Modernizing the Technical Data Package for capturing, representing, and transferring the as-built condition of air structures for establishing the foundation of a digital twin for sustainment.

Uriah Liggett – NLign Analytics, Inc.

Presenters Bio

- **Uriah Liggett – Principal Software Engineer – NLign Analytics Inc.**
  - **20+ years of industrial experience in the areas of software engineering and design**
  - **Extensive experience with problem analysis and software requirements gathering**
  - **A primary contributor to the design and implementation of the NLign Analytics platform**
  - **Has a particular focus on the design of software tools for data capture, digital thread, digital twin, and prognostics of aircraft structure**

NLIGN ANALYTICS

Agenda

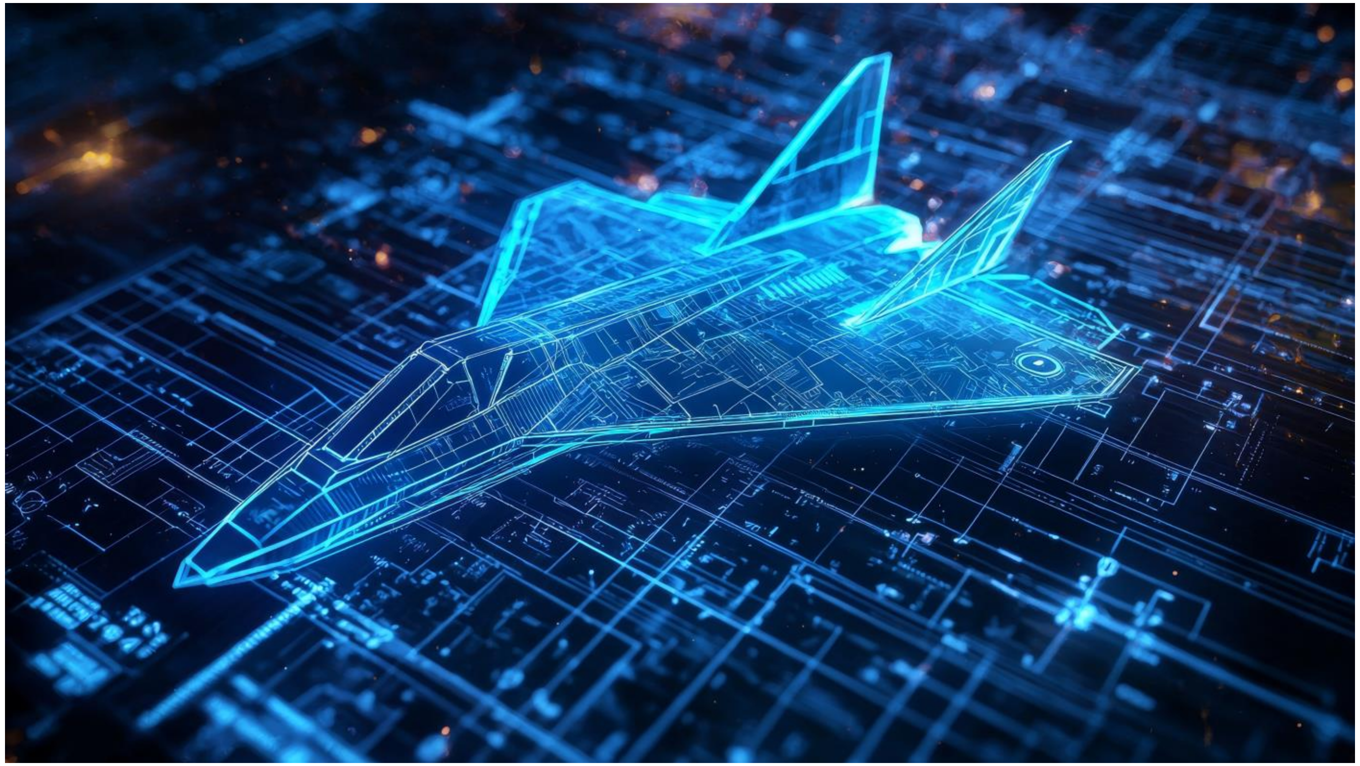
- **Background**
- **Technical Data Packages (TDP)**
- **Representing the as-built state**
- **Improving the as-designed state**
- **TDP lifecycle and data exchange**
- **Enabling the as-sustained state**

