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Cadmium Replacement Alternatives for the Joint Strike Fighter

Report to:
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Geo-Centers

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EXECUTIVE SUMMARY

This report documents our general analysis of the available technologies to replace cadmium. It is the equivalent of our earlier report for ID chrome plating replacement.[1] We have evaluated the options for replacing cadmium that appear to have the most potential, taking into account the degree of development of each technology as well as its environmental and performance issues. This is the first step in determining what will make the most sense to replace cadmium on the Joint Strike Fighter (JSF).

Part A – Cadmium Usage and Replacement Programs covers the requirements for cadmium performance for the three major types of aircraft items –components, fasteners (bolts, etc.), and electrical connectors (shells for multi-pin plugs, etc.). We also summarize current cadmium replacement programs in the US and overseas and findings of major evaluation projects by Boeing and TACOM. The section concludes with a summary of our findings and recommendations from this project.

Part B - Process Summaries of Cadmium Alternatives analyzes each of the technologies in detail. The technologies evaluated are:

Zinc-nickel aqueous electroplates	Metal-organic CVD aluminum (MOCVD Al)
Tin-zinc aqueous electroplates	Thermal spray aluminum alloys (flame and arc)
Aluminum non-aqueous electroplate (AlumiPlate)	Aluminum-ceramic slurry coatings (SermeTels)
Aluminum-manganese non-aqueous molten salt bath electroplate	Metal-filled polymers by spray and dip-spin
IVD aluminum (Ivadizing) and sputtered aluminum for IDs	New high strength stainless steel landing gear alloy

There are many other possible options, but we have covered here those that appear at the present time to offer the best chance of adoption for JSF use.

Whatever the technology chosen to succeed cadmium, there are two major issues that must be addressed

- **Chromate conversion** – An alternative must be found for chromate conversion currently required for most of these coatings.
- **Torque-tension** – Any option will require the use of some kind of lubricant coating if it is to be used on threaded fasteners.

Our conclusions are that aluminum, with its various methods of deposition, offers the best overall near-term replacement option that would be technically capable of replacing cadmium most widely. However, aluminum deposition tends to be the highest cost option.

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IVD aluminum appears to be closest to market for components, but will require replacement of chromate conversion and perhaps improvement of the coating density through the use of higher plasma densities in the deposition process.

Aqueous tin-zinc alloys appear to offer the best option for fasteners and electrical connectors, pending the outcome of testing currently under way at Boeing and NAWC.

There are some promising technologies that are currently under development

- Aluminum-manganese alloys, which appear to have the most promise for connectors (except heat-sensitive Al alloys) and fasteners – being developed at NAWC. These coatings may also be good options for components.
- Metal-organic CVD aluminum, which may similarly be a good technology for steel electrical connectors and fasteners, depending on the lowest deposition temperature at which the process will work properly
- High strength stainless steels, which avoid corrosion resistant coatings (unless they are in contact with aluminum parts). These steels are being developed for landing gear (where they would probably eliminate stress corrosion cracking, the major cause of landing gear failure), but they would also work for other aircraft parts (e.g. actuators) and fasteners.

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