Quality / Systems Engineering Interfaces to Enhance Program Success

National Defense Industrial Association
9th Annual Systems Engineering Conference
October 23-26, 2006

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Acknowledgment

Boeing Integrated Defense Systems volunteered to support the initial development of this work to provide an industry perspective. As such, Boeing was the source of much of the original input to the analyses as well as a sounding board for initial results. Boeing's contributions are greatly appreciated; they were vital to the development of the product.

Outline

- **How quality impacts technical risk**
- **Involving quality early**
- **Encouraging a quality focus**
- **Incorporating quality in the systems engineering technical reviews**
- **Concluding remarks**

Quality Matters

V-22 Osprey story

USS Thresher story

Firestone tire story

Flaw Could Shorten Raptors' Lives
The News Herald, Panama City, Fla. May 3, 2006

"Officials discovered that the titanium components [of the forward boom frames] may have been improperly treated, creating the possibility that the metal would not last as long as it is supposed to. … This is not a result of improper design, but an issue with one supplier's manufacturing process."

therefore • • •

Industry Has Adopted a New Paradigm for Quality

- **Quality is no longer limited to a centralized functional organization for:**
  - **Auditing / compliance with standards (certification)**
  - **Implementation of a quality management system**
  - **Inspections / searching for defects**

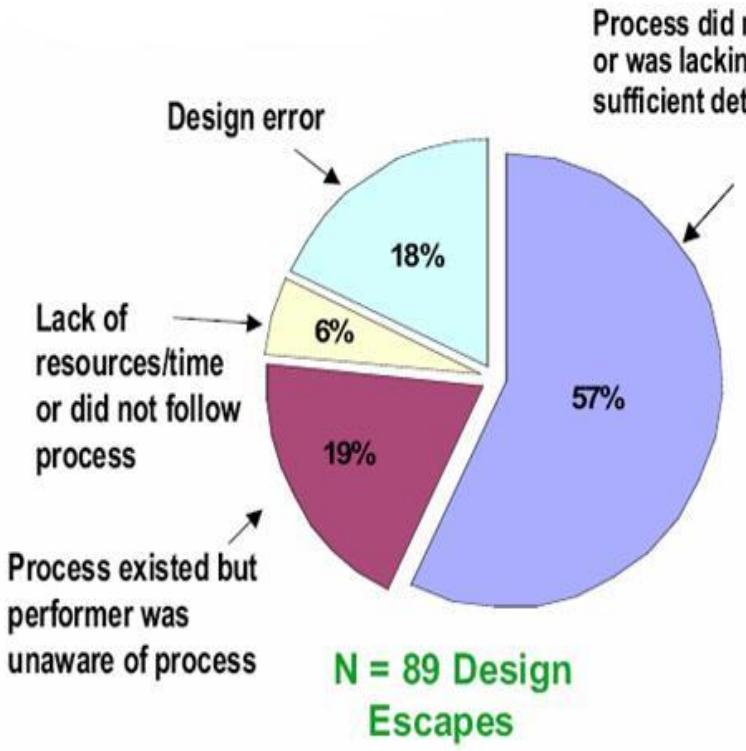
- **Today, quality engineers/SMEs are typically matrixed to a product or project early in development**
  - **Valued member of IPTs**
  - **Closely linked with a company's process improvement initiatives**
  - **Assess if processes are working as designed using objective criteria**

Process carelessness leads to technical risk

Risks that Quality Identifies and Mitigates

Quality engineers/SMEs identify situations	. . .	*that may lead to potential risks to be mitigated*
– Inappropriate application of technical processes and/or inadequate procedures		– Ill-defined requirements, a breakdown in requirements flow down, or uneconomically producible designs
– Ineffective supplier management		– Suppliers with inadequate capabilities; decreasing leverage with subtiers
– Ineffective customer engagement		– Dissatisfied customers
– Unidentified verification technologies		– Undetected product defects

Analyses Show Prevalence of Process-Based Risks



Summary Root Causes

- Lack of clear standard design process
- Insufficient process compliance accountability and enforcement requirement
- Ineffective design reviews

Root cause analysis showed 82% of design escapes attributed to "no established process" or "process non-compliance"

Presented by Lisa Kohl
Vice President, Northrop Grumman Space Technology
Lean Aerospace Initiative Plenary Conference
23-24 March 2004

Why are these Risks Important?

