The Look and Feel of a Successful CMMI Implementation

CMMI Conference Denver, Colorado 2004

Welcome

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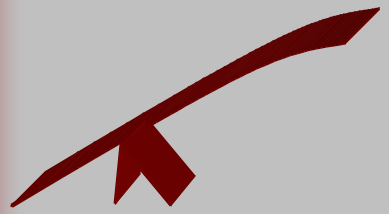
Agenda

- Engineering Systems Think
- Business Results
- Roles and Responsibilities
- Project Management
- Risk Management
- Quality Management
- Supplier Management
- Recursive Nature of Requirements Engineering
- Alternative Solutions
- Components to Products

Agenda - 2

- Improving Processes At The Organizational Level
- The Knowledge and Skills Base
- Integrated Teams
- Reducing Variation
- Establishing a Measurement Program
- Improving Beyond Stability
- Repeatable, Effective, and Long Lasting
- Process Improvement Means Change
- Constagedeous Approach to Process Improvement
- Summary



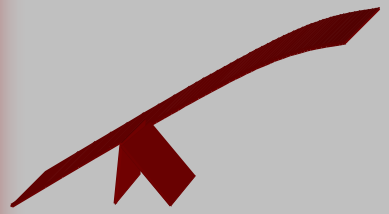
Engineering Systems Think

Laws of Engineering Systems Thinking

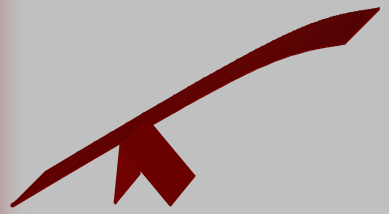
- Systems Thinking is a discipline for seeing the whole
- In all of the project's phases/stages, and along the system's life, the systems engineer has to take into account:
  - The customer's organization vision, goals, and tasks
  - The customer's requirements and preferences
  - The problem to be solved by the system and the customer's needs
- The whole has to be seen as well as the interaction between the system's elements
  - Iterative or recursive thinking must replace the traditional linear thinking

Laws of Engineering Systems Thinking - 2

- The solution is not always an engineering one – remember to always take into account
  - Business and economic costs
  - Reuse or utilization of products and infrastructure already developed
  - Organizational, managerial, political, and personal considerations
- The end user must be considered as a major part of the system
  - At each stage the human element must be considered



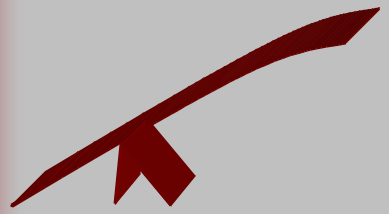
Business Results



Support for the Organization's Business Objectives

Business Objectives

- For a focus on Process Improvement to be successful, it must be tied to the organization's business objectives for example:
  - Improve predictability of development cycle length, delivery time and costs
  - Find and fix each problem once
  - Reduce system errors that are discovered by customers
  - Increased control of suppliers
  - Increase quality of products
  - Always work with the correct version of a module or life-cycle work product



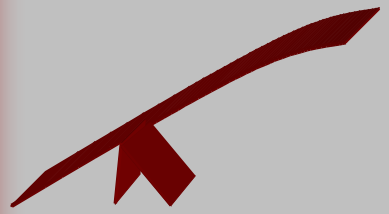
Support for Senior Management's Vision

Vision

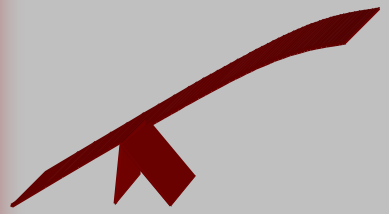
- Where does senior management think the organization will be in the next year, and in the next two to five years?
- What products will be in the mainstream?
- Who will the competitors be?
- Will there be collaborators or strategic alliance partners?
- What technology changes are expected and/or will be required to support the vision?

Vision - 2

- What does the organizational structure have to be to support this vision?
- Who will the organization's suppliers be?
- What must the organizational culture be to support this vision?
- How will a Process Improvement Initiative support this vision?



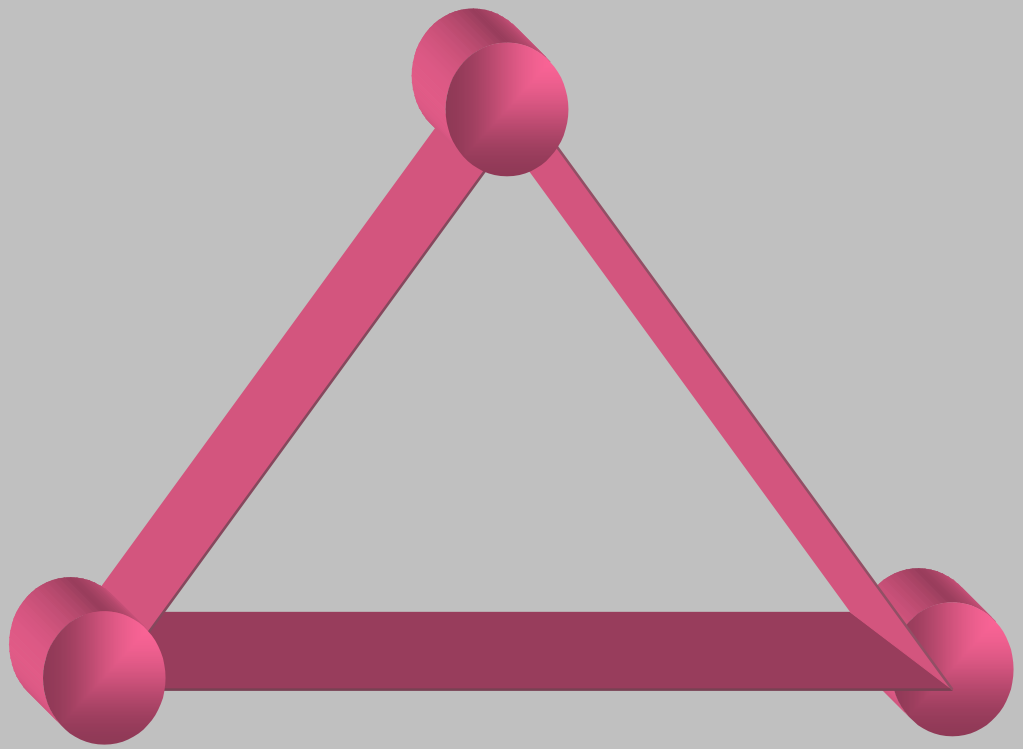
Support for Project Leaders to Manage and Control Better



Process Improvement: What Value to Project Leaders?

- What measurable value will the quality management initiative bring to the project leaders who bear the line responsibility for product delivery?
  - More accurate schedules?
  - Higher productivity of developers?
  - Better quality products?
  - Traceable requirements?
  - Controlled configuration items?
  - Reviews focused on critical components?
  - Better control of suppliers?
  - Reduction in potential risks?

Process in Perspective



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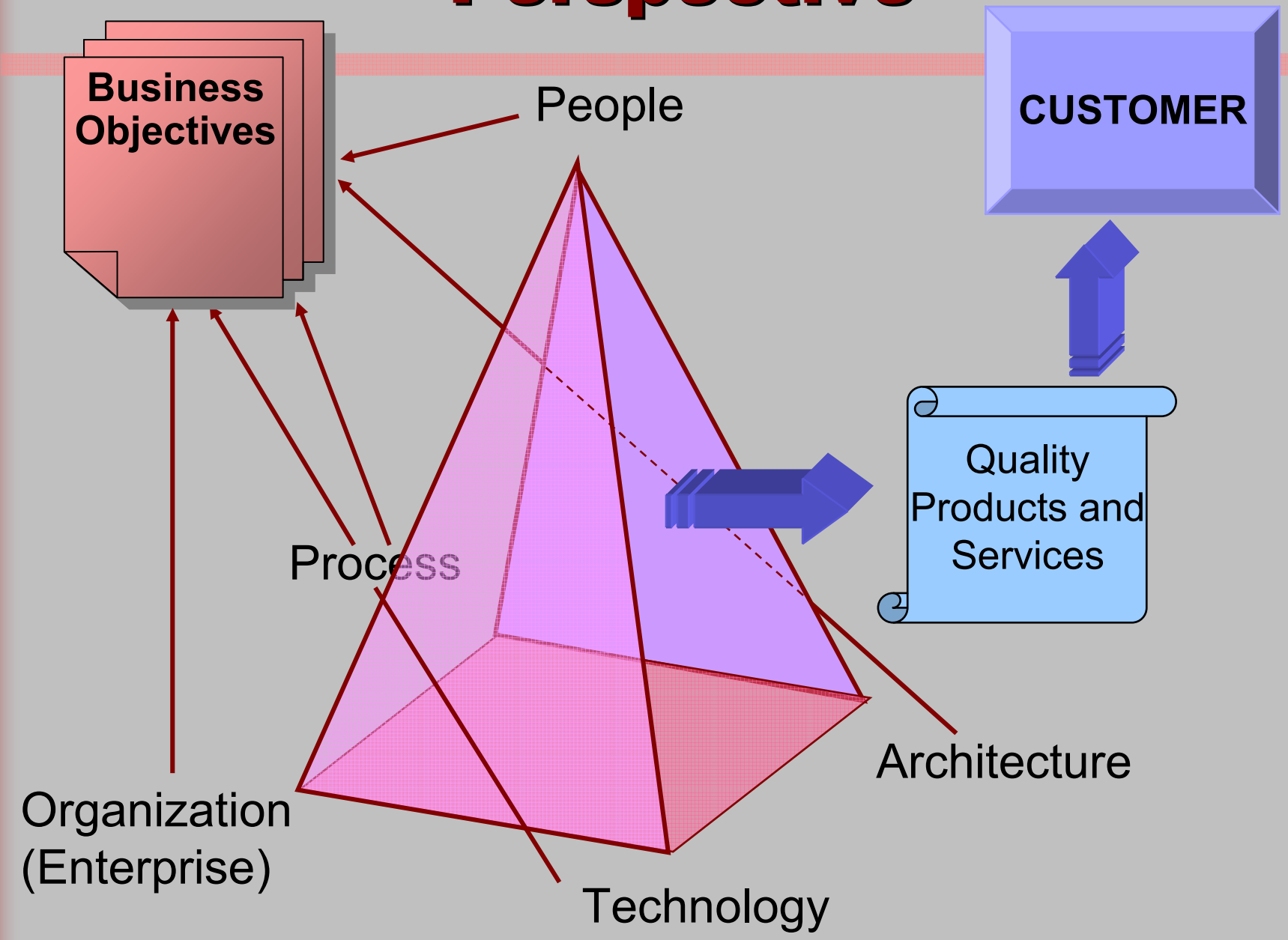
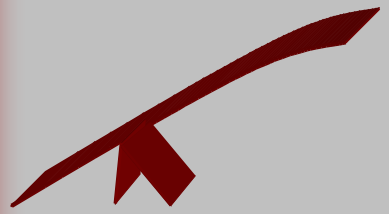
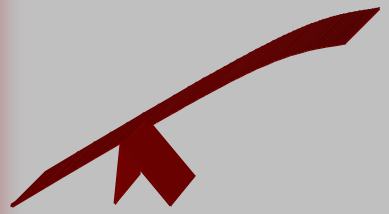
Business Process Perspective





Roles and Responsibilities



Senior Management Must Lead the Charge

- Since there are inherent costs to implementing process, Senior Management must demonstrate their belief in it through their communications, daily decision making, and financial commitment.
- Senior Management's resolve must not waiver when deadlines beg for shortcuts to get the product out the door

Senior Management

- Establish Policies – behavior expectation setting documents
- Allocate or reallocate resources
- Establish Authority and Responsibility
- Authorize Training
- Approve Organizational Commitments
- Have Senior Management Oversight into the processes used on projects and resulting product quality
- Provide Visible Management Support

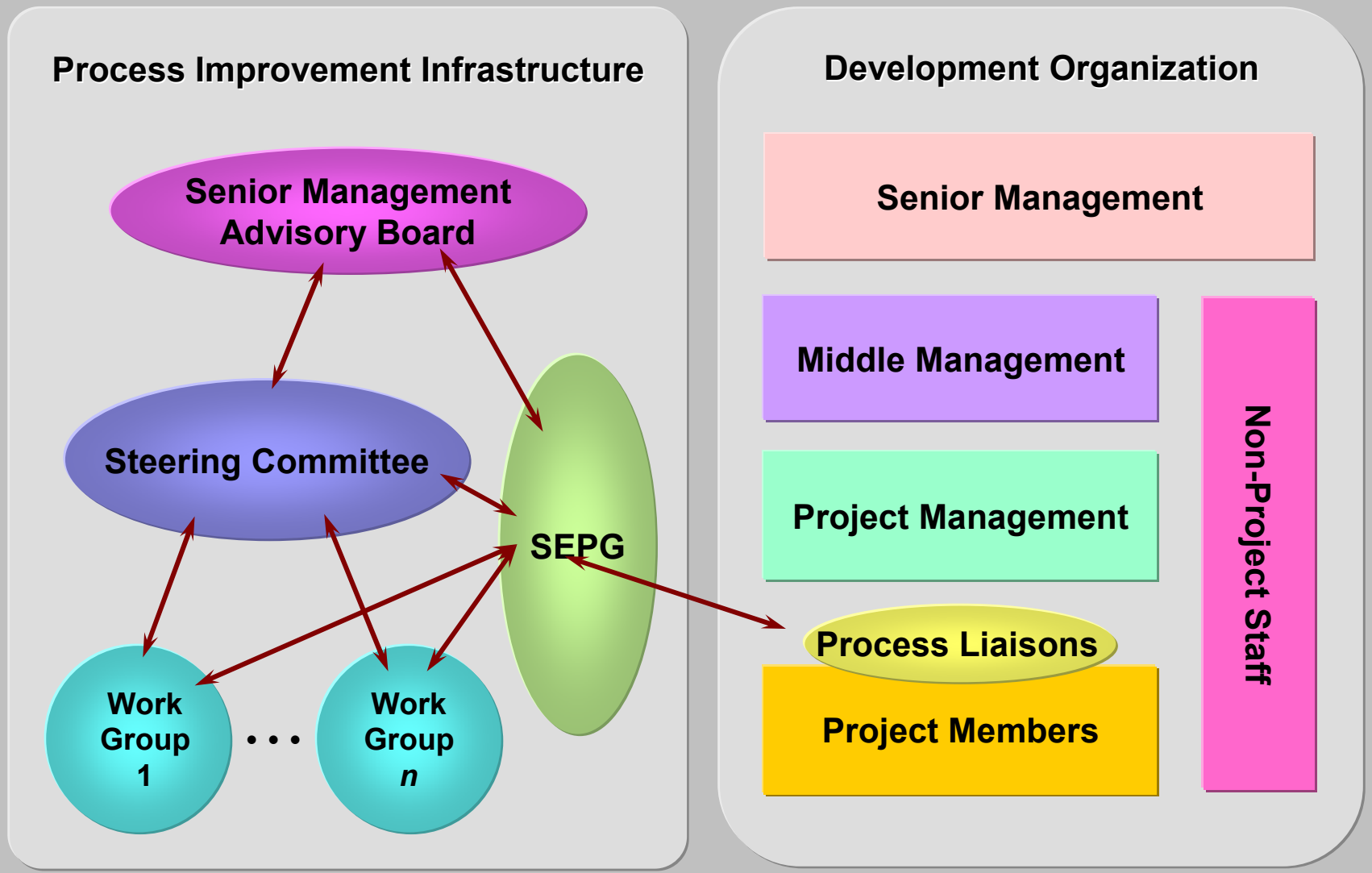
Middle Managers

- Provide the corporate bridge between the programs and projects and the senior management team
- Exercise risk management decision making based on data
- Guide the process improvement steering committee
- Serve as a “process owner”
  - The Middle Manager as “Process Owner” must participate in the periodic Senior Management Oversight Meeting and report the progress on his process focus area.

Project Manager

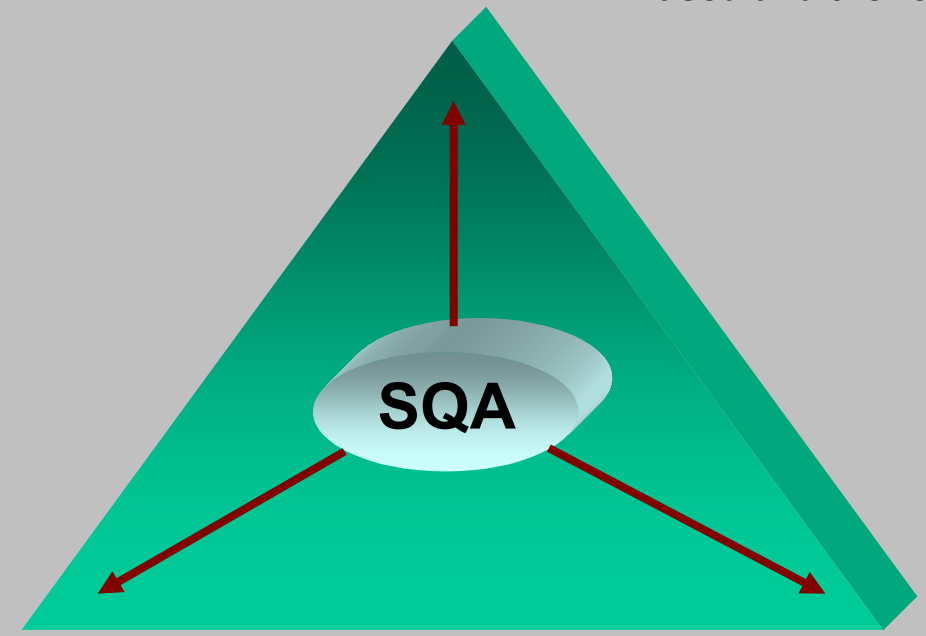
- Today's Project Manager is expected to be:
  - Better educated
  - Open, friendly, and people-oriented
  - A better listener
  - Quality conscious
  - Receptive to new ideas
  - More participative
  - A Facilitator
  - Skilled at group process and group dynamics
  - Encouraging to others to participate in plans and decisions
  - Skilled on how to coach, inspire, and motivate the project team
  - Able to span boundaries
  - Able to provide and apply integrative management techniques to unique, complex organizational ventures characterized by interdependent efforts, a variety of specialists, over multiple sites, multiple languages and multiple cultures

Process Group: Sample Improvement Infrastructure



SQA - Agent for Process Improvement

Provides visibility into the effectiveness and efficiency of the processes being used and the resulting product quality



Provides feedback to the individual projects on the efficiency and effectiveness of the processes that they are following so they can be improved at the project level

Provides feedback to the SEPG on the organizational processes they have facilitated in developing so they can be improved at the organizational level

CM Roles and Responsibilities

- Configuration Management Group
  - Configuration Management Manager
  - Configuration Management Engineer
  - Configuration Management System Manager
  - Test Library Manager
  - Release Library Manager
- Project Manager
- Project Team
- Project CM Specialist
- Configuration Control Board
  - Organizational Level
  - Project Level

Integration & Systems Testing

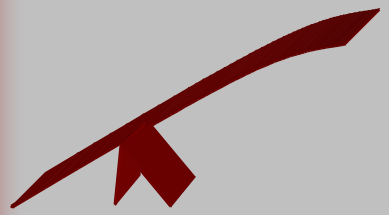
- Integration ensures the product components match the interface descriptions and “fit together”
  - Interfaces are tested to ensure that Systems Testing can be conducted against a complete system or subsystem
- Systems Testing is the first time at which the entire system can be tested against the Systems Specification
- Systems Testing measures and determines what the systems capabilities are
- Systems test plan covers types of testing to be performed, test strategies, test coverage approaches, methods and approach for tracing requirements to test cases, and reliability metrics

Measurement Team

- Most organizations have at least one person who has an interest in and an ability to understand metrics and measurements
- Few organizations have a designated Measurement Group
- While it may not seem worthwhile for an organization to form a separate Measurement Group, having a measurement expert or two supporting the organization's metrics needs is quite valuable

Systems Engineering

- Systems Engineering provides a “cradle to grave” view of the evolving system
- Systems engineers help to define the total technical and managerial effort required to transform the set of customer needs, expectations, and constraints into a life-cycle balanced solution.



