ETLS 509 - Validation & Verification
University of St. Thomas

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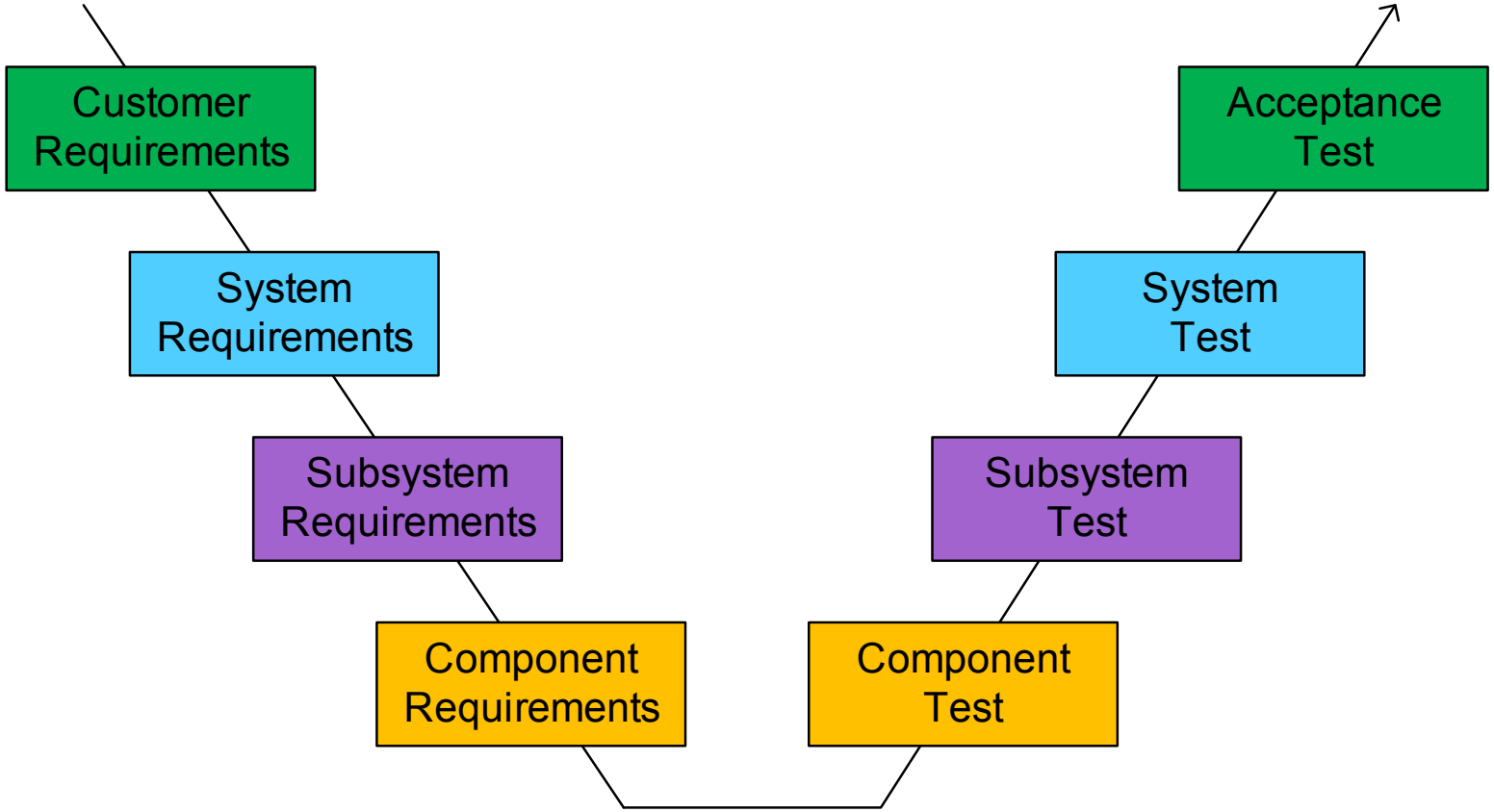
ETLS 509 - Session 3

- Review
- Validation process
- Verification process
- Example verification matrix (a small portion)
- Boeing 777 – example
- Medical Radiation Case Study (from last week)
- FBI Virtual Case File System Case Study (from last week)
- DoD - Test and Evaluation Master Plan Template outline
- California Test and Evaluation Master Plan – template outline
- Project time

