Digital Thread for Material Review Board

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Joe Kesler – Innovation Lead Engineer

GLOBAL PRODUCT DATA INTEROPERABILITY

SUMMIT 2021

Virtual Sessions

Presenters Bio

- **Uriah Liggett**
  - **Eighteen 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 is on the design of software tools for data capture, analysis, and prognostics of aircraft structure data**
- **Joe Kesler**
  - **Sixteen years of experience in software engineering and design, image processing, computer vision, and algorithm development**
  - **Principal investigator and lead researcher for numerous SBIR and IR&D efforts**
  - **Joined NLign Analytics in 2008**
  - **A Primary contributor to the NLign Analytics platform**
  - **MSEE 2008 University of Cincinnati, BSCompE 2005 University of Cincinnati**

Summary

- **The Digital Thread**
  - **End Goals**
  - **Life Cycle**
- **Material Review Board (MRB) Challenges**
- **Digital Thread Solutions for MRB**
- **Digital Thread Enabled Analysis**
- **Digital Thread Transition to Sustainment**
- **Current State of the Digital Thread**

The Digital Thread

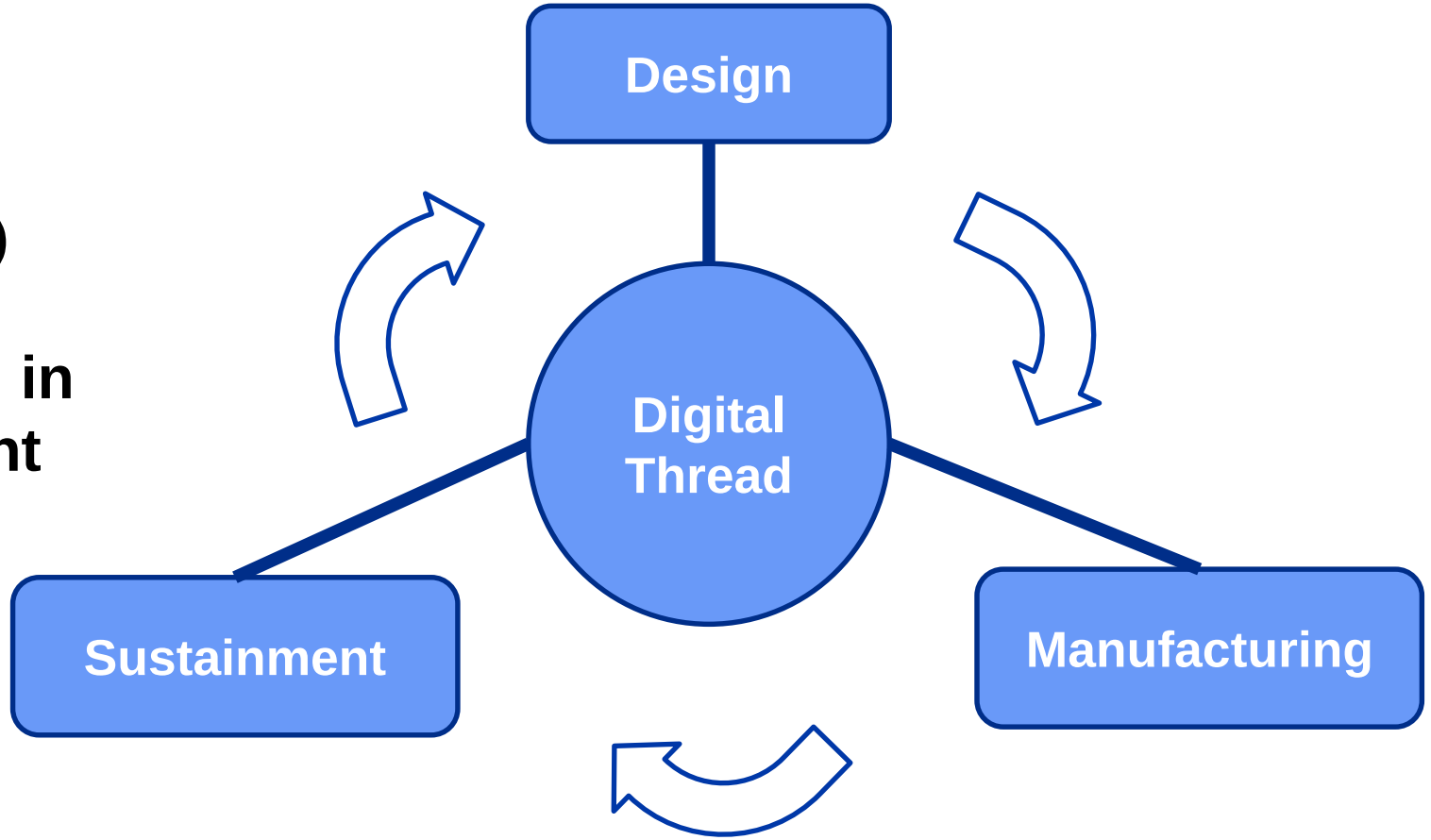
- **A complete digital record of all significant events from design, manufacturing, service/sustainment, and removal.**
  - **As-Designed**
    - **3D CAD Assemblies**
    - **Part Materials**
    - **Design Requirements**
  - **As-Built**
    - **Tests and Inspections**
    - **Discrepant Conditions**
    - **Repairs and Modifications**
    - **Part serialization**
  - **As-Maintained**
    - **Tests and Inspections**
    - **Discrepant Conditions**
    - **Repairs and Modifications**
    - **Part serialization**

