OCTOBER 6, 2021

Advancing Toward Quality 4.0 in Composites Manufacturing

Scott Blake, President

Agenda

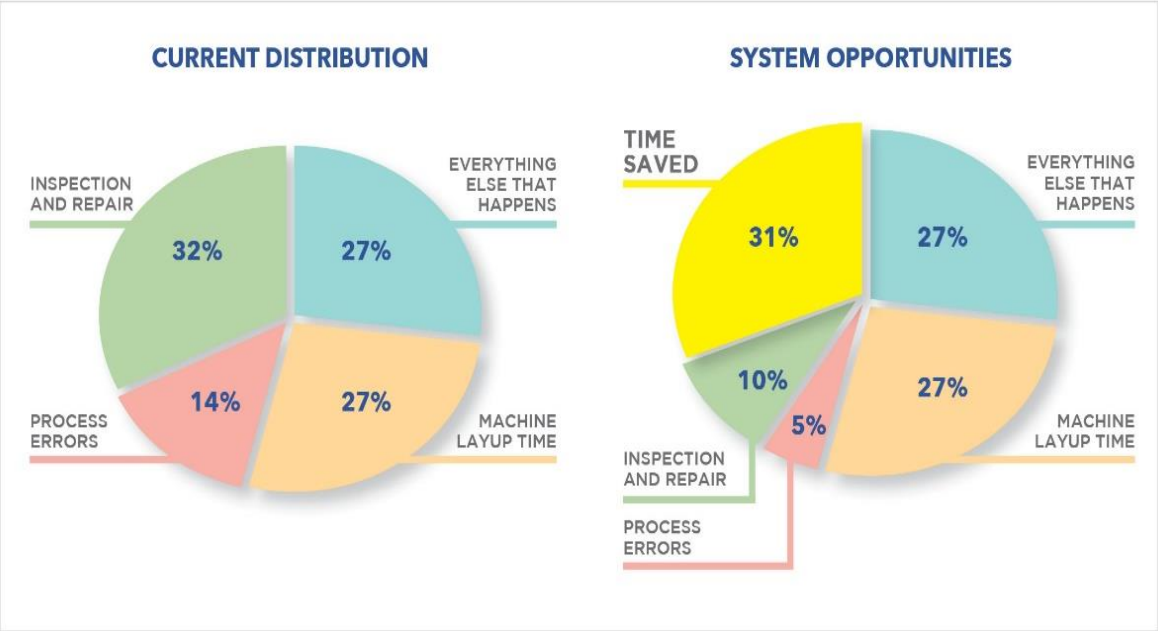
- Current status of quality processes
- Goals for quality processes
- Spotlight on automatic inspection
  - Current status
  - Advancing automatic inspection to Quality 4.0 capabilities
- Bringing Quality 4.0 to your fabrication shop

Manual Quality Processes

- Composites automation has focused on fabrication processes
- Quality processes have not kept pace
  - Paper-based process control
  - Manual inspection
  - Paper-based reports