Project Management

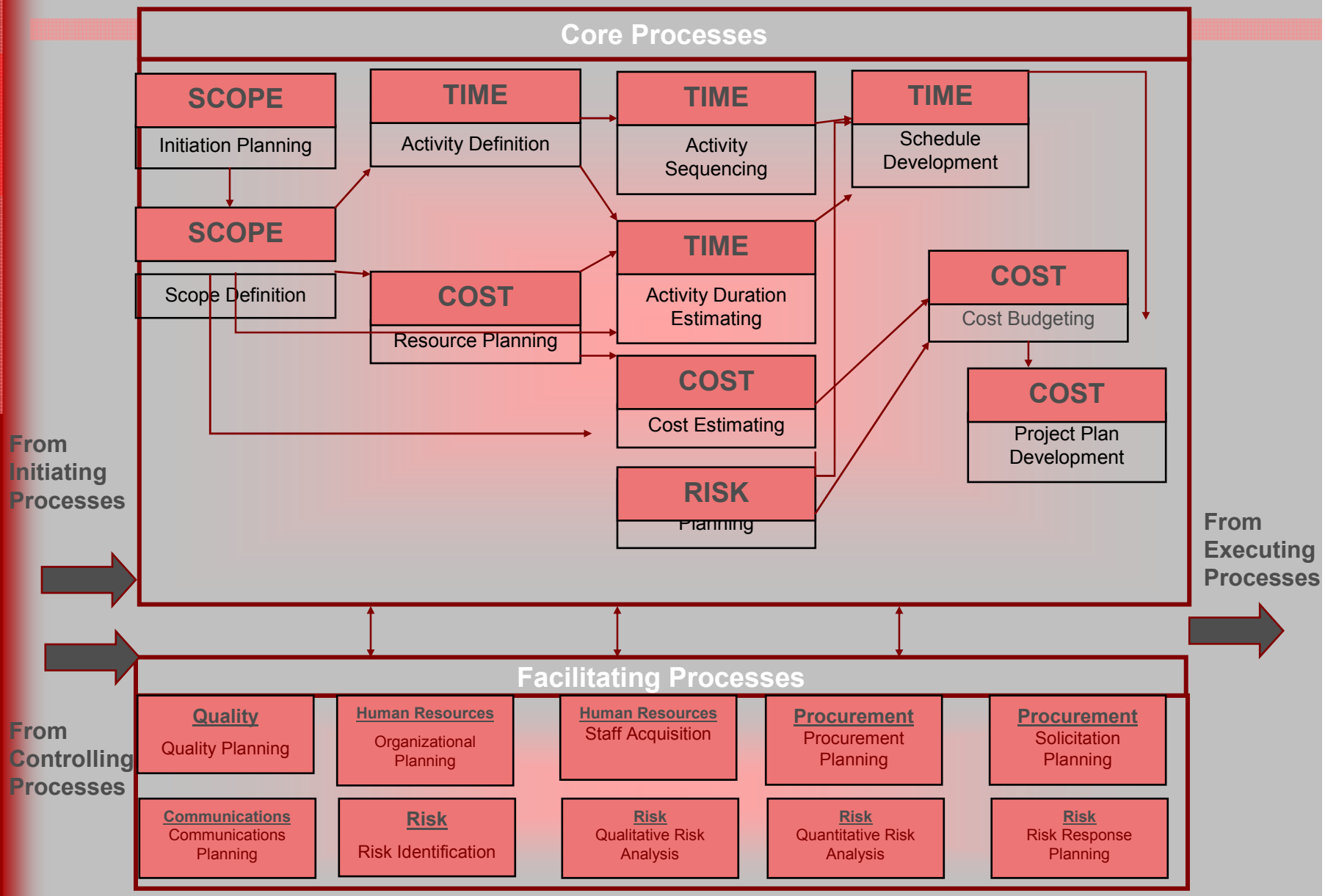
Project Management

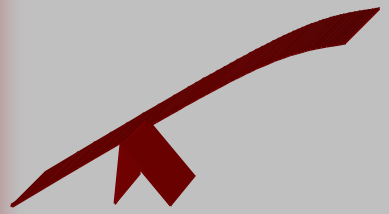
- Project Management is a set of tools, techniques and knowledge that, when applied, helps produce better results for a project
- Project Management provides a process that can help answer basic questions:
  - What are you going to produce?
  - What is it the customer wants and needs?
  - Who is going to do the work?
  - How long will it take?
  - How much will it cost?
  - What might go wrong?
  - How can you avoid potential problems?

Project Management - 2

- Project Management functions include:
  - Define scope of project
  - Work Breakdown Structure
  - Estimation
  - Risk Management
  - Stakeholder Involvement
  - Commitment Process
  - Planning including integrating all support plans that affect the project
  - Supplier Management
  - Monitoring and Control

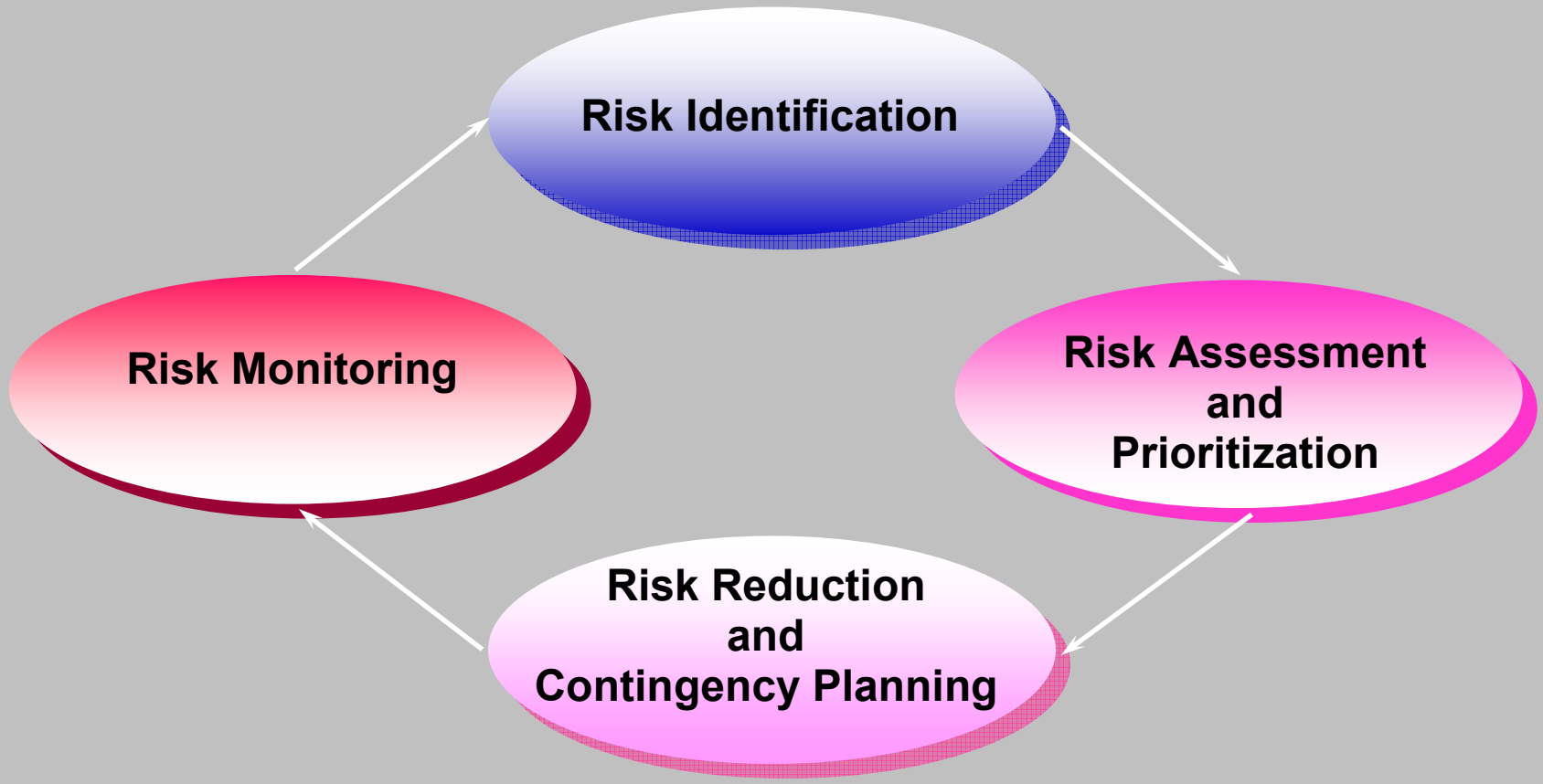
Relationships among the Planning Processes



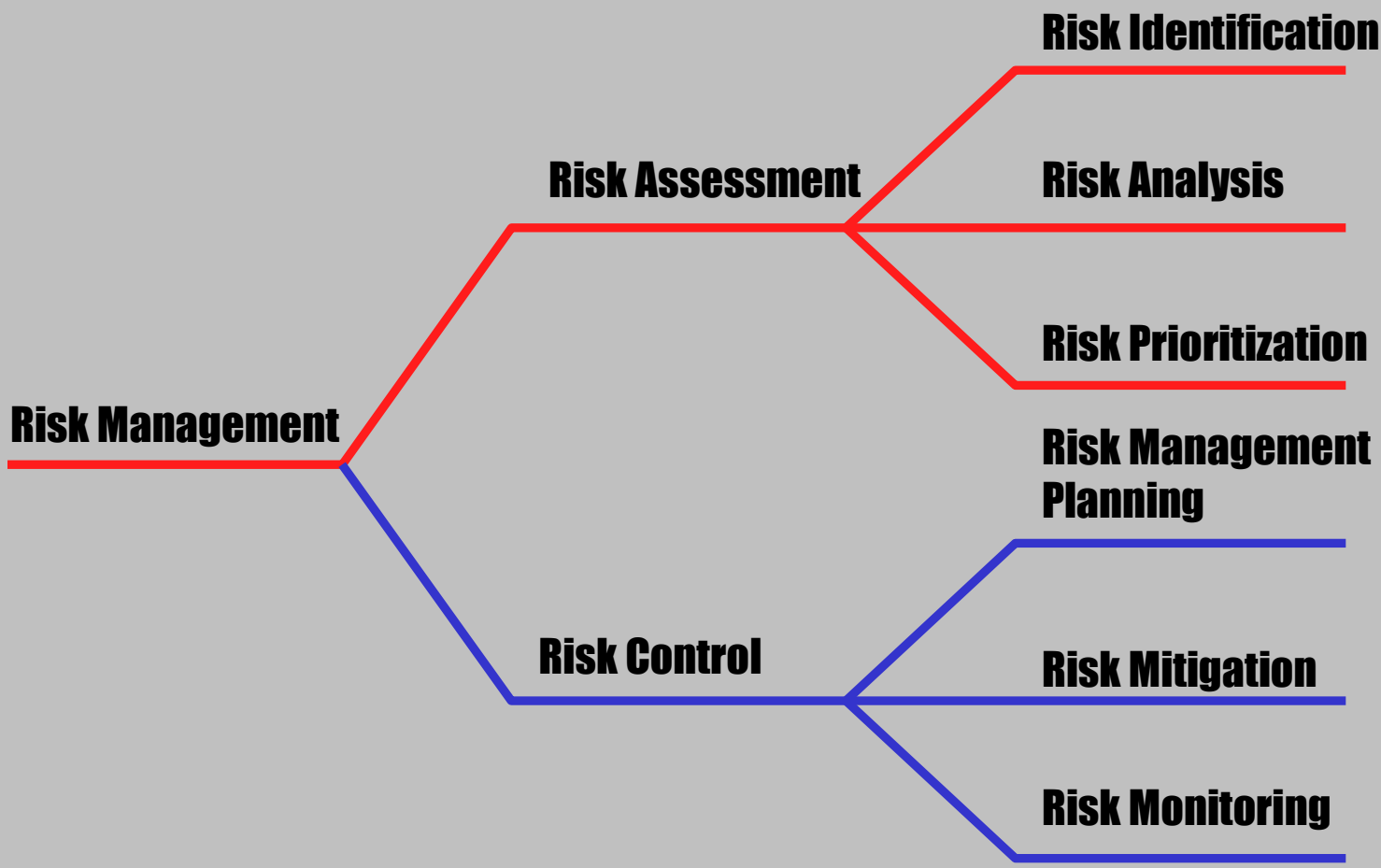


Risk Management

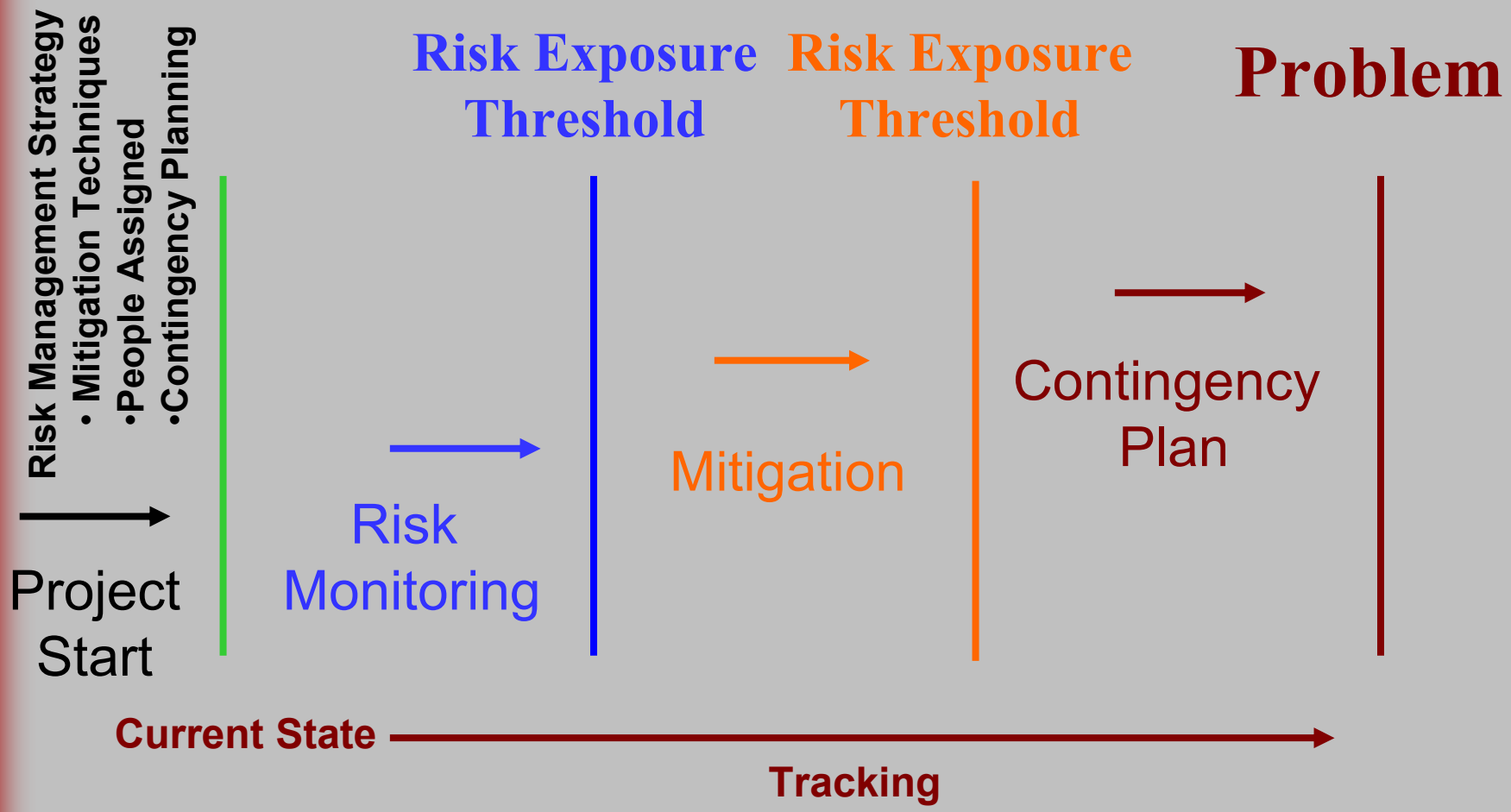
Risk Management Cycle

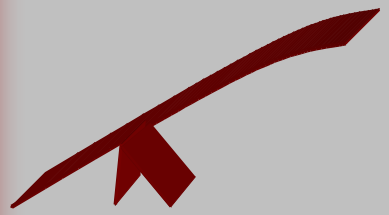


Elements of Risk Management



Establishing Risk Thresholds





Quality Management

Quality Management

- Quality Management consists of:
  - Setting Quality Goals that support business objectives
  - Establishing and enforcing a Quality Policy
  - **Planning** for quality
  - Developing Processes
  - Establishing the use of Standards and Procedures
  - Conducting Objective Evaluations Audits with respect to **product** quality
  - Conducting Objective Evaluations Audits with respect to **process** quality

