

Department of Defense Cadmium and Hexavalent Chromium Reduction Strategy and Technology Roadmap

2018 Advanced Surface Engineering Technology for a Sustainable Defense (ASETSDDefense) Workshop

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Overview

- The Cd and Cr⁶⁺ Challenge
- 5-Year Strategy and Roadmap
 - Objectives
 - Background and Problem Definition
 - Implementation Plans
- Next Steps
- Conclusions

Challenge

Why replace Cr⁶⁺ and Cd?

- Hexavalent chromium (Cr⁶⁺)
 - Known carcinogen
 - Attacks the respiratory tract, liver, kidneys, skin, and eyes
 - Exposures occur during welding, coating processes, and surface finishing processes
 - Documented 75,219 pounds of Cr⁶⁺ used in CY 2015 (5 depots); 67,173 pounds of Cr⁶⁺ used in CY2017 (14 depots)
- Cadmium (Cd)
 - Known carcinogen
 - Attacks the cardiovascular system, respiratory tract, reproductive system, neurological system, gastrointestinal system, and kidneys
 - Exposures occur during welding, coating processes, plating processes, and handling Cd coated fasteners and connectors
 - Documented 229 pounds of Cd used in CY 2015 (5 depots); 3,146 pounds of Cd used in CY 2017 (14 depots)

Challenge

Regulatory and Policy Drivers

- Clean Air Act (CAA)
- Clean Water Act (CWA)
- Emergency Planning and Community Right-to-Know Act (EPCRA)
- Resource Conservation and Recovery Act (RCRA)
- Toxic Release Inventory (TRI)
- 48 CFR Parts 223 and 252 Defense Federal Acquisition Regulation Supplement (DFARS), “Minimizing the Use of Materials Containing Hexavalent Chromium” (DFARS Case 2009–D004)
- New proposed TLV-TWA from ACGIH: **0.0002 mg/m³ Cr⁶⁺** inhalable fraction and vapor and inhalable particulate matter; **0.003 mg/m³ Cr³⁺** inhalable particulate matter
- DOD Instruction 5000.02
- Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)
- Restriction of Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)
- Memorandum from John Young, USD(ALT), to Secretaries of Military Departments, “Minimizing the Use of Hexavalent Chromium”

5-Year Strategy and Roadmap *Objectives*

Demonstrate a path to reducing and/or eliminating Cr⁶⁺ and Cd from our depots in a reasonable timeframe

- Develop a strategy and roadmap to achieve >90% reduction of Cr⁶⁺ and Cd usage in maintenance processes at DoD depots in 5 years
- Develop a strategy and roadmap to achieve >90% reduction and/or containment of Cr⁶⁺ and Cd emissions, waste streams, exposure potential, and infrastructure at DoD depots in 5 years
- Generate 6 depot-specific implementation plans to translate the strategy into finite, depot-level actions

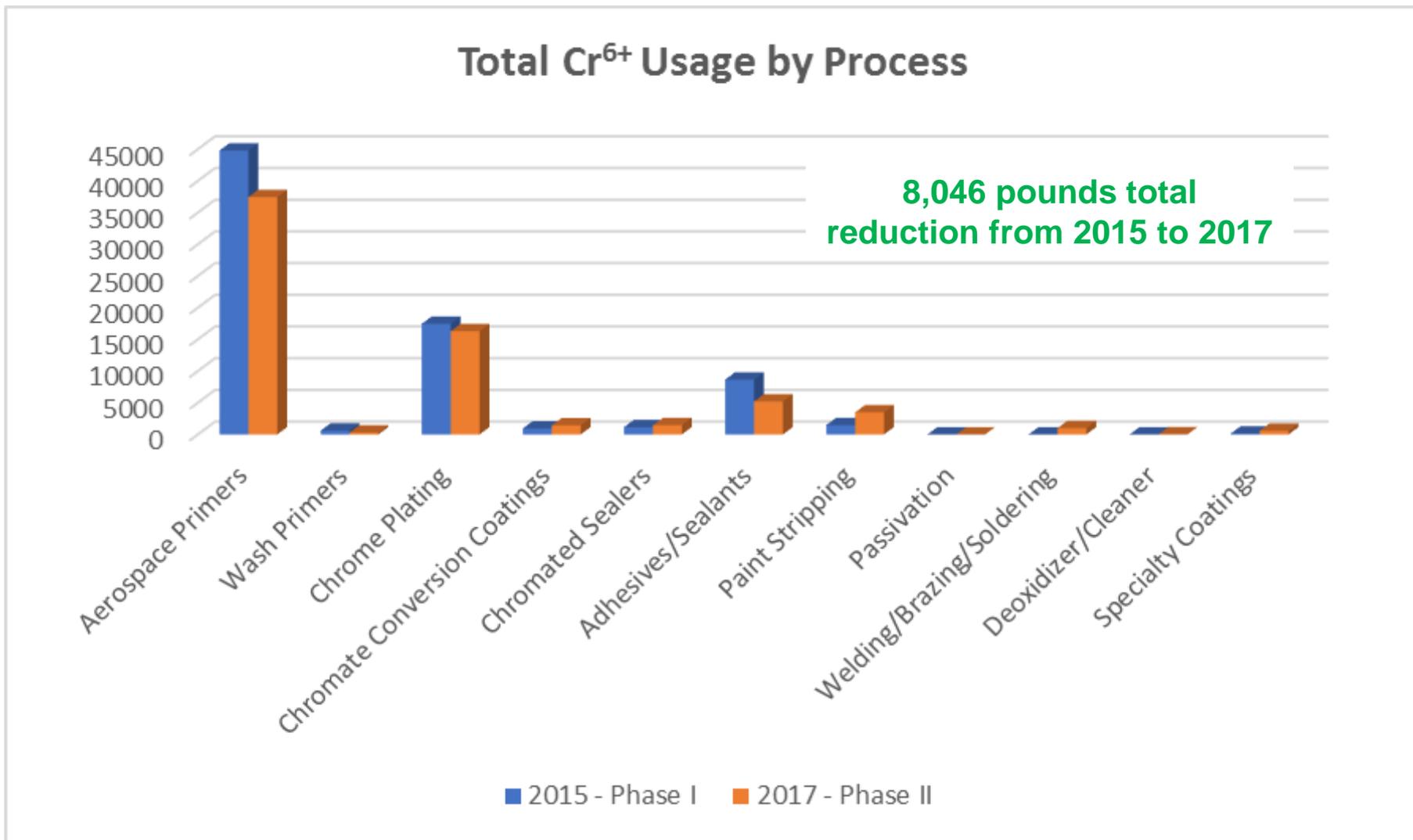
5-Year Strategy and Roadmap

Problem Definition – Cd and Cr⁶⁺ Processes

- Chromated primers
 - Aerospace primers
 - Wash primers
- Cr⁶⁺ plating
- Cd plating
- Chrome Conversion Coatings
 - Aluminum
 - Magnesium
- Stainless steel passivation
- Adhesives and sealants
- Chromic acid anodize stripping
- Cadmium brush plating
- Chromate sealers
 - Anodize
 - Phosphate coatings
 - Black oxide
 - Cadmium plating
- Topcoats and specialty coatings
- Paint stripping
- Stainless steel welding
- Chromic acid anodizing

