Air Force Life Cycle Management Center

A-10 Wing Replacement Program (WRP) – 3D MBE

30 Apr 14

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Purpose

- **The purpose of this brief is to describe the experiences of the USAF A-10 System Program Office (SPO) implementing 3D Model Based Definition (MBD) and 3D Model Based Enterprise (MBE) on the A-10 Wing Replacement Program and other efforts**

Outline

- **Overview**
- **Background**
- **Modeling Issues**
- **Implementing 3D MBD**
- **Results to Date**
- **Other A-10 CAD Projects**
- **A-10 PLM Upgrade Projects**
- **Outstanding Infrastructure Issues**
- **Lessons Learned**

Overview

- **The A-10 aircraft was designed in the 1970s using 2D drawings. The A-10 Wing Replacement Program (WRP) used 3D MBD for the new definition of the wing. The use of this data requires new methods of handling data but also provides opportunities to integrate and reuse data not previously available.**
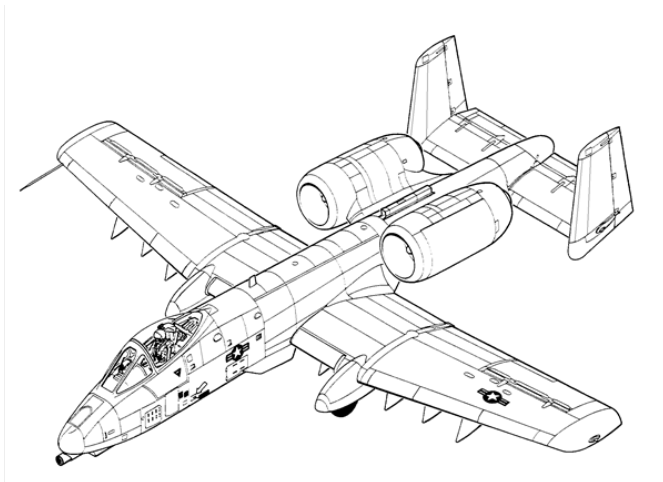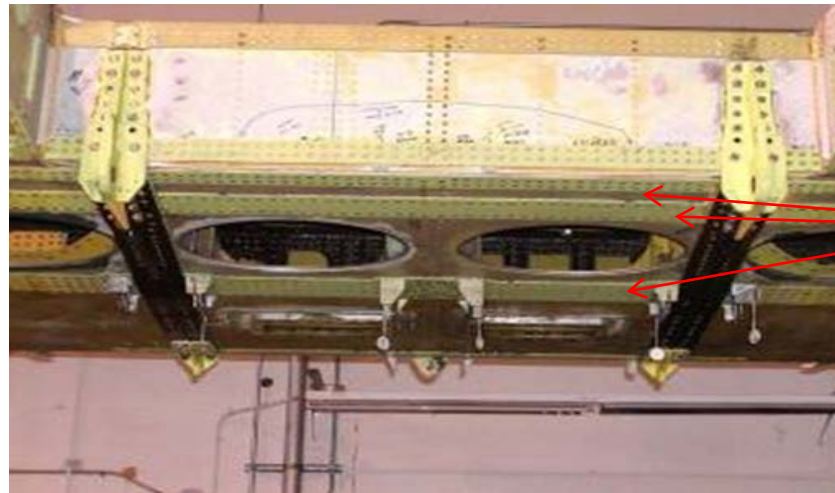
Background

- **A-10 Aircraft is the premier Close Air Support aircraft in the AF inventory**

- **Designed in the 1970s with a 6000 hour service life**

- **Service Life extended multiple times**

Background

- **AF Fleet Viability Board evaluated and recommended A-10 for continued service until 2028**

- **Service Life Extension Program to modify/repair existing wings became cost prohibitive**

Repair Straps

Background

- **Business Case Analysis – New Wings needed to meet life objectives**

- **Note: A-10 SPO situation is <u>unique</u> in DoD**
  - **A-10 SPO has ownership of engineering data**
  - **Is the engineering authority for most engineering data**
    - **SPO responsible for validity of data given as GFI, including 3D models, BOMs, Etc.**
  - **SPO serves as integrator and configuration manager**

