Inspection & Repair Preparation Cell (IRPC) Pilot

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IRPC Business Objectives

- **Demonstrate automated work cell to perform multiple operations in the repair of large composite structures:**
  - **C-130 Radomes**
  - **F-15 Radomes and Speed Brakes**
- **Provide digital data from each structure for engineering evaluation and tracking through lifecycle.**
- **Replace subjective manual processes with consistent disciplined automated approaches.**
- **Capture historical repair data to provide a basis for decision making and assessing fleet readiness.**
- **Eliminate transportation between operations.**

IRPC Pilot Objectives

Achieve savings in Targeted Operations per Composite Structure

- **C-130 Nose Radome**
  - Flow Day Reduction — 10 Days (30%)
  - Labor Hours Reduction — 35 Hours (33%)
- **F-15 Nose Radome**
  - Flow Day Reduction — 4 days (16%)
  - Labor Hours Reduction — 30 hours (18%)
- **F-15 Speed Brake**
  - Cycle Time Reductions — 4 days (19%)
  - Labor Hours Reduction — 12 hours (25%)
- **Increase in-service time for expensive, critical assets**

IRPC Project Technical Objectives

- Rapid creation of large 3D Models
- Prove the transformation of the surface data for creating an NDI and CNC program
- Test various NDI techniques and verify results
- Visualization of defective areas using Laser Projection Technique.
- Generation of 2D shapes for precise fabric plies and core plugs needed for the repair process

CTMA Project Approach

- ✓ **Use WR/ALC-provided Radome(s) and Speed Brakc for pilot.**

- ✓ **Nine month Phase 1 will qualify individual processes including:**
  - ➢ **Automated generation of Composite surface**
  - ➢ **Evaluate various advanced technologies for use in Radome repair.**

- ✓ **Twelve month Phase 2 will demonstrate the processes qualified in Phase 1 using a GFM supplied 6-Axis CNC Machining Center (RMT-50) in a computer assisted environment.**

Project Structure

- **Depot Partners-**
  - **Prime** – Warner-Robins Air Logistics Center
  - **Others -** *Hill AFB, Philadelphia Navy Propeller Shop, Oklahoma City Air Logistics Center*
- **Industrial partners**
  - GFM: Test bed, technology evaluation and process integration.
  - Assembly Guidance Systems (AGS): Laser projection technology
  - Dimensional Photonics Inc (DPI): Accordion Fringe Interferometer
  - Manufacturing Resources, Inc (MRI): Process consulting and evaluation
- **Phase 1 Funding:**
  - OSD provides (through CTMA) $0.4 million – industry provides $0.8 million

Key Enabling Technology – Accordian Fringe Interferometry (AFI)

- AFI was a precursor technology developed for Ballistic Missile defense.
- Phase 1 will demonstrate the ability of AFI technology to digitize large structures to permit the rapid creation of large three-dimensional surface models.
- These data models can then be used to create computer based machine tool programs.

Qualify advanced technologies through partners and subcontracts such as:

- ✓ Air Coupled/Non Contact Ultrasonic Inspection
- ✓ Mechanical Impedance Analysis (MIA)
- ✓ Laser Shearography
- ✓ Various Phased Array NDI Techniques

Pilot Deliverables to WR/ALC

- ✓ Complete documentation for each process evaluated.
- ✓ All special tooling developed for the project
- ✓ AFI 5000 non-contact 3D measurement system.
- ✓ *LASERGUIDE* projector and control computer.

Manual Labor and Flow Day Drivers (Current Process)

- Manual division of Composite surfaces into grids and detection of defective areas (tap test and moisture sensor scan of entire surfaces).
- Manual routing (or grinding) to remove defective composite skin.
- Manual removal of crushed core.
- Manual preparation of replacement core plugs.
- Manual preparation of dry fabric plies.
- Manual laminating process with core plugs, dry fabric plies and resin curing process.

