ETLS 509 - Validation & Verification
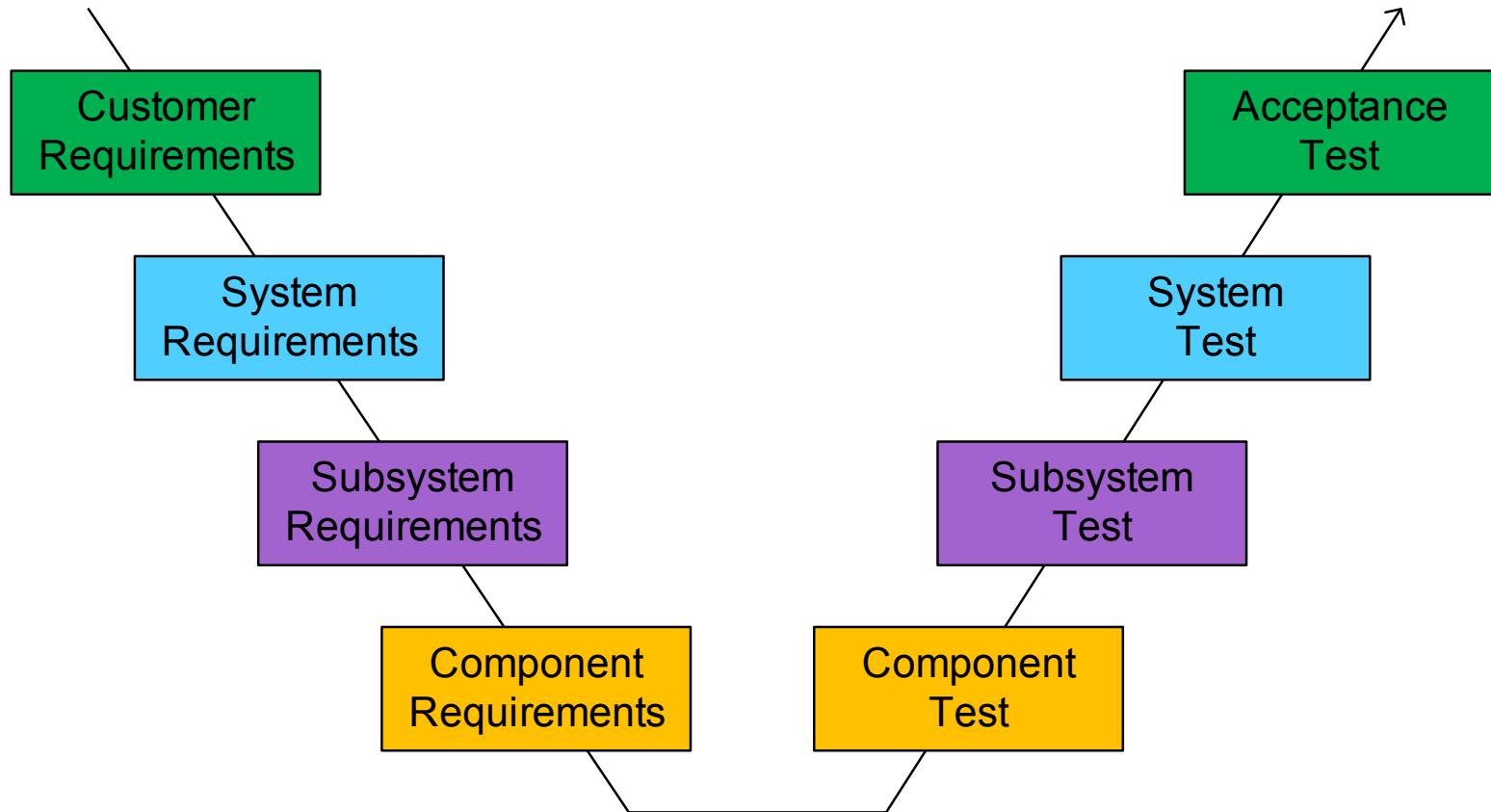# University of St. Thomas

John Engelman

Fall 2016

Agenda

- **Review of last week - questions**
- **Requirements**
  - Customer
  - Stakeholders
  - Definition Process
  - The Starting Point
- **Verifying**
- **Requirements in Process Models**
  - Spiral (2 versions)
  - Waterfall
  - Vee

ETLS 509 - Session 6

- **Voice of Customer / Requirements Definition**

Requirements Definition

- **INCOSE 4.1**
- **As stated in ISO/IEC 15288:2008:**
    - *The purpose of the Stakeholder Requirements Definition Process is to define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment. It identifies **stakeholders, or stakeholder classes**, involved with the system **throughout its life cycle, and their needs, expectations, and desires**. It analyzes and transforms these into a common set of stakeholder requirements that express the intended interaction the system will have with its operational environment and that are the reference against which each resulting operational service is validated.*
    - ***Can have threshold and objective requirements***