Background

- Aircraft are being flown longer periods of time
- ASIP programs are responsible for airframe sustainment procedures
- Better, more detailed information is required to achieve future sustainment needs
- Variances in manufacturing can impact the sustainment needs for individual aircraft
- Key Item States
  - ✓As-designed
  - ✓As-built
  - ✓As-sustained

Technical Data Package (TDP)

- **Defined by MIL-STD-31000b**
- **Provides a technical description of an item**
- **Covers the as-designed state: CAD (3D and 2D), PMI, BOM**
  - **Models**
  - **Drawings**
  - **Associated Lists**
  - **Specifications**
  - **Standards**
  - **Quality Assurance Provisions**
  - **Software Documentation**
  - **Packaging Details**



Limitations Issues with the existing TDP

- **Does not cover as-built condition**
- **Not inherently machine readable**
- **No referential integrity**

Technical Data Package SBIR

- **NLign Analytics, Inc. is contracted by the United States Air Force to propose and demonstrate an enhanced TDP format capable of representing the as-built condition for usage in aircraft sustainment.**
- **Small Business Innovation Research (SBIR) award.**
- **24-month period of performance.**
- **We are 5 months into the project.**
- **NLign Analytics is partnered with Siemens Government Technologies, Northrop Grumman, and Boeing.**

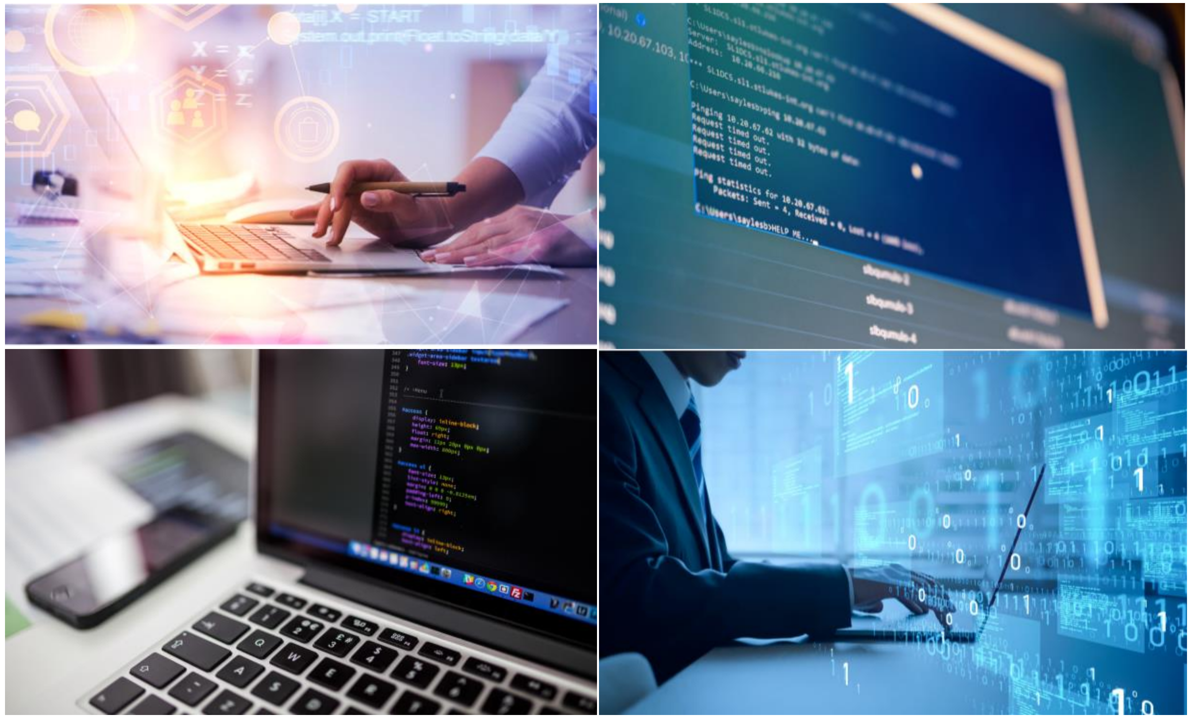
Enhanced Technical Data Package (E-TDP)

