



LESSONS LEARNED
“AN AIRLINES EXPERIENCE”

Lee Clements Manager QC-Engine Inspection

 Delta
TechOps

OVERVIEW

- Where our journey began
- Previous system
- Upgrade to a high capacity FPI Line for Engine Components
- Facilities/ equipment/ tooling

OVERVIEW

- Information improvements
- Process Control improvements
- Training Program Changes
- *More Lessons Learned !*
- Closing Thoughts

LESSON'S LEARNED!

Murphy's Law

“If anything can go wrong, it will”



HISTORY LESSON

- 1988 – B737, Aloha Airlines, near Maui Hawaii
- 1989- DC10, United Airlines, Sioux City, Iowa
- 1996- MD88, Delta Airlines, Pensacola, Florida

Flawed Processes & Human Factors

OUR JOURNEY BEGAN

- July 1996 – MD88 on takeoff roll
- First stage fan hub failure
- Investigation followed (NTSB & FAA)
- Crack missed during a “Fluorescent Penetrant Inspection” (FPI) during a routine engine heavy maintenance visit (overhaul)
- Crack initiated in the tie rod bolt hole from a flawed machining technique developed to improve productivity

Flawed Processes & Human Factors

PREVIOUS SYSTEM

- One size fits all
- Excessive Part handling
- High maintenance cost



PREVIOUS SYSTEM

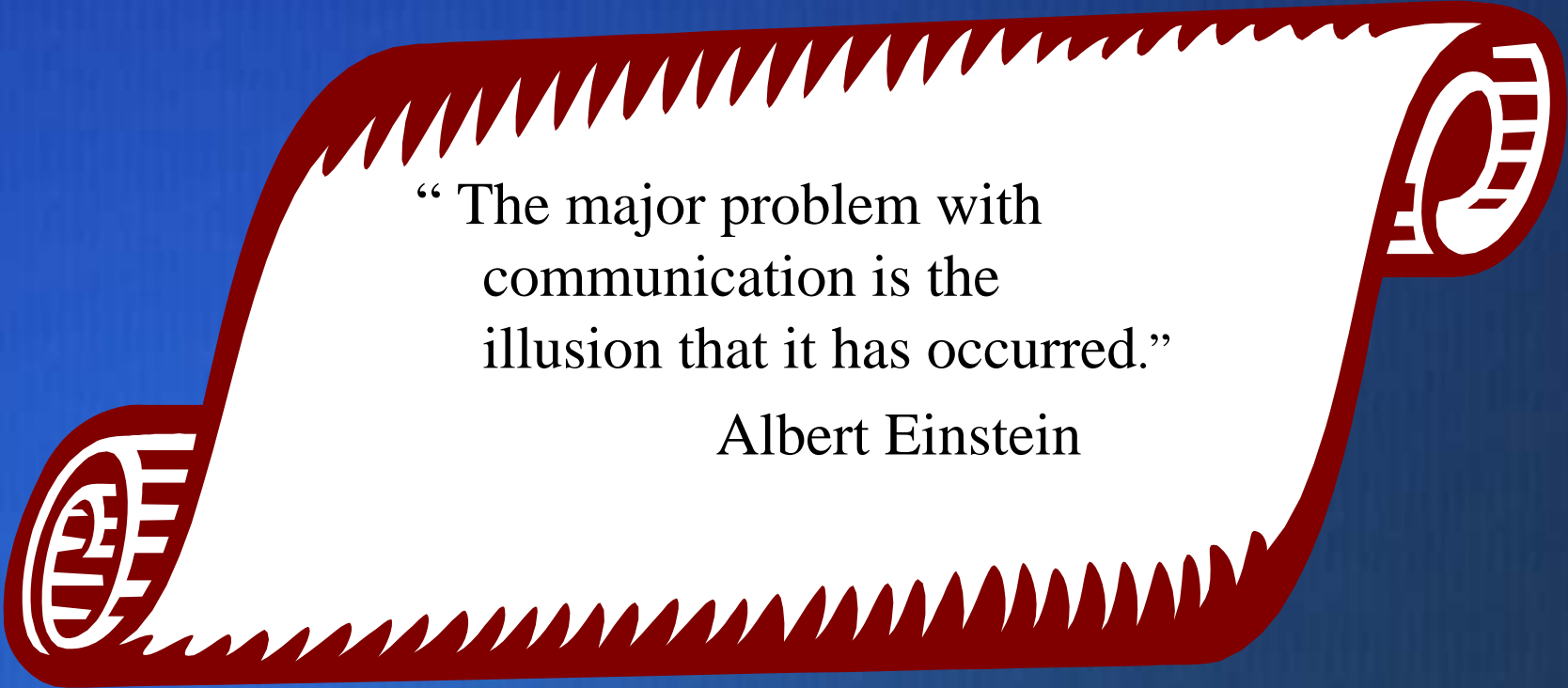
Single bay - large parts hanging system

- Part processing limitations
- Parts processed together
- Processing difficulties



LESSON'S LEARNED!

Communication



“ The major problem with communication is the illusion that it has occurred.”

Albert Einstein

Communication is key

Management must:

- Understand NDT's role with regard to safety
- Have a clear understanding of NDT's capabilities, limitations, and objectives
- Take input from frontline employees
 - Communication must be 360°



Communication and teamwork required

UPGRADE REQUIREMENTS

- Increase capacity
- Segregate of FPI process lines by part size
- Facility maintenance access
- Ergonomics and Human factors considered