Requirements

- **Who's and what's a stakeholder?**
  - From - www.merriam-webster.com
    - 1: a person entrusted with the stakes of bettors
    - 2: one that has a stake in an enterprise
    - 3: one who is involved in or affected by a course of action
- **INCOSE Systems Engineering Handbook**
  - A stakeholder is any entity (individual or organization) with a legitimate interest in the system. Typical stakeholders include users, operators, organization decision-makers, parties to the agreement, regulatory bodies, developing agencies, support organizations, and society-at-large.
- **Who is the customer?**
  - A business traveler purchases a ticket to fly from IAD to LAX from United Air Lines
    - United Air Lines purchases an aircraft from Boeing
      - Boeing purchases "wing box[1]" from Fuji
        - » Fuji purchase materials from others

1 Wing box connects the wing to the fuselage

Stakeholders – Development of the Boeing 777

- **Who are the stakeholders?**
  - Airlines (the Boeing Customers)
  - Boeing management & employees
  - Suppliers to Boeing for the manufacture of the 777
  - Boeing design subcontractors
  - Boeing design tool suppliers
  - FAA
- **Are all stakeholders equivalent?**

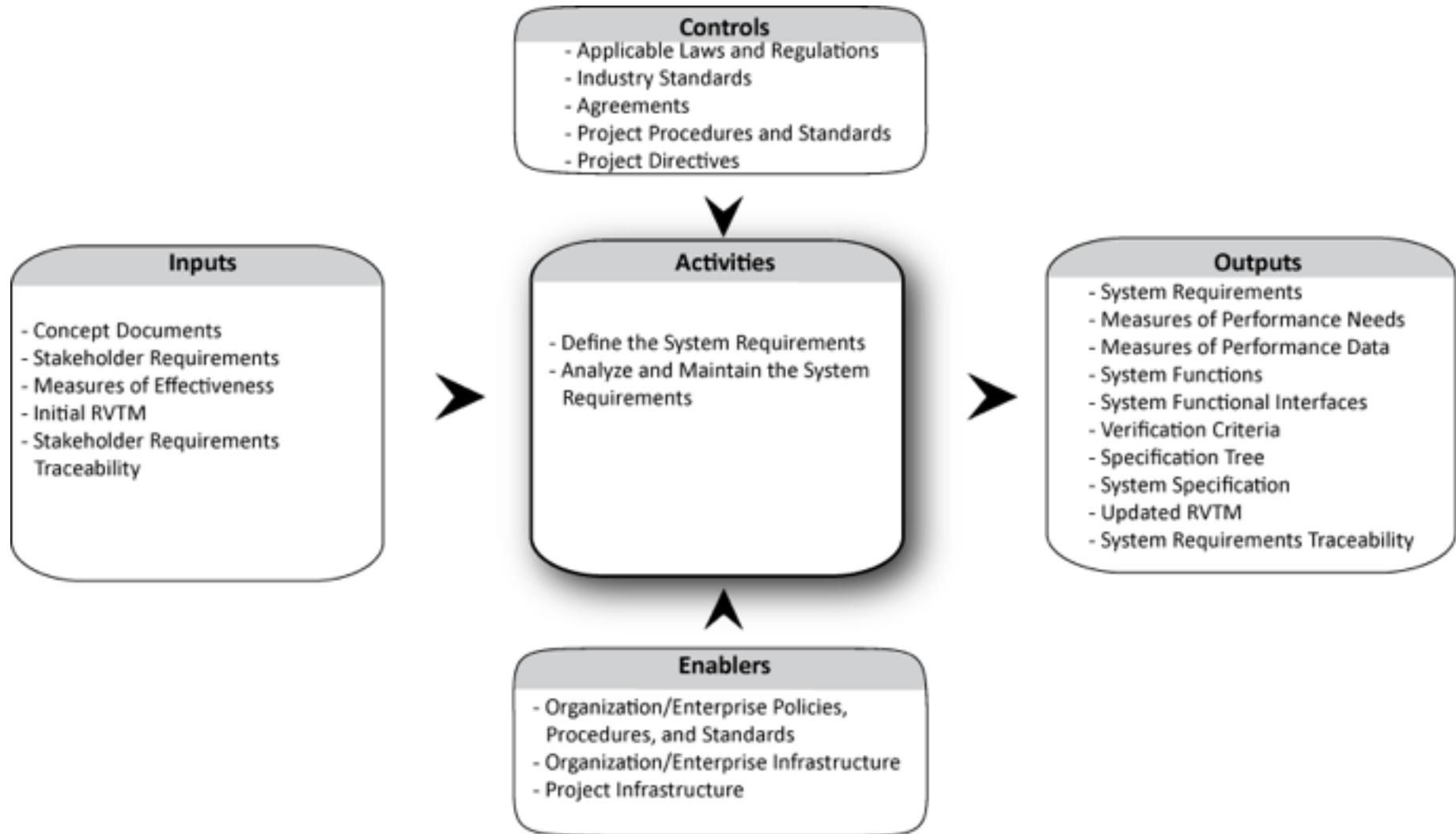# INCOSE Context Diagram for Stakeholder Requirements Definition Process