Manual Repair Operations To Be Automated Include:

- **Detection of defective areas (grid creation and tap and moisture tests)**
- **Routing and/or grinding operations**
- **Removal of defective composite skin**
- **Removal of crushed core**
- **Preparation of replacement core plugs**
- **Preparation of dry fabric plies for repair**
- **Verification of completed repairs (tap test)**

Assumptions

- Fully loaded hourly rate $92/hour (average)
- C-130 Nose Radomes 144/year
- F-15 Nose Radomes 312/year
- F-15 Speed Brakes 600/year
- Machine hours available 16 hours/day
  (16hr/5 days/50 wks) 4000 hours/year
- Required System Accuracy 0.002 inches

Radome and Speed Brake Cell (10’ x 6’ x 4’ Work Envelope)

- The pilot will be performed on a GFM RMT-50 with this envelope, enhancing opportunity to apply tooling and fixturing developed through the pilot to the production system.
- The demonstration Cell can process F-15 Nose Radomes and Speed Brakes and demonstrate proof-of-concept on C-130 Radomes.
- Similar to Systems employed at Lockheed Martin (LM) Skunk Works, plus various LM, Boeing and other major aerospace manufacturing facilities.

Current C-130 Nose Radome Repair Process

Operation	Op Time (hr)
Receive & identify	1.37
Depaint	2.44
Pre-electrical test	3.10
Sand & remove residual coatings	1.10
Evaluate for damage (coin tap, lights, moisture check)	1.10
Place in contour fixture, check contour, replace fittings or hardware as needed	20.31
Remove ducts, seal duct openings, inspect nut plates and replace as needed	3.29
Cut & remove outer skin plies and core	13.26
Prepare, replace, & sand outer core & skin plies	13.52
Cut & remove inner skin plies & core	12.98
Prepare, replace, & sand inner core & skin plies	12.80
Repair damage to corners and inspect seal (replace if necessary)	6.30
Apply filler putty & sand smooth	4.39
Inspect before electrical test	0.01
Final Electrical test	3.10
Perform final inspection and repair if needed	0.01
Paint	4.88
Install bolts in mounting holes	1.10
Final inspection and turn in	1.37
Total	**106.43**

Flow Days for Current Process: 34 days

Targeted Results (C-130 Nose Radome)

- Applied Labor Hour Reduction Per Radome
  - Identification of Defects (coin tap, moisture)
  - Outer and Inner Skin Removal
  - Core Removal
  - Core and Skin Replacement
  - Rework Avoidance
  - Total Reduction (estimated) 35 hours

- Potential Savings (35 hrs @ $92/hr x 144 Units)

  $463.7K/year

Flow Day Reduction: **10 days of 34 days**

Current F-15 Nose Radome Repair Process

- *Cells 1 through 4: depaint and prepare* *5 days*
- ***Cell 5:*** ***7 days***
  - **- Evaluate radome for repair**
  - **- Repair outside damage**
  - **- Repair inside damage**
  - **- Sand and sealcoat repairs, inner and outer**
- *Cell 6: repaint, replace boot, electrical test, final visual inspection* *12 days*

Flow Days for Current Process: 24 Days

Current F-15 Nose Radome Repair Process

F-15 Radome Work Flow	
Operation	**Op Time (hr)**
Receive & Identify Radome	1.50
Depaint by flashjet	6.26
Check attachment holes	0.50
Inspect ring frame & hinge nut plate	1.50
Remove & replace bushings	0.70
Remove boot	1.86
Remove any remaining paint	4.96
Remove grid wires & tape	2.48
Sealcoat inner & outer surface of radome	2.48
Evaluate radome for repair	1.24
Repair outside damage	10.50
Repair inside damage	10.50
Sand & sealcoat repairs (inner)	10.50
Sand & sealcoat repairs (outer)	9.24
Inspect prior to paint	0.62
Paint radome	6.00
Stencil info on radome	0.50
Replace boot	3.50
Electrical test radome	86.25
Complete AFTO 95	1.50
Final visual inspection	1.25
Total	163.84

Flow Days for Current Process: 24 days

Targeted Results (F-15 Nose Radome)

- Applied Labor Hour Reduction Per Radome

- Evaluate for repair (tap, moisture)	1
- Repair outside damage	10
- Repair inside damage	10
- Sand and sealcoat repairs	5
- Inspection and rework	4

- Total Reduction	30 hours

- Potential Savings (30 hrs @ $92/hr x 312 Units)

