



**U.S. AIR FORCE**

# Ushering in the Digital Era of Proactive Corrosion Management - A-10 ASIP Prognostic Development & Tactical Advantages 30 Nov 23

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# Outline



- **History**
  - Actions to develop system
  - Lessons learned
- **Current State**
  - How data is looks
  - How data is being applied
- **Future State**
  - Plans to enhance processes
  - Test cases by induvial aircraft and location



# Acknowledgments



- Dr. Mark Thomsen
- ASIP Team
- NGC
- SwRI
  - Dr. Paul Clark



# History - 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



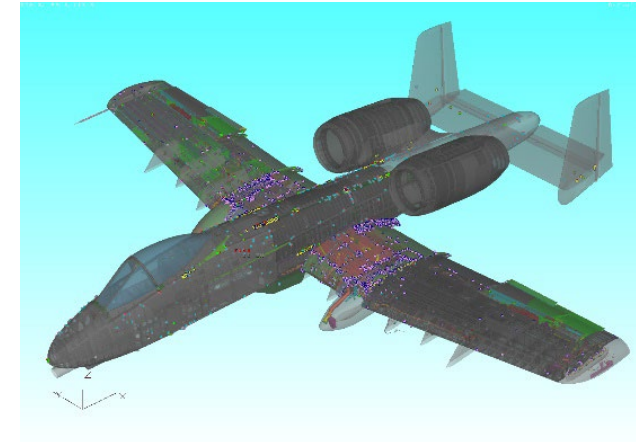


# History - Sprint Development of NLign

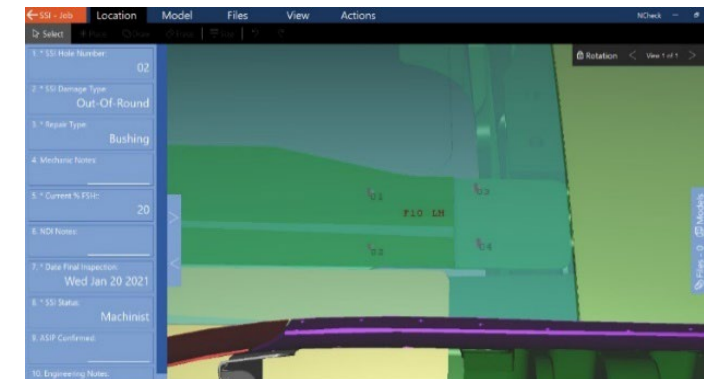
## ■ NLign Milestones

- AFRL Small Business Innovative Research funding (SBIR) - 2007
- Software Sprints Enhancements
  - SBIR, Rapid Innovation Fund (RIF) & A-10 SE funds – 2009-Present
- AF & Navy User Group Workshops 2015- present
- 2018 NLign roll out for maintenance data capture
- 2019 & 2020 **'Game Changing' milestones**
  - NCheck developed specifically for maintenance - (SBIR)
  - Data spatial position System - (RIF)

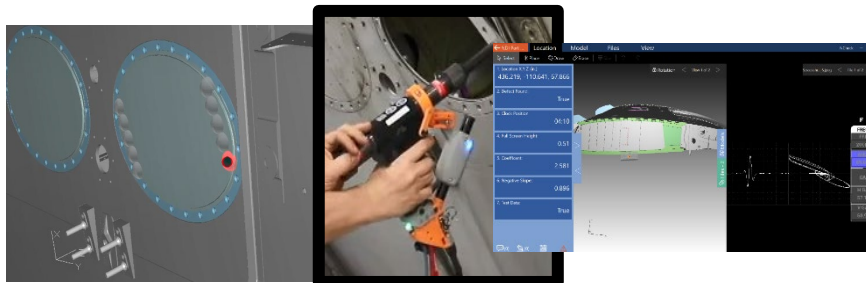
NLign – Engineering Analytics



NCheck – 'Data Wrangler'



DSP – Integrated Maintenance System (IMXS+)





