AFLCMC

U.S. AIR FORCE

A-10 ASIP Adaptation to Digital Maintenance Data

(Tactical Advantages, Lessons Learned and Future Plans)

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Acknowledgements

- Mark L. Thomsen, Ph.D. A-10 ASIP Manager
- A-10 PLM implementation team
  - Jeff Howell – A-10 SPO AFLCMC/WWAEJ
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- A-10 ASIP Organic Analysis Team
- NLign Analytics - Etegent Technologies, Ltd.
- Rick Mendoza – ESTA

Outline

- Background
- Owning the technical baseline
- Operating the technical baseline organically
- A-10 ASIP needed tools and qualifications
- A-10 PLM Implementation
- Technical data package benefits
- Tactical advantage examples
- PLM interaction tool (NLign)
- Data capture at the point of maintenance
- 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
- A-10 ASIP support group created 2003
  - Establishing a technical baseline
  - Organic capability to operate the baseline
  - Model Based Definition (MBD) for the New Wing
  - PLM implementation for configuration control of baseline data
  - MBD for the entire aircraft

Owning the Technical Baseline

Owning the baseline

VS.

OWNING and OPERATING the baseline!

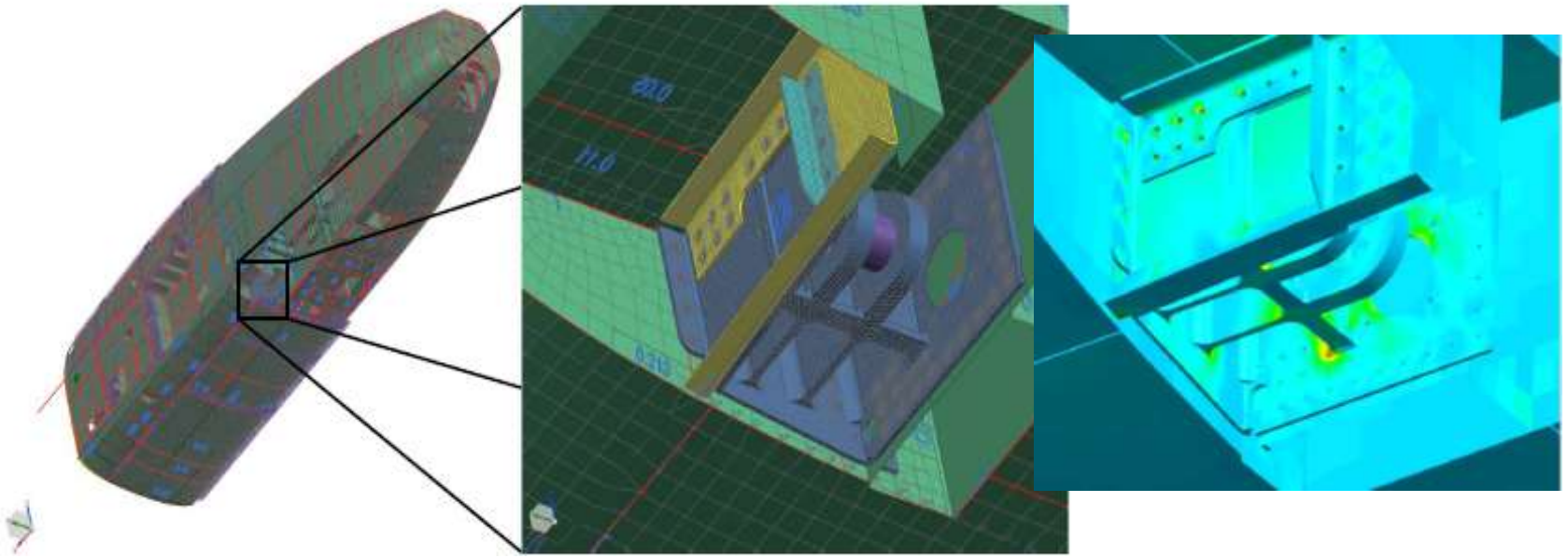
- ***Configuration control & change management***
  - ***Qualified individuals!***
  - ***Applicable tools!***
  - ***Focused team work!***
  - ***Can do attitude!***

Operating the Technical Baseline Organically

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

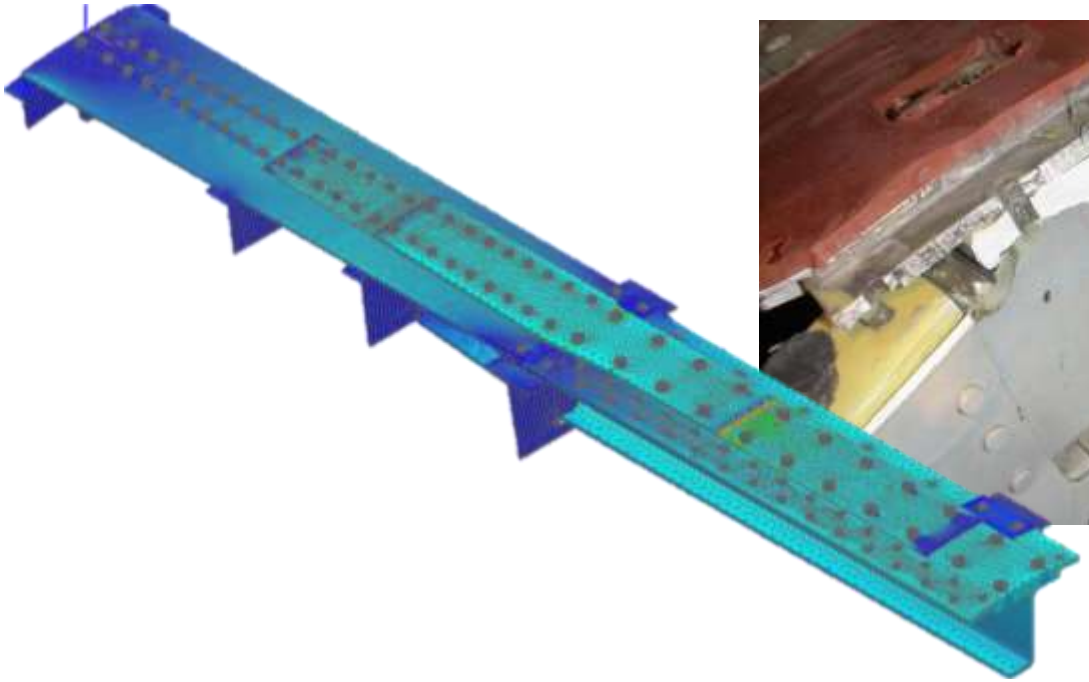
A-10 ASIP Needed Tools and Qualifications

- 3D CAD NX & Teamcenter
- Finite Element Analysis (FEA)
  - Detailed Finite Element Model (FEM) inserted into a global loads FEM
    - Boundary conditions more accurately simulated
    - Strain gauge validated



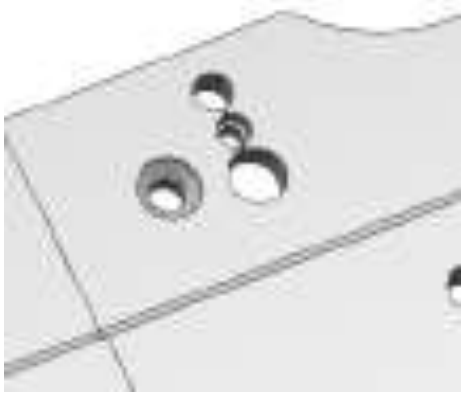
A-10 ASIP Needed Tools and Qualifications

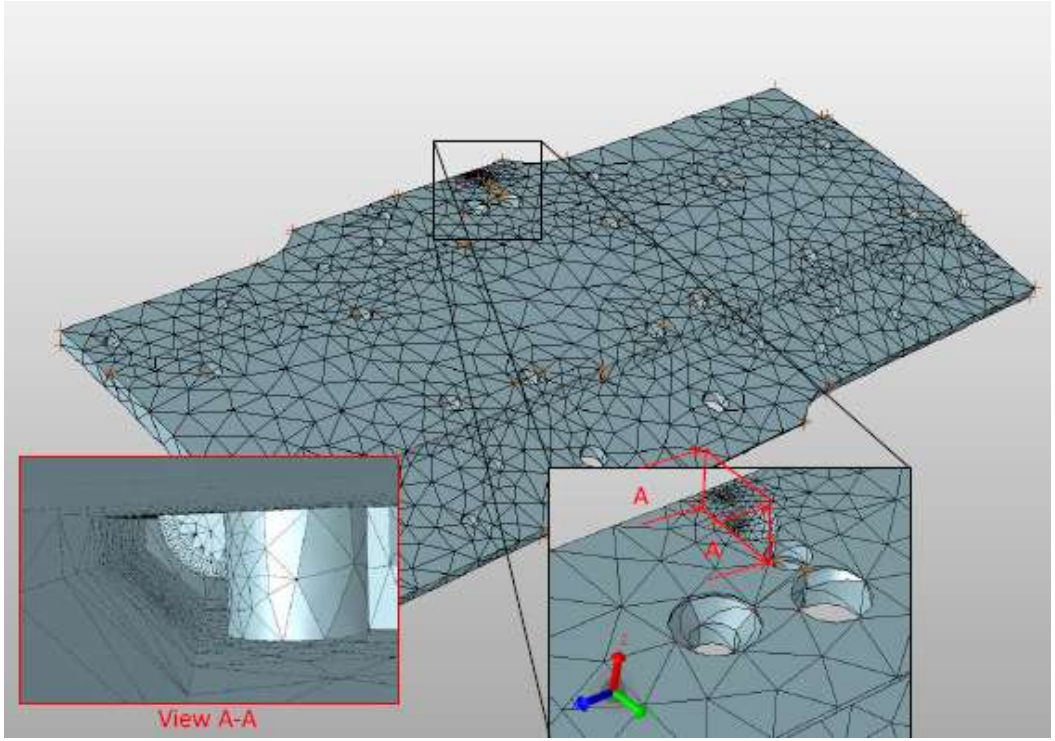
- FEA load distribution
  - Baseline structure and repair configuration
  - Fastener loads
  - Contact surfaces
  - Load re-distribution with crack propagation



