



# NOVEL RESONANCE INSPECTION OF COMMERCIAL AIRCRAFT WHEELS

Collins Aerospace | Landing Systems | Wheels and Brakes Brian Skinner | Principal Customer Support Engineer

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### NOVEL RESONANCE INSPECTION OF COMMERCIAL AIRCRAFT WHEELS

### Agenda

- Introduction
- Organizational history with PCRT
- SBIR Phase I/II accomplishments
- PCRT application development for W&B MRO
- PCRT implementation strategy & progress
- Future outlook with PCRT
- Team recognition







### THE LONG PATH OF NEW TECHNOLOGY

### **Organizational History with PCRT**



### SBIR PHASE I/II DELTA & VIBRANT

### **Delta TechOps Contributions to SBIR Phase I/II**

- Delta enabled access to wheels and bolts for fixture development and PCRT testing during SBIR Phase I
  - Collection of hundreds of wheels & bolts, with and without defects, for inspection development and validation
  - Supported MAPOD for PCRT sort development
  - Crack Detection on par with Magnetic Particle, Eddy Current, and Fluorescent Penetrant testing
  - Demonstrated additional benefits for wheels including sensitivity to geometrical and material property defects in wheels
  - Demonstrated additional benefits for bolts including sensitivity to bolt stretch, hardness variation, and defects in the bolt head





#### Groundwork was laid for more detailed studies in an MRO environment



### SBIR PHASE I/II DELTA & VIBRANT

### **Delta TechOps Contributions to SBIR Phase I/II**

- Delta supported PCRT data collection on over 400 in-service 737 and 767 wheel halves at Delta TechOps
  - Critical to understanding PCRT defect sensitivity, and field testing of portable PCRT fixture in an MRO environment
- Delta shipped all rejected wheel halves to Vibrant
  - NDT findings re-evaluated through exhaustive use of other destructive and non-destructive inspection methods
  - Identified false rejects of Eddy Current bolt hole inspections
  - Further characterization of cracks, overheat, damage, and aging
- Statistically relevant sample of data collected on 737 and 767
  - Outlier screening and VIPR targeted defect sorts created

## TechOps



A statistically relevant sample of acceptable and unacceptable conditions were tested and validated

### SBIR PHASE II VIBRANT & COLLINS

### **Collins Contributions to SBIR Phase II**

- Prototype wheel PCRT system installed in Collins Louisville Wheel & Brake MRO Service Center in 2019
  - Incorporated barcode reader
  - Direct connection to shops conveyor system
  - Lid added for ambient noise reduction and operator safety
- 737 wheel halves inspected with PCRT in Louisville
  - Validation of PCRT sorts developed at Delta TechOps
  - Validation of PCRT's insensitivity to the environment of a large scale Wheel and Brake MRO shop





#### Production grade PCRT system demonstrated high throughput in an MRO environment



### SBIR PHASE I/II SUMMARY

### **Overall SBIR Project Accomplishments**

- Successful detection of relevant bolt damage using PCRT
  - Detection of bolt cracks and defective in-service bolts
  - Successful PCRT inspection without part cleaning
  - Inspection time reduction of 90% by using PCRT
- Successful creation of PCRT inspection from modeled bolt populations
  - Verification of crack modeling techniques using physically cracked bolts
  - Demonstration of virtual Sorting Modules sensitive to cracks
  - Validation of Sorting Module using MAPOD
  - MAPOD demonstrating comparable detectability to legacy MT/PT methods
- Successful detection of relevant wheel damage using PCRT
  - Detection of cracks, gouges, and overtemperature exposure
  - Validation of Sorting Module on parts not in training populations
  - Reduction of false rejects from legacy NDT inspection methods

PCRT proven to be an effective and viable option for Wheel and Brake NDT in an MRO environment

# TechOps **Jibran** Collins Aerospace





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### APPLICATION DEVELOPMENT FOR W&B MRO

#### From Proof of Concept to Automated Agile Cell



Proof of Concept T-Bar nest used during SBIR project at Delta TechOps

#### No changes needed to the core PCRT technology, but a lot of system development for this application



### APPLICATION DEVELOPMENT FOR W&B MRO

#### From Proof of Concept to Automated Agile Cell



Prototype PCRT wheel machine used during SBIR project at Louisville Service Center

