Closed Loop Requirements and Analysis Management

Michael Lamoreaux
Brett Verhoef

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Propulsion Systems is leading an effort to improve our requirements and verification and analysis data management processes by integrating them into TcUA (Teamcenter, Teamcenter Unified Architecture)

Expected benefits:

- Facilitates getting the right data to the right person at the right time to make the right decision
- Facilitates proper documentation of analysis inputs
- Enables integrated change management
Outline

- Orbital ATK Strategic PLM Vision
- Requirements and Analysis Interactions
- Current Condition
- Target Condition
- Stakeholder Needs
- Solution Architecture
- Solution Validation Testing
Orbital ATK Strategic PLM Vision

- End-to-end program management in TcUA
- Reuse data in later project phases, enter data once and reuse multiple times
- Interrelate data elements to allow integrated change management
Focus for this presentation is on managing interactions between requirements and verification data management and analysis data management.

Types of requirement/analysis interaction:
- Concept development
- Requirement derivation
- Design verification
- Analysis scope definition
- Change management
- MRB evaluation.

These interactions are not independent of each other. Data from one interaction should be leveraged and sometimes reused for other interactions.
Current Condition

- Interactions between requirements and analysis are not as well coupled as desired
  - Requirement inputs into analysis are often verbal with little or no documentation
    - This includes design development requirements and verification requirements
  - Changes to requirements are often not communicated to analysts
  - Analysts are typically not closely involved in the requirement definition process
  - Analysis feedback to requirements is likewise often verbal with little or no documentation
- Data management
  - Data management for requirements and verification utilizes TcSE
  - Analysis data management has a wide range of implementations
    - Typically files/data are stored on hard drives or shared network drives
    - Formal ePIC documentation typically limited to customer deliverables
  - Connections between analysis and requirements are typically either managed manually in TcSE or only through human memory
Some of the challenges associated with the current condition are as follows:

- **Greater risk of miscommunication**
  - Verbal communication relies on human memory
  - Greater risk of misinterpretation without ability to refer to written communication for clarification
  - Can result in inconsistency between desired and actual analysis results. Even if this inconsistency is discovered it would still drive rework.

- **Greater risk of data loss**
  - Inconsistent data management techniques can inhibit data retrieval
  - Data may be inadvertently lost during hardware migration or personnel turn-over
  - Can result in unnecessary rework

- **Greater risk of data inaccessibility**
  - Difficult to perform complete impact evaluation, often rely on human memory
  - Analysts do not have direct access to requirements data
  - Systems engineers to not have direct access to analysis data
Target Condition

- Manage requirement and analysis data in the same system (TcUA)
- Interconnect related data through database relations (example: trace links)
- Document analysis inputs through soft release/hard release processes
- Engineering processes that drive communication and interaction between systems engineering and analysts

Benefits:

- Decreased risk of miscommunication
  - Documented inputs into analysis process
  - Document outputs from analysis process
- Decreased risk of data loss.
  - TcUA database is backed up and protected during hardware migration
  - User data in TcUA is not loss during personnel turn-over
- Decreased risk of data inaccessibility
  - Accessibility via database relations between data elements
Stakeholder Needs

- Stakeholder needs gathered to allow TcUA architecture development and evaluation
- For this paper the focus was on the needs relating to requirement/analysis integration
- User needs (generalized):
  - Systems engineer (req & verif) needs:
    - Accessibility* of analysis data:
      ◦ Analysis inputs
      ◦ Assumptions/simplifications
      ◦ Type of analysis performed
      ◦ Applicable tools
      ◦ Detailed results
      ◦ Summarized results
    - Apply problem report to requirement and analysis data elements

* Accessibility is about providing the right data to the right person at the right time to make the right decision
Stakeholder Needs (cont.)

