



Metal Finishing Workshop overview

27th HCAT Program Review
New Orleans
January 2007

Metal Finishing Workshop, Washington DC

May 22, 23, 2006

- ❑ Objective: “Strategically guide future environmental research development testing and evaluation (RDT&E) investments and to support the transition of demonstrated technologies in the area of metal plating and finishing.”
 - SERDP and ESTCP have spent a lot on money on metal finishing
 - Where are we now? What remains to be done?
 - Current state of the art in the Defense sector – OEM and MRO
 - Emerging regulatory trends – US and overseas
 - Currently used non-hazardous materials and processes
 - Barriers to adoption of clean alternatives
 - Performance shortcomings,
 - Cost and other non-technical barriers
- ❑ Read-ahead papers and briefings
 - Breakouts by application and technology

Materials:
Hard chrome
Cd
Chromates: Conversion coats,
pretreats, sealers, anodizing –
Not primers

Agenda

1. Bridging the Valley of Death, Carol Handwerker, Purdue
2. Environmental Issues and Corrosion, Lew Slotter, OSD
3. Current and Upcoming Regulations, Christian Richter, The Policy Group
4. Clean Alternatives, Keith Legg

DoD Operations and Sustainment

1. Tactical Vehicles, John Beatty, ARL, Tom Sachar Picatinny
2. Aerospace and Missiles, Eric Brooman, AFRL, Sheldon Toepke
3. Gun Barrels, Mike Audino, Benet Labs

New Platforms

1. Joint Strike Fighter, Scott Fetter, Lockheed
2. UAVs and UCAVs, Steve Gaydos and Joe Osborne, Boeing
3. Future Combat System and Stryker, John Beatty, Geoff Hoerauf, FCS

Agenda - breakouts

Applications

1. Hydraulic and pneumatic actuators
2. Turbine engines for vehicles, ships and aircraft
3. Structural (load-bearing) components
4. Gun barrels and small components (fasteners, pins, etc)

Technology

5. Chrome plating (line-of-sight and non line-of-sight)
6. Cd plating (line-of-sight and non line-of-sight)
7. Cr⁶⁺ pre- and post-treatments

Final Report

- ❑ Worked out well, with a lot of detailed information and good discussions
- ❑ Final Report available on web
 - This was US only meeting as some briefings not available for general distribution
 - Will produce a general release summary of everything for publication