# History - Organic OEM Analysis Capabilities



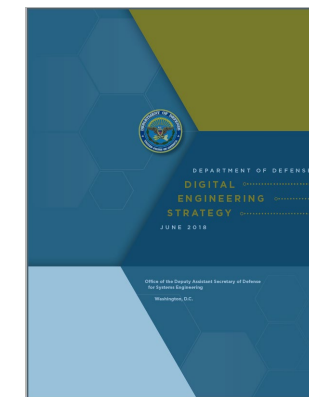
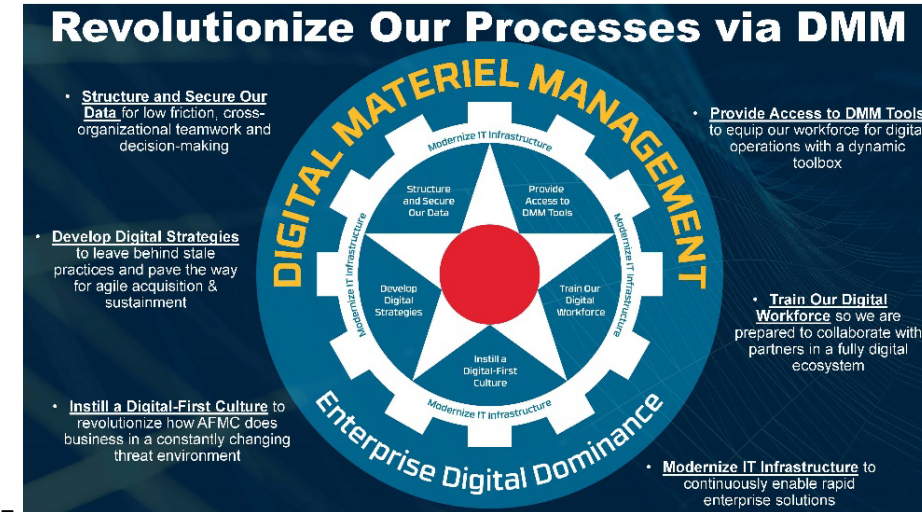
## ■ Forefront of Physics-Based Digital Engineering

## ■ Aero-Performance Analyses

- CFD; Wind Tunnel Testing; OSS&E; Flight Test
- Store Cert.; SEEK EAGLE Support; Airworthiness
- Mishap Investigation
- Aircraft Mass & Inertial Properties

## ■ Structural Analyses

- Spectra Development; Loads; Stress; Fatigue & Fracture Mechanics
- Finite Element Analysis; Global & Detailed Modeling
- Testing-Coupons, Component, Full-Scale, Sens. Studies
- Teardowns; Failure Assessments
- Prognostics; Probabilistic Risk Based Planning;



