CAMX

THE COMPOSITES AND ADVANCED MATERIALS EXPO

COMBINED STRENGTH.
UNSURPASSED INNOVATION.

October 13 – 16, 2014 / Orlando, FL , USA

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Produced by ACMA SAMPE

3D Process Analytics for Carbon Composite Manufacturing

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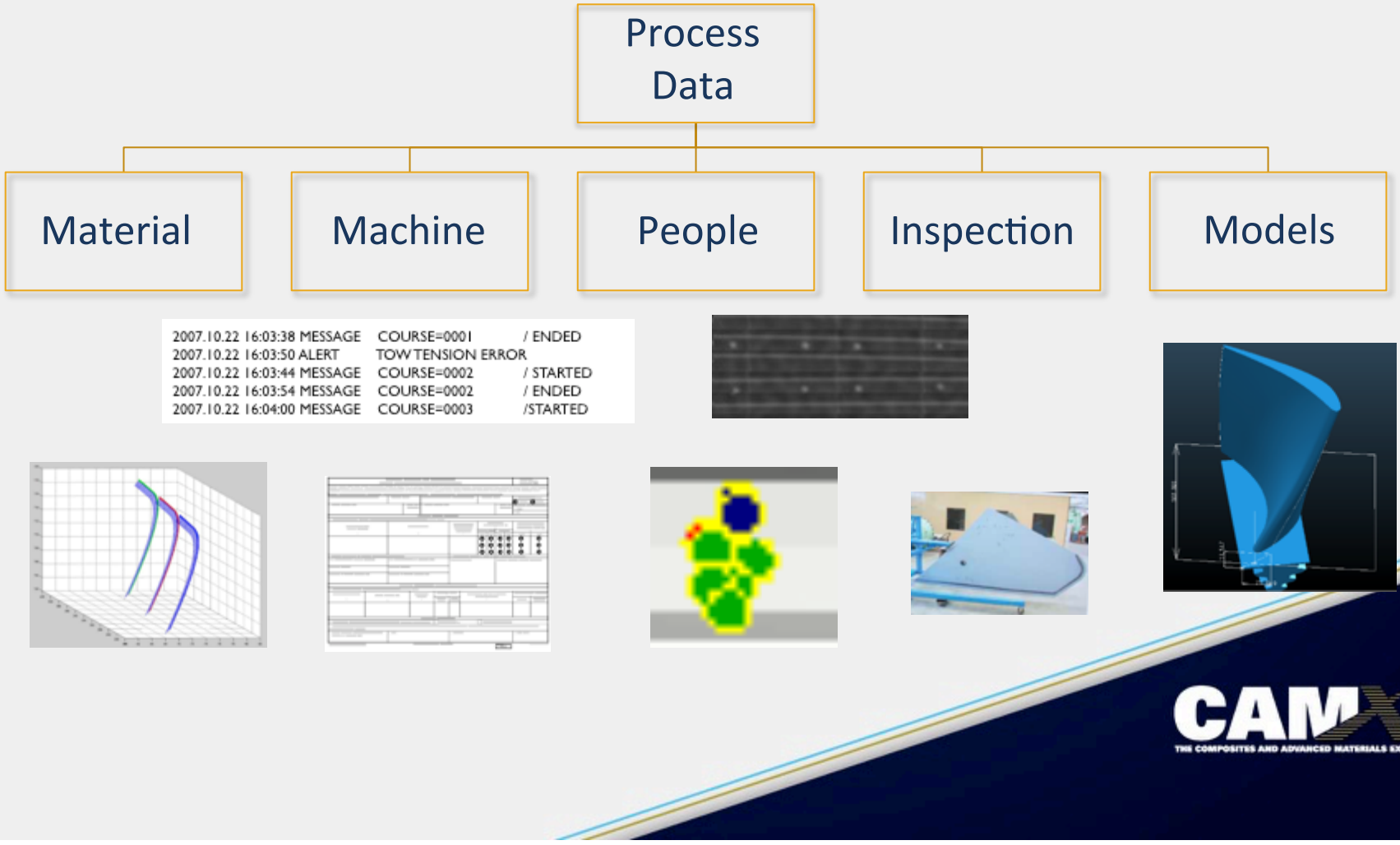
- GKN Aerospace
  - Mike Robertson

Outline

- Introduction
- NLign System Overview
- Data Organization
- Case Studies
- Conclusion

Introduction

An Unprecedented Amount of Process Data is Generated and Collected



Composite Manufacturing Process Data

- This Data is Difficult to use for Process Analysis/ Improvement
  - In many different forms
    - Paper, Text files, Proprietary data formats, etc.
  - Not meaningfully organized
    - File cabinets, File systems
    - Excel spreadsheets, Legacy Databases, ERP/MES system
  - Large volume
- What if this Data Could be Meaningfully Tied to a 3D Model?

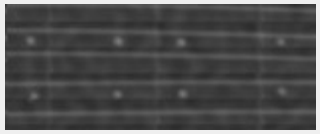
NLign

- NLign originally developed with support of Air Force and Navy to improve maintenance processes
- NLign collects, organizes, and archives a wide variety of data
- Data organized by alignment to 2D or 3D models of parts
- Analysis tools allow for visualization, trending, reporting, etc
- Further investment and support from commercial partners such as Spirit AeroSystems and early adopters such as GKN brought the use of NLign to composite manufacturing

NLign Overview

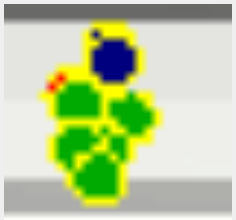
Process Data
Tool Set Number
Machine Log Files
Resin Properties
Etc.