Winning together!

NEW LARGE PARTS SYSTEM



NEW MEDIUM PARTS SYSTEM



NEW SMALL PARTS SYSTEM



INSPECTION BOOTHS



Ergonomic Improvements

IMPROVED WORK ENVIRONMENT

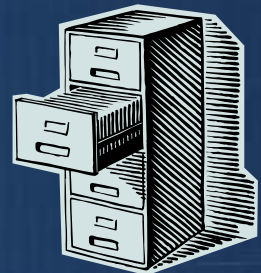


Maintenance Access



Organized & Clean

Ergonomic Improvements



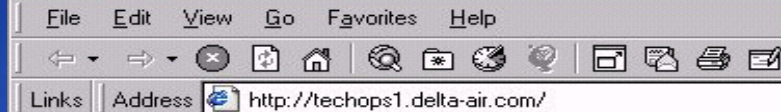
CRITICAL ROTATING DRYING SYSTEM



ELECTRONIC INFORMATION AGE



Tech Ops Home Page - Microsoft Internet Explorer provided by Delta Air Lines/Delta Technology



■ What's New ■ Search ■ Suggestions ■ Directory ■ [Revision Notification](#) [Log In](#) [Instructions](#)

Tech Ops Home

- News
- Information Technology
- Manuals
- Safety
- Human Resources
- Station Info
- Department Info
- Aircraft/Engine Info
- Part & Configuration
- Training
- Intranet/Internet
- Tech Ops Web Sites
- Aviation Links

Revision Notification inbox



About Tech Ops:

- ATL TOC
- Executive Team
- Personnel
- Line Stations
- Employee Involvement

Tech Ops News

- Latest News from the Tech Ops Bulletin Board
- Technical Communications / Schedules

Quick Links

- OCC / MCC
- Employee Council
- Quality
- High Performance Workplace
- DECU
- Strengthening The Partnership
- TravelNet
- Minimum Equipment Lists
- Stock Ticker
- FAA/NTSB / AD Compliance

Site Owner: [Technical Operations](#) Last Update: 02/09/00 ©1999
Delta Air Lines, Inc/Delta Technology, Inc. All rights reserved
Best when viewed with Microsoft Internet Explorer 4.0

The Technical Operations Division of Delta Air Lines is responsible for all maintenance and engineering activities of the airline. To keep up with Delta's fleet of more than **580 aircraft**, Tech Ops operates on a 24-hour basis in Atlanta and many areas throughout the world. A team of **10,000+ professionals** with a wide-range of specialties, talents and skills makes Delta's fleet one of the most reliable, most modern and cleanest in the transportation industry.