- **Enhancements to the existing Technical Data Package to address the identified limitations**
  - **Can represent both the as-designed and the as-built state.**
  - **Will be machine readable.**
    - **Can be directly imported into a digital sustainment system with no manual data modifications.**
    - **All data adheres to an open standard format.**
  - **Maintains referential integrity**
    - **Referential links between different types of data is included and well defined**

The As-built Condition

- **What is the as-built condition?**
- **What is important?**
  - **Information that can impact the form, fit, or function of the aircraft.**
- **Key data as identified by personnel within multiple USAF SPO, AFSC, and DCMA groups**
  - **As-built**
    - **Non-conformances (NC)**
    - **Requests for Variances (RFV)**
    - **BOM with installed Part Numbers and Assemblies**
    - **Part Serial Numbers**
    - **Engineering Change Orders (ECO)**
    - **Inspection Results (dimensional and non-dimensional)**
    - **Actual Hole Locations**
    - **Any significant deviation from the as-designed state**
    - **Others?**
- **The contract will determine which data types are included in the TDP.**

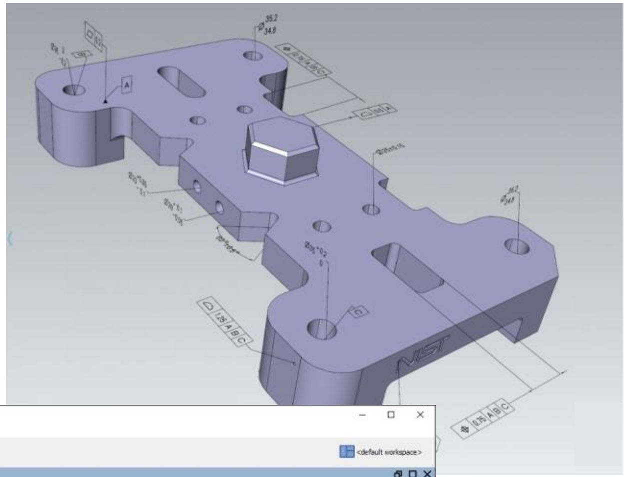
Challenges capturing as-built data

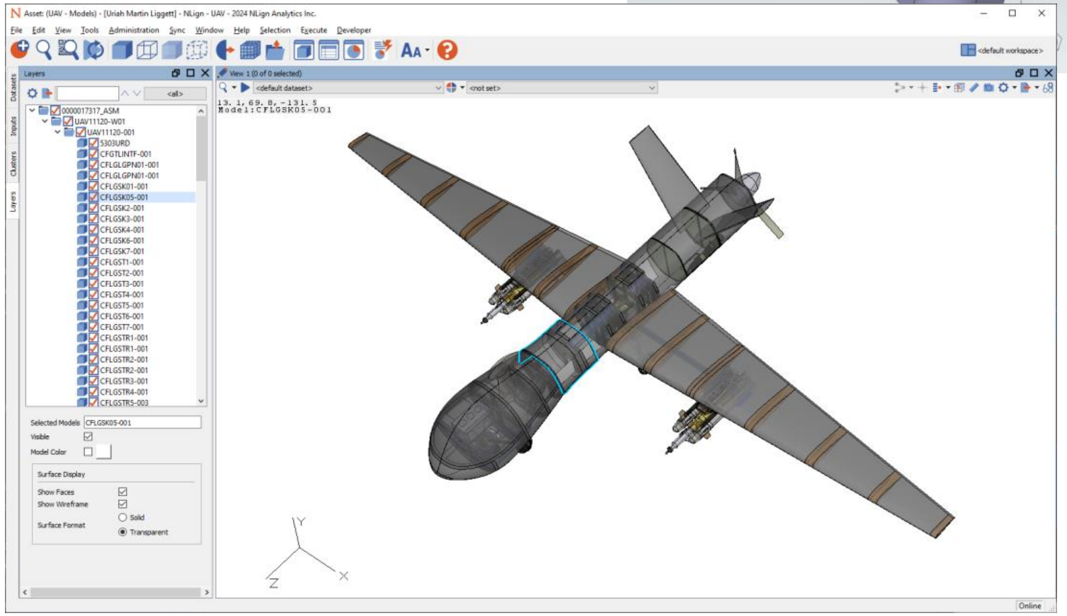


- Can be spread out across many systems
- Is not in a centralized coordinate system
- Sometimes in proprietary file formats
- Is not always associated with the impacted location on the aircraft (sometimes only known down to the part/assembly number?, sometimes associated with the aircraft as a whole?)

The As-designed Condition

- **3D CAD**
  - **Geometrical shape**
- **Product Manufacturing Information (PMI)**
  - **Geometric dimensions and tolerances**
  - **Material specifications**
  - **Notes and other information**
- **Engineering BOM**





The evolving as-designed state

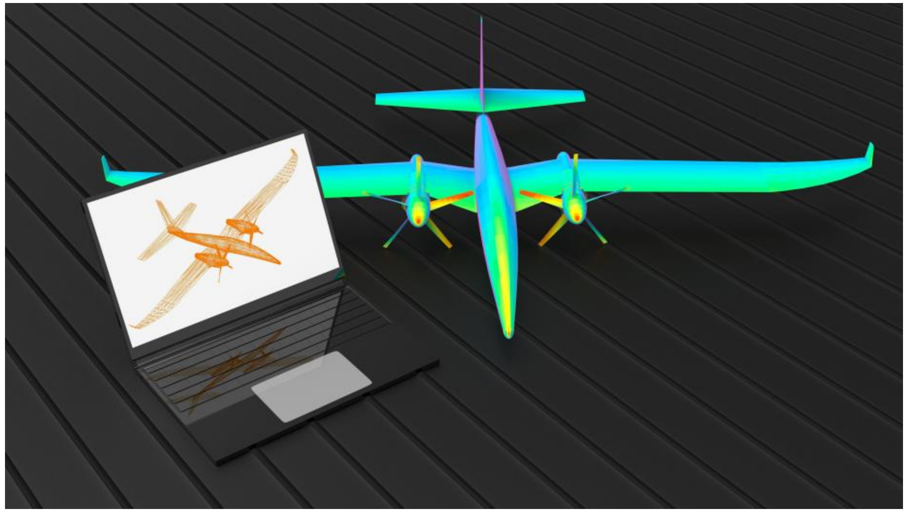
- **The as-designed data can change throughout the manufacturing process**
  - **For example: Part replacements**

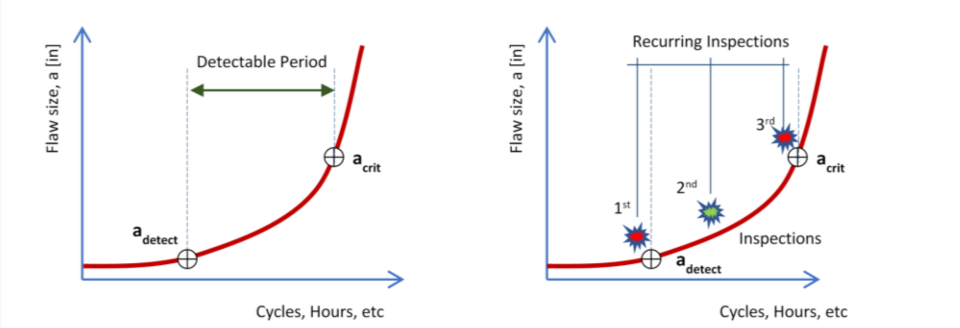
- **The As-designed state is updated as more aircraft are produced (sometimes every aircraft is different and sometimes only by block numbers)**
  - **It is not enough to store it once. All changes to the as-designed state must be captured.**

