



AlumiPlate® Electroplated Aluminum Performance and Usage on F-35 & F-22



Kelly Donaldson
AlumiPlate, Inc.
27 February 2008

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

| | | | | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------------|-----------------------------------------------------------|----------------------------------|---------------------------------|
| 1. REPORT DATE 27 FEB 2008 | 2. REPORT TYPE | 3. DATES COVERED 00-00-2008 to 00-00-2008 | | | |
| 4. TITLE AND SUBTITLE AlumiPlate Electroplated Aluminum Performance and Usage on F-35 & F-22 | | 5a. CONTRACT NUMBER | | | |
| | | 5b. GRANT NUMBER | | | |
| | | 5c. PROGRAM ELEMENT NUMBER | | | |
| 6. AUTHOR(S) | | 5d. PROJECT NUMBER | | | |
| | | 5e. TASK NUMBER | | | |
| | | 5f. WORK UNIT NUMBER | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AlumiPlate Incorporated, 8960 Springbrook Dr Nw Ste 105, Coon Rapids, MN, 55433 | | 8. PERFORMING ORGANIZATION REPORT NUMBER | | | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | 10. SPONSOR/MONITOR'S ACRONYM(S) | | | |
| | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | | | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited | | | | | |
| 13. SUPPLEMENTARY NOTES Surface Finishing and Repair Issues for Sustaining New Military Aircraft Workshop, February 26-28, 2008, Tempe, AZ. Sponsored by SERDP/ESTCP. | | | | | |
| 14. ABSTRACT | | | | | |
| 15. SUBJECT TERMS | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT Same as Report (SAR) | 18. NUMBER OF PAGES 31 | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT unclassified | b. ABSTRACT unclassified | c. THIS PAGE unclassified | | | |

AlumiPlate, Inc.

- **Minneapolis, MN**
 - Established 1995
 - Original technology acquired from Siemens
 - Focus on hi-value / hi- performance since 2002
- **Racking/Fixturing**
 - Need contact
 - (2) 21"x31"x22" chambers
25" Diam. max
- **Intricate Geometries**
 - Throwing Power
 - Supplementary anodes
 - Uniformity (Pulse Plating)
- **Does not degrade parts**
 - Low process temp. (100°C)
 - Short plating times (1-2 hrs)
- **Well Established specification**
 - MIL-DTL-83488



Electroplated AlumiPlate® Aluminum Qualified on Present Programs

| <u>PROGRAM</u> | <u>APPLICATION</u> |
|-------------------------|---------------------------------------------|
| B-1 Lancer | - Raytheon Radar Arrays |
| AH-1 Super Cobra | - M50 High Strength Steel Rotor Hub Housing |
| M119A Howitzer | - HSS Eyebolts |
| RQ-4 Global Hawk | - 6061 Al Mirrors for Targeting |
| C-5 Galaxy | - Aircraft Wheel Fuse Plugs |

Electroplated AlumiPlate® Aluminum Qualified on Present Programs

PROGRAM

F-16 Fighting Falcon

F-18 Hornet

F-22 Raptor

F-35 Lightning II
Joint Strike Fighter

APPLICATION

- Copper Grounding Straps
- Stainless Steel Fuel Mesh Screens

- Raytheon Radar Arrays

- AIBeMet Electronics Backplane
- HSS Structural Applications -
LG

- HSS Structural Applications -
Landing Gear Components -
- Electrical Connectors
- Composite Electronic
Enclosures
- AIBeMet Being Qualified