Background

- **3D CAD Model approach chosen as risk mitigation**

  - **Original intent - identify gaps/interferences and any errors with technical data package prior to competitive bid**

  - **Original approach: mimicked legacy drawing approach: 3D models with 2-D drawings similar to original drawings, just dash number rolls for configuration changes**
    - **Legacy Multi-Use drawing – Mono-detail drawing**

- **Additional benefit - reuse of data**

Background

- **Initiated Funding Request for 3D Models and New Wings in FY 2005**
  - **CAD Models – FY 2006 (Received, Awarded)**
  - **New Wings – FY 2009 (Planned)**

- **Small Business CAD Modeler Received Contract 2006**

- **AF Provided 2D Drawings and E-BOM as GFI**

- **Electronic BOM not accurate**
  - **Additional $1M to verify**
  - **Snapshot in time**

- **Model Verification was an issue**
  - **Loft critically important**
  - **Assembly Context**

- **"Model, Model, who has the Model"**
  - **Could not verify who had changed model**
  - **Implemented PLM and release process to address**

More Issues

- **Not all previous CAD Models were useable for production**
  - **Modeling methods were not robust for manufacturing and modification**

- **A-10 manual CM Process not robust**
  - **No visibility to proposed changes prior to release**
    - *"Do you want lights on that wing?"*
  - **System allowed unauthorized changes and changes outside system**
    - *"Do you want to incorporate this released change?"*
  - **Validity of data/BOM required addt'l attention**

Implementing 3D MBD
(A-10 Wing Replacement Program)

- **Funding for New Wings Arrived 2 Yrs Earlier than Planned, delivery schedule compressed**

- **Moved 3D Modeling Effort to Production Contractor to mitigate schedule risk**

  - **3D MBD Implemented for schedule and cost purposes after contract award**
  - **New paradigm, no AF data model, standards**
  - **Still needed to bridge the existing 2D world**

3D MBD Approach

- **3D Model + PLM Data = Master**
  - **Similar to Content Management for Documents**

- **PLM Data Includes: notes, materials, effectivity, etc.**

- **Delivery Formats:**
  - **Native CAD**
  - **STEP AP 203**
  - **IGES**
  - **JT**
  - **ADOBE 3D PDF**
    - **3D "Part Report" – Pseudo Drawing**

3D MBD Approach

- **Master Data Concept Very Important**

- **PLM Relationship and Control of CAD and associated data (notes, materials, etc) provides powerful tool for easy search and grouping of data***

  - **Material "Where Used"**
  - **Part "Where Used"**
  - **Specification "Where Used"**

  * (Trying to take advantage on other A-10 CAD efforts)

3D MBD Approach

- ## A-10 WRP 3D MBD Scope

  - ### Modeled complete wing, tip-to-tip*
    - All structures
    - Flight controls
    - Fairings
    - Subsystems (fuel, hydraulic, electrical, etc.)
    - Fasteners (removable & non-removable)
    - Brackets, clamps

  - ### E-BOM output of PLM Structure*
 - ### Modeled major tooling (deliverable to govmt)*

Benefits of 3D MBD + PLM

- **Communication**
  - **Picture worth 1000 words, speed of resolution**
- **Relationship to other related data**
  - **50-80% of Sustainment Engineering is researching the available data**
  - **Airworthiness data stored and related in PLM provide traceability for certification**
    - **FEA**
    - **Damage Tolerance Analysis**
    - **Static Stress Analysis**
    - **"Pass Through Part" – "Based On" relationship**