Digital Thread End Goals

- **Manufacturing End Goals**
  - **Achieving production rate**
  - **Reducing manufacturing cost**
  - **Reduce manufacturing time**
  - **Improve manufacturing quality**
  - **Improve product value**
  - **Better informed new product designs**
- **Sustainment End Goals**
  - **Increased aircraft availability**
  - **Reduce sustainment costs**
  - **Reduce sustainment risk**
  - **Improve product use lifetime**

Digital Thread Lifecycle

- **Design**
- **Manufacturing**
  - **Primary assembly**
  - **Suppliers (component providers)**
- **Sustainment**
- **Information from digital thread in manufacturing and sustainment feed back into the design**



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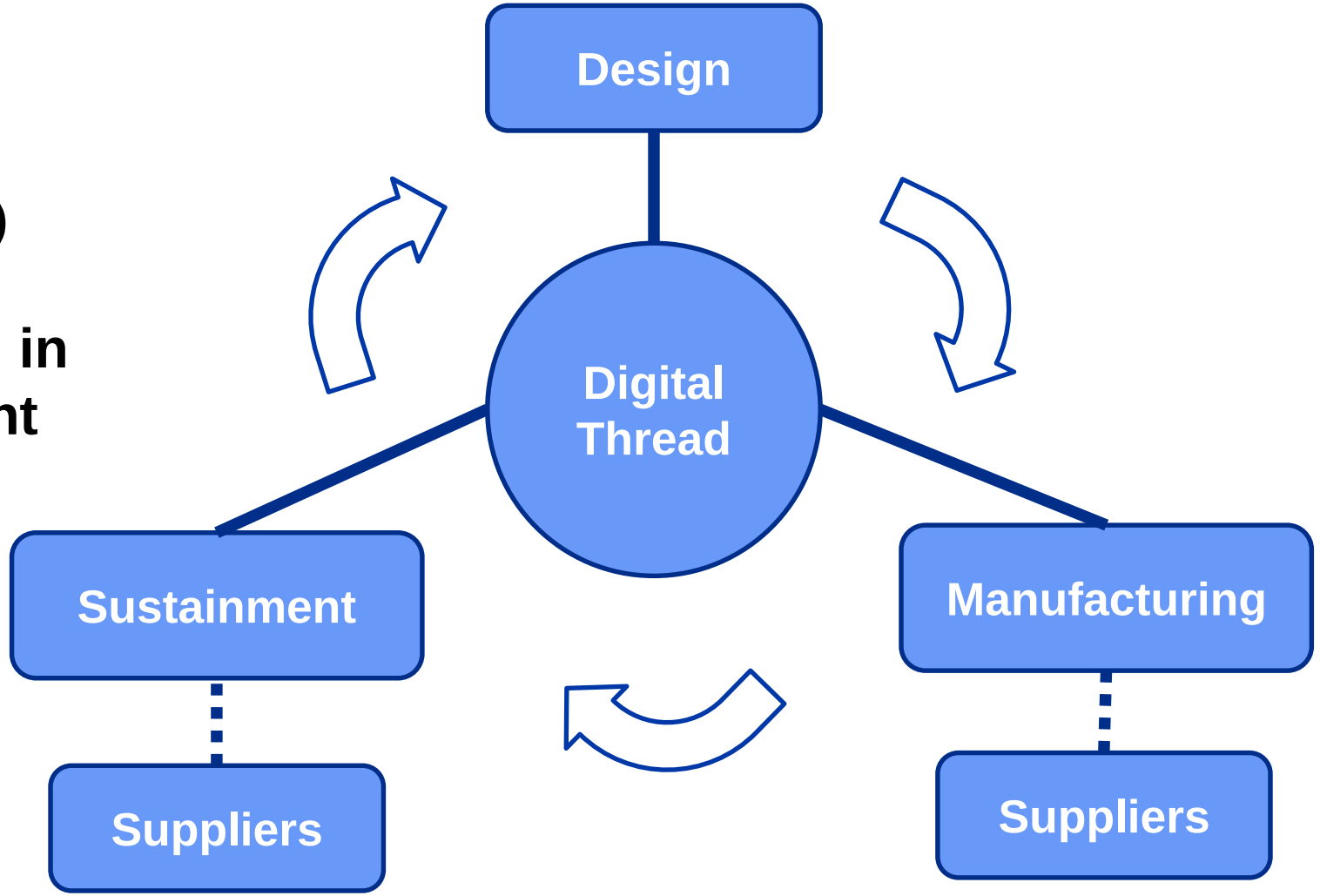
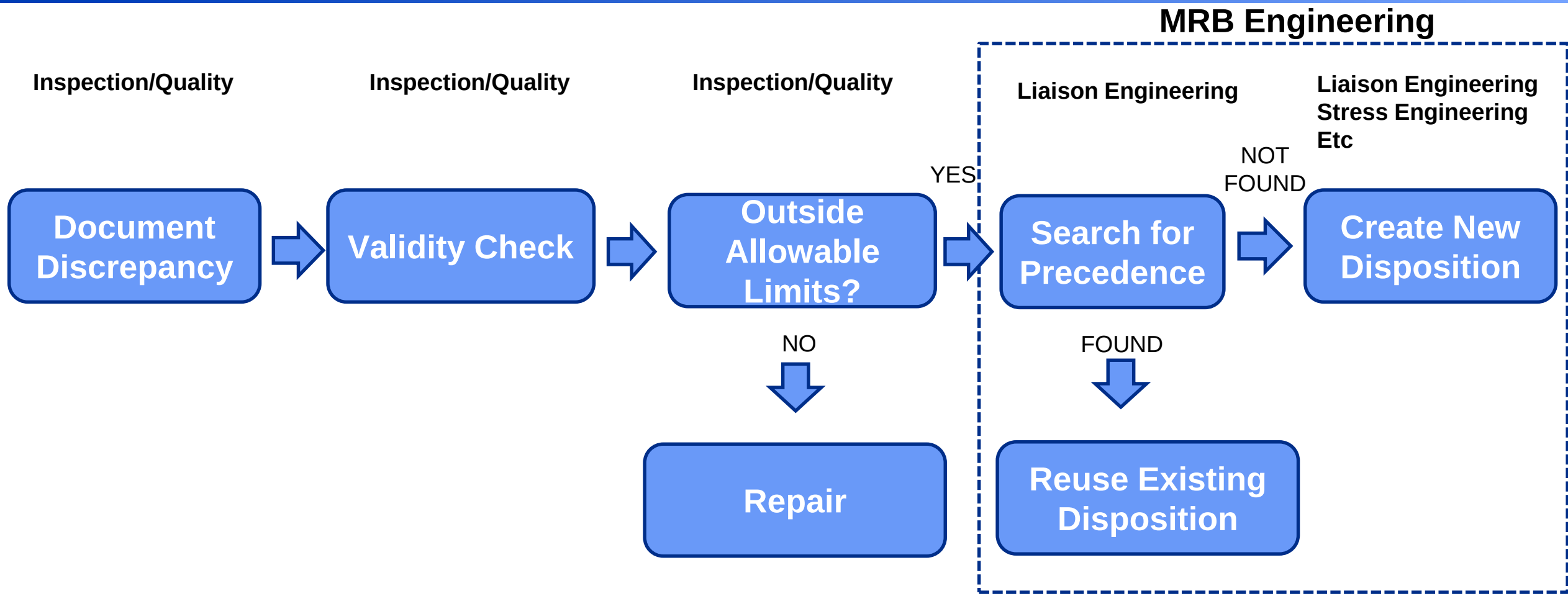


