Data Quality Impact on Product Quality

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ENGINEERING YOUR SUCCESS.
Agenda

• Parker Introduction
• Interoperability impact on Product Quality
  – Data Integrity Risks to Product Quality
  – Mitigating Data Integrity Risks
• Summary
Parker Hannifin Corporation

A worldwide, diversified manufacturer of motion and control technologies and systems

- Headquartered in Cleveland, Ohio
- 315+ facilities
- 58,000+ employees
Parker Aerospace

Global leader in flight control, hydraulic, fuel and inerting, fluid conveyance, thermal management, and engine systems and components

- $2+ billion in annual sales
- 6,000+ employees
- Seven divisions, 43 worldwide locations

Updated 07/01/12
Worldwide Divisions and Facilities
A Global Organization

- **Aircraft Wheel & Brake**
  - Avon, Ohio
  - Guaymas, Mexico

- **Control Systems**
  - Dublin, Georgia
  - Irvine, California
  - Ogden, Utah

- **Customer Support Operations**
  - Irvine, California - HQ

- **Fluid Systems**
  - Elyria, Ohio
  - Guaymas, Mexico
  - Hauppauge, New York
  - Irvine, California
  - Naples, Florida
  - Tolleson, Arizona

- **Gas Turbine Fuel Systems**
  - Clyde, New York
  - Devens, Massachusetts
  - Glendale, Arizona
  - Kuala Lumpur, Malaysia
  - Liberty Lake, Washington
  - Mentor, Ohio
  - Moncks Corner, South Carolina

- **Hydraulic Systems**
  - Kalamazoo, Michigan
  - Wiesbaden, Germany

- **Stratoflex Products**
  - Apodaca, Mexico
  - Camarillo, California
  - Fort Worth, Texas
  - Jacksonville, Florida
  - Mansfield, Texas

- **Engineering Centers, Americas**
  - Everett, Washington
  - Fort Worth, Texas
  - Irvine, California
  - Montreal, Canada
  - Portsmouth, New Hampshire
  - São José dos Campos, Brazil

- **Engineering Centers, Europe**
  - Bremen, Germany
  - Bristol, England
  - Derby, England
  - Komsomoisk, Russia
  - Moscow, Russia
  - Toulouse, France
  - Wiesbaden, Germany

- **Engineering Centers, Asia**
  - Bangalore, India
  - Nagoya, Japan
  - Shanghai, China
Common, Standardized Processes and Functions

- Program management
- Engineering
- Lean
- Supply chain management
- Quality
Standard Design and Development Process

Lean Product Development (LPD)

Risk and cycle time reduced

Monitoring and Controlling

Initiating
Planning
Executing
Closing

Contract award
Master program plan
System requirements review
Preliminary design review
Critical design review
Test readiness review
Qualification certification

Bid and proposal
Plan and organize
Requirements discovery and validation
Trade and select concepts
Design
Fabricate
Verify
Introduce, deliver, and support

Integration management
Scope management
Time management
Cost management
Quality management
Resource management
Communication management
Risk management
Supply management

Meeting Customers’ Needs through Innovation

- More electric aircraft
- Flight control systems
- Fuel cell systems
- Fuel tank inerting systems
- Hydraulic systems
- Thermal management systems
Flight Control Systems Integration Labs
Only Supplier to Offer this Capability

Features
- Fly-by-wire, stick-to-surface
- Fully integrated
- First supplier in history to provide aircraft flight control integration

Benefits
- Reduces cost
- Reduces development time
- Reduces overall risk

Integrating cockpit controls, electronics, and actuation
“More Green” Aircraft

“We want to make our aircraft even more efficient, cleaner, and quieter.”
Tom Enders
President and CEO, Airbus

Airbus is fully committed to the fuel cell technology as a key contributor to achieve the ACARE* 2020 goals

- 80% NOx emissions
- 50% CO₂ emissions
- 50% Fuel consumption
- 50% Noise emissions

*Advisory Council for Aeronautics Research in Europe
Hydrogen-suppplied fuel cell
Fuel & CO₂
Reduced fuel burn = lower CO₂ emissions
No pollutants (HC, NOx, CO, SO₂)
Less noise

Multi-function Fuel Cell System Replaces and Supports Multiple Functions

- Batteries
- Emergency power
- Ground support equipment
- Auxiliary power
- Water refilling truck
Fuel Tank Inerting Systems

Features

• Improved sensors
• Integration options (bleed air, cabin air, environmental control system)
• Nitrogen-enriched air distribution
• Highest permeability fibers and lightest weight solutions

Benefits

• Reduce flammability of fuel tank and other aircraft applications
• Increased safety
High Quality is the result of exquisite planning!