ETLS 509 - Session 3

- **Validation / Verification**



Validation
paragraph 4.8.1.1 INCOSE

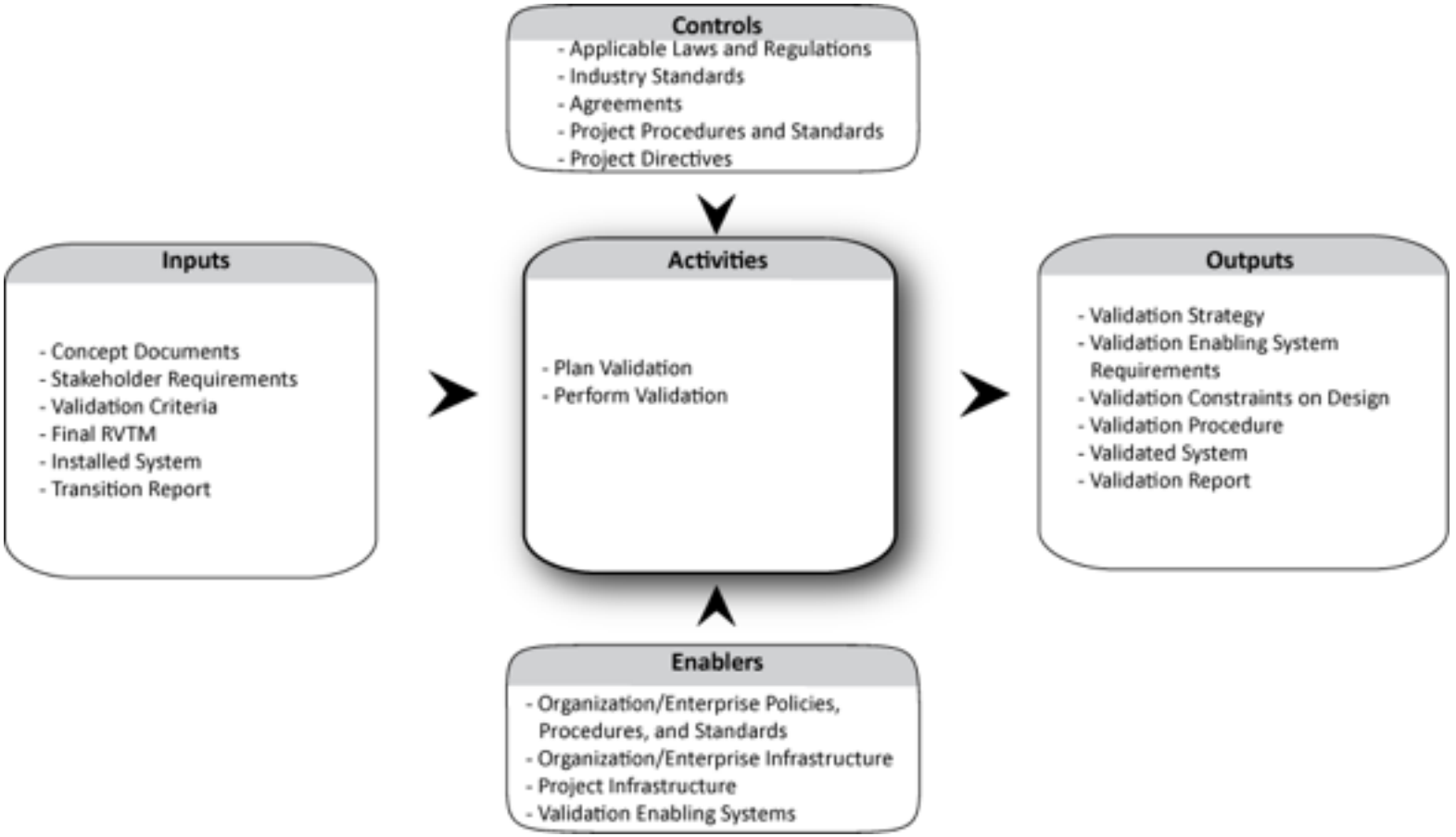
- **System Validation** - Validation is the confirmation, through the provision of objective evidence, that the **requirements for a specific intended use** or application have been fulfilled. With a note added in ISO 9000:2005: *validation is the set of activities that ensure and provide confidence that a system is able to accomplish its intended use, goals, and objectives (i.e., meet stakeholder requirements) in the intended operational environment* (ISO 2005).
- **Purpose:** ***The purpose of Validation is to provide objective evidence that the services provided by a system when in use comply with stakeholders' requirements, achieving its intended use in its intended operational environment.***