5-Year Strategy and Roadmap

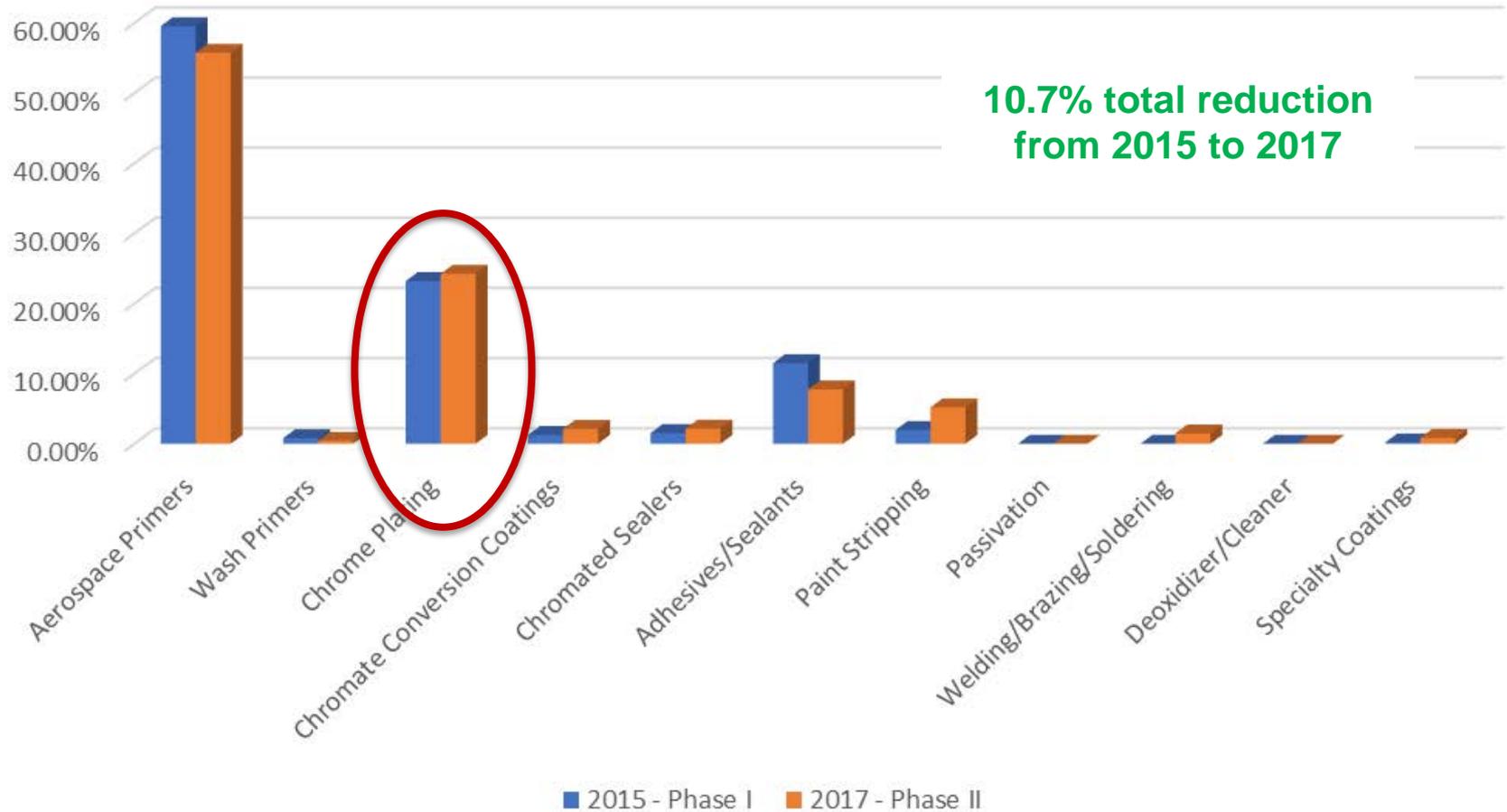
Problem Definition – Cr⁶⁺ Processes



5-Year Strategy and Roadmap

Problem Definition – Cr⁶⁺ Processes (cont.)

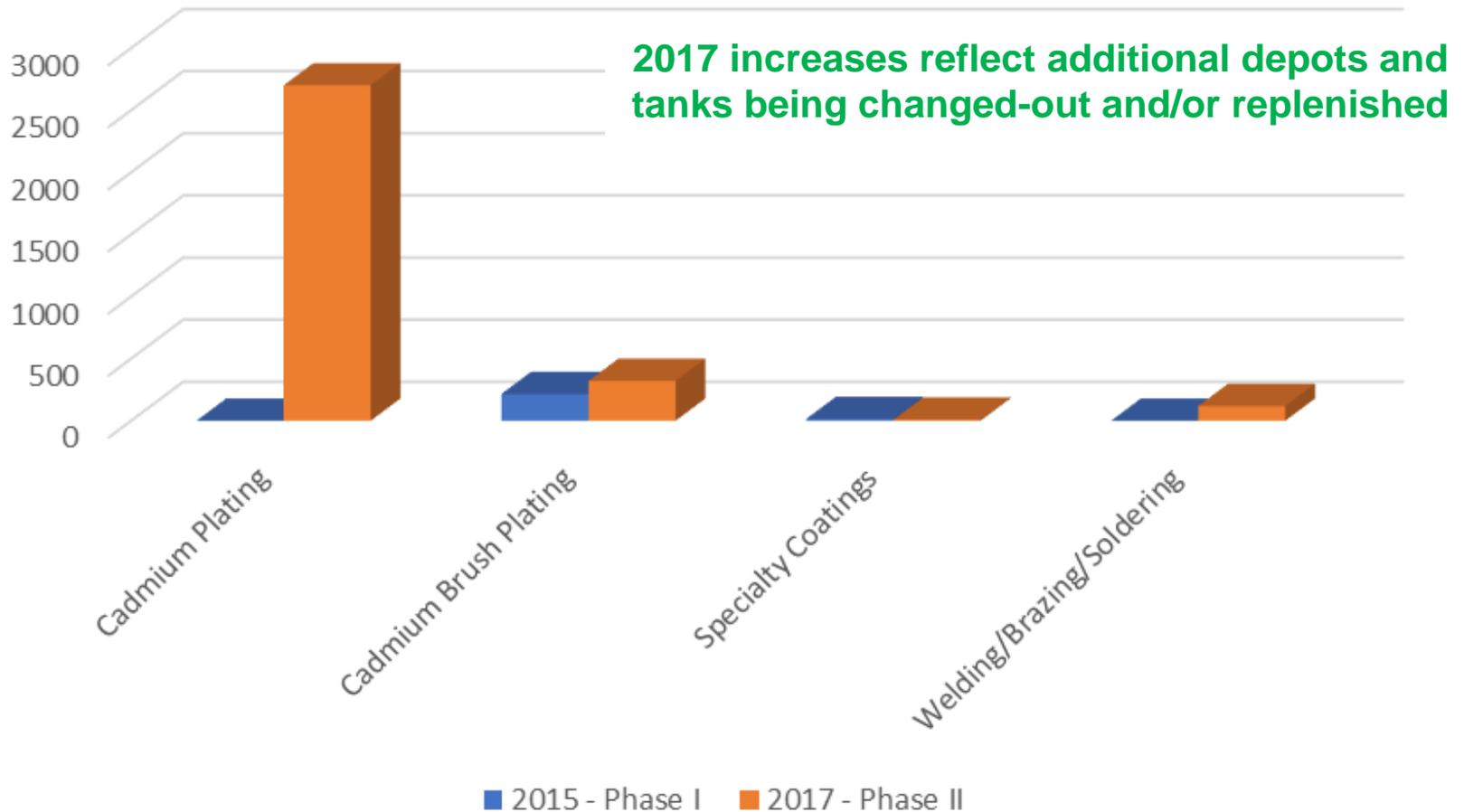
Total Cr⁶⁺ Usage by Process (percentages)