Controls
- Applicable Laws and Regulations
- Industry Standards
- Agreements
- Project Procedures and Standards
- Project Directives

Inputs
- Concept Documents
- Stakeholder Requirements
- Measures of Effectiveness
- Initial RVTM
- Stakeholder Requirements Traceability

Activities
- Define the System Requirements
- Analyze and Maintain the System Requirements

Outputs
- System Requirements
- Measures of Performance Needs
- Measures of Performance Data
- System Functions
- System Functional Interfaces
- Verification Criteria
- Specification Tree
- System Specification
- Updated RVTM
- System Requirements Traceability

Enablers
- Organization/Enterprise Policies, Procedures, and Standards
- Organization/Enterprise Infrastructure
- Project Infrastructure

Figure 4-2 INCOSE Systems Engineering Handbook

Requirements – the starting point

- **Source documents**
  - System needs related documents
  - Documents describing/defining the system to be developed
  - Concept of operation documents
  - Regulatory documents (e.g., FAA, FDA, DOD regulations, building codes)
    - Company policy documents
      - Company proprietary serial interface will be utilized on computer equipment
      - Or – IEEE industry standard interface will be utilized on all computer equipment
  - Project constraints including budgets, staffing, and other resources that can have an impact on requirements
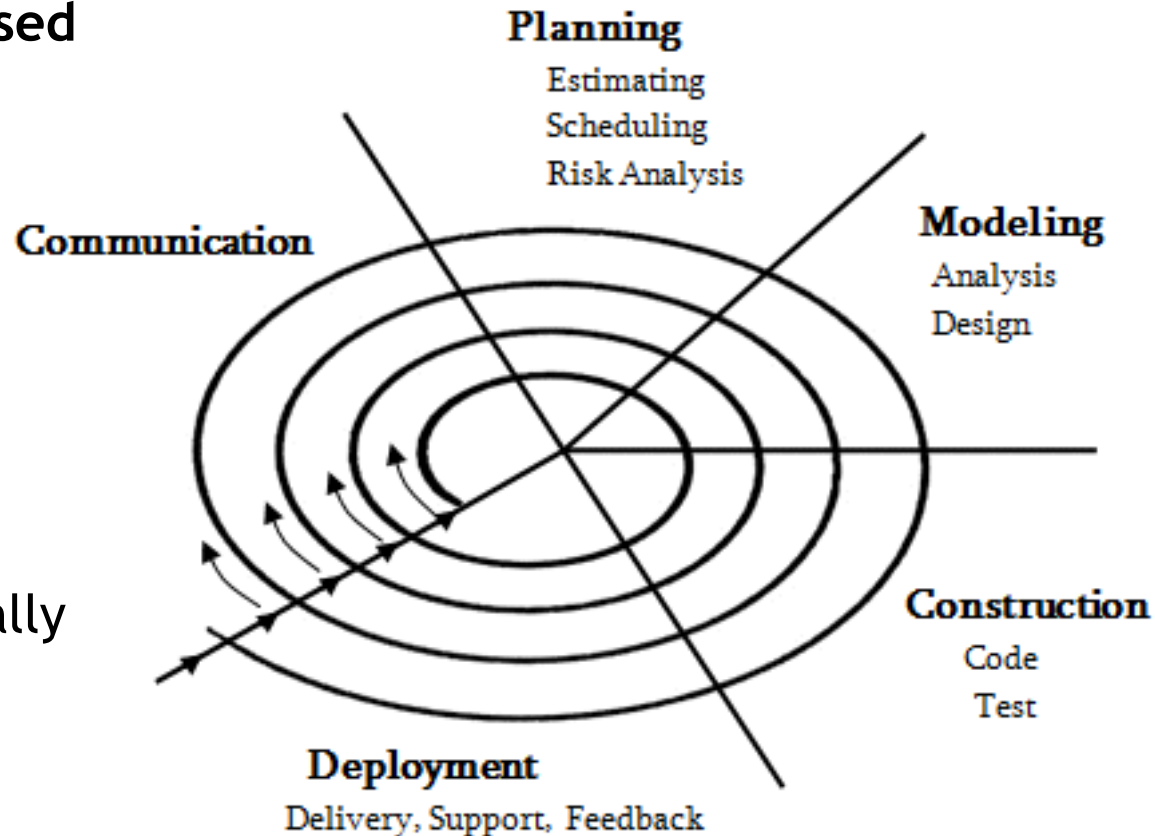
Requirements in Process Models