- **If not managed and mitigated, these risks may start a chain of events resulting in undesirable outcomes**
  - **Product defects discovered in production or testing lead to expensive and time-consuming rework**
  - **Product may not meet customer needs**
  - **Product failures discovered in the field lead to degraded mission effectiveness or mishaps**
- **The later these risks are identified, the greater the cost of corrective action and the greater the delays in schedule**

Early identification, management, and mitigation of important process-based risks to a program leads to less expensive and less disruptive preventive actions that break the chain of events

Best Practices for Reducing Process-Related Risk to a Program

- Early Quality involvement with the product line to ensure that processes are implemented correctly
- Create conditions that encourage the entire workforce to focus on quality along with cost, schedule, and performance
  - Clear, unambiguous and visible commitment from management
- Develop strong linkages between the quality engineers/SMEs on the product or project and the SE technical reviews

DoD should encourage industry to apply these best practices and follow them consistent with its oversight responsibilities

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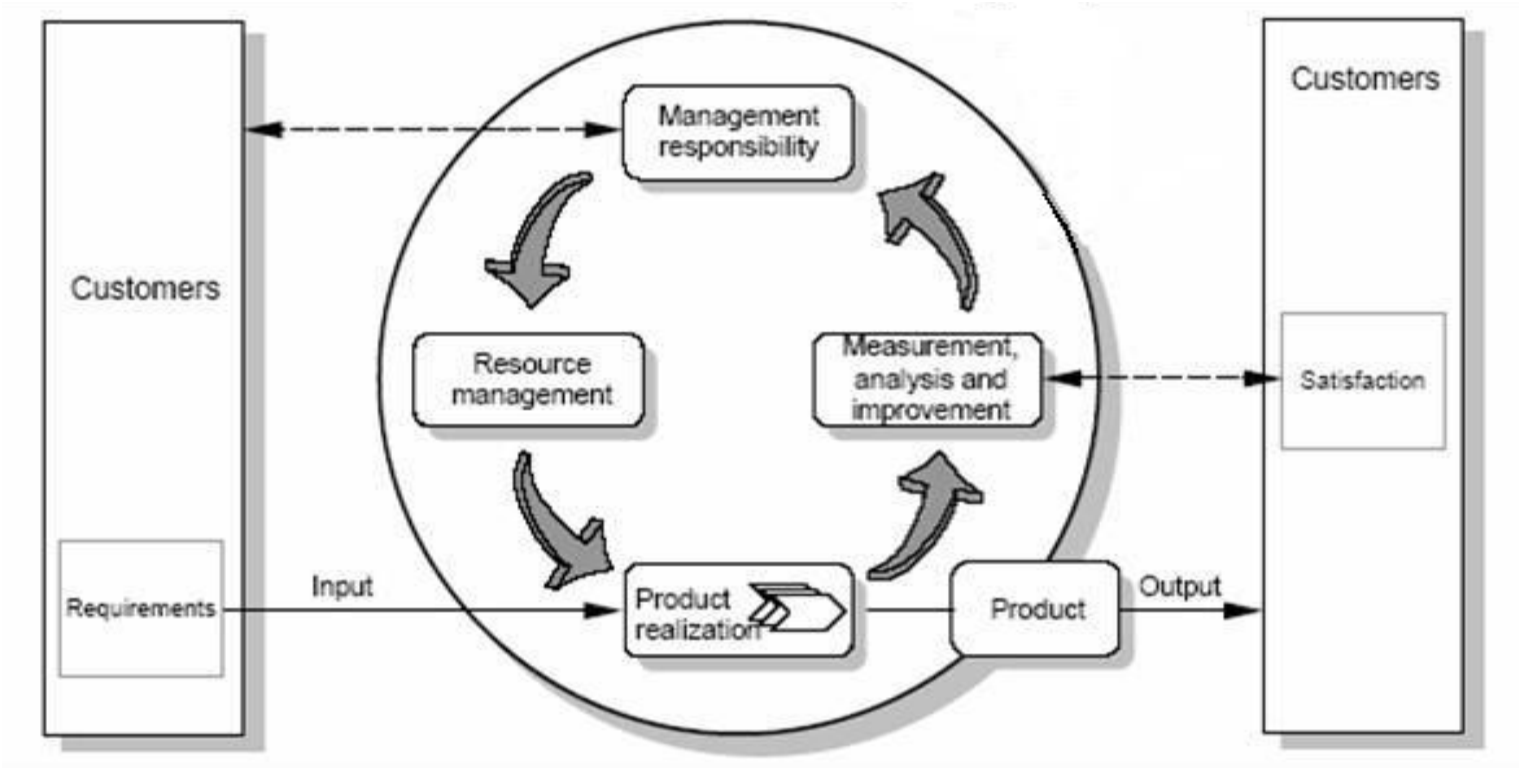
Early Quality Involvement (slide 1 of 3)