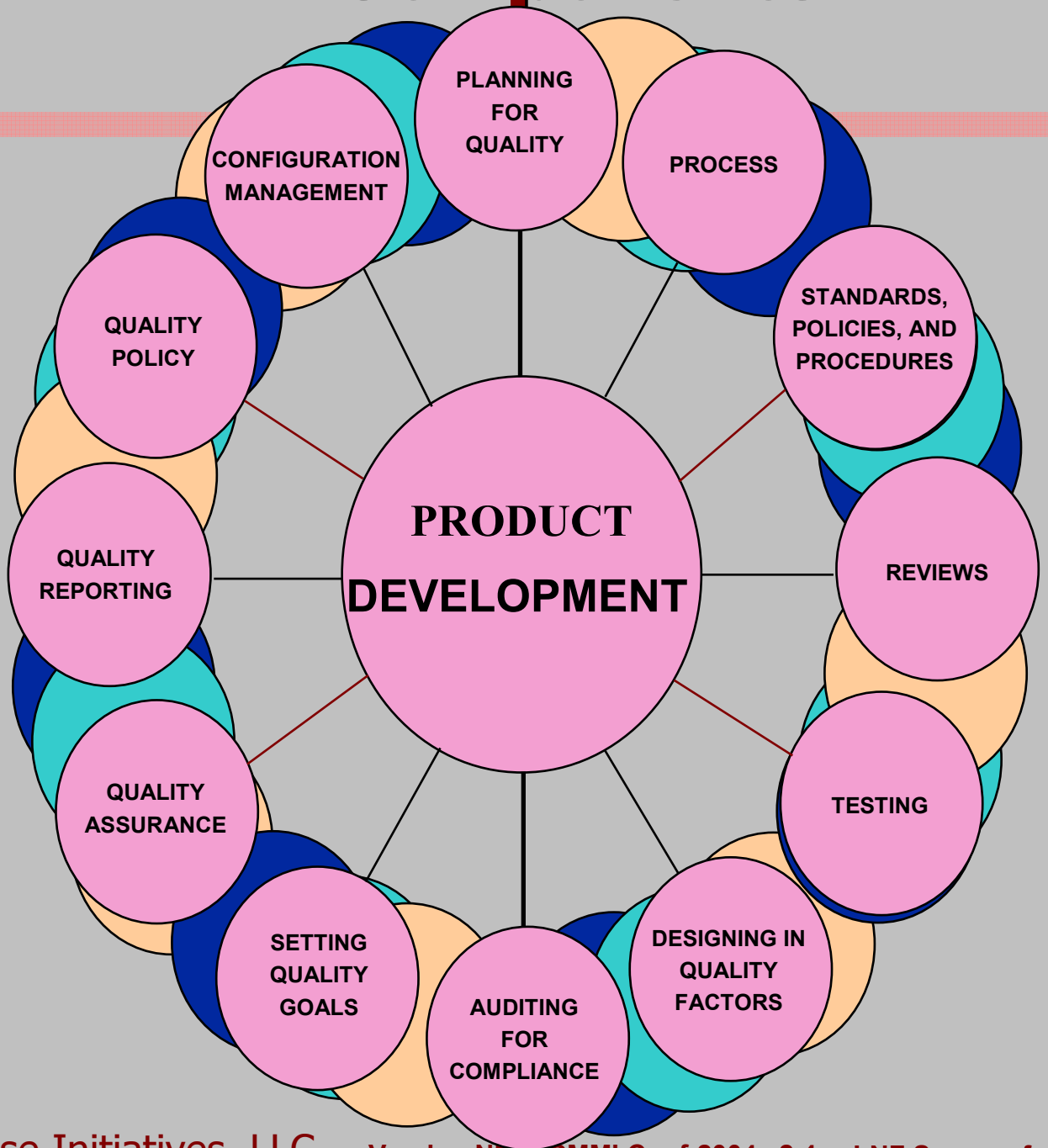
Quality Management - 2

- Performing multiple levels of Testing
- Conducting **Peer Reviews** throughout the product lifecycle
- Designing in **Quality Factors** (e.g.,maintainability, reliability)
- Providing visibility into the process and product quality for management (Reporting)
- Getting non-compliance issues resolved before the product is delivered to the customer
- Configuration Management
- **Measurement**

Quality Management - 3

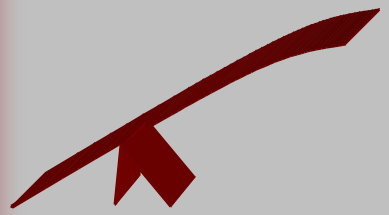
- These quality functions may be performed by:
  - Project Leaders and project staff
  - Quality Manager or Quality Representative
  - Organizational level QA Group
  - Systems Engineering
  - Independent Test
  - Documentation
  - Customer
- and others…….

Quality Management Components



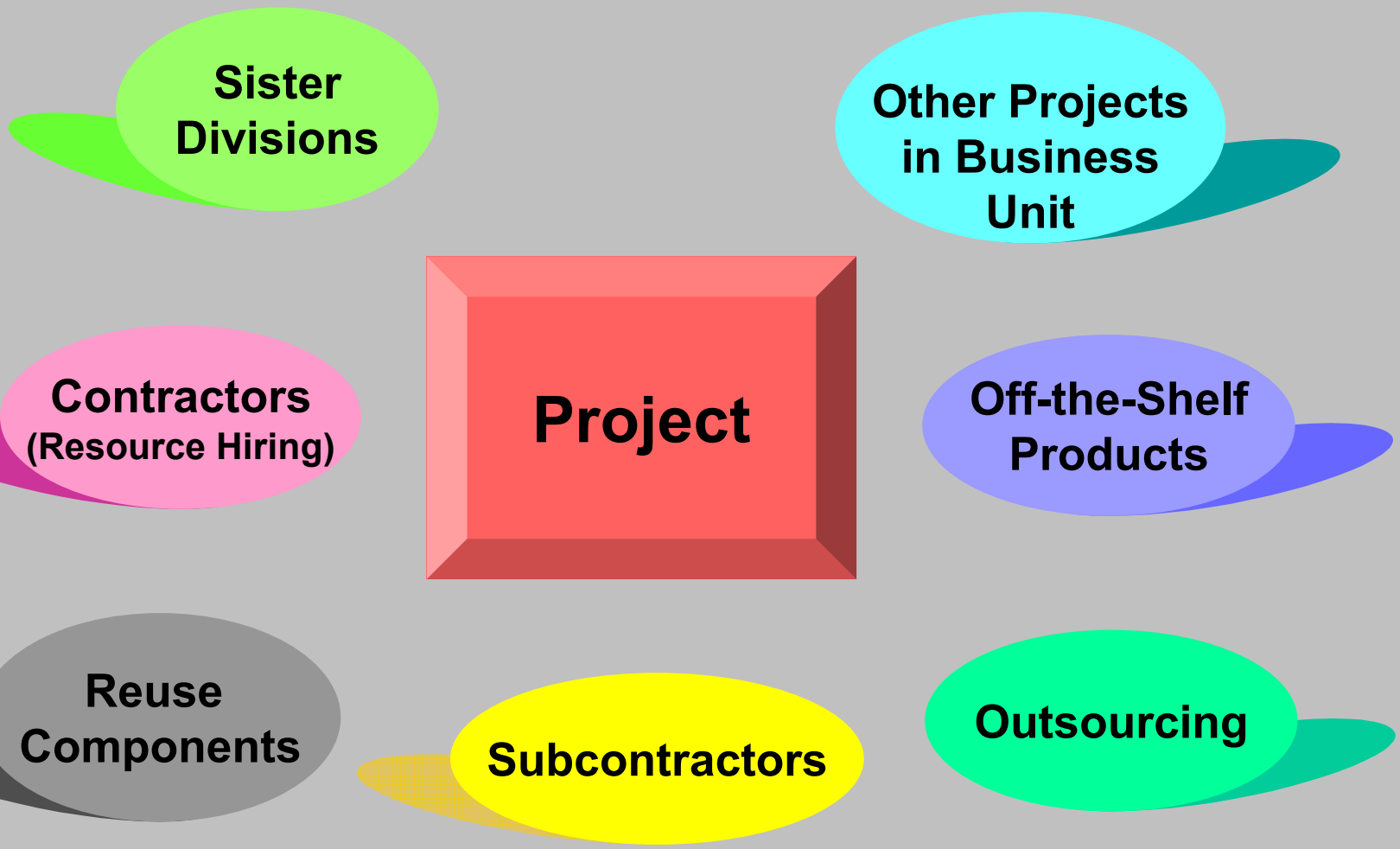
The CM Functions

- Identification
- Baselining
- Change Control
  - Organizational Change Control Board
  - Developmental Change Control Board
- Status Accounting
- Configuration Auditing
- Configuration Management System
- Interface Control
- Supplier Control