Quality is not an accident or a matter of “good luck”

It is rewarded to those who plan thoroughly and control accordingly
Quality Escape Reviews

- Executive review of every Quality Escape
  - Review Corrective Actions to eliminate recurrence
  - Evaluate business systems for satisfactory robustness
Examples of Errors

- Failure to take into account a drawing note
- Failure to install the correct bearings as defined parts list or BOM
- English to metric conversion
- Incorrect model and drawing configuration
- Misinterpreted leader lines for dimensions
- Misinterpreted feature when translating drawing into a manufacturing drawing
- Requirements not effectively flowed from contract to design, operations, supply chain, sub-tiers
Interfaces

• High percentage of process failures occur at the interface
  – Baton gets dropped during a process step handoff
  – Failure to flow data across an interface in the process

• Always review interface diagram when evaluating design FMEA – interfaces merit careful consideration

• Failure within a individual’s task much more rare
Risks - Requirement Flow Down

• Transposing Data
  – Manual transfer of data from one document to another
  – Manual conversion of data from one set of units to another
  – Manual creation of a manufacturing drawing from the original engineering drawing
  – Reading and interpreting paper drawings and standards

Common Theme: Manually doing operations that could and should be done automatically by a computer or through system to system communication
Risks - Requirement Flow Down

• Translational Errors
  – Tools have improved – still possible for STEP, IGES, 3D PDF file to not match native CAD model
  – Native CAD model to alternate CAD software package
  – Version compatibility within a single CAD tool
  – Regeneration of Model in a new CAD release
  – Unexpected errors when exporting from native CAD system to CAD/CAM/CMM systems
    ▪ Not all surfaces may transfer
    ▪ Surface edges and faces may not join at the correct position
  – Any movement from different systems/versions should be treated as suspect – must verify successful translation
Mitigating Requirement Flow Risks

• Electronic data exchange with suppliers
  – Ensure supplier capable of validating files provided to translated CAD/CAM/CMM software
    ▪ Compatibility and validation essential to qualify the process or tool path program – don’t trust everything will be OK
  – Exchange of STEP files for supplier processing / tool paths creation common
    ▪ Allow supplier to pull files directly
      ▪ Ensure correct version at start of every job
      ▪ Native CAD file preferred

Take an FMEA thinking approach – what are the opportunities to fail via failed exchanges, missed configuration checks, missed process handshakes, etc.
Risks – Purchased Product Verification

• Data Integrity from extended Supply Chain
  – Accuracy of paper CoC’s from suppliers
    ▪ Inability to interrogate paper documents to the same degree as electronic exchanges of data
  – Transposition errors with manual information exchange
  – Business process for keeping the supplier up to date when a Model / design changes
  – Business process for keeping the supplier and sub-tiers current with process standards, testing procedures …
  – Compatibility of file exchanges with supplier systems
  – Counterfeit parts
Mitigate Supplier Data Exchange Risk

• Validation of Supply Chain data flow effectiveness
  – Electronic certification, consider eliminating (at least in part) human inspection of documentation
  – Interoperability between MES, PLM, and ERP/MRP to enable automated data verification
    ▪ Validation of internal processing and inspection results
    ▪ Validation of supplier certification information
    ▪ Validation of Revisions to pertinent processes, designs, and stds
  – Increases potential for “dock to stock”
  – Extended Supply Chain “perpetual inventory” knowledge
    ▪ Knowing quantity produced and shipped to could help combat counterfeits
Risk – Design, & Design Change

• Configuration Management
  – Businesses - Model is not the design source baseline
  – Businesses - allow the Model and Drawing to diverge
  – Model repository on system, network drive, hard drive?