- **Synchronizing/fusing the as-built state to the as-designed state**

Other key sustainment data

- **Simulation and analysis data**
  - **Finite Element Models (FEM)**
  - **Part Criticality Codes**
  - **Damage tolerance analysis (DTA) reports**
  - **List of coldworked holes**





In situations where the crack is just below the threshold on the 1st inspection, then it will be approaching critical size on the 3rd inspection. In the real world where there are deferments, inaccuracy in loading, usage, and build assumptions, then only the 2nd inspection can be guaranteed to be in a position to find the flaw before the aircraft is no longer airworthy.

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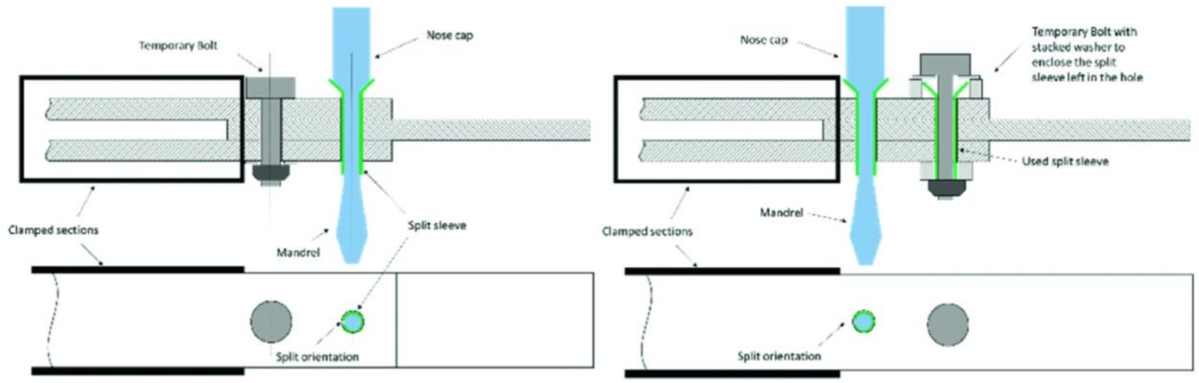

Stacked cold working process

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The As-sustained Condition

- **Includes the as-designed and as-built state**
- **Includes all significant changes to the item state that have occurred since delivery**
  - Component swaps
  - Repairs
  - Usage Information
  - Inspections Performed
  - Part conditions
  - Location history
  - Service bulletins
  - More…

