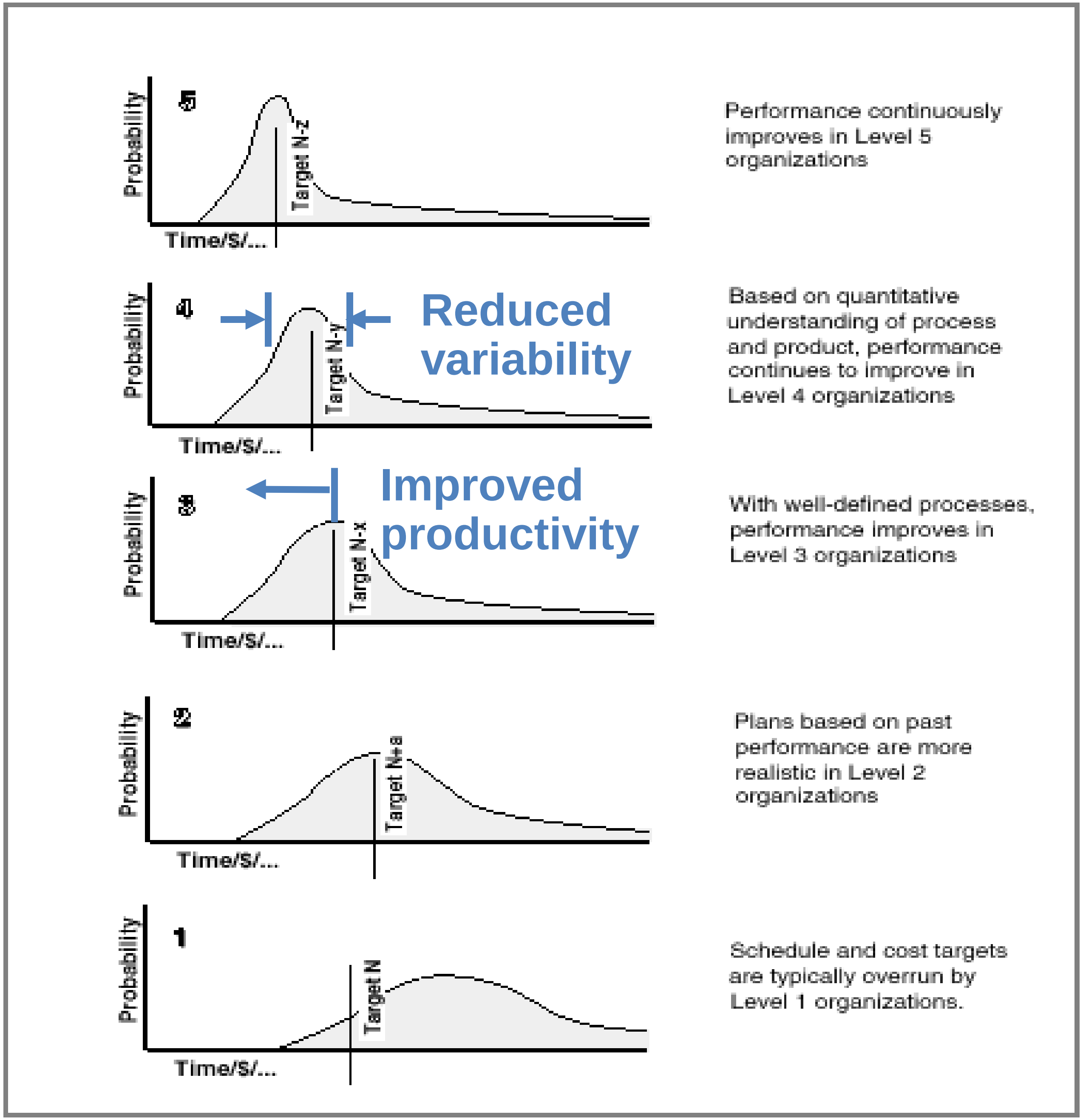

Optimizing (5)
Process change management
Technology change management
Defect prevention
Managed (4)
Software quality management
Quantitative process management
Defined (3)
Peer reviews
Intergroup coordination
Software product engineering
Integrated software management
Training program
Organization process definition
Organization process focus
Repeatable (2)
Software configuration management
Software quality assurance
Software subcontract management
Software project tracking and oversight
Software project planning
Requirements management
Initial (1)

