Requirements Engineering

What Are Requirements?

- Customer’s needs, expectations, and measures of effectiveness
- Items that are necessary, needed, or demanded
- Implicit or explicit criteria that must, should, or might be met
- Contain system and software information
- Should not contain details regarding the internal implementation of a solution
- May be derived from other requirements during analysis, operational concept and operational scenarios development

What Are Requirements? - 2

- Description of the services the system is to provide
- Description of how the system should behave
- Description of the circumstances under which it is required to operate
- Application domain information
- Constraints on the system’s operations
- Specifications of a system property or attribute
- Constraints on the development process of the system

What Are Requirements? - 3

- Requirements might describe:
  - A user-level facility – the word processor must include a spell checker and correction command
  - A very general system property – the system must ensure that personal information is never made available without authorization
  - A specific constraint on the system – the sensor must be polled 10 times per second

What Are Requirements? - 4

- Requirements might describe: - continued
  - How to carry out some computation – the overall mark is computed by adding the student’s examination, project and coursework marks based on the following formula ‘TotalMark = ExamMark + 2* ProjectMark + 2/3 * CourseworkMark’
  - A constraint on the development of the system – the system must be developed using the Ada programming language

What Are Requirements? - 5

- Requirements invariably contain a mixture of
  - Problem information
  - Statements of system behavior
  - Systems properties
  - Design constraints
  - Manufacturing constraints
- This can and normally does result in **conflicts** that must be negotiated and resolved

Sources of Requirements

- Customer
- Marketing
- Surveys
- Systems Engineering
- Existing Systems, Specifications
- Standards
- Industry Studies
- Academic Research

Sources of Requirements - 2

- Prototyping
- Simulation
- Quality Assurance Group
- Configuration Management Group

Requirements Categories or Types

- **Business** Requirements – Business requirements are the reason for developing systems and software in the first place.
  - Business requirements are the essential activities of an enterprise
  - Business requirements are derived from business goals or objectives
  - The extent to which the system supports the business requirements and facilitates an organization in achieving them is a key factor for the success of that system
  - If the systems we build do not support the business requirements effectively and efficiently, they have no reason for being -- Businesses exist to make money!

Requirements Categories or Types - 2

- **System-Level** Requirements – System-level requirements are foremost in importance, captures the vision of the customer, enables defining the scope of the system, and allows estimating the cost and schedule required to build the system

- **Functional** Requirements – Functional requirements describe what the system must do. Functional requirements are sometimes called behavioral or operational requirements because they specify the inputs to the system and the outputs from the system and the behavioral relationships between them.

Requirements Categories or Types - 3

- **Design** Requirements & **Design** Constraints – For many systems, design requirements / constraints appear at the beginning of the system formulation
  - New systems are often installed in environments that already have other systems that constrain the design of the new system
    - Example – A design constraint may be that the system to be developed must obtain its information from an existing database
  - For reasons of budget, schedule, or quality, an organization may wish to reuse some or all existing software systems in the implementation of a new system → This constrains both the requirements and the design

Requirements Categories or Types - 4

- If a system has to be approved by an external regulator, it may be necessary to use standard certified design that has been tested in other systems
- The system's user interface shall be implemented using a World-wide Web browser.

Requirements Categories or Types - 5

- **Performance** Requirements – Performance requirements define how well the functional requirements must perform. Performance requirements must be defined in quantifiable terms and avoid such terms as:
  - Fast
  - Slow
  - Regular
  - Dependable
  - Reliable
- The system shall support at least 20 transactions per second

Requirements Categories or Types - 6

- **Interface** Requirements – Interface requirements represent the physical and functional relationships among system elements and between system elements and the system environment
  - Interface requirement may be specified by the customer
  - Interface requirements will come out of the architecture specification
  - Interface requirements will be dictated by COTS products that are integrated into the system

Requirements Categories or Types - 7

- **Product** Requirements – Product requirements define the technical criteria that must, should, or might be met by the delivered product
- **Project** Requirements – Project requirements stipulate resources that will be made available, and how different aspects of the project will be carried out
- **Process** Requirements – Process requirements indicate standards, procedures, methods, languages, ...