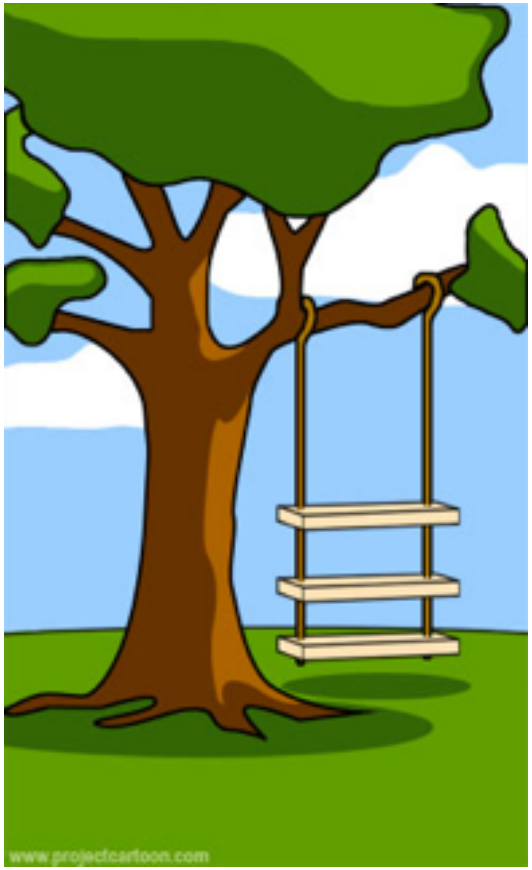
  This process performs a comparative assessment and confirms that the stakeholders' requirements are correctly defined. Where variances are identified, these are recorded and guide corrective actions. System validation is ratified by stakeholders.

  Bottom line – you built the right thing

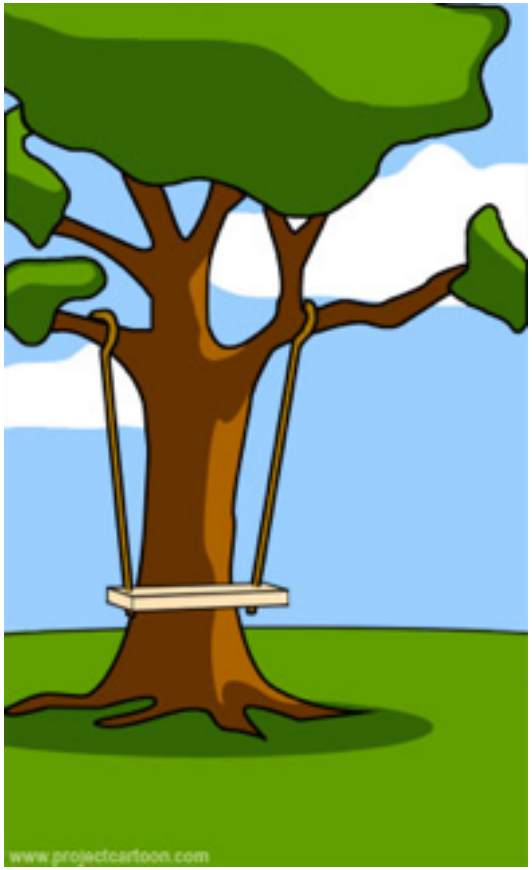
See Systems Engineering Body of Knowledge (SEBoK), section 4.8.1.1 INCOSE