Results to Date

- **I've got 3D MBD – now what?**

  - **Provisioning**
  - **AF CM Control and use of data**
  - **Distribution of data for sustainment**
  - **Use of 3D MBD data for depot support**
  - **Use of 3D MBD for repair support**
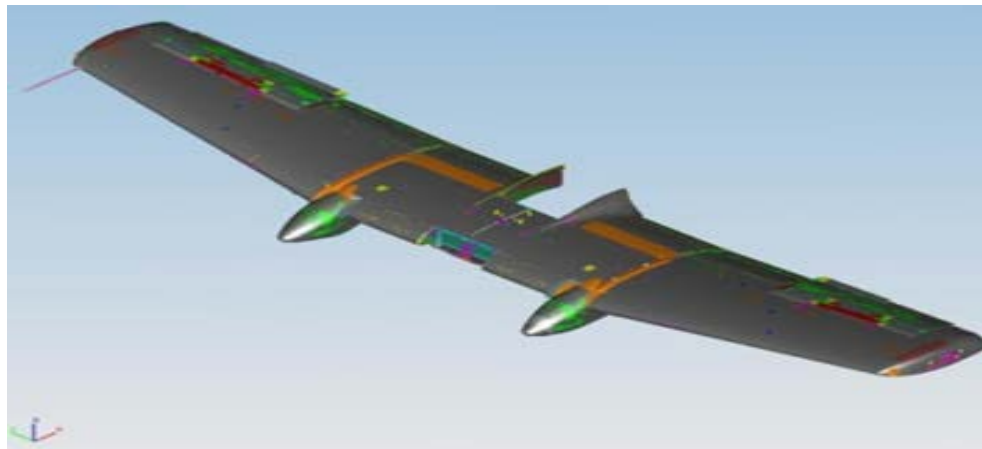
Provisioning

- **DLA Battle Creek engaged AF prior to contract award**

- **Worked to address:**
  - **Data formats (CAD and Provisioning)**
  - **CM of data and interface to D220 system**
  - **How to obtain/use MBD data**
  - **Bridge concepts from 2D culture to 3D for cataloging**
  - **Set basis for "As Sustained BOM" (S-BOM)**

Provisioning Results

- **Provisioning Data Formats**
  - **Implemented tailored GEIA-STD-0007 instead of MIL-STD-1388-2B for Logistics data**

- **CM of Data and Interface to D220**
  - **A-10 PLM could store provisioning data (Master data), but without interface and change process for D220 (or other systems), cannot keep in synch, therefore D220 - Master**
    - **Data delivered to D220 and to A-10, but no PLM storage**
    - **Further work required to define and pilot solution**

- **MBD Data Use**
  - **Present AF/DLA system is set up for 2D data**
    - **Access through JEDMICS**
    - **Obtain 2D drawing for Cataloging and Purchase Request**
    - **No enterprise system and processes for 3D MBD**
  - **How do we provide MBD to DLA or AF Supply**
    - **Access to our PLM (license costs, limited access)?**
    - **Manual Request (who pays staffing)?**
    - **DLA PLM system and A-10 PLM synch data?**
      - **Assignment/Check-out for CM purposes?**
  - **DLA working Pilot to address?**

Provisioning Results

- **Bridge concepts from 2D culture to 3D for cataloging**
  - **Culture shock when told no drawings**
  - **Workaround for Cataloging – "Provisioning Part Report"**
    - **Pseudo drawing with embedded 3D model and other provisioning data***
    - **Seemed to meet need at Provisioning Guidance Conferences**
  - **A-10 SPO must recreate this artifact for any future changes**
    - **Standards, templates?**

Provisioning Results

- **Set basis for "As Sustained BOM" (S-BOM)**
  - **Engrg BOM (E-BOM) – Master**
  - **S-BOM from E-BOM through Provisioning (SMR Code flag)**
    - **Feed D220 and other systems from Master**
    - **Feed Illustrated Parts Breakdowns (IPB) from same**
  - **Presently all three are managed separately**
    - **They can and do get out of synch**
  - **PLM provides an opportunity to address this issue**

AF Configuration Management

- **A-10 SPO and AF have same 2D infrastructure, culture and issues**

- **A-10 CM group is creating workflows, operating instructions and training to transition to PLM control all Engineering data, not just CAD**

- **Authorized by A-10 Chief Engineer to move data to PLM incrementally**
  - **JEDMICS will be reference repository for our data**

Distribution of Data for Sustainment

- **3D MBD data not effectively managed in JEDMICS**

- **Master Data in A-10 PLM system**

- **Only 3D "Part Report" will be in JEDMICS**
  - **Should be adequate for general purposes**
  - **For part fabrication, modification or repair – data or access to CAD package from PLM will be provided**

- **Ogden Air Logistic Complex Maintenance Wing is aware of the need to use 3D MBD data, but does not presently have adequate systems in place to manage**

- **They have engaged the A-10 SPO and have started a pilot effort to receive, manage and use 3D MBD at this complex**