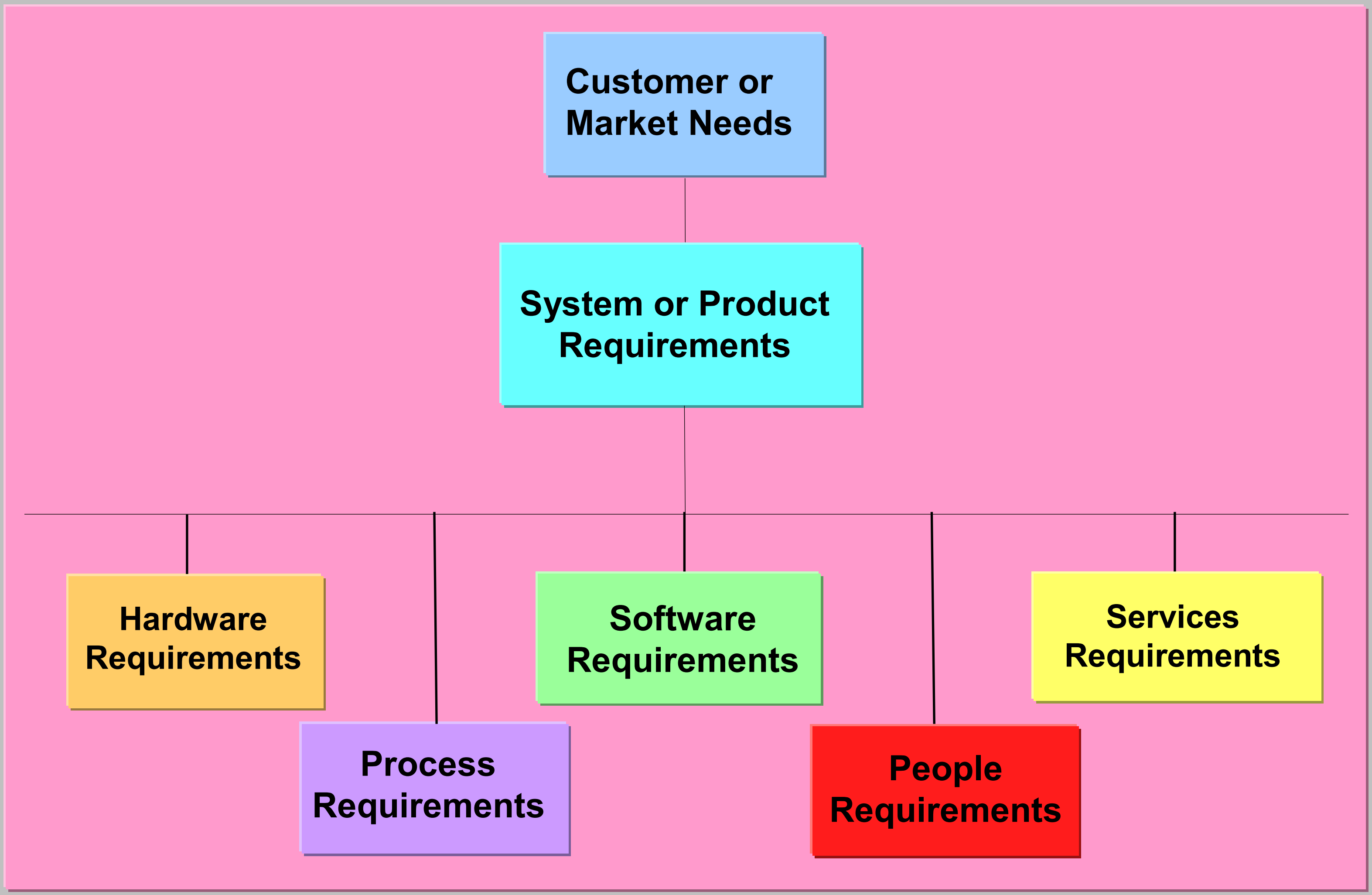
Requirements Categories or Types - 8

- **Qualification** Requirements – Qualification requirements refer to the verification and validation of item performance in a specific application and results from design review, test data review, and configuration audits
- **Environmental** Requirements – Environmental requirements result from the physical setting and social and cultural conditions of the system development effort and the setting in which the system will be used

Requirements Categories or Types - 9

- **Non-Functional Requirements** – Non-functional requirements or Quality Factors refers to characteristics the system exhibits when placed in the operational environment. These quality factors are also referred to as the “Illities” and include:
  - Maintainability
  - Expandability
  - Usability
  - Testability
  - Reliability
  - …………..