- A "process approach" is the identification, interaction, application, and management of a system of processes over the life cycle
- Quality engineers/SMEs involvement means implementing processes correctly in order to
  - Understand and meet requirements
  - Evaluate processes in terms of value added
  - Obtain results of process performance
  - Improve performance based on objective measurement

Don't wait for production before engaging Quality;
Don't delay interactions until there is a problem

Early Quality Involvement (slide 2 of 3)

ISO's Model of a Process Based QMS



Early systematic use of a process based quality management system (QMS) improves outcomes

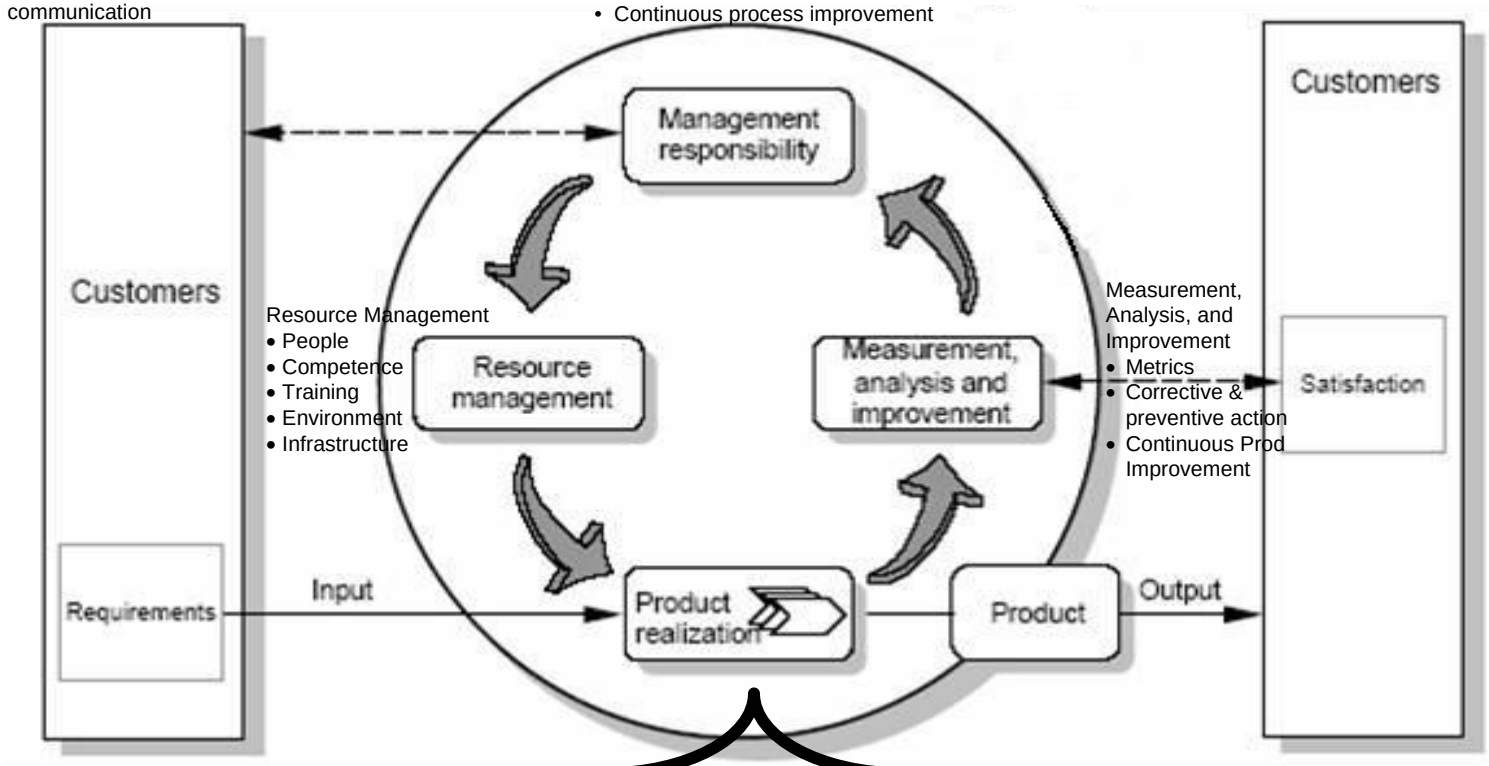
Early Quality Involvement (slide 3 of 3)

