Data Quality Impact on Product Quality

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Parker Aerospace

ENGINEERING YOUR SUCCESS.

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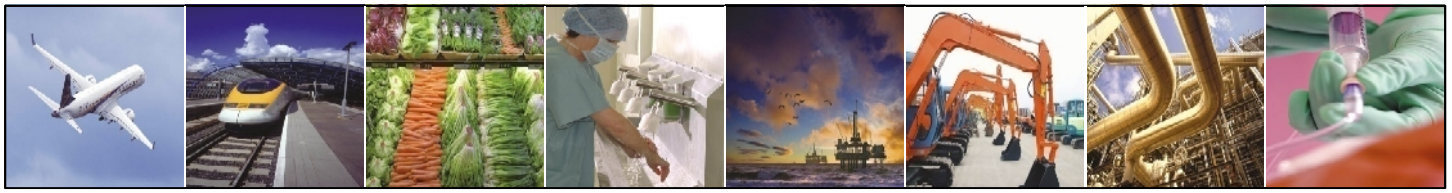
Agenda

- 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

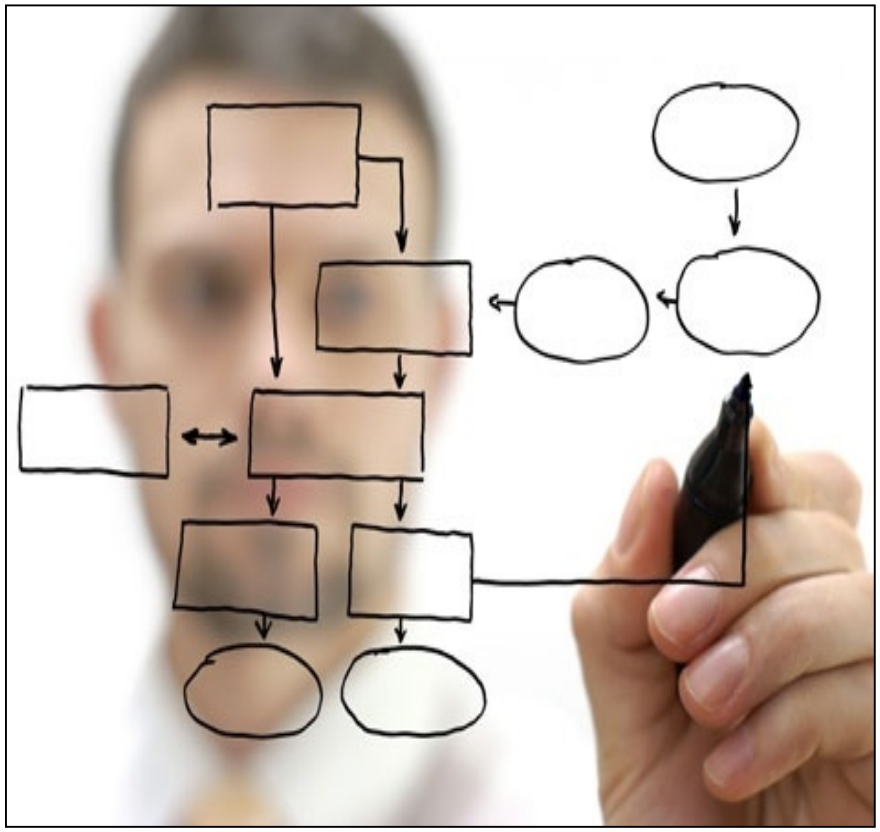
Updated 07/01/12

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, So. Carolina
- **Hydraulic Systems**
  Kalamazoo, Michigan
  Wiesbaden, Germany
- **Stratoflex Products**
  Apodaca, Mexico
  Camarillo, California
  Fort Worth, Texas
  Jacksonville, Florida
  Mansfield, Texas

