ACCELERATING INNOVATION

CTMA ANNUAL PARTNERS AND INTEGRATED PROJECT MEETING 2017

Large-Standoff Large-Area Thermography

LASLAT

Developed under SBIR NAVAIR N092-097

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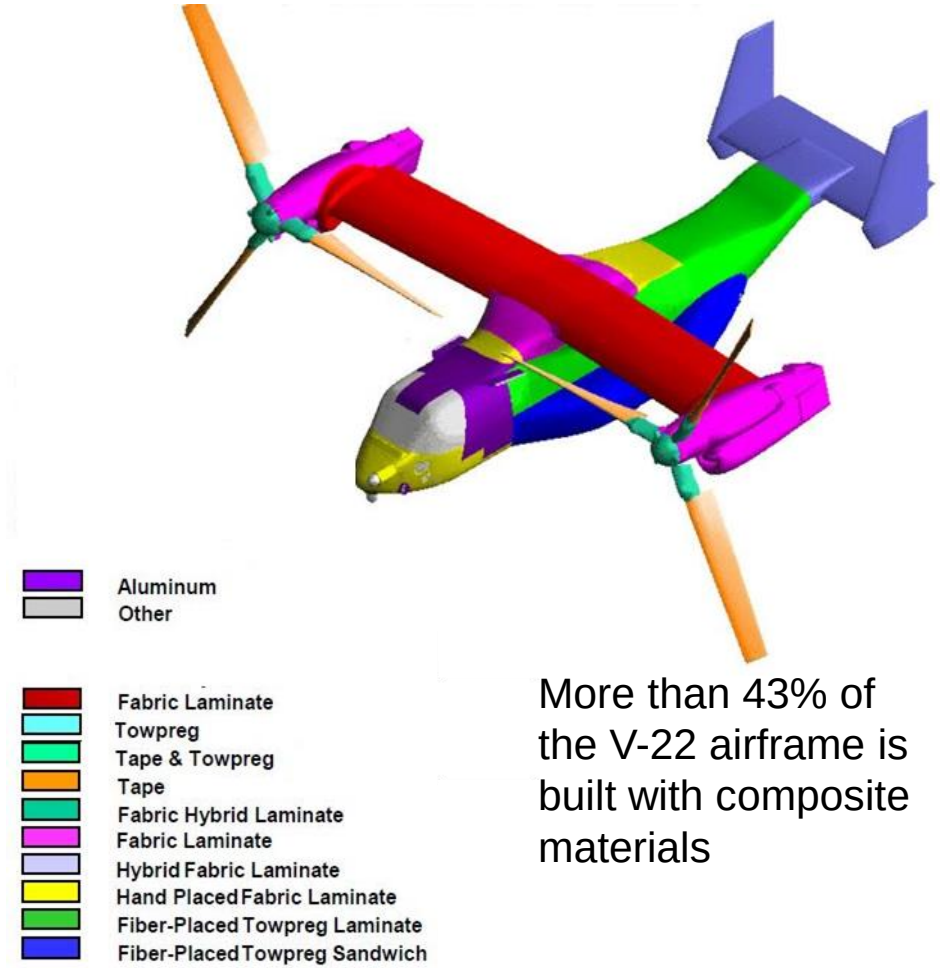
Thermal Wave Imaging

CTMA COMMERCIAL TECHNOLOGIES FOR MAINTENANCE ACTIVITIES

Challenge: NDI of Large Scale Composite Structures

- Aggressive Non-Destructive Inspection (NDI) is integral to maintaining warfighter readiness
  - Effective NDI detects the earliest indication of defects
  - Components can be repaired or replaced before the structural integrity or performance of the aircraft is compromised
- NDI of composite aircraft presents challenges to current NDI methodologies
  - No visual indications of damage
  - Large areas must be inspected



More than 43% of the V-22 airframe is built with composite materials

Challenge: NDI of Large Scale Composite Structures

- Visual inspection
  - Only detects obvious problems that reach surface
- Coin-tap
  - Only useful for severe late-stage problems
- Ultrasonic (UT) A-scan (most widely used)
  - Point inspection, time and labor intensive for large area
  - Not sensitive to water ingress, foreign object debris
  - Does not perform 100% inspection
- Thermography
  - Area inspection
  - Tradeoff between sensitivity and area coverage

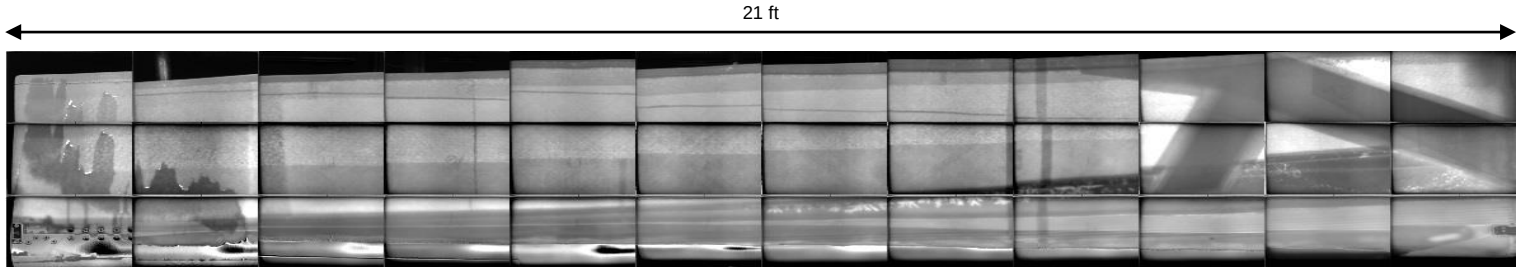
Single-point A-Scan analysis is time consuming and requires experienced operator to interpret signal trace