5-Year Strategy and Roadmap

Problem Definition – Cd Processes

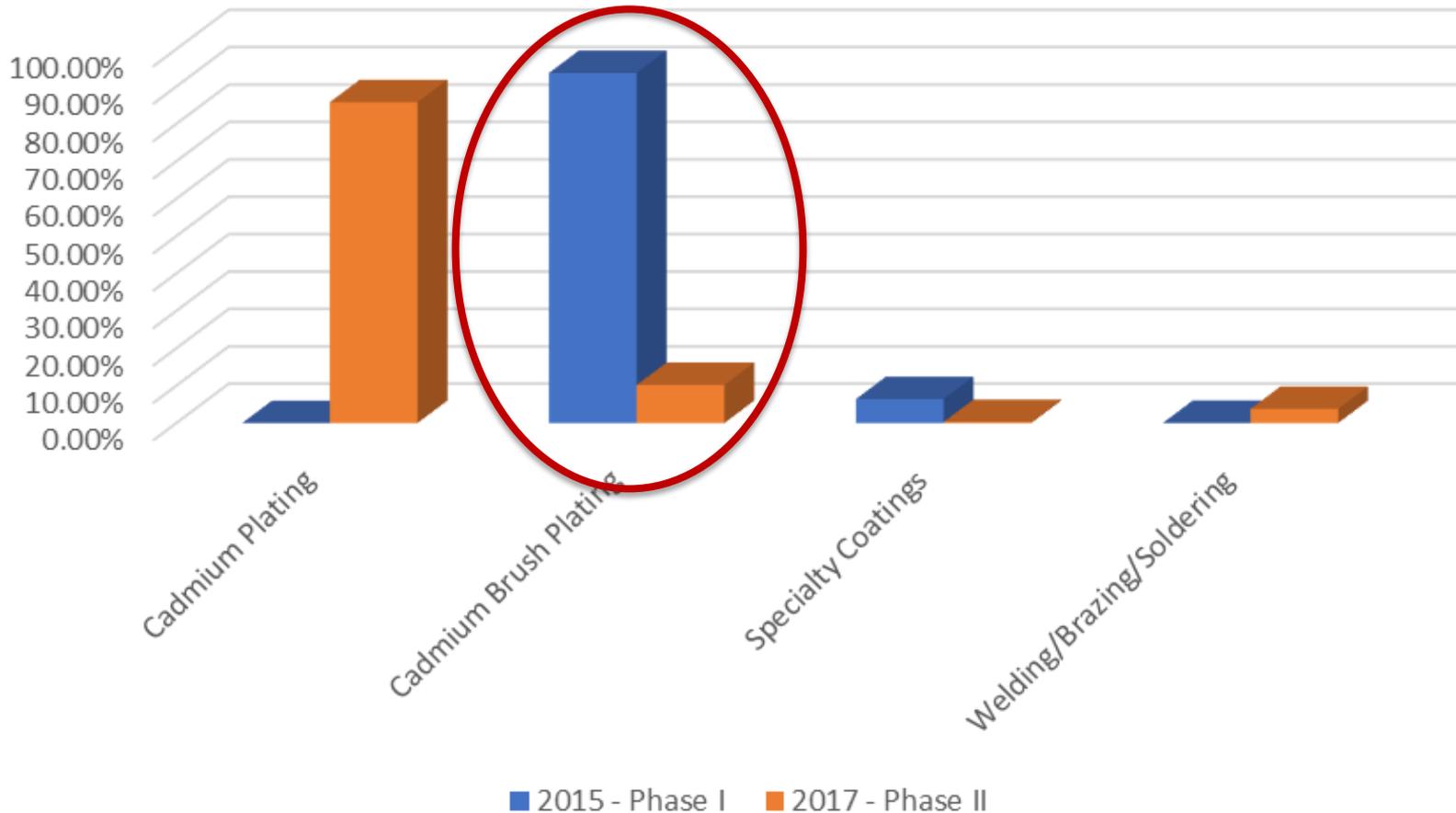
Cd Usage by Process



5-Year Strategy and Roadmap

Problem Definition – Cd Processes (cont.)