MRB Process


MRB Engineering
Inspection/Quality
Inspection/Quality
Inspection/Quality
Liaison Engineering
Liaison Engineering
Stress Engineering
Etc
Document Discrepancy
Validity Check
Outside Allowable Limits?
YES
Search for Precedence
NOT FOUND
Create New Disposition
NO
FOUND
Repair
Reuse Existing Disposition

Material Review Board (MRB) Challenges

- **Data Quality**
  - **Incorrect part numbers**
  - **Inaccurate discrepancy location**
  - **Missing data**
  - **Unstructured Data**
    - **Text Based Reporting of Measurements**
    - **Flat data**
    - **Inconsistent formatting and lack of standardization**
- **Difficulty searching for neighboring discrepancies / previous repairs**
- **Time consuming search for precedence**

A top driver of rejected MRB submittals
Identifying part number cited by inspectors as one of the most time-consuming steps of writing up a MRB tag

Difficult for MRB and liaison engineering to search

Part number is not enough

Solution - Digital Thread for MRB (DT4MRB)

- **Data Quality – DT Solution**
  - **Incorrect part numbers**
  - **Inaccurate discrepancy location**
  - **Missing or incorrect data**
  - **Unstructured Data**

Part numbers obtained interactively from 3D CAD model

Locations obtained directly from 3D CAD model and known references

Data completeness enforced with context aware rules at the time of data entry

Structured records with typed properties appropriate for data entry and future analysis

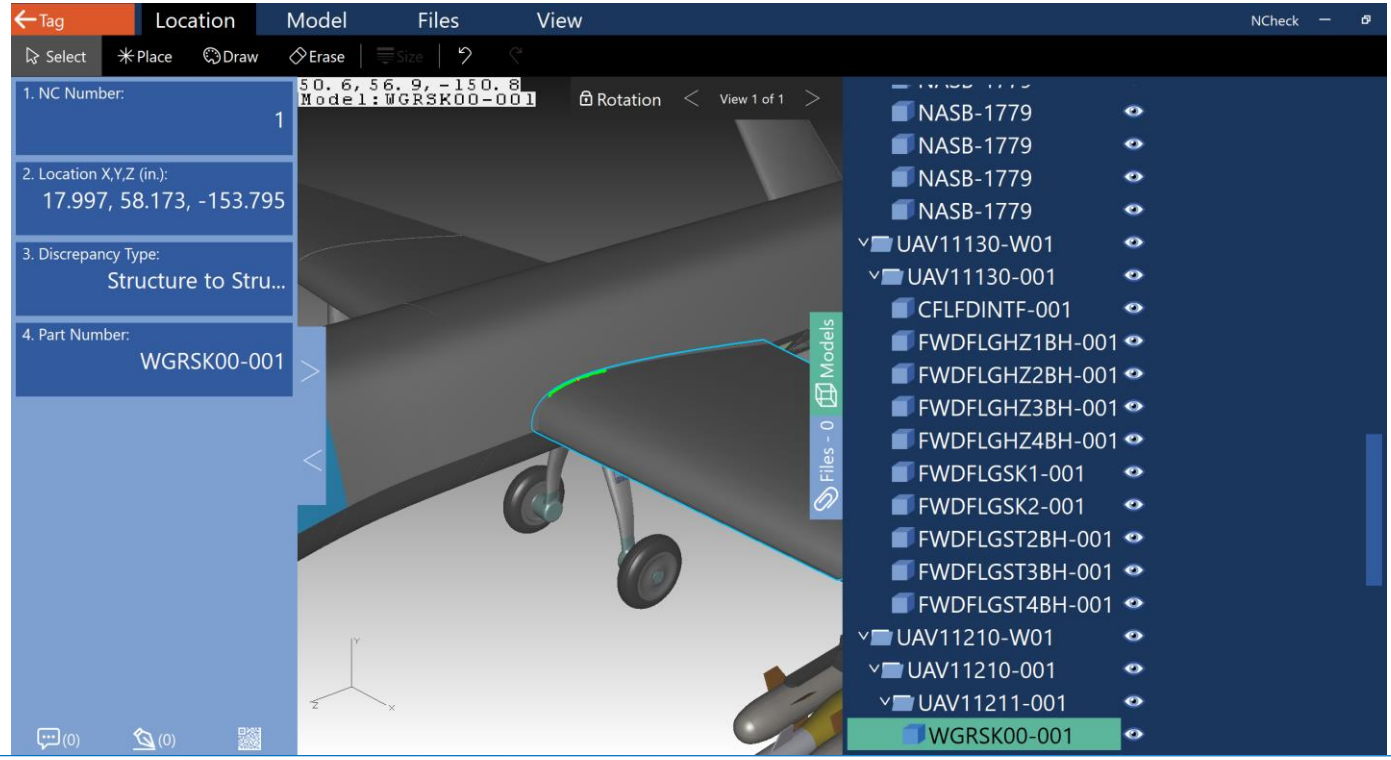
Smart spatial searches for quickly retrieving nearby records.