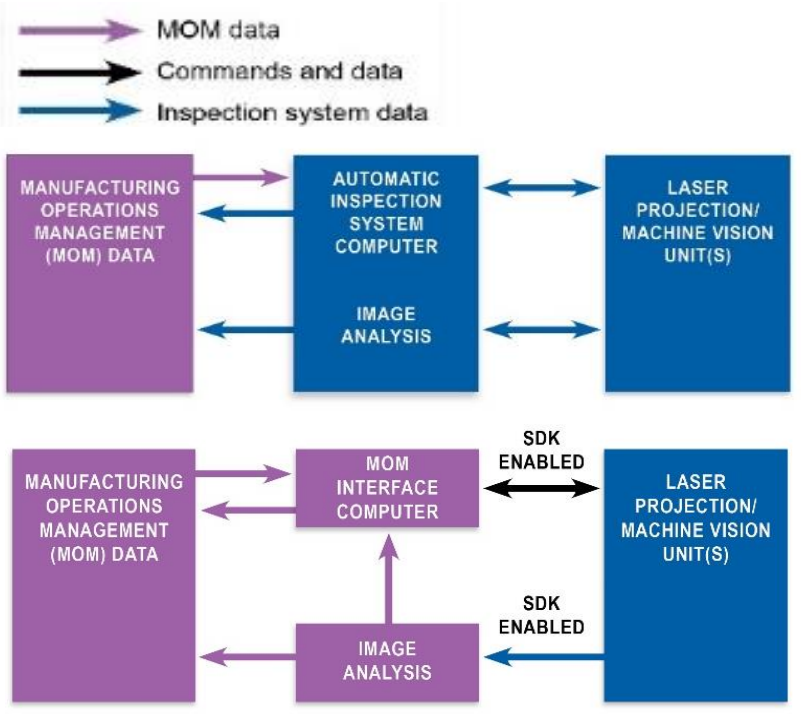
Manual Quality Processes

- Electroimpact AFP study
- Only 27% value-add time
- Potential savings from automated quality processes: **31% of cycle time**



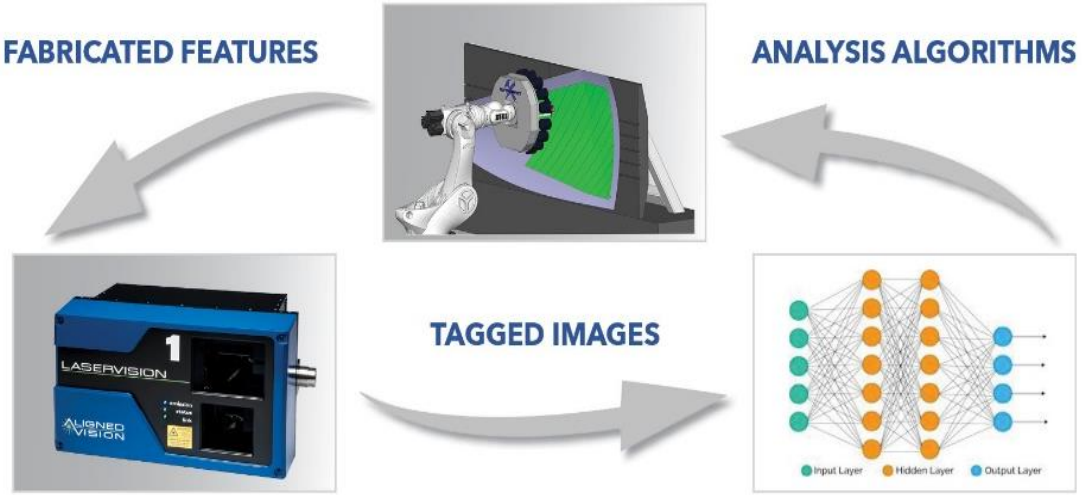
Quality 4.0 Goals

- Are you building what you designed? How do you know?
- The value of more quality data
  - Scrap reduction
  - Lightweighting (less over-design, better performance)
  - Higher throughput
- Quality 4.0
  - Integrate with ERP, MES, QMS



Quality 4.0 Digital Thread

- Method for automatically capturing thousands of tagged images
- AI/ML-based algorithm development
- AI/ML democratization through low-code software