Featured Sites

- New Uniform Information
- Wired Workforce
- National Safety Inspection 2000 Maintenance Transfer Bid System is now under Human Resources.

QUALITY HOMEPAGE



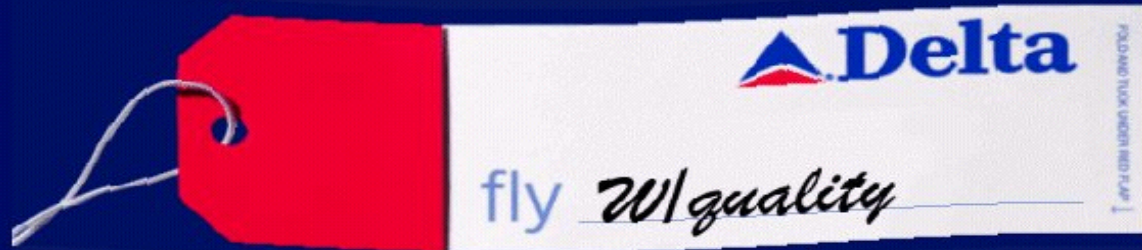
- [Directory](#)
- [Search](#)
- [Suggestions](#)
- [DECU](#)
- [TravelNet](#)
- [Stock Ticker](#)

[Tech Ops](#)

Quality

- [Contest](#)
- [FAA/NTSB](#)
- [Quals. & Training](#)
- [Quality Initiatives](#)
- [Repair Station](#)
- [NDT](#)
- [Inspection](#)
- [Inspector's Lounge](#)
- [Quality Assurance](#)
- [PMET Programs](#)
- [Quality Systems](#)
- [Hot Items](#)
- [Technical Records](#)
- [Meet Us](#)
- [Links](#)

Quality



Links

- [Contest](#)
- [Quality Celebrates](#)
- [Revision Notification](#)
- [Tech Ops Bulletin Board](#)
- [Fidelity 401K](#)
- [Wired Workforce](#)
- [Other Interests](#)
- [Chairman's Club](#)
- [ATOS](#)

TECHNIQUES SHEET INDEX PAGE



Tech Sheets

- Contest
- FAA/NTSB
- Techops
- Atlanta Wheel Book
- Process Standard
- Technique Sheets
- PEARL Records
- NDT-1
- NDT Research Req.
- Other Links



NDT Technique Sheets Index and Search Page

Search for your NDT Technique Sheet by Manufacturer Part Number or Technique Sheet Number:

Search for:

(MT) - **Magnetic Particle Testing**

- [MFG #](#)
- [Technique #](#)

(PT) - **Liquid Penetrant Testing**

- [MFG #](#)
- [Technique #](#)

(RT) - **Radiography (ATL)**

- [MFG #](#)
- [Technique #](#)

FPI TECHNIQUE SHEET PAGE



Tech Sheets

- Contest
- FAA/NTSB
- Techops
- Atlanta Wheel Book
- Process Standard
- Technique Sheets
- PEARL Records
- NDT-1
- NDT Research Req.
- Other Links

