Leveraging the Digital Thread for Manufacturing & the Continued Lifecycle Benefits

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GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2023

Presenters Bio

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NORTHROP GRUMMAN

- **Senior Principal Manufacturing Systems Engineer**
- **Areas of focus are engineering systems and technology development**
- **Product Manager and Technical lead for the Digital Thread for MRB project**
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NLIGN ANALYTICS

- **NLign Analytics – Senior Software Engineer**
- **Six years of experience in the areas of software engineering and design**
- **Primary technical contact for the DT4MRB project and other NGC efforts**
- **A primary contributor to the design and implementation of the NLign Analytics platform**
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Outline

- **Introduction**
  - **Digital Thread for Material Review Board**
- **The Problem**
- **The Solution**
  - **Accurate Data Capture**
  - **Automated Nonconformance Research**
  - **System Integrations**
- **The Journey**
  - **Future Opportunities**
- **Summary**
  - **Addressing Challenges**
  - **Impact**
  - **Complete Digital Thread**

Digital Thread for Material Review Board

Teams Involved: Northrop Grumman (NG), NLign Analytics, Air Force Research Laboratory (AFRL)

Objective: The digital thread for material board process aims to link design and production data to feed and accelerate the MRB decision making process

Material Review Board: Reviews as-manufactured vs as-designed to make sure the final product is within tolerance

Issue: The Material Review Board does not have a centralized method of collecting data and every department operates as siloed entities. Inspectors do not have access to accurate part numbers, locations and criticality codes and as such results in a lot of rework

Software Solution: NLign Analytics

Problems

- Providing customers and NG with digital package of the nonconformances associated with their delivered end item is a **manually intensive process**
- **Limited capabilities and standard processes** for mapping defects in 3D
- **Difficult to identify defects** which are occurring with high frequency in localized part locations
- **Difficult to identify hot spots** for defect occurrences
- **Missing closed loop connection** between Quality Assurance (QA) and Engineering
- Defect searching is **limited**, and results are **difficult to analyze**
- Visibility of travelled work is **manual and difficult** to assign and track on a specific aircraft

Problem Summary

- Common themes of limitations
  - **Limited mapping and analyzing capabilities**
  - **Manually intensive processes**
  - **Missing closed loop connection**
  - **Poor digital connectivity**
  - **Data loss and limited reuse**
  - **Limited root cause analysis**

Digital MRB Process

- Quality Engineering
- Liaison Engineering
- Tag Dispositioning
- Design Engineering