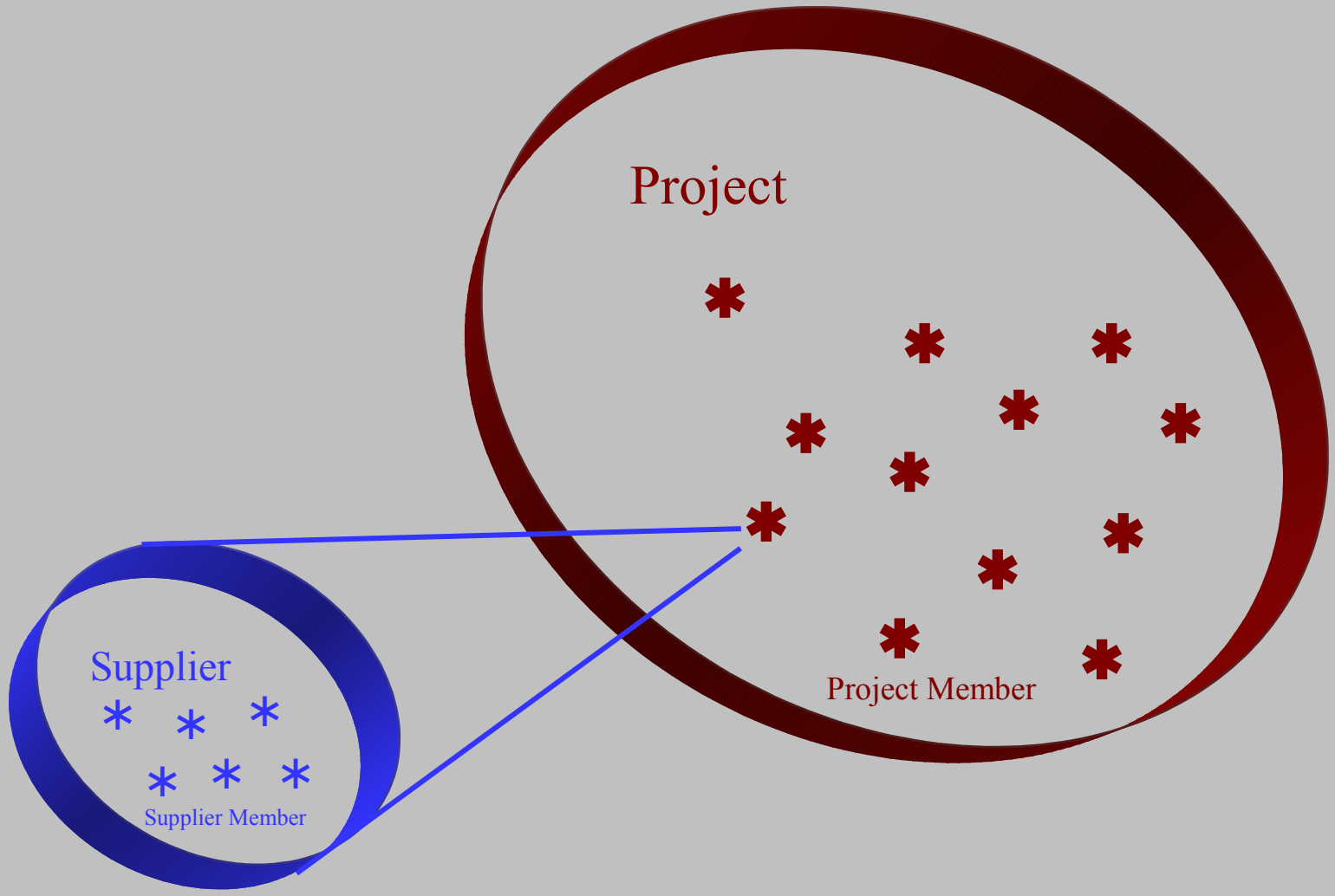


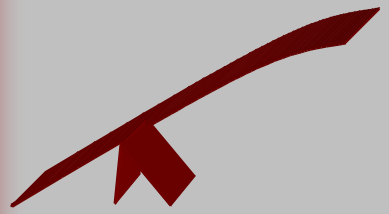
Supplier Management

Supplier Management Overview

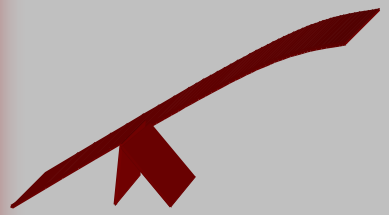


Treating the Supplier As A Project Member



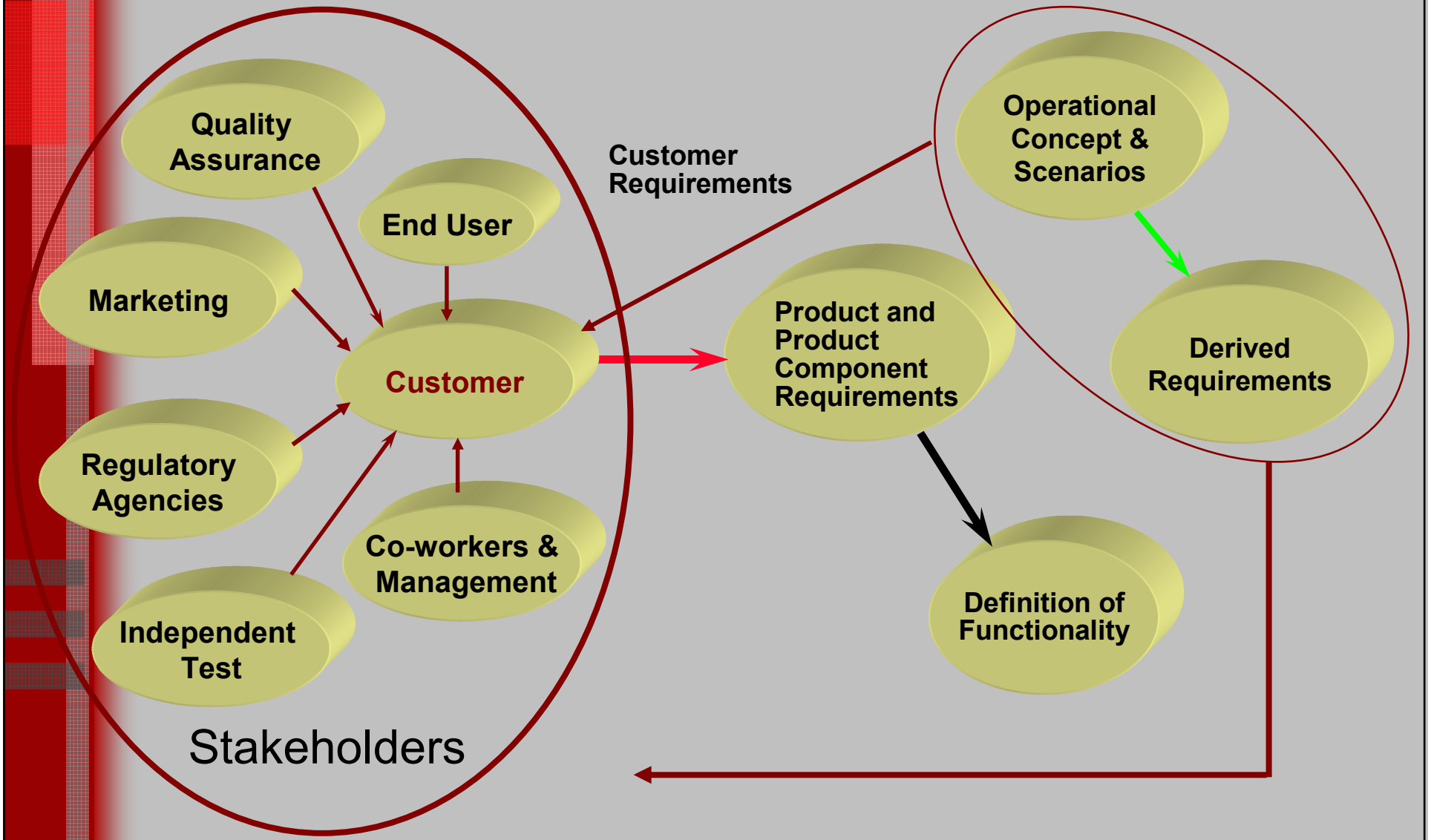


Requirements Engineering

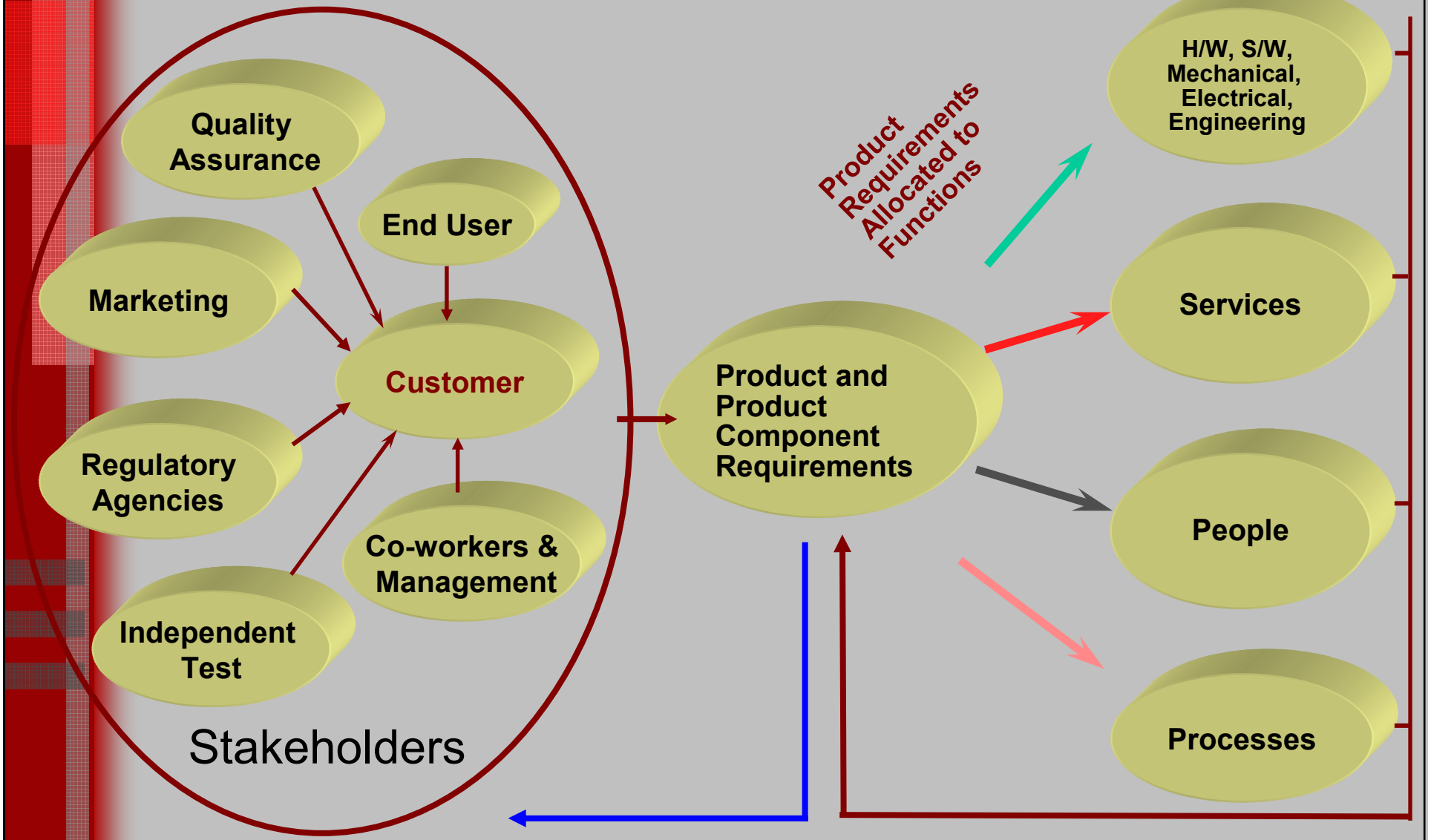


Requirements Development

Customer, Product, and Product Component Requirements



Customer, Product, and Product Component Requirements - 2



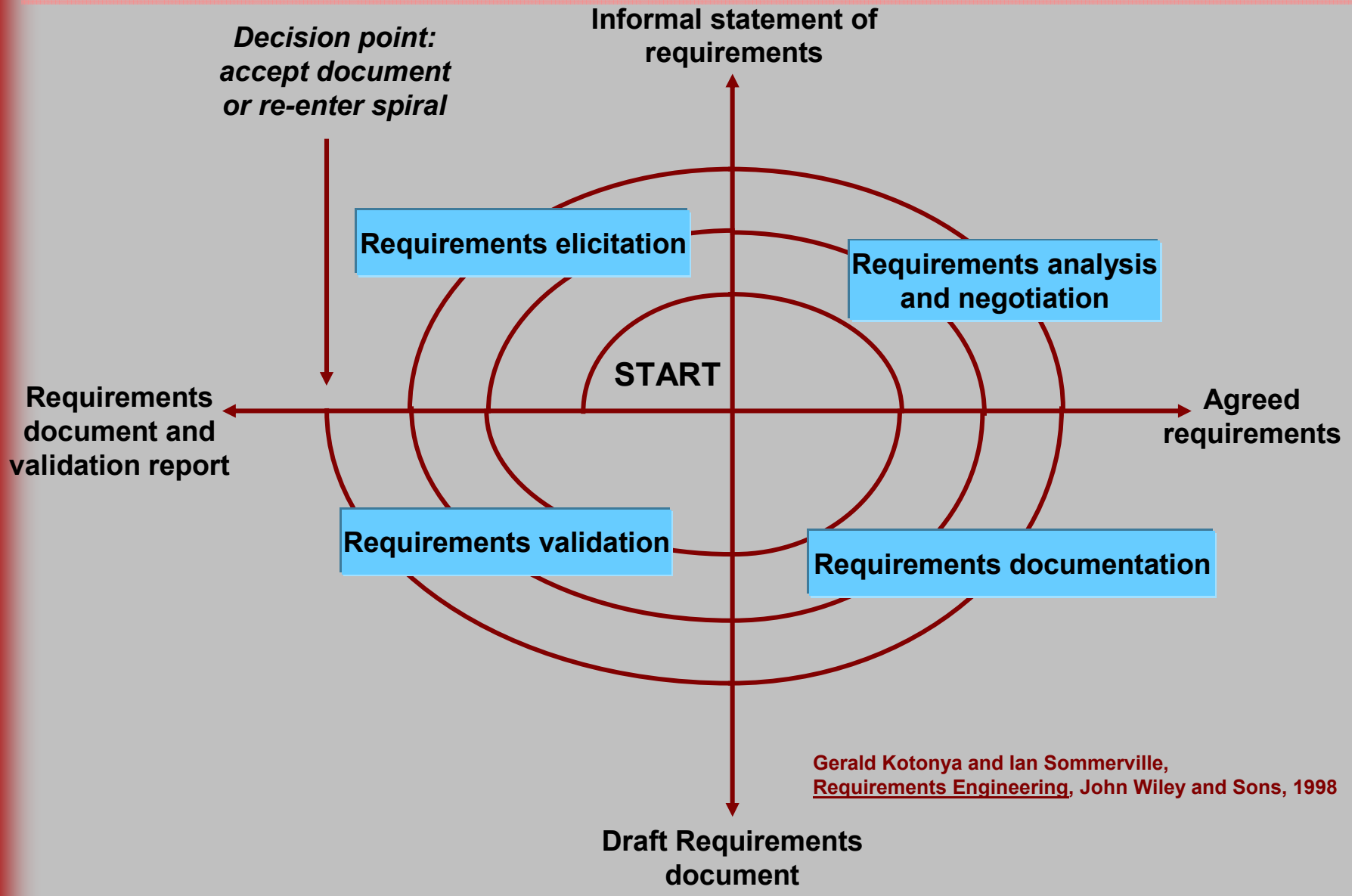
Operational Concepts and Scenarios

- Scenarios and Operational Concepts are developed, analyzed, and reviewed to refine existing requirements and discover new requirements, needs, and constraints
  - Scenarios are normally sequences of events that might occur in the use of the product
  - Operational concepts depend on both the design solution space and the scenarios
    - define the interaction of the product, the end user and the environment
    - define the operational, maintenance, support, and disposal needs

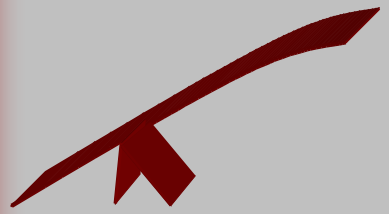
Product and Product Component Requirements

- Customer requirements are analyzed in conjunction with the development of the operational concept to derive a more detailed and precise set of requirements called "product and product component requirements"

Spiral Model of the Product Requirements Engineering Process

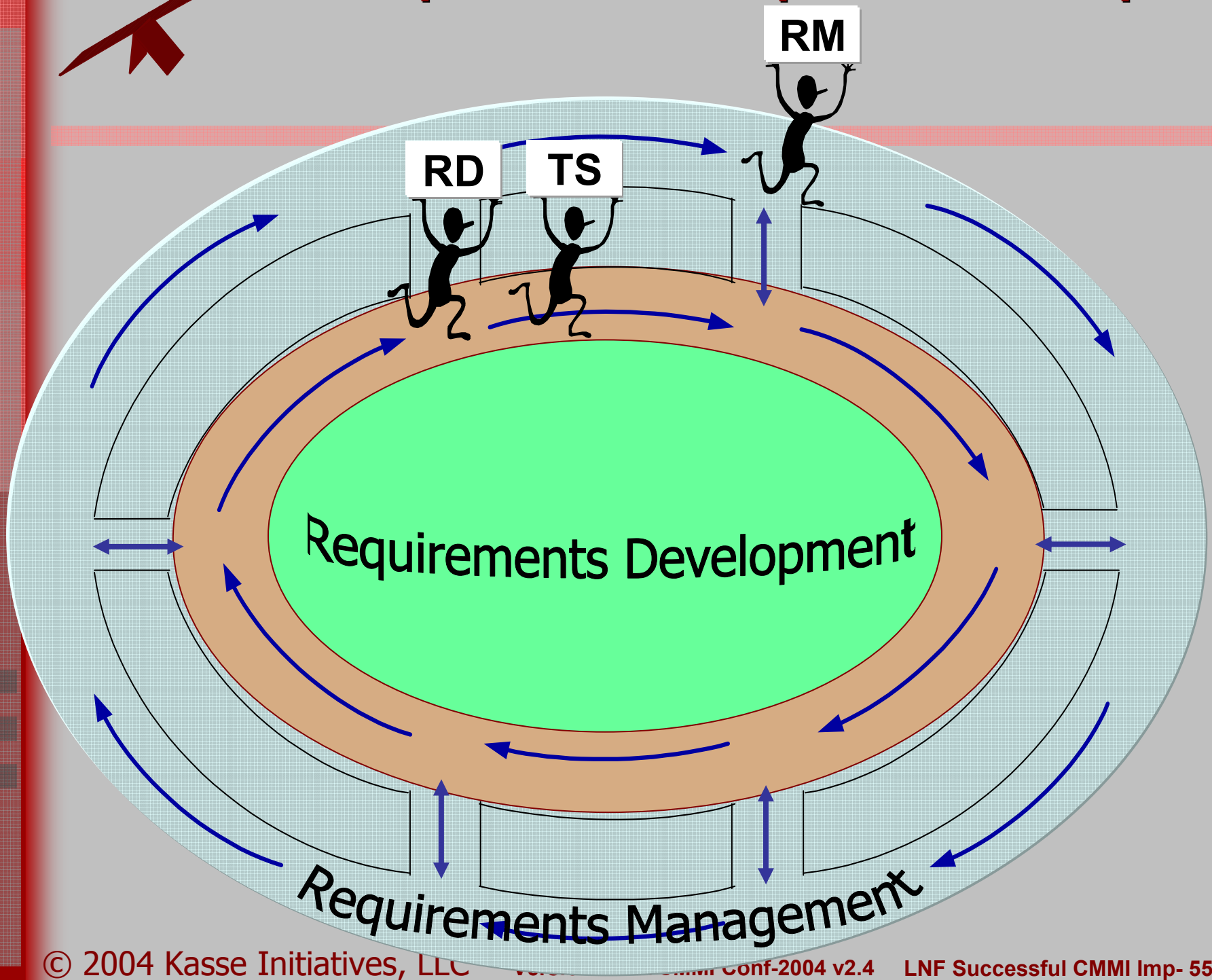


Gerald Kotonya and Ian Sommerville, Requirements Engineering, John Wiley and Sons, 1998



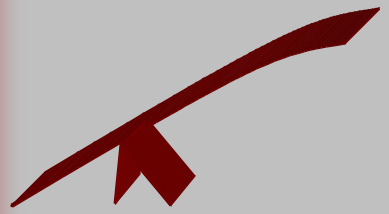
Requirements Management

The Requirements Management and Requirements Development Partnership



Impact Analysis for Requirements Change Requests

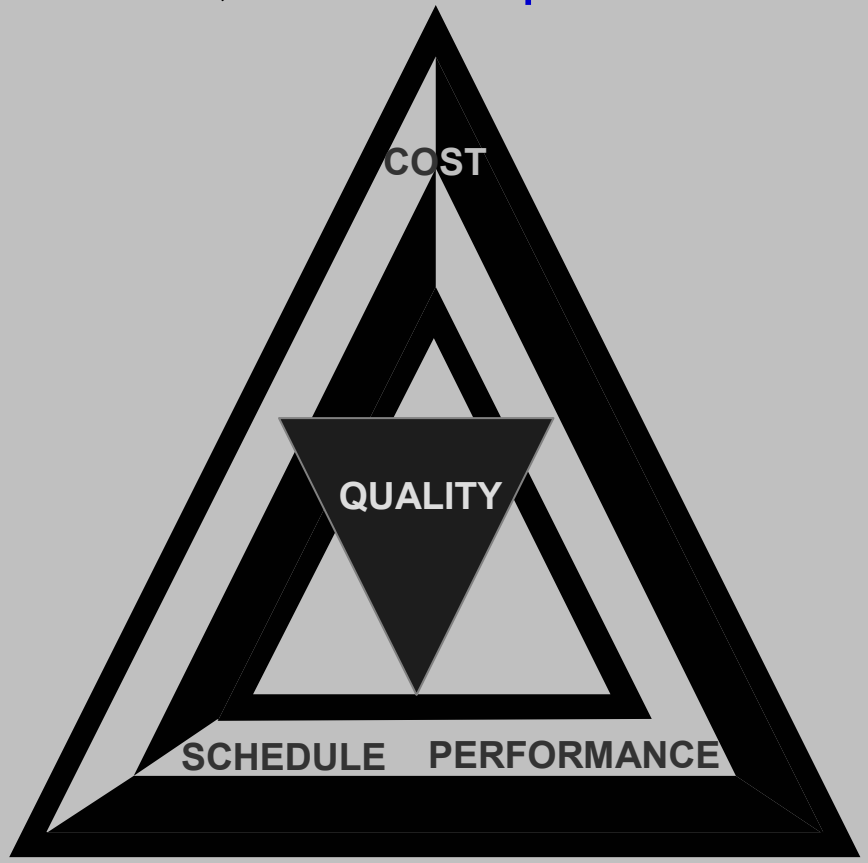
- Impact Analysis is made based on the requirements change request:
  - Development Schedule
  - Release Schedule
  - Changes required to this system
  - Staffing
  - Components
  - Development and Target equipment
  - Risks
  - SCOPE
  - Costs
  - Changes required to other systems or interfaces within the project
  - Other existing products or product lines



Alternative Solutions

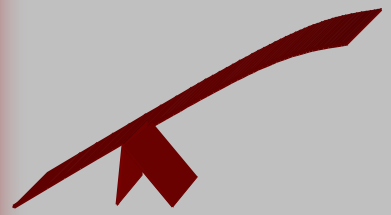
Develop Detailed Alternative Solutions and Selection Criteria

- Problem: Alternative solutions need to be identified and analyzed to enable the selection of a *life-cycle balanced solution* in terms of the quadruple constraint of cost, schedule, technical performance and quality



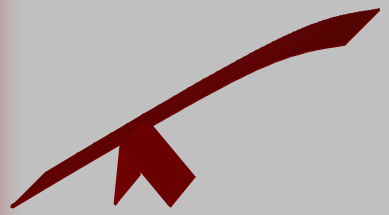
Develop Detailed Alternative Solutions and Selection Criteria - 2

- Solution: This may be accomplished through the allocation of the requirements to:
  - Software
  - Hardware
  - Electronics
  - Mechanics
  - Hydraulics
  - Manufacturing Processes
  - Services
  - People
- It may be accomplished through:
  - In house development
  - Purchase of Commercial-Off-The-Shelf products
  - Use of Suppliers
  - Use of Re-use components



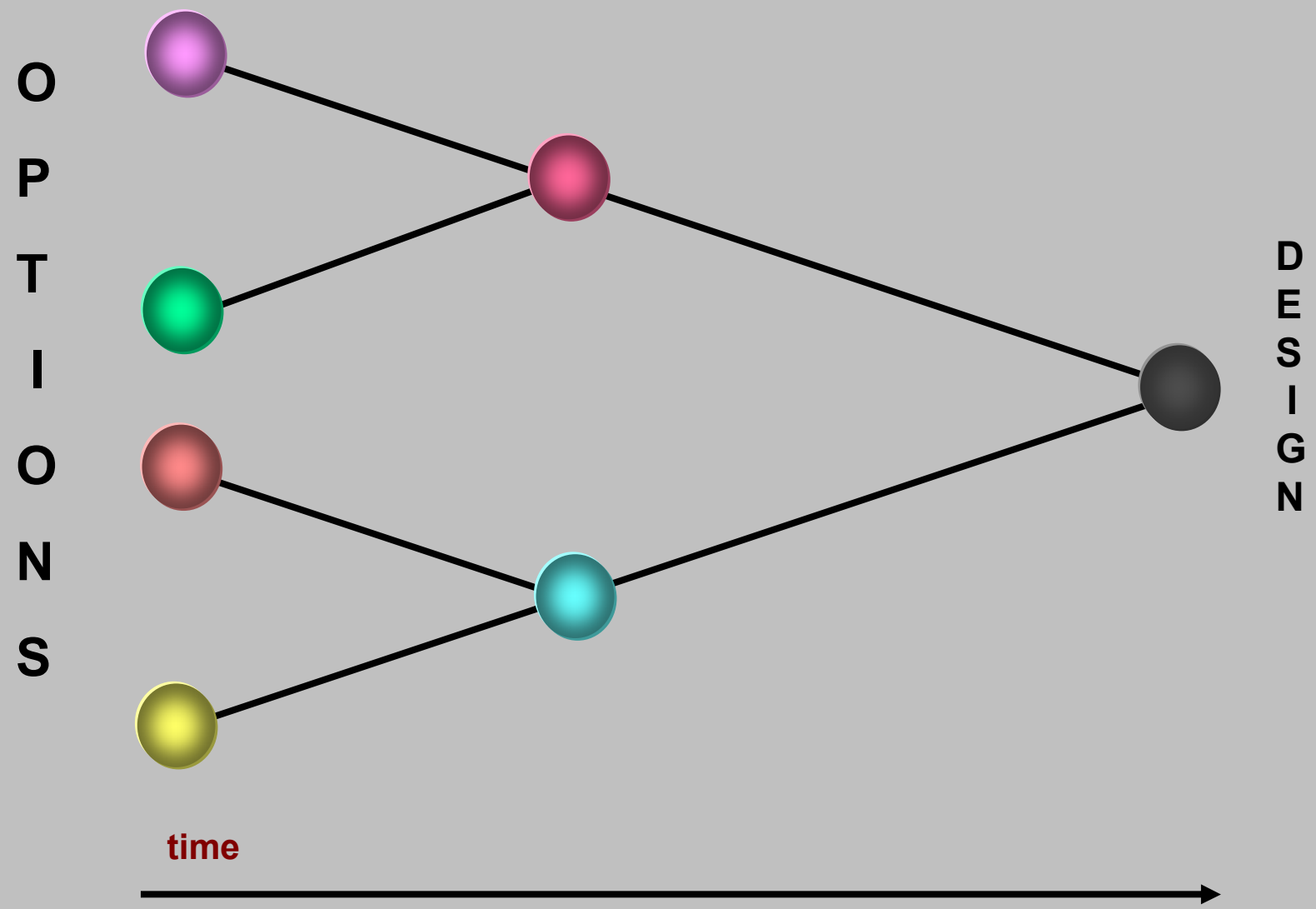
Develop the Product or Product Component Design

- Product or product component designs must provide the appropriate life-cycle content for:
  - Implementation
  - Modification
  - Reprocurement
  - Maintenance
  - Sustainment
  - Installation
- Design documentation provides a reference point to support the mutual understanding of the design by relevant stakeholders