Fluorescent Penetrant

Technique Number

1. [PT101-72](#) - LPC Fan Hub (JT8D-219)
2. [PT102-72](#) - Disk-1.5 Stage Compressor (JT8D-219)
3. [PT103-72A](#) - Disk-6th. Stage Compressor (JT8D-219)
4. [PT103-72B](#) - Disk-6th. Stage Compressor (JT8D-219)
5. [PT105-72](#) - Disk-2nd. Stage Turbine (JT8D-219)
6. [PT106-72](#) - Disk-2nd. Stage Turbine (JT8D)
7. [PT108-72](#) - Disk-3rd. Stage Turbine (JT8D-219)
8. [PT109-72](#) - Seal-Air Turbine 4th. Stage (JT8D-219)
9. [PT110-72](#) - Disk-4th. Stage Turbine (JT8D)
10. [PT112-72](#) - Hub-Front Comp. Front 1st. Stage (JT8D)
11. [PT113-72](#) - Disk-2nd. Stage Compressor (JT8D)
12. [PT114-72A](#) - Disk-LPC 3rd. Stage (JT8D-15A)
13. [PT114-72B](#) - Disk-LPC 3rd. Stage (JT8D-15A)
14. [PT115-72A](#) - Seal (Air) 2nd. Stage Compressor (JT8D)
15. [PT115-72B](#) - Spacer-3rd. to 4th. Stage Compressor (JT8D)
16. [PT115-72C](#) - Spacer-4th. to 5th. Stage Compressor (JT8D)
17. [PT115-72D](#) - Spacer-5th. to 6th. Stage Compressor (JT8D)
18. [PT116-72](#) - Disk-L.P.C. Stage 1 (RB211-524B)
19. [PT117-72A](#) - Typical LPC 5th. or 6th. Stage Disk (JT8D)
20. [PT117-72B](#) - Typical LPC 5th. or 6th. Stage Disk (JT8D)
21. [PT118-72](#) - Hub-5th. Stage Rear Turbine (PW4000)
22. [PT119-72](#) - Ring-Nose Cowl Attach (MD88)
23. [PT122-72A](#) - Disk-13th. Stage Compressor (JT8D-15)
24. [PT122-72B](#) - Disk-13th. Stage Compressor (JT8D-15)
25. [PT124-72A](#) - Disk-Turbine 1st. Stage (JT8D-15A, -219)
26. [PT124-72B](#) - Disk-Turbine 1st. Stage (JT8D-15A, -219)

ELECTRONIC INFORMATION TECHNIQUE SHEET



Seal, No. 5 Bearing Aft. Air/Oil (CF6-80A) 5/26/98 Revised 4/12/00

MFG# **9392M67P03**

Technique# **PT221-72**

NOTE: MFG # on Technique Sheet & Shop Order **MUST** match.

REFERENCE - DAL P.S. 900-6-3 No. 02

Ref. M/M 72-32-02

NOTE: Multiple Circumferential cracks found previously on seal at base of outer seal serrations.

ACCEPT/REJECT CRITERIA: NO CRACKS ALLOWED

Equipment - **System 1 or 3 in Dept. 542A**

Inspection Method - **D - Post-Emulsified**

Penetrant Sensitivity - **Class 2 - Ultrahigh Sensitivity**

NOTE:

- 1 - Mark reference point to insure complete inspection.
- 2 - Use inspection mirror or boroscope to inspect hard to see areas.
- 3 - Insure that inspection area is clean and free of excessive penetrant.
- 4 - Use sling and hoist in the Insp. booth to support inspection as necessary.
- 5 - During Inspection, "Look Before you Touch".
- 6 - Inspect entire part for defects. Pay particular attention to areas noted.

Report any problem/change to the FPI analyst concerning this Technique Sheet.

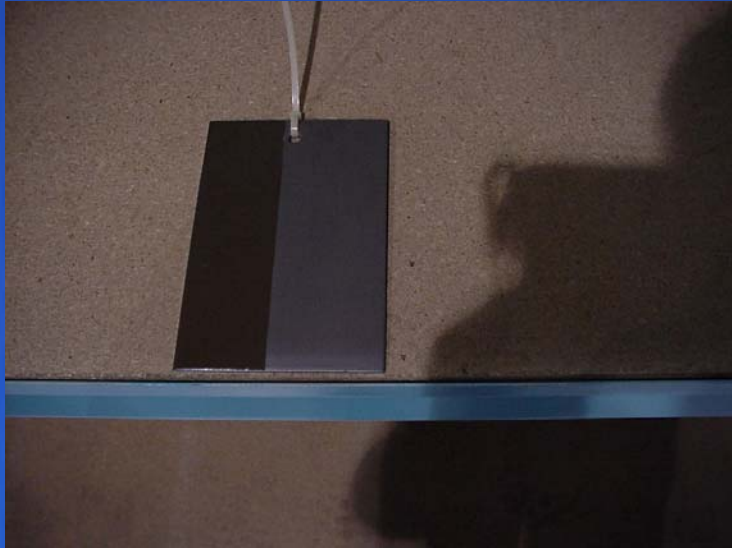


PT221-72C

KEY BENIFITS!

