Defining, Developing & Enhancing the Next Generation in Digital Engineering

-A-10 Tactical Advantages, Lessons Learned and Future Plans-

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- A-10 ASIP Organic Analysis Team
- NLign Analytics - Etegent Technologies, Ltd.
Outline

- Background
- Owning the Digital Engineering Baseline (DEB)
- A-10 Aircraft Structural Integrity Program (ASIP) organic DEB management
- A-10 Model Based Definition (MBD) & Product Lifecycle Management (PLM)
- Controlling the Technical Data Package (TDP)
- Controlled TDP benefits
- Utilizing MBD to develop validated DE – A-10 Organic Capabilities
- A-10 DE & MBD Tactical advantage - examples
- Data capture at the point of maintenance – serious risk mitigation
- Lessons learned
- Future efforts
Background

- Planned retirement
  - Funding pulled, not retired, no funds put back in POM
- Lost contractor support for configuration control
  - Multiple EOs against drawings, 50 page EOs for modifications
- SPO moved from Sacramento to HAFB – lost physical files
- Red team evaluation and get well plan, 2003
- A-10 ASIP support group created, 2003
  - Establishing the Digital Engineering (DE) requirements and digital baseline
  - Organic capability
  - Model Based Definition (MBD)
  - PLM implementation for configuration control of baseline data
Owning the Digital Engineering Baseline (DEB)

- Configuration control & change management
  - Qualified individuals!
  - Applicable tools!
  - Focused team work!
  - Can do attitude!

Owning the baseline

VS.

OWNING and OPERATING the baseline!
A-10 ASIP Organic DEB Management

Key components:
- MBD & 2D drawing configuration control is the foundation
  - No hanging EOs
- Personnel expertise and applicable tools to manage the baseline
- Product Lifecycle Management (PLM) system

Required ASIP responsibilities: MIL-STD-1530D ASIP
- Damage Tolerance Analysis (DTA) updates
- Structural inspection requirements
- Analyses for depot/field repairs (Static & DTA)
- Risk analyses for fleet cracking observations
- Risk based induction
- Damage database
- ASIP contracts (Testing, Teardowns, Repairs, Analysis, Drawing/Spec Updates)
The Beginning of A-10 MBD and A-10 PLM System

A-10 life extension required a wing replacement program

- Data loaded in Boeing’s Teamcenter environment
- Change Management process requires AF Work Flow approval
- Nightly synchronization to A-10 Teamcenter environment
- Model Based Definition (MBD) (3D CAD Model, PLM data – NO DRAWINGS! )
Overview of A-10 MBD

Because of Reuse benefits - CAD expanded to entire A-10 Aircraft

- A-10 Structure complete
- Effort to model mechanical/electrical systems – In Work
A-10 PLM Vision

D - Distribution Point – Until Further Notice
X – Decommission or Stop Using

AFMC Firewall

Primes

A-10 Data Exchange Specification
Teamcenter as Single Source of Truth
A-10 PLM Implementation

- System Program Office (SPO) Data Needs
- Depot Maintenance Data Needs
- A-10 Data Exchange Specifications (ADES)
- Data Control Center (A-10 Teamcenter)
- Field Maintenance Data Needs
- Contractor Support Data Needs
A-10 PLM Implementation

Data Control Center (A-10 Teamcenter)

SPO Data Interaction Tools:
- NLign
- FEA (NX)
- DTA toolset
- ...

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A-10 Data Exchange Specifications (ADES)
Technical Data Package Benefits

Modifications and Part Procurements

- How do we ensure safety, save $$ and time by controlling the 2D & 3D part data?

  TOP ASSY

  SUB ASSEMBLIES

  PIECE PARTS

  Contract to Manufacture

  Tool Path/G-CODE

- Risk factors
  - Was the Government Furnished Information (GFI) correct?
    - Were there any Engineering Orders (EO) to change the drawing/definition in process when the data package was released?
  - Was the GFI to produce the part from a 2D drawing or 3D part Definition?
    - Who developed the manufacturing tool path code?

*Rick Mendoza F-18, PLM Brief
Technical Data Package Benefits

Modifications and Part Procurements

- How do we ensure safety, save $$ and time by controlling the 2D & 3D part data?