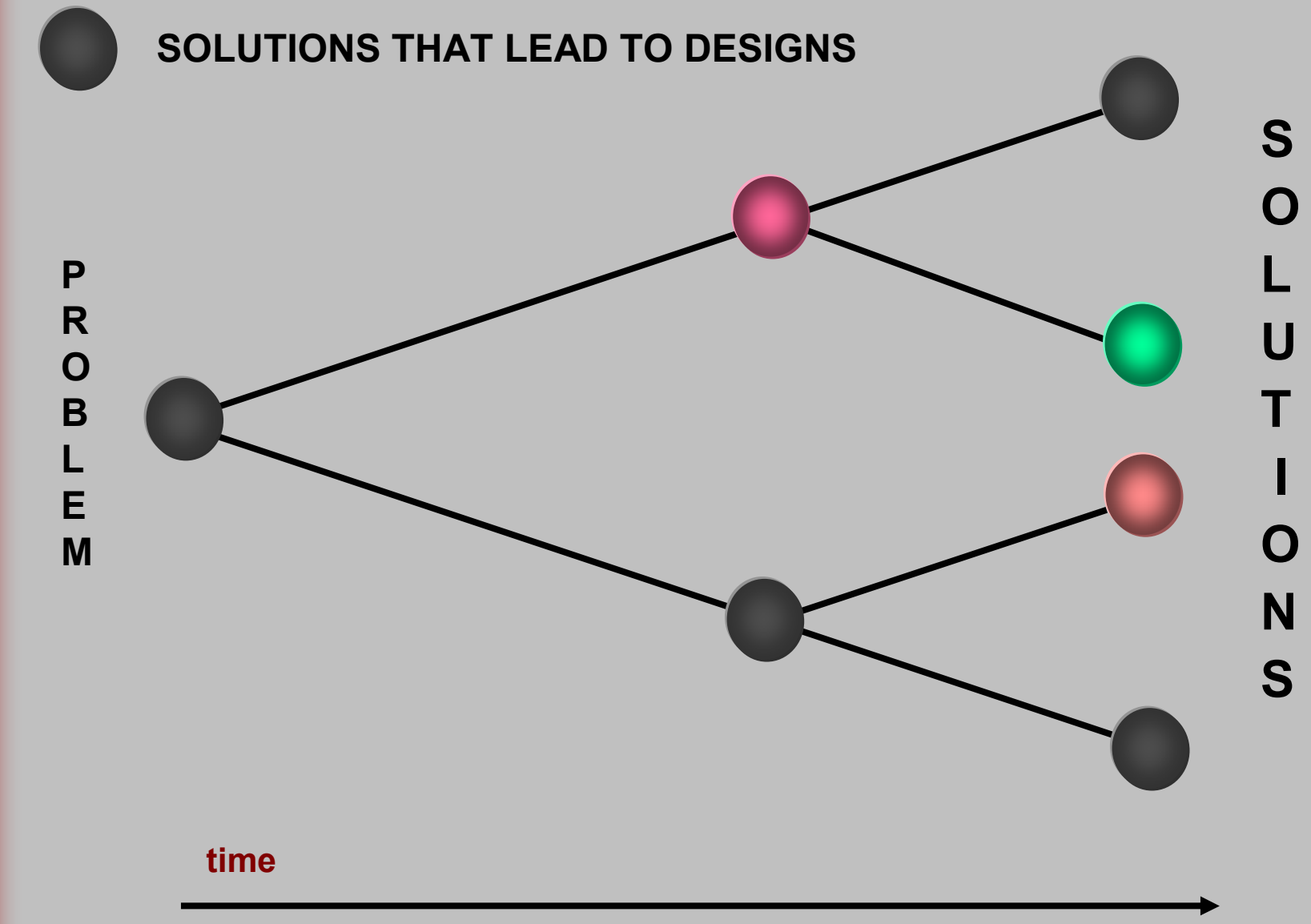


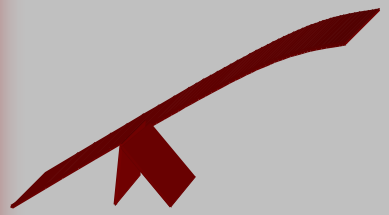
Architecting

The Traditional Approach



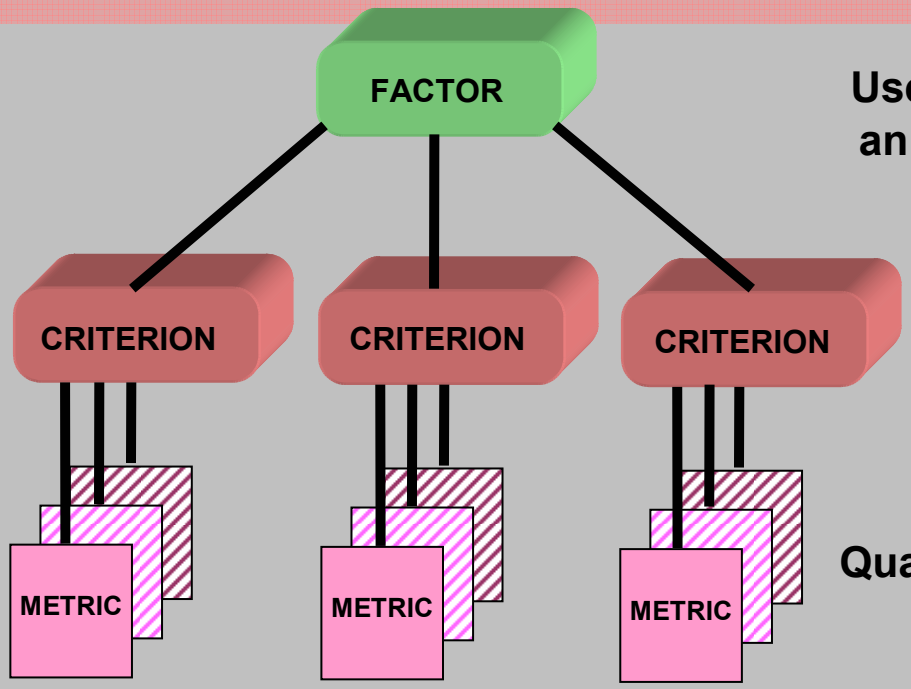
Evolutionary Approach





Quality Factors

Product Quality Metrics



User oriented view of an aspect of product quality

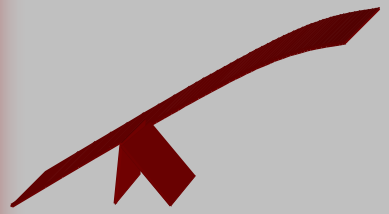
Product oriented characteristics or quality attributes indicate

Quantitative measures of characteristics

- Product Quality is described through a number of factors (reliability, maintainability)
- Each factor has several attributes that describe it called criteria
- Each criterion has associated with it several metrics which taken together quantify the criterion

Quality Factors

- Correctness
- Efficiency
- Expandability
- Flexibility
- Integrity
- Interoperability
- Maintainability
- Manageability
- Portability
- Reliability
- Reusability
- Safety
- Survivability
- Usability
- Verifiability

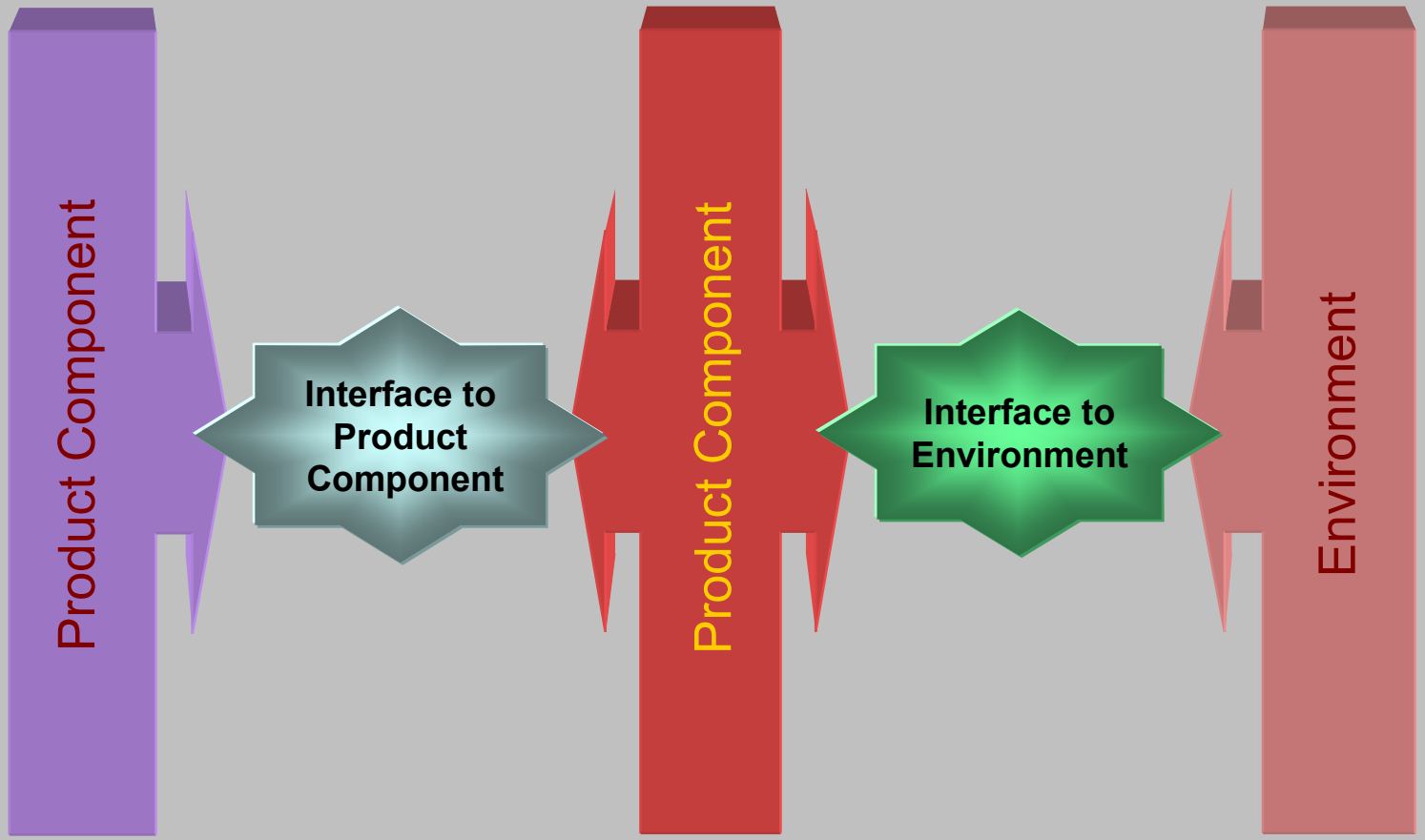


From Components to Products

Integration Strategy

- The basis for effective product integration is an integration strategy
- Establishing the product integration strategy includes the following:
  - Integration sequence
  - Work to be done
  - Responsibilities for each activity
  - Resources required
  - Schedule to be met
  - Procedures to be followed
  - Tools required
  - Product Integration Environment
  - Personnel skills

Ensure Interface Compatibility

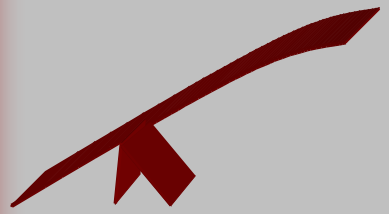


Verification

- Verification includes verification of the product and intermediate work products against all selected requirements, including customer, product, and product component requirements

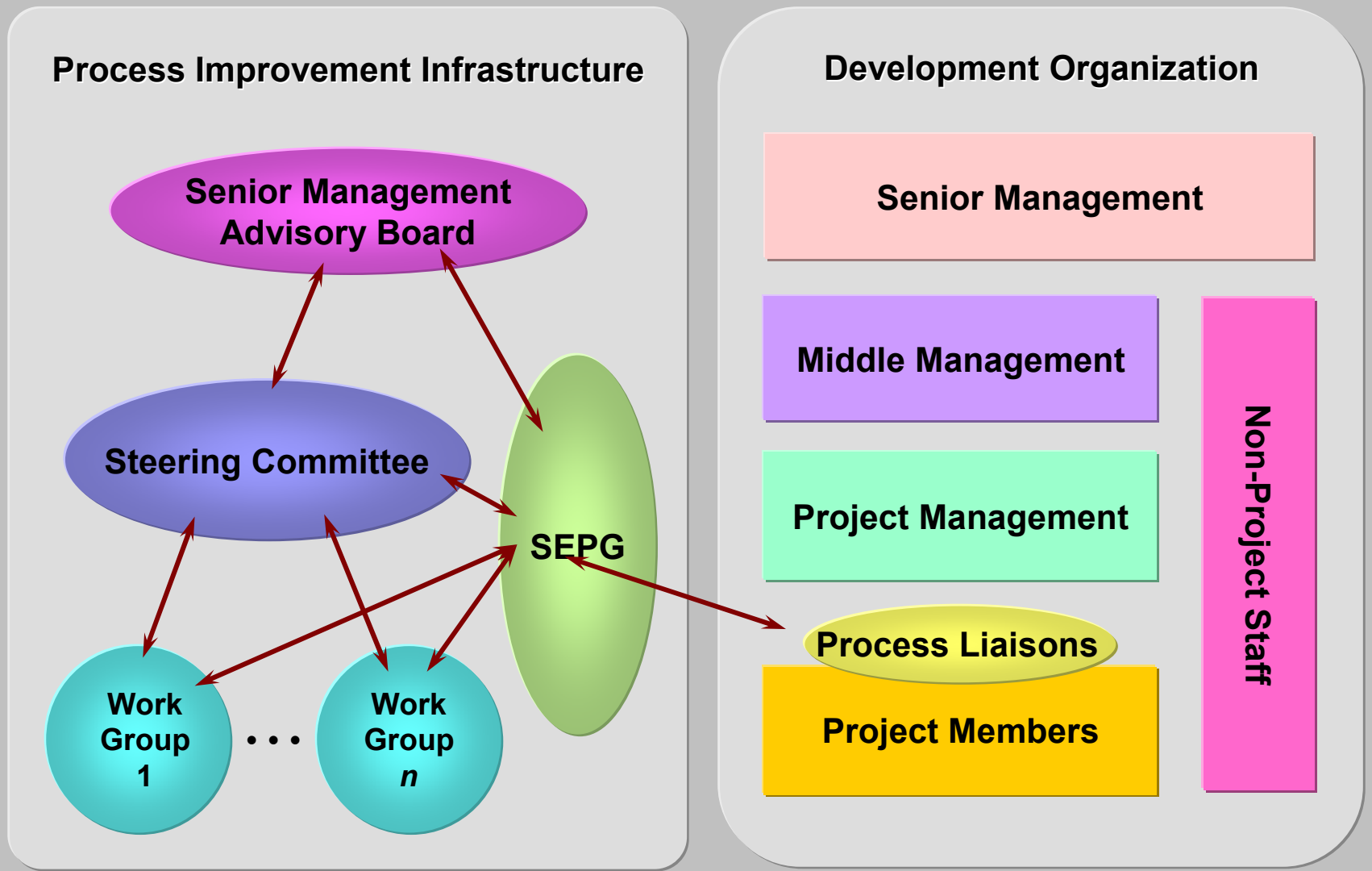
Validation

- Demonstrate that a product or product component fulfills its intended use when placed in its intended environment
- Validate Maintenance, Training, and Support Services
  - Demonstrate that the maintenance tools are operating in the actual product
  - Verify in the field that support of the product is effective as specified by the customer (e.g., Mean Time to Repair)
  - Demonstrate adequate training of the products and services



Improving Processes at the Organizational Level

Sample Improvement Infrastructure



Organization's Process Assets

OPD-SG1 Establish Organizational Process Assets

Measurement Repository

Process Asset Library

Life-cycle Models

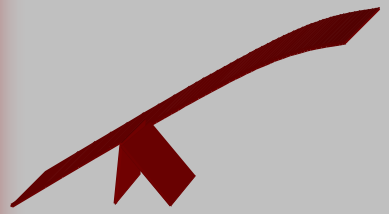
Tailoring Guidelines

Support Environment

Organization's Standard Process Definition

Process Architecture

Process Elements



The Knowledge and Skills Base

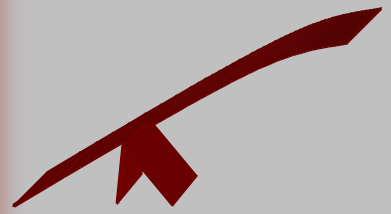
Core Competencies

- What business is the organization in?
- What are the core competencies required to perform the organization's business and remain competitive?
- What is the organizational workforce knowledge and skills base?
- What training, mentoring, and coaching does each person need in order to develop the necessary skill set to do their everyday job and gain in the organization's core competencies?
- What must recruiters do to find appropriate candidates with either the necessary knowledge and skills or the proven ability to learn

Organization-Level Training

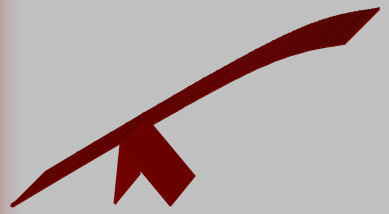
- The organization's strategic business objectives and improvement plans should be analyzed to plan for current, intermediate, and future training needs in order for the organization to remain competitive

Organization-Level Training - 2



OT-SG1 Establish an Organizational Training Capability

- Determine which training needs will be focused on at the organizational level
- Analyze the project and support groups' needs to identify common training needs that can be most efficiently addressed organization-wide
- Negotiate specific training needs with various projects and support groups
- "Economy of Scale" must always be considered when planning for organizational vs. project-level training

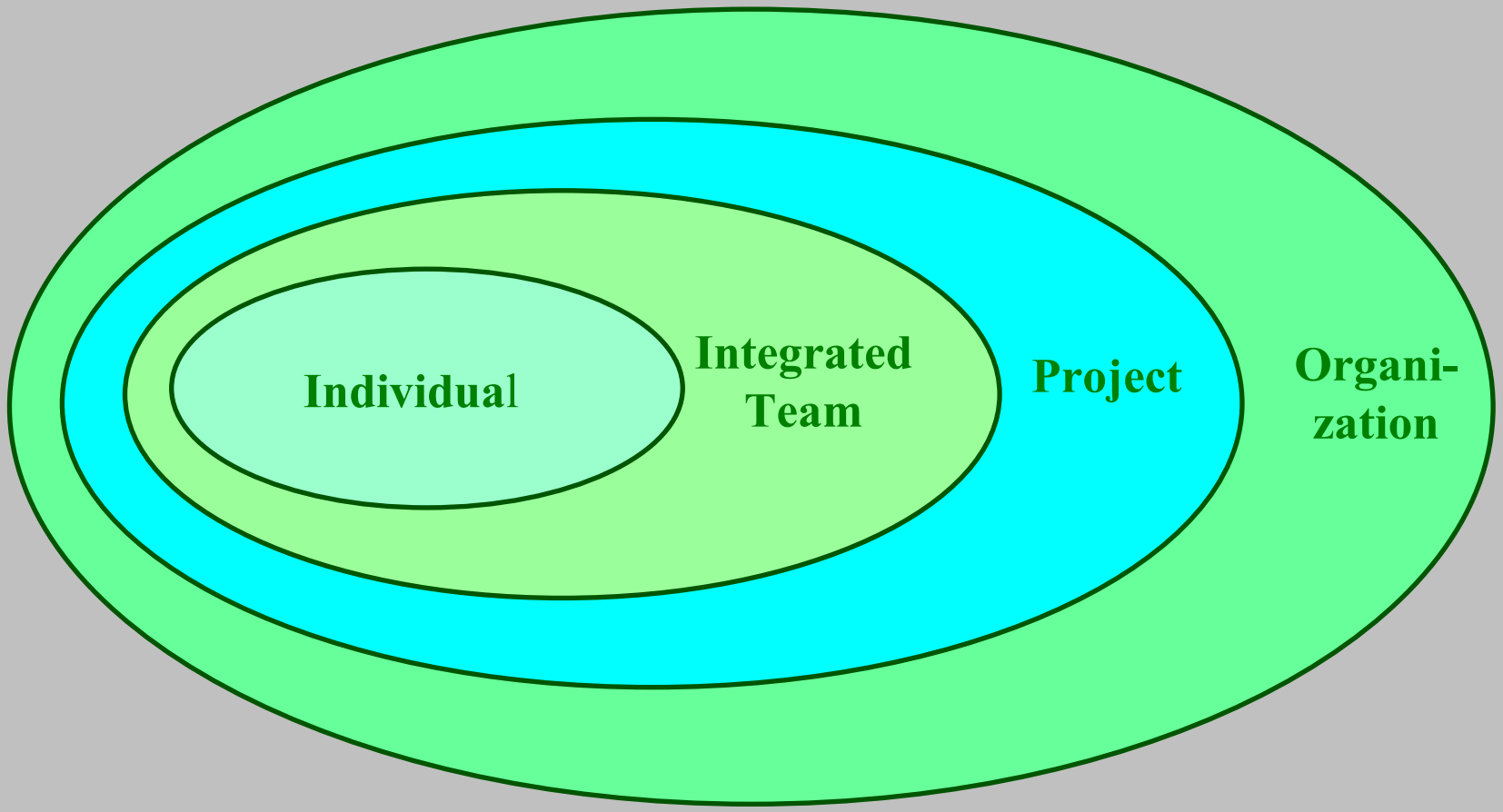


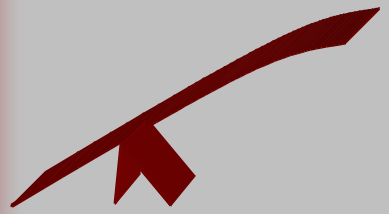
Integrated Teams

Integrated Teaming

- Successful Integrated Teaming depends on:
  - Integrated Project Management which emphasizes proactively integrate the concepts in the Project Plan and all supporting plans
  - Collaboration skills from Integrated Team members to satisfy customer and business needs that would not normally be achieved by normal project members
  - Shared Vision
  - Organizational Environment for Integration
  - Team members who have strong interpersonal skills and ability to work in a team environment and the ability to complement the mix and knowledge and skills in the team

Shared Vision Context





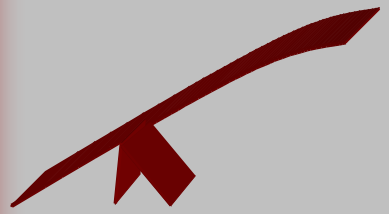
Reducing Variation

CMMI Overview

Level	Process Characteristics	Process Areas
5 Optimizing	Focus is on quantitative continuous process improvement	Causal Analysis and Resolution Organizational Innovation and Deployment
4 Quantitatively Managed	Process is measured and controlled	Quantitative Project Management Organizational Process Performance
3 Defined	Process is characterized for the organization and is proactive	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organization Process Definition Organizational Training Integrated Project Management Integrated Teaming Organizational Environment For Integration Integrated Supplier Management Risk Management Decision Analysis & Resolution
2 Managed	Process is characterized for projects and is often reactive	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Product and Process Quality Assurance Configuration Management Measurement and Analysis
1 Initial	Process is unpredictable, poorly controlled, and reactive	

Variation Among Individuals

- One of the traits of CMMI Maturity Level 1 is that the process “belongs” to the people. If others follow a process, it is normally due to the strong personality of someone on the project who has experienced using processes in another environment.
- From a variation point of view, a level one organization has great variation based on its individual employees following their own process paths. This is why maturity level one companies depend so heavily on the heroics of its people.