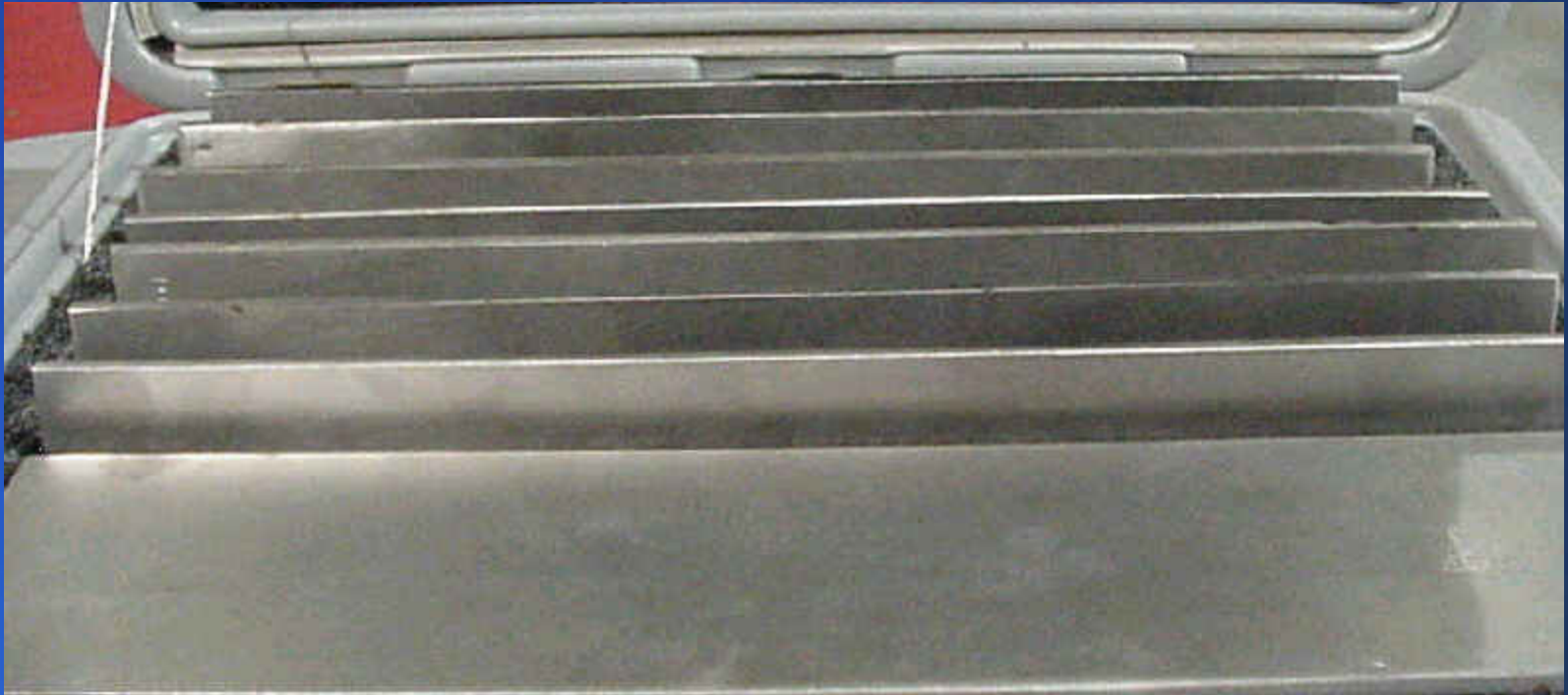
- We have placed part specific information at the inspector's fingertips
- All necessary information to perform the inspection is located on one page
- Can hyperlink to real-time source data
- Information can be easily updated

PROCESS CONTROL!