SERDP/ESTCP METAL FINISHING WORKSHOP SUMMARY

Washington, DC, May 22 - 23, 2006

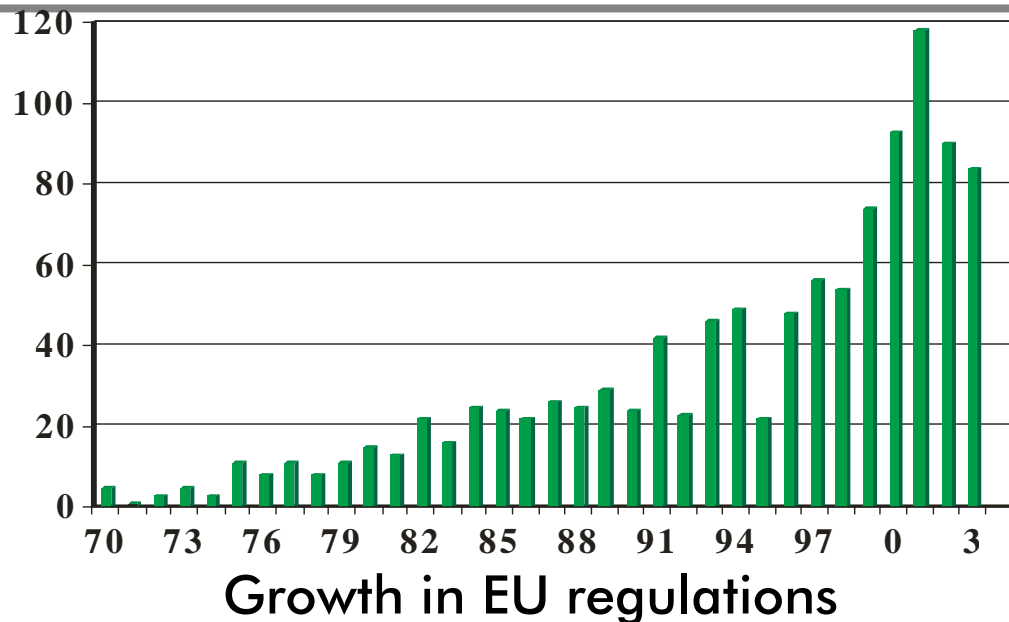
Regulations – US

- ❑ OSHA Cr⁶⁺ limit (Feb 2006)
 - Jeff Hannapel will discuss
 - Lawsuits still ongoing and limit could be lowered again
 - Primary impact for DoD and aerospace is uncontrolled emissions from painting, sanding, corrosion control
- ❑ California RoHS
 - Likely to say that anything restricted in Europe is equally restricted in CA
 - Hg, Pb, Cd, Cr⁶⁺, brominated fire retardant



Regulations - Europe

- ❑ EU used Precautionary Principle
 - Screaming trumps science
 - If we don't know let's assume it's bad
- ❑ WEEE
 - RoHS
 - China RoHS, California RoHS
 - Big issue coming up is how to measure Cr⁶⁺
- ❑ ELV
- ❑ REACH
- ❑ Lesser known regs
 - Stockholm Convention on Persistent Organic Pollutants (POPS), Convention on Long Range Transboundary Air Pollution (LRTAP) and Heavy Metals protocols



Effects of regulations

- ❑ DoD and aerospace exempt from regulations but not immune to their effects
 - Fewer suppliers of chemicals and processes, higher prices
 - Already seeing this in Pb-free solder – mixed supplies
- ❑ We still have only one periodic table
- ❑ Current “green” alternatives becoming brown
 - Zn, Ni, Co, Cr³⁺



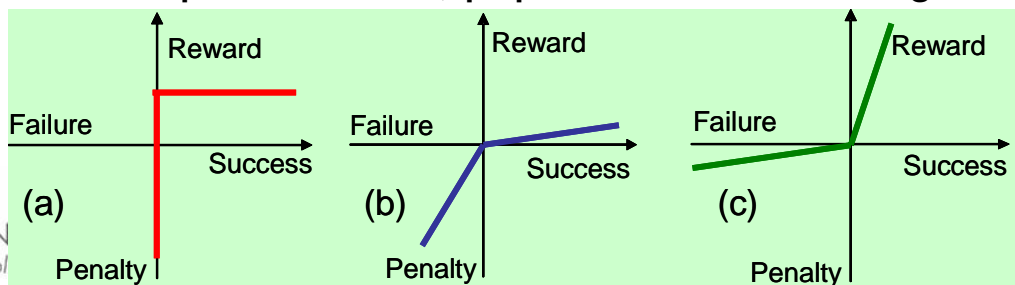
F-35 Lightning 2
CTOL first flight Dec
15, 2006



Totally green F-36 Lightning 3
CV carrier landing (circa 2050)