Inspection Data



Digital Pictures

Dimensional Data



Models
Structural
Molds
Fixtures
FEA Models
Specifications

Align & Archive

Data is then automatically aligned to CAD model and stored in an archive database

Manufacturing

- Process Improvement/RCCA
- MRB Process Improvement

Maintenance

- Aircraft Structural Integrity
- Structural Repair

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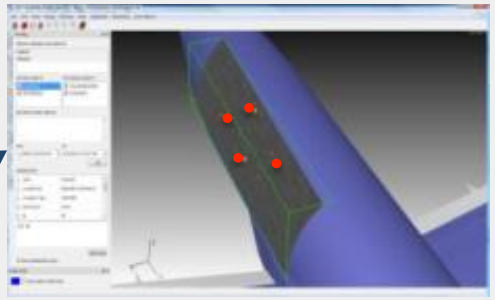
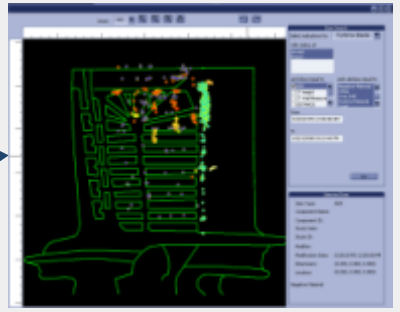
Analysis Tools

Visualize ultrasound C-Scan results



Visualize digital radiography on 2D Model



Analyze

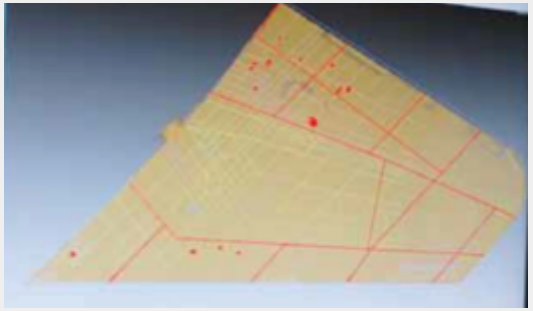
- Reporting
- Visualization
- Trending
- Root Cause Analysis
- Process Improvement
- Coverage checking
- Analysis package integration

Data Export:

- Excel
- Minitab
- FEA
- DELMIA OI/PRD

Integrated Analysis Tools

- Plotting
- Basic statistics



Overlay various models

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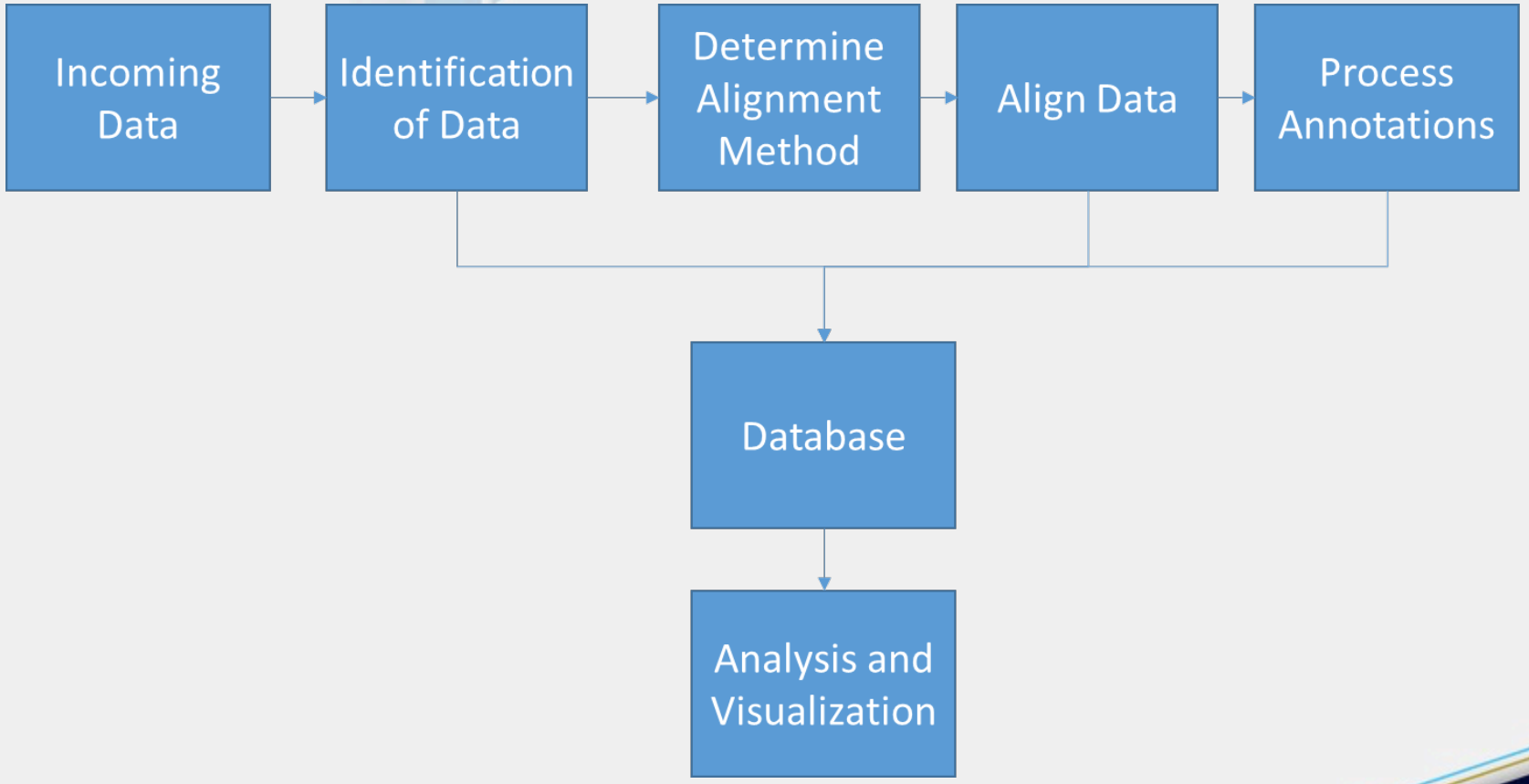
Data Organization