Standard Tools

NEW PROCESS CONTROL AIDS



Inconel POD Panels

NDT Training Program

- Level III's worked with management and frontline
- Take input from frontline supervisors and others
- Looked at training guidance (ATA 105, NAS 410, SNT-TC-1A, etc)
 - Some Manuals require Level II to perform or sign-off
 - Experienced Level I may be better than Level II who performs infrequent inspections
- Looked at ways to reduce training cost without reducing the quality of the program

Internal QC training program scrutinized

NDT Training Program

Changes made at Delta:

- For a new NDT inspectors, the Level III will perform a qualification assessment
- Changed recurrent requirements from annually to three year
- Perform annual random assessments
 - Vs annual training class in ATL
 - Practical vs written tests
- Perform performance assessments when requested by Foremen
- Use the “Special” certification when appropriate



Changes made for the better!

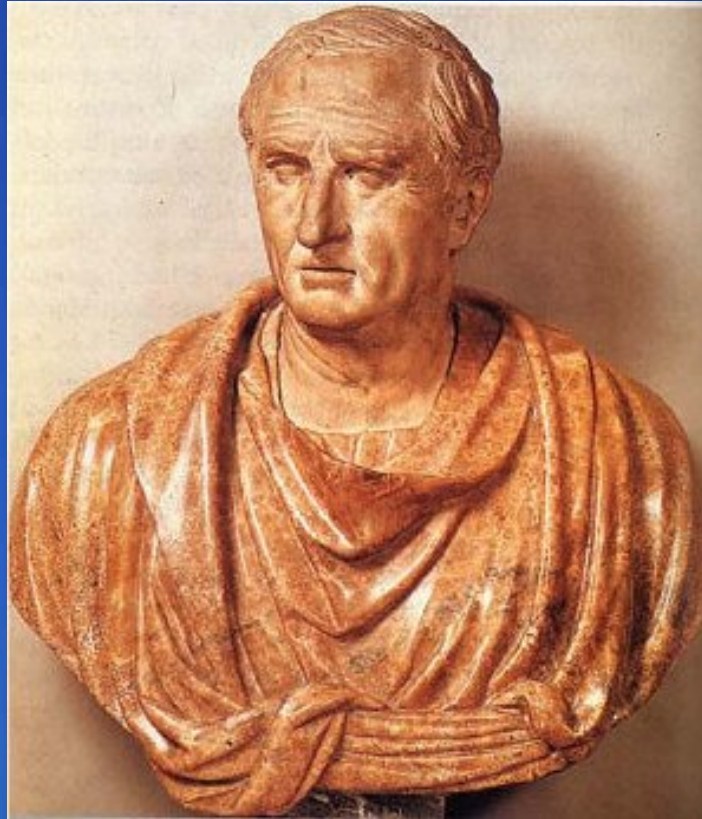
What was the impact?

- Reduction in training related cost without affecting quality of our NDT program
- NDT Program improvements, allow us to monitor our NDT inspector performance and capabilities
- Improves our ability to find and correct “ inspection creep ”
- Greater confidence in our program and inspectors capabilities and performance

It's a win-win for all

“MORE” LESSON’S LEARNED!

“To Err is Human...”