Drivers and barriers to adopting clean alternatives

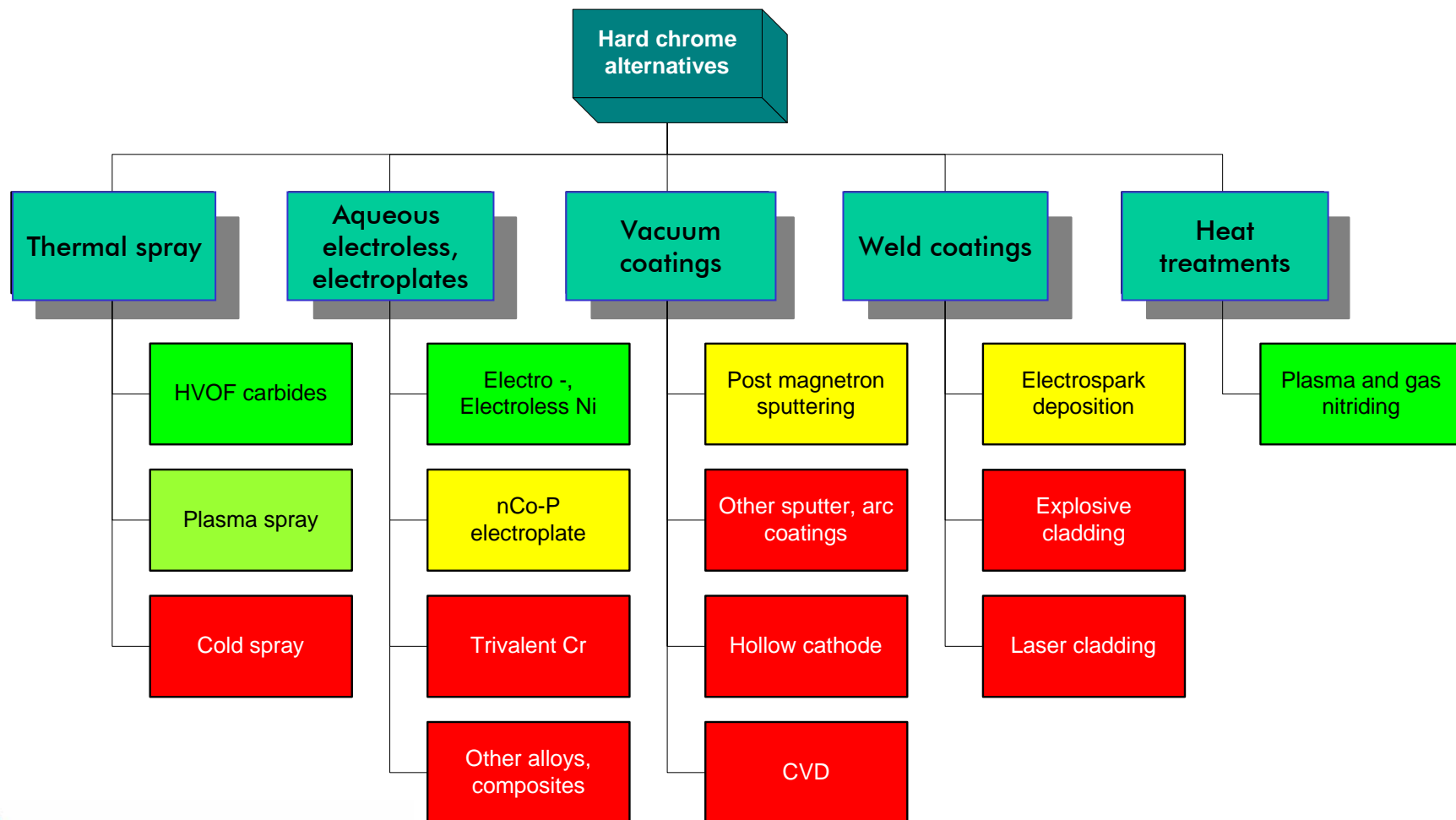
- ❑ Performance is still the strongest driver
- ❑ But ESOH regulations are becoming a strong driver as well (especially in commercial products)
- ❑ Numerous DoD barriers, including
 - Cultural barriers
 - Lack of specific requirements – policies largely ignored
 - DoD contracts incentivize cost reduction, disincentivize implementing new technologies
 - Inadequate depot engineering staffing, lack of management support
 - Technical barriers
 - Qualification cost, requirements based on existing technologies
 - Lack of data and specifications
 - Cost of implementation, paperwork and drawing changes





