Systems Engineering, AS9100 and Testing

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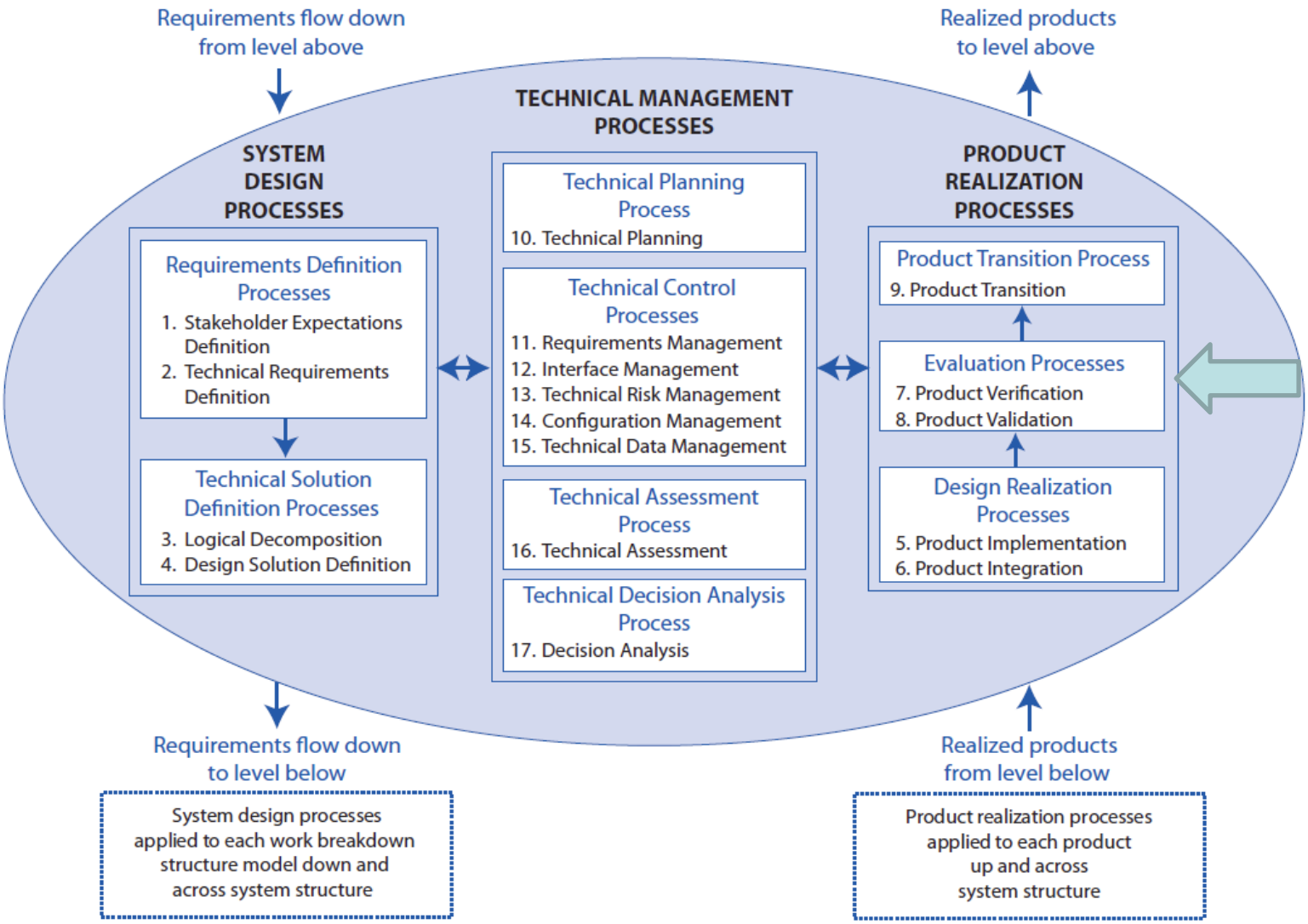
Learning Objectives

- Objective 1: Systems Engineering (SE) Processes
  - Defined by NASA PR 7123.1
- Objective 2: How SE processes are implemented by the testing organization
- Objective 3: Relationship of SE Processes to AS9100
- Objective 4: Implications for Quality Management Systems for testing
- Objective 4: Involvement beyond test article inspection
- Objective 5: Improving effectiveness, and reducing risk

Systems Engineering Processes



NPR 7123.1

Product SE Process

- Most people are familiar with the SE processes applied to a product
- Top level requirements defined by stakeholders (e.g. Congress)
- Agencies and contractors further define details
- Design, acquisition, production, assembly, test, delivery
- Technical management

Space Shuttle Main Engine

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Evaluation Processes (7&8, “V&V”)

- In order to prepare a test facility for validation of a *product*, the SE Processes are performed by the testing organization *on the facility.*
- Process Complexity varies depending on
  - Level (Integrated systems, system, subsystem, component, subscale, etc.)
  - Phase (development, V&V, qualification, acceptance)
  - Type of test (flight, “hotfire”, wind tunnel, combined environments)