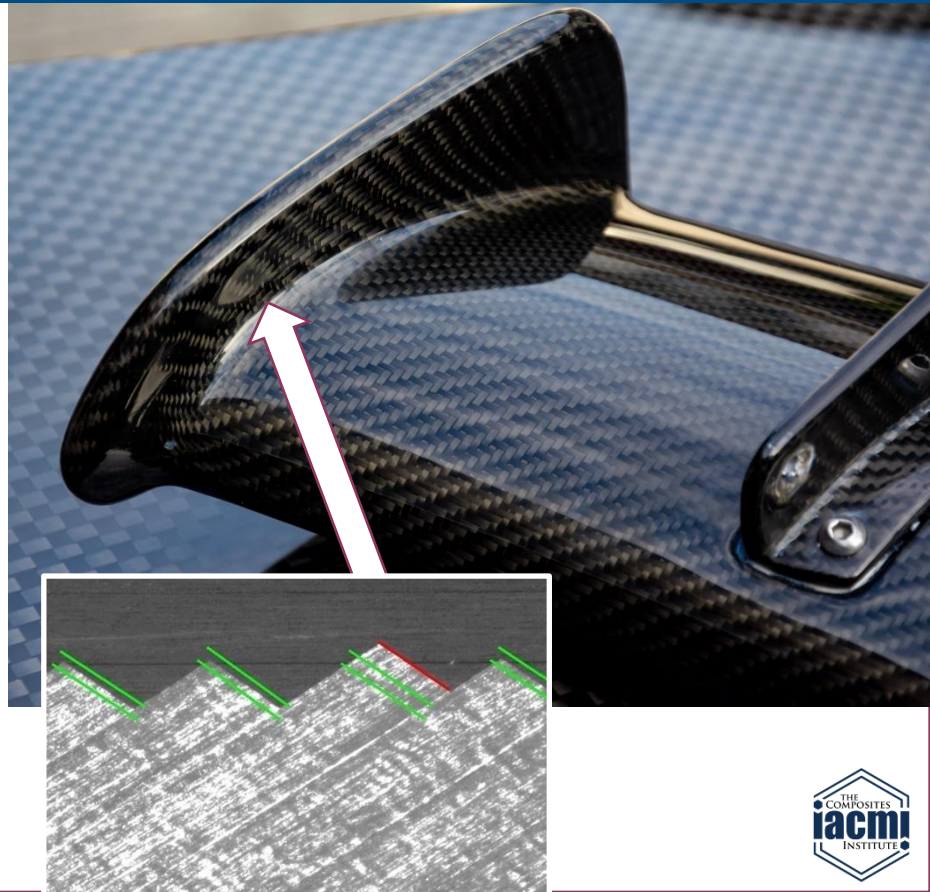


Spotlight: Automatic Inspection

ALIGNED VISION

CHALLENGES:

- Complex set of attributes to inspect
- Requires application-specific inspection engineering
  - Capture tagged images
  - Generate analysis algorithms
  - Weeks-long process with current technologies



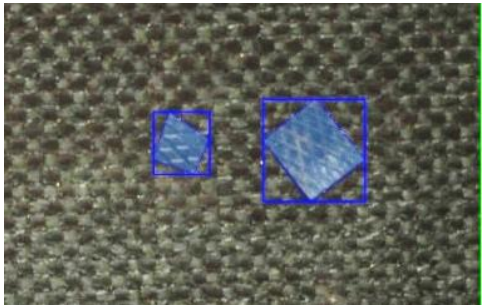
THE COMPOSITES iacmi INSTITUTE

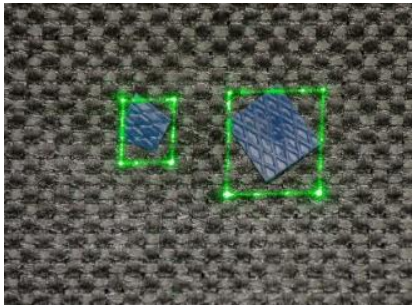
LASERVISION

ALIGNED VISION

MACHINE VISION SYSTEM

- **NOT Metrology**
- CAD model used to:
  - Aim camera
  - Project reference lines
  - Analyze data
- Machine vision captures small, high-res images in large, complex field