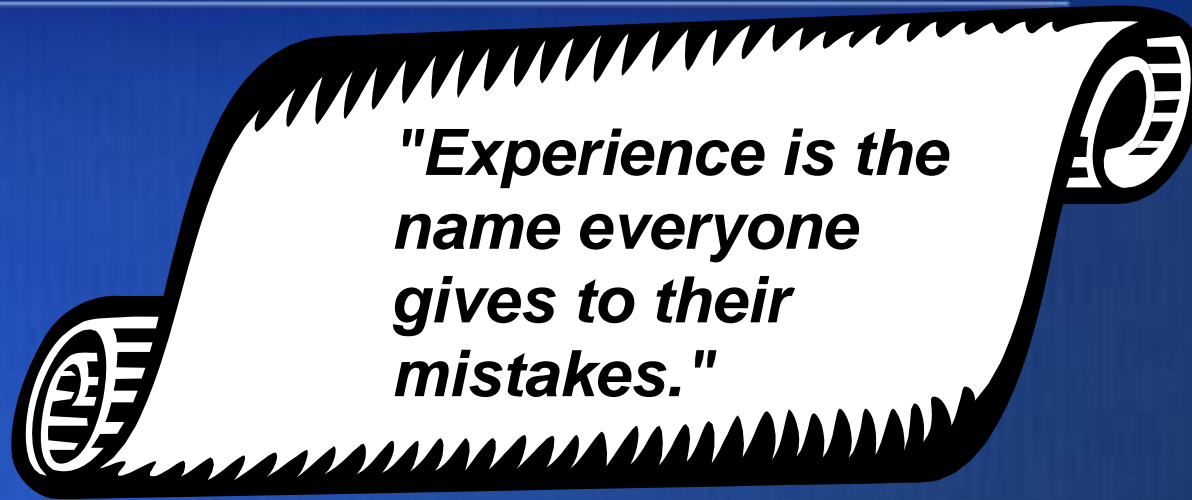


Cicero (c. 106-43 B.C.)

“MORE” LESSON’S LEARNED!

- Change for the sake of change may not be a good thing
- But looking at what we do and asking why, can be a good thing
- Examine program and find process improvement opportunities
- Look to new technologies that can improve POD’s and/or increase productivity

***“MORE”* LESSON’S LEARNED!**



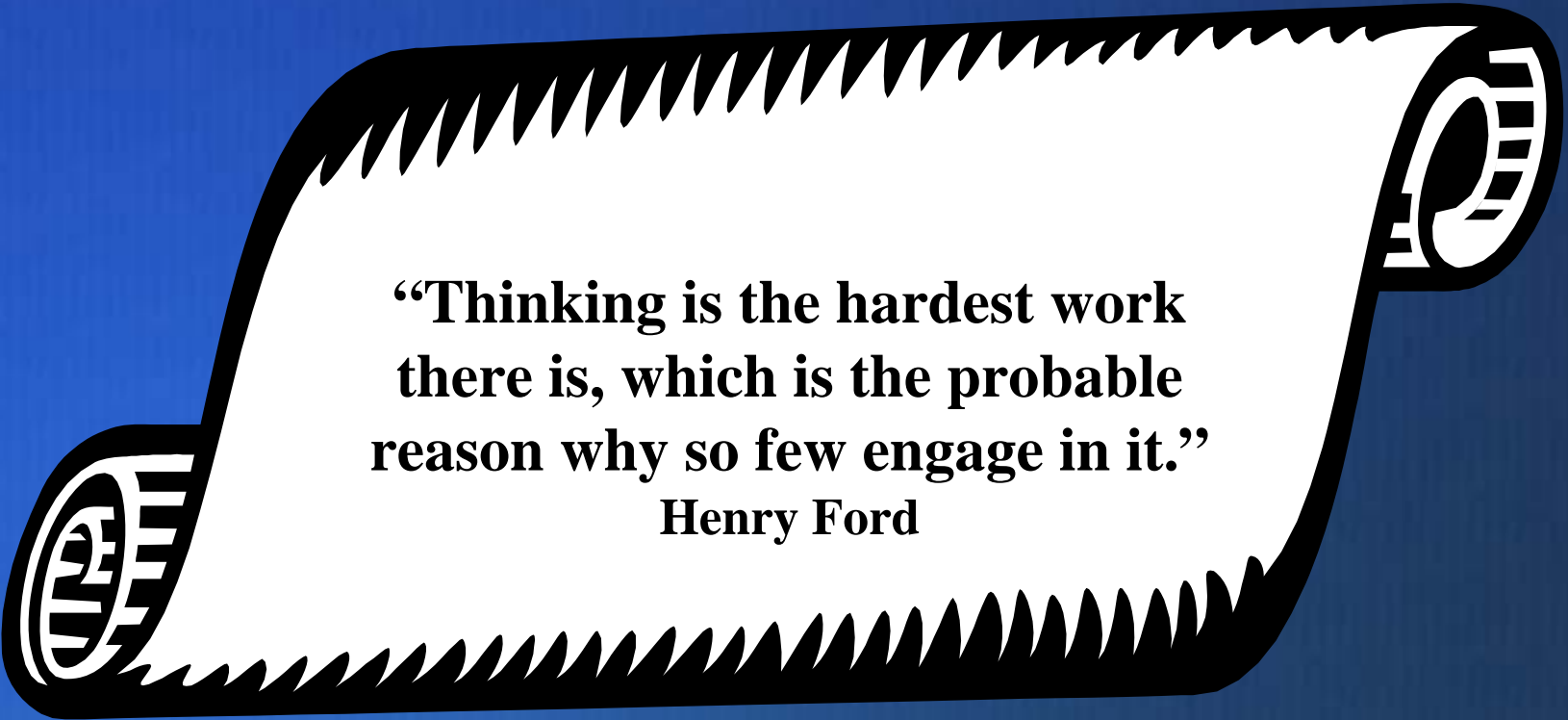
Hopefully, we are learning from our mistakes or more importantly the mistakes of others.