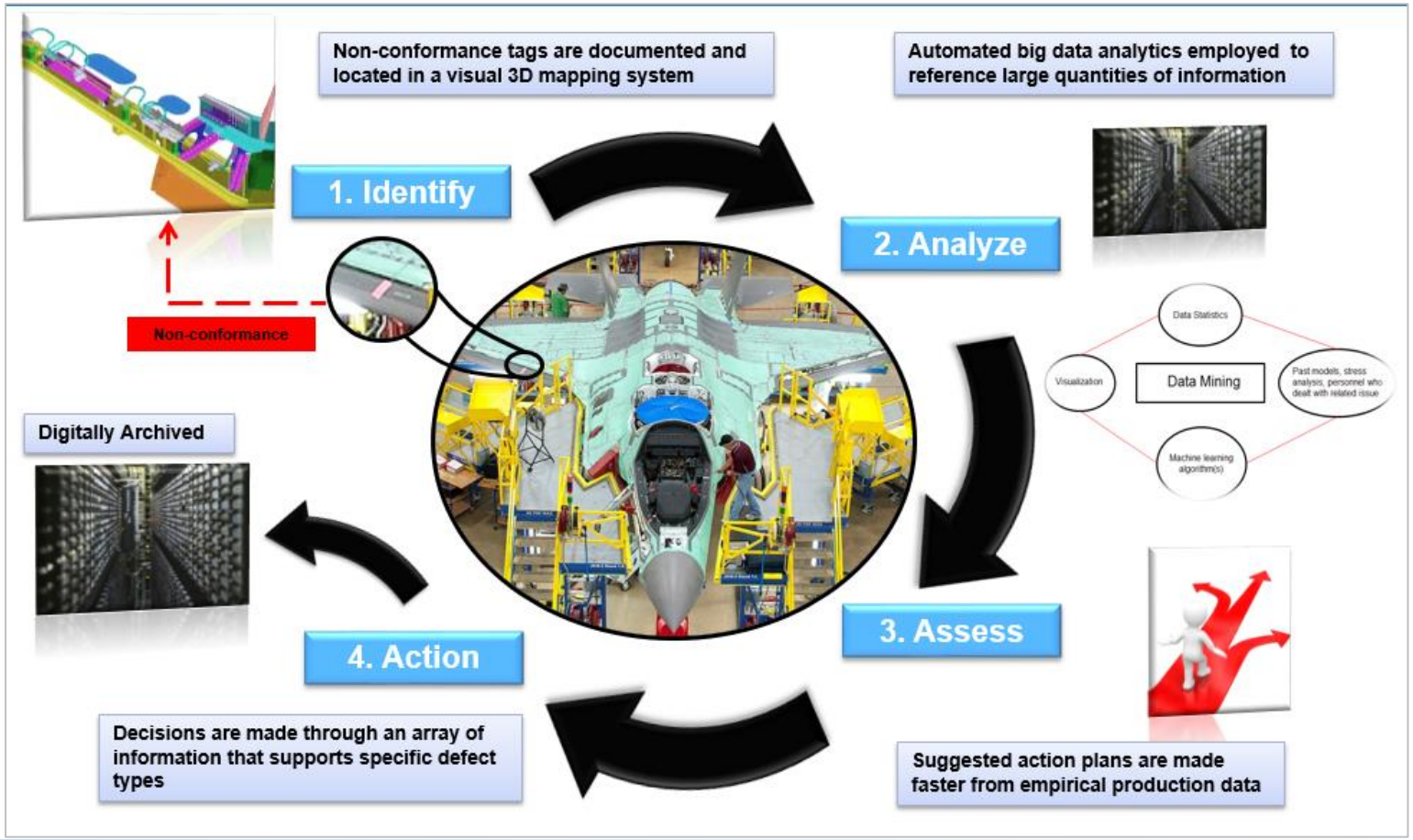
Digital MRB Uses

- Efficiently processes tags
- Facilitates defect reduction

We found that our Model-Based Quality Vision matches the AFRL vision, which aligns us with the customer