Hierarchy of Requirements


Customer or Market Needs

System or Product Requirements

Hardware Requirements

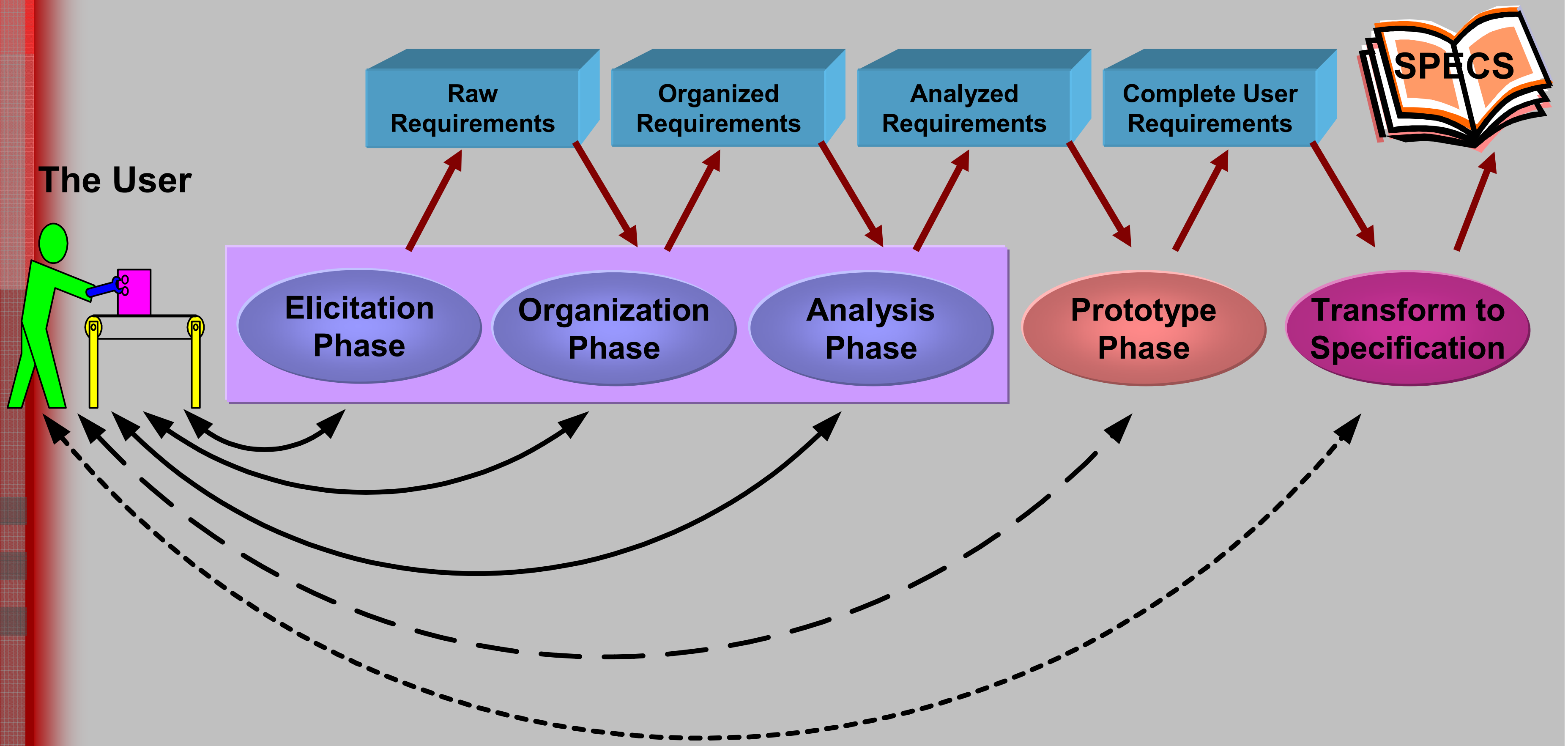
Process Requirements

Software Requirements

People Requirements

Services Requirements

Requirements Lifecycle



Requirements Engineering

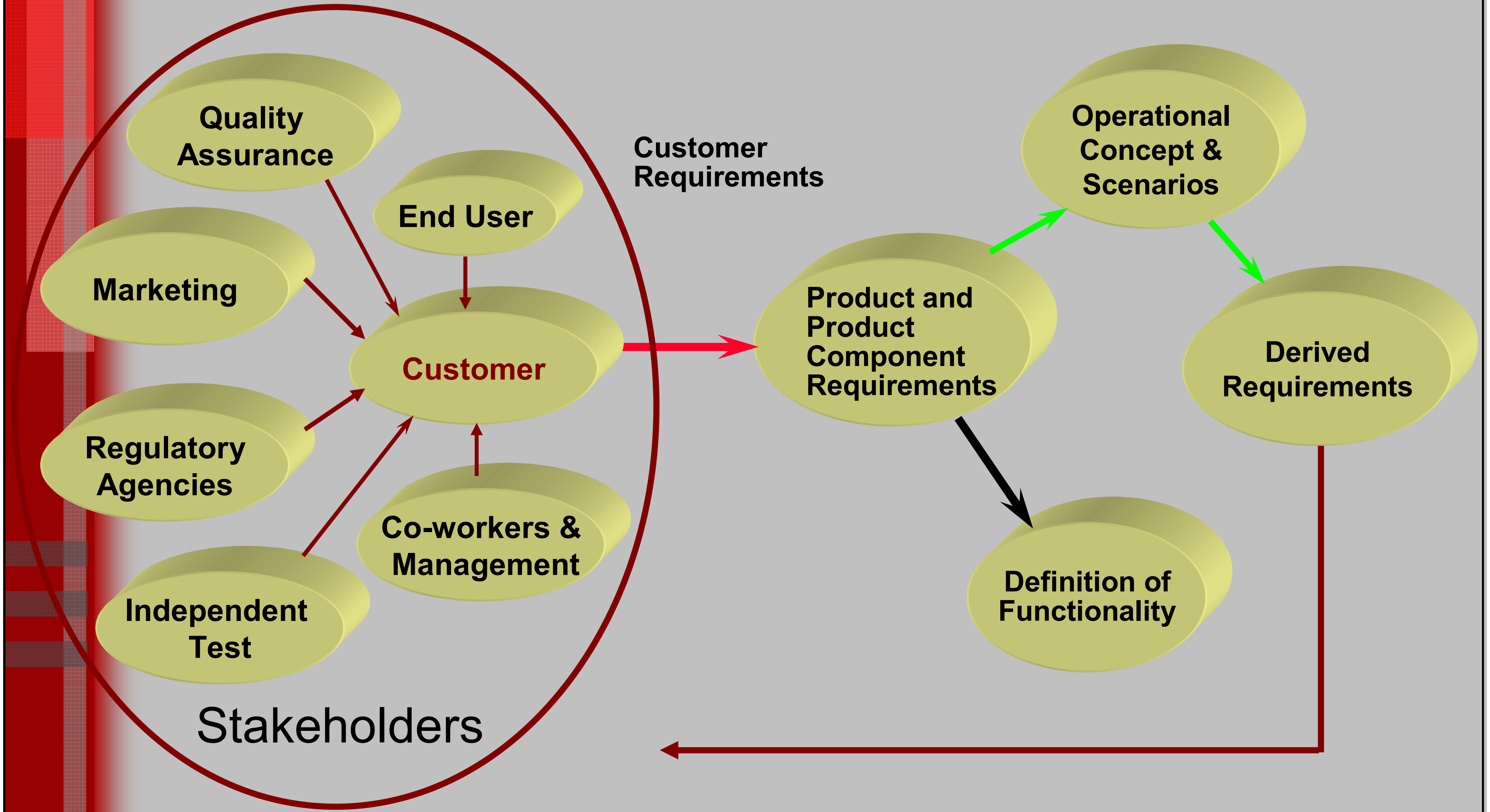
- Discovering, documenting, baselining, and maintaining a set of requirements for a computer-based system
- Requirements "Engineering" implies that systematic and repeatable techniques should be used to ensure that the system requirements are complete, consistent, relevant, etc.