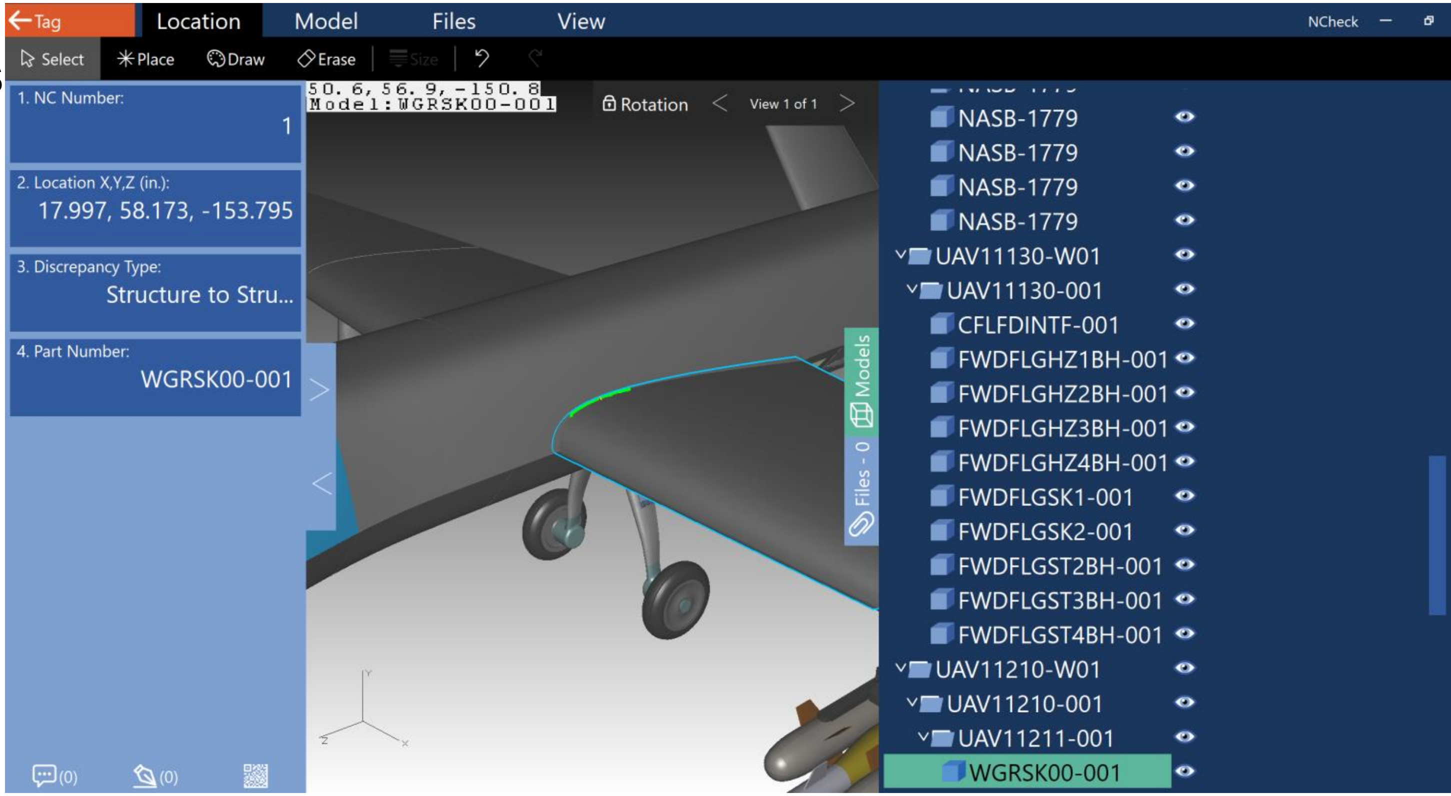
Acquiring as-built data

- **Spread out across many different systems**
  - **Manufacturing Execution Systems (MES)**
  - **Product Lifecycle Management (PLM)**
  - **Enterprise Resource Planning (ERP)**
  - **Home grown databases**
  - **Network file shares**
  - **SharePoint Sites**
  - **Inspection system computers**
  - **Embedded inspection hardware**

- **Enterprise Service Bus (ESB)**
- **software can significantly reduce the effort to retrieve the required data**