Currently used methods do not provide both large area coverage and adequate composite diagnostics

Flash Thermography

- Flash Thermography
  - Developed by TWI under NAVAIR SBIRs
  - Thermographic Signal Reconstruction (TSR)
    - Physics-based processing improves sensitivity
    - Winner, 2014 ASNT Research Innovation Award
  - Probability of Detection (POD) validation (2016 FAA / Sandia POD)
    - Outperforms UT A-scan baseline
    - Outperforms shearography, MAUS and other thermography
  - Unlike other NDI methods, Thermography can be applied from a distance.
    - Potential to perform a large area inspection from a single point

Flash Thermography Inspection of V-22 Proprotor at FRC-E



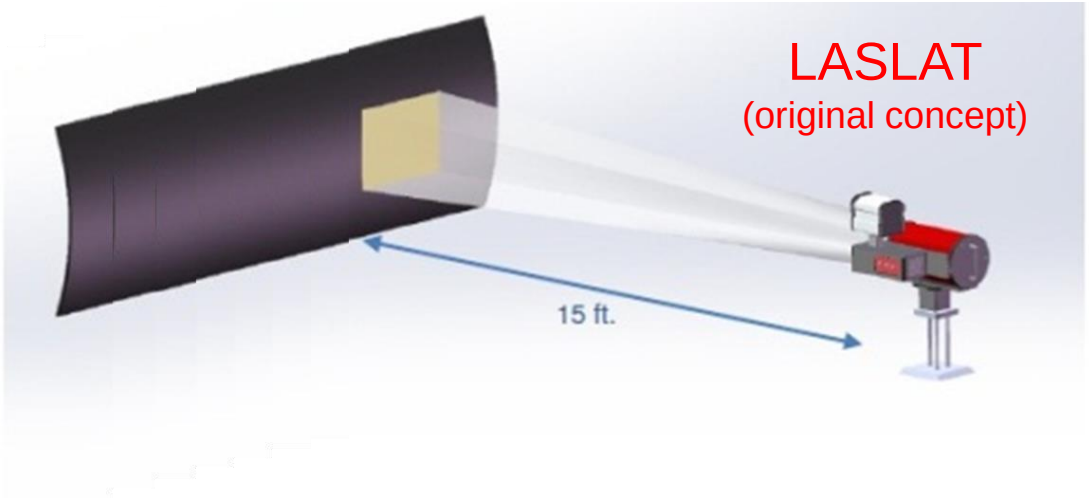
Stitched image of V-22 proprotor combines 36 shots after TSR processing using TWI MOSAIQ software

Challenge: NDI of Large Scale Composite Structures

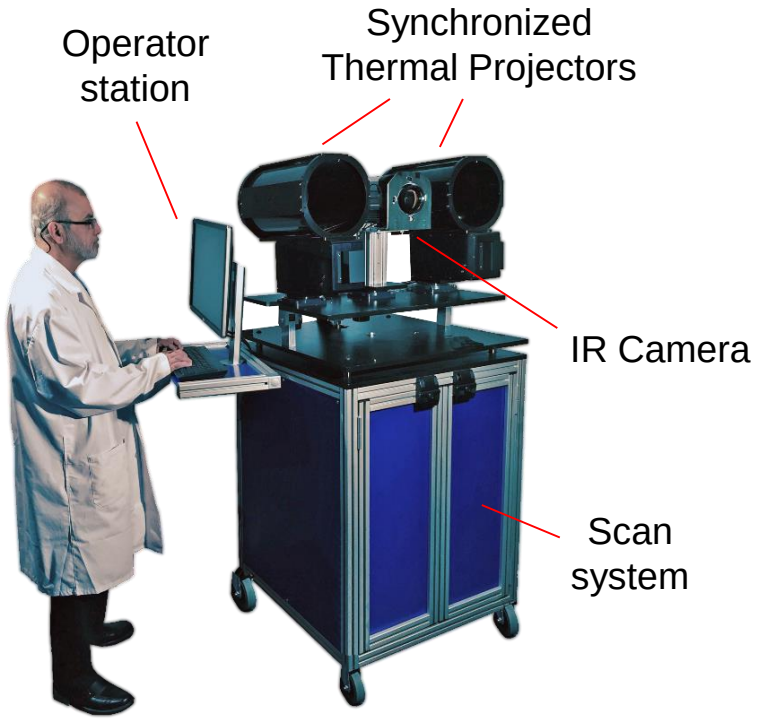
A more effective NDI solution should **address the complexities of composite aircraft inspection**, and **perform fast, 100% area inspection of large aircraft structures**.

Objectives

- Minimize inspection turnaround time
- No gantry / robot or fixed installation required
- Easily adaptable for inspection of multiple platforms
- Simplify interpretation / analysis
- Operate in open hangar