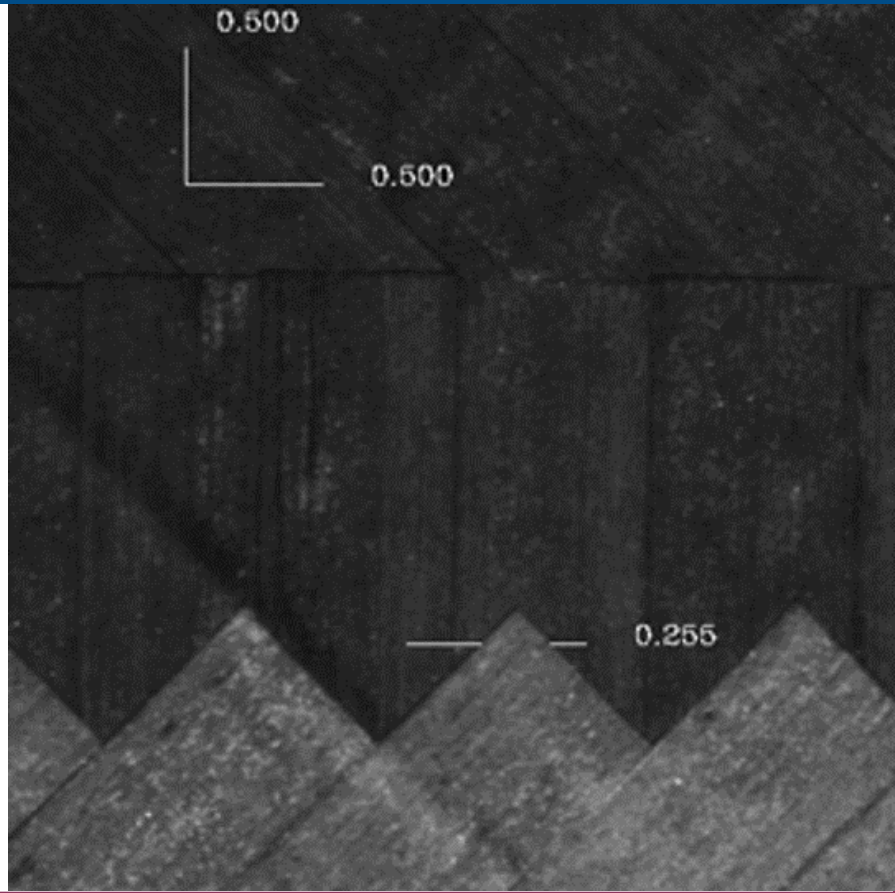


LASERVISION

ALIGNED VISION

MACHINE VISION SYSTEM

- Faster than point-cloud metrology
- Photogrammetric transform defines relationship between camera and feature
- Each pixel of 2D image dimensioned relative to 3D surface
- Gauging function assesses feature locations on a surface assumed to be correct
- Visible attributes recognized



LASERVISION STATUS

ALIGNED VISION

AUTO INSPECTION FOR AFP

- Boeing 777X
- Wingskin and Spar Cells
- Inspection occurs on any visible surface without stopping layup
- Suspect locations pinpointed with laser projection
- Inspection and projection functions integrated with cell controller with SDK