Project's Processes to Reduce Variation

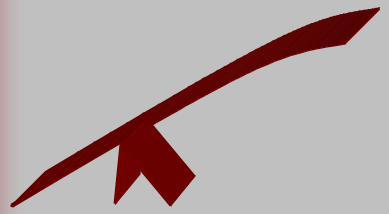
- At CMMI Maturity Level 2, processes normally belong to the project and are enforced by the Project Manager
- The processes, standards, guidelines, checklists, and templates are enforced for all of the project members to achieve more uniformity in development and product quality
- Assuming that all projects follow some form of process, the amount of variation that was seen in organizations of maturity level 1 is reduced even if all of the projects followed a different process

Organizational Processes to Reduce Variation

- At The Organizational Level, an organization that wishes to achieve CMMI Maturity Level 3 needs to have its processes owned by the organization for economy of scale to be realized and process measurement to make practical sense
- These process definitions are tailored and incorporated into the project's defined processes throughout the organization and thus variation in project development and product and service quality is again reduced.

Quantitative Project Management

- Quantitative Management is tied to the organization's strategic goals for product quality, service quality, and process performance
- When higher degrees of quality and performance are demanded, the organization and projects must determine if they have the ability to improve the necessary processes to satisfy the increased demands
- Achieving the necessary quality and process performance objectives requires stabilizing the processes that contribute most to the achievement of the objectives and reducing process variation to support the quantitative management objectives.



Establishing a Measurement Program

Measurement and Analysis Overview

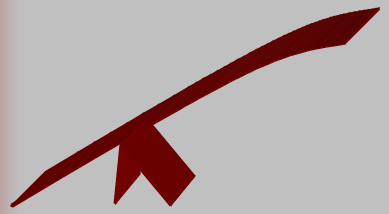
- A measurement initiative involves the following:
  - Specifying the objectives of measurement and analysis such that they are aligned with established information needs and business objectives
  - Defining the measures to be used, the data collection process, the storage mechanisms, the analysis processes, the reporting processes, and **the feedback processes**
  - Implementing the collection, storage, analysis, and presentation of the data
  - Providing objective results that can be used in making business judgments and taking appropriate corrective actions

Basic Measures

- Project Management Measures
  - Size and complexity
  - Effort and Cost
  - Schedule
  - Computer Resources
  - Data Management
  - Knowledge and Skills
  - Stakeholder Involvement
  - Technical Performance
  - Commitments
  - Critical Dependencies
  - Quality

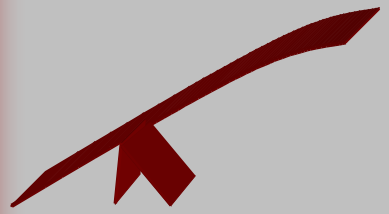
Effectiveness of Processes

- We must not only define and follow processes but we must determine if the processes are working for us the way we expected them to
  - How well are the processes working?
- Requirements Management Processes Effectiveness - Example
  - Number of change requests per month compared with the original number of requirements for the project
    - Critical change requests
    - Intermediate change requests
    - Nice to have change requests



More Advanced Measures

- Peer Review Effectiveness
- Testing Effectiveness
- Test Coverage



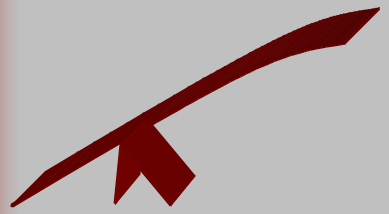
Quantitative Project Management

Quantitative Management Concepts

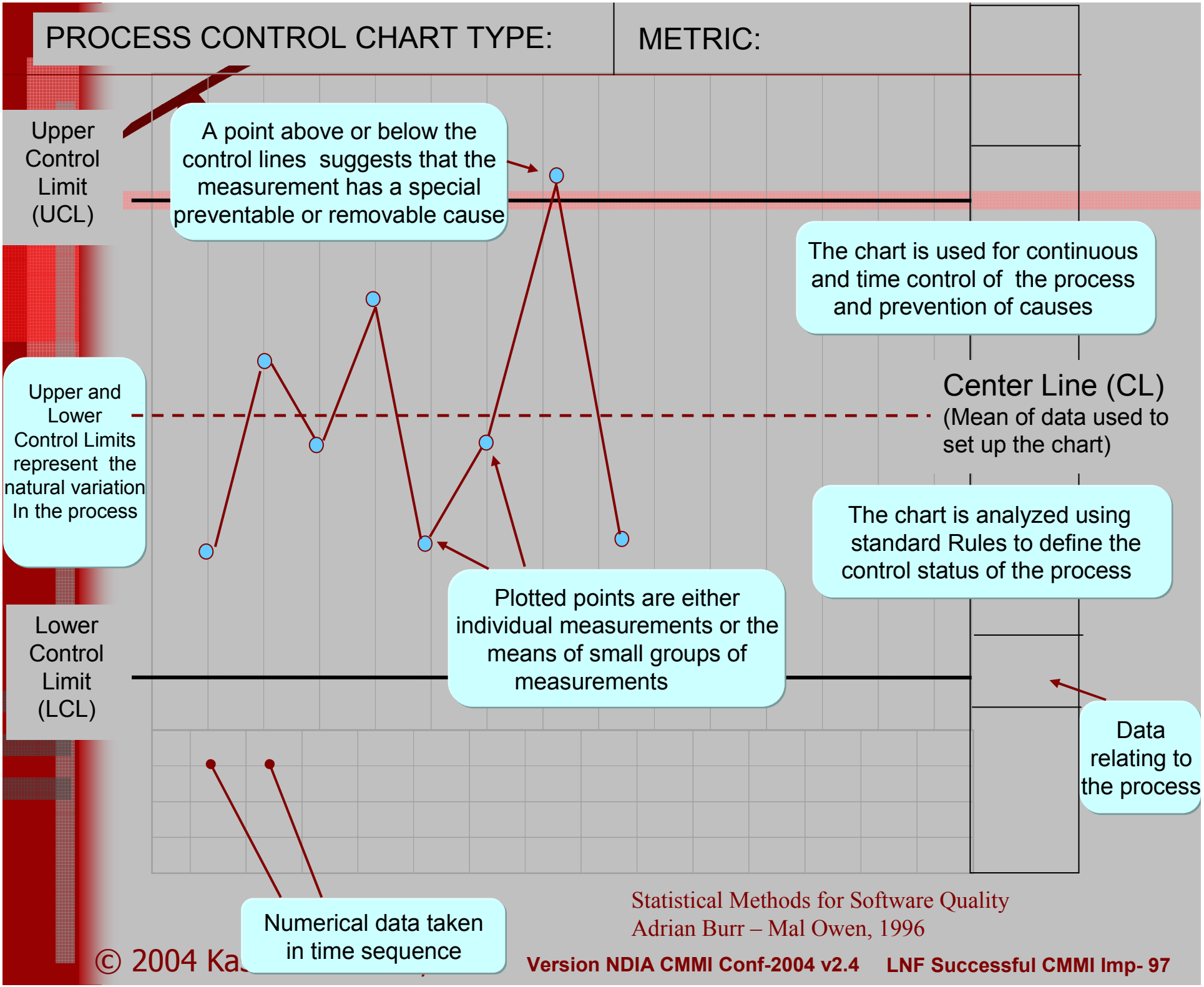
- Quantitative Management is tied to the organization's strategic goals for product quality, service quality, and process performance
- When higher degrees of quality and performance are demanded, the organization and projects must determine if they have the ability to improve the necessary processes to satisfy the increased demands
- Achieving the necessary quality and process performance objectives requires stabilizing the processes or subprocesses that contribute most to the achievement of the objectives
- Assuming the technical requirements can be met, the next decision is to determine if it is cost effective

Quality and Process Performance Objectives

- Define and document measurable quality and process performance objectives for the project
- Examples of Quality Objectives
  - Mean time between failures
  - Critical resource utilization
- Examples of Process Performance Objectives
  - Percentage of defects removed by type of verification activity
  - Defect escape rates
  - Number and density of defects (by severity) found during the first year following product delivery
  - Rework time as a percentage of total project life-cycle time

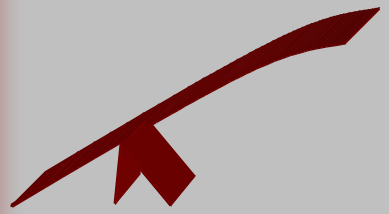


Measures and Analytic Techniques



Statistical Methods for Software Quality
Adrian Burr – Mal Owen, 1996

Histograms

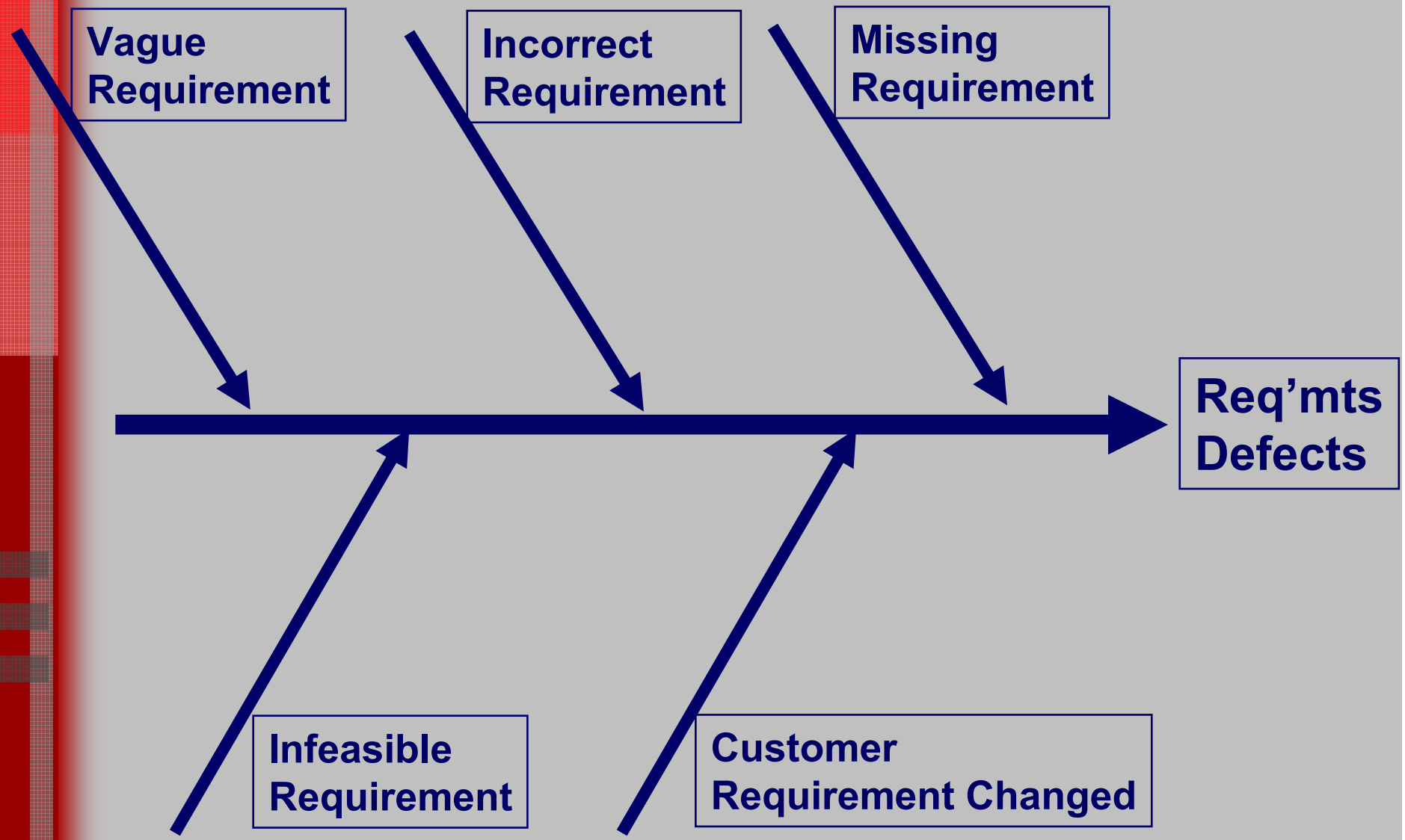


Improving Beyond Stability

Insight Into Causal Analysis and Resolution

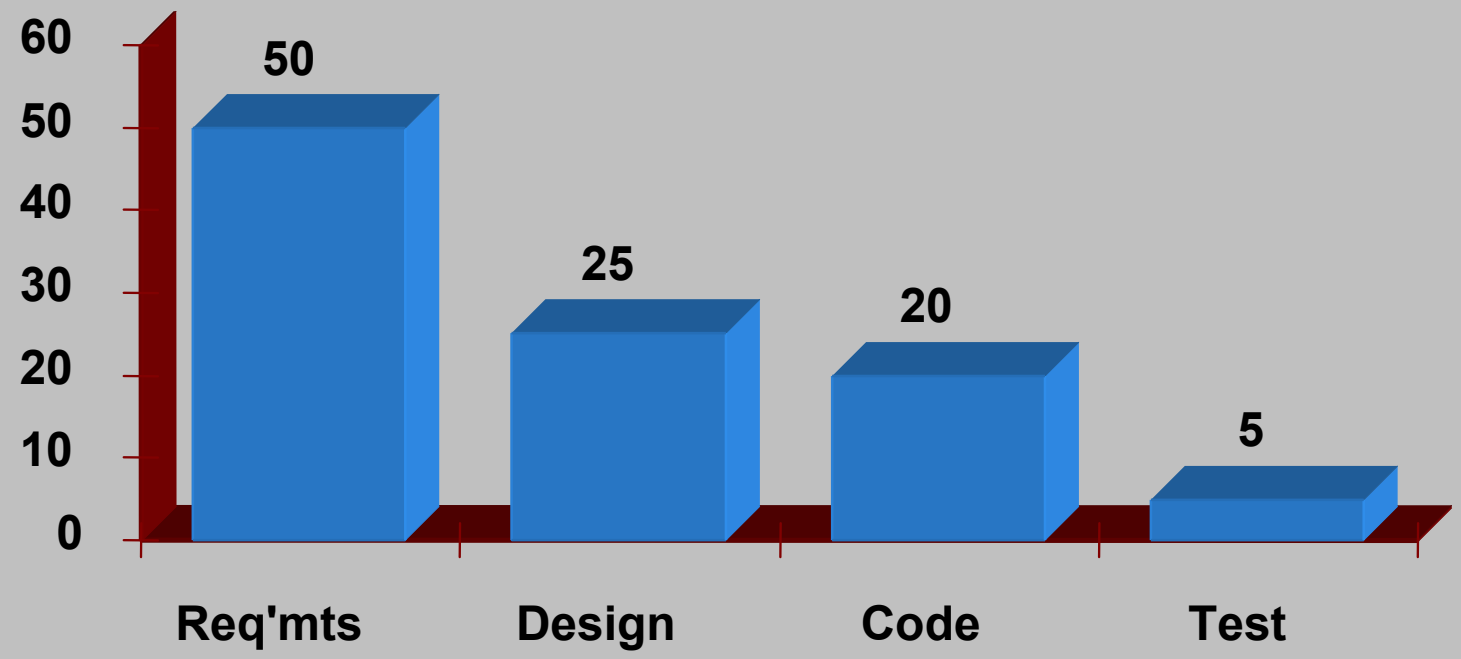
- **Causal analysis and resolution is the process of improving quality and productivity by preventing the introduction of defects into a product**
- Based on an understanding of the defined process in use and how it is implemented, the root causes of the defects and the future implications of the defects are determined

Cause and Effect Diagrams (Fishbone)