Electroplated AlumiPlate® Aluminum

Application

- **Electrical Enclosures & Connectors**

Requirements

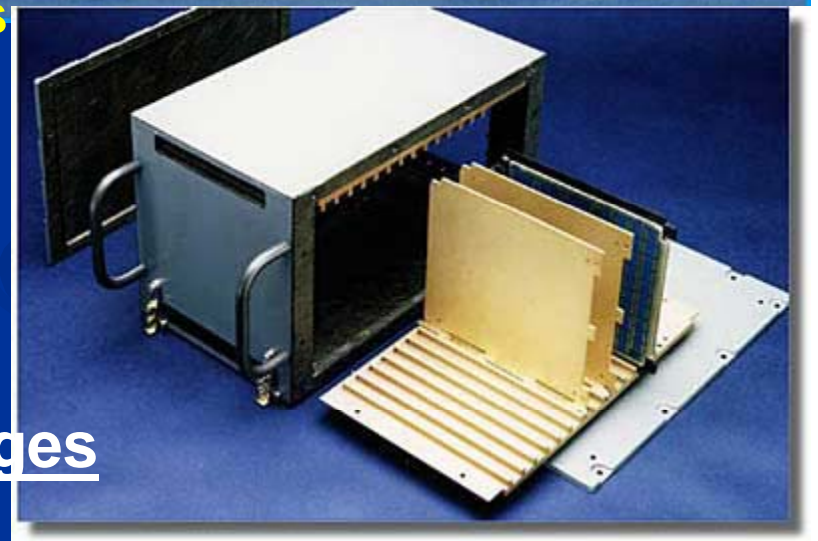
- **Corrosion Protection, HAZMAT Elimination, Conductivity, EMI Shielding, Plate on Composites**

Solution Alternatives

- **Cd, Ni, Ni-Teflon, Zn-Ni, Flame Spray Al, PVD Al, AlumiPlate**

AlumiPlate Competitive Advantages

- **Best Technical Performance**
- **Enabling Technology for Significant Weight Savings (20-40%)**
- **MIL-DTL-38999 - Class P, LMA010**



Electroplated AlumiPlate® Aluminum

Application

- Aero Landing Gear / High Strength Steels

Requirements

- Cost, Corrosion Protection, HAZMAT, Shorten Manufacturing Cycle Time

Solution Alternatives

- Ti-Cd, Sermetel, AlumiPlate

AlumiPlate Competitive Advantages

- Best Corrosion Performance – 336+ hrs SO₂
- No Hazardous Material
- Eliminate 23 hour HE Relief Bake
- Direct Drop-in Replacement
- Non-embrittling (HE & EAC) & at High Temp
- LGPS1105, LMA010



- Implementation Requirements for “Cutting-In” AlumiPlate as a Cadmium Alternative Technology

Technology Performance

- Needs to meet / exceed program requirements & existing technology

NRE Tooling & Part Process Validation - \$

- Often ^ \$ for new technology – amortizing to URF too expensive

Unit Recurring Flyaway (URF) & MRO Cost - \$

- Must be equal or less than existing technology

Supply Chain Availability

- Can the technology be deployed at a DoD FRC & ALC
- Can the technology be broadly implemented

(Eliminate Cadmium)

Implementation Requirements for “Cutting-In” AlumiPlate as a Cadmium Alternative Technology

Technology Performance

- Proven – Test data - Lockheed, Goodrich, JCAT, DoD DLA

NRE Tooling & Part Process Validation

Unit Recurring Flyaway (URF) & MRO Cost

Supply Chain Availability

Technology Performance



Corrosion - Goodrich, Lockheed, NAVAIR, DOD/DLA

- Salt Fog : 6000+ hrs (Cd is ~2000 hrs)
- SO₂ : 336+ hrs
- Ground Runway Deicers (Potassium Formate)

Hydrogen Embrittlement - Goodrich, Boeing, JG-PP JCAT

- Outperforms all Cd alternatives & Ti-Cd baseline – incl. hi-temp events
- Eliminate 23 hour HE Relief Bake (no nickel)

Fatigue, Adhesion, Reparability – Goodrich, JG-PP JCAT

- No Fatigue knock down
- Adhesion passes ASTM 571
- Repair is same as IVD Al – passes all scribe & repair tests

General – Goodrich, Lockheed

- Dimensional Drop-in equivalent to cadmium
- No Hazardous Material
- Preferred technical solution
- Matching AlumiPlate corrosion with HVOF wear performance = significant cost of ownership reduction – fewer MRO cycles

- Distinguishing Values

- Meets F-35 NAVAIR requirements for 336 hr ASTM G85 Appendix 4 SO₂ corrosion protection including use of RoHs compliant (non-Cr⁺⁶) conversion coat.
- Protects against new ground runway deicer fluids.
- Shorter processing times (no 24 hr HE relief bake requirement) due to nonembrittling process chemistry.
- Less processing steps and handling due to ability to do final HVOF surface finish grinding after plating (no masking / baking required).
- Allows lighter weight composites to be used in place of heavier metallic substrates.
- Lower lifetime costs due to higher corrosion performance matched with HVOF wear performance (fewer MRO cycles).