LASERVISION STATUS

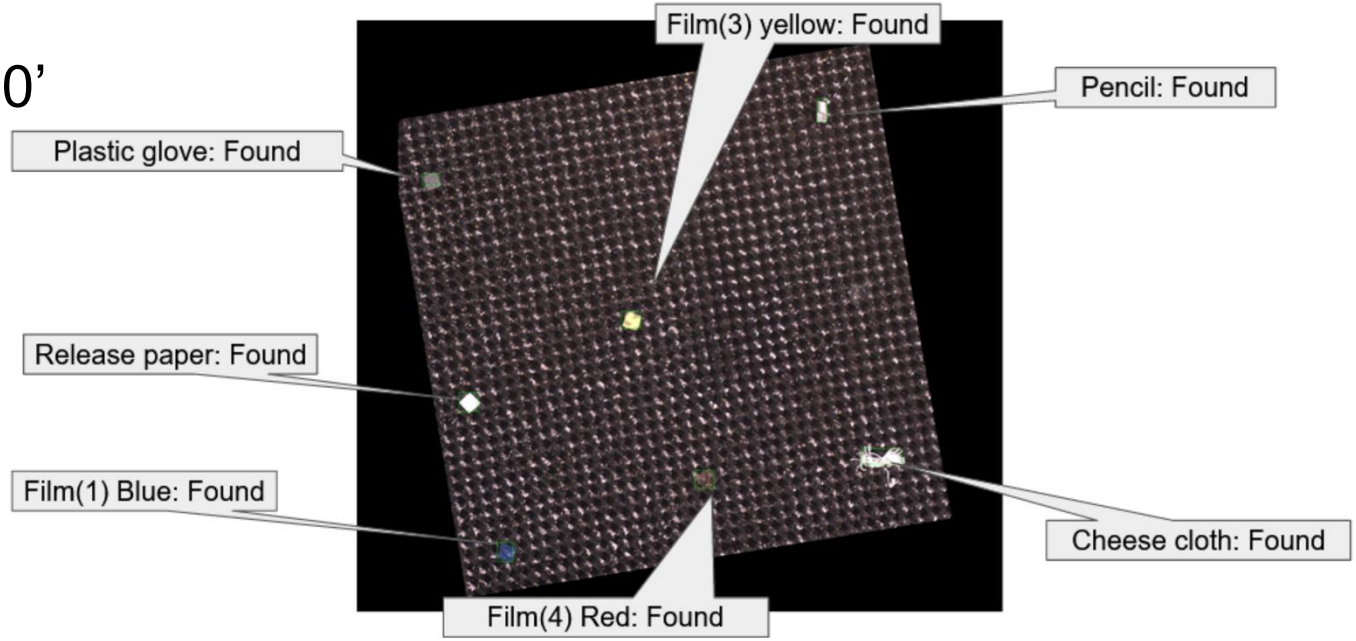
ALIGNED VISION

AUTO INSPECTION FOR HAND LAYUP

- Sikorsky Blackhawk
- Main Rotor Spar Cells
- Laser projection for hand layup
- Automatic Inspection replaces:
  - trained inspector
  - with calibrated instruments
  - for flight-critical characteristics

LAB DEVELOPMENT OF UNIQUE APPLICATIONS

- 0.125” FOD
- Viewed from 10’