Oscar Wilde (1854 - 1900)

Irish dramatist, novelist, & poet; wrote plays "The Importance of Being Earnest", "Lady Windermere's Fan", "An Ideal Husband", novel "The Picture of Dorian Gray"

***“MORE”* LESSON’S LEARNED!**

Information Processing



**“Thinking is the hardest work there is, which is the probable reason why so few engage in it.”
Henry Ford**

Technology & Productivity

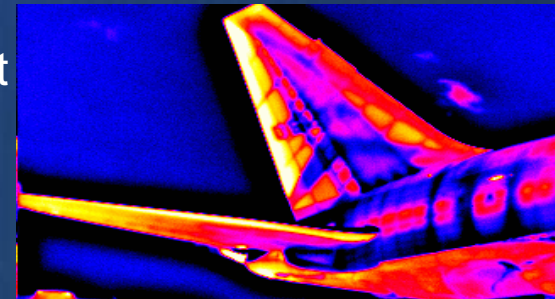
- Automation of manual techniques (Ex: Engine disk slots)

- Increase POD/reliability
- Decrease time of accomplishment
- Could lead to increase in inspection interval



- Combine efforts with Maintenance, Engineering

- 10 minute inspection, but 20 hour open-up/close-up
- Sensors to eliminate open-up requirement
- Inspection cost the same, but overall cost reduced
- Alternate inspections (Ex: Thermography vs tap-test or X-ray)



Using technology for productivity improvements

Partnerships and Teamwork

- Partnerships and teamwork needed now more than ever:
- Within Delta
 - Between NDT/Maintenance/Engineering
- Within the industry
 - Conferences for information exchange
 - FAA research projects (ISU, AANC, FAA Technical Center)
 - Transfer of new technologies
 - FAA's Aging Aircraft NDI Validation Center
 - OEMs
 - Air Force (commercial, military co-operation)

Teamwork required for success

Summary

- Open communication
- Be open to change
- Revised training program
 - Reduced cost and improved inspection quality
 - Random audits
- Using technology to reduce cost, increase POD
- Teamwork and partnerships required
 - Within and outside Of an organization

Closing thought

Quote – “It’s not always the strongest, nor the most intelligent that survive; It’s the one most willing to change!”

QUESTIONS?

Contact Info.

lee.clements@delta.com

404-714-3380