A Process Based QMS's Interactions with a Program

Customer Requirements
- Product requirements documentation
- Program cost and schedule performance data
- Formal customer communication

Management Responsibility
- Management Review
- Quality policy
- Customer focus
- Risk, issue & opportunity mgmt
- Program Independent Analysis
- Continuous process improvement

Customer Satisfaction
- Customer Reporting
- Training System
- Publications
- Post delivery support



Resource Management
- People
- Competence
- Training
- Environment
- Infrastructure

Measurement, Analysis, and Improvement
- Metrics
- Corrective & preventive action
- Continuous Prod Improvement

Systems Engineering
- Prod Reqts Alloc
- Allocation, verification & validation plan
- Configuration, data, risk mgmt

Software Engineering
- Design
- Integration
- Code
- Testing

Integrated Product Definition
- Design
- Specialty Engineering
- Support Functions

Product Support
- Performance based logistics
- Field support requirements

Test Engineering
- Test reqts
- Test planning
- Test conduct
- Reports

Supplier Management and Procurement
- Purchasing process
- Purchase order reqts
- Purchase process verification

Manufacturing Engineering
- Manufacturing and inspection work instructions
- Producibility
- Work flow

Manufacturing Product
- Fabrication
- Assembly

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Encourage Quality Focus (slide 1 of 3)

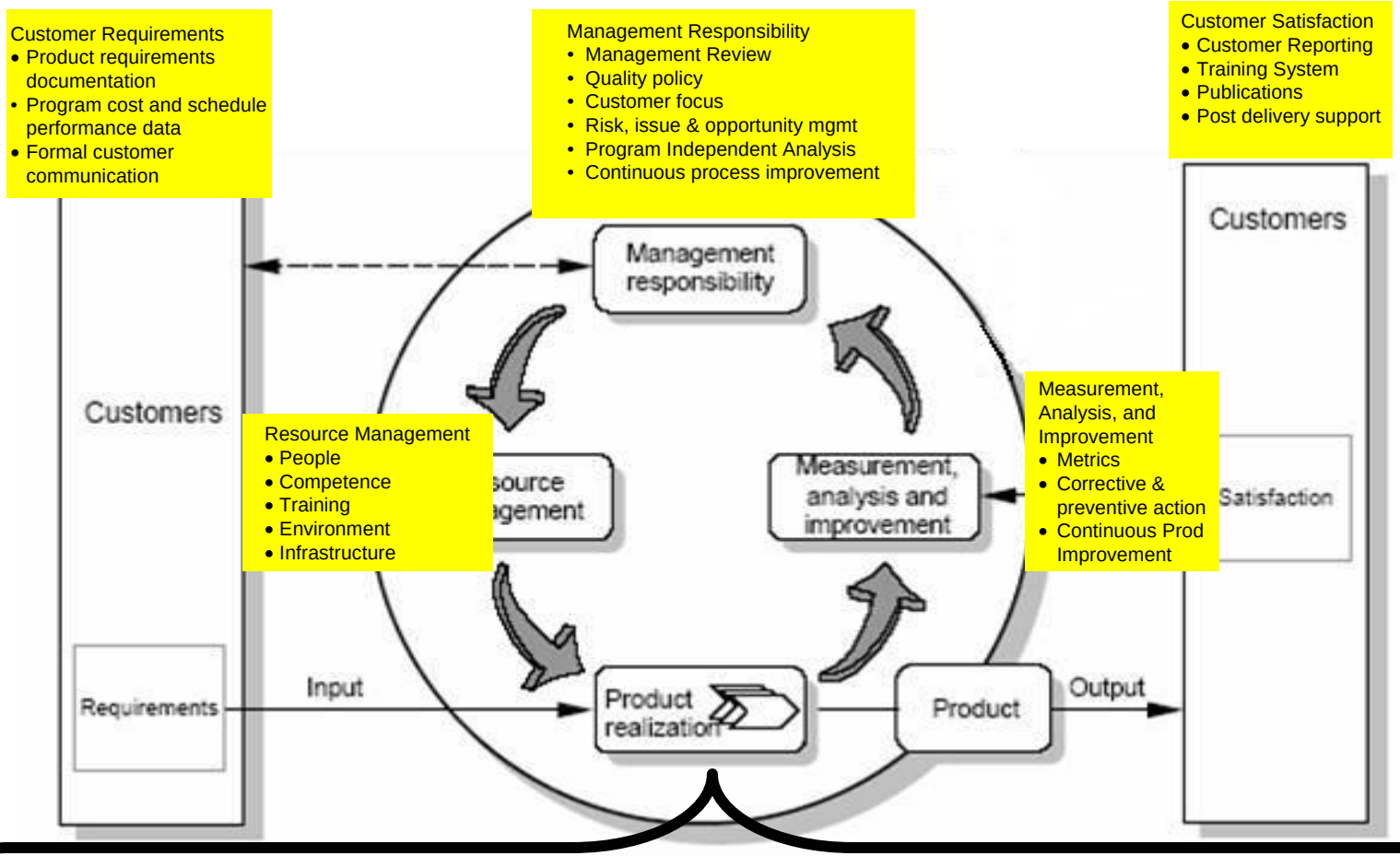
- ***Values*** **are ideas or things accepted as good, desirable, and important as codified by policy and guidance**
  - **Example: "nothing goes out the door if it's not done right"**
- ***Beliefs*** **are what people really think**
  - **Example: people do not ask penetrating questions in meetings to avoid elevating issues**
- ***Behaviors*** **are what the workers really do**
  - **Example: due to schedule or cost pressures, workers draw conclusions from incomplete or inadequate data thereby accepting, ignoring, underestimating, or hiding risks**