- **Difficulty searching for neighboring discrepancies / previous repairs**
- **Time consuming search for precedence**

Automatic retrieval of similar records in the same area

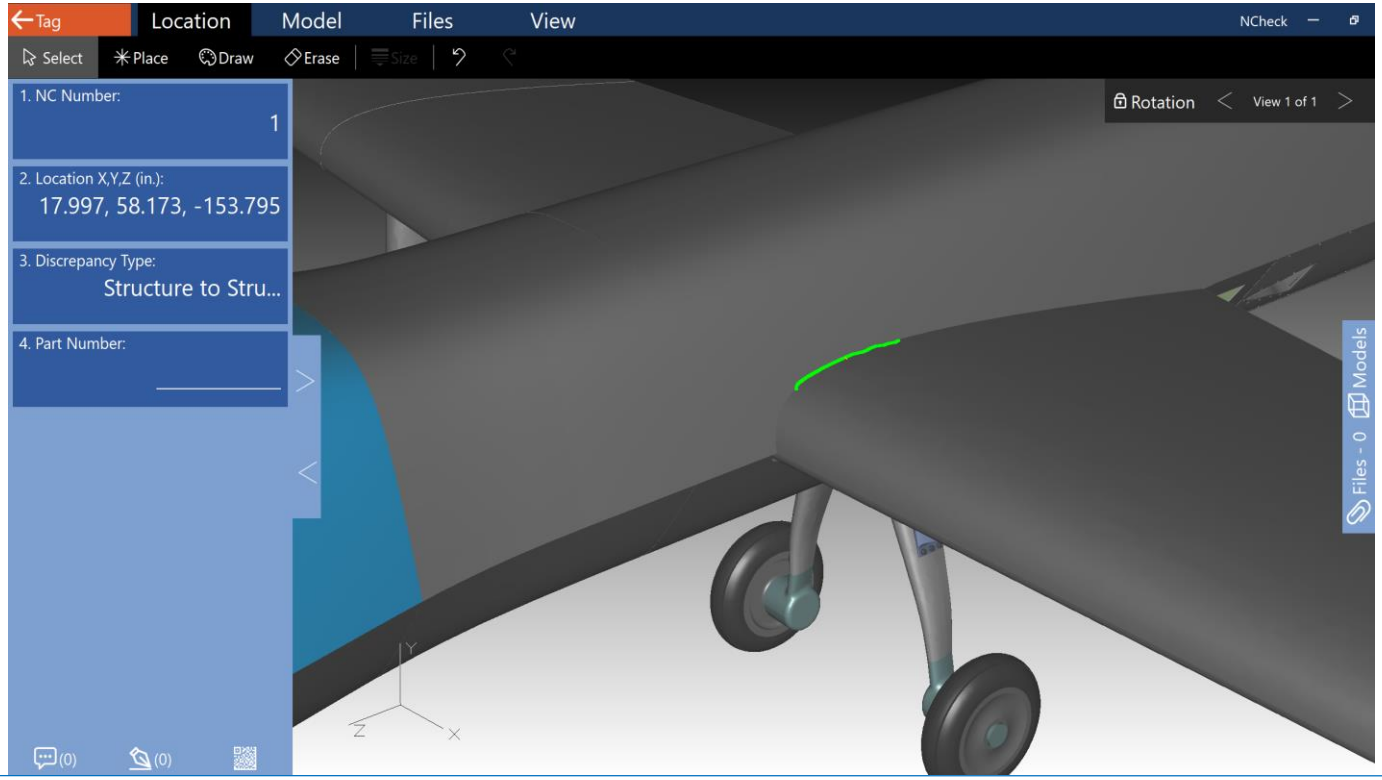
Data Quality Challenges and Solutions

- **Inspector / Quality access to MBD enables fast and accurate part number reporting**
  - **Part numbers obtained interactively from 3D CAD model**
  - **Every MBD revision need to be distributed to Quality**
    - **Developing ways to distribute just what has changed – minimizes quantity of data that needs to be updated**



Data Quality Challenges and Solutions

- **Current methods of estimating discrepancy locations introduce errors**
  - **Estimations derived from precomputed views of the part**
  - **Measurements made physically as distances to known features**
- **MBD should be used directly for accurate localization of discrepancies**
  - **Direct selection of point location on 3D model**
  - **Direct drawing on model for area based discrepancies**
  - **Location lookup via mapping of named structure (ex: named fastener holes)**



Data Quality Challenges and Solutions

- **Missing or incorrect data**
  - **Data is unreliable and cannot be used without assumptions**
  - **Data inconsistencies**
  - **Data trends are incomplete**
- **Solution**
  - **Automated enforcement of data completeness**
  - **Automated detection of data inconsistencies**
  - **Detection of incorrect data**
  - **Prevention of ambiguous data being created**

Data Quality Challenges and Solutions

- **Current process often result in discrepancies written up in long, freeform text fields**
  - **Hard to search**
  - **Inconsistent discrepancy description**
  - **Increases potential of missing data, resulting in tag rejection from MRB**
  - **Inaccurate discrepancy locations**
- **Solution**
  - **Separate record for each discrepancy**
  - **Distinct location, measurements, and discrepancy data**
  - **Enforce required data and configure based upon discrepancy type**
  - **Reduce text entry in favor of selection from lists – standardize nomenclature**
  - **Direct Selection of point location on 3D model**
  - **Direct drawing on model for area-based discrepancies**
  - **Location lookup via mapping of named structure (ex: named fastener holes)**

Faster MRB Turn-around Time – Data Capture

- **Reduction in Inspection Time**
  - **Documentation takes 50% of inspectors time within DoD**
  - **Interactive 3D models with correct part numbers**
  - **Eliminate double data entry**
  - **Capture photos and video simultaneously with data entry**
  - **Completely digital input**
  - **Fewer MRB rejections due to incorrect or incomplete data**
- **Informal time studies seeing significant reduction in tag documentation time**
  - **Formal time studies to be performed in 2022**