- Varying inspection modalities, equipment, and processes require various methods of organizing data
- No “one size fits all” approach
- Techniques range from fully automated to manual entry

High Level Workflow

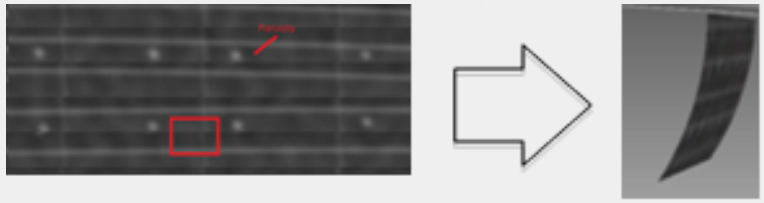


Ultrasonic Data Mapping using Robot Trajectory

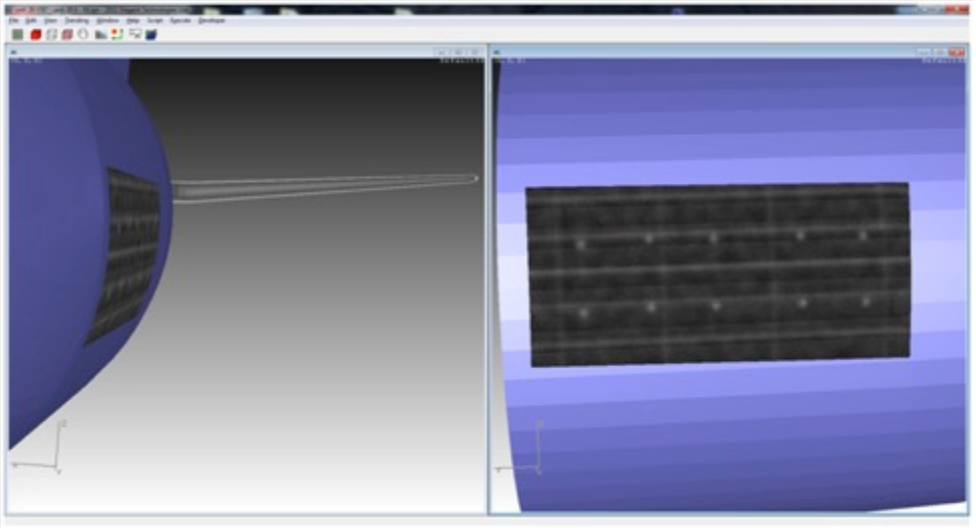
- Robot positioning information used to transform 2D scan to 3D approximation of surface
- Features in data matched to features on 3D CAD model
- Rigid body transformation registers data to model

C-Scan Data Mapping using Robot Trajectory

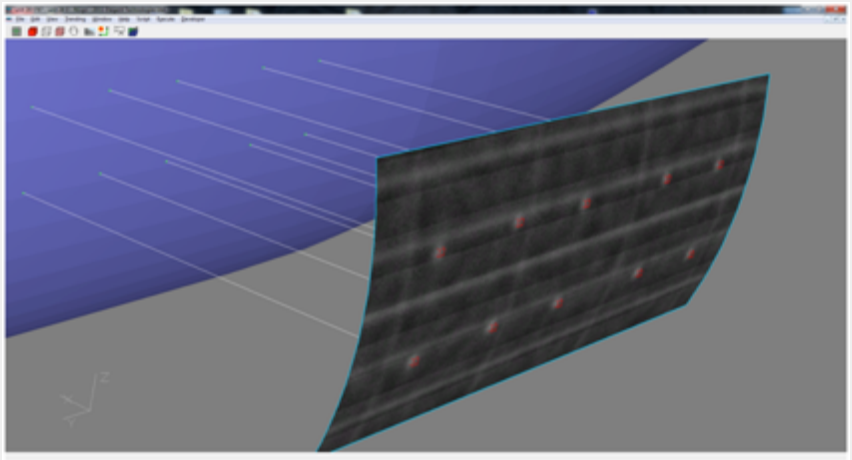
Robot positioning to 3D



Registration of Data



Feature Correspondence



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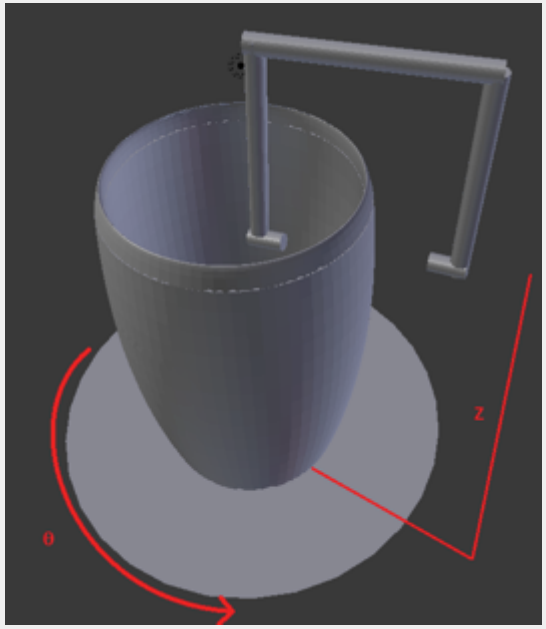
Turntable UT Inspections