**U.S. AIR FORCE**

**A-10 Thunderbolt II**

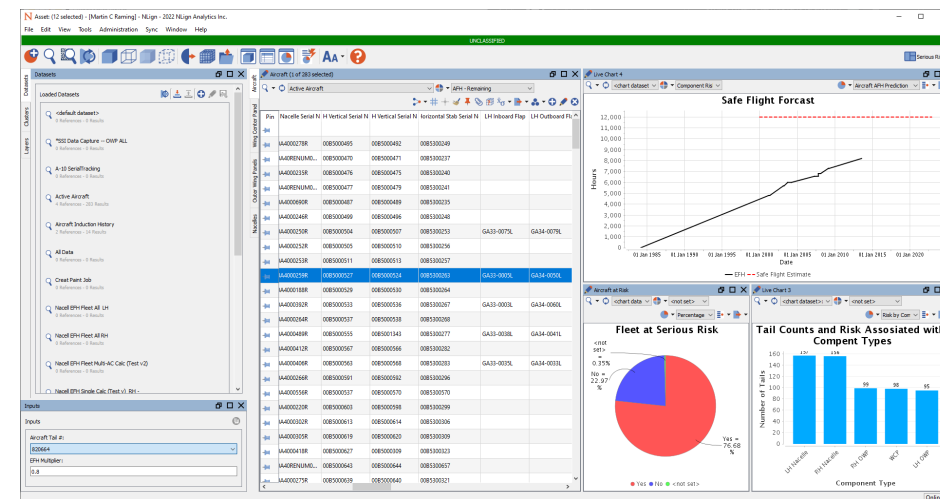
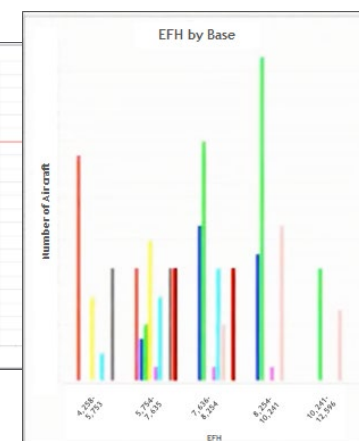
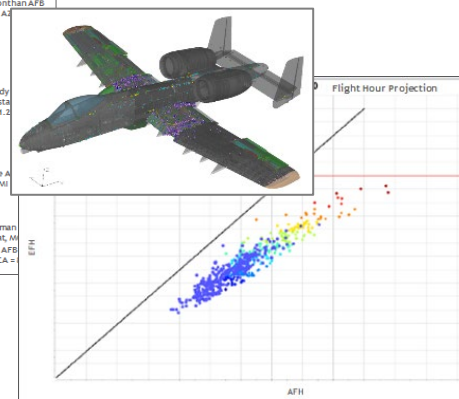
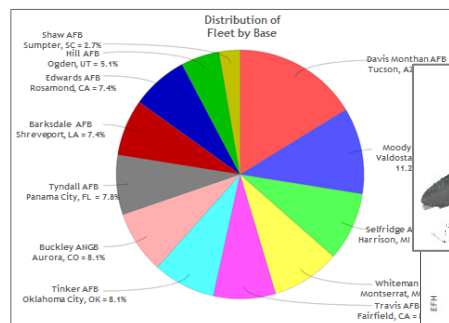
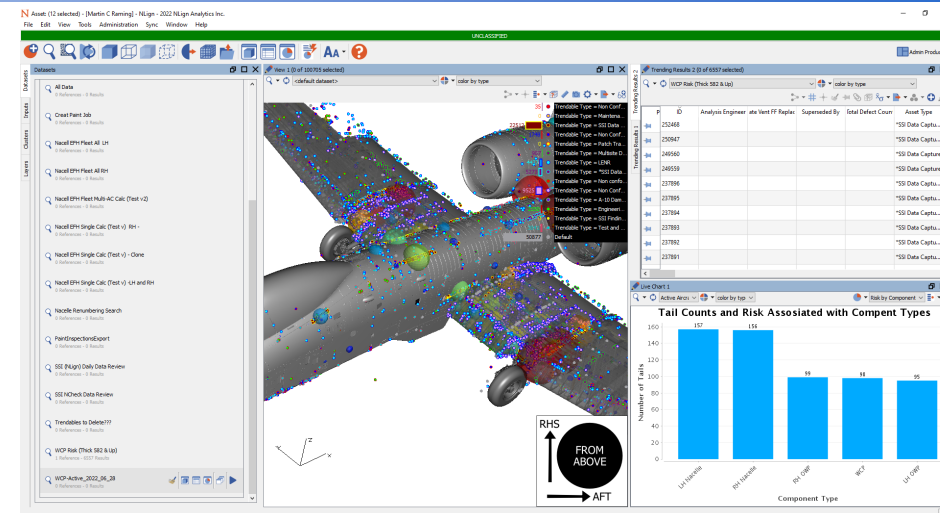
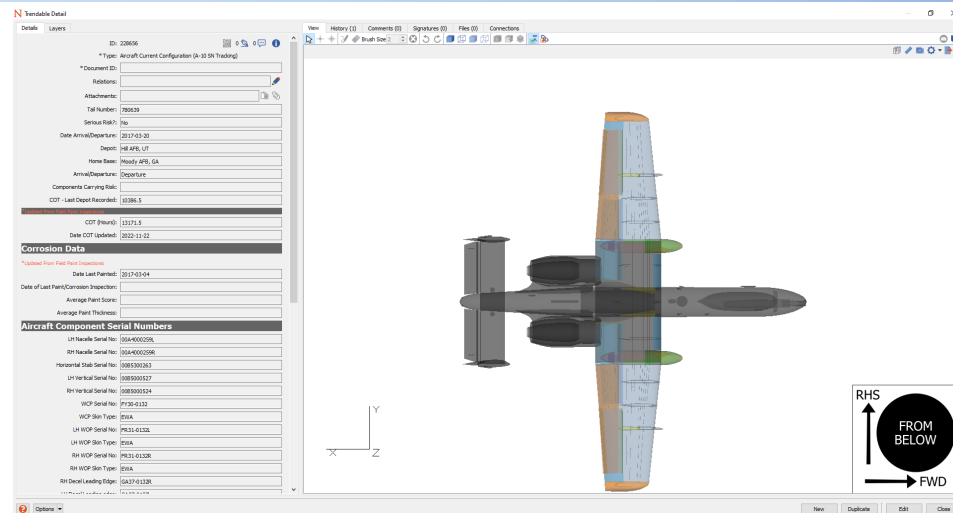
**A-10**

The A-10 aircraft was designed in the 1970s using 2-D drawings. The A-10 Wing Replacement Program (WRP) infused 3-D model-based design (MBD). The program developed approximately 10,000 unique models that required new methods to allow for handling and integrating data. A-10 also adopted a new technology, NtLign, to map repairs onto the 3-D model. The adoption of 3-D MBD and Product Lifecycle Management (PLM) allowed A-10 to construct the digital thread for the sustainment phase of the lifecycle and identify the authoritative source of truth for A-10 engineering data.

**EXAMPLE: Incorporate Technological Innovation (Goal 3)**



# History - Data Analytics with NLight - Customizable Dashboards with Live Charts





# Current - Authorization for NLink Usage



**A-10 Thunderbolt II**

**A-10**  
WARTHOG

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**EXAMPLE: Incorporate Technological Innovation (Goal 3)**

Updating technical work documents is critical to changing culture and authorize mechanics to use new software (i.e. scheduled structural inspections, corrosion management)

**Vision for Weapon System SPO users is to incorporate NLink into their Mx tech data**

Excerpt from DoD Digital Engineering Strategy - June 2018  
Michael Griffin – Undersecretary of Defense for Research and Engineering  
OUSD R-E