A-10 ASIP Needed Tools and Qualifications

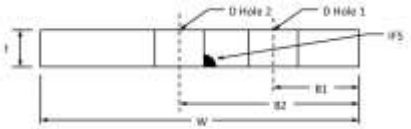
- **Stress intensity solution – StressCheck**
  - **Unique Geometry/Loading not represented by standard solutions**

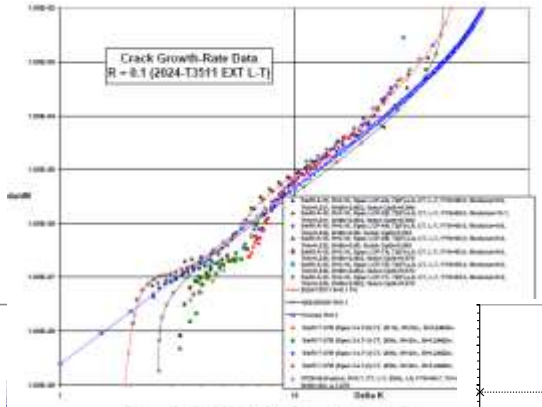


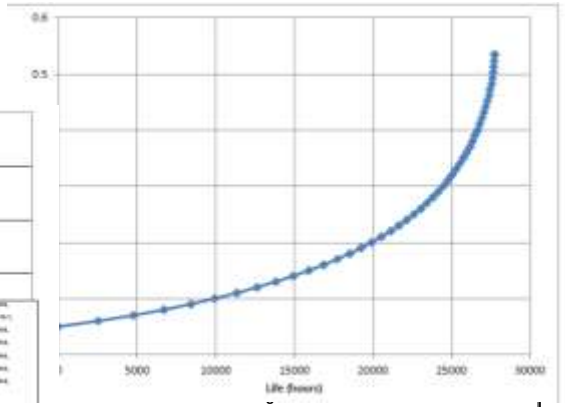


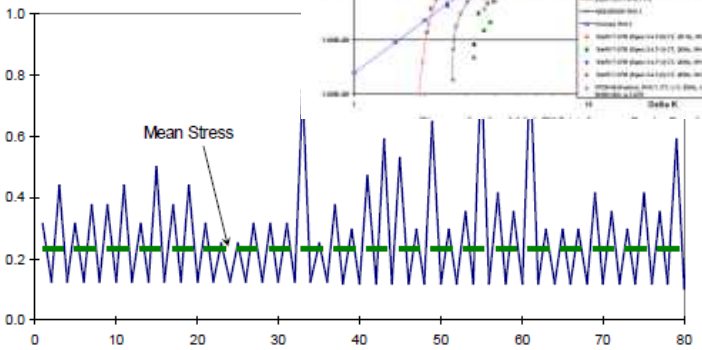
A-10 ASIP Needed Tools and Qualifications

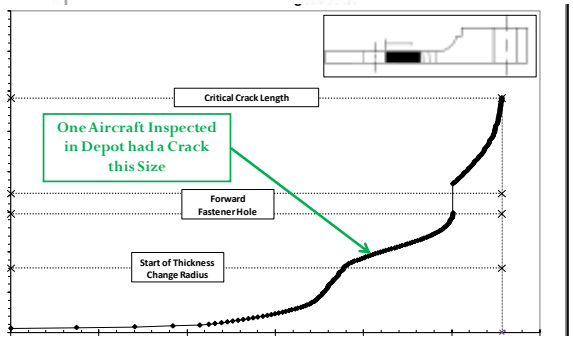
- **Damage Tolerance Analysis (DTA)**
  - **AFGROW, StressCheck, BAMF**
- **Technical data required for organic DTA**
  - **Usage Data / Loads / Stress Analysis → Stress Spectra**
  - **Material Data**
    - **Crack Growth Rate Data**
    - **Spectrum Testing**





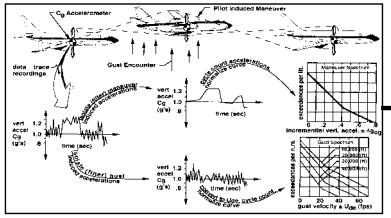






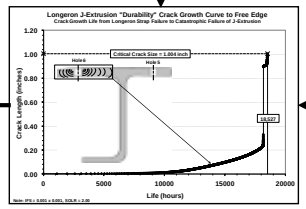
A-10 ASIP Needed Tools and Qualifications

- **Fleet health – PRoF**
  - **Update 11/2015**
- **Risk based induction**
  - **Condition and need**

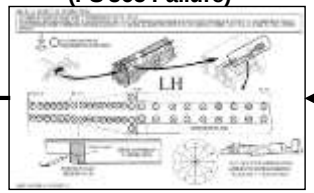


Aircraft Usage

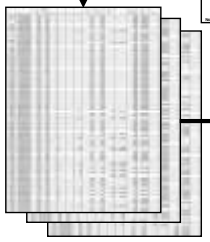
Test Experience (FS 365 Failure)