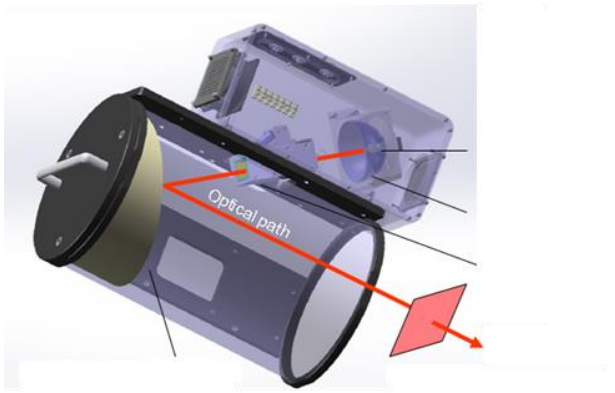
The Solution - LASLAT



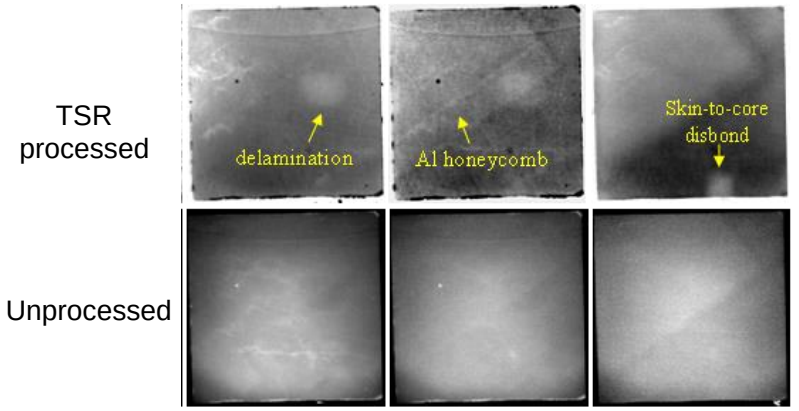
Large area inspection from a fixed position

- Automated area scan
  - Produces single image of entire area
- Advanced signal processing provides simplified interpretation / analysis
- No gantry, creeper or track
- Operate in open hanger
- Flat or curved surfaces
- Easily configured for new inspection
- Working Distance: 10 – 15 ft.
- Coverage Area: 17 ft x 15 ft @ 15 ft standoff
- Inspection Rate: 4.4 ft^2/min
- Provides significant labor reduction

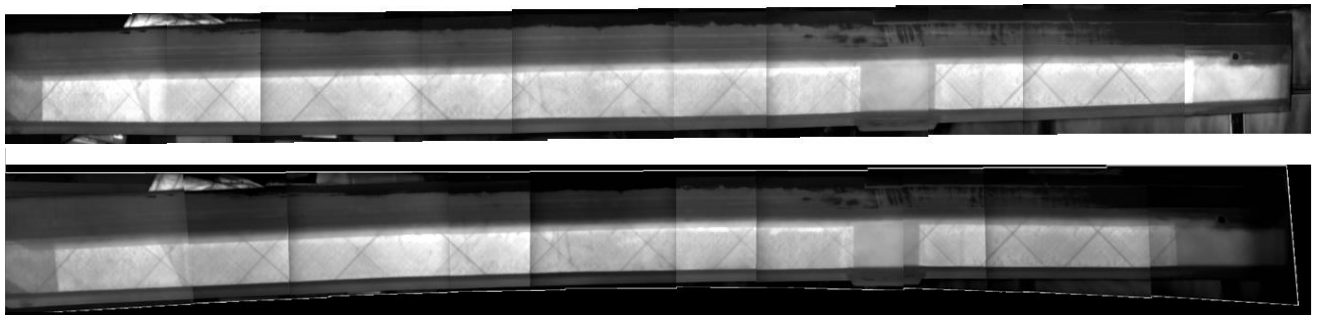
LASLAT Innovations



Novel thermal projection optical system for highest efficiency excitation



Extended TSR signal processing



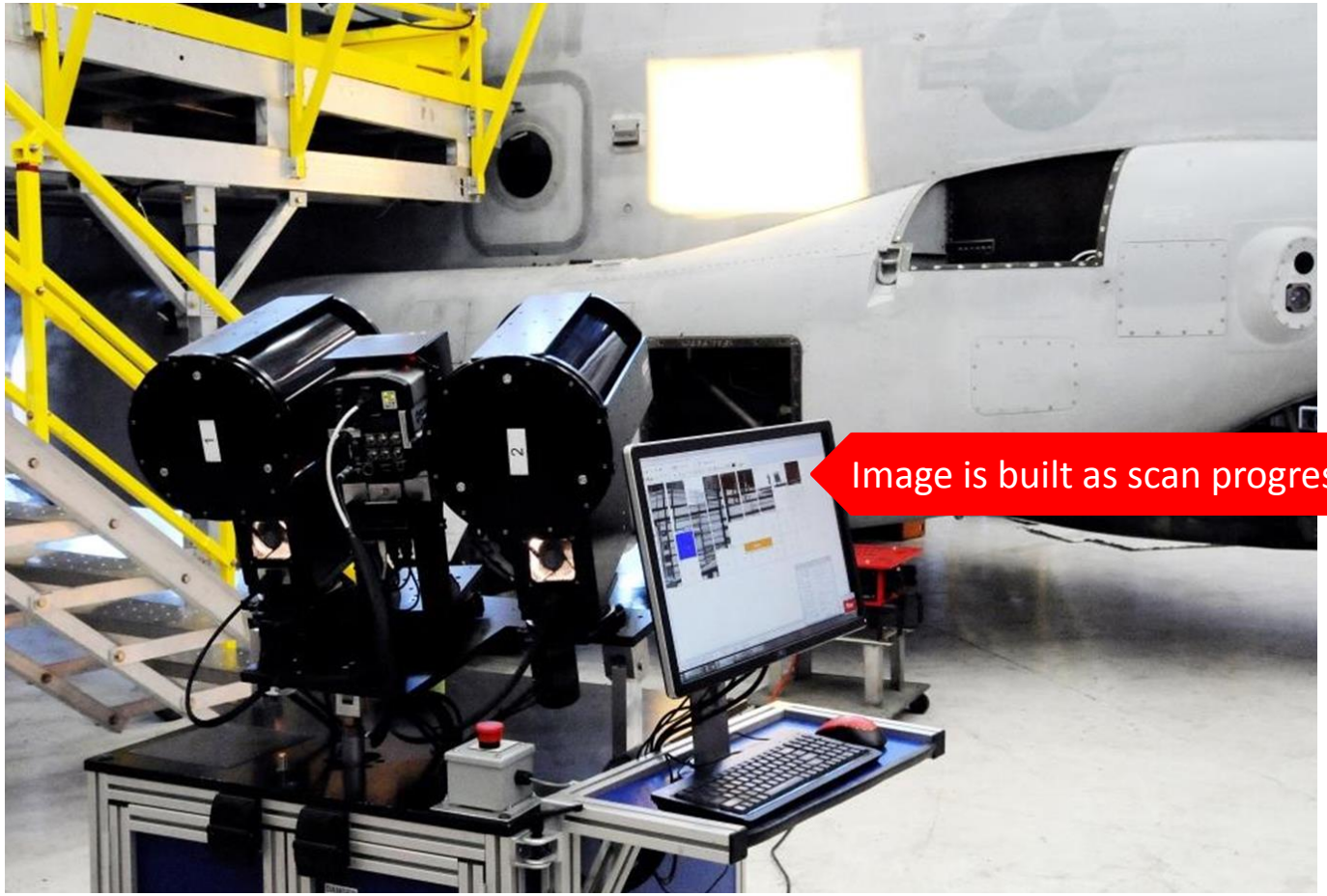
Optical correction over entire inspection field of Ch-46 main rotor allows for accurate defect sizing