Alternatives

Hard chrome alternatives



Hard chrome alternatives

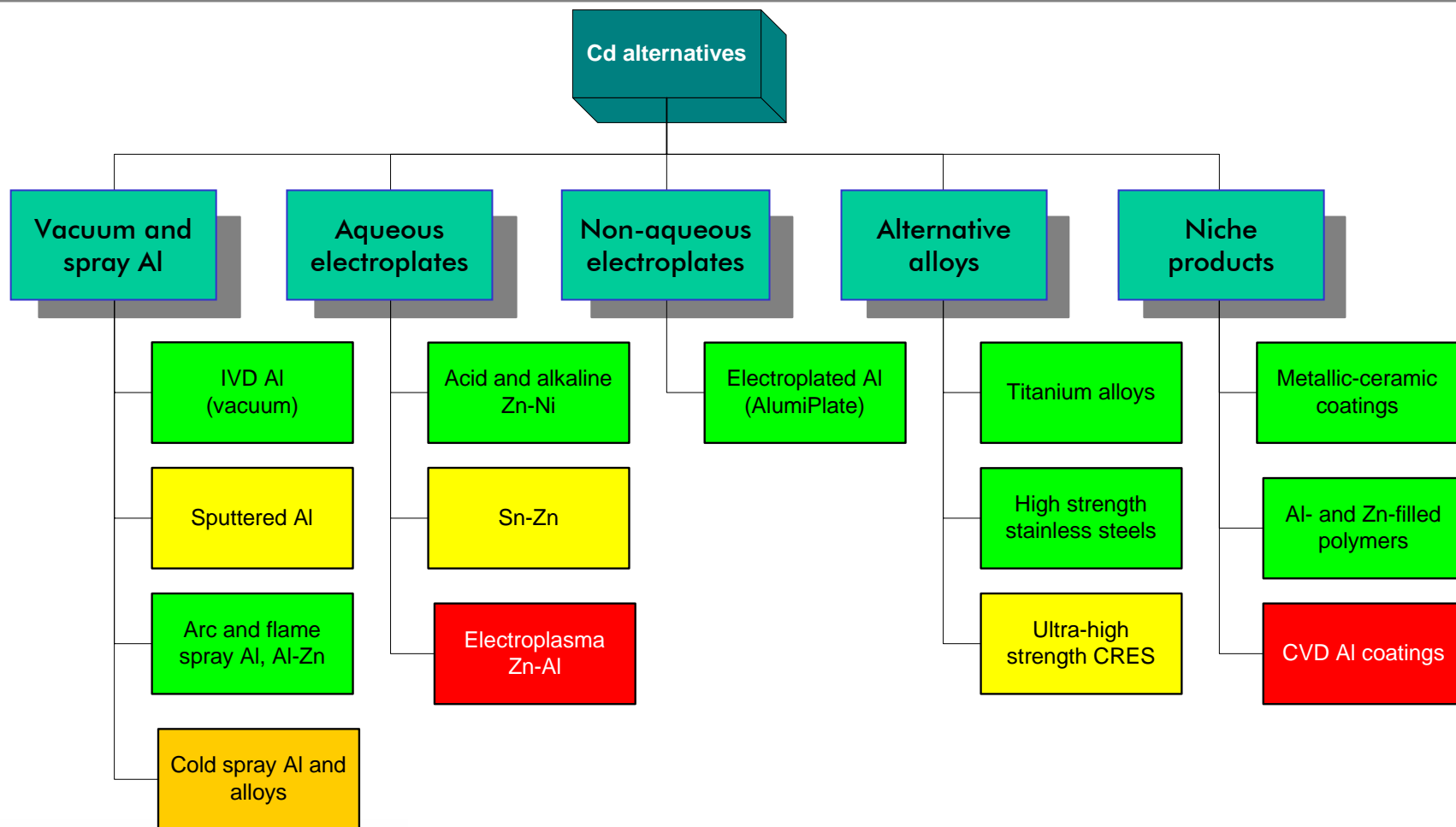
Alternatives adopted

- ❑ HVOF WC-CoCr now specified for all new Landing Gear programs, many aircraft hydraulics
- ❑ HVOF baselined for JSF (all)
 - nCo-P promising for IDs and TDC alternative
- ❑ OO-ALC major project to replace EHC with HVOF across depot
- ❑ NADEPs JAX and CP use HVOF for engine parts
- ❑ WR-ALC, OC-ALC beginning to adopt
- ❑ New Army vehicles using electroless Ni, Ni-W-B and Ni-W-SiC electroplate
- ❑ HVOF Cr₃C₂-NiCr beginning to be used for commercial hydraulics
- ❑ Gun barrels – sputtered Ta nearing production for large caliber

Remaining needs

- ❑ Alternatives mostly identified but adoption rate still low
- ❑ HVOF spalling still an issue
 - So far looking good for typical 0.003" thick OEM use
- ❑ IDs still uncertain
- ❑ Gun barrels still under development
- ❑ Ni likely next against the wall, so Ni alternatives are interim solution