  $861.1K/year

Flow Day Reduction: **4 days of 24 days**

Current F-15 Speed Brake Repair Process

- Cell 1 — 2.5 Hours (labor)
  - Receive and ID damage
  - Change bearings
  - 100% coin tap
- Cell 2: — 36.2 hours (labor)
  - Sand top and bottom
  - Remove damage
  - Oven cure
- Cell 3 — 26.3 hours (labor)
  - Clean surface
  - Fill and sand
  - Lay up patches and bag
  - Wet lay up (fiberglass) if needed
- Cell 4 — 13.2 hours (labor)
  - Bag and cook patches
  - Debag
  - 100% coin tap

Current F-15 Speed Brake Repair Process

- Cell 5 — 1.2 hours (labor)
  - Seal
  - Sand cure/seal edges
  - Inspect
  - Turn in

Total Labor: 79.5 hours

Flow Days for Current Process: 24 Days

Targeted Results (F-15 Speed Brake)

- Applied Labor Hour Reduction Per Unit

  Total Reduction: 12 hours (15%)

- Potential Savings (12 hrs @ $92/hr x 600 Units)

  $662.4K/year

Flow Day Reduction: **4 days of 21 days**

Radome Cell Potential Annual Benefits ($000)

- Labor reduction
  - C-130 Nose Radome 463.7
  - F-15 Nose Radome 861.1
  - F-15 Speed Brake 662.4

  Total **$1,987.2**

- Total Flow Day Reductions/Year: **5,088 days**
- Historical Data Captured in Digital Form
- Improved Quality and Process Consistency
- Demonstrated technology applicable to other structures (new parts)

Pilot Radome Cell Costs ($000)
10’ x 6’ x 4’ Work Envelope

Multi-Axis Machining Center	$2,000
AFI	250
Laser Sherography or equiv	250
Assembly Guidance	100
Other Technologies	150
Tooling & Fixturing	250
Process Control Integration	1,000
Deliverables from CTMA Pilot	(850)
Total	$3,150

- ***Technical and business risks to WR/ALC eliminated through CTMA funded pilot prior to production decision.***

Radome Cell Payback (10 x 6 x 4 Envelope)

DRAFT

- Total System Cost to USAF $4,000.0K
- Labor Savings 1,987.2K
- ROI **2.0 years**

- Total System Cost to WR/ALC $3,150.0K
- Labor Savings 1,987.2K
- ROI **1.6 years**

- 20% Flow Day Reductions
- Historical Data Capture
- Improved Quality and Process Consistency

Technical and business risks to WR/ALC eliminated through CTMA funded pilot prior to production decision.

Project Champion – GFM/AGFM Corporation

- **Background -** A technically high level machine tool builder with extensive computer controlled machine tool integration experience, and experienced in building automated cells for delivery of advanced technology.

- **IRPC Role-**Provide the use of a 6-axis machining center for the pilot. Evaluate potential advanced technologies. Integrate the computer management control system, material handling and selected technologies into the IRPC.

Assembly Guidance Systems (AGS)

- **Background-** The first manufacturer of advanced laser projection systems for industry. Winner of the Tibbets Award for small business for development of the Composites Mfg. Process Control System for the USAF.

- **IRPC Role-** Provide laser projection technology and application expertise, and provide a *LASERGUIDE* and *KITGUIDE* systems for integration into the cell..

Dimensional Photonics International, Inc. (DPI)

- Background - DPI designs and produces Accordion Fringe Interferometry (AFI) based scanners. DPI is staffed with technical professionals with more than a hundred years of large scale metrology experience. DPI has an exclusive global license from MIT to commercialize AFI technology.

- IRPC Role – DPI will provide an AFI Scanning System, successfully demonstrated in two completed CTMA projects, to be mounted on a GFM 6-axis machining center, plus develop the inspection technique and required software.

Manufacturing Resources, Inc. (MRI)

- **Background-** Experienced manufacturing and engineering consultant specializing in new product introduction, manufacturing planning, process development and optimization, and Lean systems implementation. Worked at Tinker (OC/ALC) with OptiCAM/I-POMX and Six Sigma CTMA projects
- ✓ **IRPC Role-** Will map the "as is" processes at WR/ALC and document "to be" processes supported by the cell. MRI will counsel GFM in technology selection and document final project results.