- **In this variant of the Spiral Process model Need drives System Requirements**
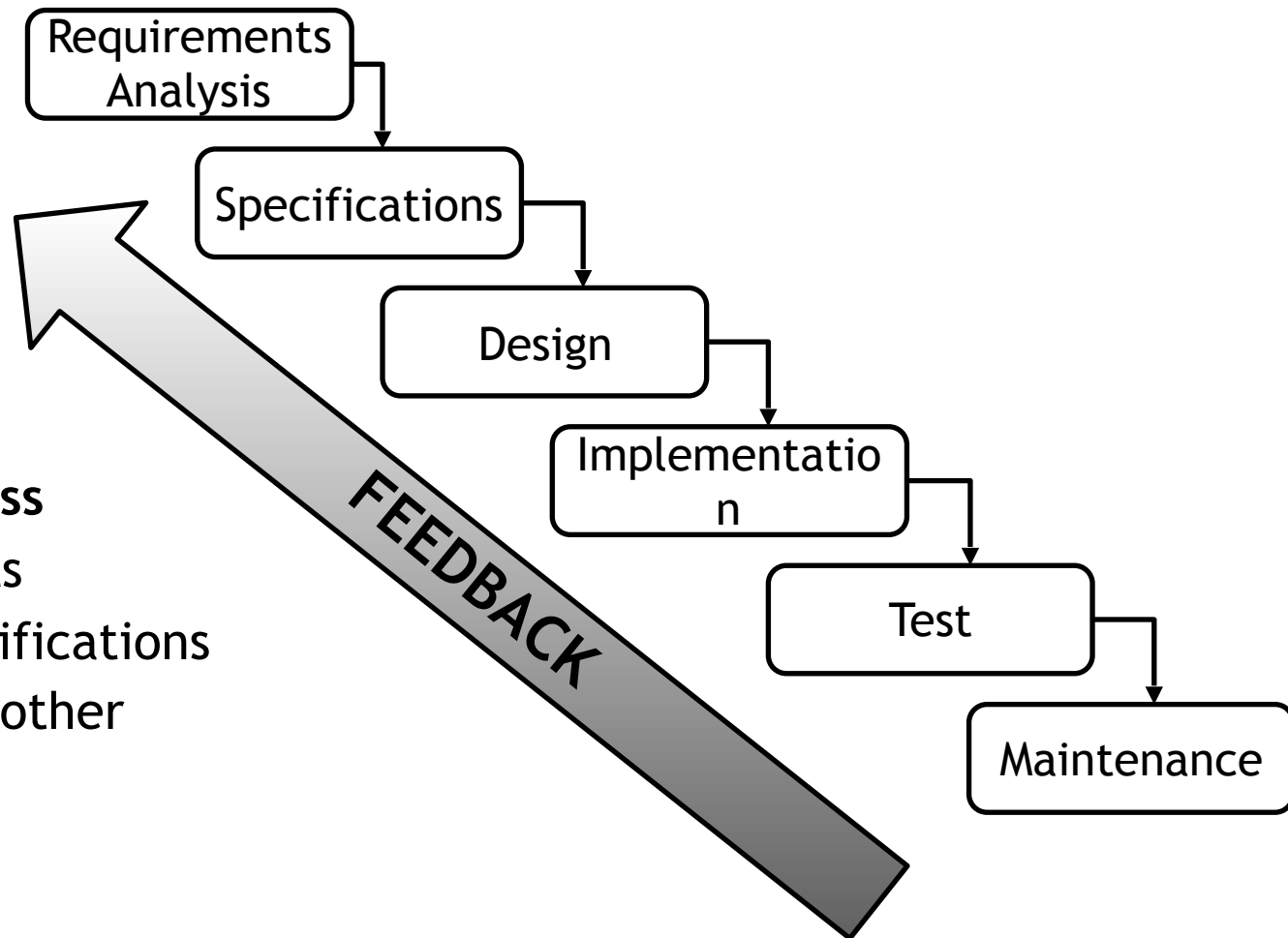
Spiral Process Model

Requirements in Process Models

- **Spiral model sometimes used in software development**
  - Requirements are implicit in the communication
- **Fundamentally multiple cycles through the process are planned**
  - Graphic implies sequential steps, typically this is not how it works