Cd Usage by Process (percentages)



5-Year Strategy and Roadmap

Background and Problem Definition

- Wastes
 - Coatings removal
 - Solid and liquid hazardous wastes
- Emissions
 - Engineering controls
 - Stainless steel welding largest source of Cr⁶⁺ emissions
- Exposures
 - Engineering controls and PPE
 - Stainless steel welding
- Infrastructure
 - For some processes, a better reference than usage
 - Reflects burden or liability



5-Year Strategy and Roadmap

Strategy and Roadmap Example

Goal 1 – Reduce the use of Cd and Cr ⁶⁺ containing compounds in DoD depots by 90% in 5 years.							
Objective	Success Metric	Baseline	Actions	Depot(s)	Priority	Initiation	Alternative Technologies
1.1 Reduce the use of chromated primers in DoD depots by 90% within 5 years.	Reduction in pounds of Cr ⁶⁺ species (e.g., strontium chromate, barium chromate) as compared to the baseline established in this Strategy and Roadmap.	37,445 lb Cr ⁶⁺	1.1.1 Non-Chromate Primer on Aircraft OML	OC-ALC, OO-ALC, WR-ALC, FRCSE, FRCE, FRCSW	1	Ongoing	Rare Earth Primers <ul style="list-style-type: none"> PPG Deft 02GN084 Hentzen 17176KEP Mg-Rich Primers <ul style="list-style-type: none"> Aerodur 2100 Al-Rich Primers ²
			1.1.2 Non-Chromate Primer on Aircraft non-OML Surfaces	OC-ALC, OO-ALC, WR-ALC, FRCSE, FRCE, FRCSW	1	Ongoing	Rare Earth Primers <ul style="list-style-type: none"> PPG Deft 02GN084 Hentzen 17176KEP Mg-Rich Primers <ul style="list-style-type: none"> Aerodur 2100 Al-Rich Primers ²
			1.1.3 Non-Chromate Primer on Off-Aircraft Components and Commodities	OC-ALC, OO-ALC, WR-ALC, FRCSE, FRCE, FRCSW	1	Ongoing	Rare Earth Primers <ul style="list-style-type: none"> PPG Deft 02GN084 Hentzen 17176KEP Mg-Rich Primers <ul style="list-style-type: none"> Aerodur 2100 Al-Rich Primers ² E-Coat

5 Year Strategy and Roadmap

Priority Tiers

- Tier 1 Priority Actions/Initiatives
 - Critical to meeting strategic reduction goals
 - High impact to readiness

- Tier 2 Priority Actions/Initiatives
 - Moderate impact to strategic reduction goals
 - Moderate to high impact to readiness

- Tier 3 Priority Actions/Initiatives
 - Not critical to meeting strategic reduction goals
 - Low to moderate impact to readiness

5-Year Strategy and Roadmap

Tier 1 Initiatives

- Non-chromate primer on aircraft outer mold line (OML)
 - Non-chromate primer on aircraft non-OML surfaces
 - Non-chromate primer on off-aircraft components and commodities
 - Alternative to chrome plating
 - Non-chromated structural adhesives and sealants
 - Non-chromated paint strippers
 - Alternative coatings removal processes to reduce Cr⁶⁺-containing waste streams
 - Implementation of engineering controls for stainless steel welding operations
-
- Alternative to cadmium plating
 - Alternative to cadmium brush plating

Depot-Specific Implementation Plans Overview

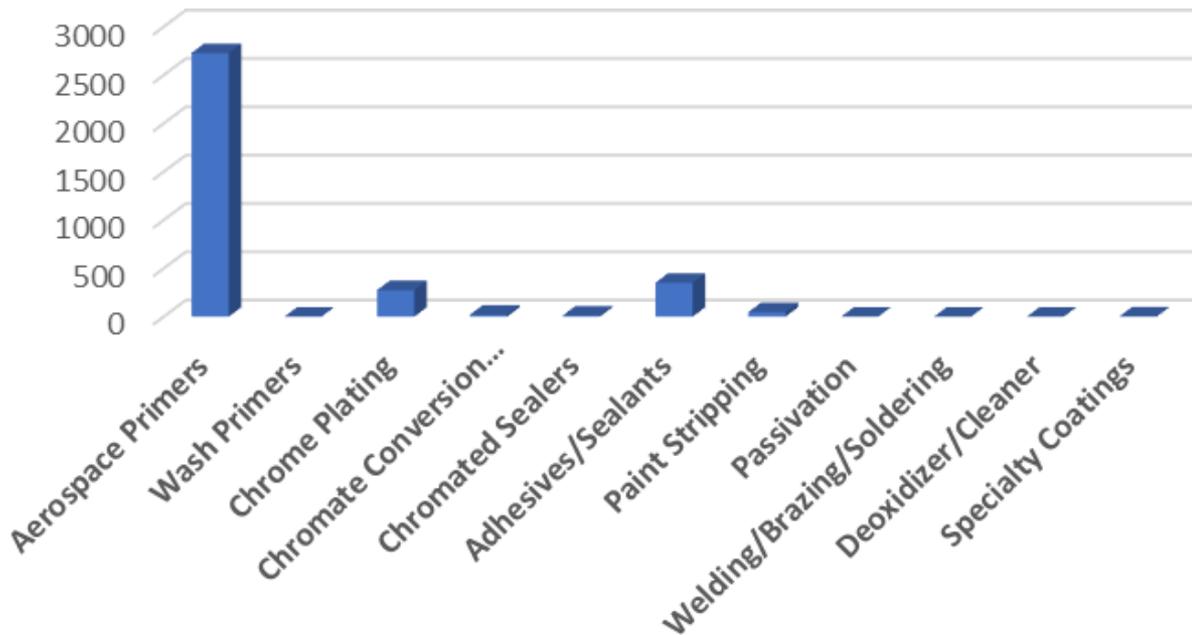
- Letterkenny Army Depot (LEAD)
- Fleet Readiness Center Southeast (FRCSE)
- Oklahoma City Air Logistics Complex (OC-ALC)
- **Fleet Readiness Center East (FRCE)**
- **Norfolk Naval Shipyard (NNSY)**
- **Marine Corps Logistics Base (MCLB) Albany**



Depot Specific Implementation Plans

FRCE – Priority Initiatives (Cr⁶⁺)