Figure 3.2 The Key Process Areas by Maturity Level

More Mature

→ Better Way to Run a Business



Reduced variability

Improved productivity

Performance continuously improves in Level 5 organizations

Based on quantitative understanding of process and product, performance continues to improve in Level 4 organizations

With well-defined processes, performance improves in Level 3 organizations

Plans based on past performance are more realistic in Level 2 organizations

Schedule and cost targets are typically overrun by Level 1 organizations.

Figure 2.4 Process Capability as Indicated by Maturity Level

Assessments and Quality Frameworks

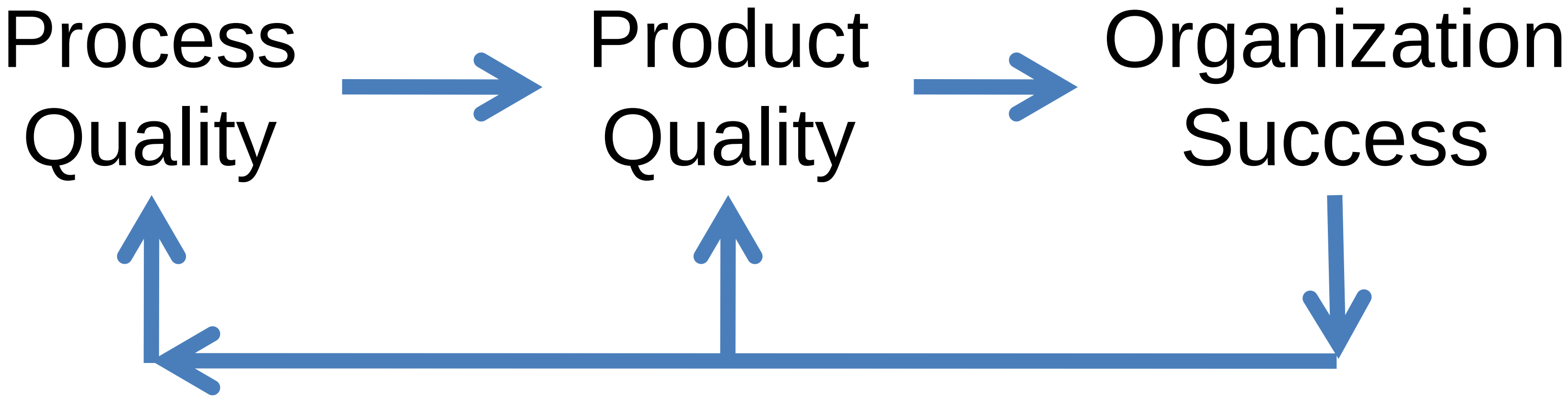
- Assessments baseline quality processes; Frameworks provide benchmarks
- ISO 9000 Family of Standards
  - A general international standard for organizational quality systems
  - Oriented towards assessment and certification
- Malcolm-Baldrige Assessment Discipline
  - A set of criteria for the (US) Malcolm-Baldrige Quality Award.
  - Designed to encourage and recognize excellence
- SEI CMM (Capability Maturity Model family)
  - A software-specific model for improving the maturity of software development practices
  - Oriented towards self-assessment and improvement
- Total Quality Management (TQM)
  - A philosophy and practices for improving quality
  - Focuses on building an organizational quality culture

Applying the Concepts

- Creating a Quality Systems Improvement Plan
  - Quality objectives
  - Quality approach
  - Product quality
    - Defects
    - Other quality attributes
    - Customer satisfaction
  - Process quality
  - Incremental implementation plans
  - Assessment plans

Conclusion

A systematic approach to measuring and improving software product and process quality will help ensure organizational success



Process Quality

Product Quality

Organization Success

Measure quality, analyze results, and identify improvements