- **Presently using JT model files as a shop aid for installing the wings in the hanger**
  - **Proven to be very beneficial and welcomed by shop personnel**

- **Hand off and control of 3D models a concern**
  - **Unauthorized use of models**
  - **Models and data must be used for work contracted for – no freelance**

Use of 3D MBD for Repair Support (Reuse of Data)

- **A-10 SPO has organic analysis capability**
  - **Using existing CAD models reduce FEA modeling time by 50%**
  - **Allows more repair option iterations in shorter time for standard repairs**
  - **Allows quick analysis and risk assessment of potentially grounding structural conditions**
  - **Quicker response = less interruption to Depot Flow time**
  - **Quicker response = Less aircraft down time for field SPO assistance repairs**

FEA Examples

- **A-10 Aircraft Structural Integrity Group uses CAD files to generate FEA models of aircraft damage and proposed repairs**
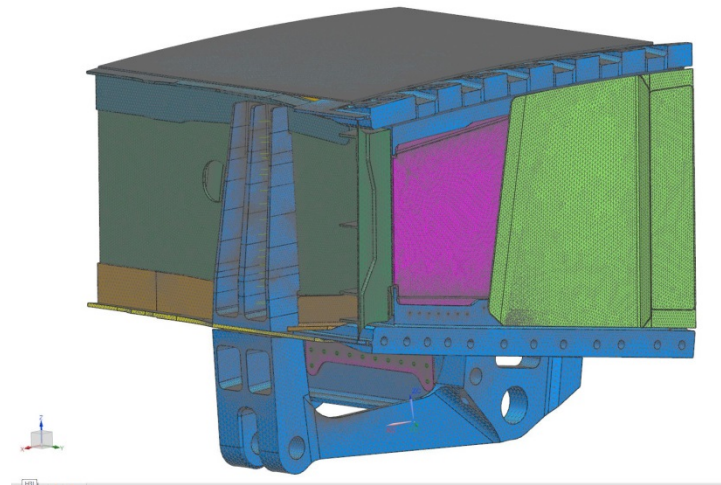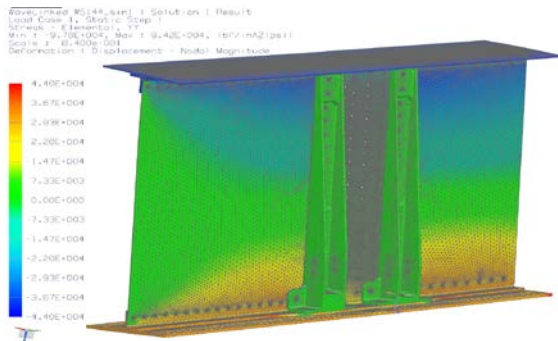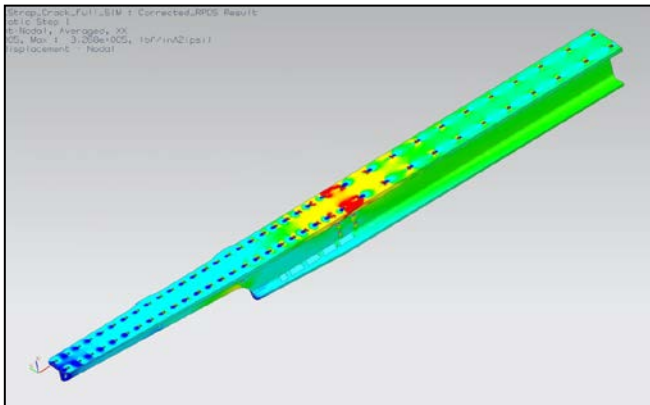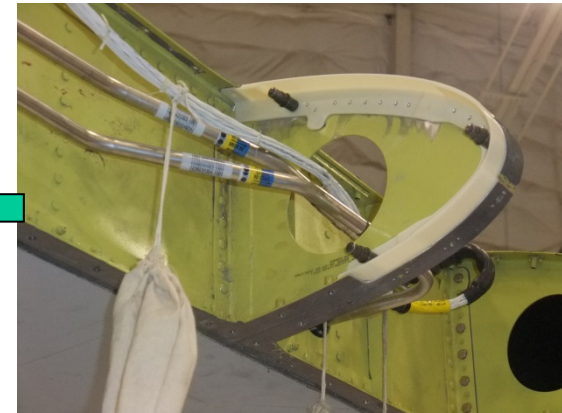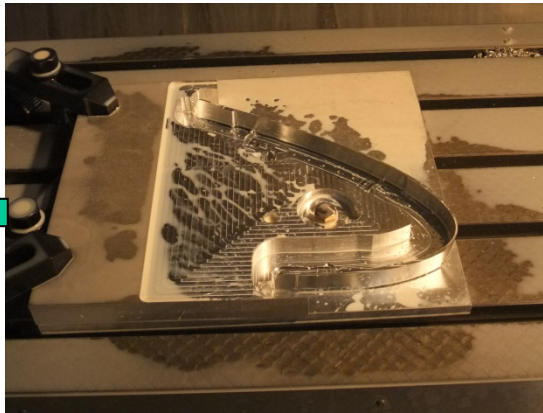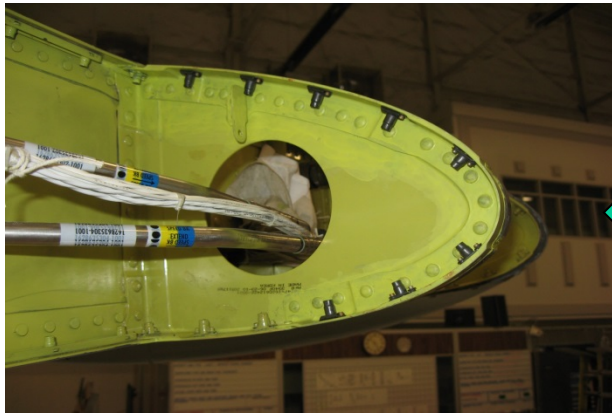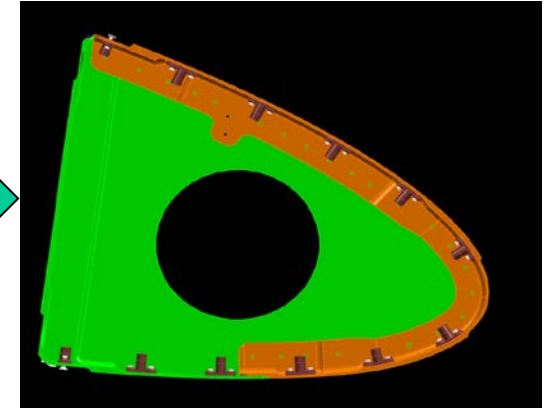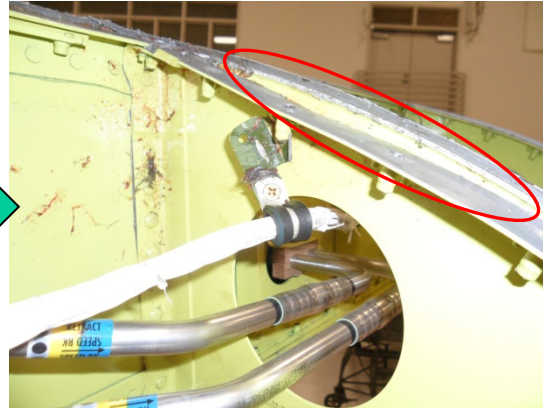
A-10 Bird Strike Example