FRCE Cr⁶⁺ Usage



Tier 1 Initiatives

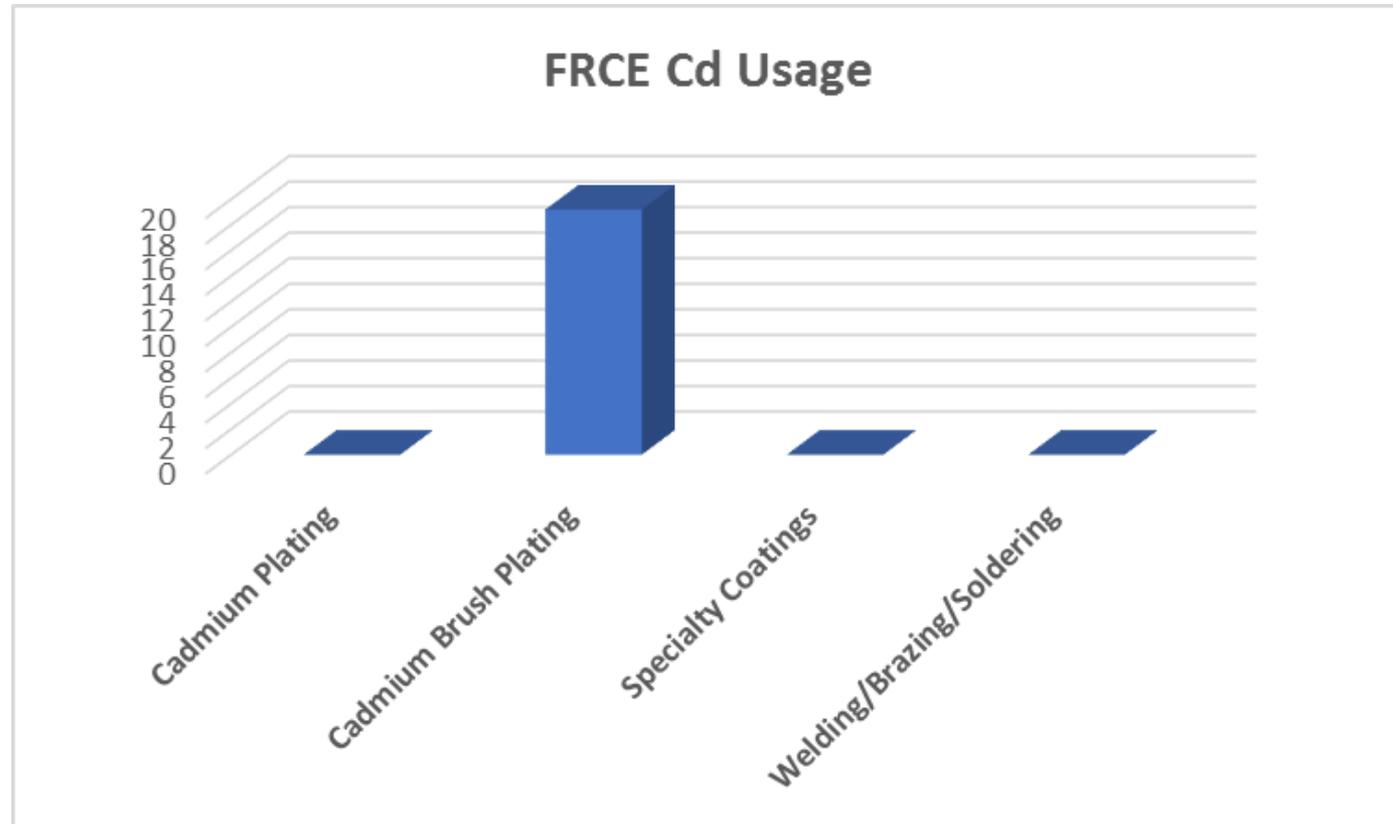
- Chrome-free primer on OML
- Non-chrome primer on non-OML applications
- Alternative to hard chrome plating
- Chrome-free adhesives and sealants

Depot Specific Implementation Plans

FRCE – Priority Initiatives (Cd)

Tier 1 Initiatives

- Alternative to cadmium brush plating
- Alternative to cadmium plating (2,785 gallons of dedicated infrastructure)



Depot Specific Implementation Plans

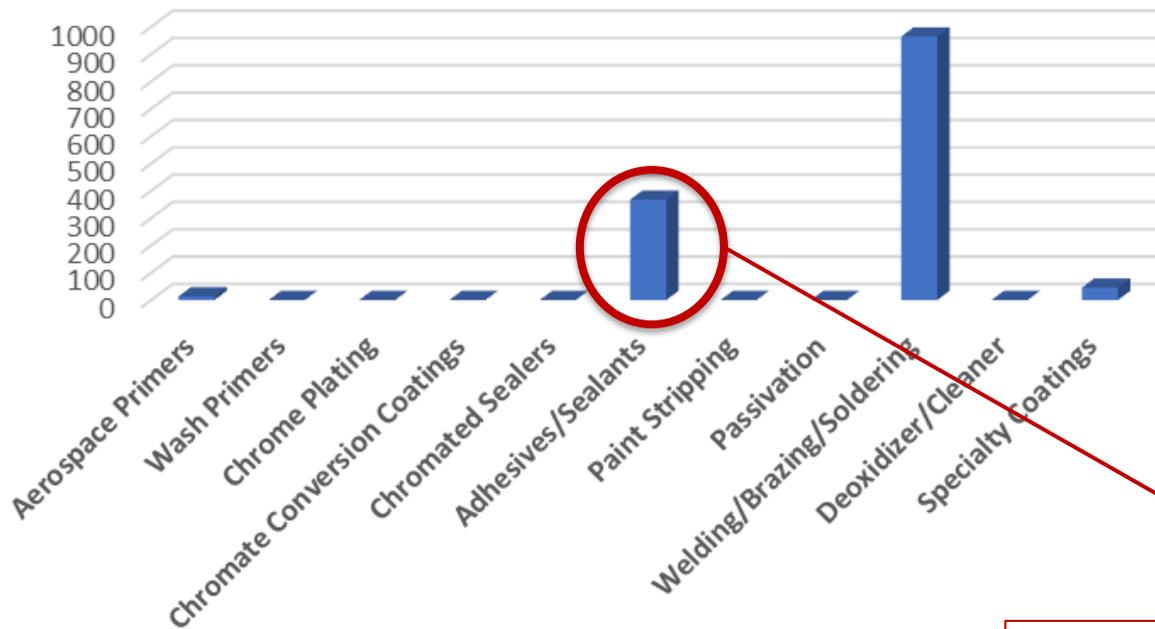
FRCE – Past and Current Efforts

- Chromated Primers
 - Non-Chrome Primers on OML of Gloss-Finish Aircraft
 - Non-Chrome Primers on OML of Tactical Aircraft
 - Comprehensive Evaluation and Transition of Non-Chromated Paint Primers (ESTCP WP-201132)
- Cadmium Plating
 - LHE ZnNi for Cd Replacement at FRCE
- Stainless Steel Passivation
 - Citric acid passivation
- Chromate Conversion Coating
 - TCP for all rotary wing aircraft (spray-on)

Depot Specific Implementation Plans

NNSY – Priority Initiatives (Cr⁶⁺)