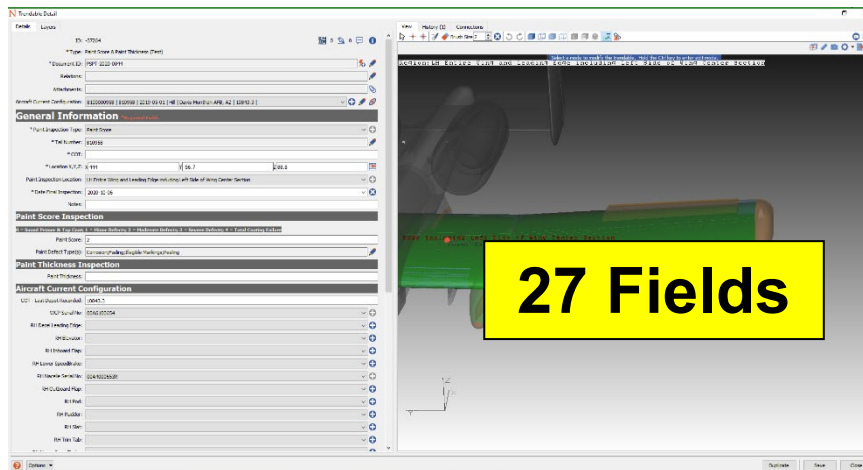
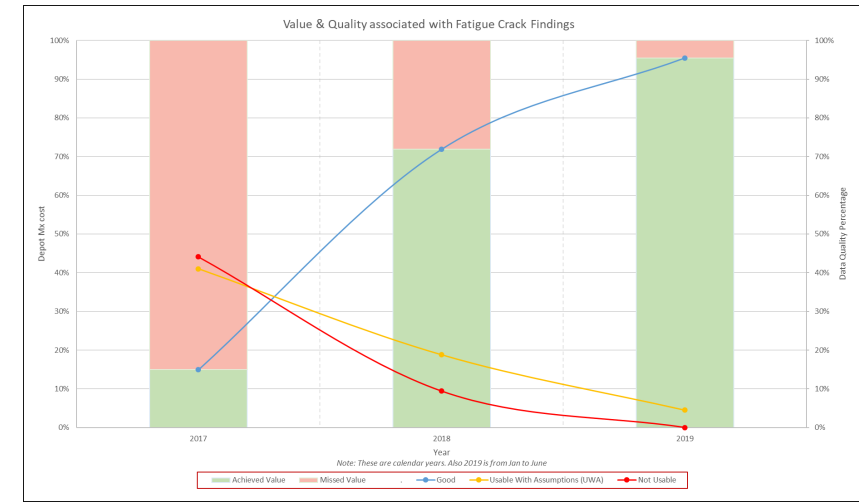




# Current – Application Lessons Learned



- Digital input
  - Culture change = time + training
  - ~80% quality improvement – 3-yrs
  - ~500% decrease in time
- User interface is key
  - NLogn vs NCheck





# Current - NCheck & Proactive Corrosion Management



- **Develop Architecture**
  - Digitize -23 requirements
  - Develop data capture environment
- **Change -23 reporting requirements**
  - Paint Thickness
  - Paint Scores
- **Val/Ver new method**
- **Enable success**
  - Provide tablets





# Current - Data Capture Case Study: Without & With a Tablet



## ■ Without Tablet

- Pictures were cumbersome
- 2-3 hrs of work
- 30-45 min boot time for laptop
- Located at C-130 wash area (.75 mi)
- Two A-10 wash areas; no internet

## ■ With Tablet

- Offline mode available
  - 2 hrs savings per day
- 15 – 20 minutes of data entry
- Some ergonomic adjustments needed
  - Shoulder strap – ladder usage is required