Planning
Estimating
Scheduling
Risk Analysis

Communication

Modeling
Analysis
Design

Construction
Code
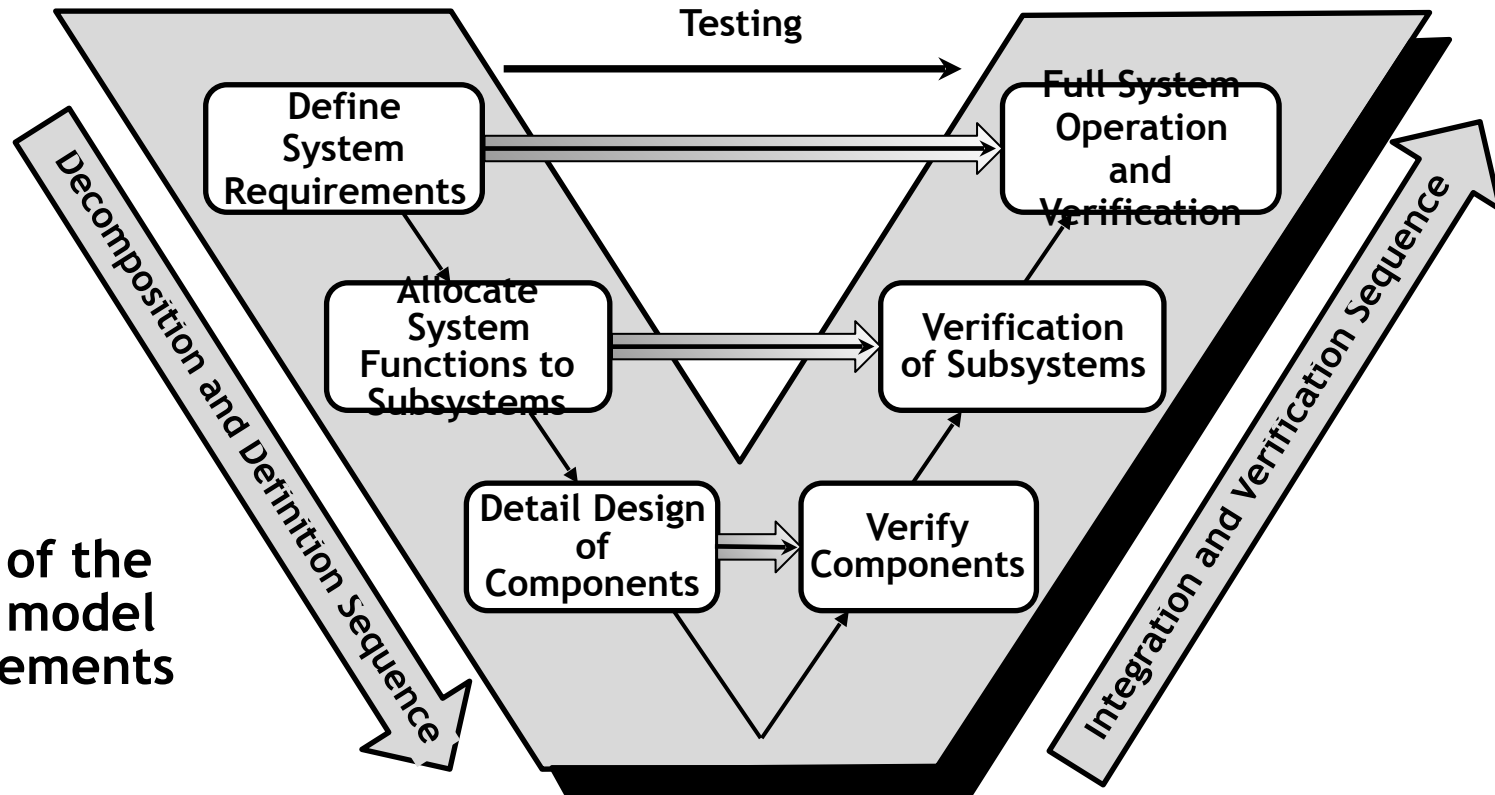Test

Deployment
Delivery, Support, Feedback

Requirements in Process Models - Waterfall

- **Waterfall process**
  - Requirements
  - Flow to specifications
  - Followed by other steps

Requirements Analysis

Specifications

Design

Implementation

Test

Maintenance

FEEDBACK

Requirements in Vee Process Model

"Vee" Process Model

Testing

Define System Requirements

Full System Operation and Verification

Decomposition and Definition sequence

Allocate System Functions to Subsystems

Verification of Subsystems

Detail Design of Components

Verify Components

Integration and verification Sequence

- This variant of the Vee process model flows requirements the left side verifying requirements up the right side

Requirements

Qualitative

- Water is to be safe from formaldehyde
- Drapes will not allow light into a room
- The food will taste good
- The food will be notorious mix