Cd alternatives



Cd alternatives

Alternatives adopted

- ❑ IVD-Al used at OO-ALC, CCAD, NADEPs JAX, NI, CP
- ❑ Stryker has no Cd plated hardware or fasteners
- ❑ F-35 likely to replace LG Cd with AlumiPlate
- ❑ F35 uses CRES fasteners, AlumiPlated steel or composite elec. Connectors
- ❑ Metallic-ceramic (SermeTels) esp. on F-22 LG etc
- ❑ Carmakers use Zn-Ni and similar alloys

Cd used for protecting steels
Military and aerospace are
only remaining coating uses

Remaining needs

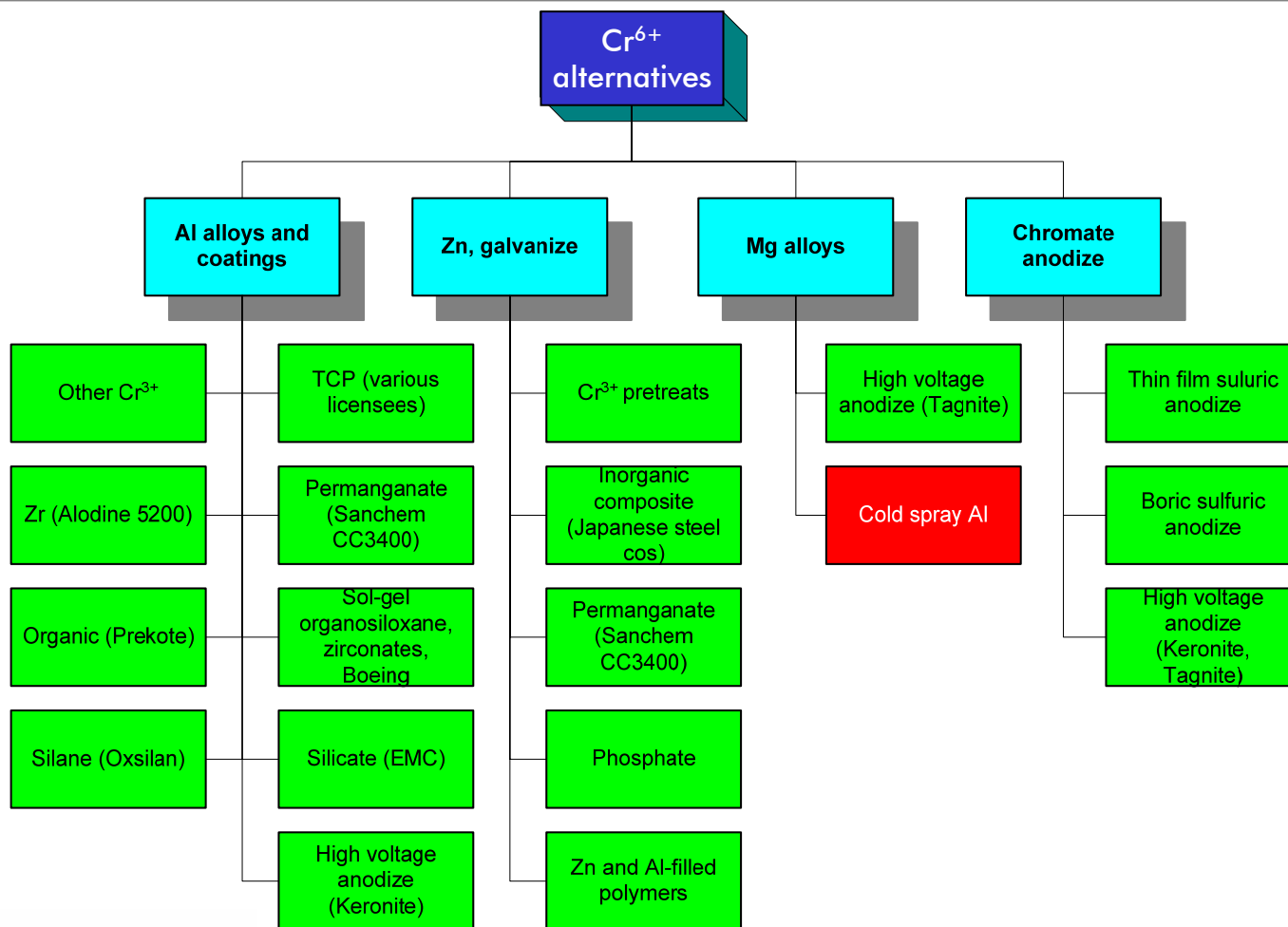
- ❑ HSS fasteners
 - Everyone's problem, no-one's responsibility
 - Carmakers use Al/Zn filled ceramic and polymer coatings
- ❑ Cd-free electrical connectors
- ❑ LHE alkaline Zn-Ni (Boeing, Dipsol America)
- ❑ Corrosion-erosion resistant coatings
- ❑ Brush Cd alternatives
- ❑ More options for high density Al coatings
- ❑ Corrosion resistant structural materials (CRES alloys, composites, etc.)