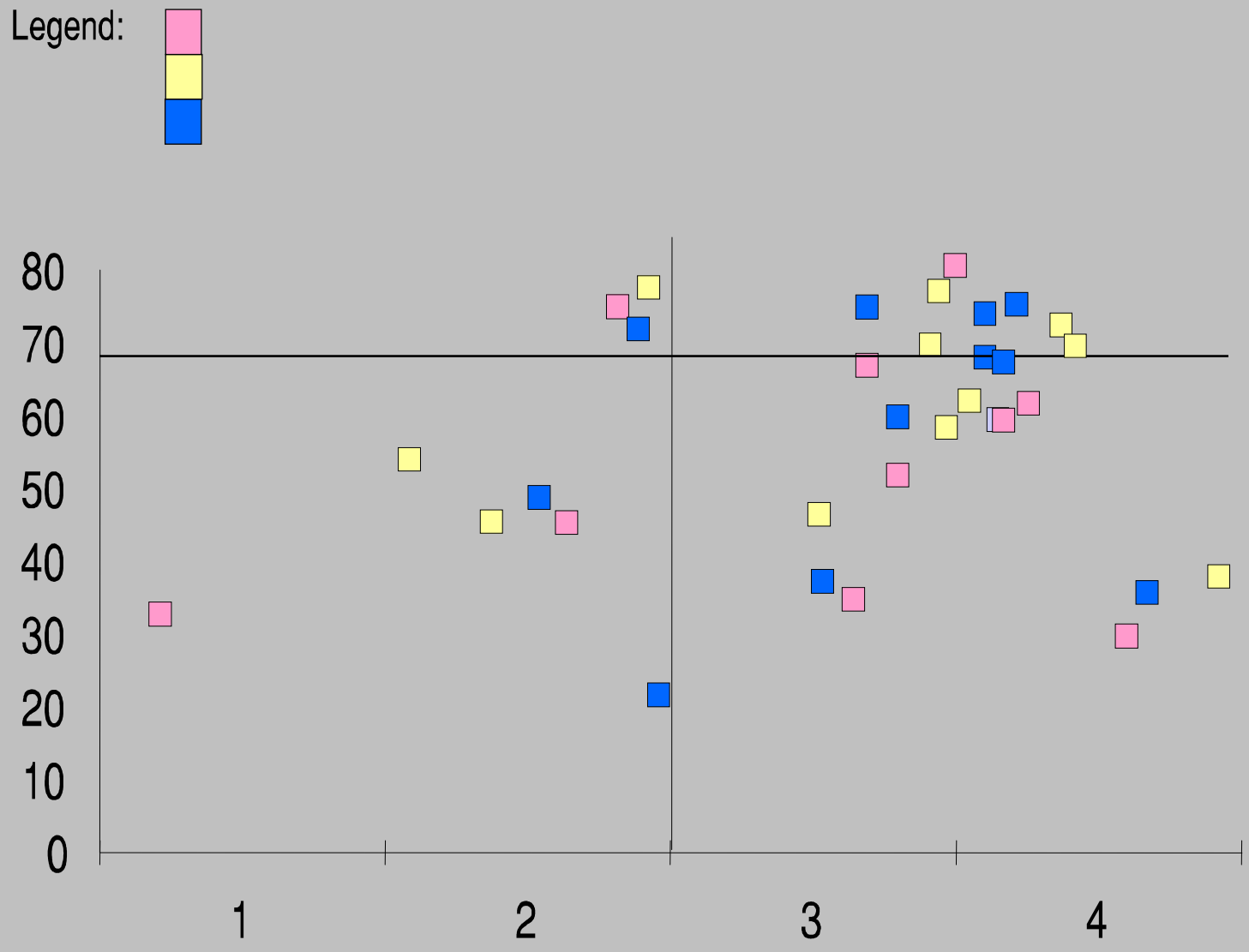


Pareto Charts

Percentage of Defects Detected During System Testing by Phase Where Defect Was Injected

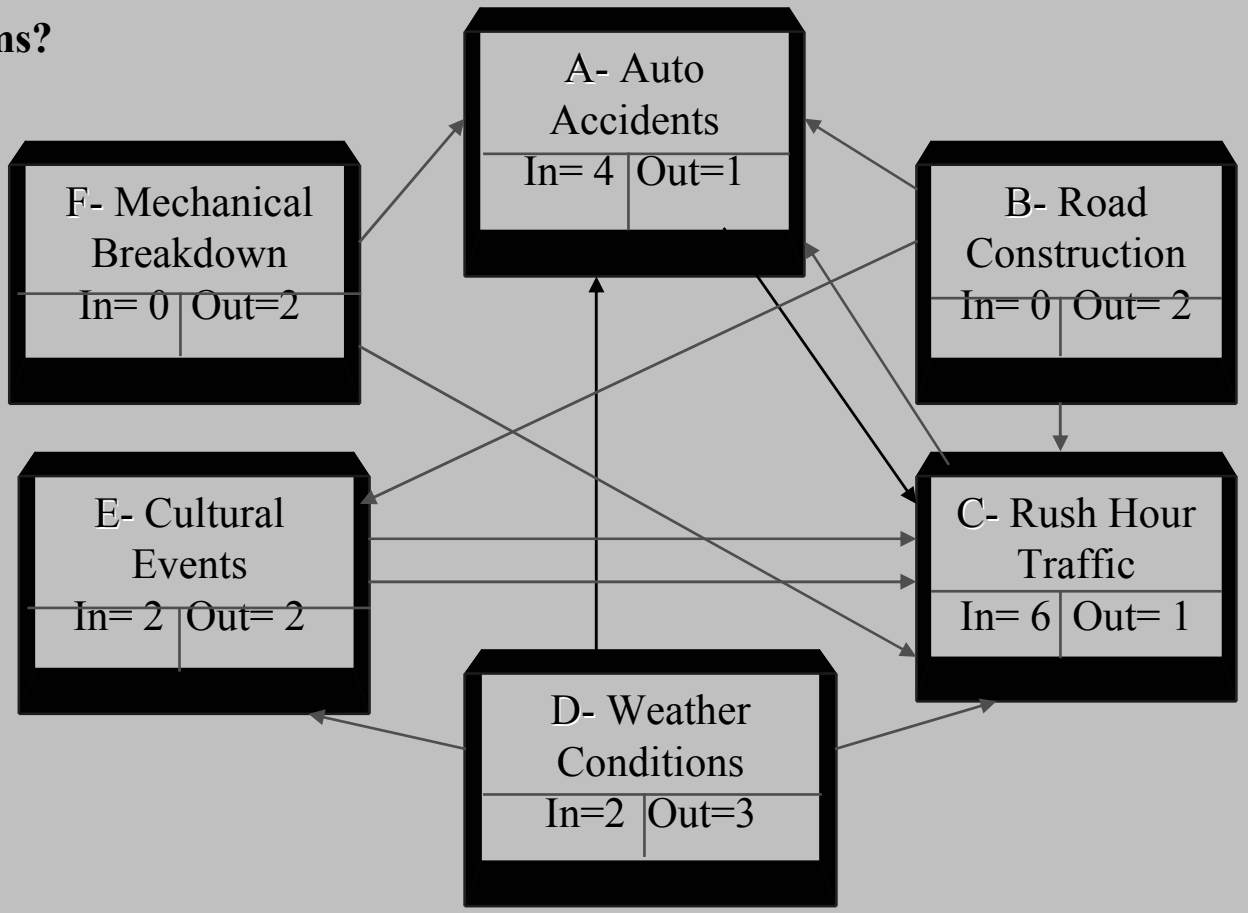


Scatter Diagrams



Interrelationships Diagraph

What are the issues relating to traffic jams?



Organizational Innovation and Deployment Overview

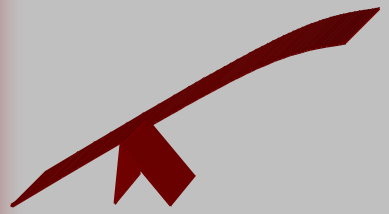
- The Organizational Innovation and Deployment process area selects and deploys improvements that can enhance the organization's ability to meet its quality and process performance objectives
- Quality and process performance objectives that this process area might address include:
  - Improved product quality
  - Increased productivity
  - Decreased cycle time
  - Greater customer and end user satisfaction
  - Shorter development or production time to change functionality, add features or adapt to new technologies

Organizational Innovation and Deployment Overview - 2

- Process performance is a measure of the actual process results achieved and is characterized by both process measures and product measures.
- Process measures include:
  - Effort
  - Cycle time
  - Defect removal efficiency
- Product measures include:
  - Reliability
  - Defect density
  - Response time

Organizational Innovation and Deployment Overview - 3

- Process and Quality performance objectives that will be deployed are selected from proposals based on the following criteria:
  - A quantitative understanding of the organization's current quality and process performance
  - The organization's quality and process-performance objectives
  - The resources and funding available for that deployment
  - Estimates of the improvement resulting from the deployment
  - The expected benefits weighed against the cost and impact to the organization



Repeatable Effective and Long Lasting

Institutionalization

- Institutionalization involves implementing practices that
  - Ensure the process areas are effective, repeatable and long lasting
  - Provide needed infrastructure support
  - Ensure processes are defined, documented, understood
  - Enable organizational learning to improve the processes

CL-2 Generic Practices

- GP 2.1 Establish an Organizational Policy
  - Establish and maintain an organizational policy for planning and performing the process
    - Policies exist for Project Planning
    - New Client Offers
- GP 2.2 Plan the Process
  - Establish and maintain the requirements, objectives, procedures and plan for performing the process
- GP 2.3 Provide Resources
  - Provide adequate resources for performing the planned process, developing the work products, and providing the services of the process

CL-2 Generic Practices - 2

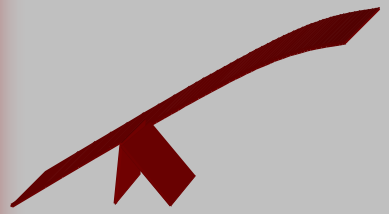
- GP 2.4 Assign Responsibility
  - Assign responsibility and authority for performing the process, developing the work products, and providing the services of the process
- GP 2.5 Train People
  - Train the people performing or supporting the planned process as needed
- GP 2.6 Manage Configurations
  - Place designated work products of the process under appropriate levels of configuration management
- GP 2.7 Identify and Involve Relevant Stakeholders
  - Identify and involve the relevant stakeholders as planned

CL-2 Generic Practices - 3

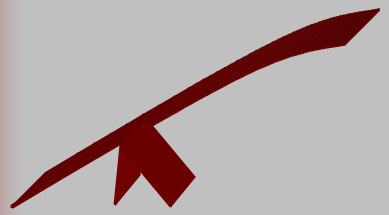
- GP 2.8 Monitor and Control and Measure the Process
  - Monitor and control the process against the plan and take appropriate corrective action
- GP 2.9 Objectively Evaluate Adherence
  - Objectively evaluate adherence of the process, and the work products and services of the process to the applicable requirements, objectives, and standards, and address non-compliance
- GP 2.10 Review Status with Higher-Level Management
  - Review the activities, status, and results of the process with higher-level management and resolve issues

CL-3 Generic Practices

- GP 3.1 Establish Defined Process
  - Establish and maintain the description of the defined process
- GP 3.2 Collect Improvement Information
  - 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



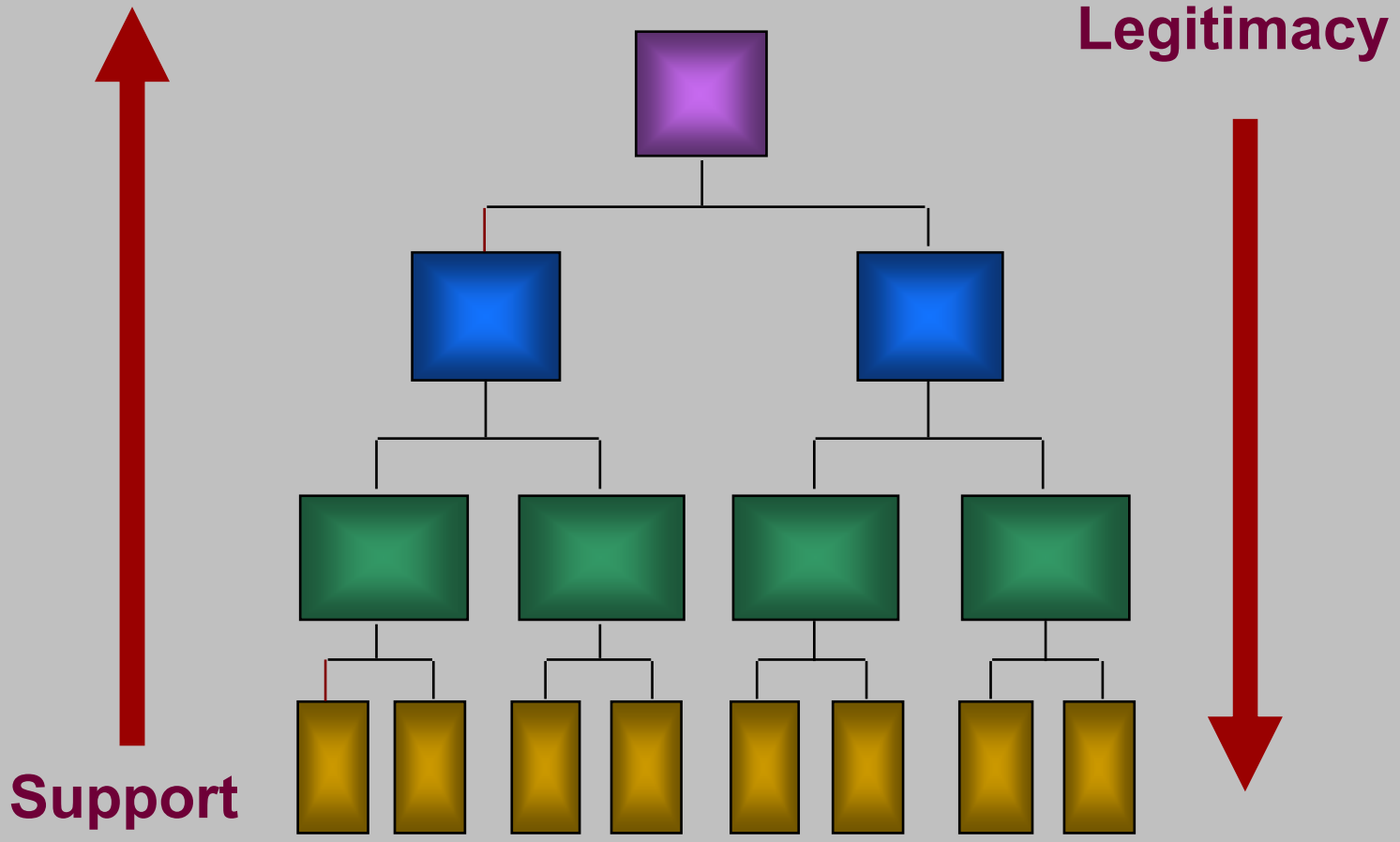
Process Improvement Means *Change!*



Principles of Process Change

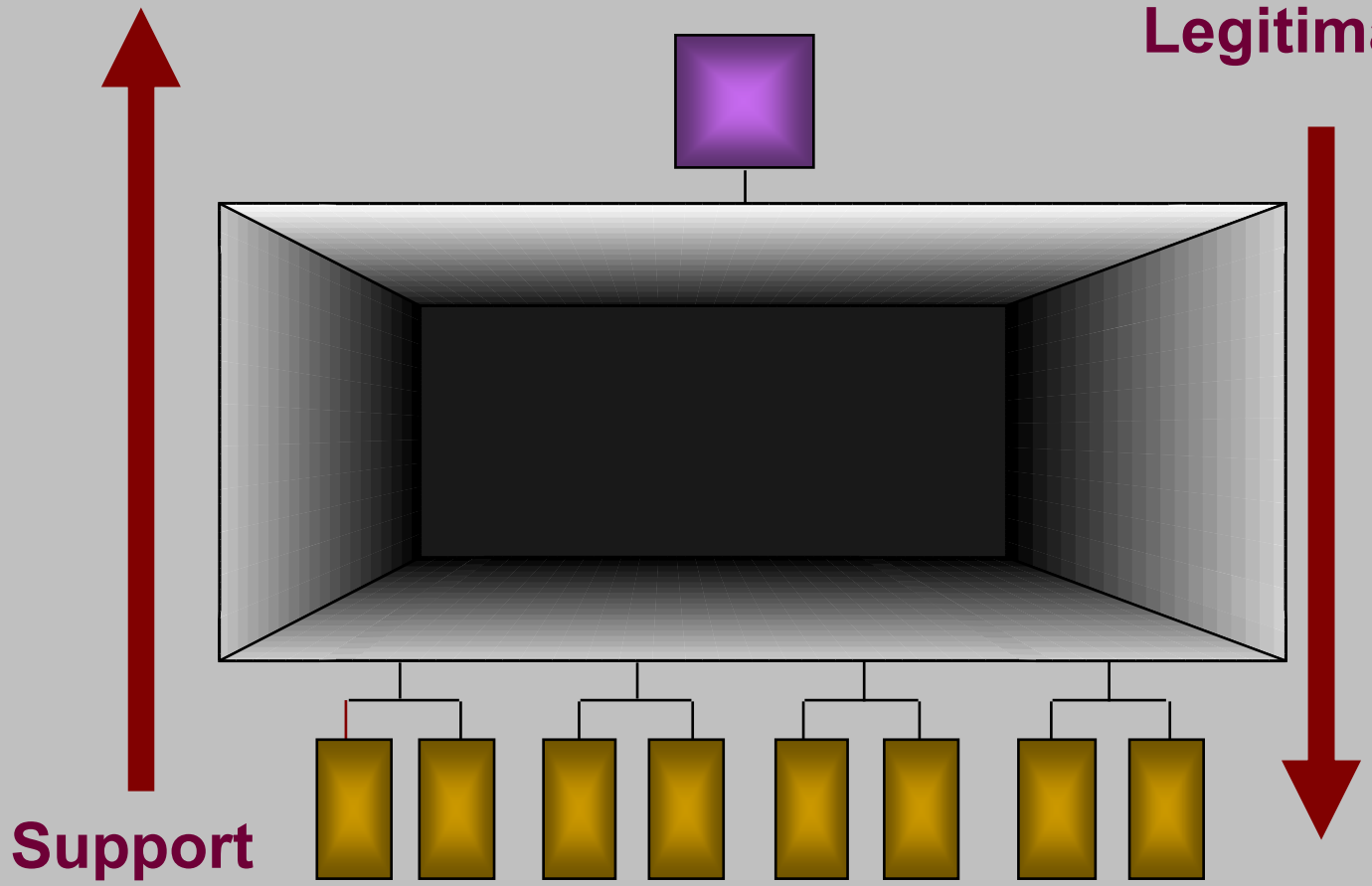
- Major changes must be sponsored by Senior Management
- Focus on fixing the process, not assigning the blame
- Understand current process first
- Change is continuous
- Improvement requires investment
- Retaining improvement requires periodic reinforcement