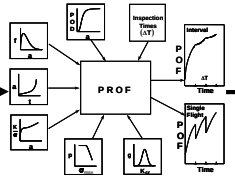
Damage Tolerance Analysis



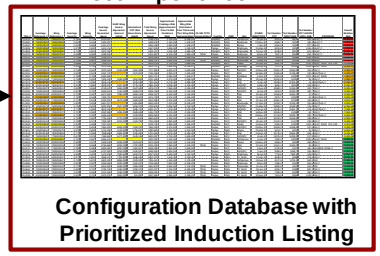
Fleet Experience



Processed Inspection Data

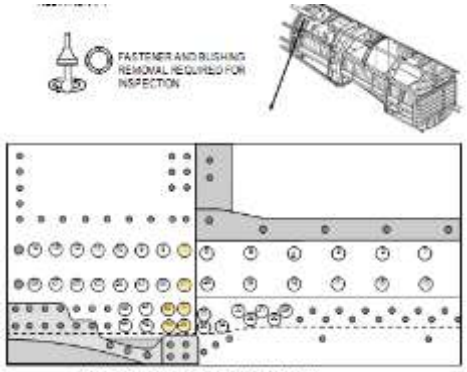


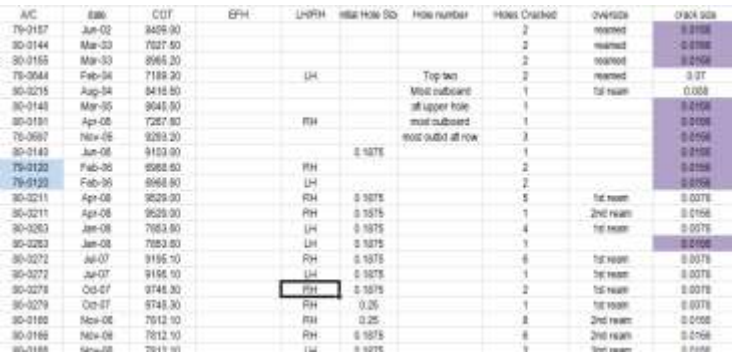
Risk Assessment



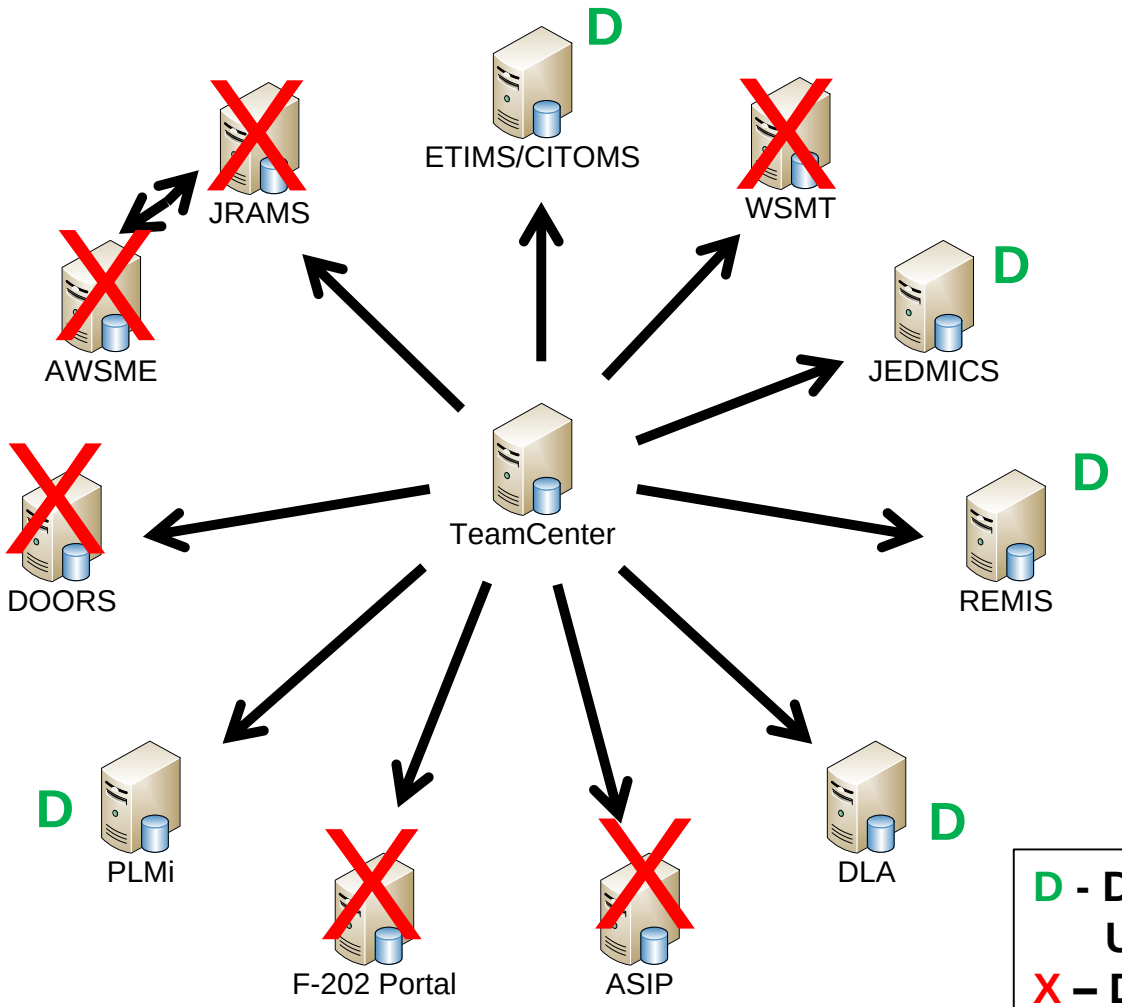
Configuration Database with Prioritized Induction Listing