- Through transmission UT turntable scans do not generally generate positional information that approximates the surface
- Algorithmic model of turntable inspection developed to “unwrap” 3D CAD to 2D image



UT Crawlers

- Crawler robots may not have any positioning information
- Part geometry, inspection setup, and model of robot motion can be combined and utilized to perform 3D to 2D mapping

Dimensional Data

- Existing software tools do a good job of visualizing dimensional data and comparing the “as manufactured” to the “as designed”
- Less emphasis has been placed on software to try to trend dimensional data across multiple parts

Other Inspection Data

- 2D radiographs can be mapped to 2D diagrams
- Data can be manually entered or imported via spreadsheets
- Damage indicated within a photograph can be mapped onto a 3D model in a user-in-the-loop process

Other Process Data

- Tooling data
- Cure data
- Tool repairs
- Incidents associated with fiber placement
- Prior repairs and analyses
- Prior MRB dispositions

Case Studies

- Manufacturing Process Improvement
  - Monitor tool degradation
  - Root cause analysis
  - Inspection Coverage
  - Detection of Dimensional Trends
  - Use at Spirit AeroSystems
- MRB Process Improvement
  - MRB Process Improvement
  - MRB Analysis
  - Use at GKN Aerospace

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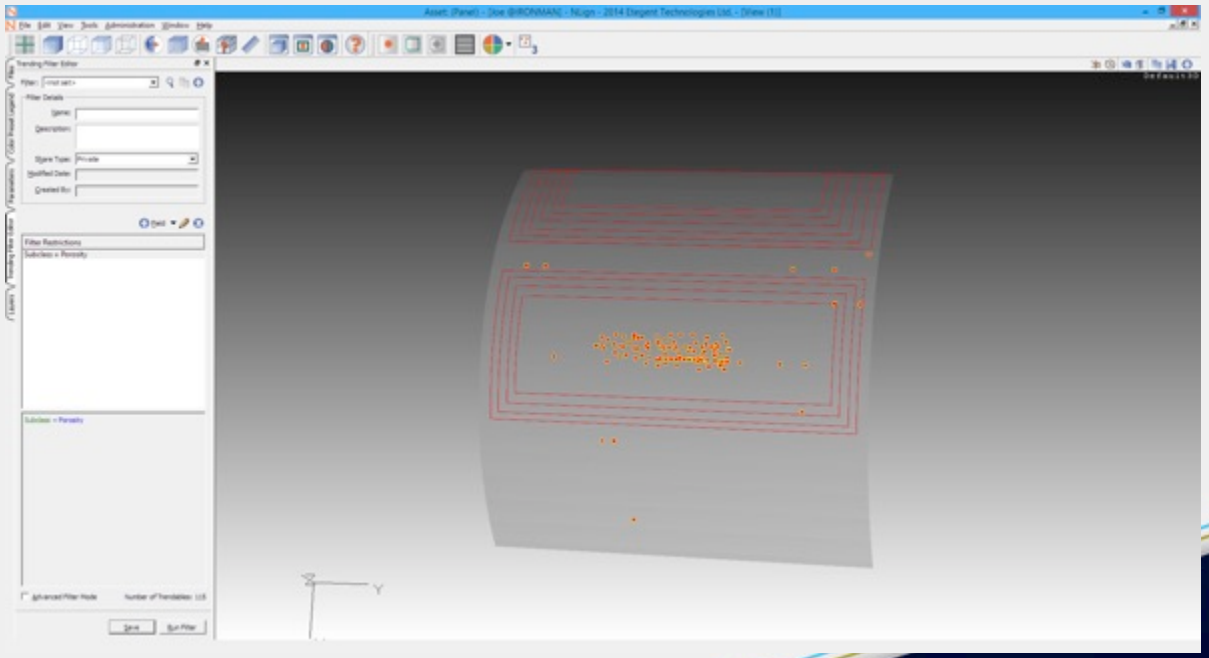
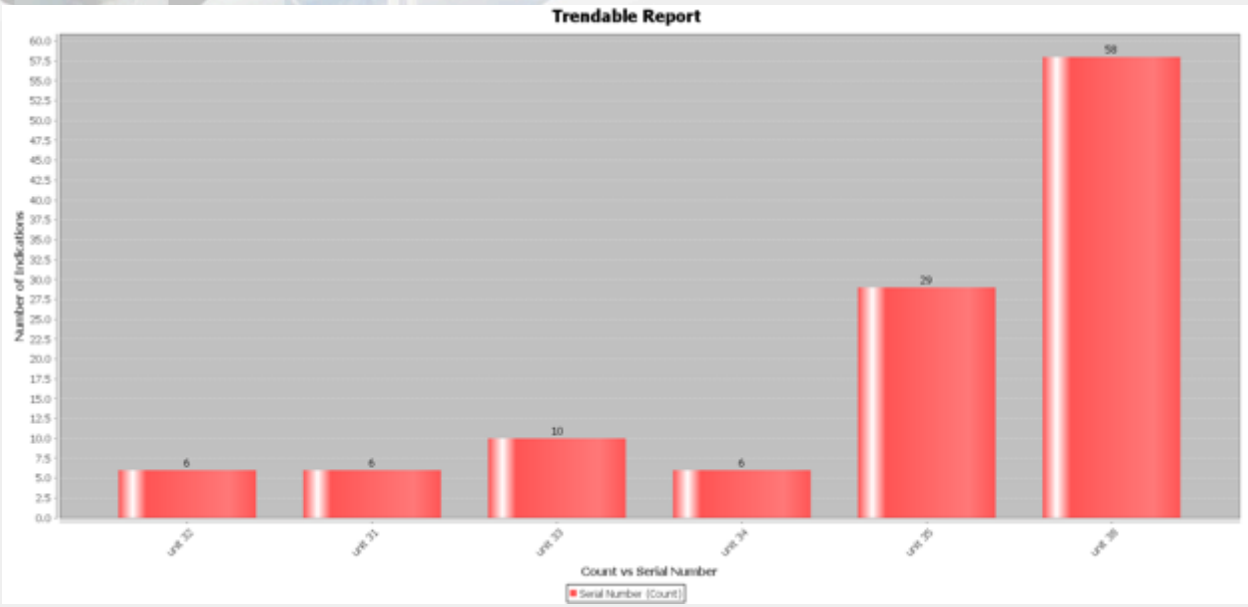
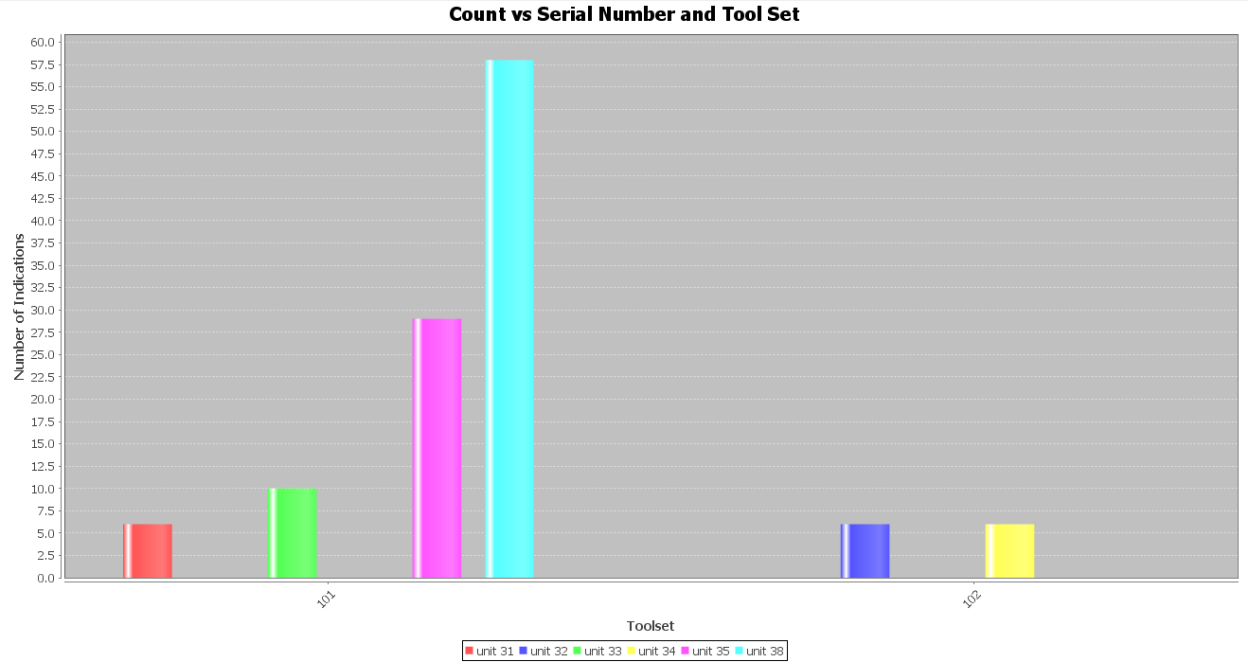
Detection of Tool Wear