Building Support for Change

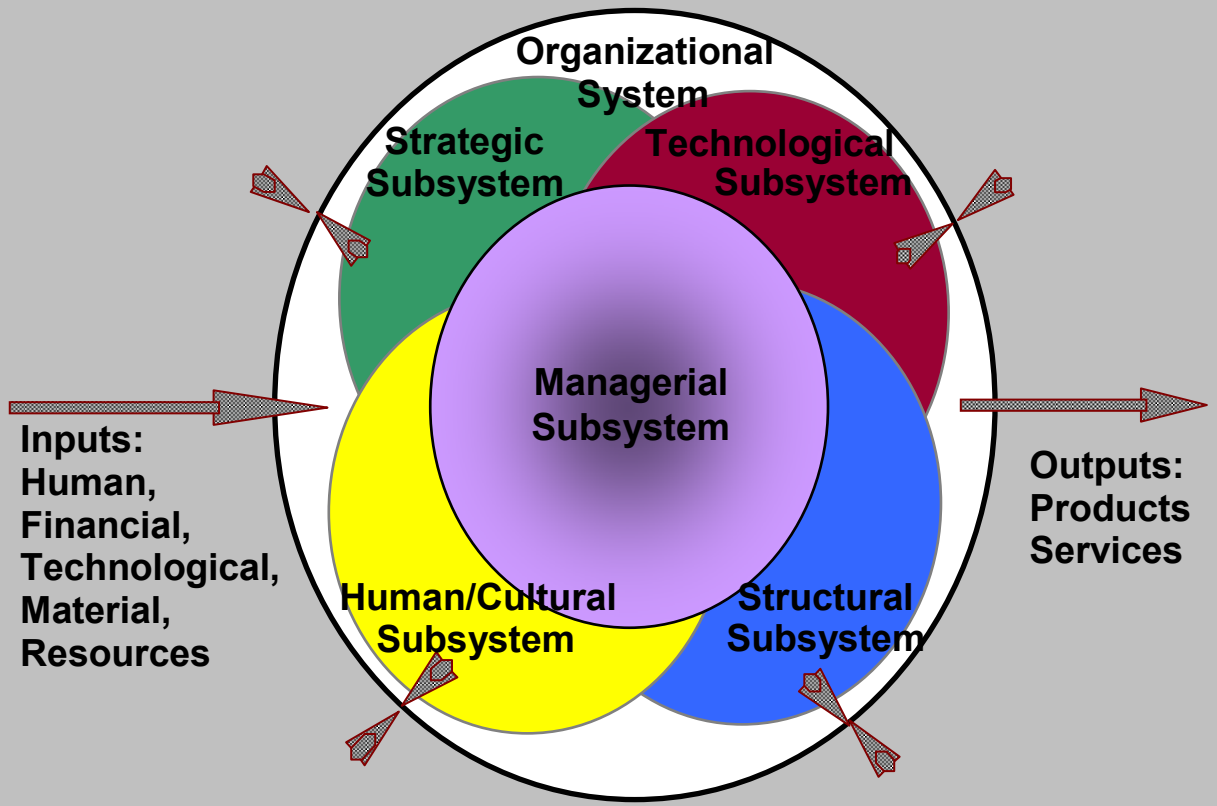


[courtesy JMaher]

Building Support for Change - 2

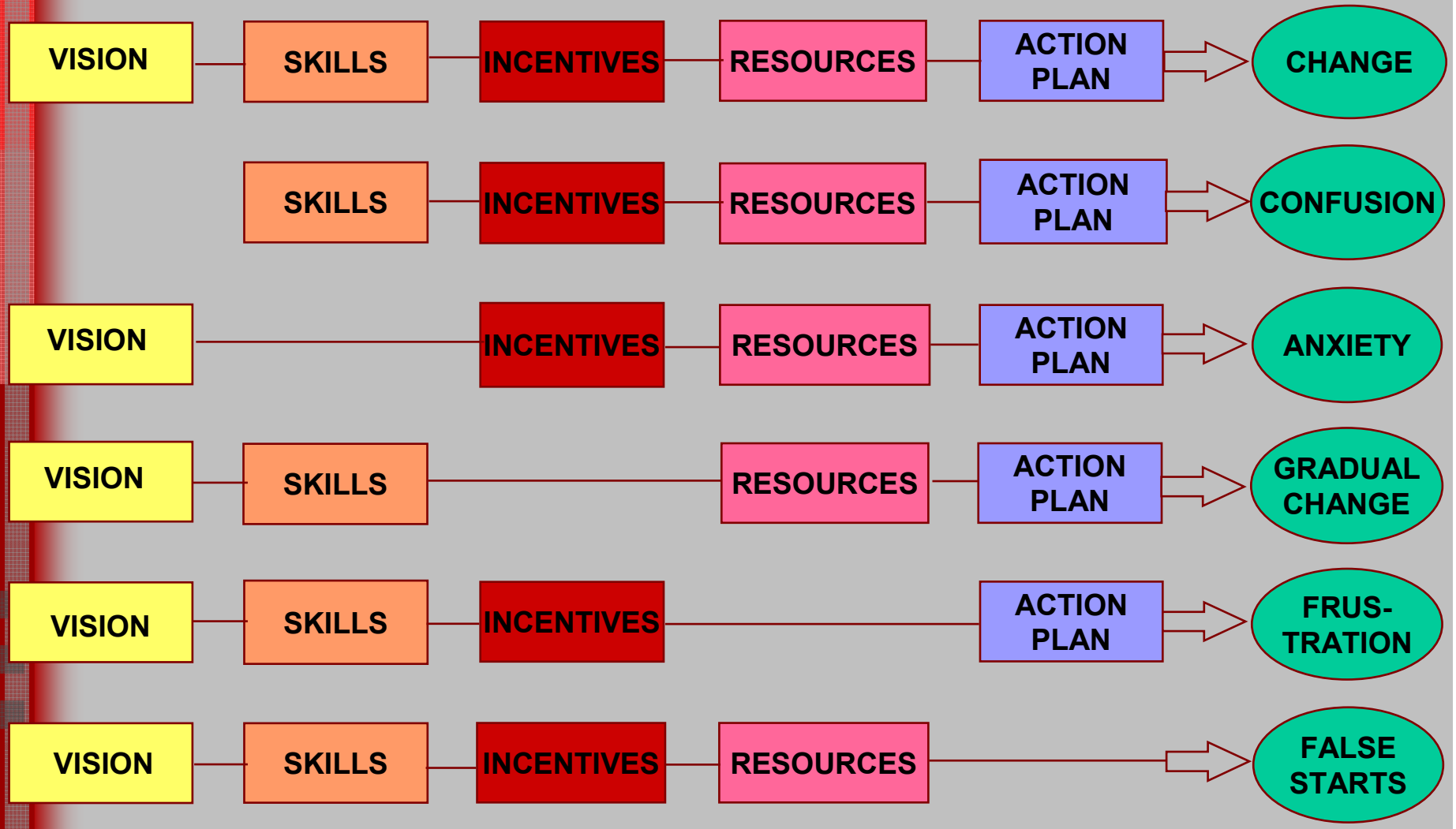


Organizations as Systems

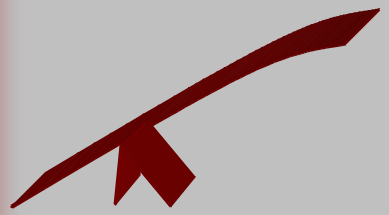


[Source: Morgan, 1986]

Managing Complex Change Requirements

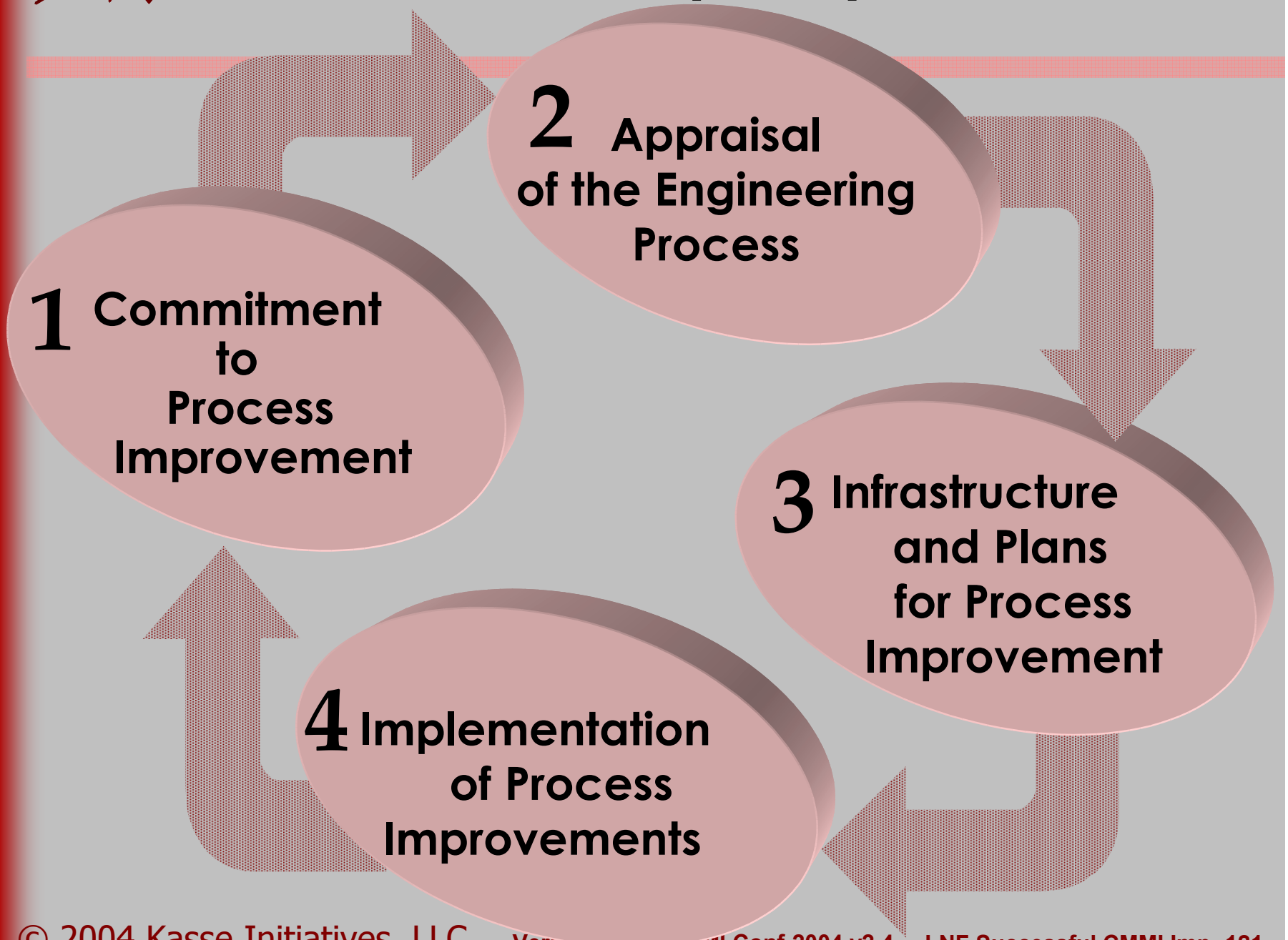


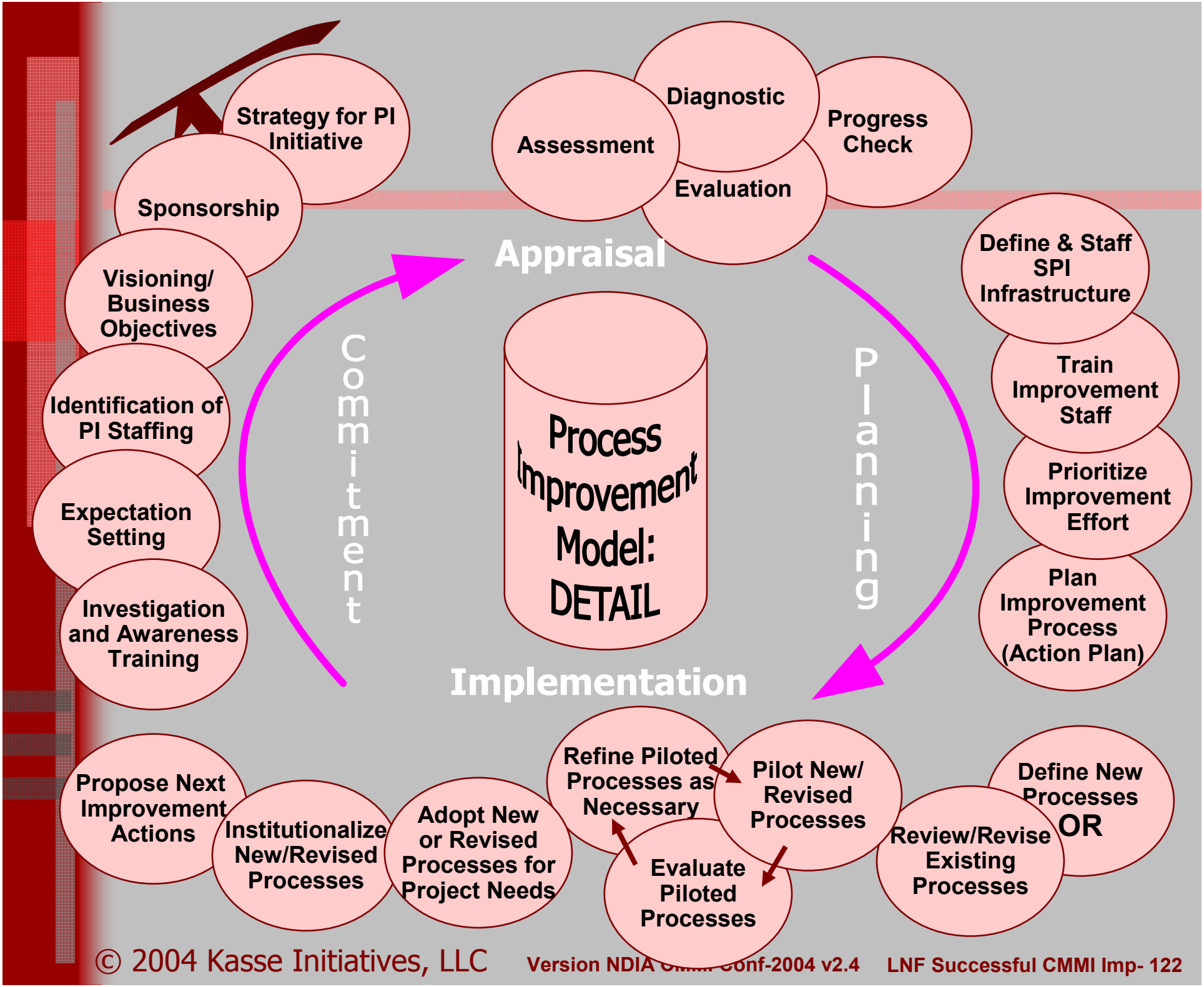
"Managing Technological Change"
Carnegie Mellon University
Software Engineering Institute

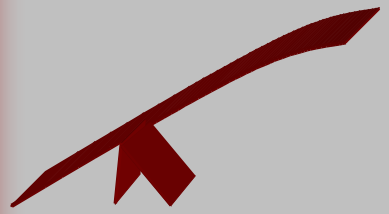


Process Improvement Model

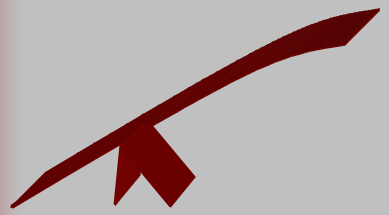
Process Improvement Model (PIM)







Constagedeous Approach to Process Improvement

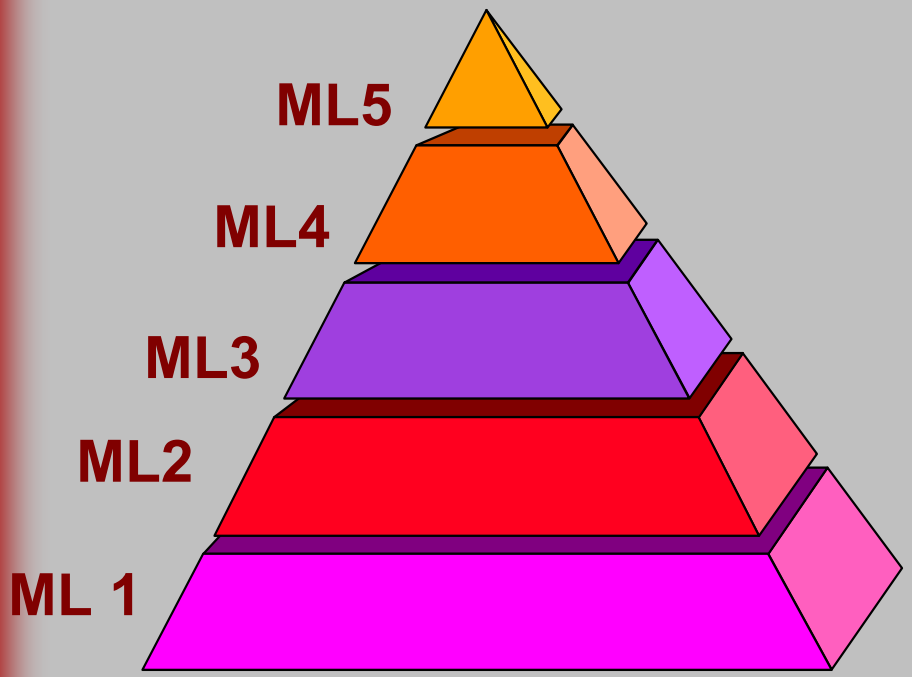


Constagedeous Approach

- Both the Staged Representation and the Continuous Representation not only can be but **must** be used together to provide proper guidance that results in effective process improvement that supports an organization's business objectives

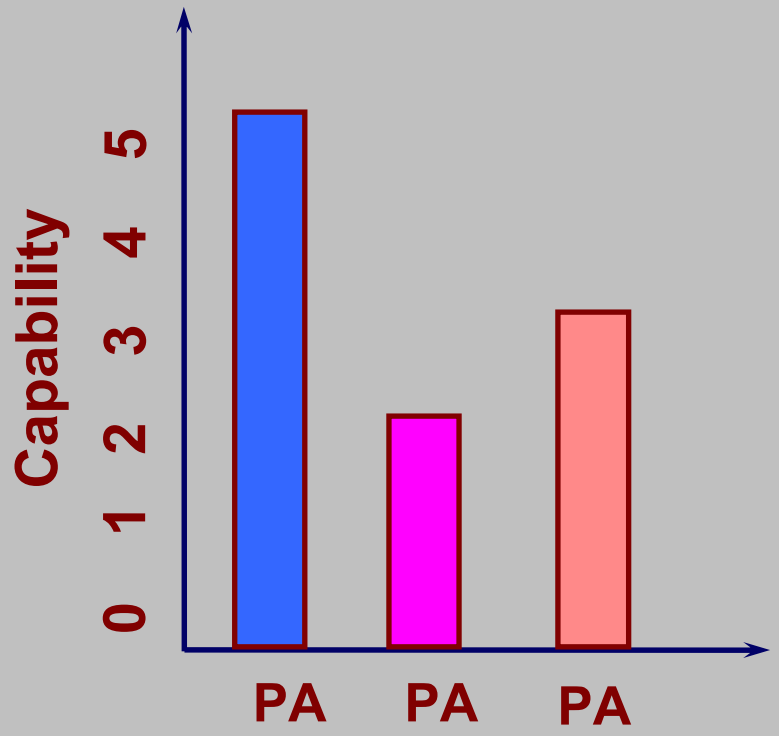
CMMI Model Representations

Staged



Organization

Continuous



Process

Summary

- The CMMI has evolved from contributions of engineers, managers, and social psychologists over the past 100 years
- The multiple views of the CMMI contribute to the picture that process improvement must concern itself with people, technology, measurement, risk, and customer satisfaction if an organization's business objectives are to be supported with the CMMI-based process improvement initiative

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