NNSY Cr⁶⁺ Usage



Tier 1 Initiatives

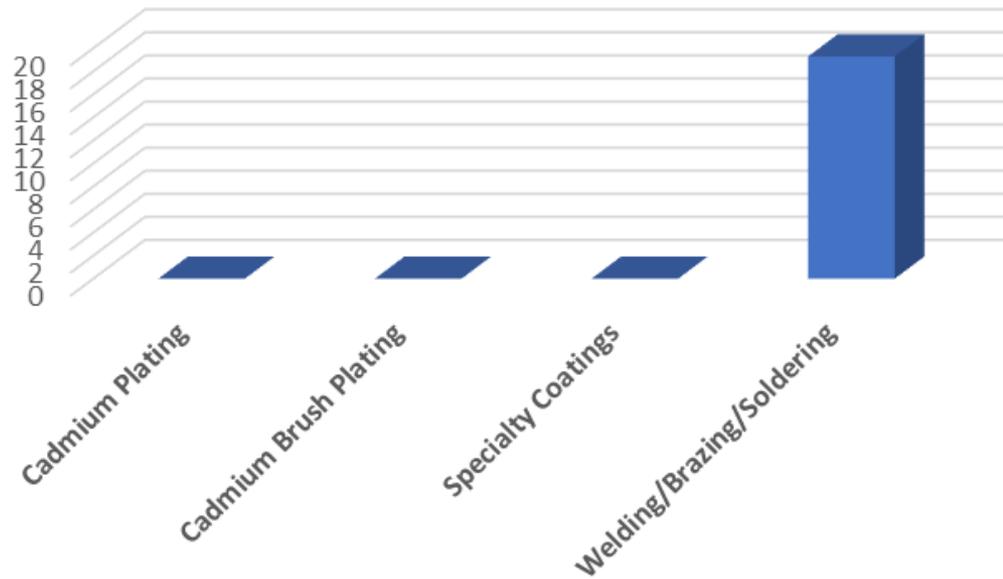
- Non-Chrome Welding Rods/Wire
- Alternative to hard chrome plating
- Alternative to chromic acid anodizing
- Alternative to Cr⁶⁺ sealer for zinc plating

Material used on a single weapon platform; workload no longer to be maintained at NNSY

Depot Specific Implementation Plans

NNSY – Priority Initiatives (Cd)

NNSY Cd Usage



Tier 1 Initiatives

- Non-cadmium soldering wire

Depot Specific Implementation Plans

NNSY – Past and Current Efforts

- Chrome plating
 - Thermal spray technologies (HVOF, plasma spray, electric arc)
- Adhesives/Sealants
 - Workload is going away
- Stainless steel welding
 - Almost all stainless steel welding is done using metal inert gas (MIG) or tungsten inert gas (TIG) welding with controls that meets current exposure standards

Depot Specific Implementation Plans

MCLB Albany – Priority Initiatives (Cr⁶⁺)

- Chromic acid anodize stripping
 - 2 – 157 gallon tanks
 - Chromic acid
 - Chromic/Sulfuric acid
 - HMMS indicated that no chromic acid was purchased in 2017 for addition to or change-out of the tank

Depot Specific Implementation Plans

MCLB Albany – Past and Current Efforts

- Aluminum chromate conversion coating
 - TCP
- Magnesium chrome conversion coating
 - Metalast TCP
- Chromated sealer for zinc phosphate
 - Oakite Gardolene D6871 non-chrome seal
- Chromated wash primers
 - Zn-rich primers

Next Steps

- Complete the update of the Strategy and Roadmap
- Complete the Implementation Plans for FRCE, NNSY, and MCLB Albany
- Outreach materials to communicate the strategy and how to use it...
 - Process One-Pagers
 - Alternative Technology One-Pagers
 - Briefing at ASETSDefense
 - Poster Session and briefing at the SERDP/ESTCP Symposium

Conclusions

- Dynamic Strategy that has changed since inception to present
- The Strategy compliments other DoD and Services programs
- In many cases, programs have been initiated to address high-impact needs
- There remain barriers to implementation
 - Risk
 - Funding
 - Technical maturity
- Still need additional outreach and collaboration to ensure all stakeholders needs are addressed

Questions?

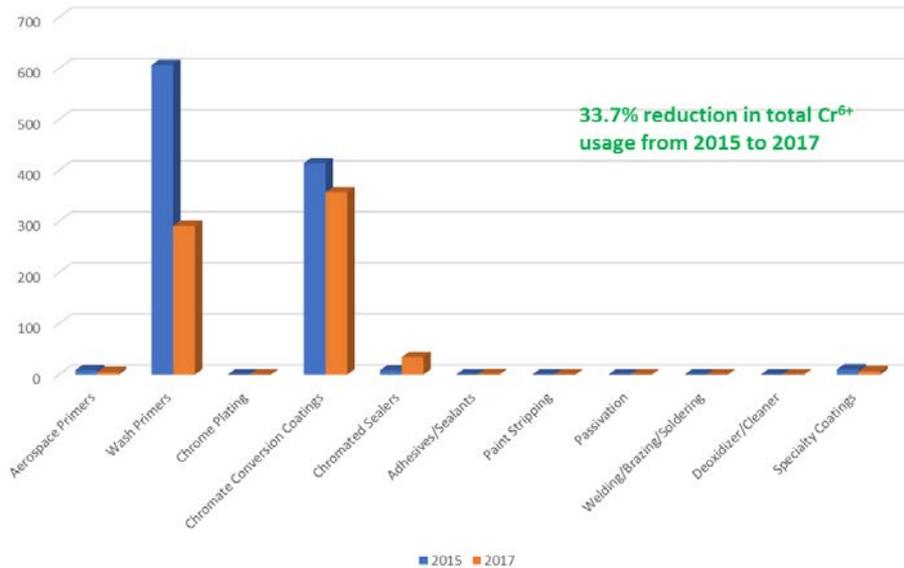


Back-Up Slides

Depot Specific Implementation Plans

LEAD – Priority Initiatives

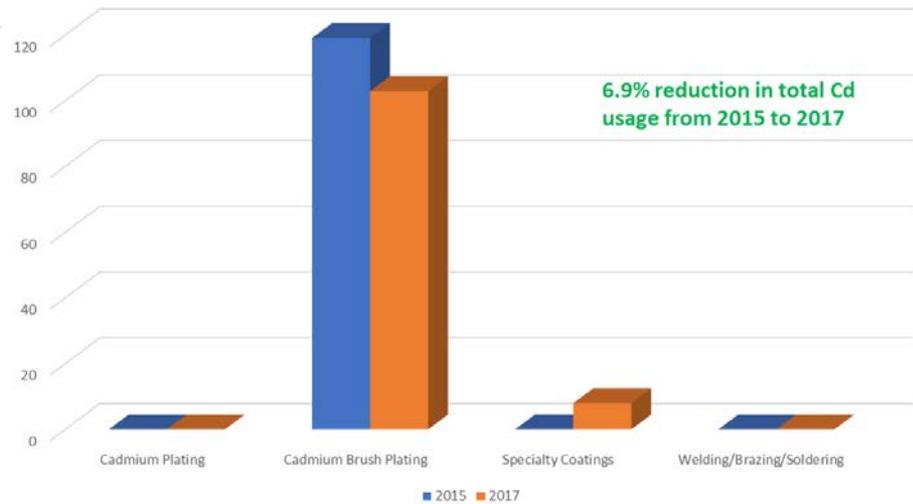
LEAD Cr⁶⁺ Usage by Process



Tier 1 initiatives

- HAP-free, non-Cr(VI) wash primer
- Non-chromate conversion coatings for Aluminum
- Alternative to Cadmium brush plating
- Reduction of Cr⁶⁺ and Cd Spent blast media