- Tool wear over time can result in increasing numbers of defects
- Mapping defects to 3D model and associating tooling information enables easier detection of trends



Detection of Tool Wear





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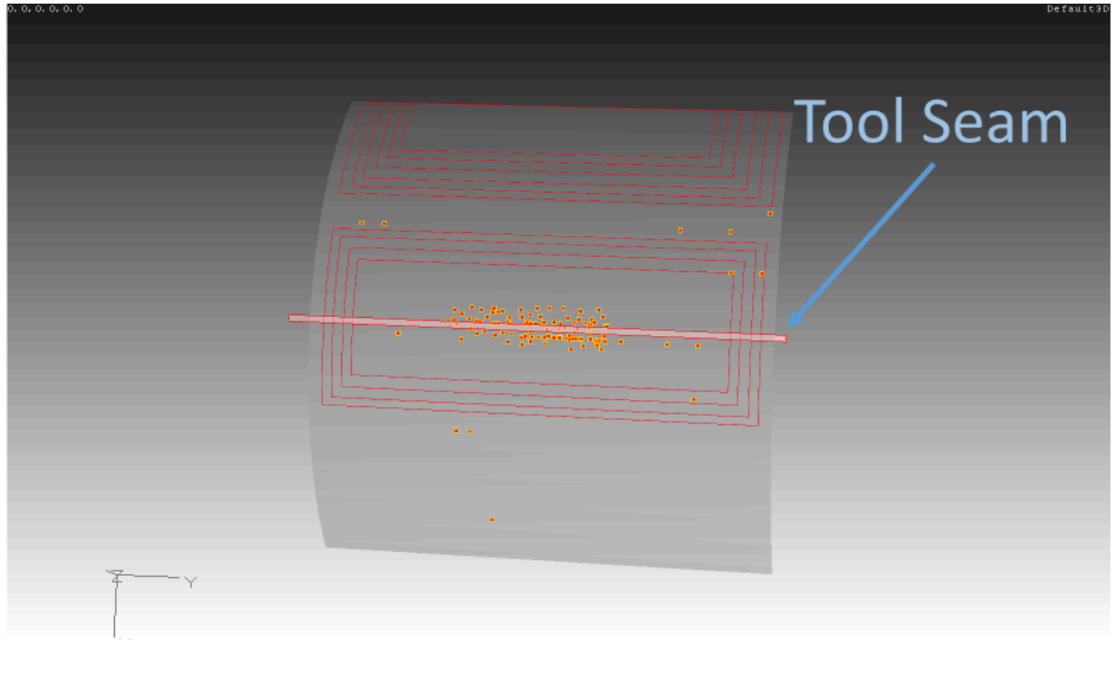
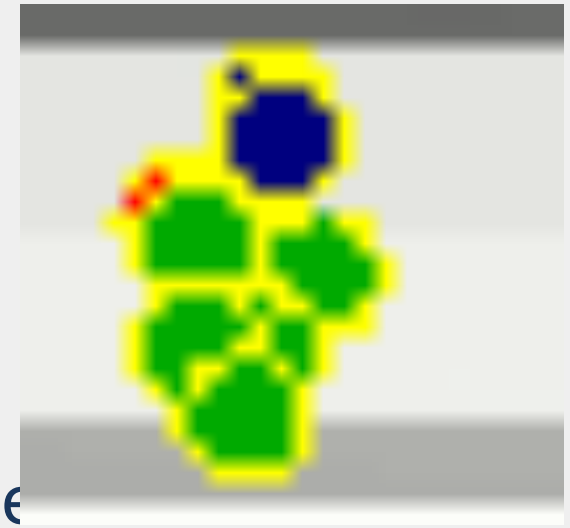
Root Cause Corrective Action (RCCA)

- Root cause of issue can also be determined
- Additional data, such as tool models or joints between tools or parts of tools can be overlaid
- Defects correlated with tool seam



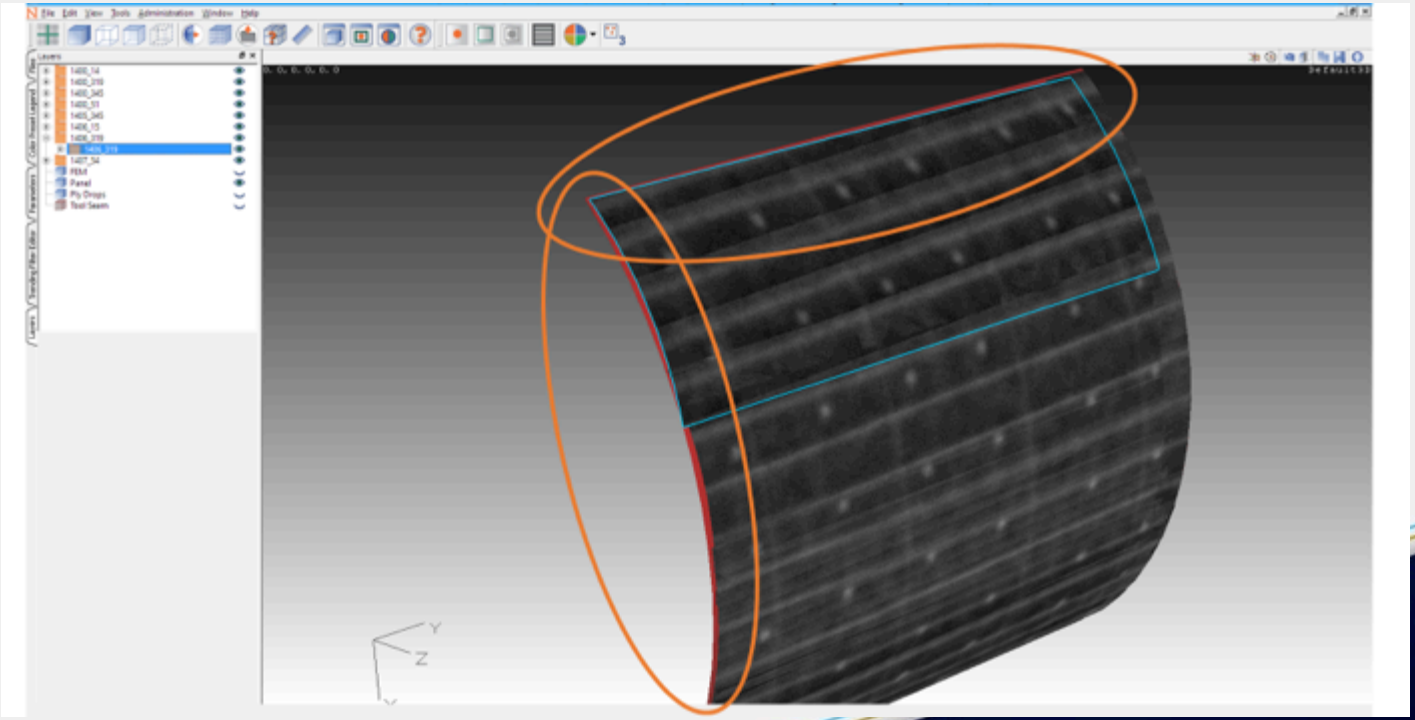
Detection of Dimensional Trends

- Dimensional data can also be trended
- 7 parts worth of CMM data for drilled hole organized
- Visualized position exaggerated
- Orange dot is nominal location
- Green dots are holes shifted in one direction
- Blue dots are holes shifted in the othe
- Bias in deviation visible