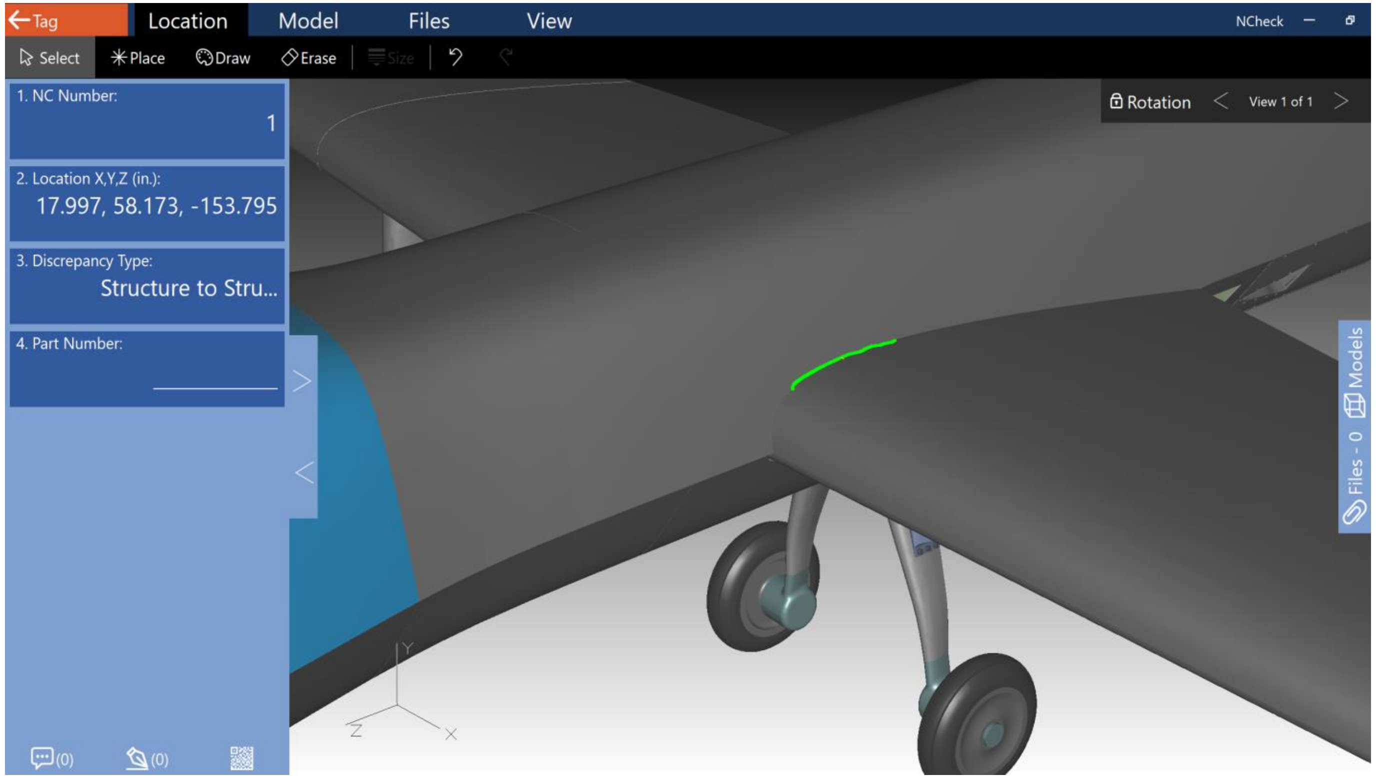
Capturing as-built Data

- **CAD enabled environment**
- **Full BOM with up-to-date part numbers for the item being built**
- **Accurate 3D XYZ locations**
- **Machine readable numerical measurements**
- **Accurate item identifying numbers (serial, tail, effectivity, etc)**



As-built Data Characteristics

- **Important characteristics for as-built data**
  - **Data that apply to physical locations on the aircraft should have accurate XYZ location information**
    - **Can be a single location, a boundary, or volume**
  - **Data should be linked to the BOM part they are associated with.**



Data Representation

- **File based**
- **Schema driven**
- **Includes CAD and other design files in a single package**
- **Establishes the references/links between the design and as-built files**

Lifecycle of the Enhanced TDP

- **Data is acquired from manufacturing systems**
- **An E-TDP file is generated prior to delivery with the as-built state**
- **The operator imports the E-TDP into their sustainment system**
- **The sustainment system is updated throughout the life of the item**
- **The sustainment system generates an E-TDP file to provide sustainment information to third parties assisting in sustainment (including the original OEM)**