# Current - Prognostic/Predictive Corrosion Growth

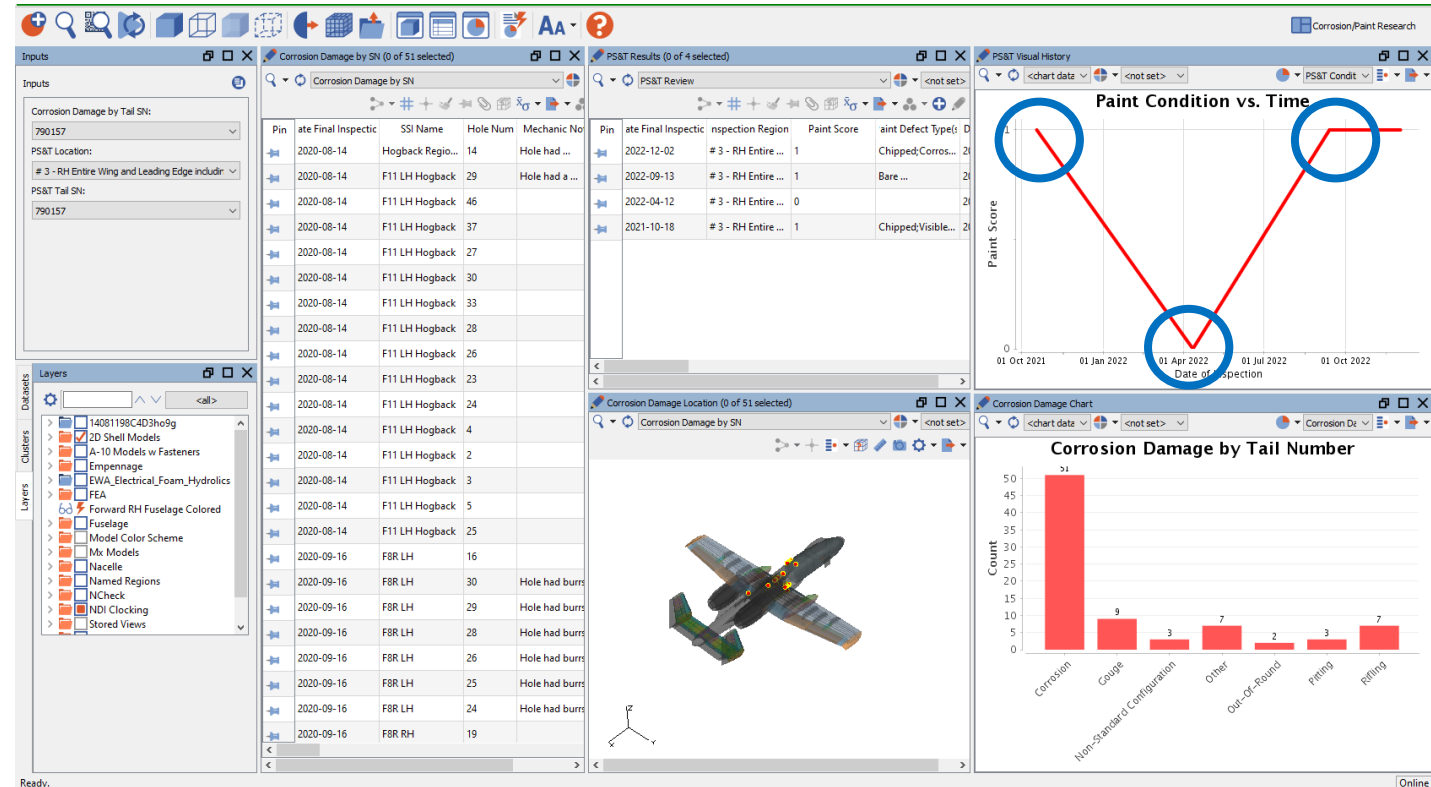


## ■ Present capability

- Inspection damages/repairs
- >2 yrs OML condition
- OML condition trends
- TAR historical records

## ■ Present mitigations

- Repeat damage leads to TO updates
- Phase inspection collection
- Early response to odd data