V-22 Fuselage Inspection at FRC-E

Automated scan of inspection area

Thermal Wave Imaging

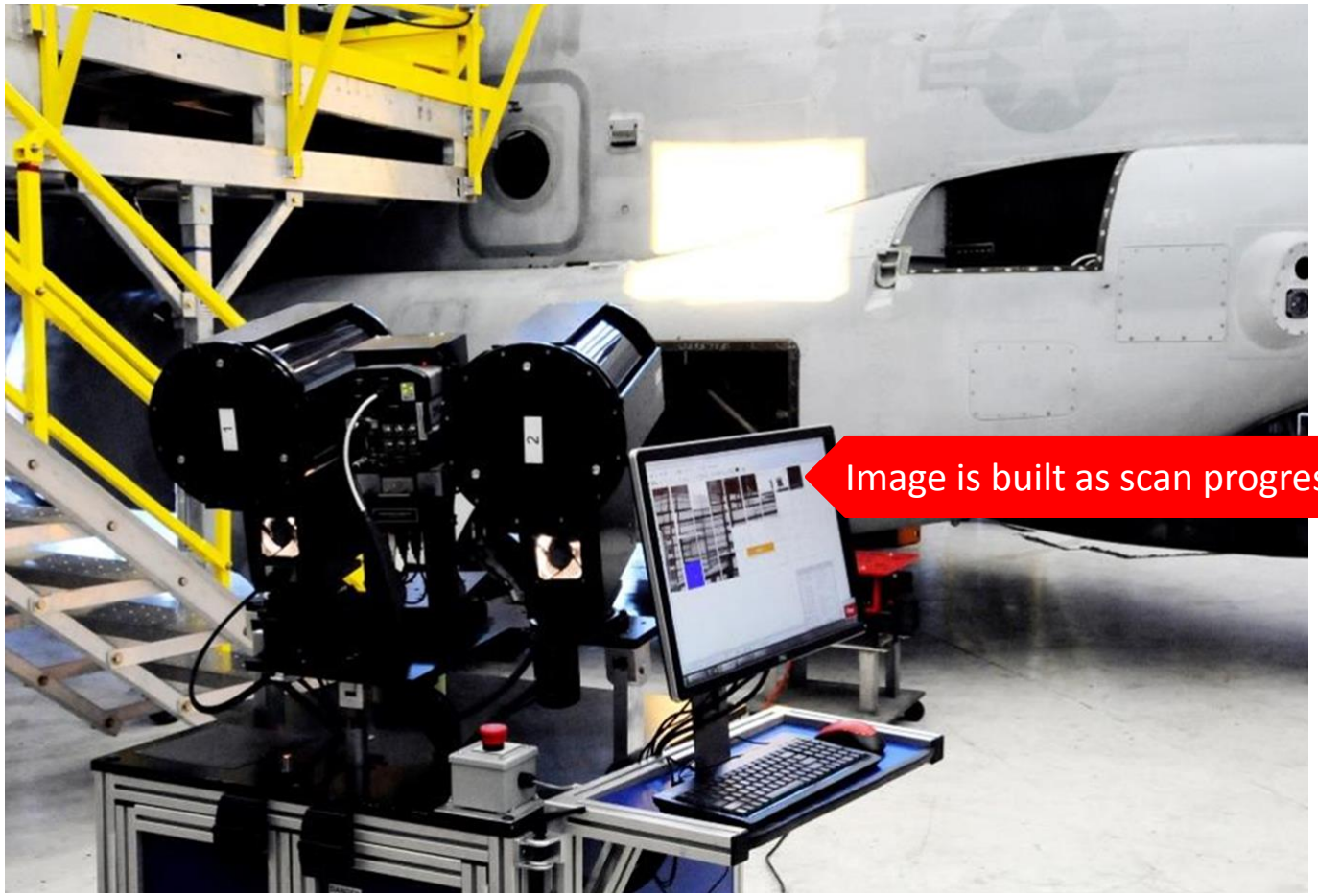
V-22 Fuselage Inspection at FRC-E



Automated scan of inspection area

Thermal Wave Imaging

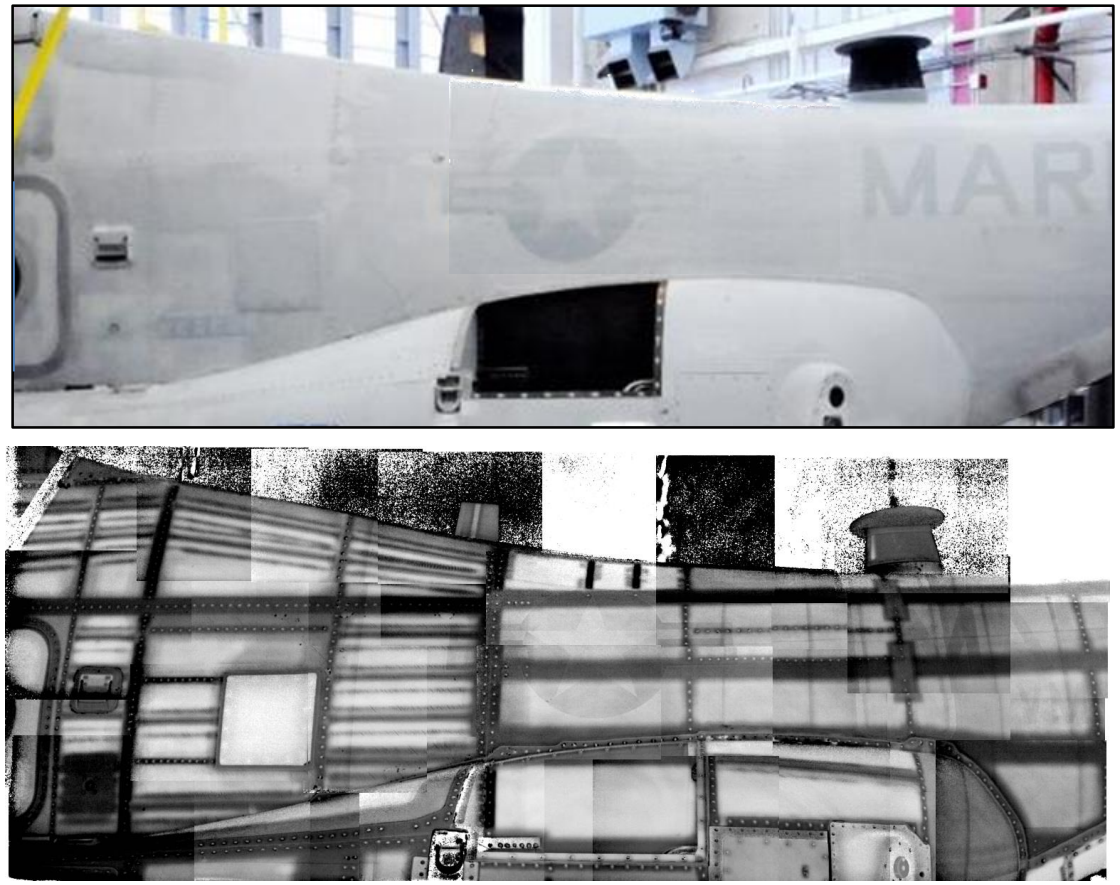
V-22 Fuselage Inspection at FRC-E



Automated scan of inspection area

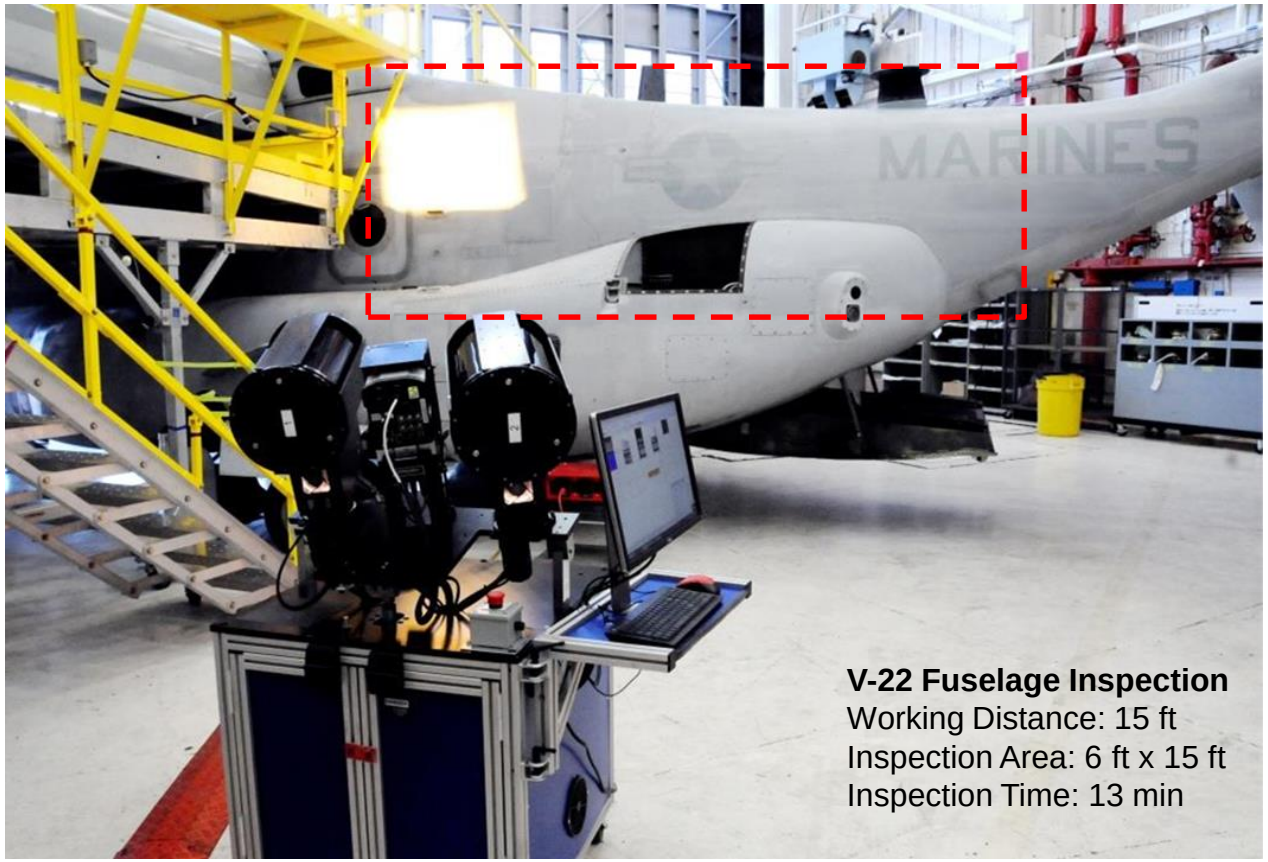
Thermal Wave Imaging