Requirements Engineering - 2

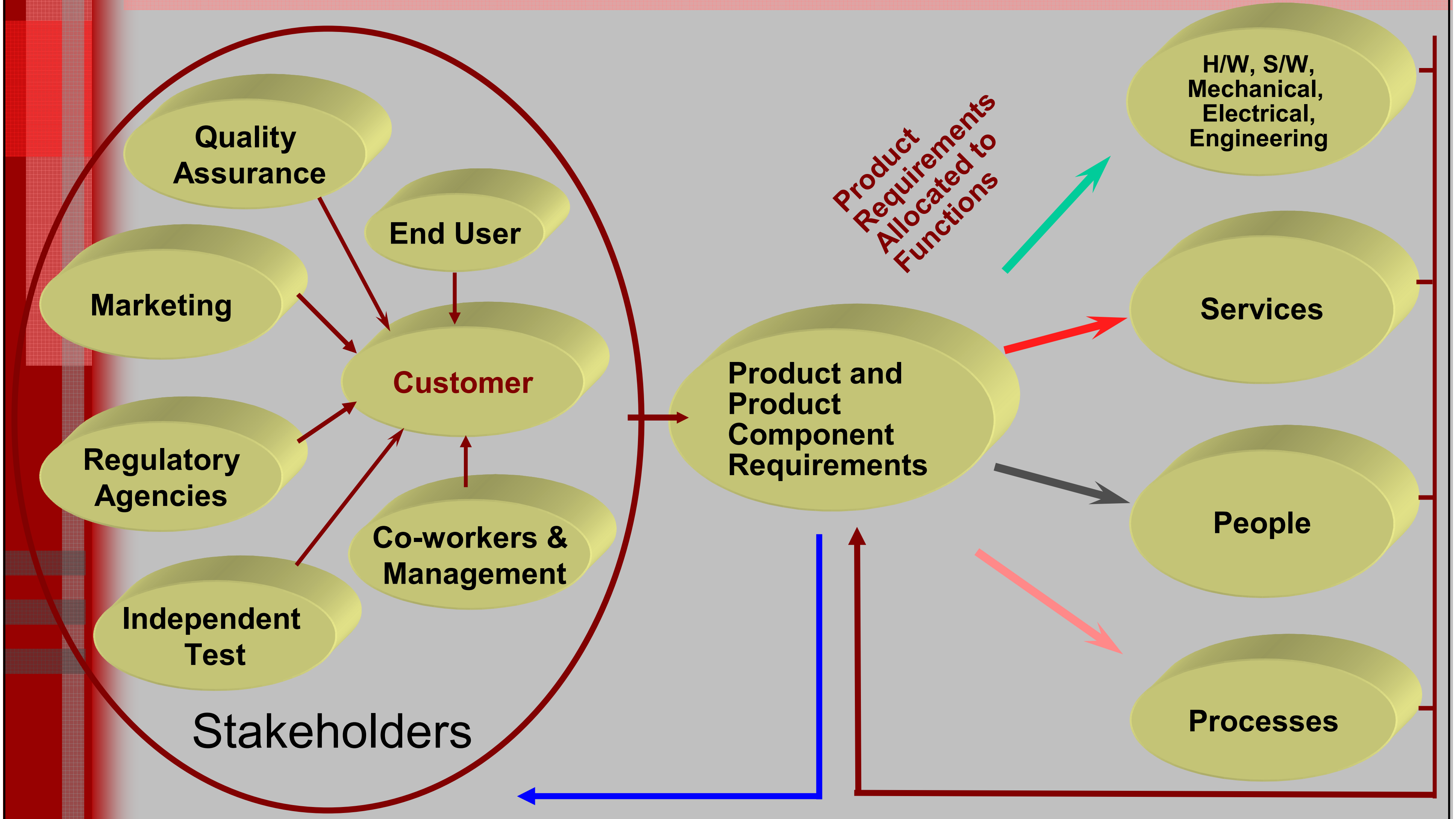
- Requirements Engineering topics include:
  - Elicitation
  - Analysis
  - Specification
  - Review
  - Traceability
  - Management
    - Change Requests
    - Impact Analysis
  - Verification
  - Validation