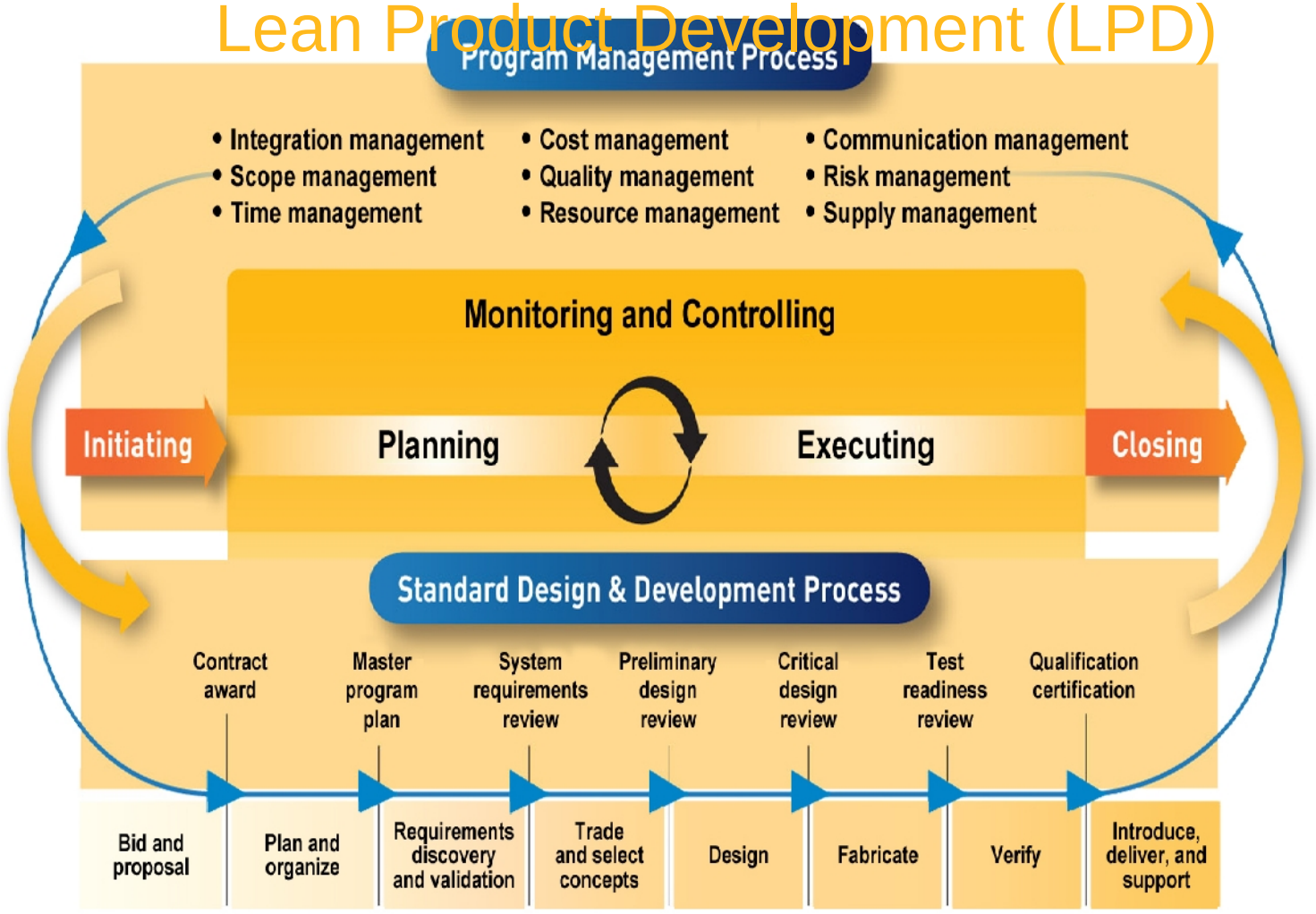
Common, Standardized Processes and Functions



- Program management
- Engineering
- Lean
- Supply chain management
- Quality

Standard Design and Development Process

Lean Product Development (LPD)