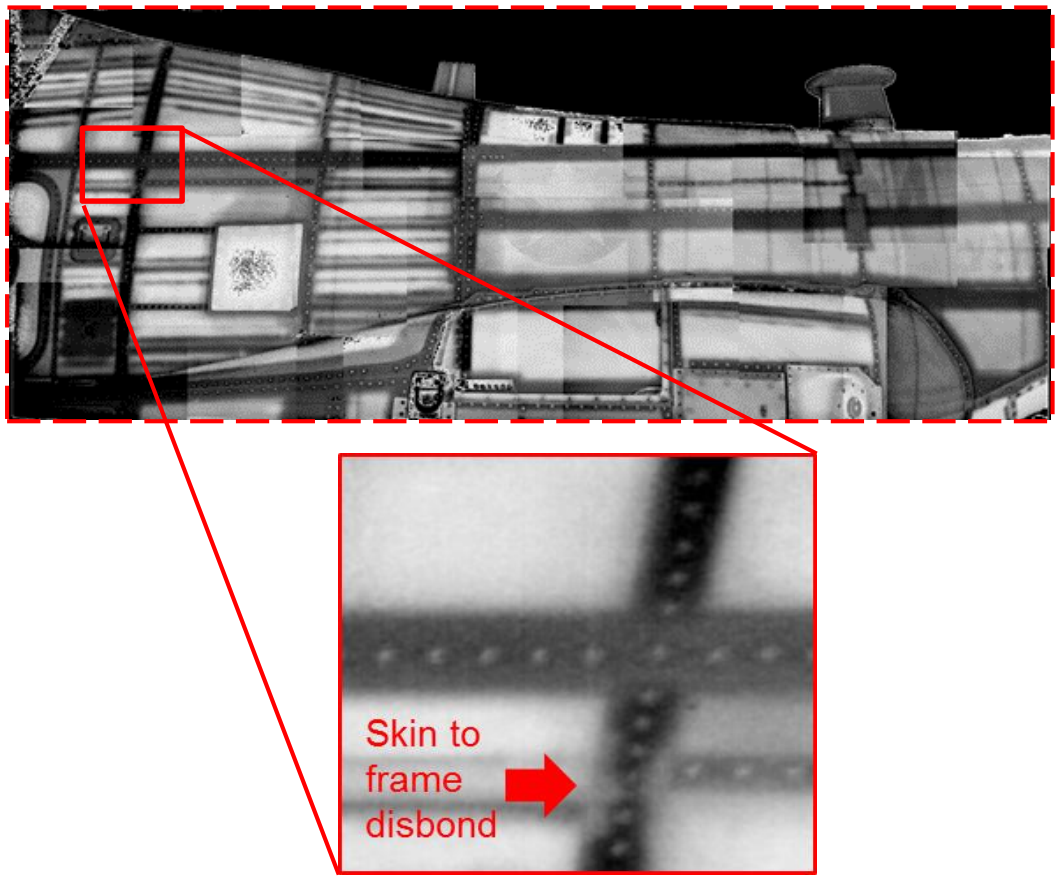
V-22 Fuselage Inspection at FRC-E



V22 Fuselage: 6’ x 15’ inspection area

V-22 Fuselage Inspection at FRC-E





Zoom view of inspection area in MOSAIQ

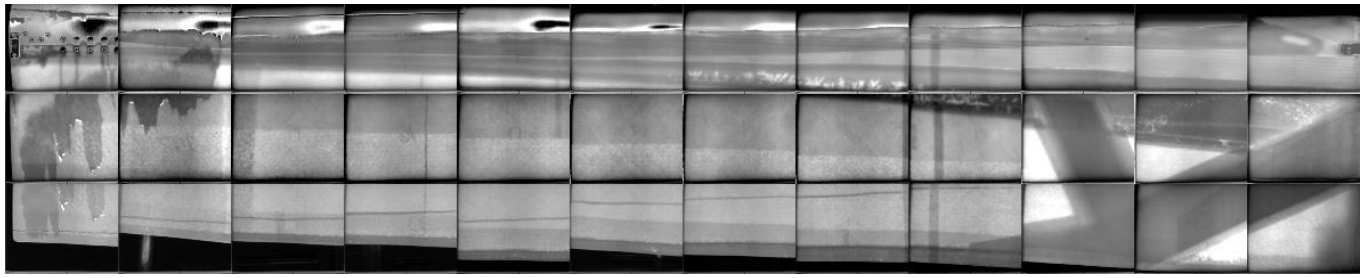
Key Features / Advantages / Benefits

Features	Advantages	Benefits
Large standoff distance	Access to large structures without fixed gantry or immersion tank installation	• Reduced cost • Adapt to multiple inspections • Safe operation near fueled aircraft
Large inspection area	No scanning apparatus required	• Reduced installation cost • Reduced inspection time
TSR signal processing	• Improved sensitivity • Single image of entire structure • Quantitative results	• Assist operator flaw detection • Simplified analysis • Track condition over lifetime