Validation Process
Fig 4-17 in INCOSE



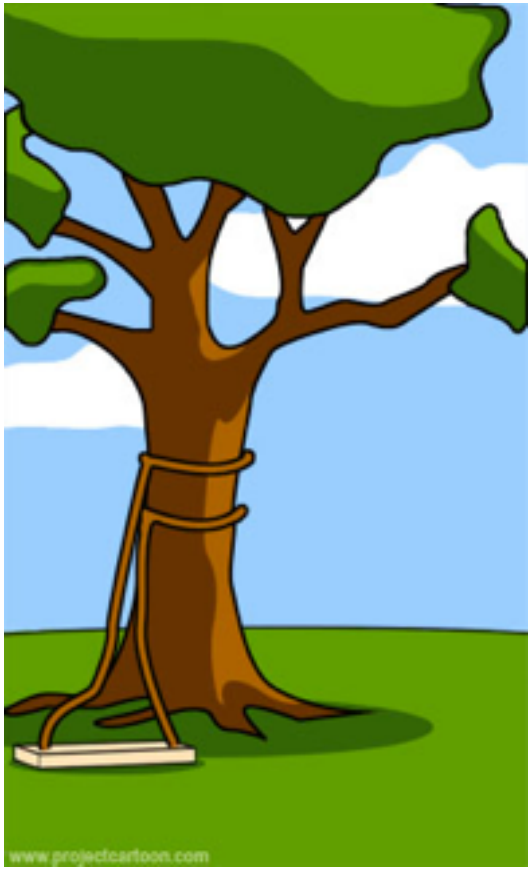


How the customer explained it



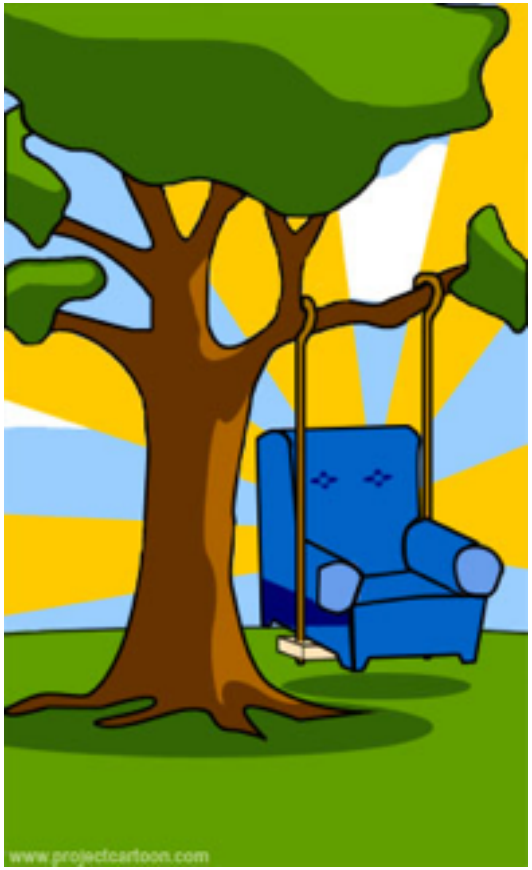
How the project leader understood it

How the analyst designed it

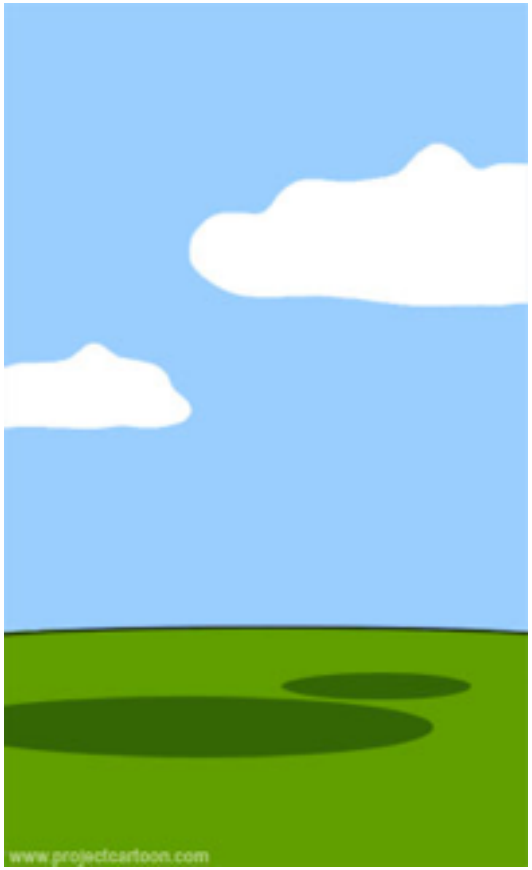


How the programmer wrote it

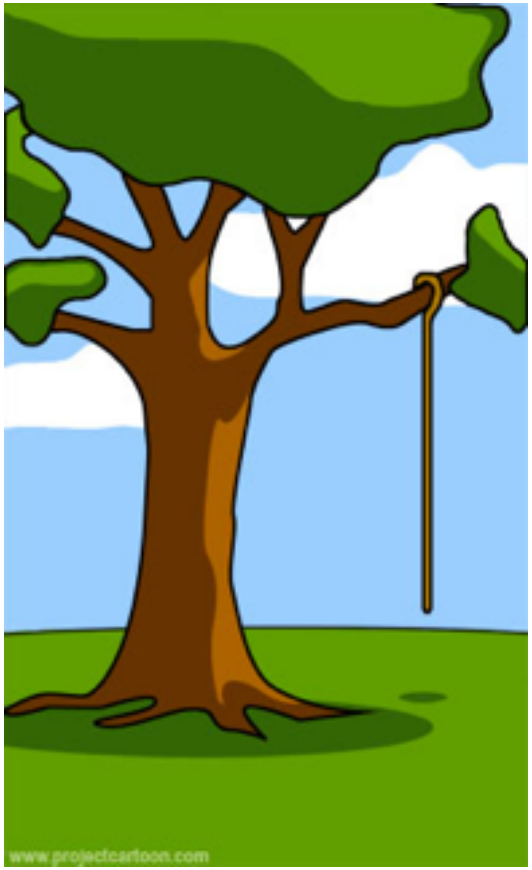
What the beta testers received



How the business consultant described it

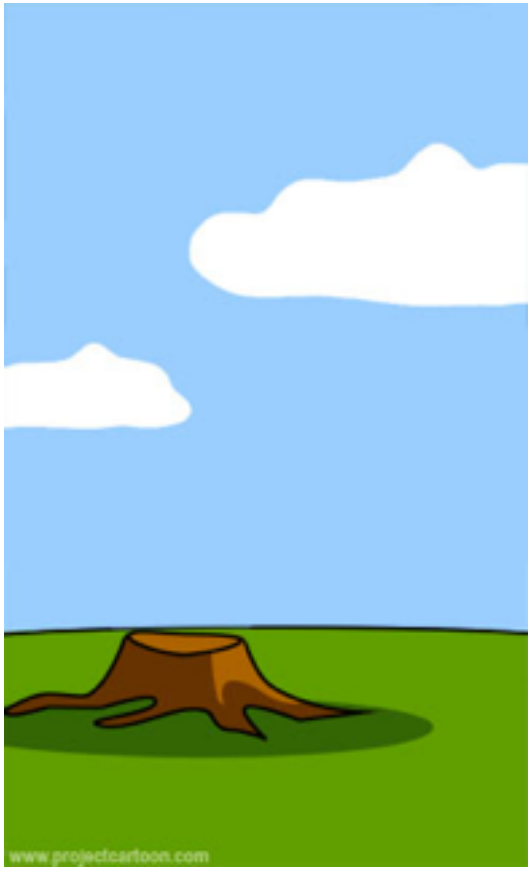


How the project was documented



What operations installed

How the customer was billed



How it was supported

What marketing advertised

What the customer really needed

This is why we do validation!!

http://www.projectcartoon.com/cartoon/2

Validation Process

- **Inputs – during the Stakeholder Requirements Definition Process**
  - Concept Documents
  - Stakeholder Requirements
  - Validation Criteria
- **Inputs – during the Verification and Transition Process**
  - Final Requirements Verification and Traceability Matrix (RVTM) – see example
  - Installed System
  - Transition Report
- **Outputs**
  - Validation Strategy
  - Validation Enabling System Requirements
  - Validation Constraints on Design
  - Validation Procedure
  - Validated System
  - Validation Report
- **Enablers**
- **Controls**
- **Process Activities**