- User needs (generalized, cont.):  
  - Analysis engineer needs:  
    - Accessibility of the engineering analysis request (EAR)  
    - Accessibility of the requirements model  
    - Input stability (soft release/hard release)  
    - Change visibility  
  - Design engineer needs:  
    - Accessibility of applicable requirements  
    - Accessibility of verification objectives  
    - Accessibility of analyses
Solution Architecture – Design Development

- Stakeholder Need
- External Requirement
- ATK Performance Req
- Qual Design
- Design
- ATK Design Rules
- ATK Internal Standards
- ATK External Standards
- ATK Design Rules
- ATK Internal Standards
- ATK Performance Req
- Test Procedure Results
- Test Compliance Results
- Requirements Analysis
- Design Verification
- Design Validation
- Test / Demonstration / Hardware Inspection

These derived design req are for internal DE design control/validation. In general req may be reused in more than one specification and at more than one level if the derivation drives the need.

Validation Req are setup by the Designer to connect IPT/DE specified constraints to the NX Model. If a later change to the NX Model by the same Designer or a different one invalidates one of these constraints NX will tell them.

Illustrated with NX, similar configuration for CATIA, Solid Works, and PRO-E.
Solution Architecture – Req Derivation

Diagram showing the relationship between Engineering Management, Systems Engineer, ATK Internal Standards, Stakeholder Need, External Requirement, ATK Performance Req, Design Development Req, and additional nodes with connector labels and traceability links.
Database Relations

- Investing time in creating/maintaining relations pays off in the long run
  - Data is readily accessible to support engineering processes
  - Enables effective change management
Engineering Analysis Request

- Investing time in planning analysis before execution is consistent with PES continuous improvement process
- Analysis results will be applicable for the intended use the first time*
- Deliberate decision about input maturity minimizes unnecessary analysis iterations

* “There is never enough time to do it right the first time, but there is always enough time to do it over.” - anonymous
Solution Architecture – Design Verification
Illustrated with NX. Similar configuration for CATIA, Solid Works, and PRO-E.

The analyst would form these relations for convenient reference.

Compliance statements created by IPT/DE and linked to verification objectives with the compliance statement data populated by the analyst.
Solution Validation Testing

- iDev testing (individual development environment on virtual machine)
  - Primarily tested by engineers developing the requirements and analysis data management architectures
  - Work out details of requirement/analysis interactions
  - Validate the concept prior to deployment to development server

- Development server testing
  - Involvement of key supporters from several different sites
  - Involvement of systems engineers and analysts
  - Validate that solution works with multiple users
  - Validate accessibility of data to users
  - Get early feedback from users on the progress of the solution architecture
Case Study 1: Simple Timing Tolerance Analysis

- **Input:**
  - Dummy customer requirement for FTS S&A safe timing

- **Objectives:**
  - Demonstrate an analysis performed by systems engineer using spreadsheet
  - Demonstrate derivation of requirements through analysis
  - Demonstrate iteration of the derivation process driven by req and design changes
  - Demonstrate reuse of req derivation analysis for design verification
  - Demonstrate data accessibility
Case Study 2: Hardware Structural Analysis

- **Inputs:**
  - Dummy customer requirements for loads and factors of safety
  - Dummy preliminary design concept

- **Objectives:**
  - Demonstrate a more complex analysis performed by a dedicated analyst
  - Demonstrate design analysis driven through verification objectives
  - Demonstrate generation of compliance statements
  - Demonstrate data accessibility
Case Study 3: Thermal Conditions
Determination Analysis

● Inputs:
  ➢ Dummy customer requirements for loads and factors of safety
  ➢ Dummy preliminary design concept

● Objectives:
  ➢ Demonstrate a more complex analysis performed by a dedicated analyst
  ➢ Demonstrate derivation of requirements through analysis
  ➢ Demonstrate iteration of the derivation process driven by req and design changes
  ➢ Demonstrate the evolution of analysis when design matures to a higher fidelity analysis
    – Create traceability between new and old analyses
  ➢ Demonstrate generation of compliance statements
  ➢ Demonstrate data accessibility
Conclusion

- The proposed solution architecture for requirements and analysis data management in TcUA is expected to provide the following benefits
  - Facilitates getting the right data to the right person at the right time to make the right decision
  - Facilitates proper documentation of analysis inputs
  - Enables integrated change management

- Continuing efforts to validate these solutions and expand our TcUA capability should be supported by management through budget and resource allocation