Requirements Development

Customer, Product, and Product Component Requirements



Customer, Product, and Product Component Requirements - 2



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Collecting and Translating Stakeholders' Needs

- The needs, expectations, constraints, interfaces, operational concepts, and product concepts of all stakeholders are collected, analyzed, harmonized, refined, elaborated and translated into customer requirements
- Environmental, legal, regulatory and other constraints that may be external to the customer must also be applied when creating and resolving the set of customer requirements

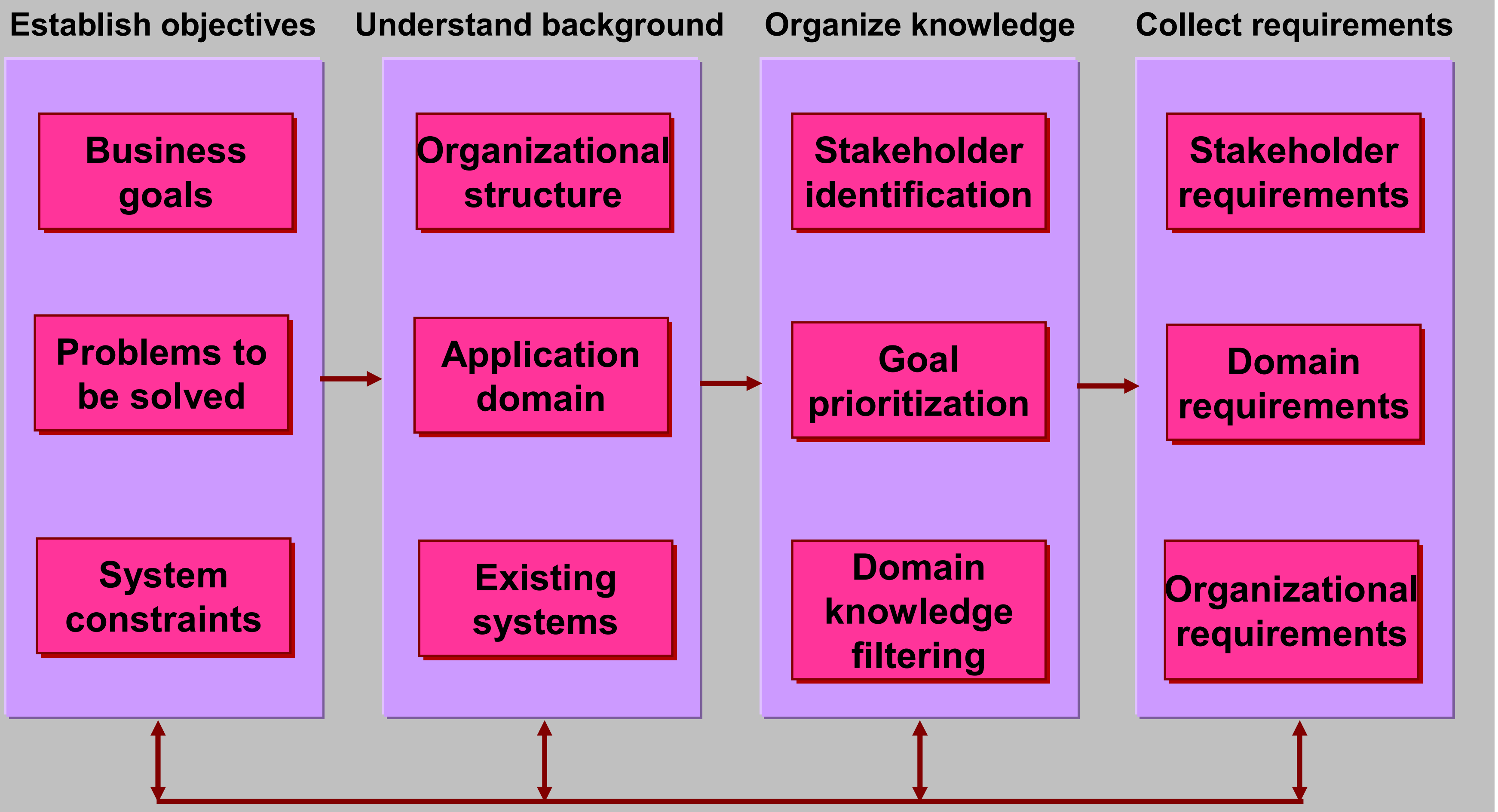
Collecting and Coordinating Stakeholders' Needs - 2