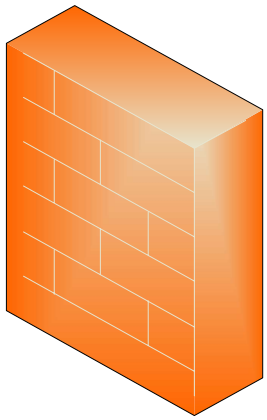
- **Fleet risk assessments**





A-10 PLM Implementation

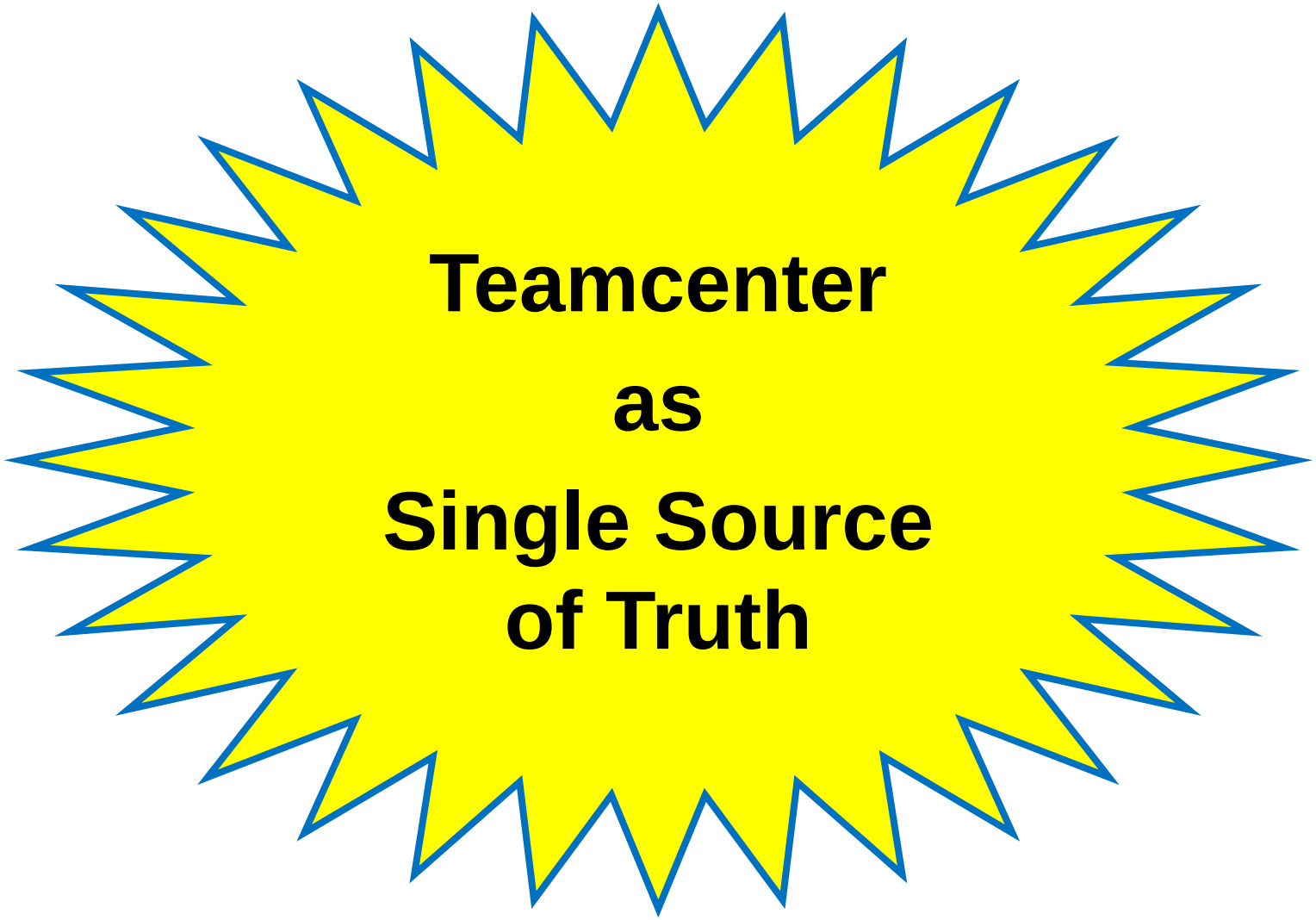




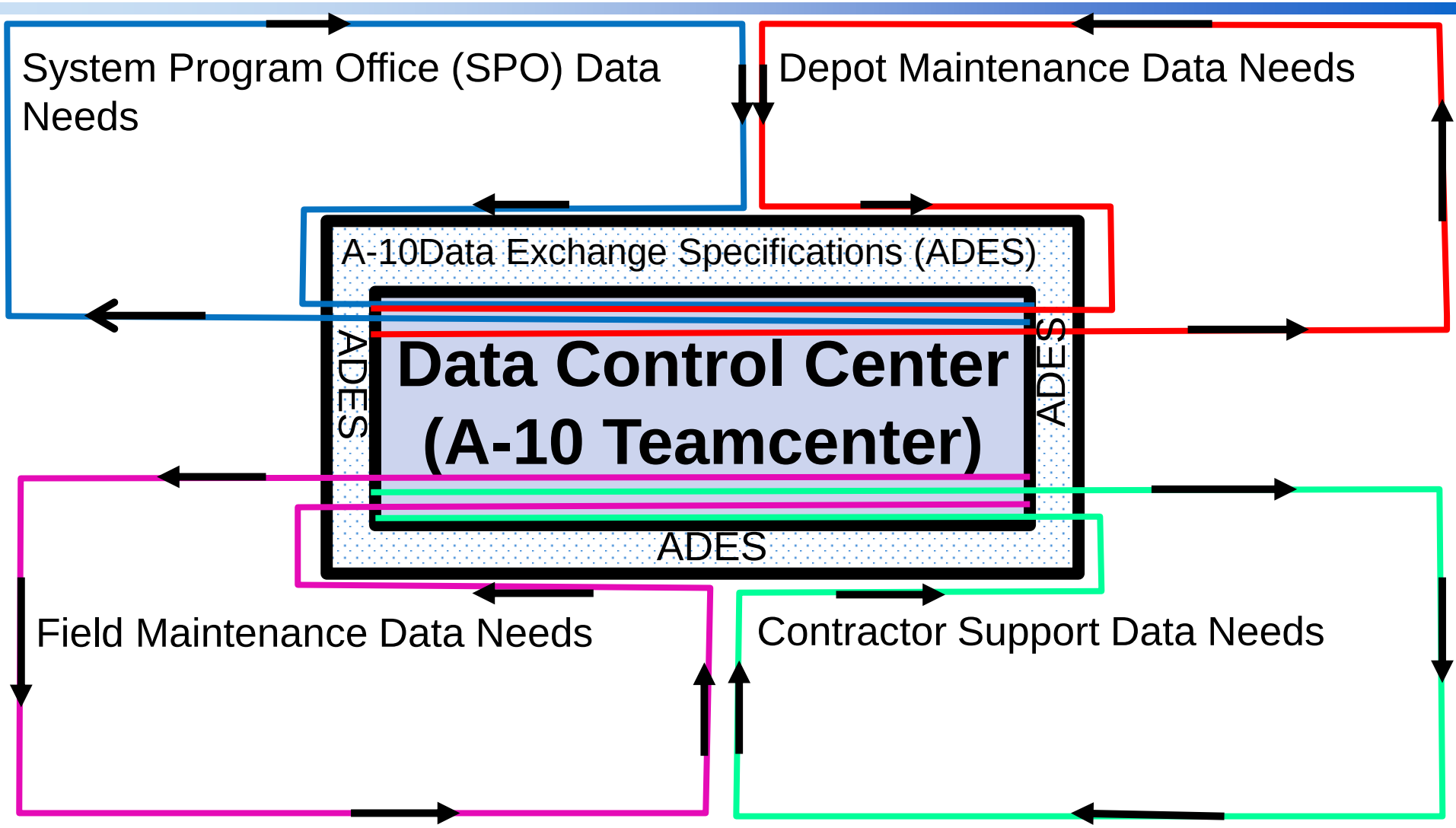
A-10 Data Exchange Specification

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

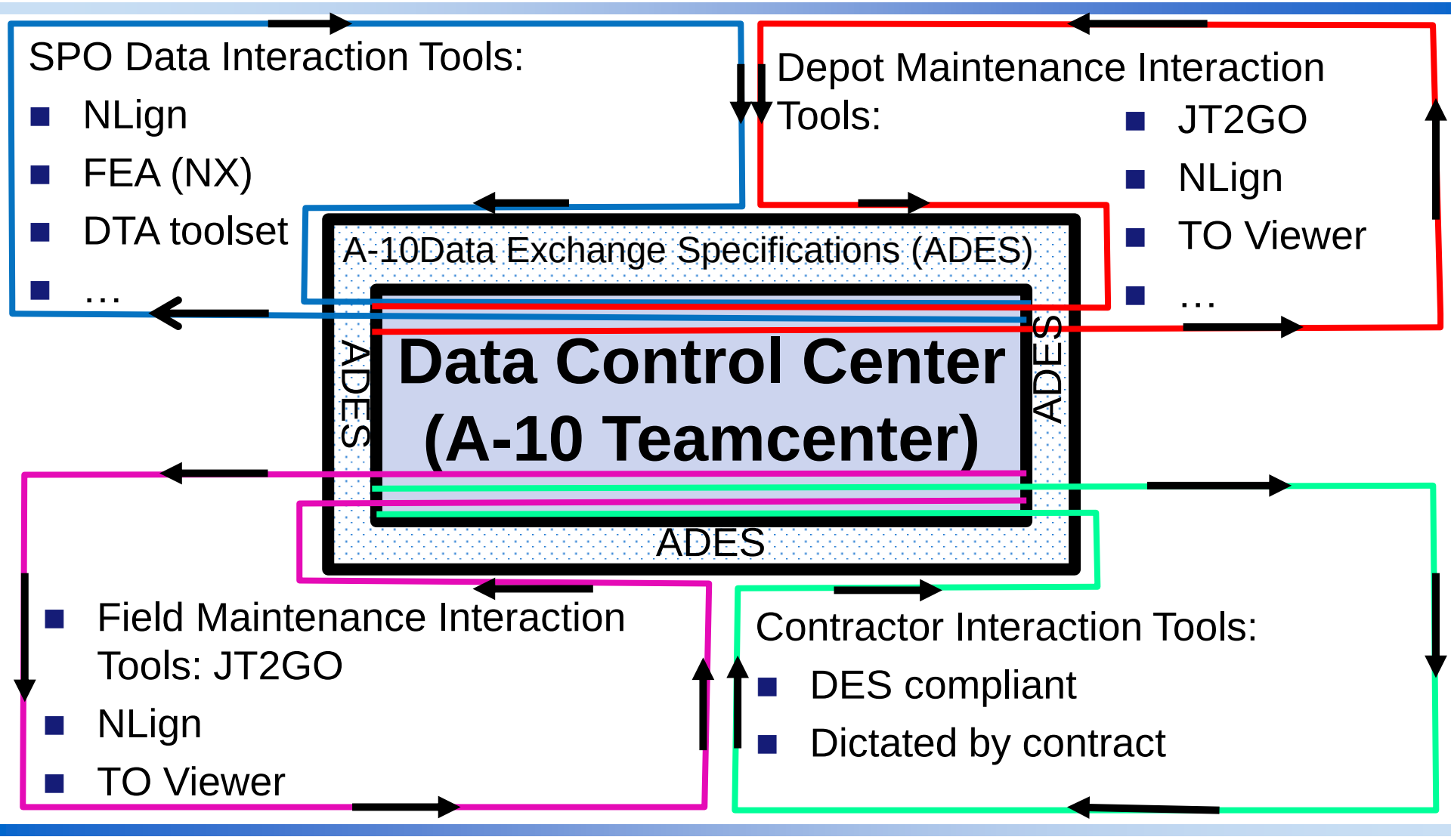
A-10 PLM Implementation



A-10 PLM Implementation

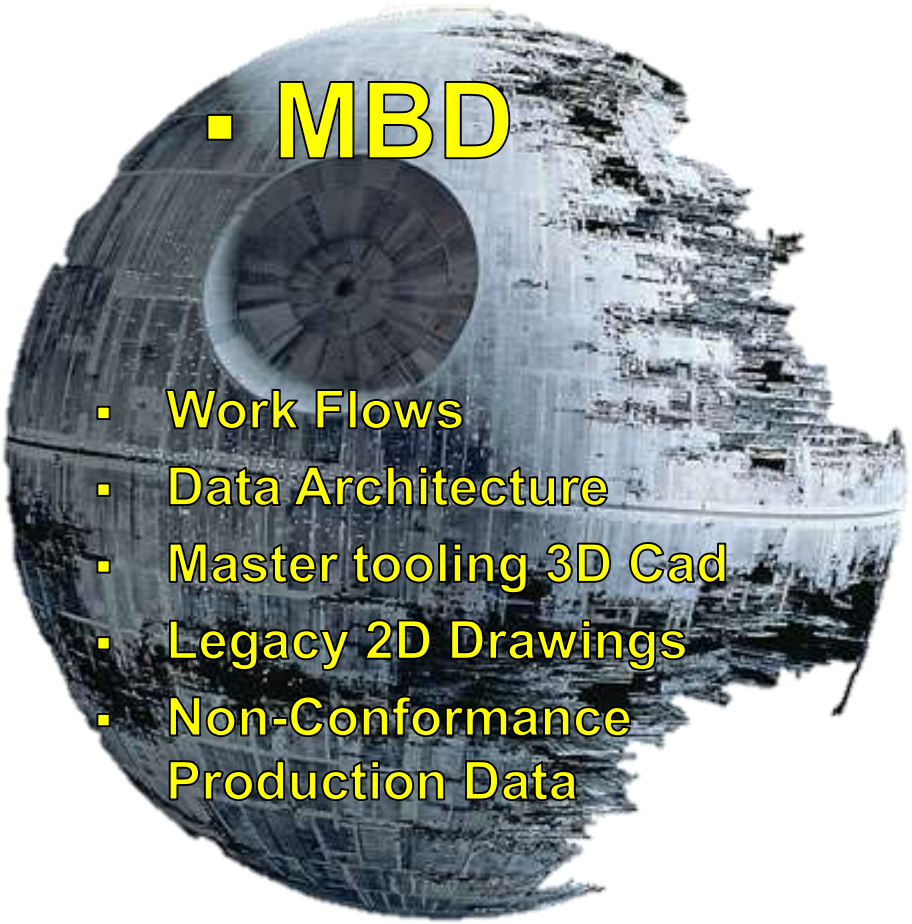


A-10 PLM Implementation



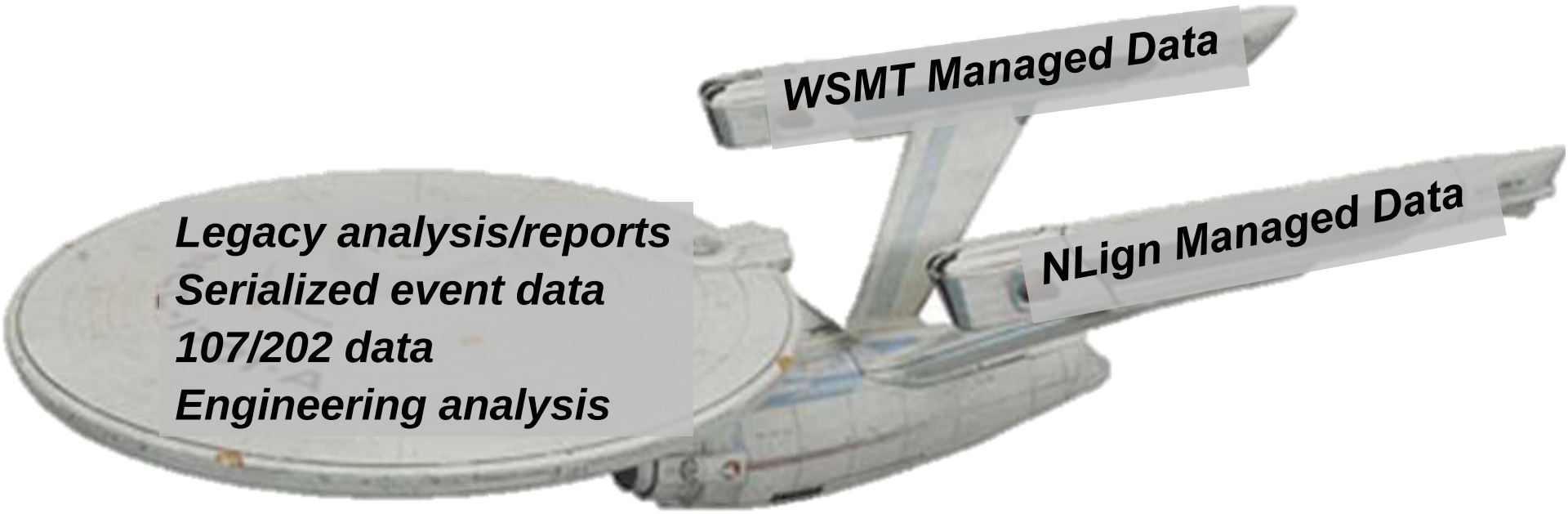
A-10 PLM Implementation

- **Current state of the A-10 PLM effort – Are we there yet?**



A-10 PLM Implementation

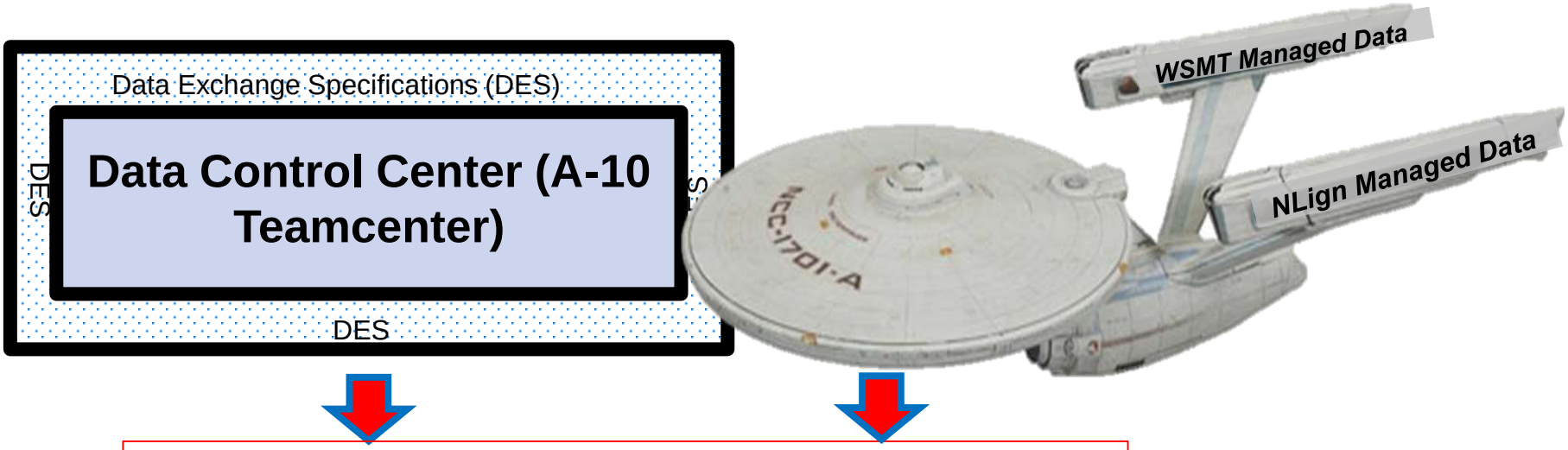
- **Data migrating from other systems – Currently testing**



A-10 PLM Implementation

The Death-Star-Trek