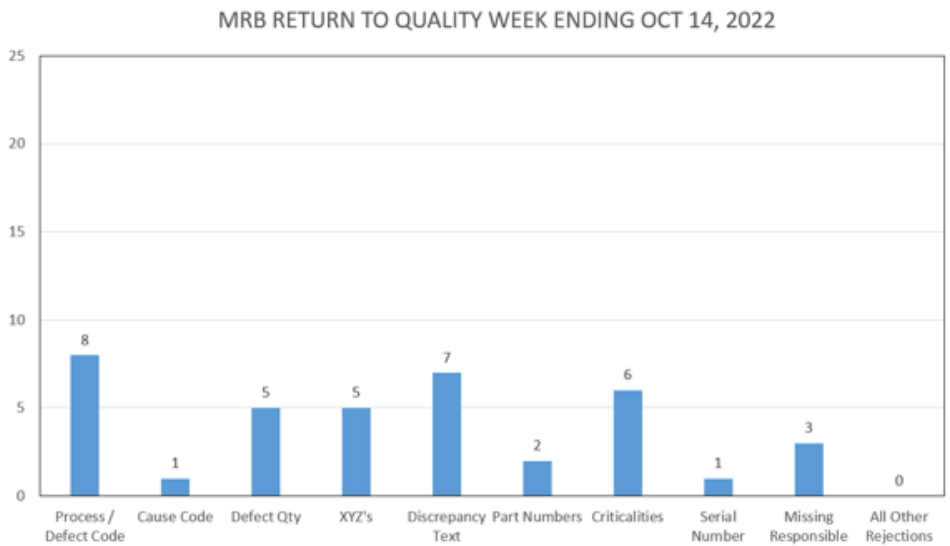
Solution Map

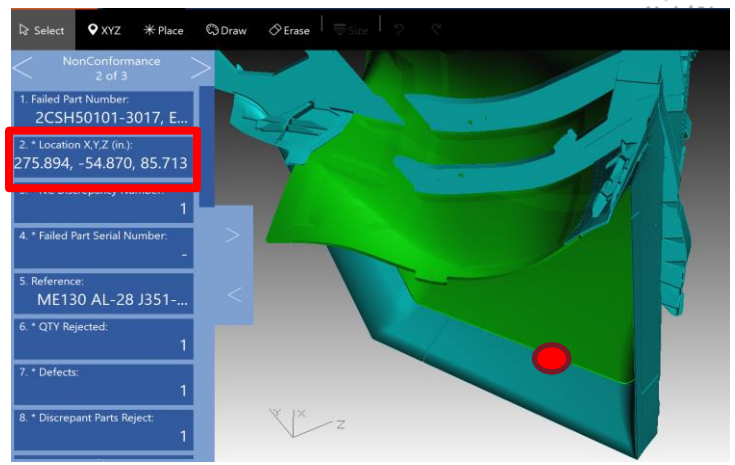
- Detect locations in 3D and allows corrective actions to be implemented.



Reduction in RTI/RTQ rejections

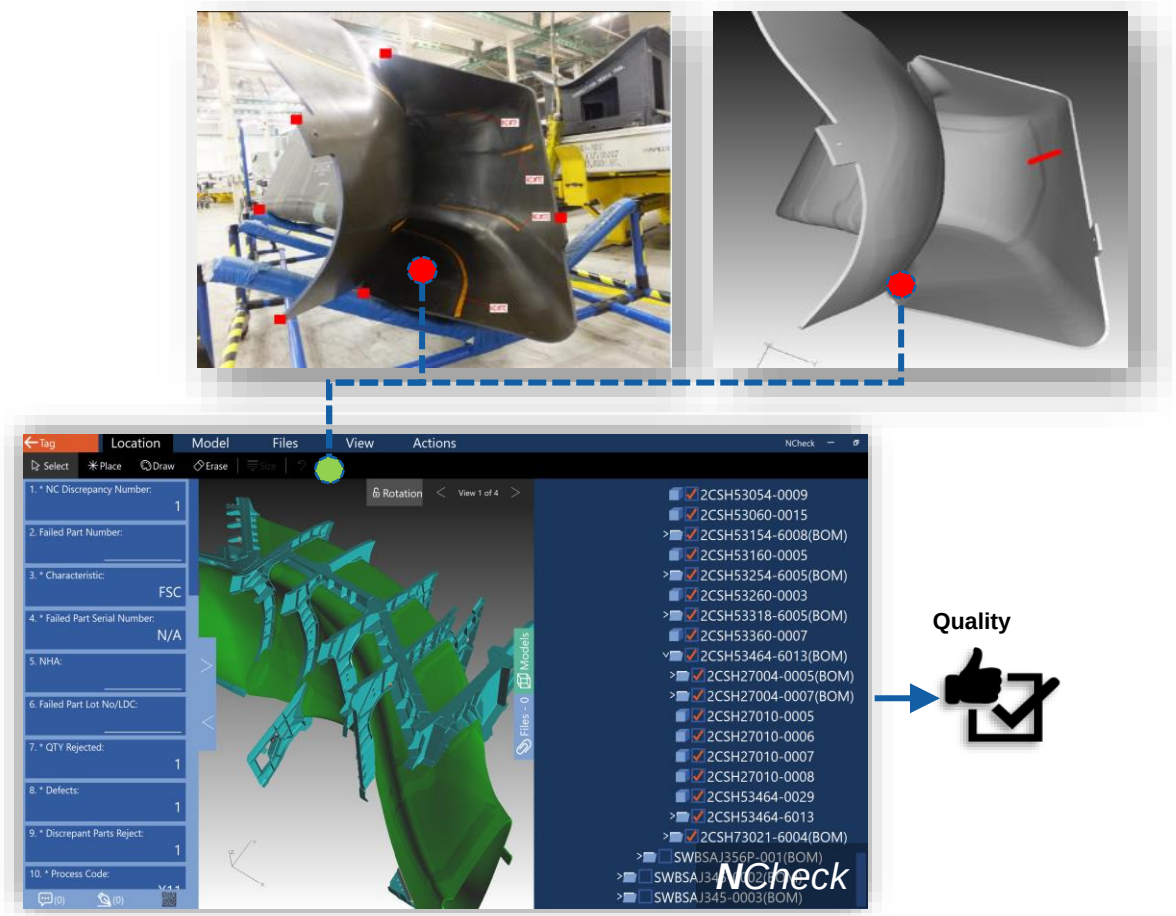
- **Incorrect part numbers, common to parts**
  - Assisted part number selection from 3D model
- **Inaccurate locations**
  - X,Y,Z auto-populates in tag text (header and face)
- **Incorrect Process/Defect code selection**
  - Auto-populates based on templates
- **Missing information**
  - Text box broken down into individual fields
  - Incompletion error if any required field is left blank
- **Incorrect Criticalities**
  - Criticalities are auto-populated from the selected part number