• Multiple non-linked Databases
  – Manual manipulation of data between systems
  – Manual re-entry of data
  – Manual movement of common data between deliverables
  – When no “Single Source of Truth” across the enterprise

• Manual rebuild / re-mastering during an Engineering change
Mitigating Design Data Risks

- Design and Change Control
  - Move to 3D Model as Master – Model Based Enterprise
    - Eliminates model to drawing integrity risk
    - Eliminates use of drawing as master and transposing data risk
    - “Saves trees” – no drawings need to be produced
  - Disciplined use of Model checking tools
    - Ensure CAD Model conformance to design standards
    - Validate intended and unintended design changes
    - Eliminates geometry errors that impede re-use of Model data in analysis and manufacturing
  - Beware of unintended consequences
    - Thoroughly evaluate potential adverse effects of a change
Mitigating Design Data Risks

- **Design and Change Control**
  - **3D Functional Tolerancing & Annotation (FT&A)**
    - Use FT&A to define characteristics of the part in 3D environment
    - Avoids reliance on 2D drawings
    - More difficult for a designer to “fake” a dimension
      - Check Tools report features that have not been dimensioned
  - **Burn down disparate design tools**
    - Parker to simplify from current 400+ engineering system tools
    - Eliminate as many tool/interfaces as possible – less to go wrong!
  - **Virtual Trial Production?**
    - Potentially qualify the model through First Article Inspection (FAI)
Checking Tool Cost Considerations

• Expenses
  – Model checking tools
  – Manpower to perform validations

• Benefits
  – Eliminates “suitability verification” by all downstream users
    ▪ Exponential increase in waste if all downstream users do not trust the Model provided
  – Eliminates Analysts modifying the model
  – Eliminates scrap, missed deliveries, program delays

Likely comes out of the CAD or Design Team budget, but everyone else is the beneficiary
Risks - Traceability/Product Control

• Bill of Materials (BOM)
  – Non electronic flow of Parts Lists and Engineering BOM into Manufacturing BOM
  – Isolated documentation of “As-Built” BOM
  – Isolated documentation of “As-Serviced” BOM
  – Manipulation of ERP/MRP item masters and advice in Purchasing System

• Multiple potential interface errors
  – May see the use of alternate tools to pull together disparate information within the organization
  – Insufficient communication between various systems
  – Potential for data re-entry related errors
Mitigation of Traceability Risks

• Interoperability enhancement between design and manufacturing systems could eliminate several traceability and production control risks
  – Interoperability between MES, PLM, and ERP/MRP to enable automated data exchange
  – Traceability and availability of both “as Built” and “As-Serviced” BOM in Manufacturing Execution System
  – Manage and compare “as-designed”, “as-planned”, “as-built”, and “as-serviced” BOM
• Eliminate manual interventions and potential errors
Risks – Human Factors

• Human influences and errors
  – Failure to maintain Model to Drawing integrity
    ▪ Aligned or diverging?
    ▪ Similar to double dimensioning - keeping everything aligned is not always easy
  – Inclination for “paper” in many parts of the business
  – Failure to validate CAD data after Long Term Archival
  – CAD tools that are not open to 3rd party assessment tools or interoperability with other systems
Mitigating Human Factor Risks

• Succession Planning
  – Experienced employees being replaced as retire
  – A brute force manual process will not get better with less experienced employees
    ▪ However “earlier in career” employees often quicker to embrace new tools and methods
  – Include broader systems understanding in position competency curriculum

• Improve interoperability between systems to eliminate error potential
Mitigating Human Factor Risks

• Mistake Proofing – Any mechanism in the process that helps the operator avoid mistakes
  – Prevents, corrects, or draws attention as they occur
  – Eliminate manual data entry operations. Examples:
    ▪ Part number, Revision, Serial Number, Certifications, and similar that are frequently re-entered on shipping declarations
    ▪ High potential for data to be transposed or rearranged in error
  – Compare multiple sources to isolate an error
    ▪ Look at three identical entries that should have the same information and highlight when a disconnect is discovered
  – Eliminate employee to look up and interpretation to accomplish their task
Summary

• “Never do what a computer can do”
  – Avoid data entry, transferring, and transposing
  – Highest risks to quality occur in these hand offs
  – Mistake proof to the maximum extent possible

• Plan for changes in the human factor environment
  – Succession planning and assurance of new team member success

• “Single Source of Truth”
  – Avoid systems that do not allow common data to be shared as opposed to requiring additional processing
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Parker Aerospace

We do not make aircraft, we just make them fly!