Adaption to the Current Digital Data Environment

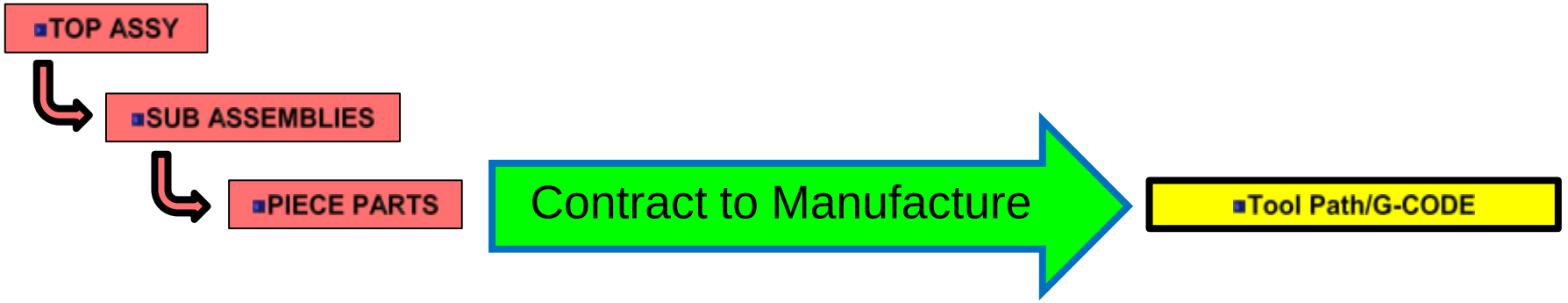


- Configuration control
- Change management
- **Technical data packages**
- Service Lifecycle Management (SLM)
  - **Condition based maintenance**
  - Predictive analysis

Technical Data Package Benefits

Modifications and Part Procurements

- How do we save $$ by controlling the 2D & 3D part data?



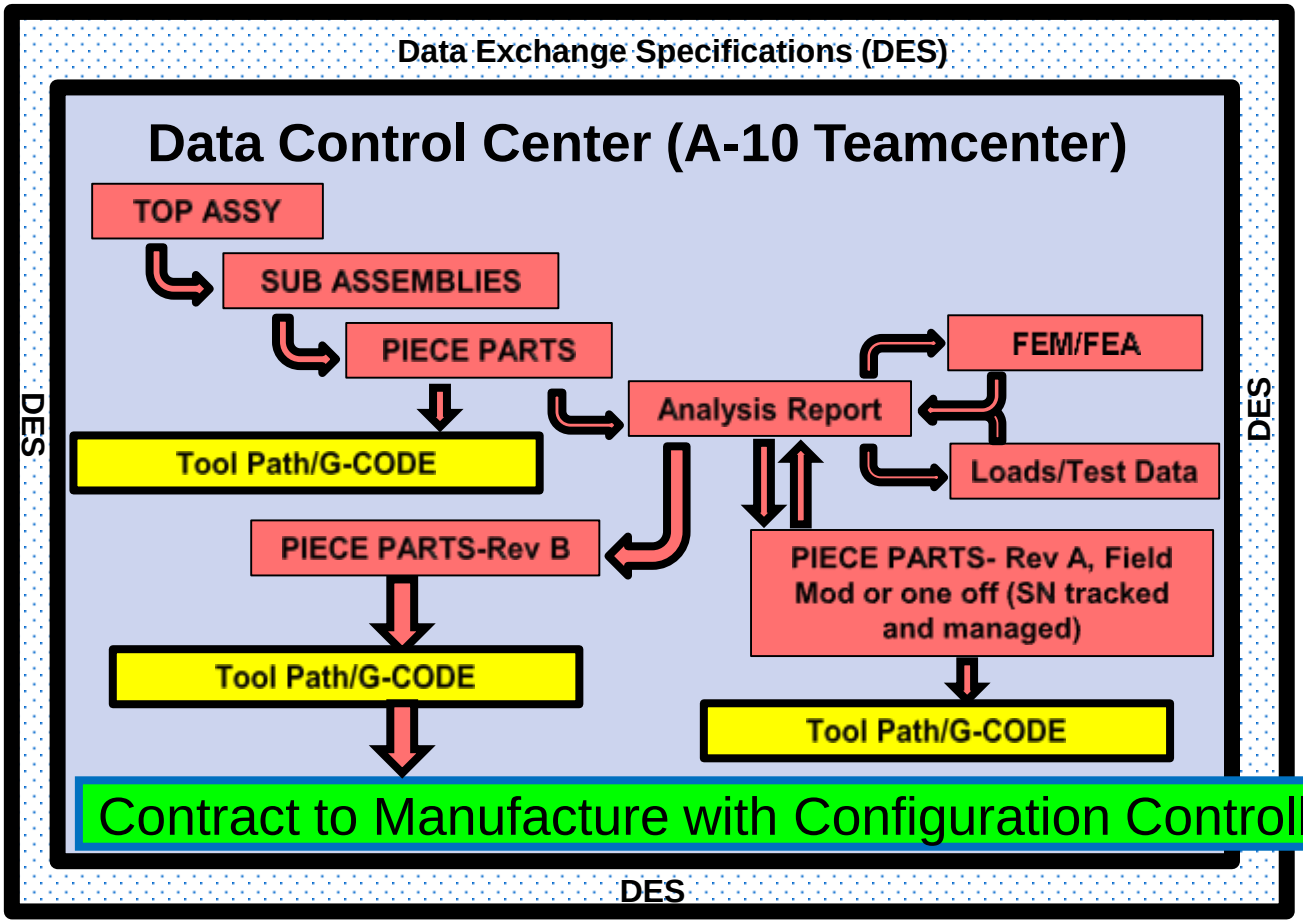
- Risk factors
  - Was the Government Furnished Information (GFI) correct?
    - Were there any Engineering Orders (EO) to change the drawing/definition in process when the data package was released?
  - Was the GFI to produce the part from a 2D drawing or 3D part Definition?
    - Who developed the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