Stennis A-1 Test Stand

KSC Shuttle Launch Pad

MSFC Advanced Engine Test Facility

Vandenburg AFB SLC-6 Space Shuttle

SE Processes for a Test Facility

- Customer provides a Test Requirements Document
- Detailed Test Parameters defined
- Test engineers break down (decompose) requirements into facility systems
- Test organizations and customers determine whether to modify, or build new facilities
- Testing organization
  - designs,
  - builds hardware
  - prepares infrastructure
  - programs computers
  - establishes and activates support systems (design solution, product realization)

SE Processes at a Test Facility

- Test facility systems are installed and connected (mechanical, control and instrumentation)
- Test facility systems' configuration is verified
- Test facility systems are tested, checked-out, validated

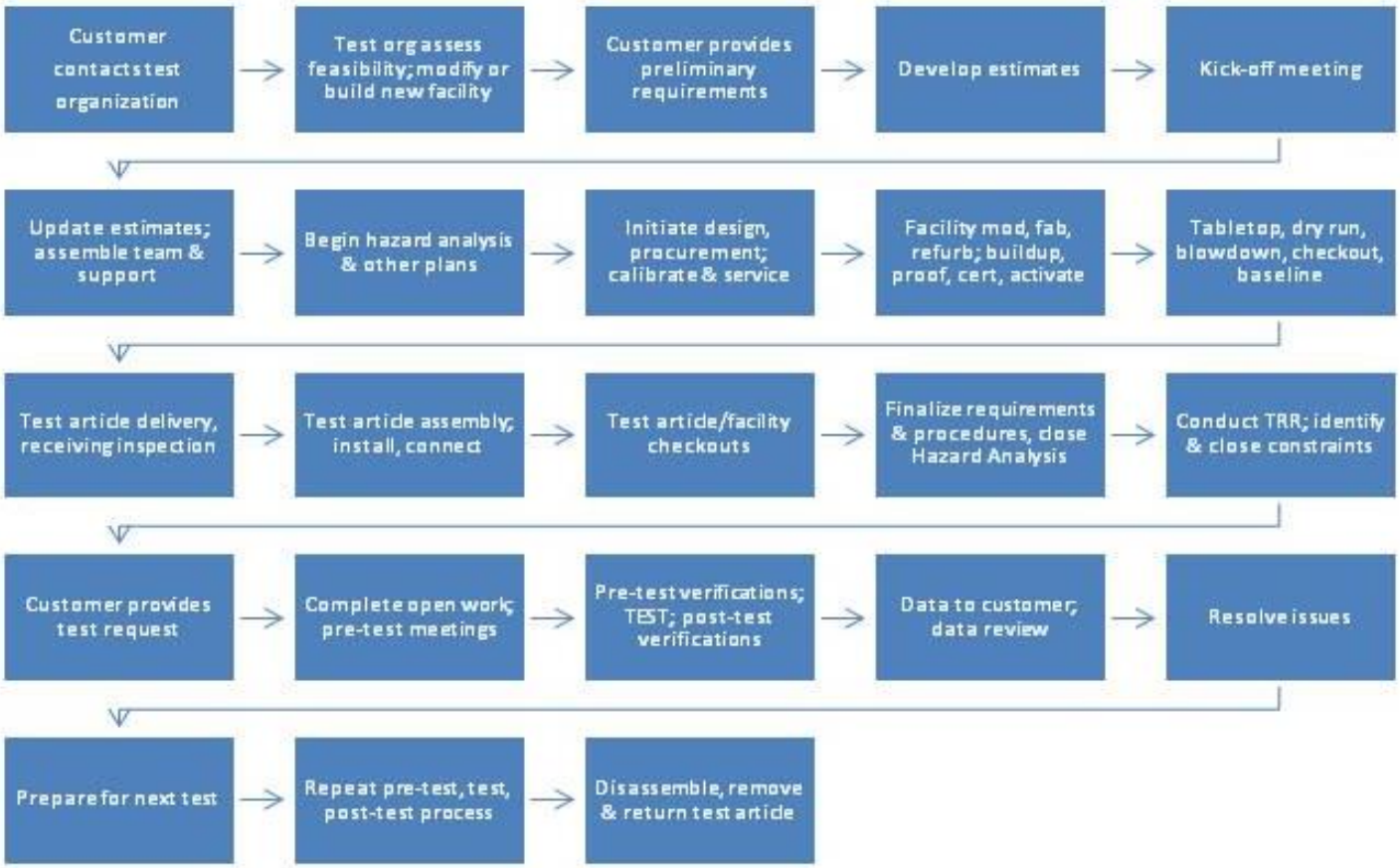
MSFC Test Stand 116
J2-X Gas Generator

SE Processes at a Test Facility

- Depending on the complexity, the Technical Management Processes can be a major activity
  - Technical Planning
  - Management of Requirements
    - Customer, AS9100, OSHA, ISO 14001, technical, policy, etc.
  - Configuration of facility and facility/test article interface
    - Work is often done in parallel
  - Risk Management
  - Data Management
  - Design Reviews, Operational Reviews, Readiness Reviews, Hazard Analysis