- Stakeholders include:
  - Customers
  - End-users
  - Developers
  - Producers
  - Testers
  - Suppliers
  - Marketers
  - Maintainers
  - Safety Regulation Agencies
  - Managers

Elicitation Techniques

- Examples of techniques to identify and elicit Stakeholders' needs include:
  - Dialogue
  - Scenario reviews
  - Technology demonstrations
  - Models
  - Simulations
  - Prototypes
  - Brainstorming
  - Observations of existing systems
  - Extractions from sources such as documents, standards, and specifications

Generic Requirements Elicitation Process



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

Customer Requirements

- Customer requirements make up a common understanding of what will satisfy the stakeholders
- Customer requirements are analyzed to ensure that they are complete, realizable, and verifiable, consistent, and testable
  - The analysis helps to determine what impact the intended operational environment will have on the ability to satisfy the stakeholder's needs, expectations, constraints and interfaces

Product and Product Component Requirements

- Product and product component requirements define what the system is required to do and the circumstances under which it is required to operate
- Product and product component requirements define the services that the product or product component should provide and establish constraints on how they will operate
- Product and product component requirements include technical requirements and the criteria that will be used to verify that the products satisfy the requirements

Product and Product Component Requirements - 2

- The customer requirements are normally expressed in the customer’s terms and may include non-technical descriptions
- Product requirements are the expression of those requirements in technical terms that can be used for design decisions
- 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”

Product and Product Component Requirements - 3

- The analysis of requirements may produce derived requirements including:
  - Constraints
  - Implicit end-user issues
  - Factors introduced by the developer’s unique business considerations, regulations, and laws
- Requirements are allocated to functions, product components, product performance and design constraints including objects, people, and associated processes or services

Analyze Requirements

- During the iterative process of requirements analysis the following guidelines should be continuously applied:
  - Analyze stakeholder needs, expectations, constraints, and external interfaces to remove conflicts and to organize into related subjects
  - Analyze requirements to ensure that they are complete, feasible, realizable and verifiable
  - Identify key requirements that have a strong influence on cost, schedule, functionality, risk, or performance
  - Identify technical performance measures that will be tracked during the development effort

Interface Requirements

- Interfaces between functions must be defined and controlled as part of the product and product component integration
- As interface designs are defined, the design becomes a requirement for products and product components that are affected by the interface

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

Operational Concepts and Scenarios - 2

- Operational concepts and scenarios need to be developed that include functionality, performance, maintenance, and disposal as appropriate
- The environment the product will operate in, including boundaries and constraints, needs to be defined