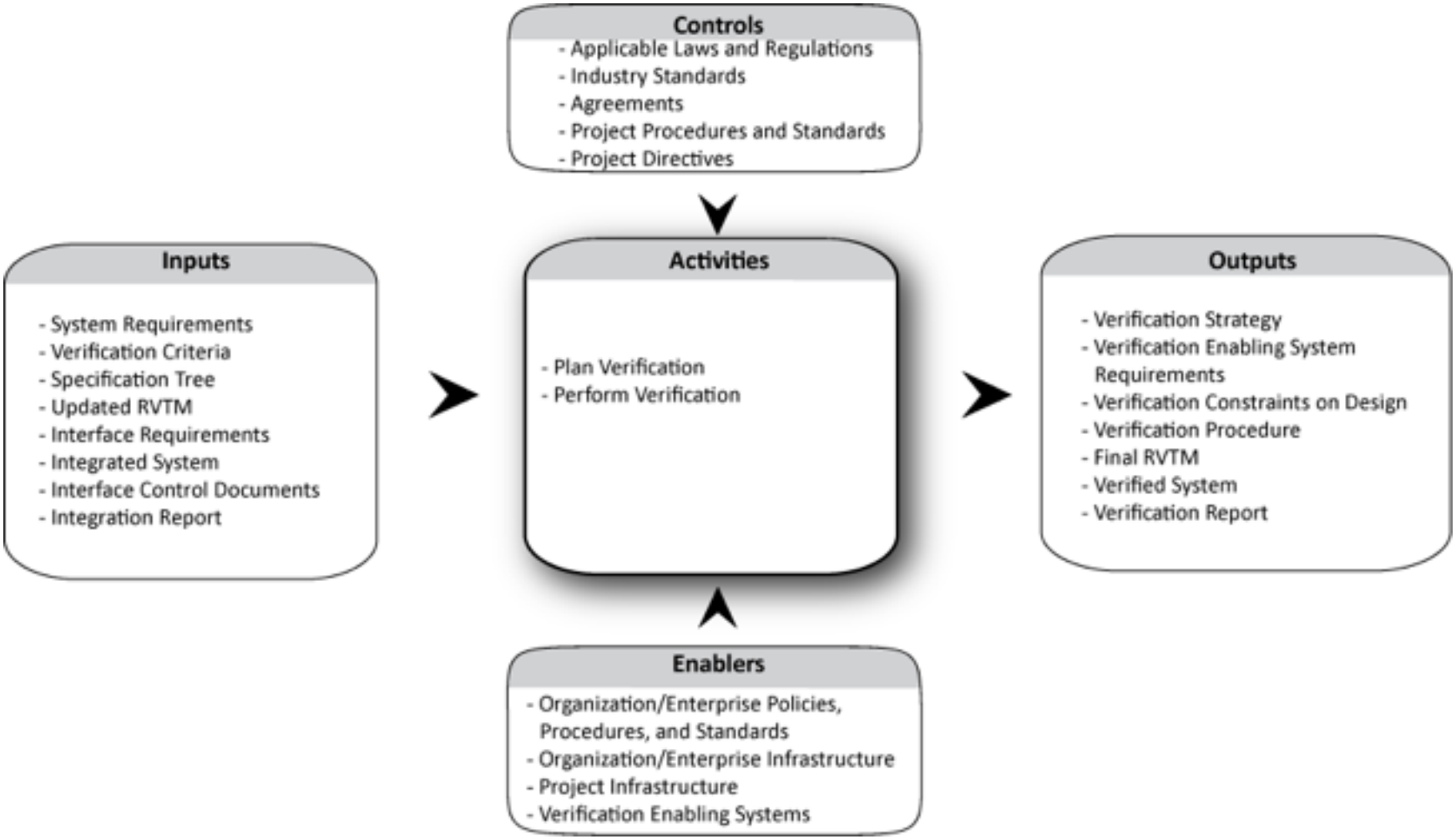
Validation Process

- **Measures of Effectiveness (MOEs)**
  - Measures how well a system in operation meets its intended goals
    - MOEs, are one of the best methods for quantifying the validation process. Metrics provide a quantitative method for determining if a system is meeting is objectives versus qualitative methods, e.g., asking someone “is this OK?”
- **Process Activities – 4.8.1.5 INCOSE**
  - Plan Validation – both after requirements are defined and after system built
    - Focus groups with stakeholders / users when requirements are complete
    - Use case review with stakeholders / users
    - Customer testing before final release / pilot runs
  - Perform Validation
  - Document Results

System Verification (from last week)

- **System Verification** - Verification is the confirmation, through the provision of objective evidence, that **specified requirements have been fulfilled**. With a note added in ISO/IEC/IEEE 15288, verification is a set of activities that compares a system or system element against the required characteristics (ISO/IEC/IEEE 2008). This may include, but is not limited to, specified requirements, design description, and the system itself.
  - From the Systems Engineering Body of Knowledge (SEBoK)

Verification Process
fig 4-14 INCOSE



Verification
paragraph 4.6.1.2 INCOSE

Purpose: *The Verification Process confirms that the system-of-interest and all its elements perform their intended functions and meet the performance requirements allocated to them. Verification methods include inspection, analysis, demonstration, and test and are discussed in more detail below. Verification activities are determined by the perceived risks, safety, and criticality of the element under consideration.*

The Verification Process works closely with other life cycle processes. A key outcome of the Planning Process is the creation of project procedures and processes that specify the forms of system assessments (e.g., conformation audits, integration, verification, and validation) in appropriate project documents (e.g., SEPs, schedules, and specifications). Specification of verification criteria takes place as the requirements are written, but the creation of a procedure to assess compliance is part of this process (Test & Evaluation Master Plan (TEMP). Figure 4-14 is the context diagram for the Verification Process.