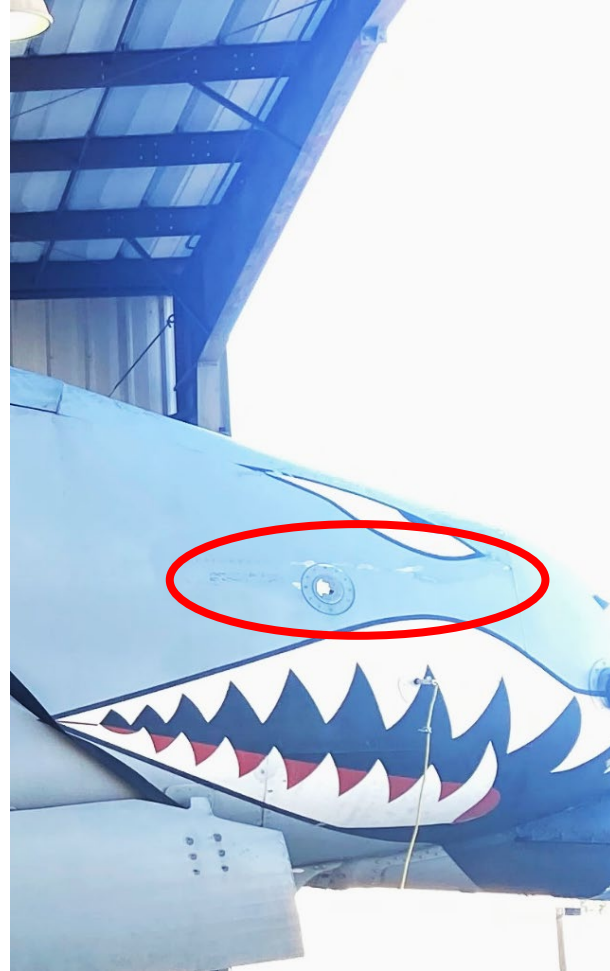


# Current – A-10 Nose Example



**Pictures from field are instantly uploaded and can be viewed seamlessly by EN**

17 November 2021



25 April 2022



24 August 2022





# Current – A-10 Nose Example

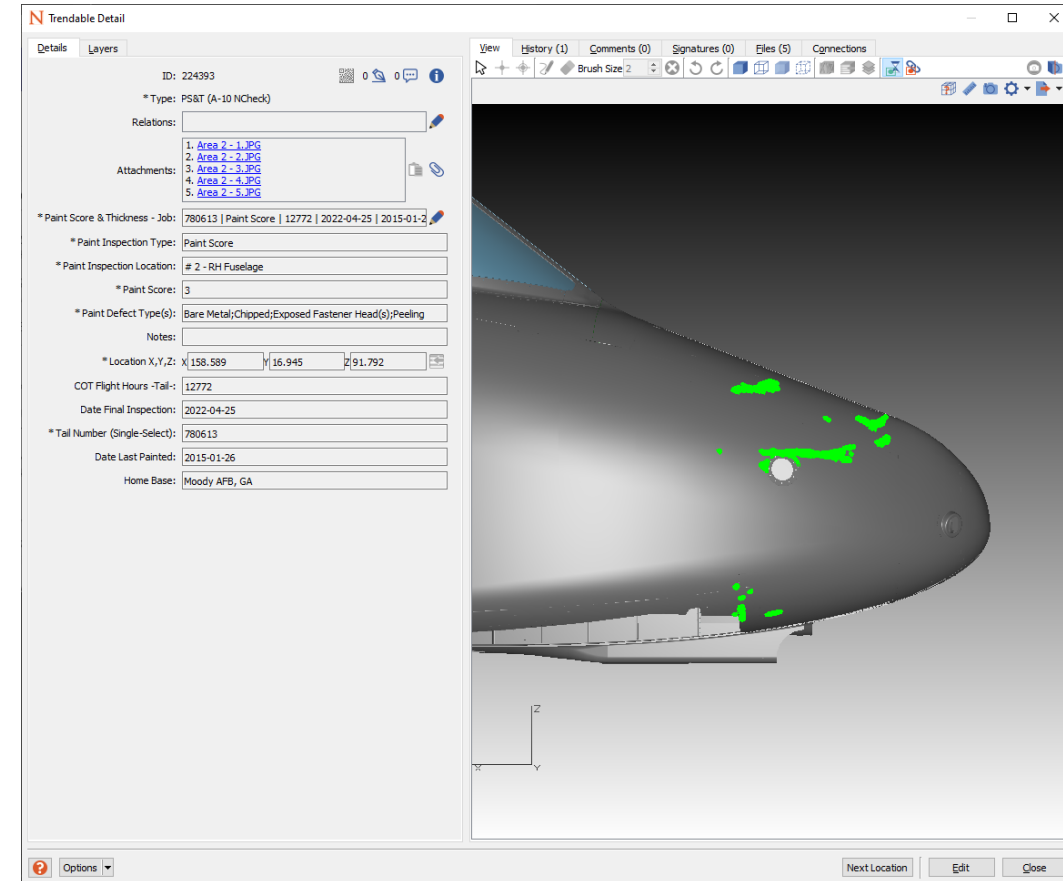
**Damages are “mapped” and digitized in the record**

**One step closer to a digital twin**

Pictures from the field



NLign database and damage mapping





# Current - Tactical Usage – 8YC Waivers



- 8-Year Corrosion Inspection
- SN tracking provides previous inspection date
- Waiver receives new record
  - Recent paint score of OML
  - Visual inspection results
  - Relations to other records
  - Formal chief EN letter

Trendable Detail
View History (1) Comments (0) Signatures (0) Files (2) Connections

ID: 289402  
 \* Type: LENR (A-10 107/202 Data (EN))  
 \* Document ID: LENR-2023-004836  
 Relations: [LENR-2023-004356](#)  
 Attachments: 1. [80-0243 - 8YC 6+ Month Extension - 107-20](#)  
                   2. [Current 80-243 Paint Score.pdf](#)  
 \* AC Serialized Components: 800243 | 800243 | 593 | 160D110000-47 | Active |  
 Engineering Support Analysis: <not set>

**General Information** \*Required Fields

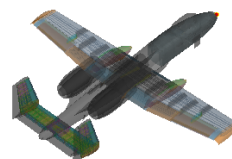
\* Document Title: 8YC 9-Month Extension Request  
 \* 202/107 Project No: 107-2023-100296  
 \* Project Type:  PIWG  
                    TECH Order Change  
                    Technical Assistance Request  
 Control No-F202 Ref:   
 \* Doc Created By: McLaughlin, Chris  
 \* Date Document Created: 2023-08-23  
If this is an abbreviated LENR add a relation to the original LENR doc ID above.

Abbreviated:  <not set>  
                    N/A  
                    No  
                    Yes

26E - Approving Engineer:   
 26E - Approval Date:   
 Notification Email?:

**Location & Inspection** \*Required Fields

\* Description: 8 Year Corrosion inspection on A0243 was due on 14 May 2023. It was approved to be moved to 14 Oct 2023 to align with the SSI input date but that input date has slipped to 9 Jan 24. The aircraft is currently in 1336A, ECI hangar and  
 \* Location X,Y,Z: X: 130 Y: 0 Z: 82  
 SSI Name:   
 SSI Hole Number:   
 Station:



Left Wash, prior to aircraft being removed from the was rack. Complete the Paint Score IAW LA-plate records in Nugin/Check IAW LA-100-23 Paragraph 1.13 Steps 3 & 4.  
See report in Nugin/Check IAW LA-100-23 Paragraph 1.13 Steps 3 & 4.