Risk and cycle time reduced

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

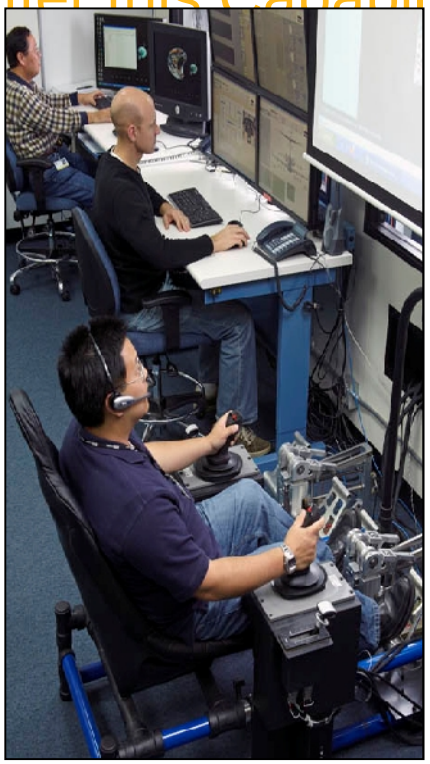
Only Supplier to Offer this Capability

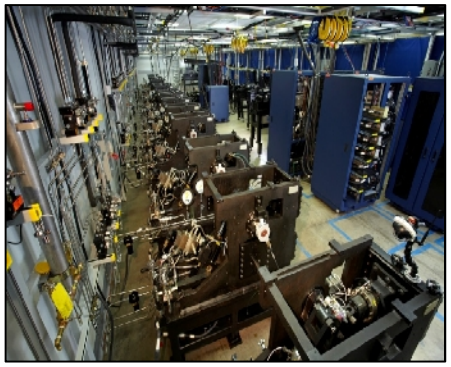
Features

- 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

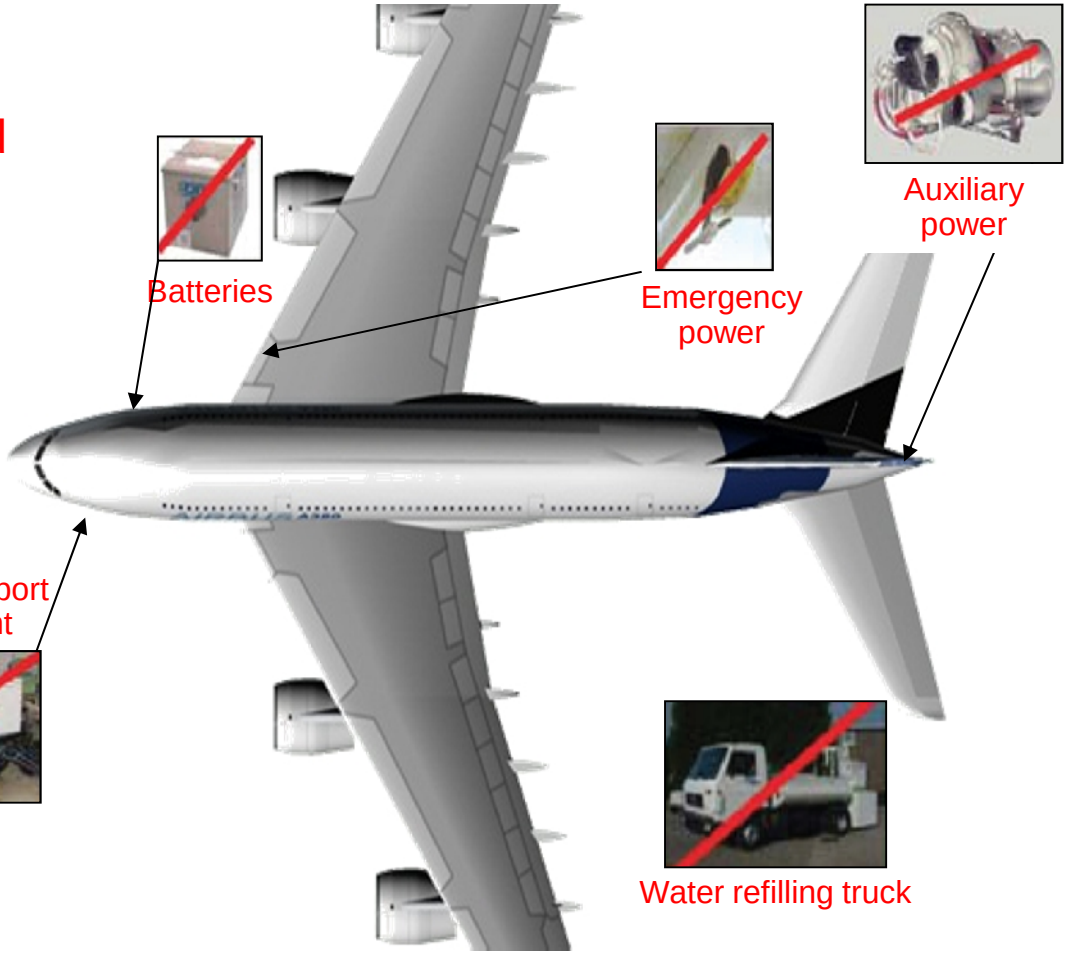
*Advisory Council for Aeronautics Research in Europe