Bottom line – you built the system right.

paragraph 4.6.1.2 INCOSE

Verification Inputs & Outputs

- **Inputs**
  - System Requirements
  - Verification Criteria
  - Spec Tree
  - Updated RVTM
  - Interface Requirements
  - Integrated System
  - Interface Control Docs
  - Integration Report
- **Outputs**
  - Verification Strategy
  - Verification Enabling System Requirements
  - Verification Constraints on Design
  - Verification Procedure
  - Final RVTM
  - Verified System
  - Verification Report

Verification Controls & Enablers

- **Controls**
  - Applicable Laws & Regulations
  - Industry Standards
  - Agreements
  - Project Procedures & Standards
  - Project Directives
- **Enablers**
  - Organization / Enterprise Policies, Procedures, and Standards
  - Organization / Enterprise Infrastructure
  - Project Infrastructure
  - Verification Enabling Systems

Verification Matrix

			Comply		Verification Phase			Verifiaction Method			
Requirement	Req ID	Subsystem	Y	N	D	Q	A	I	T	A	Comments
The contractor shall provide an automated toll collection solution for the bridges in the state of Euphoria.	1	Vehicle ID & Attribute	x		x	x	x	x	x	x	Model, simulate, and FAT the tolling system.
The system of systems shall operate 24 hours per day.	2	All Systems		x	x	x	x	x	x	x	Model, simulate, and FAT the system. Realistically, situations will arise that will not allow for 100% operational time.
The system of systems shall provide data on each vehicle that crosses a bridge in the state.	3	Vehicle ID & Attribute		x	x	x	x		x	x	Model, simulate, and FAT the system. Realistically, situations will arise that will not allow for 100% data collection.
The system of systems shall provide a health monitoring function, including structural sensors, equipment, and software that will be used to estimate the health of the bridges.	4	Bridge Health	x		x	x			x	x	Model and simulate the system. Simulation should include known varying degrees of bridge wear.

D-demonstration
Q-qualification
A-analysis

I-Inspection
T-test
A-analysis

777 Project

- **Boeing 777**
  - Staff – 10,000,
  - schedule – 5 years,
  - parts > 4 million
  - cost - $5 Billion
  - A major system development
- **The Boeing 777: A Look Back**
  - http://ftp.rta.nato.int/public/PubFullText/AGARD/CP/AGARD-CP-602/08CHAP05.pdf
- **21st Century Jet - Making the Boeing 777 2-5**
  - A 9:40 minute segment of the PBS Making the Boeing 777, all 5 one hour parts of this PBS special can be found at:
    - https://www.youtube.com/watch?v=0oyWZjdXxlw
- **What are the what validation / verification testing considerations for the 777?**

Case Studies

Requirements – what happens when it's wrong

- **Medical Radiation Case Study (Material from SEBoK v1.3)**
  - Radiation used in treating tumors
  - Atomic Energy of Canada (AECL) developed dual mode (X-rays or electrons) Therac-20 linear accelerator
    - Successful in clinical use
  - New development of Therac-25 integrated DEC (Digital Equipment Corporation) PDP-11 for command/control/user interface into the device
    - Software written in PDP-11 assembly code
    - Fault tree of Therac-25 did not include software
    - Testing was principally "integrated systems testing"
  - Operational use of Therac-25 resulted in multiple cases of radiation over exposure and multiple cases resulted in patient death
- **What went wrong?**

FBI Virtual Case File System Case Study

- **Following 9/11 there was a desire/urgent need for better sharing of information across the FBI (law enforcement in general)**
- **Money was no object, time was the only relevant factor**
  - Congress easily appropriated $380M for the FBI to create the virtual case file system. More funding would come.
    - The Trilogy Information Technology Modernization Program was created
      - Part 1 – update all 56 FBI field offices computer equipment
      - Part 2 – re-implement the FBI Intranet, LANs, etc.
      - Part 3 – Replace FBI's investigative software applications, including the obsolete Automated Case Support (ACS) system

FBI Virtual Case File System Case Study – cont.

- **FBI selected Science Applications International Corporation (SAIC) to develop the software applications**
  - Search all FBI databases without having prior knowledge of its location, with a single query through the use of search engines
  - Web-enable the existing investigative applications;
  - share information inside and outside the FBI;
  - provide access - both internal and external databases
  - Etc.
- **SAIC and the FBI committed to creating an entirely new case management system in 22 months**
  - No time to follow those pesky systems engineering practices, must code, code, code…
  - By the time VCF was canceled, there were over 700,000 lines of code along with and incomplete set of requirements documented in an 800-page volume
- **Your tax dollars at work** ☺

DoD - Test and Evaluation Master Plan Template - outline

PART 1 – INTRODUCTION 1.1 PURPOSE
1.2 MISSION DESCRIPTION
1.3 SYSTEM DESCRIPTION
1.3.1 System Threat Assessment
1.3.2 Program Background
1.3.2.1 Previous Testing
1.3.3 Key Capabilities
1.3.3.1 Key Interfaces
1.3.3.2 Special Test or Certification Requirements
1.3.3.3 Systems Engineering (SE) Requirements
PART II – TEST PROGRAM MANAGEMENT AND SCHEDULE
2.1 T&E MANAGEMENT
2.1.1 T&E Organizational Construct
2.2 COMMON T&E DATA BASE REQUIREMENTS
2.3 DEFICIENCY REPORTING
2.4 TEMP UPDATES
2.5 INTEGRATED TEST PROGRAM SCHEDULE
Figure 2.1 – Integrated Test Program Schedule (Modified)
APPENDIX D – DESIGN OF EXPERIMENTS