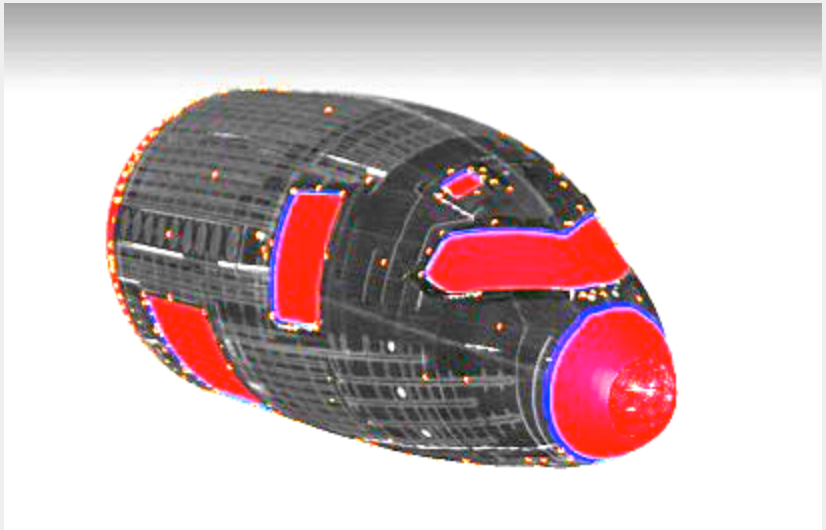
Detection of Coverage Issues

- Ensuring inspection coverage of parts can be challenging
- Registering all scans and visualizing simultaneously makes this process easier



NLign At Spirit AeroSystems

Problem: Root cause of localized sporadic acceptable porosity indications on fuselage section was unknown



Solution: NLign allowed for visualization of porosity indications on the3D model. This visualization allowed for a problematic bladder to be identified.

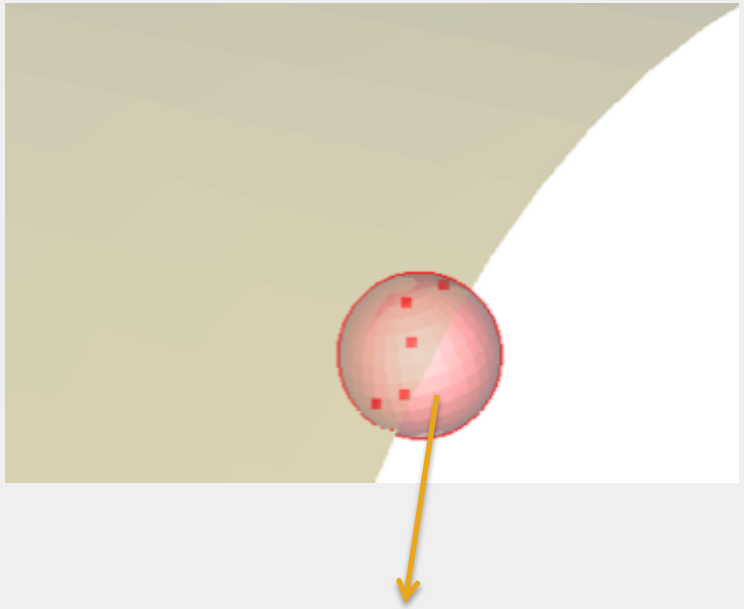
Value: NLign allowed for early detection of pattern that if undetected would have led to expensive rework and potential scraping of fuselage section

NLign At Spirit AeroSystems

- Combination of mapped NDI data and process information organized with NLign used on a regular basis to promote manufacturing process improvements
- NLign used for coverage verification in support of NDI machine qualification

Case Study: MRB Process Improvement

- OEM disposition taking over a month
  - Reduce risk of continued manufacturing
  - Repository of acceptable defects
  - Confident decision to either
    - Continue processing part while MRB analysis is being performed
    - Stop processing part until MRB analysis is complete
- Yield: a significant rate increase while managing risk