Area	Score
Area 3: Left Fittings	0
Area 8: Entire Left Wing and Leading Edge Including Left Side of Wing Center Section	0
Area 9: Left Nacelle and Intake Lip	0
Area 10: Left Horizontal Stabilizer and Left Vertical Fin, plus Leading Edges	2
Area 11: Left Landing Gear, Wheel Well and Trunion	0
Stab Caps	0
<b>Total</b>	<b>0</b>

4

**Paint Guide for Finish Ratings**

See Notes to topcoat ONLY.

Less than 1 inch in diameter. No areas of chipped/removed topcoat that are 1 inch or greater in diameter. Slight flaking, pin, flakes, chips, lumps or irregularities in topcoat. Partially missing topcoat from removable fastener heads (self-insulating) and not faded. No evidence of corrosion on permanent or removable fastener heads and/or tails.

Removed topcoat that are less than 1 inch in diameter. No areas of chipped/removed topcoat that are 1 inch or greater in diameter. Less than 5 areas of missing primer. No area larger than 5 inches missing primer. Topcoat completely missing from and/or tails show evidence of minor corrosion (red rust). Slightly peeling and faded and only partially legible.

Less than 1 inch in diameter. Less than 5 total areas of chipped/removed topcoat that are 1 inch or greater in diameter. Less than 20 total areas of missing primer. No area larger than 5 inches missing primer. Topcoat completely missing from and/or tails show evidence of minor corrosion (red rust). Slightly peeling and faded and only partially legible.

Less than 1 inch or greater in diameter. Evidence of significant corrosion on exposed bare metal. Greater than 10 areas of 1/2 inch or greater in diameter. Permanent or removable fastener heads and/or tails show minor corrosion (red rust). Also, red streaks of primer.

**ALL PRIORITY RATING**

<small>Aircraft requires no additional work. This is only applicable if no topcoat is missing from any permanent fastener heads.</small>	
<small>Aircraft requires touch-up in all areas of degraded topcoat and/or primer.</small>	
<small>Aircraft requires full paint.</small>	

Regardless of aircraft score, 3 or 4 on ANY location = Any area that receives this score requires it and/or primer. Within a group

NOTES CAT 1



# Current - Lessons Learned

## ■ Every base has distinct challenges

- Transition areas
- Lighting
- Dust accumulation
- Exposed electrical
- Non-aircraft corrosion
- Lack of internet ports
- Distance to work location
- Outdated hardware
- IT

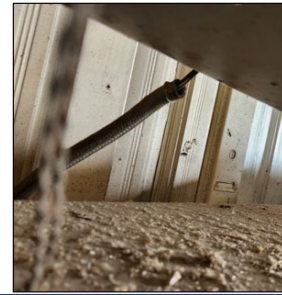
- RAC 5
  - Transition Areas
    - Insufficient transition areas for CCF ops



- RAC 6
  - Large Booth Lighting
    - Insufficient light supply for work



- RAC 8
  - Large Booth Exposed Wiring
    - Combustion hazard from blaster dust and vapors