- **October 2013 Bird Strike to A-10**
- **Best repair option was to make one-off repair part**
- **CAD model facilitated:**
  - **Several repair options (3D models)**
  - **FEA Model**
  - **Repair CAD Model to machine repair part using CNC mill**
  - **Field (Air National Guard) had CNC capability**
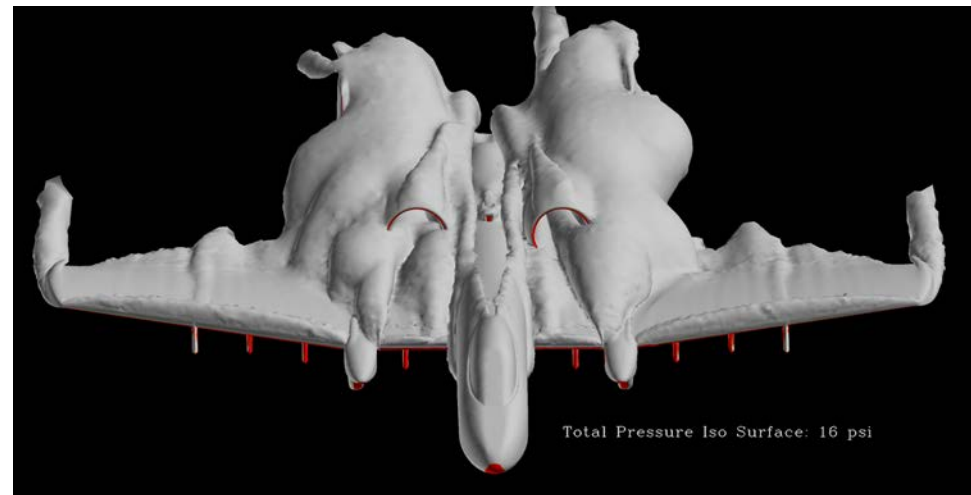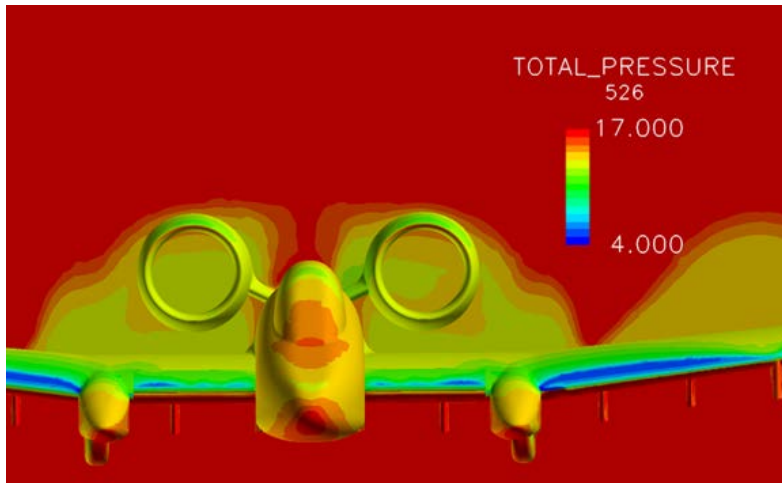   - **Fabricated, inspected and installed repair part**