- The paint is to be pleasing to the eye
- The car is to be very fast

- The medical device will reduce pain levels

Quantitative

- Water shall contain less than 1 part per thousand of Formaldehyde
- The illumination in the room shall be less than 10 lumens with drapes shut
- ?
- Specify calories, nutrient mix, carbohydrates, protein, salt, etc.
- ?
- The car shall have a top speed of over 150 MPH
- In clinical trials the device will reduce patient pain level by a minimum of 2 steps on the subjective pain scale
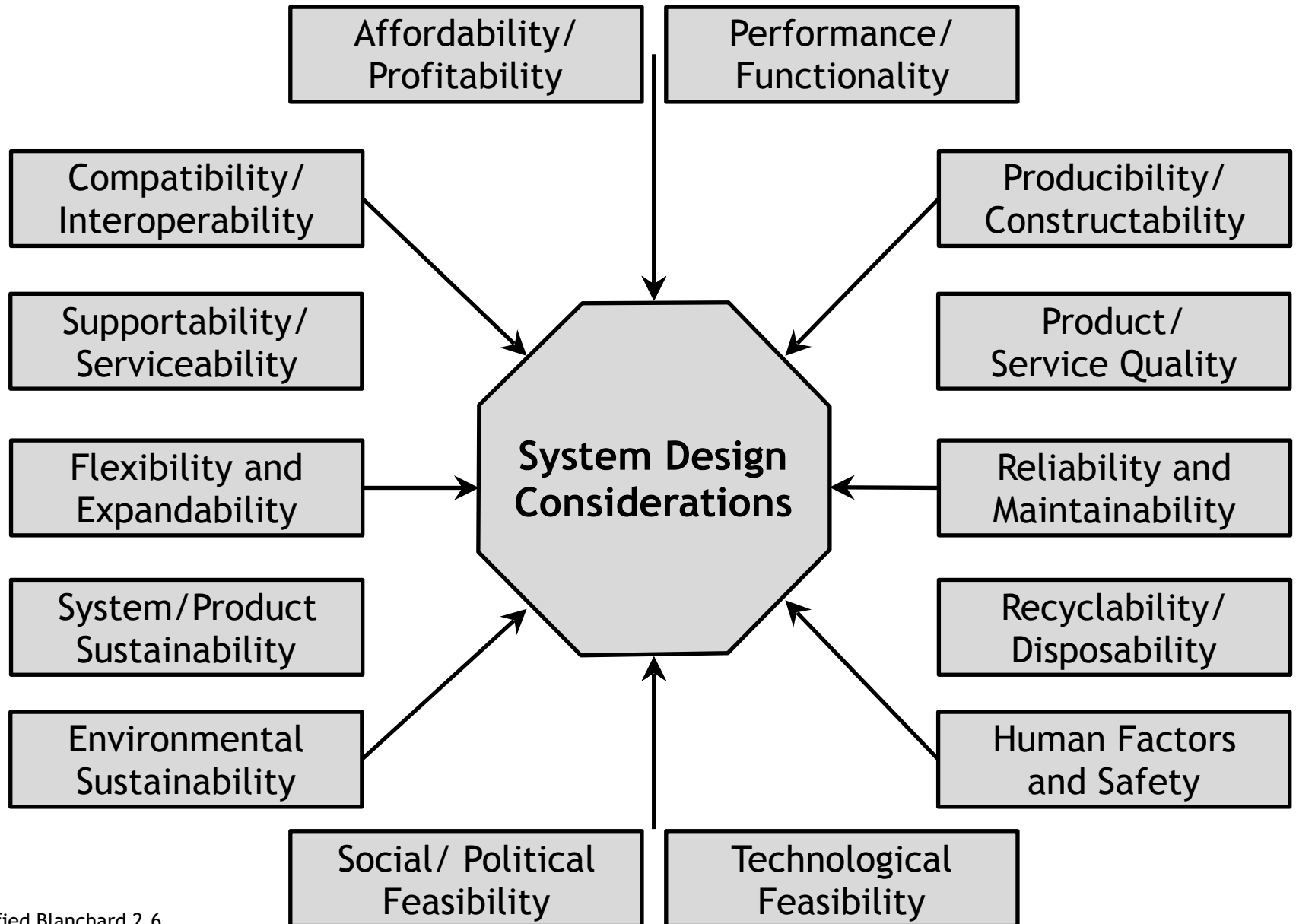
Methods for Quantitatively Measuring Requirements