Model-based 3D Data Capture

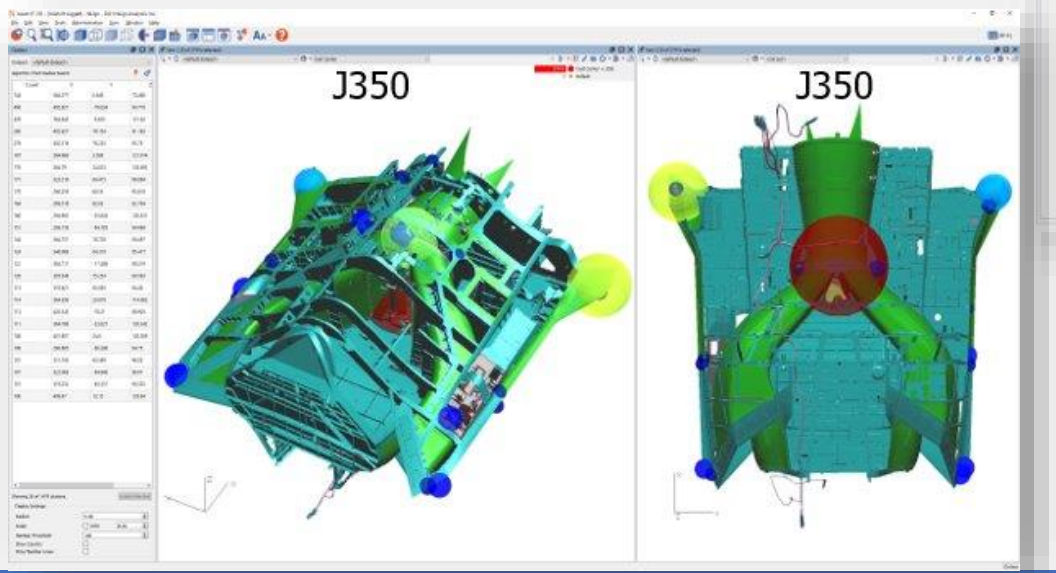
- The Visualization Assembly System (VAS) share drive contains released models in a virtual environment
- NLign Model Monitor Application loads exact 3D model and part numbers for each effectivity
- Nonconformances (NC) photographically registered to 3D Database
- Provides accurate location in the aircraft coordinate system

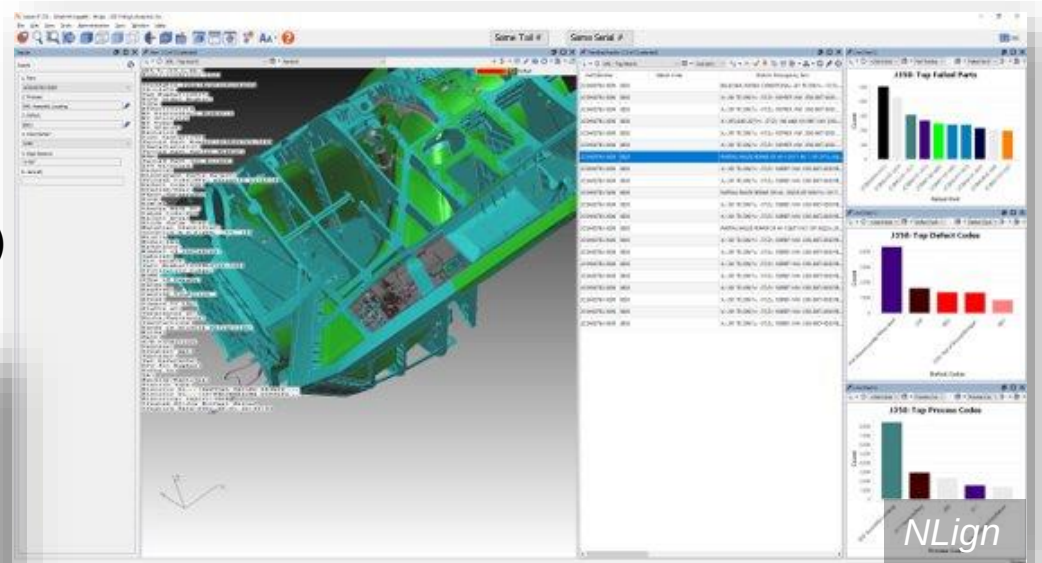


Accurate Registration of NC into the 3D Database, Providing Quick Access to Information for Disposition