A-10 Bird Strike Example

CFD Example

- **A-10 Aero Performance Group also uses CAD loft files to evaluate proposed modifications**

Other A-10 CAD Projects

- **We are expanding the library of CAD models beyond the A-10 Wing Program**

- **Various contracts for additional <u>structural</u> models**

- **3D MBD not used for remaining structural models**

- **Approach – 3D model defines geometry, legacy 2D drawing still defines notes, effectivity, tolerances, etc. (raster edit)**
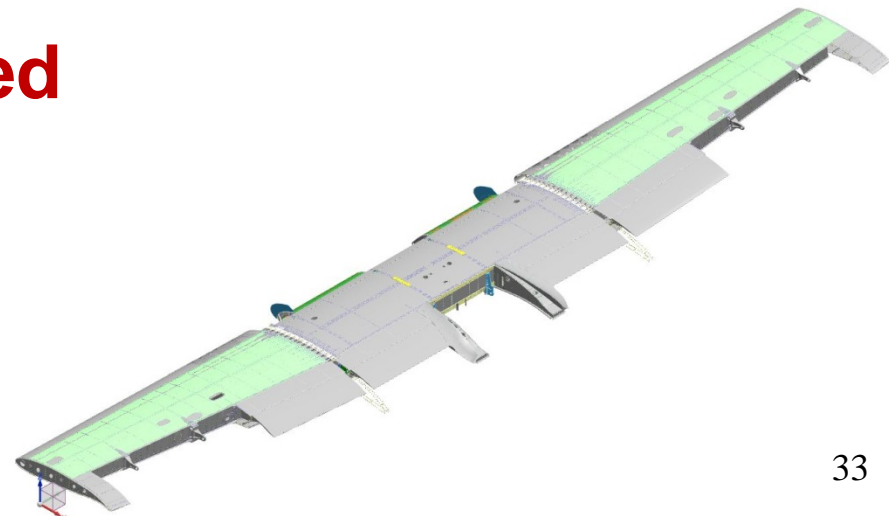
Other A-10 CAD Projects