Multi-function Fuel Cell System Replaces and Supports Multiple Functions

Hydrogen-supplied fuel cell

Fuel & CO_2
Reduced fuel burn
= lower CO_2 emissions

No pollutants
(HC, NOx, CO, SO_2)
Less noise



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

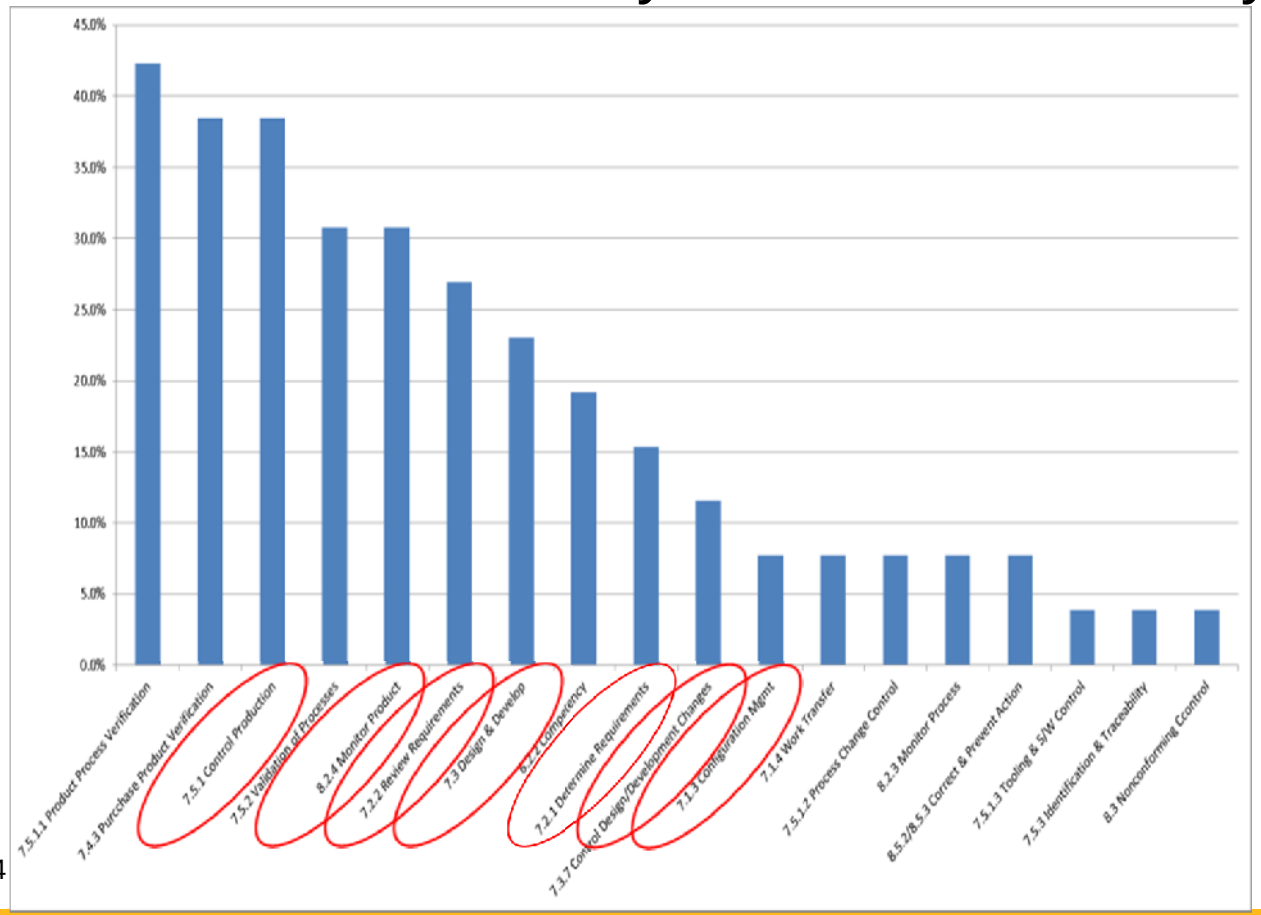
High Quality is the result of exquisite planning!

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



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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

Likely comes out of the CAD or Design Team budget, but everyone else is the beneficiary

- Benefits
  - Eliminates “suitability verification” by all down stream 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

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