LEAD Cd Usage by Process



Depot Specific Implementation Plans

LEAD – Past and Current Efforts

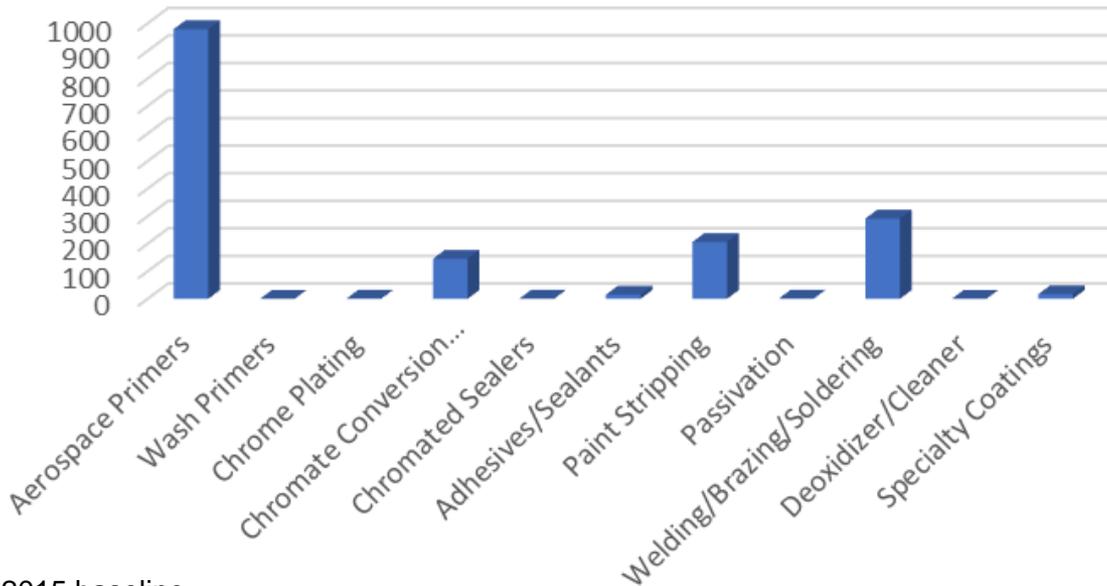
- Wash Primers
 - Replacement Alternatives to the Chromate Wash Primer DOD-P-15328 (ARL)
 - Cr (VI)-Free, Low VOC Alternatives for Spray-in-Place, Mixed Metal Pretreatment (TMR 12-01)
 - Validation/Demonstration of a Zero-VOC/HAPS-NC Wash Primer for Department of Defense Weapons Platforms (WP-201621)
 - Non-Chromate, ZVOC Coatings for Steel Substrates on Army and Navy Aircraft and Ground Vehicles (WP-200906)
- Chromated Conversion Coatings
 - Cr(VI)-Free Conversion Coatings (TMR 14-02)



Depot Specific Implementation Plans

FRCSE – Priority Initiatives

FRCSE Cr⁶⁺ Usage by Process



CY 2015 baseline

Tier 1 Initiatives (Cr⁶⁺)

- Chrome-free primer on OML
- Non-chrome primer on non-OML applications
- Non-chromate conversion coatings for Aluminum
- Alternative to hard chrome plating
- Alternative to coatings removal processes to reduce Cr⁶⁺ containing waste streams

Tier 1 Initiatives (Cd)

- Alternative to cadmium brush plating (14.97 pounds CY 2015)
- Alternative to cadmium plating (5,858 gallons of dedicated infrastructure)

Depot Specific Implementation Plans

FRCSE – Past and Current Efforts

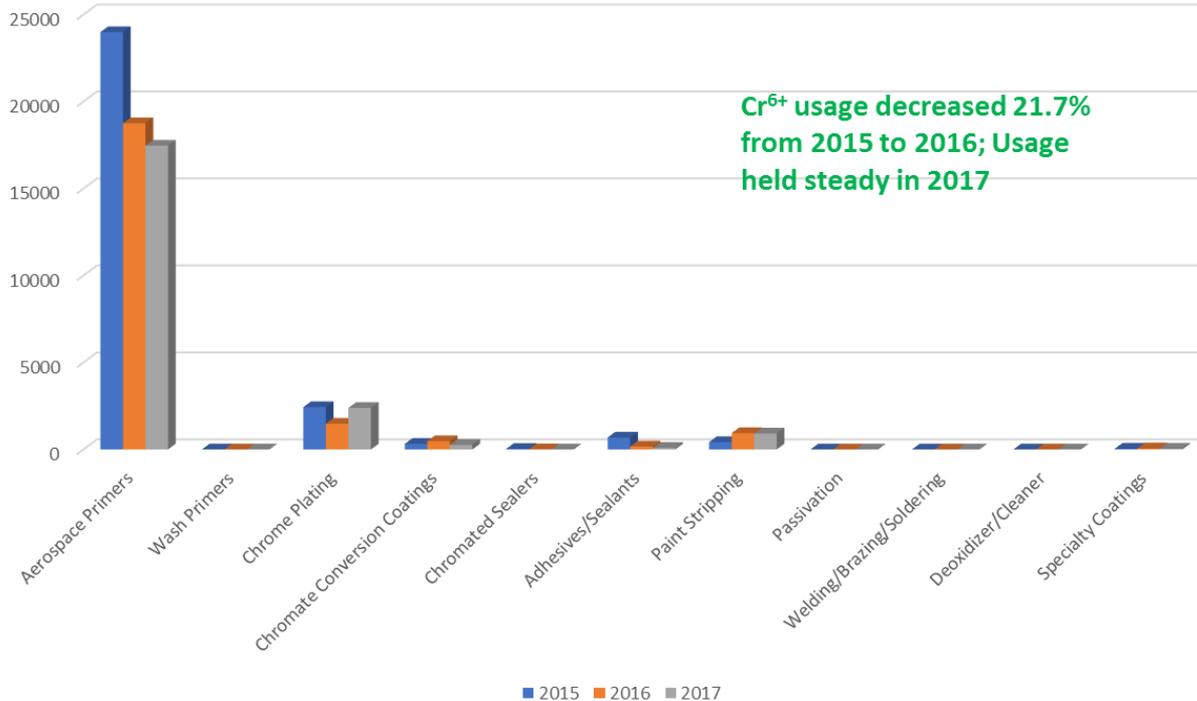
- Chromated Primers
 - Non-Chrome Primers on OML of Gloss-Finish Aircraft
 - Non-Chrome Primers on OML of Tactical Aircraft
 - Comprehensive Evaluation and Transition of Non-Chromated Paint Primers (ESTCP WP-201132)
- Chrome Plating
 - Electrodeposition of Nanocrystalline Co-P Coatings as a Hard Chrome Alternative (ESTCP WP-200936)
 - Nanocrystalline Cobalt Alloy Plating for Replacement of Hard Chrome and Thin Dense Chrome on Internal Surfaces (ESTCP WP-200411)
 - Industrial Implementation of Environmentally Friendly Nanometal Electroplating Process for Chromium and Cadmium Replacement Using Low Cost Pulse Current Power Supplies (ESTCP WP-200934)
- Cadmium Plating
 - LHE ZnNi for Cd Replacement at Jacksonville Navy Aviation Depot
- Stainless Steel Passivation
 - Citric acid passivation
- Chromate Anodize Sealer
 - Sulfuric acid anodize with TCP sealer
- Cadmium Brush Plating
 - ZnNi brush plating