*Rick Mendoza F-18, PLM Brief

Technical Data Package Benefits

Modifications and Part Procurements

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



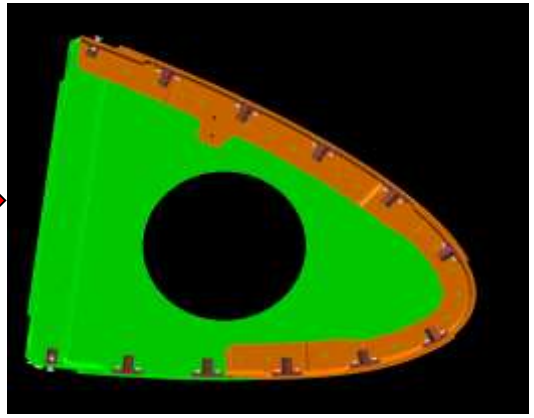
- Eliminate multiple geometry interpretations
  - No EO overlay or interpretation
- Eliminate modeling costs on future contracts
- Quicker delivery of Spare Part contracts

Tactical Advantages

Rapid Field Support (Bird Strike)

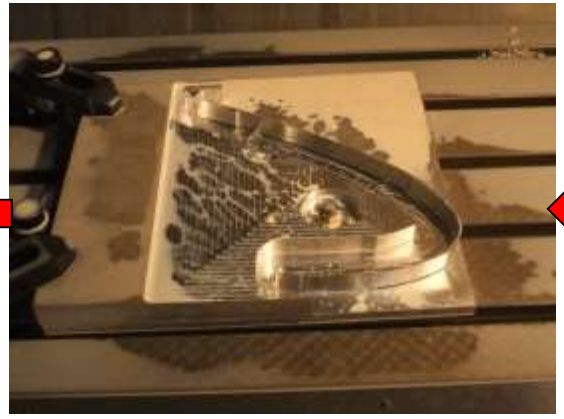
Bird Strike Area

Damage to Leading Edge



CAD Model of Repair

Test fit of 3D Printed Repair Part

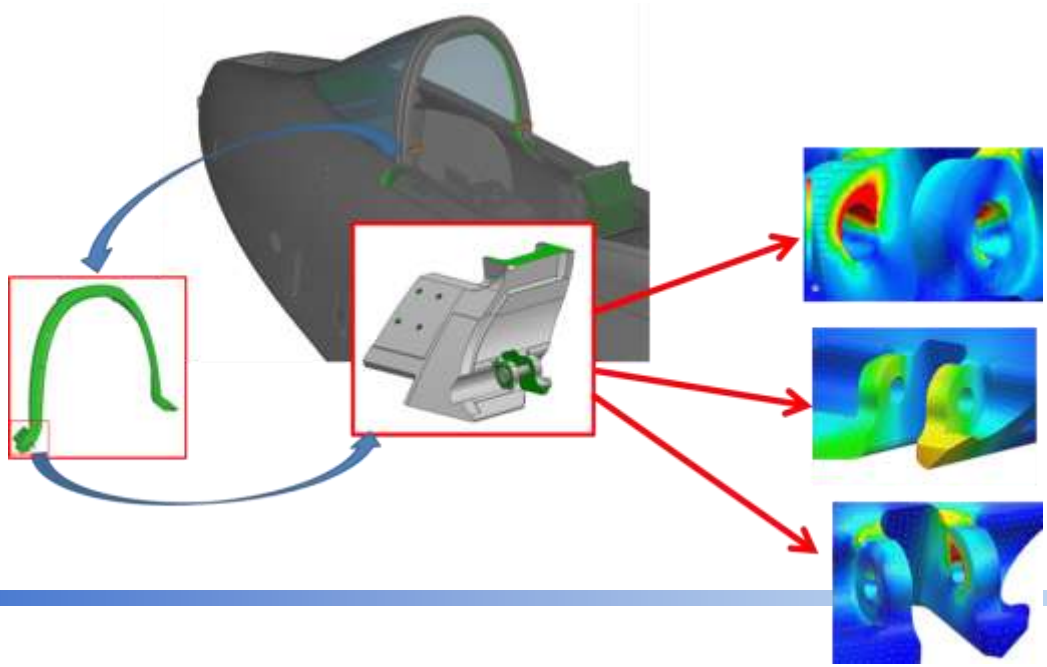


CNC Milling of Repair Part

Final Installed Repair

Tactical Advantages
Rapid ASIP Support (Canopy Lug)

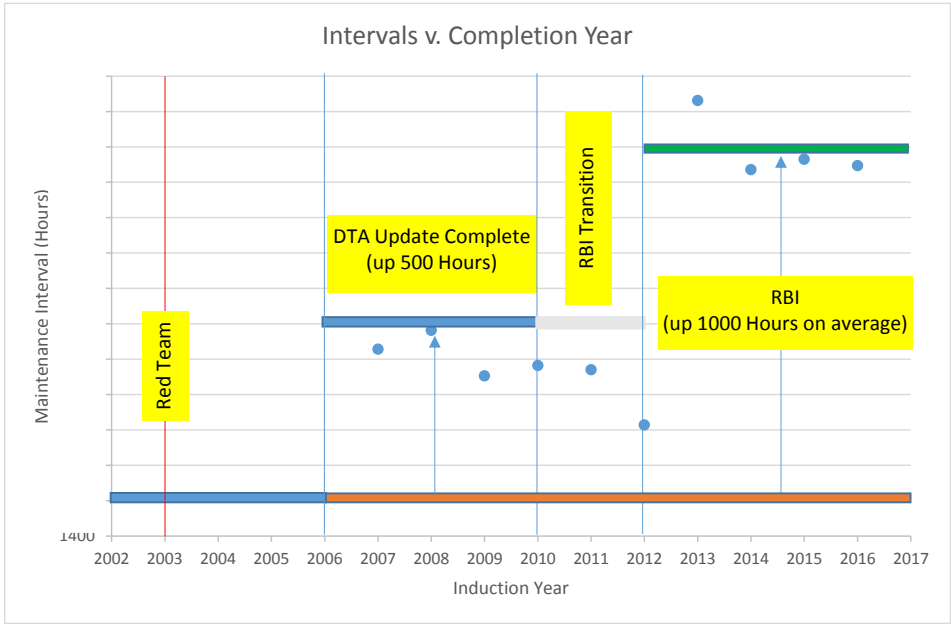
- 29 Feb 2016 – A-10 aircraft mishap at Osan Air Base, Republic of Korea
- 2 Mar 2016 – A-10 Division made aware of mishap
- Utilized ‘In-House’ analytical expertise and provided Osan support within 48 hrs
  - Leveraged A-10 Model Based Definition (MBD)
  - Comparison of simple lug Finite Element Model (FEM) & a FEM with the actual lug geometry
    - Identified appropriate analytical approach to support the situation
  - Provided procedures and analytical support to inspect the remaining AC Osan jets.



Tactical Advantages
Fleet Management

Risk-Based Induction

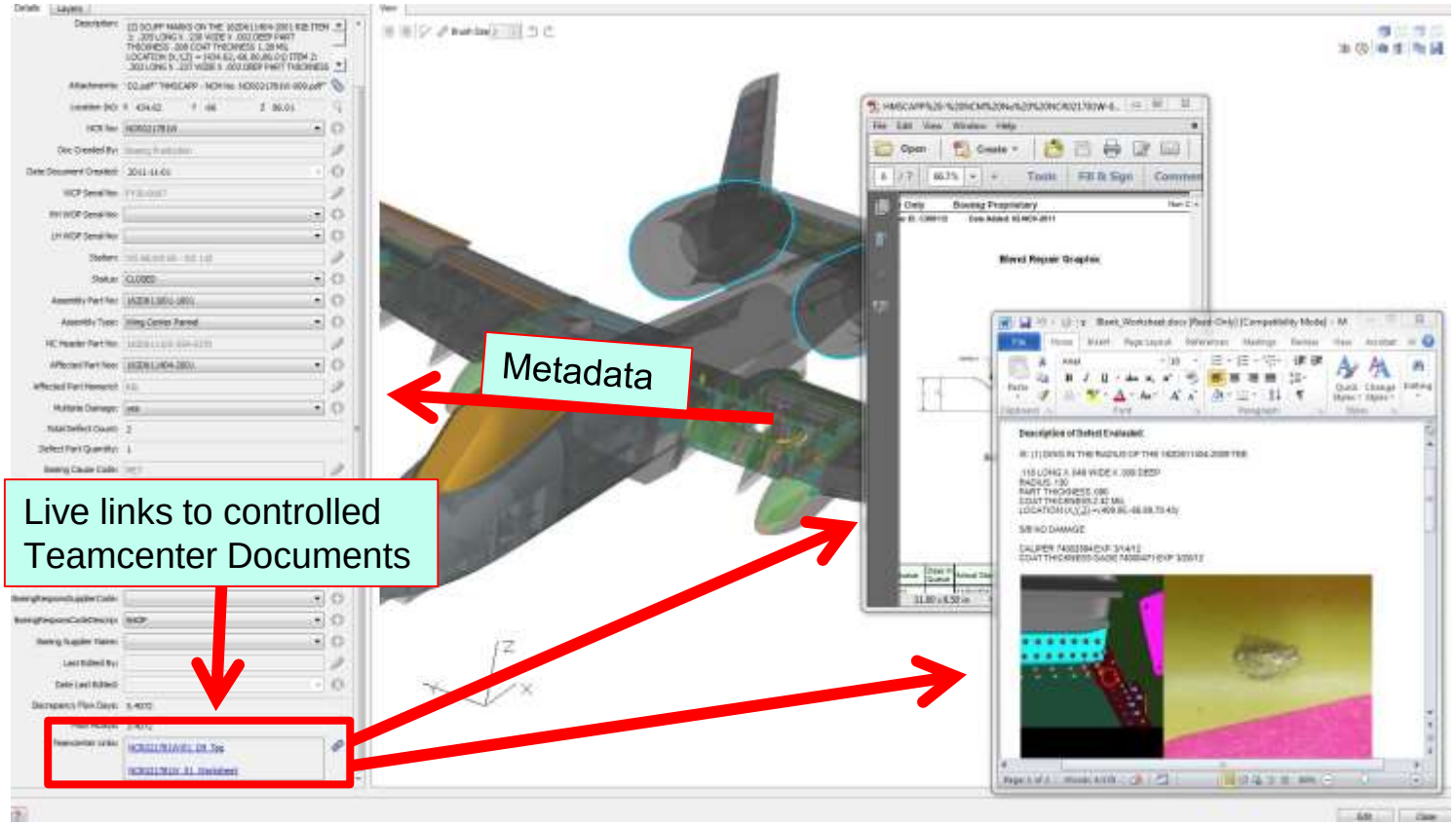
- Previously – One Size Fits all approach to aircraft depot maintenance
  - Based on 2000 hour flight induction
- Now – Visibility of individual aircraft configuration including damage and flight condition
  - Aircraft now inducted based on **condition and need** instead of calendar or flight hour threshold
- Benefits
  - $100M savings to date based on reduced depot maintenance needs
  - Maintaining aircraft availability beyond 1.5X the original design service objective