DoD - Test and Evaluation Master Plan Template - outline

PART III – TEST AND EVALUATION STRATEGY
3.1 T&E STRATEGY
3.2 EVALUATION FRAMEWORK
Reliability Growth (Moved from Section 3.8)
Design of Experiments (New Section)
Figure 3.1 – Top-Level Evaluation Framework Matrix
3.3 DEVELOPMENTAL EVALUATION APPROACH
3.3.1. Mission-Oriented Approach.
3.3.2 Developmental Test Objectives
3.3.3 Modeling and Simulation
3.3.4. Test Limitations
3.4 LIVE FIRE EVALUATION APPROACH.
3.4.1 Live Fire Test Objectives
3.4.2 Modeling and Simulation
3.4.3 Test Limitations
3.5 CERTIFICATION FOR CERTIFICATION FOR INITIAL OPERATIONAL TEST AND EVALUATION (IOT&E)
3.5.1 Assessment of Operational Test Readiness
3.6 OPERATIONAL EVALUATION APPROACH
3.6.1 Operational Test Objectives
3.6.2 Modeling and Simulation
3.6.3 Test Limitations
3.7 OTHER CERTIFICATIONS
3.8 DESIGN OF EXPERIMENTS
3.9 FUTURE TEST AND EVALUATION

DoD - Test and Evaluation Master Plan Template - outline

PART IV – RESOURCE SUMMARY
4.1 INTRODUCTION
4.1.1 Test Articles
4.1.2 Test Sites and Instrumentation
4.1.3 Test Support Equipment
4.1.4 Threat Representation
4.1.5 Test Targets and Expendables
4.1.6 Operational Force Test Support
4.1.7 Models, Simulations, and Test-Beds
4.1.8 Joint Operational Test Environment
4.1.9 Special Requirements
4.2 FEDERAL, STATE, LOCAL REQUIREMENTS
4.3 MANPOWER/PERSONNEL TRAINING
4.4 TEST FUNDING SUMMARY.
Table 4.1 Resource Summary Matrix
APPENDIX A – BIBLIOGRAPHY
APPENDIX B – ACRONYMS
APPENDIX C – POINTS OF CONTACT

California Test and Evaluation Master Plan – template outline

1. INTRODUCTION
1.1 PURPOSE
1.2 SCOPE
1.3 REFERENCES
1.3.1 Project WorkSite Repository
1.4 GLOSSARY AND ACRONYMS
1.5 DOCUMENT MAINTENANCE
2. PARTICIPANTS ROLES AND RESPONSIBILITIES IN TEST AND EVALUATION

2.1 PROJECT DIRECTOR
2.2 PROJECT MANAGER
2.3 TEST MANAGER
2.4 TEST MANAGER
2.5 TEST TEAM
2.6 QUALITY MANAGER
2.7 INDEPENDENT VERIFICATION AND VALIDATION

California Test and Evaluation Master Plan - template outline

3. TEST STRATEGY AND METHOD

3.1 UNIT TESTING

3.2 FUNCTIONAL TESTING

3.3 INTEGRATION TESTING

3.4 SYSTEM TESTING

3.5 INTERFACE TESTING

3.6 PERFORMANCE/STRESS TESTING

3.7 REGRESSION TESTING

3.8 USER ACCEPTANCE TESTING

3.9 PILOT TESTING

California Test and Evaluation Master Plan – template outline

4. EVALUATION CRITERIA
5. INCIDENT MANAGEMENT
6. REQUIREMENTS TRACEABILITY MATRIX
7. REVIEW AND APPROVAL PROCESS
8. TEST RESOURCES
9. TEST SCHEDULE
10. TEST PLAN TEMPLATE
11. TEST CASE REPORT
12. TEST LOG
13. INCIDENT TRACKING LOG
14. CORRECTIVE ACTION PLAN (CAP):
15. TEST SUMMARY REPORT
16. APPENDICES

APPENDIX A : TEST PLAN
APPENDIX B : TEST CASE REPORT
APPENDIX C : TEST LOG
APPENDIX D : INCIDENT TRACKING LOG
APPENDIX E : CORRECTIVE ACTION PLAN (CAP)
APPENDIX F : TEST SUMMARY REPORT