ELV, RoHS
drivers

Under development

- ❑ SERDP has issued RFP for Cd and Cr⁶⁺-free fastener technologies
- ❑ LHE Zn-Ni promising option as drop-in
 - Long term issues with Ni and Zn

Chromate alternatives



Chromate usage

- ❑ Chromates (strontium dichromate, zinc chromate, etc.) contain Cr^{6+} and are used everywhere for corrosion protection and adhesion
 - Conversion coatings and sealers for Al, Mg alloys, Zn, Al, Cd, ZnNi and other corrosion resistant coatings
 - Anodizing, esp. where paint adhesion is essential
 - Primers and bonding primers
 - Fuel tank coatings
 - Wash primers for steels (military vehicles)
 - Metallic-ceramic paints (SermeTels)
 - Passivation of stainless steels
- ❑ EU ELV, WEEE, RoHS rules forcing elimination of chromates from galvanized sheet, fasteners, etc.

Cr⁶⁺ alternatives

Alternatives adopted

- ❑ Primary alternatives are Cr³⁺ chemistries, Zr, Mn, rare earth inhibitors; also adhesion promoters – silanes, etc.
- ❑ NAVAIR TCP (TriChrome Pretreatment) commercially available from several suppliers
 - NAVAIR approved for some Al alloys
- ❑ Many commercial Cr³⁺ options
- ❑ PreKote AF approved for F-16, T-37, T-38
- ❑ F-35 Deft non-Cr primer for internal bays
- ❑ Alodine 5200/5700 approved for USMC Expeditionary Fighting Vehicle
- ❑ Cr³⁺ on Al road wheels – Army
- ❑ NAVAIR approved boric-sulfuric anodization in place of chromic
- ❑ Phosphates on steels commercially
- ❑ Keronite (for Al) and Tagnite (for Mg) increasingly used as anodize
- ❑ Non-Cr or low-Cr metallic-ceramics approved by P&W and others in place of SermeTel W
 - SermeTel, Ceral, Ipcote, Alesal now available