- **Thick Skin Wings – Delivered**
  - **Legacy, still supported version**
- **Center Fuselage - Delivered**
- **Master Tools (14 Tools) - Delivered**
- **Forward Fuselage – In Work**
- **Nacelles – Just initiated**
- **Future efforts as needed**
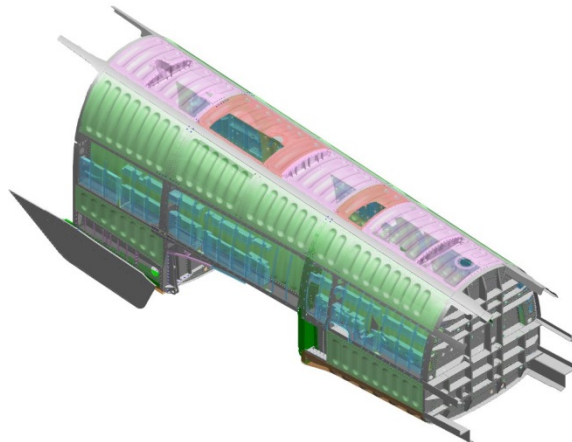
A-10 PLM Upgrade Projects

- **CM Architecture Mapping - Completed**
  - Maps engineering data together (P/N to stress analysis, test data, etc.)
  - Identifies PLM schema changes to support data import

- **Bring A-10 Production Drawings under PLM Control**
  - Create E-BOMs for all flying configuration

- **Link Technical Orders to Engineering data**

- **Link Requirement Documents to Engrg**

A-10 PLM Upgrade Projects

- **Individual Serial Number configuration tied to E-BOM**
  - **Future state – include modifications and repairs ("As Maintained" configuration)**
  - **Allow for flight hour tracking for structures**
  - **Allow for Maintenance Data to be tied to aircraft tail or item serial number for fleet trending and effective root cause analysis**
  - **Facilitates active RCM tied to configuration**
  - **Facilitates more accurate fleet and individual maintenance requirement for depot and CAMS (LRDP)**

Outstanding Infrastructure Issues

- **DLA/USAF Logistics Support – MBD**
- **Provisioning data, PLM or D220?**
- **Hand off MBD data to Depot Maintenance**
- **Standards and Templates for Implementation**
  - **Modeling Guides**
  - **PLM Schema**
  - **3D PDF**
  - **CDRLs**
- **Security of Data**
  - **License Management?**

Lessons Learned

- **Configuration Management is Critical**
  - **Master Data is important concept with CM**

- **3D Models must be created such that they are producible and can be modified**

- **Having and using CAD models increases communication and understanding immensely**

- **Relationships in PLM enhance the usability of the data and is also critical to keeping data in synch**

Summary

- **A-10 SPO is now using 3D MBD for sustainment of the aircraft**

- **DoD does not yet have robust systems and business processes in place to utilize**

- **Response time and costs reduce through use of 3D CAD**

- **PLM must go hand-in-hand with 3D CAD**

- **Big Elephant – Where do you start?**

Questions

Acronym List

- **BOM – Bill of Material**
  - **E-BOM – Engineering Bill of Material**
  - **S-BOM – Sustainment Bill of Material**
- **CAMS – Centralized Asset Management System**
- **CDRL – Contract Data Requirements List**
- **CFD – Computational Fluid Dynamics**
- **CM – Configuration Management**
- **CNC – Computer Numerically Controlled**
- **D220 – AF Provisioning System (Computer System - Supply)**
- **DLA – Defense Logistics Agency**
- **FEA – Finite Element Analysis**
- **GFI – Government Furnish Information**
- **IGES - Initial Graphics Exchange Specification**
- **IPB – Illustrated Parts Breakdown**
- **JEDMICS – Joint Engineering Data Management Information and Control System**
- **JT – Neutral CAD File Format for visualization (ISO 14306)**
- **LRPD – Logistics Requirements Determination Process**
- **PDF – Portable Document Format (Adobe)**
- **PLM – Product Lifecycle Management**
- **SMR – Source, Maintenance and Recoverability**
- **STEP – Neutral CAD File Format (ISO 10303)**