



RDT&E NEEDS for METAL SURFACE FINISHING  
for DEFENSE APPLICATIONS



BACKGROUND PAPER ON  
AEROSPACE & MISSILE NEEDS

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# INTRODUCTION

Quick overview of environmentally acceptable alternatives for cadmium and chromium coatings on aerospace weapon systems

- Focus on those alternatives that have been independently tested
- Alternatives to chromate conversion coatings on metals also considered
- “Environmentally acceptable” is a broad term usually encompassing or impacting the following issues:
  - Local, state, federal and international environmental pressures
  - Worker occupational safety and health concerns
  - Productivity and facility compliance concerns
  - Availability and cost effectiveness
- Systems approach *must* be used in finding acceptable alternative processes



# ENVIRONMENTAL DRIVERS



Wow, what a broad mixture of issues to analyze!

- ❖ Current and pending local , state, federal regulations
- ❖ DoD directives
- ❖ Programmatic environmental safety and health evaluations (PESHE)
- ❖ Executive Orders
- ❖ Foreign country regulations (including the E.U. and ISO)

EPA and OSHA have both published some general guidance for selecting alternative technologies ....

- ❖ But weapon and ground support equipment performance requirements and facility compliance issues, etc., must be used for down selecting, evaluating, demonstrating, and qualifying the best candidates before they can be considered for implementation by Weapon System Managers, Program Offices, Specification Owners, and so on ...



# GUIDANCE FOR SELECTING ALTERNATIVE TECHNOLOGIES



Alternative technology must perform equal to or better than the technology being replaced:

- “Environmentally acceptable”
- Production friendly (work load maintained)
- Cost effective (capitol and operating)
- Minimal facility change requirements
- Worker friendly (skills already available, or training possible)
- Repairable (damage during manufacture or field use)
- Maintainable (for life cycle or until replaced by another alternative)



# TECHNICAL / PERFORMANCE REQUIREMENTS ISSUES



- Older specifications written around a material and process
- Military specifications being converted to industry specifications
- More performance specifications now being developed *vs.* material specifications
- Alternative technologies may perform adequately in service but not meet old specifications
- New specifications often too broad due to including input from all stakeholders for all applications



# ALTERNATIVES IN USE OR BEING EVALUATED



More frequently, new designs are changing base materials so as not to require cadmium or chromium platings

Alternative surface finishing technologies are in various stages of development and use

- **Short term alternatives**

- Commercially available or will be available within 3 years
- Potential ESTCP funding for demonstration/evaluation

- **Mid-term alternatives**

- Commercial technologies that may be available in 3-5 years
- Potential SERDP or ESTCP funding depending on process maturity

- **Long term alternatives**

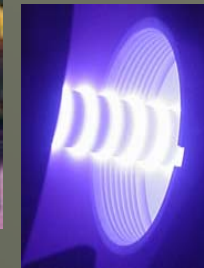
- Technologies that require R&D and optimization in 5-10 year time frame
- Higher risk technologies, but large potential payback
- Potential SERDP funding for emerging technologies



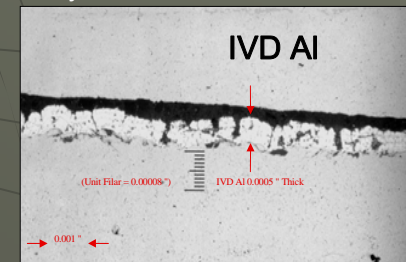
# CADMIUM ALTERNATIVES

Started work in 1967: Boss said “we have to get rid of CADMIUM soon”  
Retired in 2003: told my co-workers – “have to get rid of CADMIUM soon”

- Implemented technologies
  - Ion vapor deposited aluminum
  - Sputtered aluminum
  - Zinc-nickel alloy plating
  - Nickel-phosphorus electroless plating
  - Cermet coatings