Remaining needs

- ❑ Qualify COTS alternatives
- ❑ Electrical equipment
- ❑ Anodize for use for paint adhesion
- ❑ Improve TCP for ease of use
- ❑ Chromate alternatives for Mg
- ❑ NDI of Mg through anodize layer
- ❑ Scientific understanding of non-Cr⁶⁺ inhibitors
 - New SERDP RFP

Particularly difficult applications

- ❑ Al electrical boxes and electrical equipment (also coated composite electrical equipment and boxes)
 - Not primed and painted
 - Alternative must work alone and have low electrical resistance
- ❑ Fasteners (esp. threaded fasteners)
 - Must have right torque-tension to avoid changing maintenance manuals
 - Must have low volume corrosion products to avoid seizing

Common needs

- ❑ Better H embrittlement test – funded
- ❑ Qualification of COTS products (esp. Cr⁶⁺ alternatives)
- ❑ Cost-benefit analyses people can believe
- ❑ Better test and NDI methods (reduce qual cost)
- ❑ Some funding of OEM implementation
- ❑ Technical Database of Surface Finishing Technologies
 - Starting to assemble



Follow-on Metal Finishing Session and Side Meeting

Partners in Environmental Technology
Symposium
November 2006

Aim of meeting

□ Session 1C

- Make DoD attendees aware of the results of the workshop, and the options used in the commercial world.
- 120-150 attendees

□ Side Meeting

- Initiate collaboration between DoD and commercial organizations on the best approaches for reducing hazardous materials in DoD weapons systems and sustainment.
- Involved DoD engineers, commercial suppliers and users, call-in by GM, Ford
- 60+ attendees

Session 1C on Metal Finishing - Agenda

- ❑ **Keynote: Regulatory Trends for Metal Finishing** –Christian Richter, The Policy Group
- ❑ **Surface Finishing Community Response to ESOH Regulations** – Craig Bishop, Atotech USA
- ❑ **Addressing Emerging Environmental Regulatory Requirements on DoD Tactical Ground Vehicles** – John Beatty, Army Research Lab
- ❑ **Replacing Cd and Chromates on Boeing Commercial Airplanes** – Joe Osborne, Boeing
- ❑ **Elimination of Cd and Cr platings and Cr6+ from DoD Aircraft Systems, New and Legacy** – Sheldon Toepke, Toepke Consulting
- ❑ **Fasteners for Military and Commercial Systems** – Liang Zeng, Alcoa Fastening Systems

Discussion in side meeting

- ❑ Concentrated on Cd and Cr⁶⁺
- ❑ Automakers have a voluntary Global Automotive Declarable Substances List (GADSL) to track hazmats
 - Whole supply chain involved
 - Not old enough to remember when Cd last used in cars!
- ❑ On-line tool at www.dsp.dla.mil for companies to input products for DLA approval without publicly disclosing data
- ❑ Interesting issues brought up
 - Intriguing report of 300-800ppm in Cr⁶⁺ in EHC
 - Cr³⁺ not usually as good as Cr⁶⁺
 - Not always – AlumiPlate data to be presented
 - Mold can grow in non-Cr⁶⁺ primers and paints

Side meeting – next steps

- ❑ Follow-on joint meeting between DoD, NASF, SFIC to discuss specific commercial solutions to DoD problems
 - Will take place May 16, 17 in Ogden, UT
 - Visit to Hill AFB afternoon of May 15
- ❑ Database of engineering data
 - Engineers need ready access to engineering data on alternatives adequate for making engineering decisions
 - Under way and should take place over coming year. Should include
- ❑ Expand and rename HCAT to encompass metal finishing in general (or materials in general)