Analysis and Trend Capabilities

- Customized trend searches
- Creation of datasets for advanced searches
- Clustering to identify hot spots
- Structured Data for Analytics (Exportable charts and data tables)
- Tag Number based search

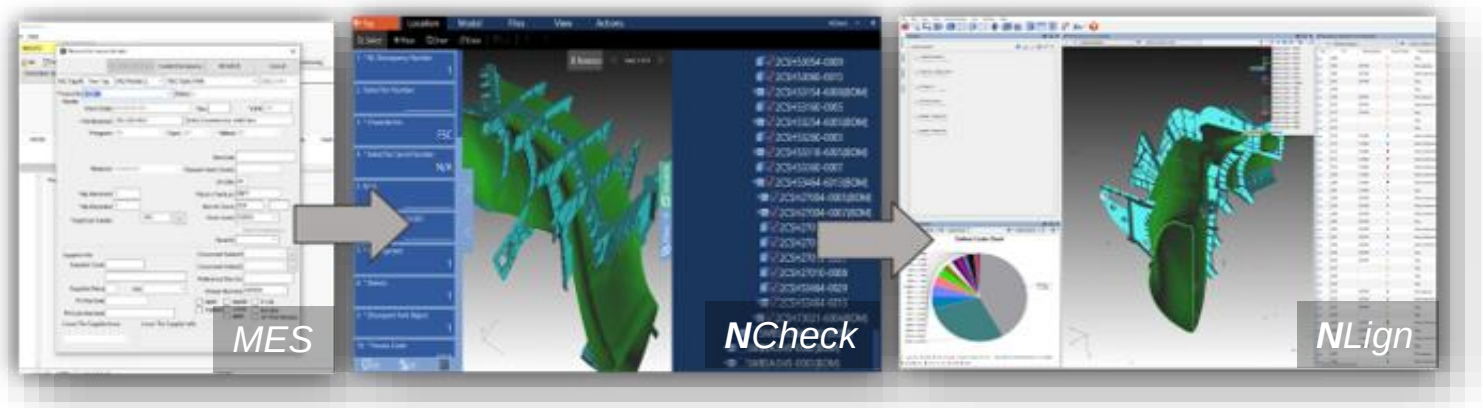




Accurate Registration of NC into the 3D Database, Providing Quick Access to Information for Disposition