Electroplated AlumiPlate® Aluminum in Aerospace Applications

Design Considerations for AlumiPlate Process

F-22 work was done to prove plating process – F-35 work has been done to prove out thru full assembly – final full assembly environmental and performance testing is in progress

Our hot solvent electrolyte doesn't allow typical plating maskants – selective strip is preferred

Typical plating uniformity is 4 to 1 in thickness variance – critical surfaces can be controlled to +/- 0.0002"

Current density variation (sup anodes w faces & bores) is alleviated by breaking sharp corners

AlumiPlate is more dense and less 'squishy' / porous than cadmium: critical surfaces need tolerance callouts - primer needs to be 'wipe' vs. 'fill & drain' at interfaces

Threads and sliding members need lubrication for gaging and assembly

Developed a best practice for HVOF & plate

Implementation Requirements for “Cutting-In” AlumiPlate as a Cadmium Alternative Technology

Technology Performance

NRE Tooling & Part Process Validation

- 2003 DoD funded process validation on F22 MLG piston & pins
- 2007 / 2008 AFRL contract for NRE on F35 LG

Unit Recurring Flyaway (URF) & MRO Cost

Supply Chain Availability

NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

F35 LG PNs using AlumiPlate –(5) now flying on A1 side by side with equivalent cadimum parts