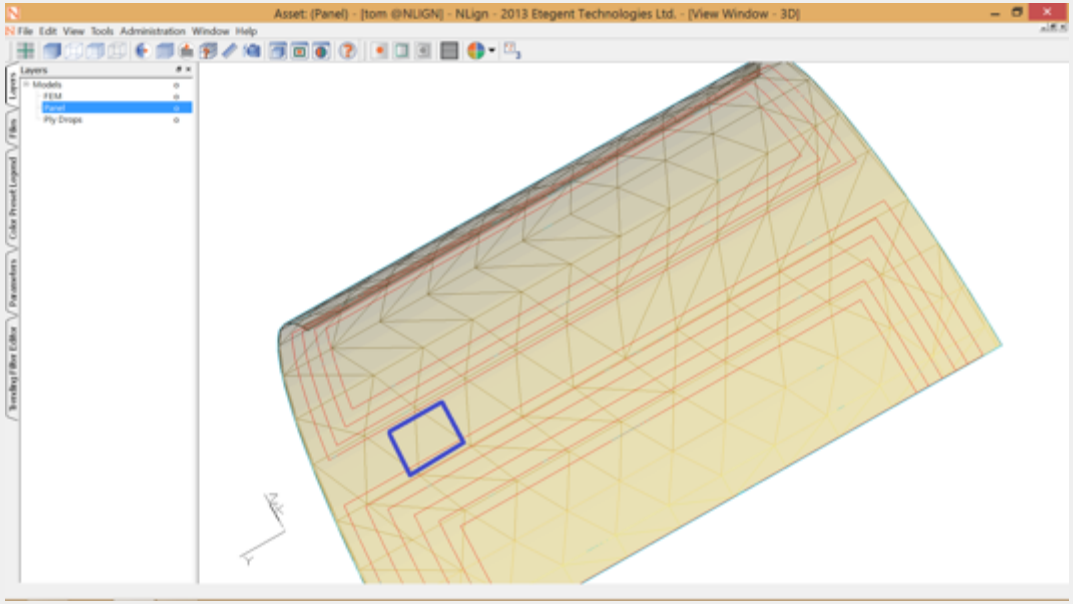
Trending Results - (0 of 5) selected

Select Filter: <active filter>

ID	erial Numb	le Nom or .	Class	Subclass	Toolse
3387	unit 34		Feature	Delamination	102
2955	unit 34		Feature	Void	102
692	unit 31		unknown	Adhesive	101
125	unit 32		Feature	Adhesive	102
123	unit 32		Feature	FOD	102

Case Study: MRB Analysis

- Combine Non-conformance with design models
  - FEM Models
  - Ply Models
  - Historical Non-conformances
- Enable quick analysis of Non-conformance



GKN Aerospace – Improved MRB Process

- Delays in OEM MRB decisions causing process flow problems
  - OEM MRB takes 4 weeks
  - Parts are pulled out of production flow waiting for MRB disposition
  - Limits production rate
- NLign used to store historical MRB decision at GKN
  - Allows GKN to assess likelihood of eventual disposition
  - Reduced work in progress by three weeks
  - Highlighted areas of process improvements
  - Increase Inventory turns

GKN AEROSPACE

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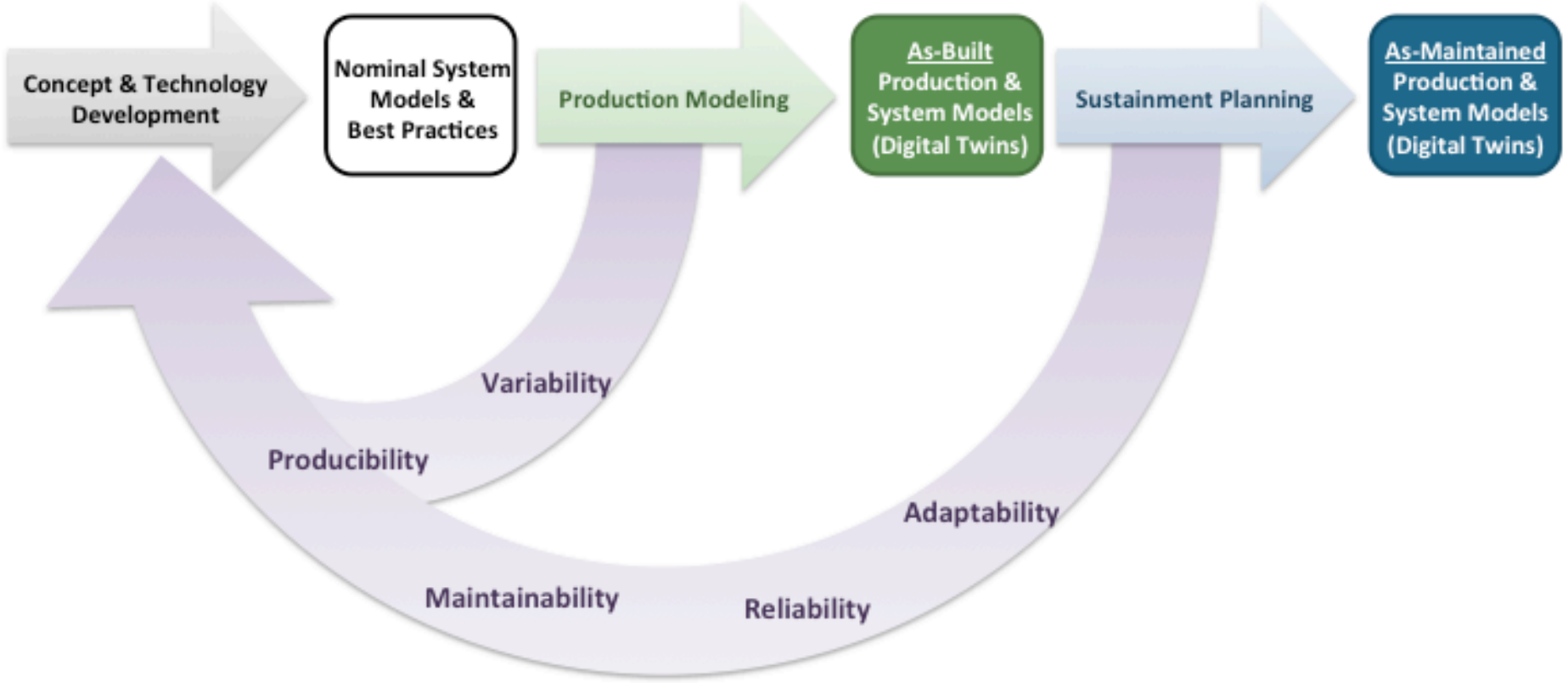
Looking Forward – The Digital Thread and Digital Twin



- Seamless flow of information through lifecycle
- Supported by DoD

Conclusion

- NLign's ability to organize and analyze various types of data has been successfully used to improve CFRP manufacturing processes
- Customers have realized improvements to first pass yield, reduction of scrap, reduced work in progress, and other process improvements