Faster MRB Turn-around Time - Engineering

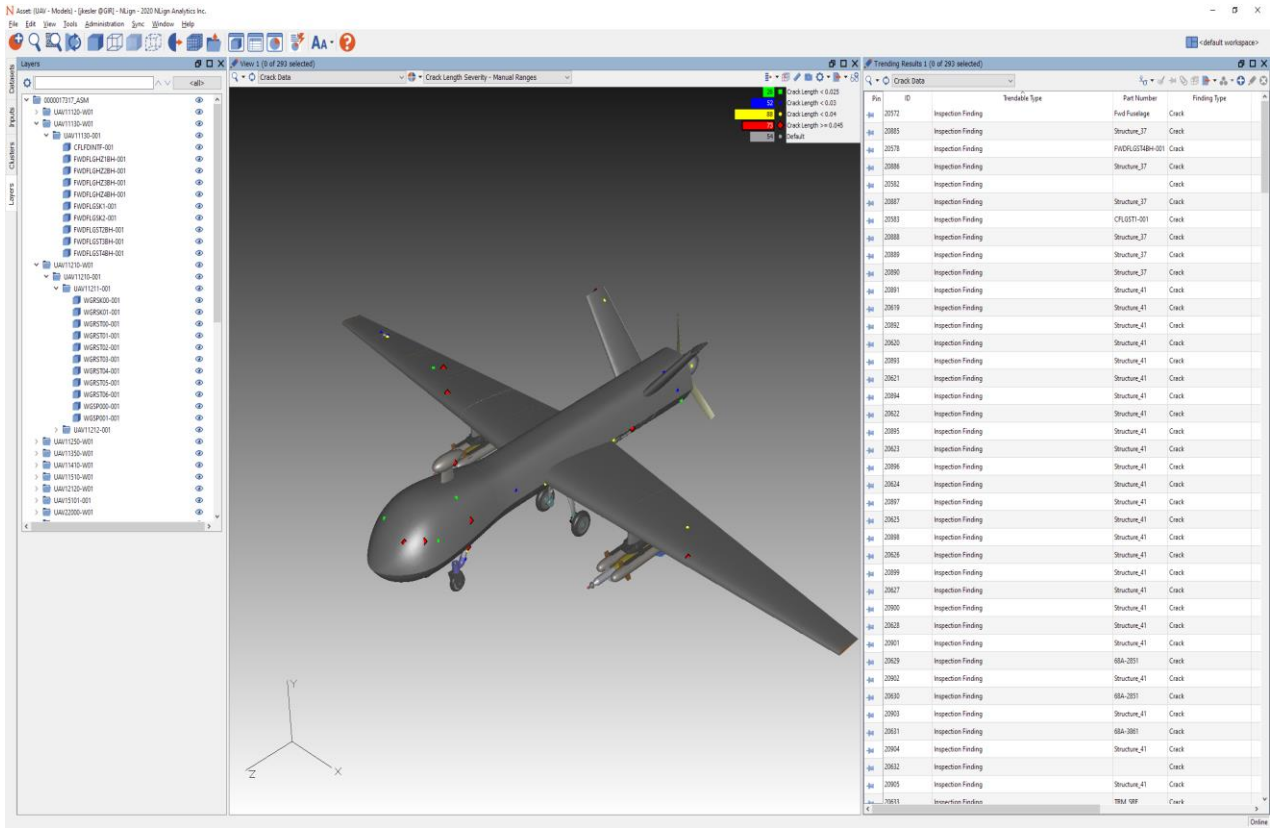
- **Reduction in Engineering Time**
  - **Discrepancy aggregation**
  - **Accurately determine where the problem exists**
  - **Quickly find a reusable disposition or confirm that one does not exist**
  - **Awareness of nearby discrepancies or previous repairs**
- **Joint AFRL/NGC/NLign Analytics project in performed in 2014-2016 estimated 33% savings in MRB labor hours**
  - **John Crawford et. al. (2016), "Digital Thread for Material Review Board", AA&S Conference Proceedings.**

Data Exchange – Integrations with Key Business Systems

- **PLM Systems**
  - **What product is being manufactured**
- **MES Systems**
  - **How the product is being manufactured**
- **ERP Systems**
  - **What is being used to manufacture the product**

Qualities of a Digital Thread Analysis Solution

- **Accurate Discrepancy Location**
- **Real-time Data Validation**
- **Numeric Measurements**
- **Consolidate data from all stages of manufacturing and sustainment**
- **Streamlined access to current state of structure**



Digital Thread Enabled Analysis

- **Accurately determine precise locations for repeat damage**
- **Detect and correct trends in location specific sub-rejectable discrepancies before bad parts are created**
- **Quickly identify part redesign ROI**
- **Visualize 3D heat maps of past manufacturing and sustainment discrepancies**
- **Utilize manufacturing information for automatic planning of inspection events during sustainment**

Sustainment Benefits

- **From Manufacturing to Sustainment**
  - **Provides knowledge of as-built state**
    - **Documentation of previous discrepancies / repairs**
  - **Enables tailored sustainment for each structure**
  - **Inspection data can be used with fewer assumptions resulting in more “credit” being taken for risk-based analysis**
  - **Result: Product lifespan is increased, sustainment costs are reduced**

Current State of Digital Thread in Aerospace

- **Currently in use by:**
  - **Major commercial aircraft manufacturers**
  - **Major defense aircraft manufacturers**
  - **Aerospace supply chain providers**
  - **Defense individual aircraft tracking and MRO**
  - **Defense structural integrity programs**

Conclusion

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Question and Answer

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