Depot Specific Implementation Plans

OC-ALC – Priority Initiatives (Cr⁶⁺)

OC-ALC Cr⁶⁺ Usage by Process



Tier 1 initiatives

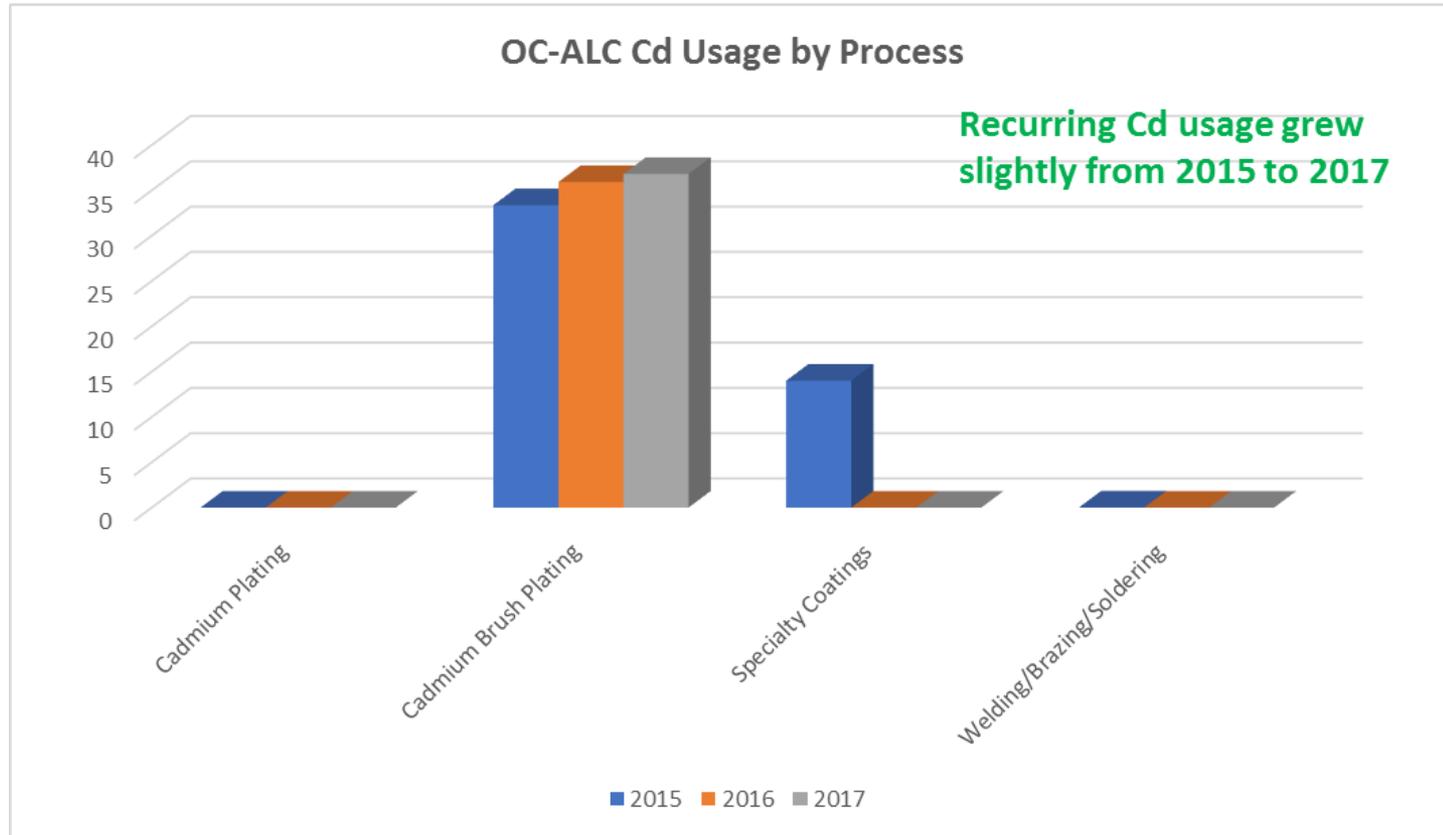
- Non-chrome primer on aircraft Outer Mold Line (OML)
- Non-chrome primer on non-OML Aircraft, components and commodities
- Non-chrome primer on composite parts
- Non-chrome electro-deposited E-Coat on KC-135 and E-3 parts
- Alternative for chrome plating
- Alternative coatings removal processes to reduce Cr⁶⁺-containing waste streams

Depot Specific Implementation Plans

OC-ALC – Priority Initiatives (Cd)

Tier 1 Initiatives

- Alternative to cadmium brush plating
- Non-cadmium containing safety red paint (Identified in 2015; since eliminated)



Depot Specific Implementation Plans

OC-ALC – Past and Current Efforts

- Chromated Primers
 - Prototype Non-Chromate Coating System on E-3
 - Prototype Non-Chromate Coating System on KC-135
 - Evaluate Chemical Stripping Properties of the Non-Chrome Mg-rich Coating System
 - Prototype Non-Chrome Electro-deposited E-Coat on KC-135 and E-3 Parts
- Chromated Conversion Coatings
 - Non-Chromate Conversion Coating on Outer Mold-Line (PreKote)
 - Non-Chromate Conversion Coating on Flight Controls (PreKote)
- Chromate Sealers
 - Non-Chrome Sealer and Primer for Anodized Parts
 - Trivalent Chrome Dipsol IZ-264 for Post Treatment of Zinc-Nickel Plating