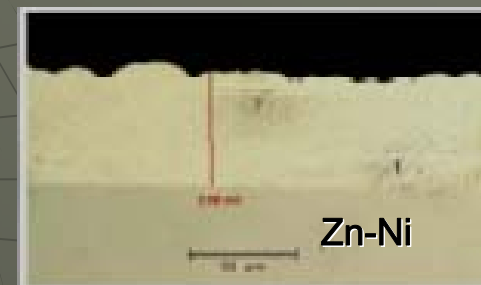
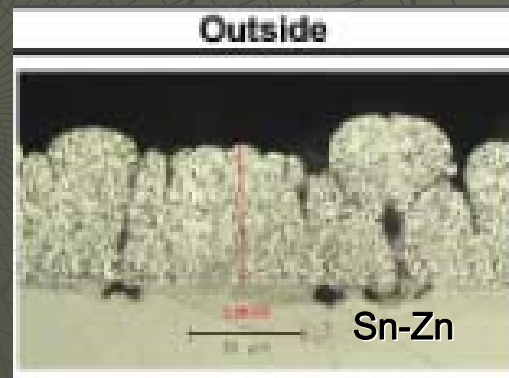
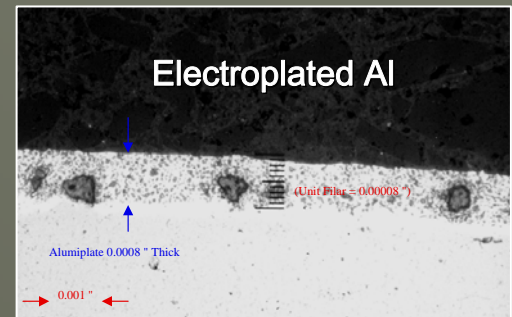
C-141 Axle  
During  
Deposition  
in “Plug and  
Coat”  
System



# CADMIUM ALTERNATIVES (continued)

- Short term candidates

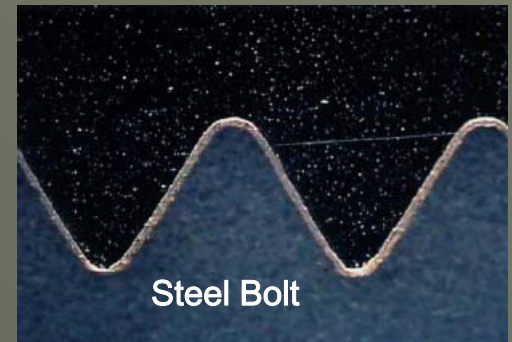
- Aluminum plating
- Aluminum- manganese alloy plating
- Zinc-nickel alloy brush plating
- Tin-zinc alloy plating
- Metal-filled inorganic coatings



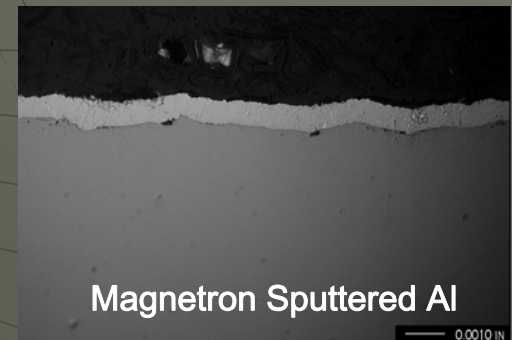
# CADMIUM ALTERNATIVES (continued)

- Mid and long term candidates

- Laser assisted surface improvements
- APCVD Al-based coatings
- Magnetron sputtered (PVD) aluminum-based coatings
- Zinc-nickel-phosphorus alloy plated coating
- Zinc-nickel+silicon dioxide plated coating
- Multi-layer (plated and diffused?) coating
- Ion beam assisted alloy or compound deposition