2649A4103-101

TORQUE ARM, MACHINED, LOWER, SHOCK STRUT –
LH MLG

2648M2121-1

PIN, APEX, TORQUE ARM - NLG

2648A2206-101

SPINDLE, MACHINED, LOWER, DRAG BRACE ASSY - NLG

2648M2209-1

PIN, ECCENTRIC, DRAG BRACE - NLG

2648M2675-1

BRACKET, TAXI LIGHT, BACK



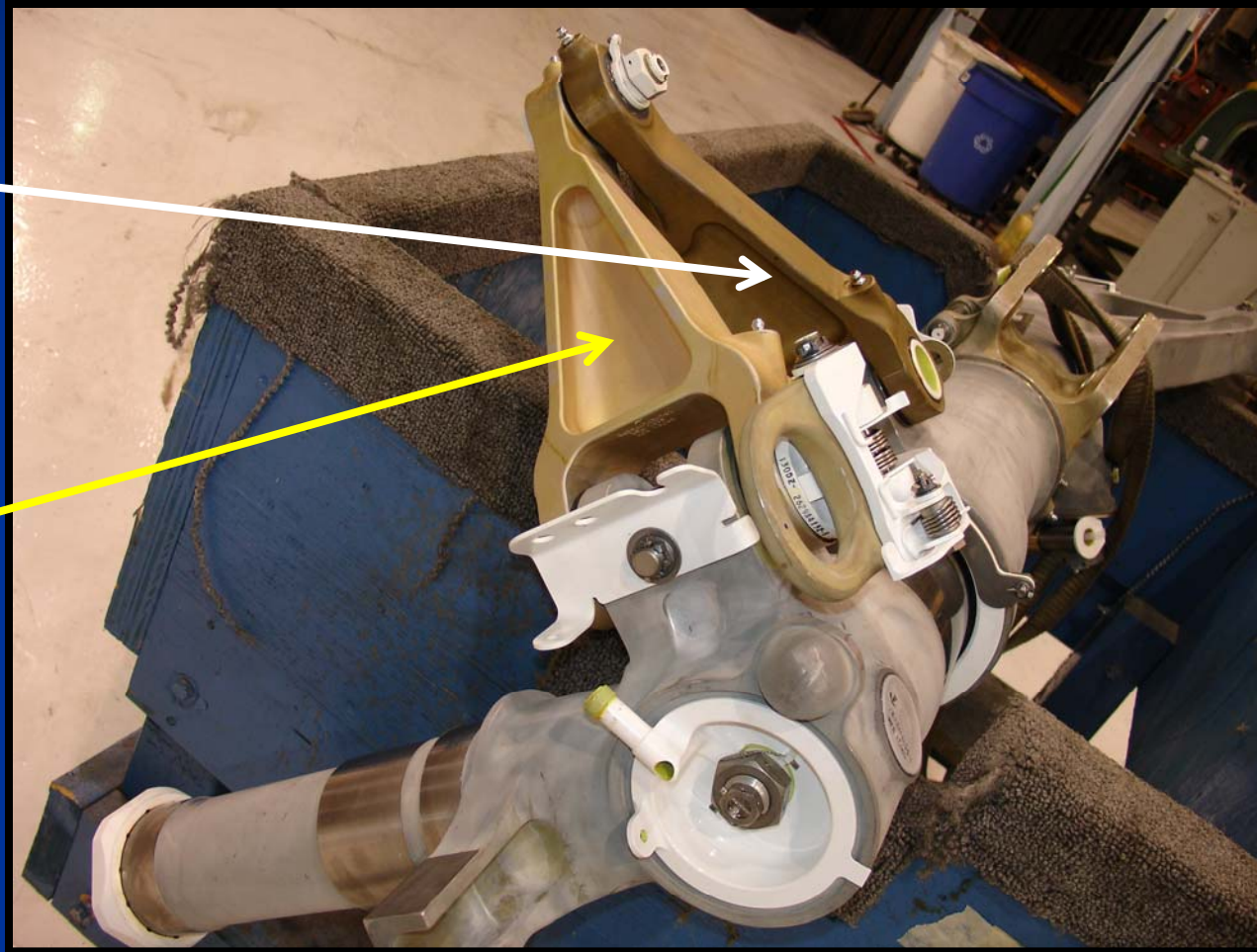
Present Applications – 2649A4103 Torque Arm F35 Main Landing Gear