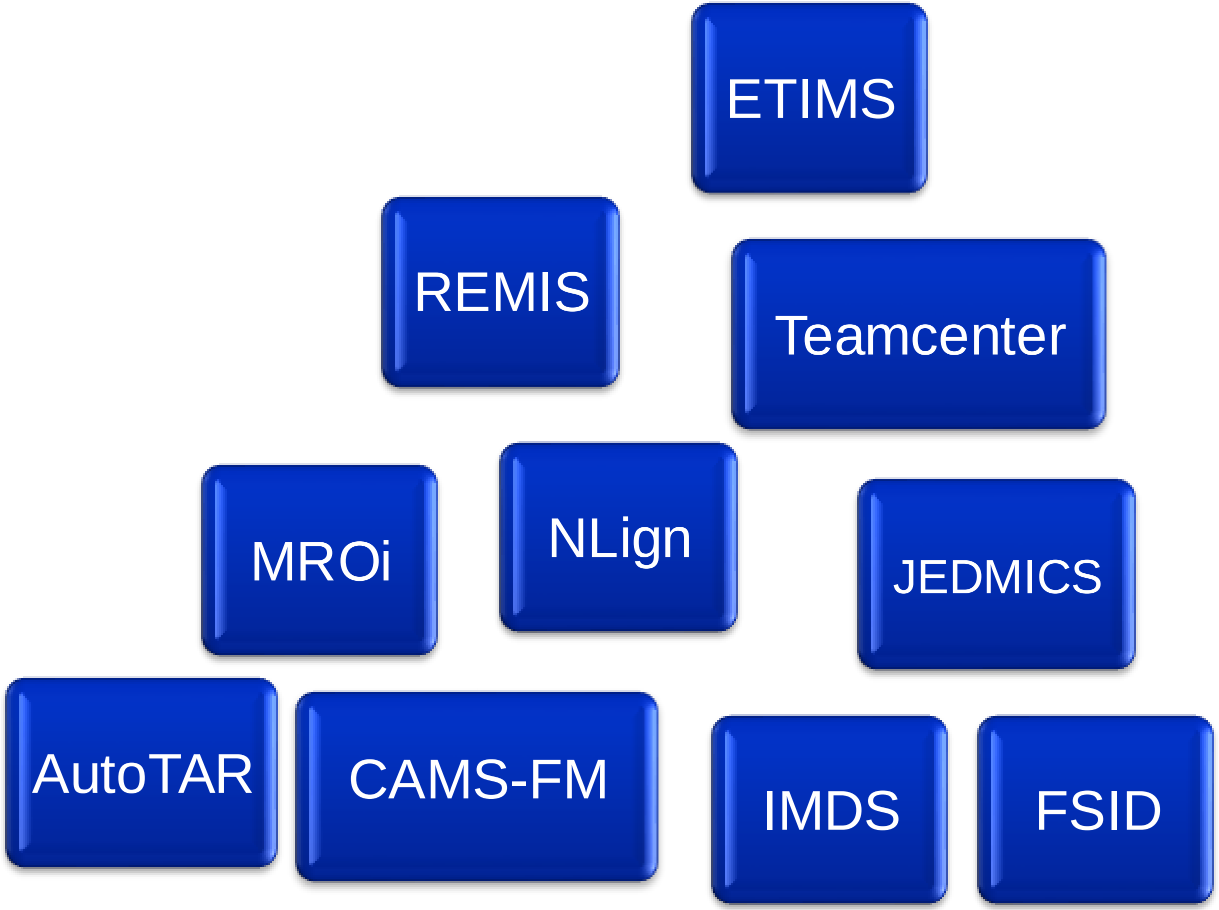
Data Exchange

- **Supplier to OEM data exchange**
  - **The E-TDP format used as a standard method of as-built data exchange between suppliers and OEM**
  - **Supplier generated Non-conformances**

- **OEM to DoD data exchange**

Enabling the As-sustained state

- **Maintaining the as-sustained state with E-TDP aware systems**
- **Challenges with USAF Sustainment**
  - **There are not a standard set of systems used for aircraft sustainment**
  - **The field units use completely different systems from the depot**



Summary

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Questions

Questions?

Citations

1) Dosman, C. (n.d.). *Scheduling Inspections Using Damage Tolerance Methods*. LinkedIn. Retrieved September 13, 2024, from https://www.linkedin.com/pulse/scheduling-inspections-using-damage-tolerance-methods-dosman-fraes/
2) Pichon, G., Daidie, A., Fau, A., Chirol, C., Benaben, A. (2021). Cold Working Process on Hard Metal Stacked Assembly. In: Roucoules, L., Paredes, M., Eynard, B., Morer Camo, P., Rizzi, C. (eds) Advances on Mechanics, Design Engineering and Manufacturing III. JCM 2020. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-70566-4_8