Avoid mismatches among values, beliefs and behaviors

Adapted from David Leetsma, Manager Advance Planning Office, Johnson Space Center, as presented to the 2006 Conference on Quality in the Space and Defense Industries

Encourage Quality Focus (slide 2 of 3)

Emphasis in the ISO Context



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Encourage Quality Focus (slide 3 of 3)

Understand/Evaluate Key Practices

- ***At Program Startup***
  - **The process for establishing the product or project Quality budget**
  - **Where Quality responsibility is placed in the program**
  - **How quality skills have been assigned to the project**
  - **The process for analyzing quality requirements and mitigating associated risks**
  - **The quality strategy's consistency with industry best practices**
- ***Throughout the Life Cycle***
  - **How management uses quality data**
  - **The contractor's approach for continuous process improvement**
  - **The contractor's approach for preventive and corrective action**
  - **The contractor's approach for achieving customer satisfaction**

DoD should encourage and participate with industry to apply effective practices in these areas

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Develop Strong Linkages to the SE Technical Reviews (TRs) (slide 1 of 5)

- **The purpose of these reviews is to provide the program manager with an integrated technical assessment of program technical risk and readiness to proceed to the next technical phase of the effort**
- **Process-based technical risks affect readiness to transition**
  - **System engineers develop, manage and execute processes**
  - **Quality engineers independently assess if they are working as designed**

Develop Strong Linkages to the SE TRs (slide 2 of 5)