Improvement over Current NDI

V-22 Proprotor Blade Inspection at FRC-E

Current: Flash Thermography

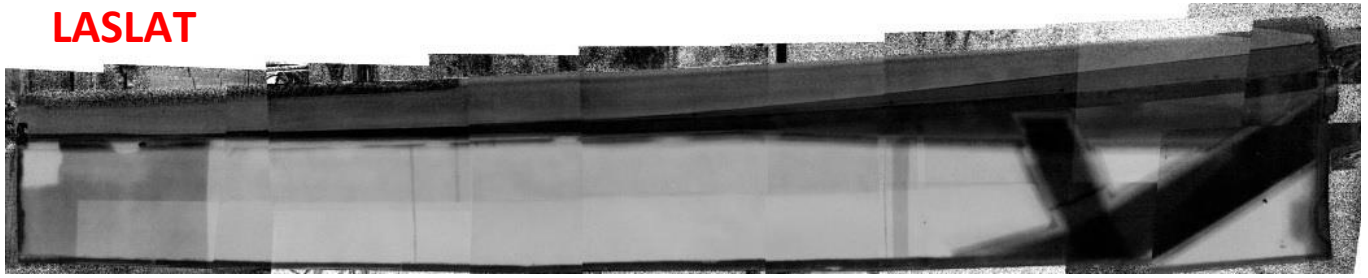


- 4 hours
- 36 shots
- Close proximity

System is manually repositioned after each shot

19 ft

LASLAT



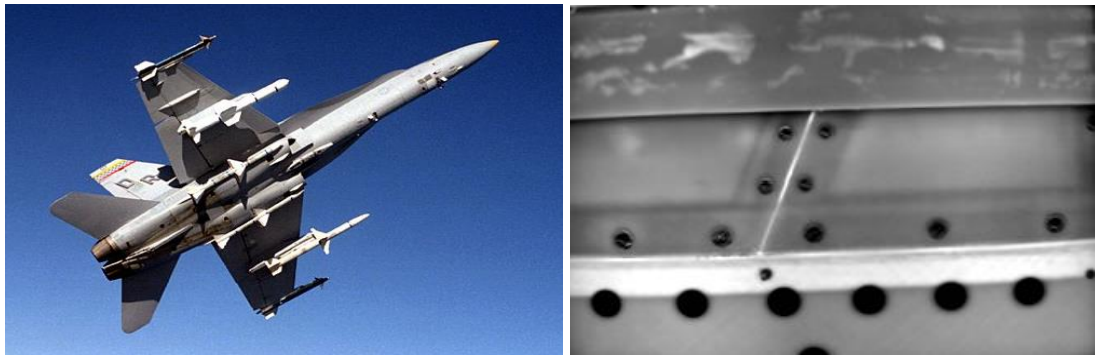
- 9 minutes
- 18 shots
- 15 ft standoff

Blade is automatically scanned by system at fixed position

Benefits

Direct Benefits

- FY17 FRC-E deployment for V-22 Blade Inspections
  - Estimated labor reduction: 7-10 hrs/blade
  - Man-Hour savings/ year: 525-750 labor-hrs
  - Cost Reduction/ year: $68K-$98K



Thermographic image of RAM coating disbonds under F/A-18 wing.

Anticipated Benefits

- H-1 main rotor blade work
  - Estimated 875-1250 labor-hour avoidance => $116K - $167K / yr cost avoidance
- Large area laminate inspections:
  - AV-8B wing: Estimated 320 labor-hour avoidance => $ 43K / yr cost avoidance
  - V-22 Mods: Estimated 80 labor-hour avoidance => $10K / yr cost avoidance
- Other potential targets include:
  - H-53K fuselage, V-22 wing, F-35 fuselage, F-18 wing/fuselage

Challenges & Risks

- Innovation Maturity:
  - Proven technology that has been validated by independent comparison and POD studies
- DoD Community Awareness / Exposure:
  - Technology use within NAVAIR since 1998 and since is used by FRCs, USAF, Army, Coast Guard and primes
- Risk: Low-risk, high reward
  - LASLAT is an extension of proven flash thermography method
- Most significant challenge: Establishing equivalence with existing inspections
  - Quantifying inspection requirements
  - Overcoming culture / inertia (from UT and tap test)
  - Training / certification (programmatic evolution)

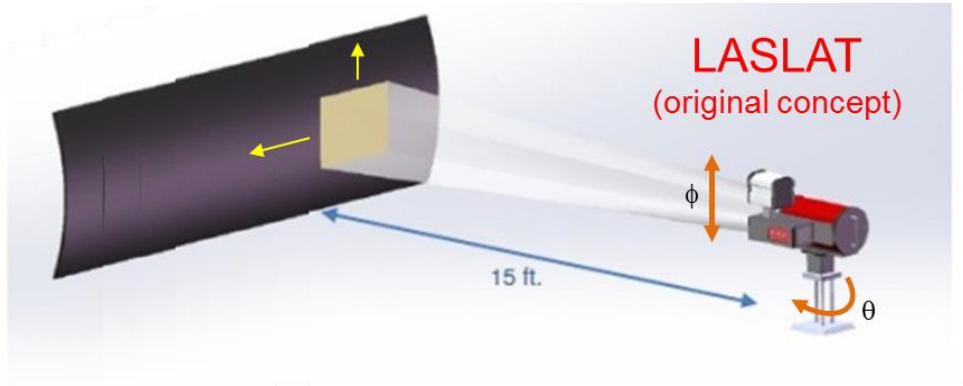
Innovation Status

- Technology Readiness Level:
  - TRL 7, successfully demonstrated on application
- Initial deployment:
  - FRC-E Capital Improvement Program (FY17), SBIR Phase III
- Alternate solutions:
  - Laser ultrasound
    - High sensitivity yet expensive, requires fixed installation
  - Linear Array ultrasound (roller probe)
    - High sensitivity yet slow, extensive equipment setup and analysis
- Applications:
  - Maintenance or manufacturing quality assurance
  - DOD
    - All fixed and rotary wing platforms
    - Older platforms with composite upgrades
  - Civilian Sector
    - Commercial aircraft operators
    - Wind turbine industry
    - Composite manufacturers of large structures
    - Detection of Foreign Object Debris (FOD)
    - Energy / infrastructure inspection