Side by Side with Cadmium

F35 Main Landing Gear

Cadmium
Upper

AlumiPlate
Lower



NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

F35 STOVL LG PNs TARGETED for AlumiPlate as Cadmium Alternative

Nose Landing Gear - NLG

50 Total Part Numbers (15 are bushings)
61 Total Pieces per Ship Set

Main Landing Gear - MLG

72 Total Part Numbers (41 are bushings)
99 Total Pieces per Ship Set

TOTAL Landing Gear SHIP SET

122 Total Part Numbers (56 are bushings)
160 Total Pieces per Ship Set

NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

Generic Tooling – Plating Validation Categories

Wireform/Hooks – Generic Tooling

65 Total Part Numbers (mostly bushings)

ID Pins – Generic Tooling – 26xxx2209 Style

18 Total Part Numbers

Solid Pins - Generic Tooling -26xxx2121 Style

9 Total Part Numbers

Small Sup Anode - Generic Tooling -26xxx2206 Style

3 Total Part Numbers

Large Sup Anode - Generic Tooling -26xxx4103 Style

2 Total Part Numbers

Custom Design – Specific Tooling

25 Total Part Numbers

- NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

Tooling Category

ID Pins - Generic Tooling
- 26xxx2209 Style

16 Total Part Numbers on
F35 STOVL

Several potential cost
down parts on F22



NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

Tooling Category

Solid Pins - Generic
Tooling -26xxx2121
Style

9 Total Part Numbers
on F35 STOVL

Several potential cost
down parts on F22



NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

Tooling Category

Small Sup Anode –

Generic Tooling -
26xxx2206 Style

5 Total Part Numbers
on F35 STOVL



NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

Tooling Category

Large Sup Anode -

Generic Tooling -

26xxx4103 Style

**2 Total Part Numbers
on F35 STOVL**



NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

F-22 MLG Piston - 2003

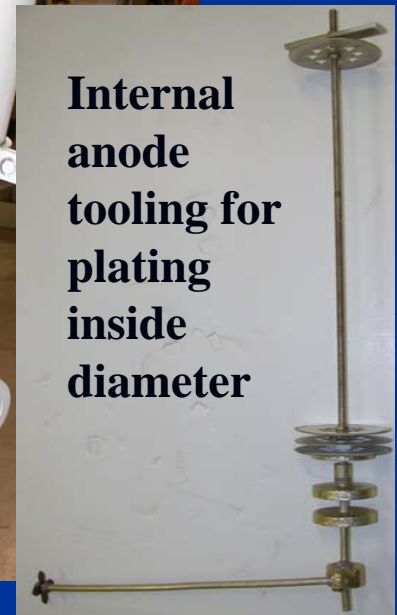
Tooling Category

Custom Design –

Specific Tooling

**25 Total Part Numbers on
F35 STOVL**

F35 MLG





NRE Tooling & Part Process Validation

2007-2008 DoD AFRL Funded Contract

F-35 GLG PNs TARGETED for AlumiPlate as Cadmium Alternative

TOTAL Landing Gear SHIP SET

122 Total Part Numbers (56 are bushings)

160 Total Pieces per Ship Set

■ Plating Validation – completed as parts are received from GLG

| <u>Category</u> | <u>Parts Req'd for Plating Validation</u> | |
|------------------|-------------------------------------------|--------------------|
| Wireform/Hook | 0 | Complete F35 & F22 |
| Solid Pins | 0 | Complete F35 & F22 |
| I.D Pins | 3 | Complete F22 |
| Small Sup Anodes | 2 | |
| Lrg Sup Anodes | 1 | |
| Custom Tooling | 20 | |

26 - TOTAL Parts to Essentially Complete AlumiPlate Tooling & Validation for F-35 STOVL LG

- Implementation Requirements for “Cutting-In” AlumiPlate as a Cadmium Alternative Technology

Technology Performance

NRE Tooling & Part Process Validation

Unit Recurring Flyaway (URF) & MRO Cost

- Trade studies show competitive URF
(DoD DLA – C130, B52) (GLG F16, F22, F35 Pending)
(NG – Composite enclosures)
- Operation costs similar to Cd
- Early performance data indicates potential significant MRO savings

Supply Chain Availability

From Goodrich Aerospace LG

JG-PP HCAT/JCAT

Greensboro, NC March 16th, 2005

Cost & Capacity Considerations

- Compared to other Cadmium alternatives AlumiPlate is less expensive on average
- Capacity to do future high volume work is needed
- Capacity to do future large parts is needed
- Capacity addition is capital intensive

Challenges / Issues in “Cutting-In” AlumiPlate as a Cadmium Alternative Technology