Sharper Focus on Product Realization

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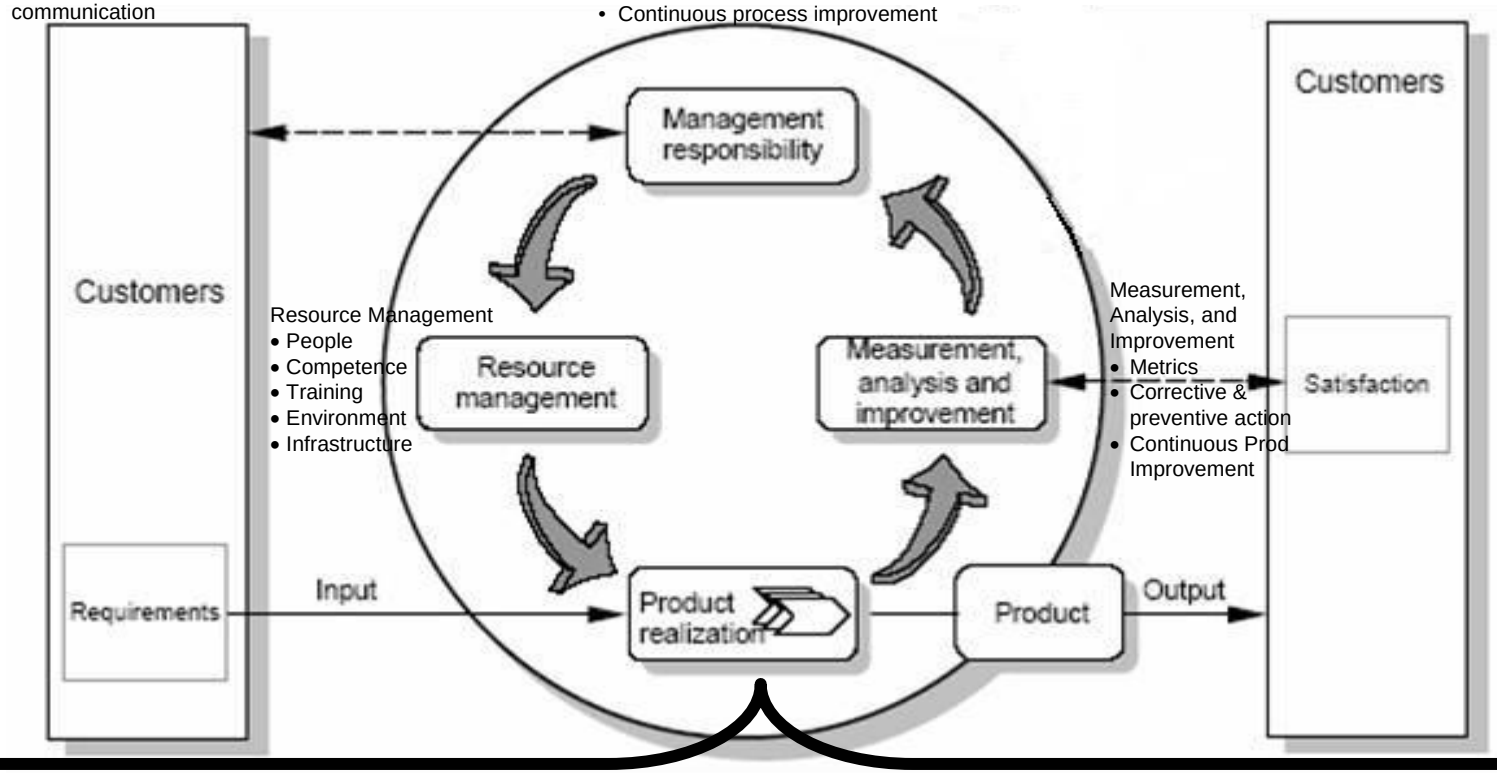

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Develop Strong Linkages to the SE TRs (slide 3 of 5)

Best Practices Check List Process Description

- **Quality engineers/SMEs at the prime should:**
  - **Tailor quality questions for each component of the product realization process to the specific situation for the technical review**
  - **Pose the questions to the quality teams at the prime contractor and the principal subs during their technical reviews**
  - **Assign a red-yellow-green indicator to reflect an assessment of the situation based on the answer to each question**

Develop Strong Linkages to the SE TRs (slide 4 of 5)

Red-Yellow-Green Indicator Example

Legend:	R	Y	G	U	NA		
1. Customer						**Comments/Mitigation**	**Criteria**
Has the local DCMA been involved and or briefed on program reviews, (for example have they been activiely involved, and/or participating in PMR, SRR, PDR's and FAI's etc.)?							**Green -** Involved & Integated **Yellow -** briefed, little involvement **Red -** No Involvement
If GSI is required, is there delegation in place?							
Does the program have a customer contact plan?							**Green** - working to Plan **Yellow** -no documented Plan **Red** - No plan
Are Boeing Supplier Quality Source Reps (PQA) identified and engaged?							**Green** - frequent visiit and engaged **Yellow** - not engaged on specific program **Red** - Not identified and or engaged
Is the program measuring customer satisfaction? How Often?							**Green** - feedback is avaialble on a routine basis **Yellow** - inconsistent **Red** - no measurement
2. Design for Producibility							
Has Quality has been established in the Design review process							**Green** - Yes **Red** - No
Are verifications and acceptance criteria being incorporated into the design							**Green** - is yes **Red** - is No
3. SVR/FAI							
Has the SVR been incorporated into the master schedule and identified as a major milestone							**Green** - Tier I thru Tier II or III schedules to support **Yellow** - no tier II, III schedule to backup major milstone accomplishment **Red** - not

Develop Strong Linkages to the SE TRs (slide 5 of 5)

Best Practices Check List Process Description cont'd

- **Situation should be summarized at prime's technical review with the DoD program office**
  - **Summary could be done using the eight categories of the product realization process**
  - **Further aggregations may be made, e.g.,**
    - **Product development**
    - **Software development**
    - **Verification and validation**
    - **Supplier management**
    - **Manufacturing**
  - **Utilize a red-yellow-green scale**
    - **Judgment is needed**
    - **Aggregation should be based on organizational needs, program complexity, etc.**
  - **Mitigation actions underway (if needed) should also be presented**