- **Technical Performance Measures (TPMs)**
- **Measures of Performances (MOPs)**
- **Measures of Effectiveness (MOEs)**
- **What happens when a requirement is not put forth in a method that immediately lends itself to quantifications, e.g.,**
  - "to promote those products world wide" – products referring to breadfruit products
  - What are the options?
- **Why are quantitative measures better from a systems engineering perspective than qualitative measures?**
  - Consider the following
    - Formaldehyde is in your drinking water (qualitative statement)
    - Formaldehyde is in your drinking water at a concentration of less than 1 part per million (over 1000 times lower than the World Health Organization (WHO) than the safe level of formaldehyde in drinking water
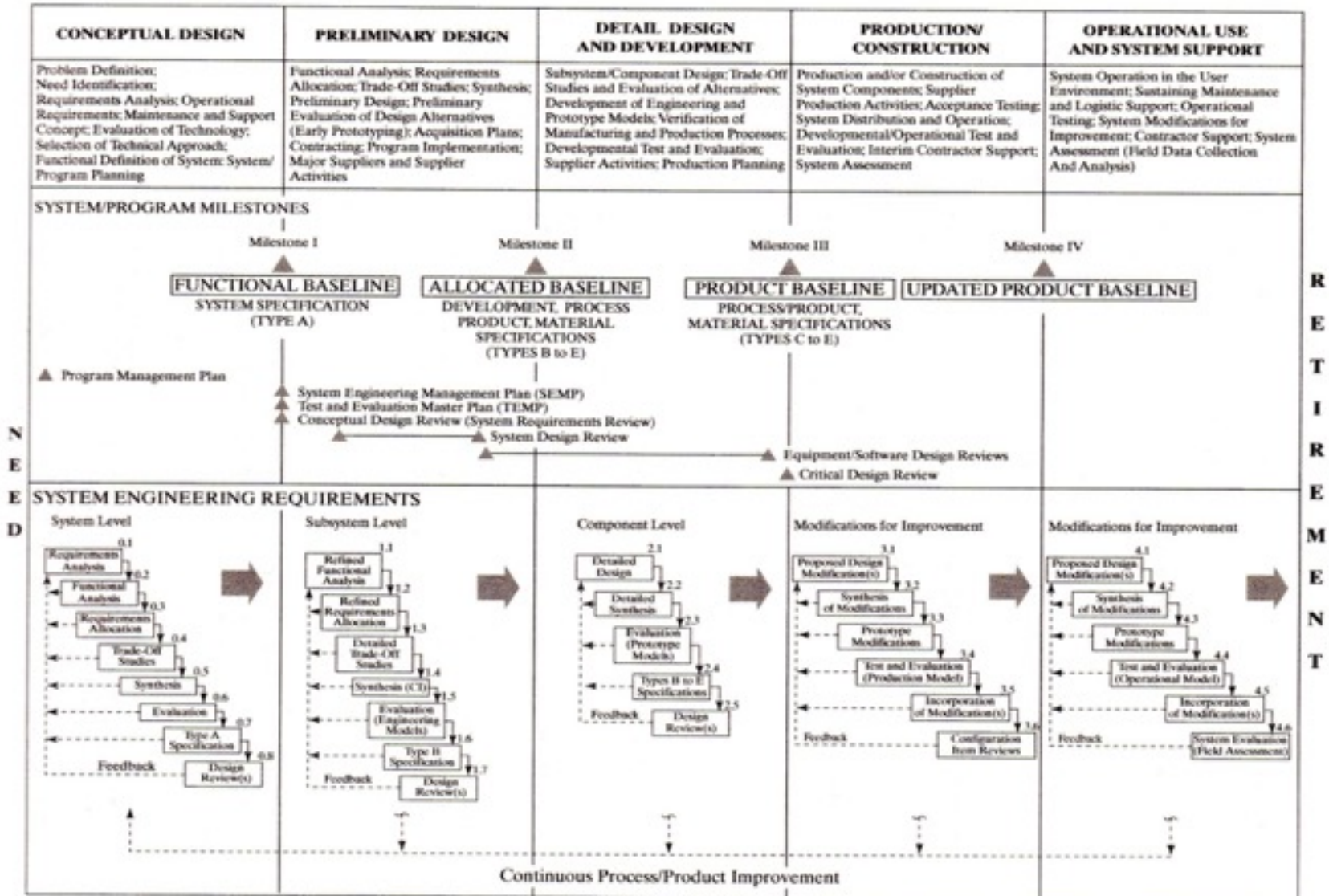
Verification of non-quantified Requirements

- **Not all requirements can be quantified, when requirements are not quantified, how are they verified?**
  - Qualitative requirements, in general, should be avoided. If it cannot be avoided, how the requirement is satisfied needs to be agreed upon in advance.
    - The equipment case shall be painted in a color pleasing to the eye
      - Customer will sign-off on selected color prior to paint of the equipment case.
- **In general making qualitative requirements into agreed upon quantitative requirements will reduce misunderstandings and enhance the potential for a successful outcome**

Requirements – System Design Considerations

Affordability/ Profitability

Performance/ Functionality

Compatibility/ Interoperability

Producibility/ Constructability

Supportability/ Serviceability

Product/ Service Quality

Flexibility and Expandability

System Design Considerations

Reliability and Maintainability

System/Product Sustainability

Recyclability/ Disposability

Environmental Sustainability

Human Factors and Safety

Social/ Political Feasibility

Technological Feasibility

Modified Blanchard 2.6

System Process Activities Over the Lifecycle

Blanchard figure 2.4

Prepare for wordy definitions….

Type A Specification (System/Subsystem Specifications)

- **This type of specification states the technical and mission requirements for a system/subsystem as an entity, allocates requirements to functional areas, documents design constraints, and defines the interfaces between or among the functional areas.**
  - Normally, the initial version of a system/subsystem specification is based on parameters developed during the Concept Exploration phase. This specification (initial version) is used to establish the general nature of the system that is to be further defined and finalized during the Demonstration and Validation phase. The system/subsystem specification is maintained current during the Demonstration and Validation phase, culminating in a revision that forms the future performance base for the development and production of the prime items and configuration items. The System/Subsystem Specification shall be prepared by the contractor and shall be in accordance with the format and content of the System/ Subsystem Specification Data Item Description (see 6.2).