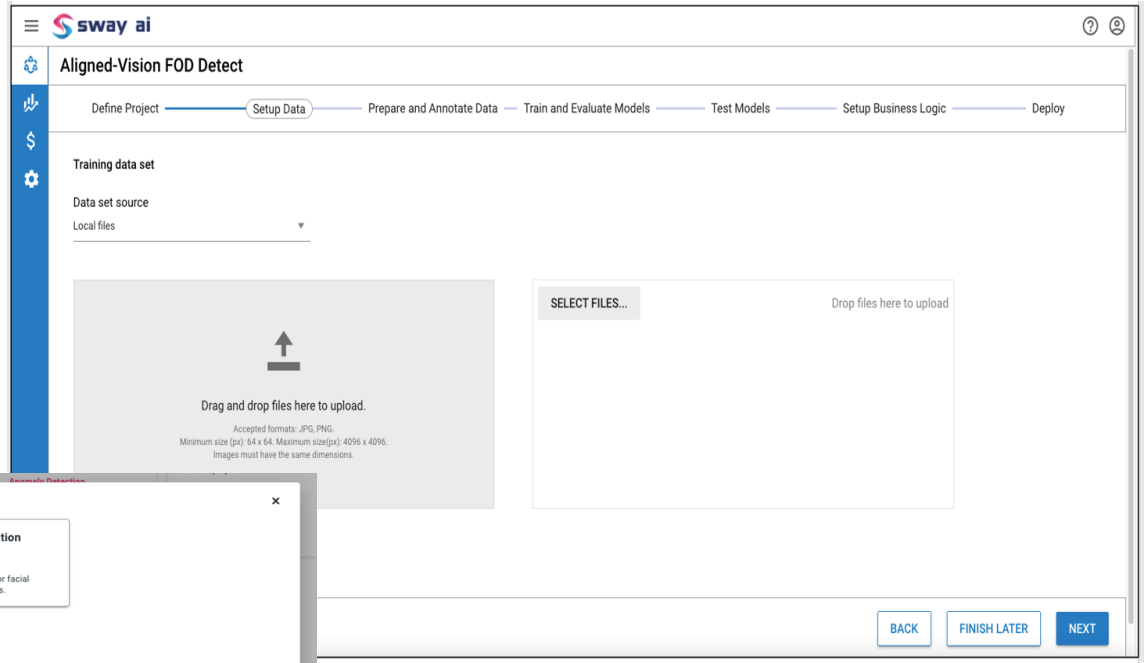
Applying AI/ML

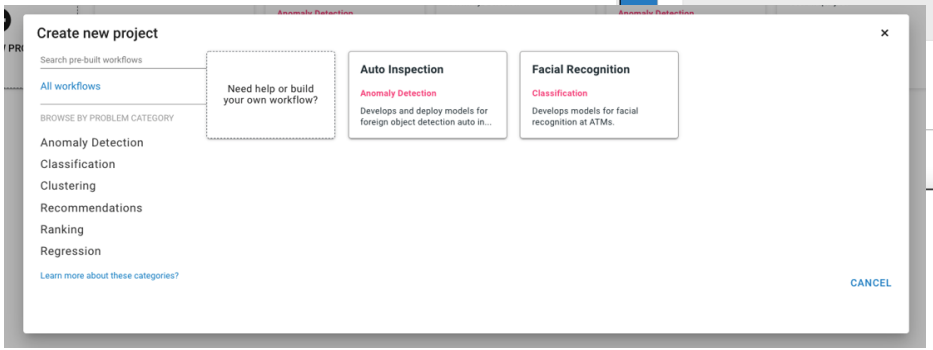
LOW-CODE AI/ML

- Data in: Tagged images identified as flaw-free or containing a particular flaw
- ML model trains a classifier to categorize images with similar characteristics