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Summary

- **Quality engineers / SMEs help identify and mitigate process-based technical risks to a project**
- **Industry should involve quality early in a project's life cycle**
- **DoD should encourage and participate with industry on the application of effective practices to encourage a quality focus throughout a project's life cycle**
- **Quality engineers / SMEs at the prime contractor should summarize the status of the product realization process at systems engineering technical reviews**

Next Steps

- **Further refinement through government review**
  - **Being circulated among members of Quality Advisory Group**
- **Further refinement through industry review**
  - **NDIA Quality Assurance Committee members**
  - **AIA Quality Assurance Committee**
  - **MMA suppliers**
- **Incorporate into Defense Acquisition Guidance**
  - **How quality impacts technical risk, involving quality early, establishing quality focus material to be incorporated into new Quality Management Section (11.3.3)**
  - **Incorporating quality in the systems engineering technical reviews to be incorporated into section 4.5 on SE Execution: Key SE tools and techniques**

Factors behind "encourage quality focus" evaluation areas

The Process for Establishing the Product or Project Quality Budget

Example evaluation considerations:

- **Project quality administration, product verification, quality engineering (hardware and software), quality planning, and supplier quality**
- **Specific quality deliverables**
- **Capital, equipment, and software verification needs**
- **How the estimates are modified when there are changes to the strategy and/or scope of the program**
- **Measurement technology needs**

Where Quality Responsibility is Placed in the Program

Example evaluation considerations:

- **Role in the general risk identification, classification, and mitigation process**
- **Involvement in the design change control and release process**
- **Role in processing waivers, deviations and engineering change proposals**
- **Representation on Integrated Process Teams and boards (e.g., change control board, risk) for all product and process development activities**
- **Involvement in test plans, material reviews, design reviews, build/buy/support to packages**
- **Participation in the integration of inspection points into processing and test documentation**
- **Role in the supplier management, development, incentivization, and control process**

How Quality Skills Have Been Assigned to the Project

Example evaluation considerations:

- **The process to identify the need for quality management, quality engineering (hardware and software), quality planning, supplier quality, and product verification skills across the life cycle**
- **The process to identify quality skills and any associated certifications and qualifications**
- **The process for addressing quality staffing ratios and skill shortfalls**

The Process for Analyzing Quality Requirements and Mitigating Associated Risks

Example evaluation considerations:

- **The process for identifying and achieving quality tasks in support of contract deliverables**
- **How a post award contract analysis for Quality's tasks was performed / has been updated**
- **An evaluation of how the Quality plan matches the program requirements and their integration across program sites, IPTs, partners and suppliers**
- **How quality activities factored into the Integrated Master Plan and Integrated Master Schedule**

The Quality Strategy's Consistency with Industry Best Practices

Example evaluation considerations:

- **The use of lessons learned**
- **How similar programs' quality past performance have been reviewed**
- **How the quality plan addresses program unique processes**
- **How plans include verification approaches, nonconformance handling, operator verification manufacturing self-examination, nondestructive inspection, manufacturing systems, measurement approach, special measuring and test equipment**
- **Adequacy of the quality plan to address all other program plans (manufacturing, systems engineering, subcontract management, delivery, …)**
- **Periodic review and update**
- **Early involvement in the program**

How Management Uses Quality Data

Example evaluation considerations:

- **Audit needs and addressing audit findings**
- **The process for analyzing and performing trend analysis of internal/external audit findings**
- **How quality is defined, measured, analyzed, controlled, and used to drive management decisions and actions on the program**
  - **The process for developing and identifying requirements for quality metrics and measurement systems**
  - **The system for monitoring supplier performance, including their product development activities**
  - **The process for review and update**

The Contractor's Approach for Continuous Process Improvement

Example evaluation considerations:

- **Baldridge business model**
- **CMMI**
- **Lean**
- **Six sigma**
- **ISO recertification**
- **Actions taken to address feedback from assessments performed**

The Contractor's Approach for Preventive and Corrective Action

Example evaluation considerations:

- **The process for addressing test and inspection findings and discrepancies**
- **The process for addressing supplier nonconformances**
- **Establishment and maintenance of a closed loop corrective action system that includes the reporting, root cause analysis, and implementation of actions necessary to correct and preclude recurrence of problems, failures, quality issues, defects/nonconformances**
- **The process for using lessons learned to drive continuous improvement**

The Contractor's Approach for Achieving Customer Satisfaction

Example evaluation considerations:

- **The process to collect, monitor, and analyze information for measuring customer satisfaction**
- **The process to rapidly mitigate customer concerns**
- **The process to communicate with customers at all levels**
- **The process / organizational structure for reacting to customer inquiries and needs**

Extract from SE TR Questions
Systems Engineering

- **Determine/evaluate the process for identifying, allocating, and documenting product requirements including safety and environmental requirements**
- **Determine/evaluate the configuration management approach for hardware**
- **Describe/evaluate how verification plans are being developed for new products and manufacturing/measurement processes**
- **Describe/evaluate how trade studies been completed, and are incorporated into the design baseline**
- **Identify and assess the overall Risk Management Program and determine if it is adequately documented**

Extract from SE TR Questions
Software Engineering

- **Determine/evaluate the processes and equipment for performing software unit testing, integration testing, software qualification, regression testing, and operational testing**
- **Determine/evaluate the software acceptance process for assuring deliverable software complies with contractual requirements, and that all discrepancies and nonconformances are properly documented and resolved**
- **Determine/evaluate the processes, procedures, and tools for performing software quality assurance, software quality assessments, verification, validation, configuration control, metrics, management review, audits, etc.**
- **Determine/evaluate the process for determining the quality requirements for non-deliverable software**
- **Determine/evaluate the root cause analysis and corrective action process for software quality issues**

Extract from SE TR Questions
Integrated Product Definition

- **Describe/evaluate the verification plans for "non-tooling" concepts (e.g., determinant assembly, self locating parts, etc.); describe/evaluate how verification is accomplished**
- **Describe/evaluate the process for integrating the verification requirements into the work instructions**
- **Describe/evaluate the process that identifies key characteristics (i.e., the features of a material, process, or part whose variation has a significant influence on product fit, performance, service life, or producibility)**
- **Determine/evaluate the process for integrating verification requirements and key design characteristics**
- **Describe/evaluate the process for design evolution**

Extract from SE TR Questions
Product Support

- **Describe/evaluate any field support requirements for quality (hardware/software)**
- **Determine/evaluate if there are any post-production considerations or topics, such as spares, technical bulletins, support equipment, modifications/retrofit that must be considered**
- **Describe/evaluate any training requirements for quality such as simulators**

Extract from SE TR Questions
Test Engineering

- **Determine/evaluate the plan and process for conducting verification and validation including those accomplished for Spares, Kits and Support Equipment**
- **Describe/evaluate the processes to validate that tests adequately assess the requirements such as interface definition and control**
- **Describe/evaluate the contractual test plan requirements, if applicable**
- **Describe/evaluate how verification and test plans were developed concurrently with the design**

Extract from SE TR Questions
Supplier Management and Procurement

- **Describe/evaluate the process for defining and flowing down to suppliers the quality requirements, special processes, tools, design criteria and specifications**
- **Describe/evaluate how quality requirements are incorporated into supplier Statements of Work (SOW) and Supplier Data Requirements Lists**
- **Determine/evaluate the process being used to transfer work to other sites and to define the quality requirements for this work**
- **Describe/evaluate any partnering arrangements with other suppliers/customers that impact quality (hardware/software)**
- **Describe/evaluate how the program utilizes the company's preferred supplier certification process**

Extract from SE TR Questions
Manufacturing Engineering

- **Describe/evaluate the configuration management (including change control) process**
- **Describe/evaluate the current documented Geometric Dimensioning and Tolerancing (GD&T) approach (Common datums being utilized, and datum management)**
- **Describe/evaluate the program approach for verifying that prescribed manufacturing methods have produced an item conforming to engineering drawings, planning, purchase order, engineering specifications and/or other applicable design documents**
- **Describe/evaluate the process for validation and periodic verification of production tooling**
- **Describe/evaluate the process for determining the capability of processes and measurement systems (e.g., Process Capability, Measurement Systems Analysis, SPC); Describe/evaluate the mitigation plan, if applicable**

Extract from SE TR Questions
Manufacturing Product

- **Determine/evaluate the process for identifying, documenting and segregating nonconforming materials**
- **Determine/evaluate the process for identifying and controlling purchased items awaiting test and inspection, those which have been accepted, those which have been rejected, and those awaiting material review action**
- **Describe/evaluate tests and inspections used as a basis for government acceptance of contract end items and the Acceptance Test Procedure process**
- **Describe/evaluate the program for the control of limited-life items in production and storage areas**
- **Determine/evaluate the adequacy and implementation of test and inspection procedures**