Technology Performance

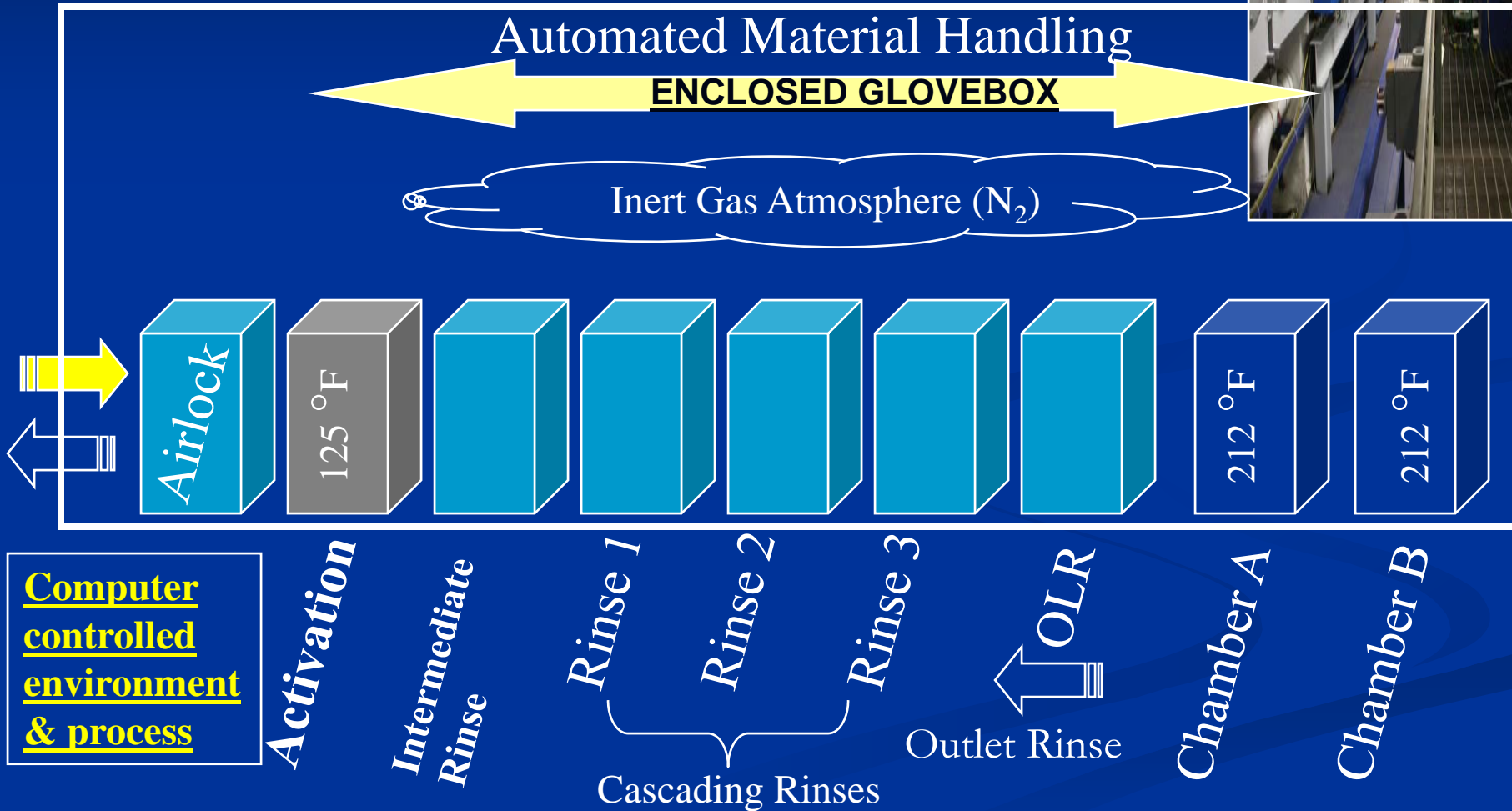
NRE Tooling & Part Process Validation

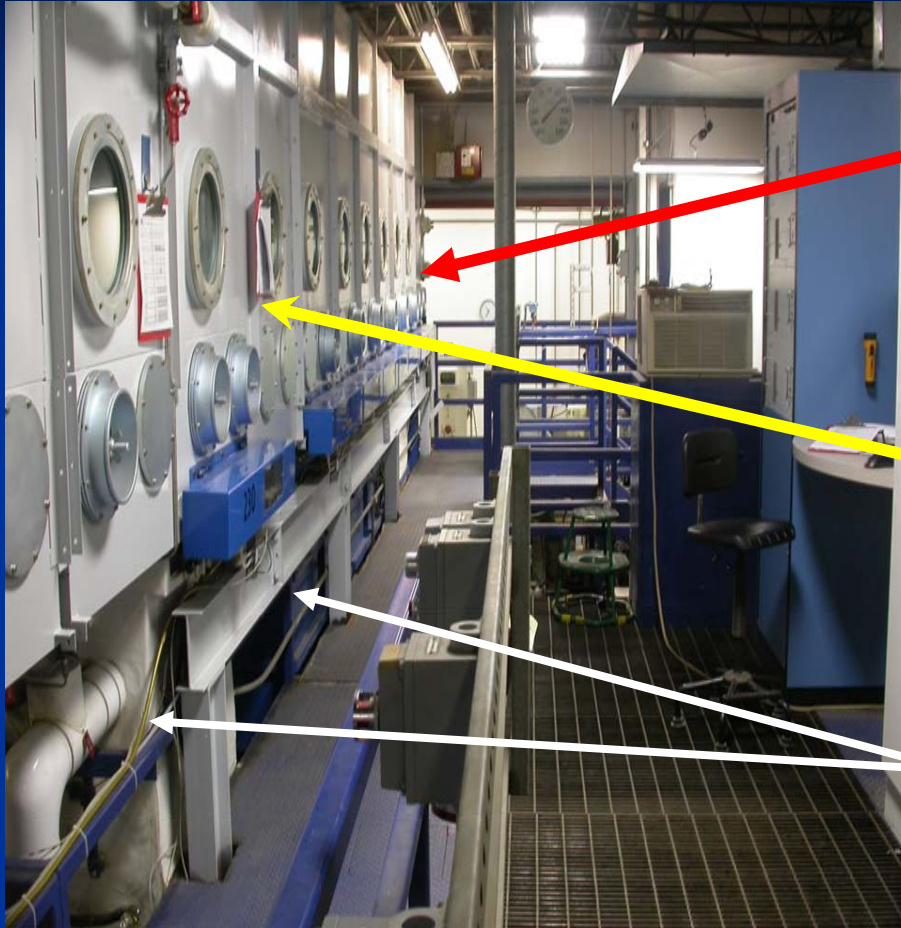
Unit Recurring Flyaway (URF) & MRO Cost

Supply Chain Availability

- DoD ESOH concerns with chemistry at MRO sites

Al Electroplating Process





Airlock entry
is at this end

Glovebox
with
overhead
transport

Plating tanks
are below
glove box



Racked
parts ready
to enter
airlock

In this photo, parts enter the airlock at the far end and go thru the process being moved toward you by the automated transport

Equipment and ESOH

- **Twelve Year Safety Record**
- **ESOH / IH Review**
 - Reviewed by DoD AFRL, NAVAIR, LMA
 - Considering DemVal Project
 - Well below all permissible exposure limits (PEL)
 - Closed Loop Systems
 - Enclosed process glovebox
 - Point source control – no hazmat in field or at MRO
(NO - Ni, Cr⁺⁶, Cd)
 - Blended fuels disposal of chemistry
 - Coating is 100% RoHS compliant



- Challenges / Issues in “Cutting-In” AlumiPlate as a Cadmium Alternative Technology

Technology Performance

NRE Tooling & Part Process Validation

Unit Recurring Flyaway (URF) & MRO Cost

Supply Chain Availability

DoD ESOH concerns with chemistry at MRO sites

2nd plating line is capital intensive

→ DoD prime contractor’s hesitancy adopting a new material available at only one location, coupled with the new material provider’s lack of orders to drive expansion of a 2nd fabrication capability; a so-called chicken-versus-egg problem (which comes 1st?)

From Goodrich Aerospace LG

JG-PP HCAT/JCAT

Greensboro, NC March 16th, 2005

Future Planning

- Implement program wide on F-35
 - When we have the data we are gathering
 - When Lockheed says, “No more Cadmium”
 - May need to use without chromate
 - Alternate conversion coats such as Cerium Oxide?
- Implement on F/A-22 for cost savings
 - On those parts where it is cheaper
 - Give us leverage against other cadmium alternatives

- Summary of AlumiPlate as a Cadmium Alternative Technology on F22 / F35

Technology Performance

Well established – better than cad and any cad alternative

NRE Tooling & Part Process Validation

**Most difficult applications successfully addressed
F35 LG NRE nearing completion**

Unit Recurring Flyaway (URF) & MRO Cost

**Trade studies show equal or less cost than cadmium
Potential MRO Lifetime Cost Savings**

Supply Chain Availability

**ESOH / IH concerns addressed
Potential DemVal Project
2nd facility discussions progressing - chicken & egg biz issue still difficult**