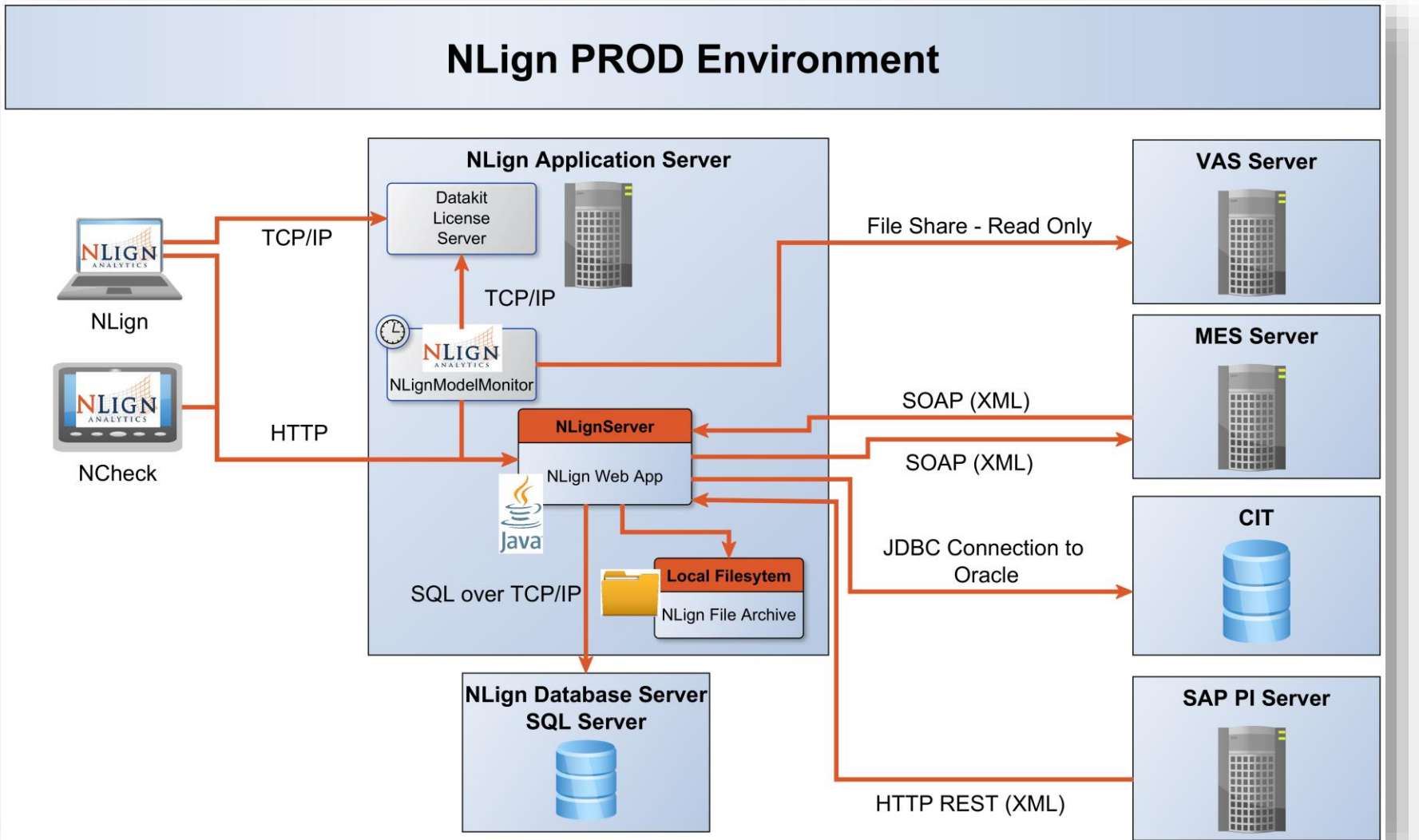
Historic Data

- Searchable data knowledgebase referenced by salient features
  - Damage Type, Serial Number, Aircraft Tail Number, Left/Right Hand, and/or any other user defined criteria
- 3D region and location searches
- Retrieval and dissemination of information for non-standard dispositions
- Eliminates redundant analyses and streamlines new analyses



Accurate Registration of NC into the 3D Database, Providing Quick Access to Information for Disposition

Solution - System Integration Architecture



Visualization Assembly System (VAS) Integration

- Populates the NLign platform with 3D models for location-based data capture

Transmission and Data Types

- JT files
- Network share drive

How it works

- The VAS network share drive stores the released JT assembly and part files
- The NLign Model Monitor application downloads JT files directly from the VAS network share drive
- The NLign Model Monitor application reads and converts the JT geometry and assembly structure to an NLign-specific model file and accurate part numbers for each effectivity
- The models are "tagged" so that the exact geometry and part numbers are automatically presented to the user based on the Tag they are writing

Manufacturing Execution System (MES) Integration - ***First Stage***

- Initiates the Tag creation in the NCheck application

Transmission and Data Types

- Simple Object Access Protocol (SOAP)
- XML content defined by a Web Services Description Language (WSDL)

How it works

- The user initiates the process to create a Tag in NCheck from MES via an "NCheck" button
- MES sends a SOAP request to the NLign server; MES opens NCheck directly to the record created from the request
- The user enters Nonconformance information into NCheck – including text, location, and file data
- (continued with the Second Stage)

Manufacturing Execution System (MES) Integration - ***Second Stage***

- Creates and updates discrepancy information in MES from data captured in NCheck

Transmission and Data Types

- SOAP
- XML content defined by a WSDL

How it works

- The user enters Nonconformance information into NCheck – including text, location, and file data
- The NLign server sends a SOAP request to the MES server
- MES performs validation checks and responds with a success message or validation errors to be fixed and saved in NCheck