#### No changes needed to the core PCRT technology, but a lot of system development for this application



### APPLICATION DEVELOPMENT FOR W&B MRO

### From Proof of Concept to Automated Agile Cell

Pilot PCRT Cell installed in Louisville Service Center in 2021



#### No changes needed to the core PCRT technology, but a lot of system development for this application







# TechOps



# Semiautomated Aircraft Wheel Inspection System

### COLLINS MRO GOALS AND PCRT BENEFITS

Goals	Current State with LPI	Future/Current State with PCRT
	Image: wide wide wide wide wide wide wide wide	
Improved Efficiency	Media blasting, inspecting, repainting 100% of wheels for the 2-3% with findings	Paint removal and replacement goes from required to condition based
More Sustainable	Media blasting, penetrant, & painting generates significant amounts of waste material	No chemicals or waste produced
Better EH&S	A lot of part handling during media blasting with potential for minor injuries	Minimized part handling
Higher Quality	Subjective interpretation of LPI results	Objective results with quantified records and no operator interpretation

A big challenge, but even bigger rewards

### PCRT IMPLEMENTATION AT COLLINS MRO

### A Risk Mitigation Approach to PCRT Implementation and Refinement

#### **Defect history review**

- Review defect history for each component
- Highlight most typical/critical defects that must be accounted for
- Which NDT method is detecting these today?
- Is that the most sustainable and robust way?

#### PCRT Sort development

- Train the system on 100+ parts
- Correlate resonance spectra to legacy NDT results for all training parts to develop <u>Outlier Screening Sorts</u>
- Validate sort against parts with known defects to develop <u>Targeted Defect Sorts</u> as needed



- Perform all legacy NDT on all PCRT outliers
- Review all PCRT passes and failures
- Vibrant and MRO Responsible Level III recommend Technique Sheet modifications
- Engineering / MRO review of proposed changes

#### **PCRT Technique Sheet creation and release**

- Release PCRT Technique Sheets with artificially conservative boundaries & supplemental inspections
- Release supporting aftermarket service documents
- Full spectra stored by S/N for every PCRT inspection to support future <u>Part to Itself Sorts</u>

A conservative, step-wise approach to PCRT implementation



### PCRT IMPLEMENTATION AT COLLINS MRO

### What we have learned so far

- PCRT Outlier Screening is flagging the big things
  - The big defects typically found with LPI (cracks, gouges, moderate corrosion)
  - Other defects that LPI can't find (Overheat, out of round, loose bearing cups)
- Targeted defect and supplemental inspections needed to detect smaller defects
  - Implemented improved cleaning processes to facilitate better visual inspection
  - Investigating waxes, coatings, and sustainable dry washes to further improve cleaning
- PCRT has helped to broaden our perspective
  - Renewed focus on finding a more sustainable way to perform W&B MRO

Great progress so far, but more work to do





**Collins** Aerospace

### WHERE WE ARE AND WHERE WE ARE GOING

### What we have done so far

- Extensive Engineering Justification
- W&B NDT Manual Updated to include PCRT
- Introduced customers to PCRT via Service Letter
- Training / Development / Release by P/N
- · Lean events in all Service centers
  - Shop floor layout and process flow
- Production PCRT systems operational
  - Louisville, Fort Worth, LA, London
  - Hong Kong scheduled for Q4-2022
- Sorts implemented for top 5 wheel assembly PNs
  - Over 50% of shop volume being tested with PCRT

#### Where we are going next

- Roll out PCRT on remaining wheel halves
  - 20+ additional wheel halves in immediate plan
- Future targets for PCRT in MRO
  - Torque Bars / Drive Inserts
  - Bearing cones
  - Bolts
  - Torque Tubes / Torque Plates
  - Piston Housings
- PCRT for new production
  - Creation of Birth Certificates for immediate PTI sorts in MRO





#### Customers may contact Vibrant Corporation to inquire about getting PCRT for their shops

### SUMMARY

#### A lot of things have happened at once to produce success



#### **AFRL Materials Directorate** Siamack Mazdiyazni (Retired) Dr. Eric Lindgren Collins Andy Birch, Director of Operations Scott Whittle, Chief Structures Engineer Brian Spencer, MRO Responsible Level III Brian Skinner, Principal Customer Support Engineer Steve Campbell, Operations Value Stream Engineering Manager **Delta TechOps** David Piotrowski, Senior Principle Engineer Joe Benjamin, Principle Engineer Wheel & Brake Roland Johnson, Wheel Shop Lead Technician Vibrant Corp. Leanne Jauriqui, VP of Technology

Julieanne Heffernan, Application Engineer Mark Ortega, Manufacturing Engineering Manager Robert Parker, Application Engineer **Pratt & Whitney Canada** David Craig, Senior Fellow & Manager NDT











Teamwork makes the dream work!