Looking Ahead

UT point scan

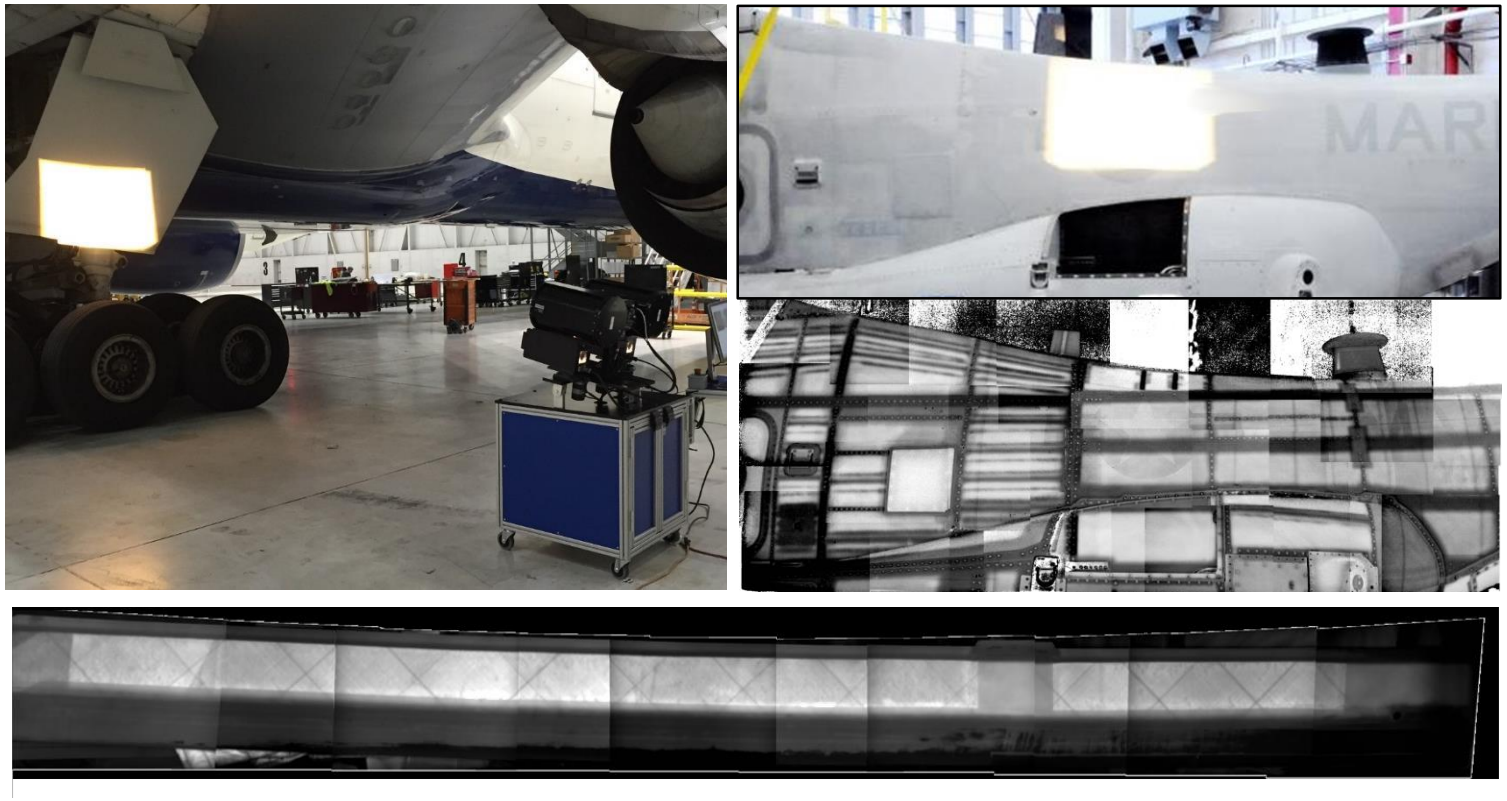
flash thermography



- LASLAT bridges gap between advanced technology used in manufacturing QA and the realities of the maintenance hangar
  - Same high standards for both, but flexibility and TAT needed for maintenance
- Phase II.5 – Expansion work (2017-2019)
  - General Use Process Controls
  - Accelerate Acquisition/Data Processing
  - Investigate Real-Time Capability
  - Investigate Thru-Transmission Capability

Expect significant reduction in inspection time.

Questions



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Comparison to Alternatives

Method	Advantages	Issues
Coin tap	Low cost	Large, near surface features only
Ultrasound	Excellent penetration Well-established	Point inspection or scanning required
Radiography	Area inspection Excellent crack detection	Insensitive to many voids or delaminations
Conventional Thermography	Noncontact area inspection Provides information about flaw	Operates in close proximity to aircraft Limited depth range Not for use near fueled aircraft
Shearography	Noncontact area inspection	Limited depth range Issues at edges and corners
LASLAT	Noncontact large area inspection Automated scanning No gantry or contact with aircraft OK for use near fueled aircraft	Requires development of training, standards and procedures