Manufacturing Execution System (MES) Integration – ***Third Stage***

- Creates and updates historic Tag information, including discrepancy and disposition text, in the NLign platform after the Tag has been closed

Transmission and Data Types

- Oracle
- Java Database Connectivity API (JDBC)

How it works

- MES commits Tag information to a Common Interface Table (CIT) in an Oracle environment
- The NLign server connects to the Oracle CIT table directly and parses row data into the NLign platform using pre-defined field mappings

SAP Integration

- Updates Part Number information in the NLign platform with data from the Material Master in SAP

Transmission and Data Types

- HTTP REST
- XML content defined by an XML Schema Definition (XSD)

How it works

- The SAP server initiates periodic REST Post requests to the NLign server
- The NLign server parses the XML and creates or updates Part Number records based on primary key fields

The Journey - Future Opportunities

Digital Thread for MRB in Factory of the Future

- Digital Twin Representation of As-Built
- Enhanced Technical Data Package of As-Built condition
- Structured Data for Data Analytics
- Preventive Actions for Lower Cost and Improved Quality

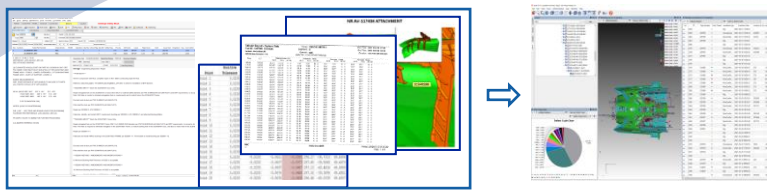
DT4MRB CRAD

- AFRL recommendation (2015)
- Evaluation of COTS software (2016)
- Baseline Evaluation and System Design (2020)
- System Development and Realization (2021)
- Transition to Production(2022)

Future State

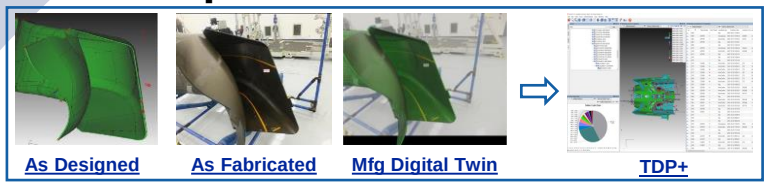
Future Aircraft Sustainment & Management

Implementation



TDP+

CRAD Development



As Designed | As Fabricated | Mfg Digital Twin | TDP+

The Journey - Future Opportunities

Extension to other programs

- Potential to become enterprise solution within NGC

Pilot of sticker-less/tape free inspection use case

- A pilot has been completed for digital creation, tracking, and review of RTS Tags without requiring any physical tape

Standard Disposition use case

- Ability to determine disposition based on historical data, thereby eliminating several approval stages

Standard Troubleshooting use case

- Ability to determine troubleshooting method based on historical data

Improvements to integrations

- Finalize automation of VAS Import, expand fields captured and Tag templates to support remaining process and defect codes

Challenges with System

- Free form texts limited Tag reuse
- Rejected Tags due to incomplete/incorrect information
- Laborious and error prone process of capturing Tag information on paper and later entering in MES
- Inaccurate part number and locations
- Increased time to disposition tags

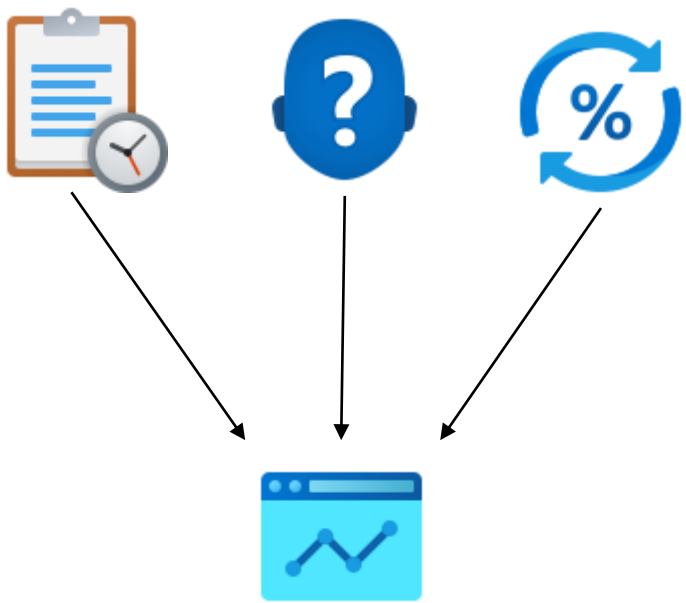
Status

- Deployed tablet application at point of inspection
- Reduced time required to initiate a Tag
- Added structure to captured data to support automated research
- Reduced number of Tag rejections
- Provided accurate nonconformance locations, part numbers