Applying AI/ML

- Low-code ML interface developed

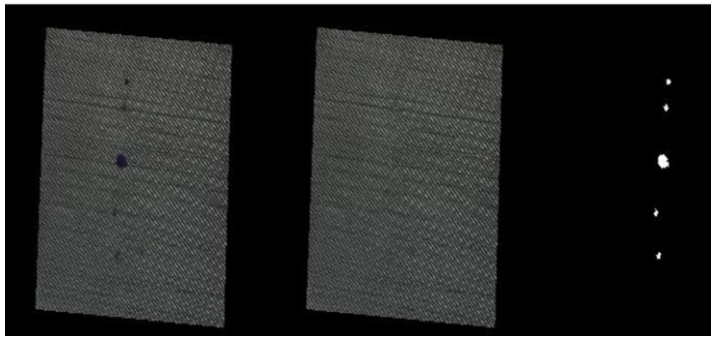


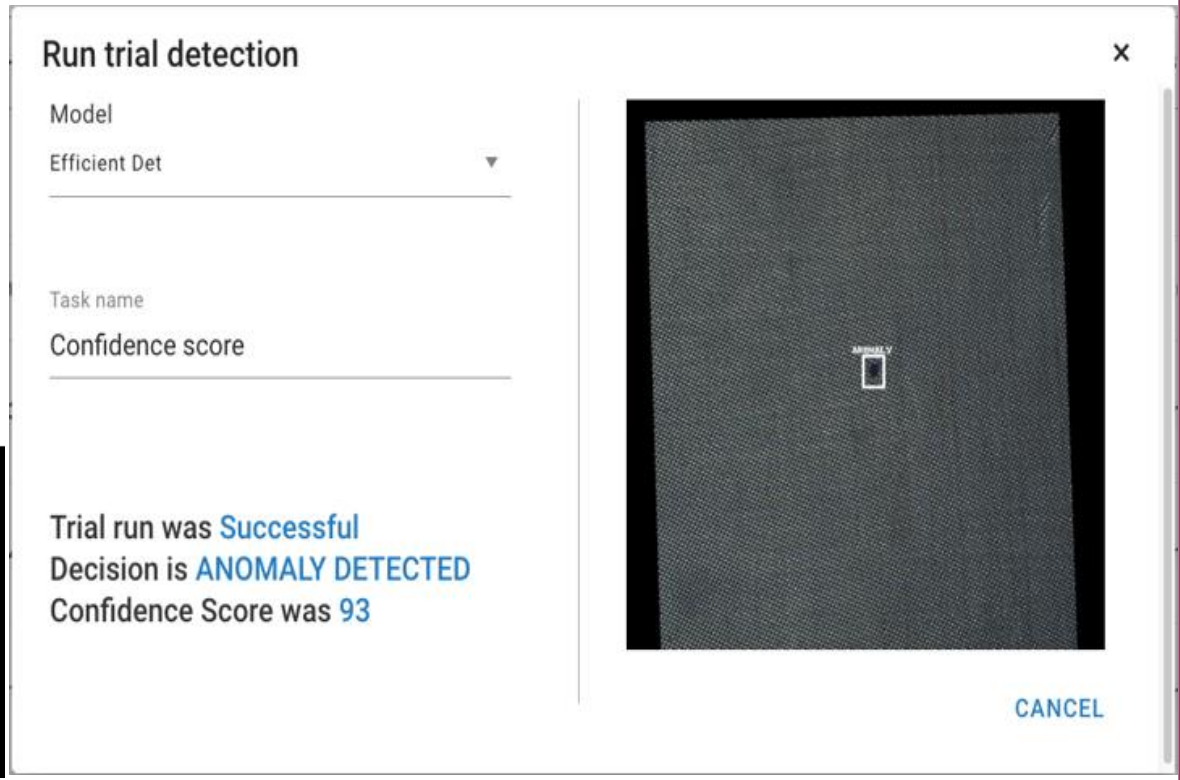


Applying AI/ML

- Development and training of ML tool with low-code system

sway ai





Quality 4.0 Pilot Programs

- All data interfaced through Industry 4.0 systems
  - ERP
  - MES
  - QMS
- Software Development Kit

Quality 4.0 Pilot Programs

ALIGNED VISION

HAND LAYUP OPERATION

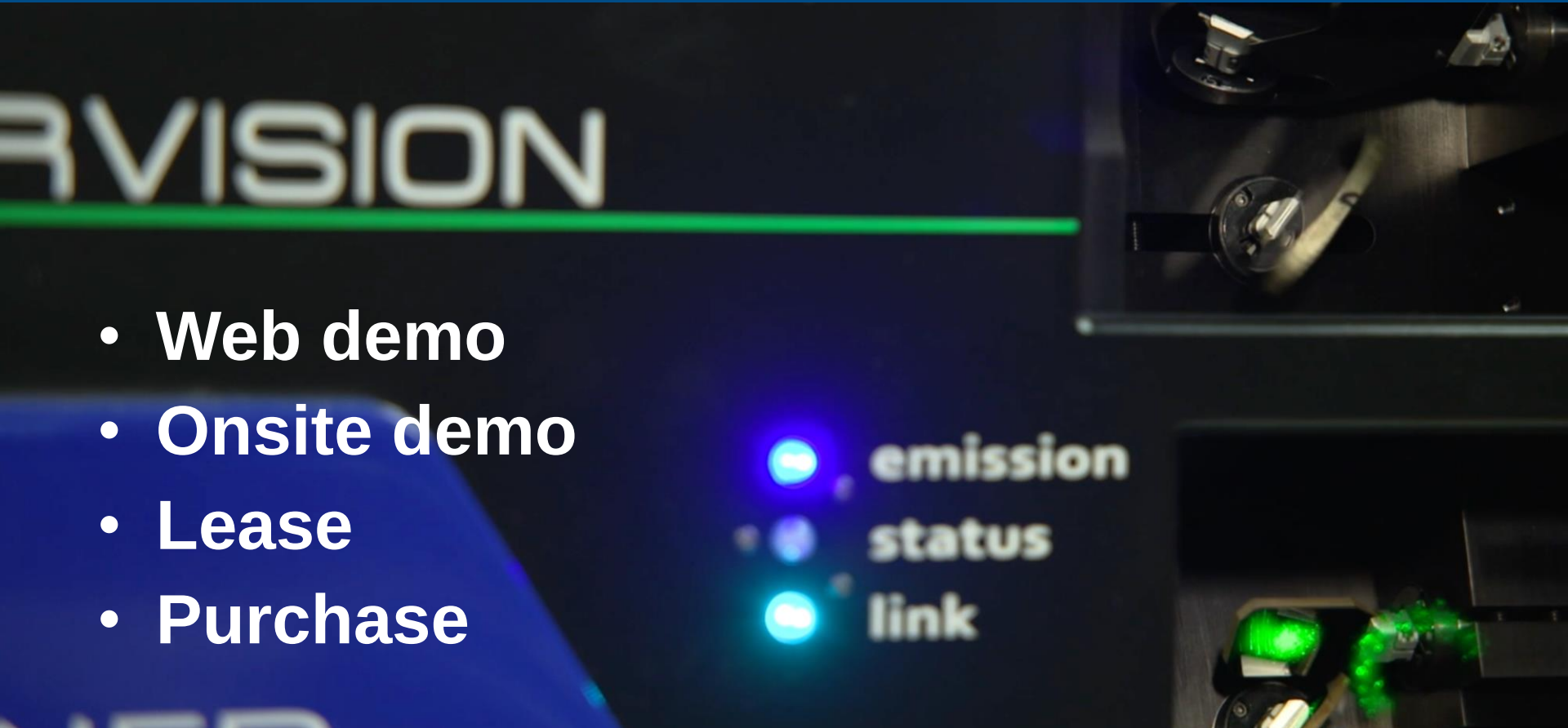
- Drop-in replacement for standard laser projector
- Image capture in background
- Build image database
- ML classifier training
- Qualify alongside traditional inspection