Tactical Advantages

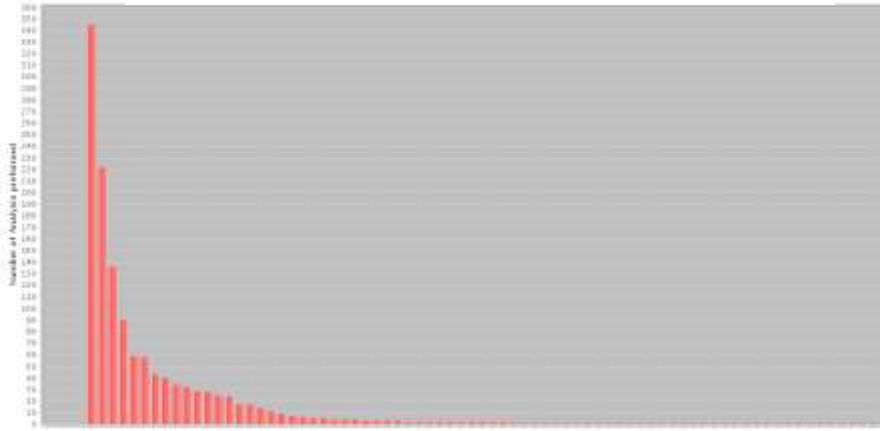
Rapid data Collection and Communication

- A-10 PLM interaction Tool
  - NLign

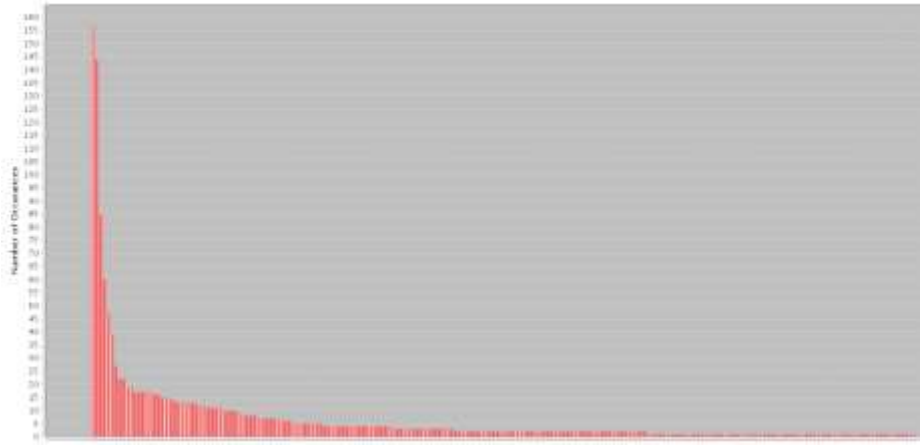


PLM Interaction Tool (NLign)
Trend Analysis

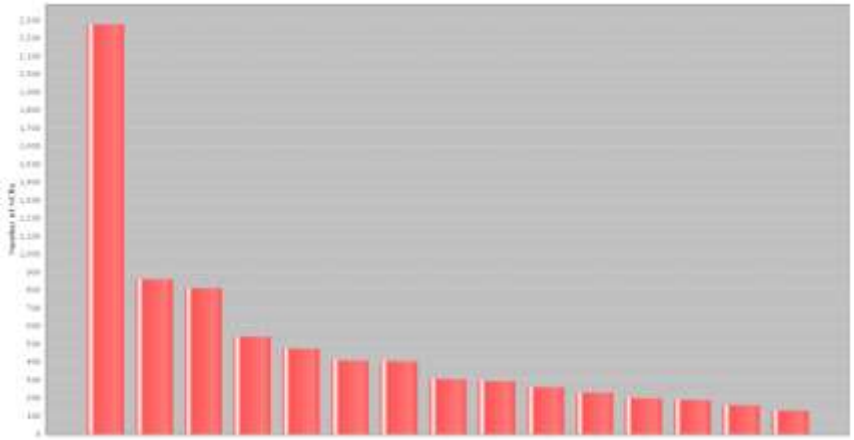
202/107 Analysis Support Reasons



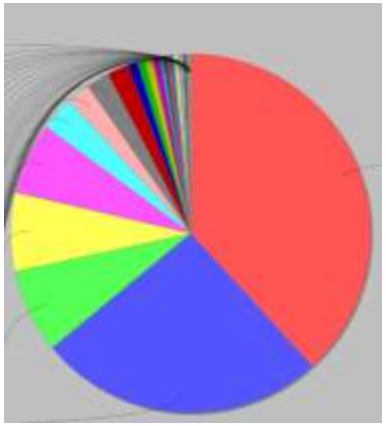
Test and Teardown Cracking by Location



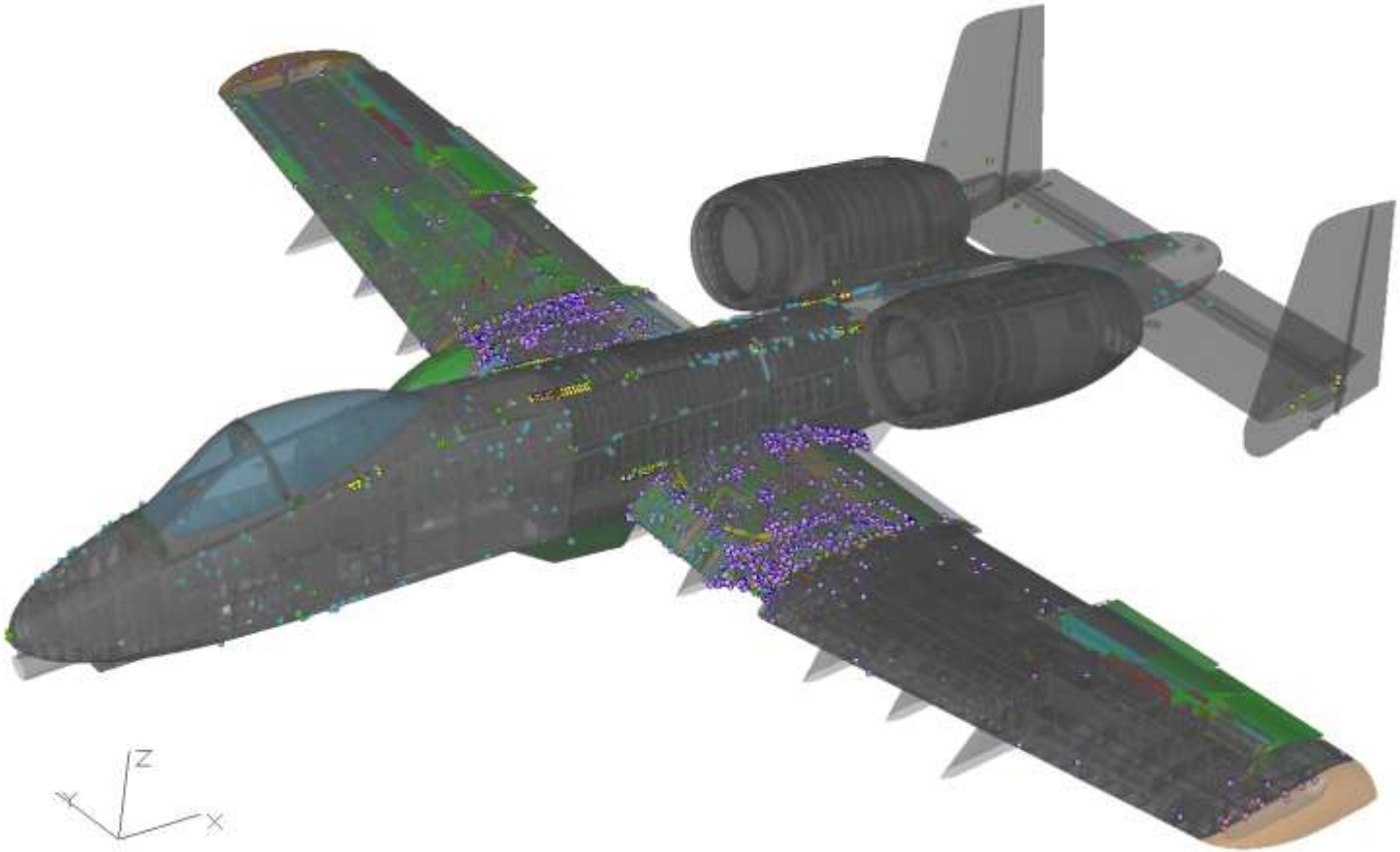
EWA NCR Defect Description (Top 15)