MSFC Dynamic Test Stand
Space Shuttle Mated Vehicle
Ground Vibration Test

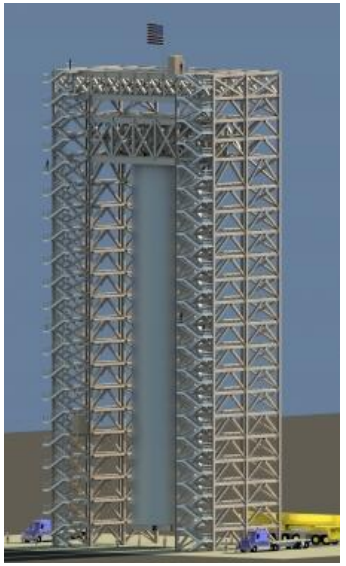
Test Project Process Flow



Much of the process between kickoff and TRR is done in parallel.
Technical planning meetings, reviews and assessments are scheduled as required.

Why is this Important?

- Test facilities have to be safe, reliable
- Achieved in part by compliance with industry codes and standards
  - Stringent design and quality requirements, configuration control, accept/reject criteria (you meet code or you don't)
- Mechanical, control and instrumentation systems have to communicate, and also communicate with the test article
- All systems must have configuration control
- Work authorizing documentation, planning
- Hazard analysis is based on code compliance, configuration control



Artist Concept: MSFC Test Stand 4693
Planned for SLS LH2 Tank

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Why is this Important?

- Multitude of Critical Processes
  - Precision cleaning, field cleaning, contamination prevention
  - Calibration
  - Assembly operations; mechanical, electrical
  - FOD Control
  - Valve and component servicing
  - Welding, weld inspection and NDE
  - Transportation and handling
- Multitude of Safety Considerations
  - Hazardous operations: explosive devices, propellants, high pressure, confined spaces, etc.
  - Safety and quality are often inseparable
- Multitude of Interfaces

KSC Ares-1X Flight Demonstration

SE and AS9100

MSFC Solid Propulsion Test Facility
MNASA 48” Motor

SE PROCESS	AS9100 REQUIREMENT
Stakeholder Expectations	Customer Requirements
Technical Requirements Definition	Planning of Product Realization
Logical Decomposition	Design and Development Input
Design Solution Definition	Design and Development Output
Product Implementation	Control of Production
Product Integration	Control of Production
Product Verification	Verification
Product Validation	Validation
Product Transition	Control of Work Transfers; Post Delivery Support, Preservation of Product
Technical Planning	Planning of Product Realization; Review of Requirements; Measurement, Analysis and Improvement
Requirements Management	Design and Development Planning; Purchasing
Interface Management	Configuration Management
Technical Risk Management	Risk Management
Configuration Management	Configuration Management; Identification and Traceability; Control of Nonconforming Product
Technical Data Management	Control of Documents; Control of Records; Control of Design and Development Changes
Technical Assessment	Design and Development Review
Decision Analysis	Measurement, Analysis and Improvement; Analysis of Data

Typical QA Functions at a Test Site

- Test Article Inspections
- Procedure Approval
- Surveillance of handling and testing
- Discrepancy Reports
- Audits

Super Guppy at MSFC
Cryogenic Composite Tank

How Can QA Support SE/Testing?

- Develop and manage a relevant, effective QMS*
- Technical Planning
  - Design, plan, prevention, problem solving
- Quality Requirements for Procurements
  - Test operations, hardware, software
- Critical Processes
  - Process improvements, compliance
- V&V of the Facility
- Risk Management
  - Identify, mitigate, control
- Design Reviews & Readiness Assessments
  - Work the issues before TRR
- *Requires in-depth understanding of SE processes applied to testing and various critical processes required to prepare the facility.

MSFC Structural Test Facility; Aluminum Lithium Test Article

Caveats

- If you wait till the test article is delivered, you won't understand the rest of the activities.
- Development and "V&V" tests can cost millions of dollars and be a significant risk to the programs; don't ignore them.
- The actual test is often run by computers; don't ignore test data.
- Don't write a manufacturing QA Plan for a test site

MSFC T-Tower; Saturn 1B

“Take-Aways”

- By understanding SE Processes, SE Processes applied to testing, and how it all maps to AS9100, the Quality Professional can contribute to test projects by:
  - Improving *effectiveness* of the Quality Management System
  - Reducing risk
  - Enhancing safety and sustainability
  - Supporting cost, schedule and technical management
  - Improving the auditing process
  - Improving contract requirements

References

- MPR 7123.1*MSFC Systems Engineering Processes and Requirements;* https://dml.msfc.nasa.gov/directives/component/main?__dmfClientId=1407509929413
- NPR 7123.1 *NASA Systems Engineering Processes and Requirements;* http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7123&s=1B
- SAE AS9100 *Quality Management Systems-Requirements for Aviation, Space and Defense Organizations;* 2009, SAE International; http://www.sae.org