From MIL-STD-490A Specification Practices
http://search.cpan.org/dist/Docs-US_DOD-STD2167A/lib/Docs/US_DOD/STD490A.pm#3.1.3.1_Type_A_-_System/subsystem_specification

Type B Specification (Development Specifications)

- Development specifications state the requirements for the design or engineering development of a product during the development period. Each development specification shall be in sufficient detail to describe effectively the performance characteristics that each configuration item is to achieve when a developed configuration item is to evolve into a detail design for production. The development specification should be maintained current during production when it is desired to retain a complete statement of performance requirements. Since the breakdown of a system into its elements involves configuration items of various degrees of complexity which are subject to different engineering disciplines or specification content, it is desirable to classify development specifications by sub-types. The characteristics and some general statements regarding each sub-type are given in the following paragraphs (see 6.2).

From MIL-STD-490A Specification Practices
http://search.cpan.org/dist/Docs-US_DOD-STD2167A/lib/Docs/US_DOD/STD490A.pm#3.1.3.1_Type_A_-_System/subsystem_specification

Type C Specification (Product Specifications)

- **Product specifications are applicable to any configuration item below the system level, and may be oriented toward procurement of a product through specification of primarily functional (performance) requirements or primarily fabrication (detailed design) requirements. Sub-types of product specifications to cover equipments of various complexities or requiring different outlines of form are covered in paragraphs 3.1.3.3.1 through 3.1.3.3.5.**
    - A product function specification states (1) the complete performance requirements of the product for the intended use, and (2) necessary interface and interchangeability characteristics. It covers form, fit, and function. Complete performance requirements include all essential functional requirements under service environmental conditions or under conditions simulating the service environment. Quality assurance provisions for hardware include one or more of the following inspections: qualification evaluation, preproduction, periodic production, and quality conformance.
    - A product fabrication specification will normally be prepared when both development and production of the HWCI are procured. In those cases where a development specification (Type B) has been prepared, specific reference to the document containing the performance requirements for the HWCI shall be made in the product fabrication specification. These specifications shall state: (1) a detailed description of the parts and assemblies of the product, usually by prescribing compliance with a set of drawings, and (2) those performance requirements and corresponding tests and inspections necessary to assure proper fabrication, adjustment, and assembly techniques. Tests normally are limited to acceptance tests in the shop environment. Selected performance requirements in the normal shop or test area environment and verifying tests therefore may be included. Preproduction or periodic tests to be performed on a sampling basis and requiring service, or other, environment may reference the associated development specification. Product fabrication specifications may be prepared as Part II of a two-part specification (See 3.1.4) when the contracting agency desires close relationships between the performance and fabrication requirements.

From MIL-STD-490A Specification Practices

http://search.cpan.org/dist/Docs-US_DOD-STD2167A/lib/Docs/US_DOD/STD490A.pm#3.1.3.1_Type_A_-_System/subsystem_specification

Type D Specification (Process Specification)

- This type of specification is applicable to a service which is performed on a product or material. Examples of processes are: heat treatment, welding, plating, packing, microfilming, marking etc. Process specifications cover manufacturing techniques which require a specific procedure in order that a satisfactory result may be achieved. Where specific processes are essential to fabrication or procurement of a product or material, a process specification is the means of defining such specific processes. Normally, a process specification applies to production but may be prepared to control the development of a process.

From MIL-STD-490A Specification Practices
http://search.cpan.org/dist/Docs-US_DOD-STD2167A/lib/Docs/US_DOD/STD490A.pm#3.1.3.1_Type_A_-_System/subsystem_specification

Type E Specifications (Material Specifications)

- This type of specification is applicable to a raw material (chemical compound), mixtures (cleaning agents, paints), or semi-fabricated material (electrical cable, copper tubing) which are used in the fabrication of a product. Normally, a material specification applies to production but may be prepared to control the development of a material..

From MIL-STD-490A Specification Practices

http://search.cpan.org/dist/Docs-US_DOD-STD2167A/lib/Docs/US_DOD/STD490A.pm#3.1.3.1_Type_A_-_System/subsystem_specification

Requirements Process

- **Inputs**
  - Source Documents
  - Stakeholder's needs
  - Project Constraints
- **Outputs**
  - Concept Documents
  - Stakeholder Requirements (threshold and objective)
  - Measures of Effectiveness Needs / Data
  - Validation Criteria
  - Initial Requirements Verification and Traceability Matrix (RVTM)
  - Stakeholder Requirements Traceability
  - System Boundary

Concept of …..

- Another way of looking at, thinking about, how the system will be used – ties to DoDAF.
- A scenario-based, textual description of "a day in the life of system X".
- A number of different views:
  - Concept of Production
  - Concept of Deployment
  - Concept of Operations
  - Concept of Support
  - Concept of Disposal

777 Project

- Boeing segment 1 5:00-14:30
- 21st Century Jet - Making the Boeing 777 3-5