SSI Finding Damage Type



PLM Interaction Tool (NLign)



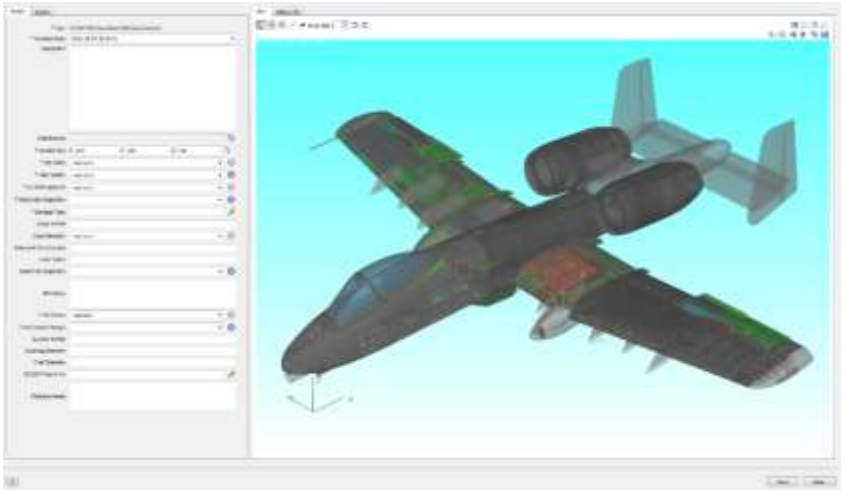
Data Capture at the Point of Maintenance

- A-10 Scheduled Structural Inspection (SSI) program.
  - Historically it takes 7-9 months from the asset induction date before Engineering sees SSI data
    - Low quality
  - No ability for engineering to address data issues while the asset is open and accessible
    - Usually asset is back on an aircraft and ready for service when the maintenance data is received
  - Engineer Tech required to manually input data into database

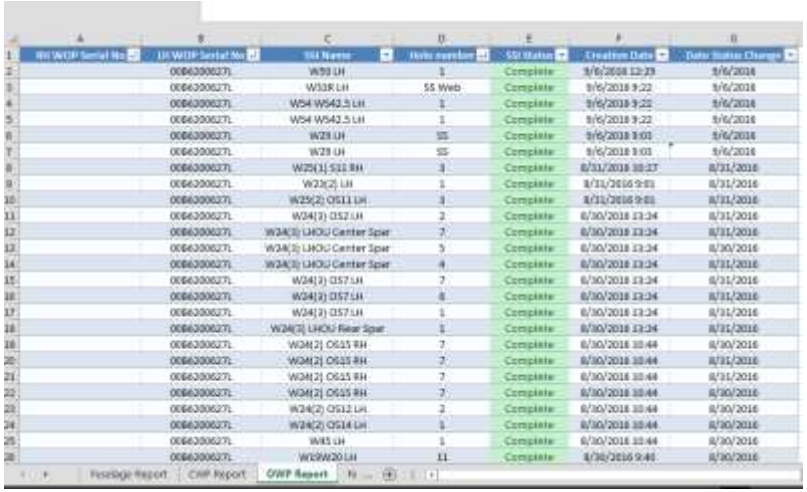
Data Capture at the Point of Maintenance

- Aug-Sept 2016 NLign data collection test.
- Customized NLign data capture trendable
- Developed quick ‘at a glance’ reporting tool
  - Keep supervisors informed
  - Keep NDI tech and Mechanic in sync to work remaining

Data input screen



Coordination Report



	A	B	C	D	E	F	G
1	RH WOP Serial No	LH WOP Serial No	SSI Name	Hole number	SSI Status	Creation Date	Date Status Change
2		00B6200627L	W30 LH	1	Complete	9/6/2016 12:29	9/6/2016
3		00B6200627L	W30R LH	SS Web	Complete	9/6/2016 9:22	9/6/2016
4		00B6200627L	WS4 WS42.5 LH	1	Complete	9/6/2016 9:22	9/6/2016
5		00B6200627L	WS4 WS42.5 LH	1	Complete	9/6/2016 9:22	9/6/2016
6		00B6200627L	W28 LH	SS	Complete	9/6/2016 9:01	9/6/2016
7		00B6200627L	W28 LH	SS	Complete	9/6/2016 9:01	9/6/2016
8		00B6200627L	W25(1) SS1 RH	3	Complete	8/31/2016 10:27	8/31/2016
9		00B6200627L	W22(2) LH	1	Complete	8/31/2016 9:01	8/31/2016
10		00B6200627L	W25(2) OS11 LH	3	Complete	8/31/2016 9:01	8/31/2016
11		00B6200627L	W24(3) OS2 LH	2	Complete	8/30/2016 13:24	8/31/2016
12		00B6200627L	W24(3) LHOU Center Spar	7	Complete	8/30/2016 13:24	8/31/2016
13		00B6200627L	W24(3) LHOU Center Spar	5	Complete	8/30/2016 13:24	8/30/2016
14		00B6200627L	W24(3) LHOU Center Spar	4	Complete	8/30/2016 13:24	8/31/2016
15		00B6200627L	W24(3) OS7 LH	7	Complete	8/30/2016 13:24	8/31/2016
16		00B6200627L	W24(3) OS7 LH	8	Complete	8/30/2016 13:24	8/31/2016
17		00B6200627L	W24(3) OS7 LH	1	Complete	8/30/2016 13:24	8/31/2016
18		00B6200627L	W24(3) LHOU Rear Spar	1	Complete	8/30/2016 13:24	8/31/2016
19		00B6200627L	W24(2) OS15 RH	7	Complete	8/30/2016 10:44	8/30/2016
20		00B6200627L	W24(2) OS15 RH	7	Complete	8/30/2016 10:44	8/31/2016
21		00B6200627L	W24(2) OS15 RH	7	Complete	8/30/2016 10:44	8/31/2016
22		00B6200627L	W24(2) OS15 RH	7	Complete	8/30/2016 10:44	8/30/2016
23		00B6200627L	W24(2) OS12 LH	2	Complete	8/30/2016 10:44	8/30/2016
24		00B6200627L	W24(2) OS14 LH	1	Complete	8/30/2016 10:44	8/30/2016
25		00B6200627L	W45 LH	1	Complete	8/30/2016 10:44	8/30/2016
26		00B6200627L	W19W20 LH	11	Complete	8/30/2016 9:40	8/30/2016

Fuselage Report | OWP Report | OWP Report

Data Capture at the Point of Maintenance

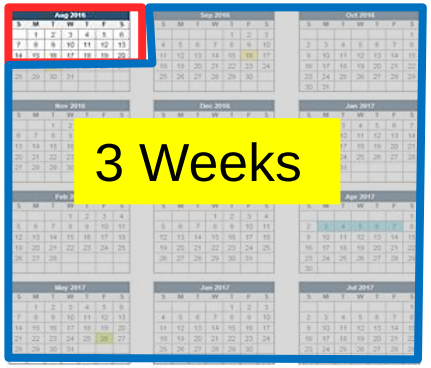
Historic SSI Data Capture Process

=

Low Quality

VS.

NLign Data Capture Test Case



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- Data delivered ~800% faster
- 3 Weeks from the day of induction till the final inspection was complete
- Data available the moment it was captured
- High Quality data!

Lessons Learned

- NLign was easy to understand and use by the Maintainers
- Most data is input by the NDI tech
  - Mechanic is required for dimensional data
- Keeping NDI techs trained to use NLign could be challenging
  - NDI techs rotate between weapon systems and shops monthly
    - Specific data capture software just being used by the A-10
- MX tough-books are still 32 bit not the required 64 bit system required for NLign
  - Different IT organization with conflicting views on upgrading tough books
- Engineering tech was present for support
  - Not a true ‘hands off’ test of the system
- MX Process Engineering is needed to develop the official procedures
- A-10 Wing Shop is eager to start a second round of testing
  - The first test allowed the shop to sell the asset sooner
  - Two more assets are ready to test the NLign tool

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
  - MBD/part number is the base structure for data to be related to
- 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
- Continue NLign testing with maintenance
  - Enhancement of smart fields for data input
  - Maintainer version of NLign with only applicable functionality to the job

Questions?