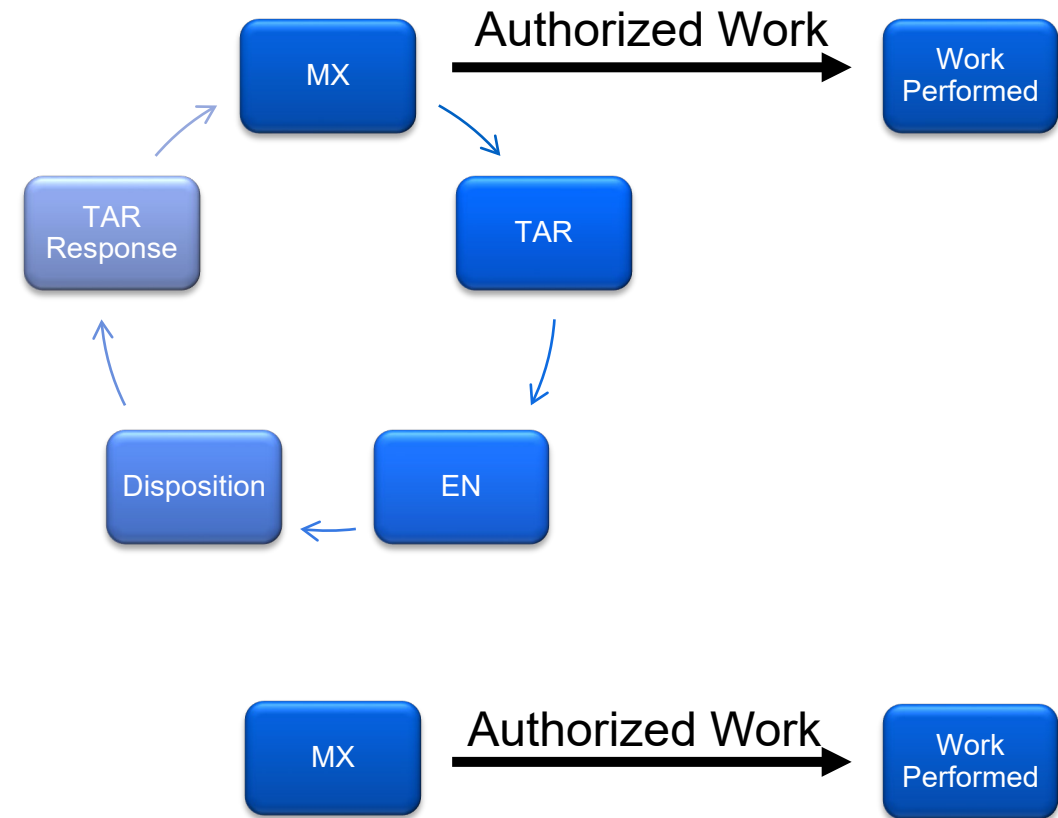




# Current - Data Collection vs. TO Updates



- Damage outside of tech guidance
- Normal flow of communication
  - Technical Assistance Request (TAR)
  - Engineer documentation NLogn
  - Disposition created
  - TAR response authorizing work
- Repeat damage = update to tech data
  - Where is damage data collected?



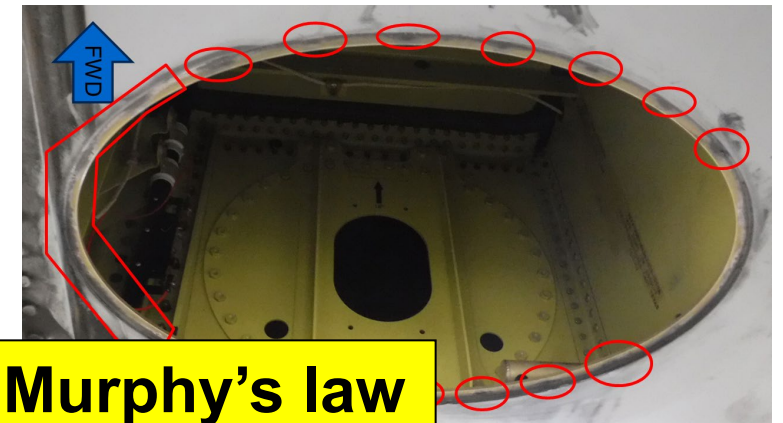
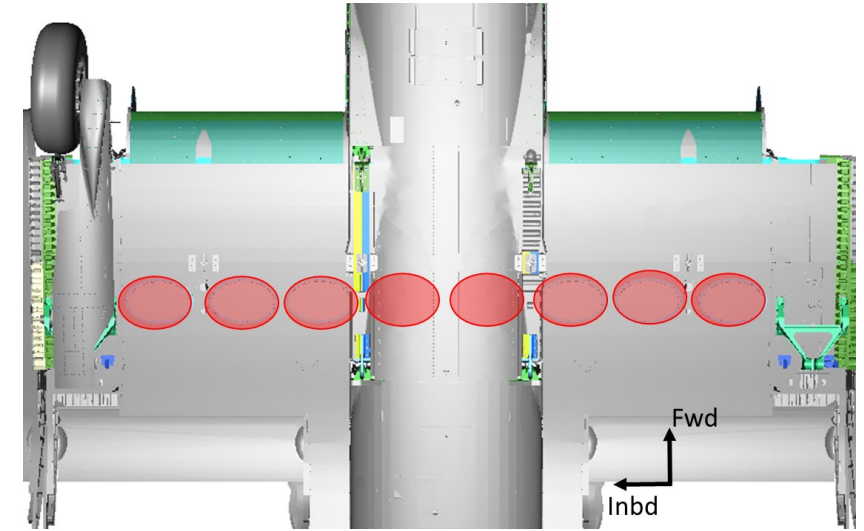
**No requirement for data capture on updated TO**



# Data Collection vs. TO Updates

## ■ Recent Example

- Enhanced Wing Assembly (EWA)
- Brand new in 2014
- Induction scheduled for Oct 2022
- “It’s a new wing...”
- Research into common corrosion
- 3 of 8 fuel access doors corroded on “new wing...”
- Depot reports 100% corrosion
- Where’s the data?



**New or old, corrosion is epitome of Murphy’s law**



# Future Efforts

- **Correlation of paint score data and corrosion damage**
- **Training all bases to provide data remotely**
- **Review currently collected data**
  - **Is it the right data to collect?**
  - **Where is data on TO authorized repairs?**



# Questions?



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