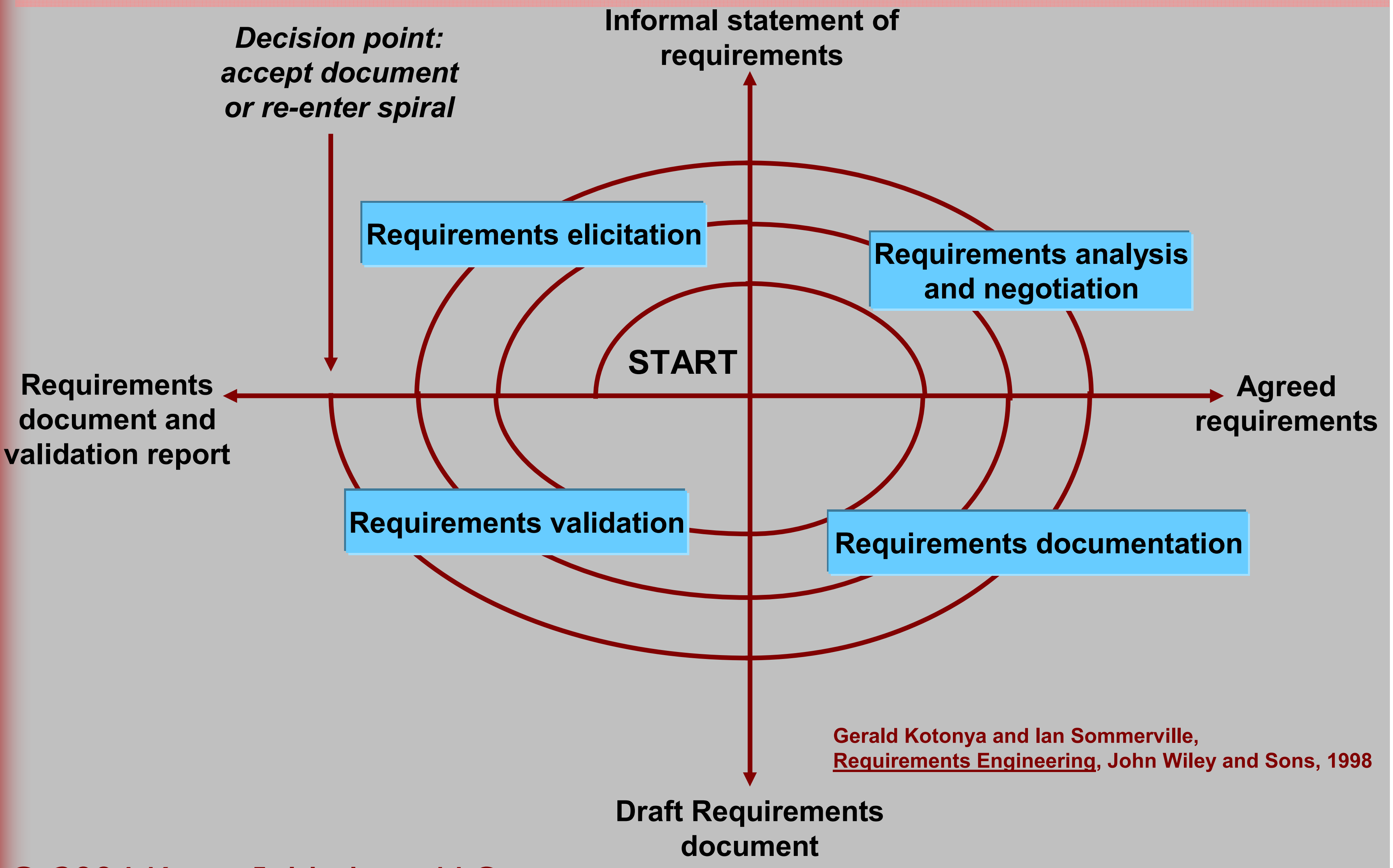
Derived Requirements

- Derived requirements are analyzed, based on the operational concept and scenarios, to develop a more detailed and precise set of product or product component requirements
- Analysis of derived requirements makes sure that they are necessary and sufficient to meet the objectives of higher level requirements
- Determination must be made as to which requirements will be identified to track technical progress against

Validating Requirements

- Customer requirements should be **validated** early in the development schedule to **gain confidence** that the customer requirements are capable of guiding a development that results in the customer’s operational needs being met

Spiral Model of the Product Requirements Engineering Process


Decision point: accept document or re-enter spiral
Informal statement of requirements
Requirements elicitation
Requirements analysis and negotiation
START
Requirements document and validation report
Agreed requirements
Requirements validation
Requirements documentation
Draft Requirements document