- Eliminate multiple geometry interpretations
  - No EO overlay or interpretation

- Eliminate modeling costs on future contracts

- Quicker delivery of Spare Part contracts

Data Control Center (A-10 Teamcenter)

Data Exchange Specifications (DES)

Contract to Manufacture with Configuration Controlled GFI
A-10 ASIP Organic Capabilities

Utilizing MBD to Produce Validated DE
A-10 Digital Engineering Tools

- 3D CAD
- Finite Element Analysis (FEA)
  - Detailed Finite Element Model (FEM) inserted into a global loads FEM
    - Boundary conditions more accurately simulated
    - Strain gauge validated
A-10 Digital Engineering Tools

- FEA load distribution
  - Baseline structure and repair configuration
  - Fastener loads
  - Contact surfaces
  - Load re-distribution with crack propagation

![Diagram of FEA load distribution and repair configuration](image-url)
Stress intensity solution

- Unique Geometry/Loading not represented by standard solutions
Damage Tolerance Analysis (DTA)
  - AFGROW, StressCheck, BAMF

Technical data required for organic DTA
  - Usage Data / Loads / Stress Analysis → Stress Spectra
  - Material Data
    • Crack Growth Rate Data
    • Spectrum Testing
A-10 Digital Engineering Tools

- Fleet health – PRoF
- Risk based induction
  - Condition and need
- Fleet risk assessments

**Risk based induction**

- Condition and need

**Fleet health – PRoF**

- Aircraft Usage
- Test Experience (FS 365 Failure)
- Damage Tolerance Analysis
- Processed Inspection Data
- Risk Assessment
- Configuration Database with Prioritized Induction Listing

**Fleet risk assessments**

- View looking down at LH upper longeron
- Chart showing data with titles like 'Probabilistic - Versa'
A-10 Digital Engineering Tools

Spatial DE and maintenance data assessment
-NLign Software-
A-10 DE & MBD
Tactical Advantages
-Examples-
Tactical Advantages
Rapid Field Support (Bird Strike)

Bird Strike Area

Damage to Leading Edge

CAD Model of Repair

Final Installed Repair

CNC Milling of Repair Part

Test fit of 3D Printed Repair Part
Tactical Advantages
Rapid ASIP Support (Canopy Lug)

- A-10 aircraft canopy mishap
- Utilized MBD & DE tools to provide answers within 48 hrs
- Developed analytical justification and inspection procedures to determine fleet safety and prevent groundings.
‘At a glance’ data communication

Tactical Advantages
Fleet Management

Record Type
Crack Direction
Damage Type
Tactical Advantages
Fleet Management

- Controlled macro and micro data
  - Rapid decision making
Tactical Advantages
Merging DE with MX Data
Tactical Advantages
Merging DE with MX Data
Tactical Advantages
Merging DE with MX Data
Tactical Advantages
Merging DE with MX Data
Tactical Advantages
Merging MBD with MX Data & Photos

Photo of Damage → Photo alignment to Model → Photo Enhancements to amplify damaged regions

Damaged Mapped on Model for Trending
Tactical Advantages
Merging MBD with MX Data & Photos

Photograph Damage

Align to Model

Evaluate Indication

Crack Marking

Damage Extraction

Standard Repair Cutout Area

Crack Mapping
Digital Data Capture at the Point of Maintenance

Mitigation of Serious Safety Risk
ASIP Process and Risk Identified

- MIL-STD-1530D
# A-10 Hazard Risk Index

(Tailored from MIL-STD-882E)

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<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
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- A: Frequent
- B: Probable
- C: Occasional
- D: Remote
- E: Improbable
Paper-based Processes

A-10 Scheduled Structural Inspection (SSI) program

- Historically it takes 7-9 months from the final inspection date before Engineering sees SSI data
  - The asset is closed and or sold
  - Concern with the data cannot be addressed easily
  - Effects of training or data quality improvements efforts are slow to be seen
  - Engineer Tech required to manually input data into database

- Lack of quality in reporting process
  - Missing data/Lost paperwork
  - Dependent on interpretations of handwritten notes
  - Sequences not followed
MBD Based Digital Inspections Developed –NLign-
Shop Floor Digital Data Capture
Tests & Implementation

- **Initial testing**
  - OWP, three weeks to complete (~800% faster data availability to ASIP)
  - CWP, 2.5 months to complete (~500% faster data availability to ASIP)
  - 100% data accuracy with near real time data

- **Requirement change and implementation**
  - Shop training on active assets
  - *Requirement effective October 2018*
Value Impact & Risk Mitigation from DE & MBD Based Requirement
Lessons Learned

- Data control and communication is Key!
  - PLM data exchange specification
  - Data is controlled at one source
  - Data flow is not just ‘one way’
- PLM solution must be tailored to the weapon system
  - A-10 new wing MBD vs Legacy MBD/part report/2D drawing hybrid
  - Needed interaction tools for analysis and communication to contractors/OEM

- Qualified individuals!
- Applicable tools!
- Focused team work!
- Can do attitude!
Future Plans

- Complete the data migrating legacy systems to Teamcenter
- Continue development on NLign to enable seamless communication of the data being managed in Teamcenter
  - Identify other data interaction tools that need to integrate with Teamcenter.
- Refine workflow processes within Teamcenter for data control
- Prognostic enhancements to the NLign software
- Data spatial positioning system for smart tool interaction with the NLign software
Questions?