Impact

Quantitative Savings

- **33%** labor hour savings for creation and disposition of tags

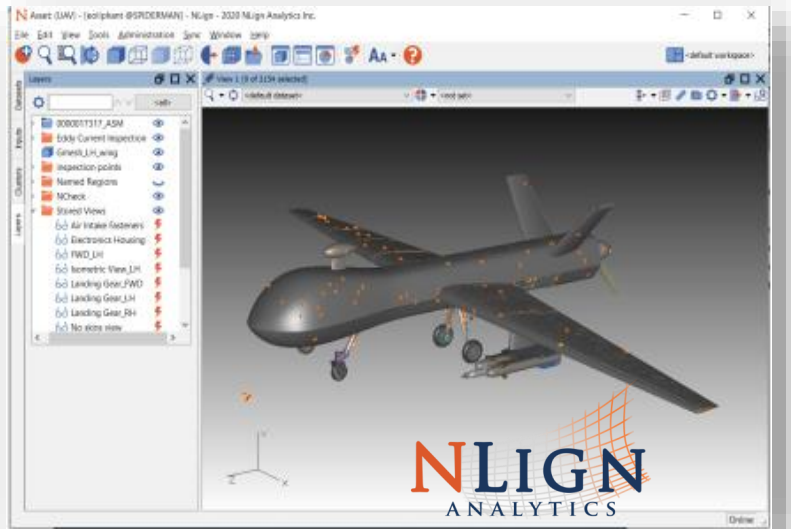


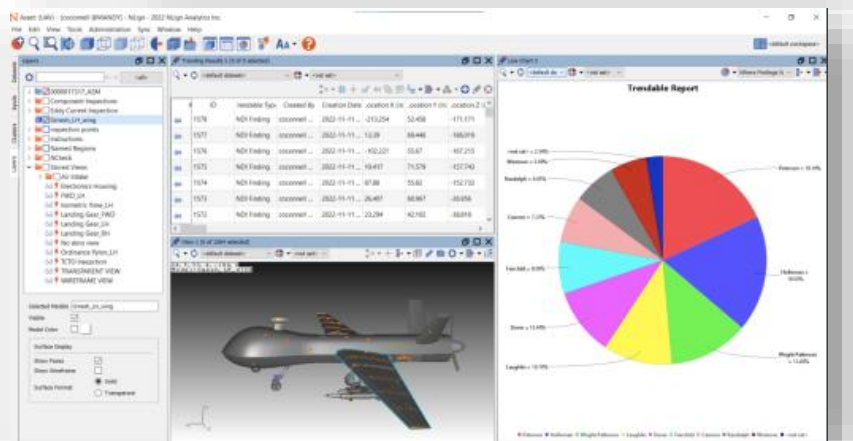
Qualitative Savings

- **Tag Reductions**
  - Feedback loop, design, and process changes that lead to a more manufacturable design
  - Reduced build schedule impact due to time to disposition tags
  - Fewer tags
- **Sustainment**
  - Feedback loop creating better performing, easily maintained products to reduce issues in the field
  - Facilitates high fidelity digital twin creation which brings benefit to design, manufacturing, sustainment, and condition-based maintenance

Complete Digital Thread

- **Built** an interactive 3D environment to aid in decision making
  - Acquires and stores data that makes every aircraft unique
  - Allows user to tie discrepancies/nonconformances to exact X,Y,Z locations
  - Adds ability to gain structured data for analytics and sustainment
  - Provides immediate feedback to engineering
- **Integrated** with VAS, MES, and SAP systems
- **Enhanced** the quality and accuracy of data
- **Realized** and **increased** first time quality yield using new system
- Data Reuse and Part State Awareness





Questions?