Quality 4.0 Pilot Programs

AUTOMATED PROCESSES

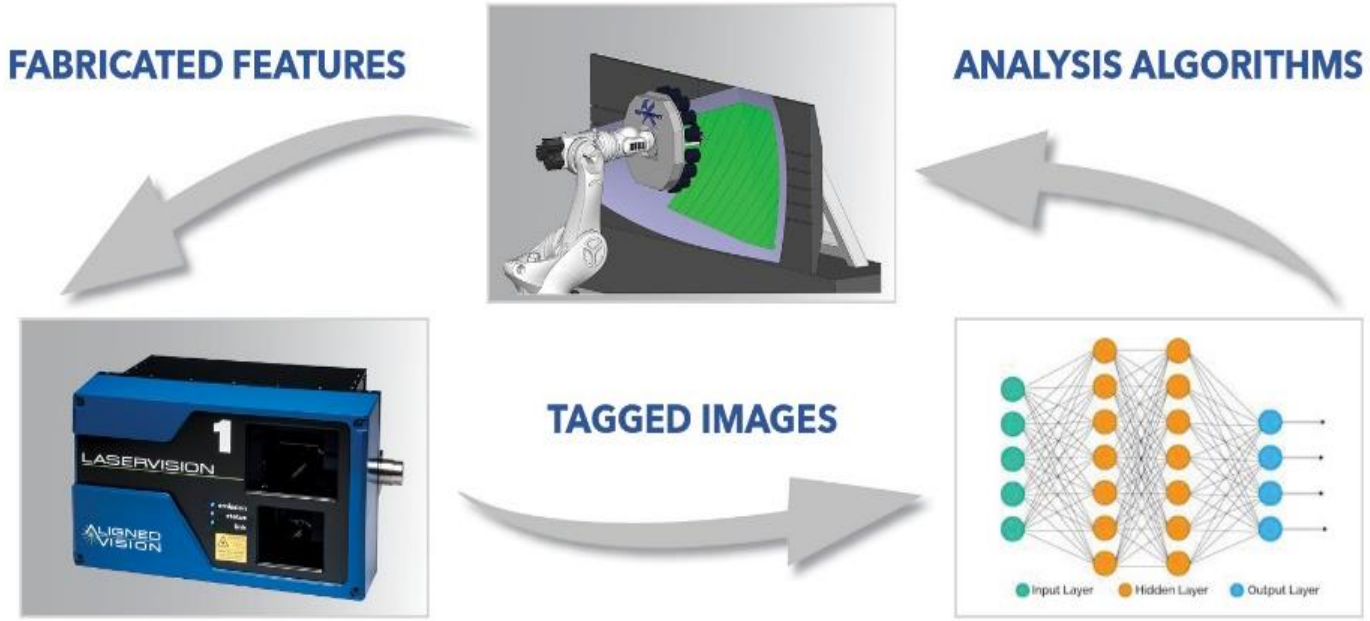
- Run standalone unit for initial application development
- Run automatic inspection in parallel with manual protocols
  - Continue ML training
- SDK integration
- Low-code ML for new applications

Next Steps



- Web demo
- Onsite demo
- Lease
- Purchase

Thank You!



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