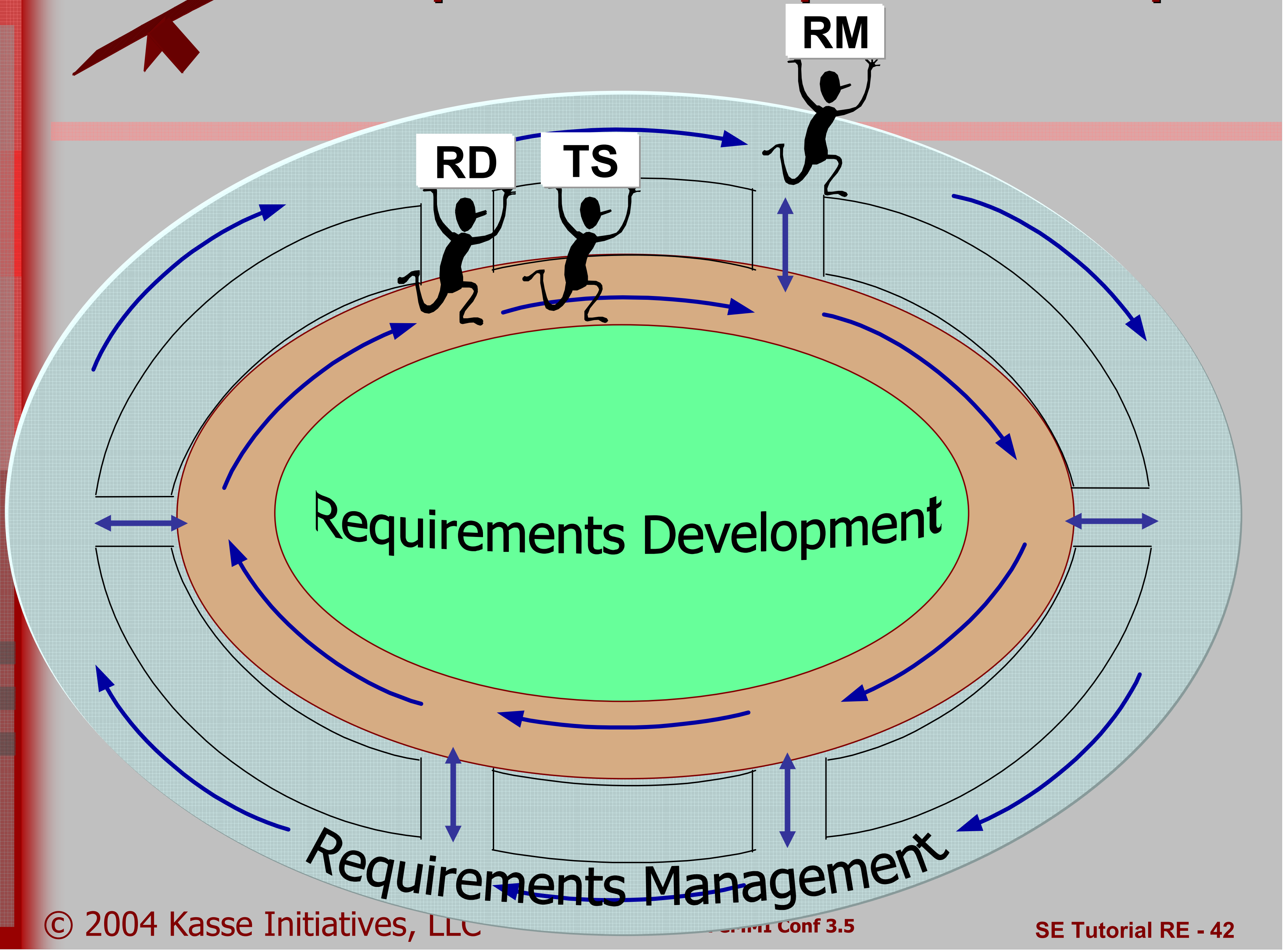
Gerald Kotonya and Ian Sommerville, Requirements Engineering, John Wiley and Sons, 1998

Acceptance Criteria

- Acceptance Criteria should be part of the requirements capture and specification process
  - Who will perform the acceptance testing
  - What environment or portion of the user's environment must be exercised to satisfy the acceptance criteria
  - How much simulation is allowed to verify and validate the requirements
  - What process will be followed if errors are found
  - What classification of errors must be fixed before the system will be accepted
  - What classification of errors may allow the system to be accepted in the event that workarounds can be provided

Requirements Management

The Requirements Management and Requirements Development Partnership



Understanding of Requirements

- The project reviews the requirements to resolve issues before they are incorporated into the product
- Requirements and requirements change requests are analyzed and reviewed to ensure that a compatible, shared understanding is reached on the meaning of the requirements:
  - Clearly and properly stated
  - Complete
  - Consistent with each other
  - Uniquely identifiable
  - Feasible and appropriate to implement
  - Able to be verified and validated through reviews and testing
  - Traceable

Changes to Requirements

- Changes to the requirements must be controlled as they evolve over the product lifecycle due to changing needs and derived requirements
- All appropriate stakeholders review and agree on the change requests to the requirements before they are applied
- Approved changes to the requirements are tracked
- A change history is maintained for each requirement along with the rationale for the change
    - Initially captured and/or derived
    - After approved changes have been applied
- Applied changes to requirements are communicated to all stakeholders in a timely manner

Changes to Commitments Based on Requirements Changes

- Changes to commitments must be negotiated with all stakeholders

- Changes to commitments made external to the organization should be reviewed by senior management, as one of the stakeholders, to ensure that commitment can be accomplished along with the other previously approved commitments

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

Requirements Traceability

- Requirements cannot be managed effectively without requirements traceability
- A requirement is traceable if:
  - You know the source of each requirement
  - Why the requirement exists
  - What requirements are related to it
  - How that requirement relates to other information such as systems designs, implementations, and user documentation
- Traceability information is used to find other requirements which might be affected by proposed changes

Requirements Traceability - 2

- All requirements and requirements change requests throughout the product lifecycle are captured and placed under configuration management
- Traceability is needed in conducting the impact analysis of requirements change requests on the project plans, activities, and work products
- A requirements traceability matrix is generated and used for forward and backward tracing

Consistency of Life-Cycle Work Products

- The project plans, work products, and activities are changed to be consistent with approved changes made to the requirements and must be:
  - Identified
  - Evaluated
  - Assessed for risk
  - Documented
  - Planned
  - Communicated
  - Tracked to completion

Summary

- Requirements development and requirements management contribute to product development
  - Requirements and analysis are essential to producing high quality software and maintaining control over product development
  - Supports controls of requirements change requests throughout the development lifecycle
  - Takes all stakeholders views into consideration
  - Is an iterative and recursive process

Summary - 2

- Requirements are the foundation:
  - For the product (H/W and/or S/W)
  - For the planning
  - For acceptance by the customer
  - For defining quality expectations