Photomicrograph courtesy of Akzo Nobel Chemicals

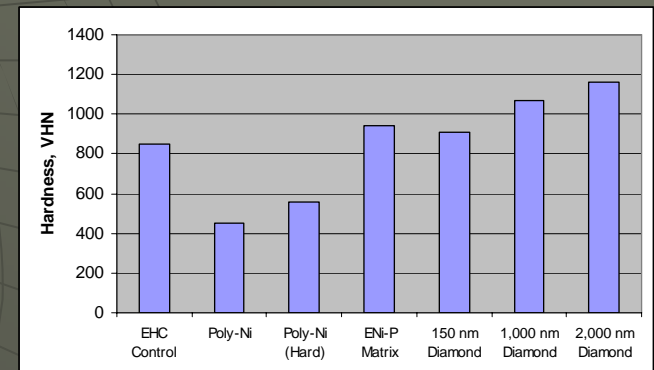




# CHROMIUM ALTERNATIVES: Metallic Coatings



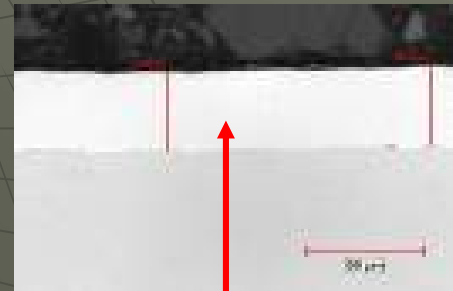
- Implemented technologies
  - High velocity oxy(gen) fuel coatings
    - WC-Co composite coatings
    - WC-Co-Cr composite coatings
- Short term candidates:
  - High-velocity oxy(gen) fuel coatings
  - Other alloy/composite compositions
  - Nickel alloy/composite plated coatings
  - Nickel-boron electroless coating
  - Sputtered chromium
  - Cermet coatings





# CHROMIUM ALTERNATIVES: Metallic Coatings (continued)

- Mid and long term candidates
  - Laser assisted surface improvements
  - Ion beam assisted deposited coatings
  - Micro-welding based coatings
  - Trivalent chromium plated coatings
  - Nano-composite Ni-P and Co-P based plated coatings
  - Thermal diffusion coatings
  - Plasma anodized coatings



Cross-section of a Nano-Co coating at 500X

# CHROMIUM ALTERNATIVES: Conversion Coatings, Adhesion Promoters



Replacement technologies that will provide corrosion protection and adhesion of subsequent coatings

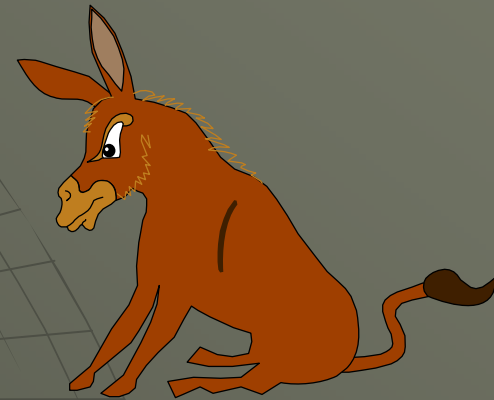
- Implemented technologies
  - PreKote™ adhesion promoter
  - Navy “TCP” licensed process
  - Other commercial (e.g., Alodine™) processes
  - Sol-gel pretreatments (e.g., AC131)
- Short term candidates
  - Navy “NCP” process
  - UMR cerium-based pretreatment
  - OSU hydrotalcite-based pretreatment?
- Mid and long term candidates
  - Other sol-gel and silane-based pretreatments with inhibitor packages
  - Sol-gel chemistries with nano-particles
  - Self-assembled nano-phase particle (“SNAP”) silicon sol-gel coatings





# BARRIERS to IMPLEMENTATION

- Many reasons given for not implementing material and process changes
- Some barriers are real, others due to negative desire to change
  - Technical / performance issues
  - Practical / production issues
  - Financial / funding cycles
  - Institutional / specifications
  - Qualification / acceptance issues
  - Availability / sole source issues
- Most barriers can be overcome
  - Customer demands that change occurs
  - Cost/risk analysis models support change
  - Time frames for change can be reduced with joint efforts





# LESSONS LEARNED

- Very few materials have been eliminated due to environmental and/or occupational safety and health pressures alone!
- Customer's specific requirements and the improved performance of alternative technologies greatly reduce implementation of "bad" processes and materials
- Systems approach has to be taken: changing one process or material can affect others
- Lack of confidence in ES&OH cost projections
- Commitment and involvement of customers and stakeholders early in substitution process greatly improves chances of successful outcome

