

**Raytheon**

*Customer Success Is Our Mission*



AIR  
LAND  
SEA  
SPACE  
CYBER

***Aerospace Collaboration  
Activities – Raytheon  
Successfully Drives  
Implementation of Hex  
Cr Alternatives through  
Collaboration***

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# Raytheon's Sustainable Collaboration

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- Why Collaborate
- External Activities
  - Customers
  - OEMs
  - Industry Groups
  - Academia
- Internal Collaboration
  - Global Substance Program

# Raytheon's Sustainable Collaboration

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- Participate in numerous collaborative activities
  - Internally and externally, domestically and internationally
- Aerospace/Defense's unique performance requirements mandate our substance and materials needs which are often varied from other market sectors such as automotive and commercial
- Limited volumes of our specialized supply chain may affect our overall influence as individual companies
- Current economic environment for the industry makes it challenging to obtain R&D funding for new alternative materials and technologies
- Collaboration is an excellent way to:
  - Increase the overall likelihood for successful alternatives implementation
  - Decrease the time to test
  - Decrease overall cost for testing

**Combining forces for a common goal  
more effective than working individually**

# NASA TEERM - Hex Cr Free Coatings for Electronics

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## NASA Technology Evaluation for Environmental Risk Mitigation (TEERM) – Cr6+ Free Coatings for Electronics

- Determine suitability of trivalent chromium conversion coatings that meet the requirements of MIL-DTL-5541, Type II, for use in high-frequency electrical applications
- Demonstrate ability of Type II conversion coated aluminum to form adequate EMI seals
- Assess performance of the trivalent chromium coatings against the known control hexavalent chromium MIL-DTL-5541 Type I Class 3 before and after they have been exposed to a set of environmental conditions
- If a qualified technology or product is implemented, it will:
  - Meet environmental and safety regulatory requirements
  - Reduce need to monitor for chromium exposure due to new regulations
  - Decrease risk of environmental, worker and public exposure
  - Reduce maintenance cost and government liability



**Raytheon heavily involved in development and testing for JTP**

# Consortium to JTP - Structural Bond Primer

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## Industry Bond Primer Consortium

- Knowledge sharing of individual contributions towards finding non-chromate bond primer alternatives for company specific applications:
  - Alloys, Surface Preparations, Adhesives, Processing
- Boeing lead consortium with participation from:
  - Suppliers, including Cytec and 3M
  - Aerospace/Defense OEMs
  - DoD

**Gap: No existing coordinated testing efforts, creating overlap and duplication of efforts**

- Raytheon initiated a new project with the NASA TEERM office
- GOAL: Test and qualify an effective Cr6+ free, waterborne sprayable and brushable bond primer meeting corrosion resistance requirements for structural applications
- Kick Off meeting – 6/25/2014



# Customer Lead – Cr+ Free Paint Primers

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## Comprehensive Evaluation and Transition of Non-Chromated Paint Primers

- **Strategic Environmental Research and Development Program (SERDP)**
- Environmental Security Technology Certification Program (ESTCP)
  - Project WP-201132 lead by NAVAIR
  - To accelerate the implementation of non-chromate primers within the aviation community
  - 5 year study, testing and validation
  - Multiple non-DoD stakeholders including:
    - Lockheed Martin
    - Sikorsky
    - Raytheon
    - Boeing



# External Presentations - NASF SUR/FIN

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## National Association for Surface Finishing/Surface Finishing Trade Show and Conference 2014

- Sustainability Summit, Aerospace Track, Regulatory Track, etc.
  - 90 presentations over 2 ½ days - concurrent tracks sessions, trade show floor, panel discussions, keynote speakers
- Presentation on Cr6+ Free Wash Primers Alternatives
  - Available for online download to all attendees for two years
- Additional Aerospace track presenters:

Airbus

US Army Research Lab

Technical University of Denmark

Concurrent Technologies Corp

Boeing

Bell Helicopter

Lockheed Martin

Socomore



# Aerospace Industries Association (AIA)

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- Chemicals Subcommittee (formerly the REACH Working Group) - Responsible for coordinating activities related to European Union Registration, Evaluation, Authorization, and Restriction of Chemical regulations (REACH)
- There are other working groups that coordinate with the Subcommittee addressing legal, defense, IT, engineering and other aspects of REACH
- Rapid response network provides quick turn around engineering technical support
  - Where/how regulated chemicals are used in the Aerospace industry.
  - Provides consensus response on impact of the substance regulation to the industry
  - Recent reviews include:
    - Cr6+
    - Cadmium
    - Phthalates
    - Refractory Ceramic Fibers
    - Decabromodiphenyl ether (deca-BDE)
    - Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic (PFOS)



# Aerospace Chromium Elimination (ACE) Team

- Established in 1986
- Yearly face-to-face meeting rotating location and 3 teleconferences
- Common use of commercial off the shelf materials as qualified to military/industry specifications
- ACE team shares OEM successes/failures at minimizing and eliminating hexavalent chromium and cadmium thereby decreasing the duplication of efforts and maximizing the implementation of alternatives

Members:

OEMs: Boeing, Lockheed Martin, Northrop Grumman, NASA, UTC, Pratt Whitney, Sikorsky

Customers: NAVAIR, AMCOM G4, ARL, AFRL



2012 ACE Team Meeting Hosted by Raytheon Tucson

Alkaline Clean	Anodize	Anodize Seal	Bond Primer	Chrome Plate	Conversion Coating
Deoxidize	Descale	Electrical	Prebond etch	Fuel Tank Coatings	Inks
Magnesium Processing	Passivation	Primers	REACH	Sealants	High & Low Strength Cadmium

## International Aerospace Environmental Group (IAEG™)

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- Non-Profit corporation developed comprised of a global group of aerospace companies
- Established to facilitate compliance among the member companies and their shared supply chain
- Promotes the development of voluntary consensus standards, prioritized lists of declarable substances, information exchanges, and common requirements
- Raytheon has members on the team that participate on each of the various working groups (WG)
  - WG1 – Industry standard for Reporting of Chemical Content
  - WG2 – Replacement Technologies
  - WG3 – Greenhouse Gas Reporting
  - WG4 – Standard Environmental Vocabulary
  - WG5 – Common Industry approach to REACH Process Authorization
  - WG6 – Supply Chain Sustainability Survey harmonization



**Global Aerospace Industry  
One Common Approach**

**Industry Groups** 10

# CalPoly: Heavy Metal Free Marking Inks

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- Most common specification called out for marking inks is A-A-56032.
  - Current suppliers formulations for colors (red, yellow, orange, green, brown) contain combinations of Cr6+, Cadmium, and Lead
- Cal Poly San Luis Obispo Marking Inks Evaluation
  - Environmentally Friendly Marking Ink Study
  - Raytheon-funded through Global Substances Program
- Testing completed and published by graduate student with supervision from faculty and Raytheon SAS engineer.
  - Work performed by Liang Li under supervision of Dr. John Pan
  - Project managed by Aaron Stein; assistance from Andrew McBeath , Dr. John Jacobs, and David Pinsky of Raytheon
- Conclusion: Identified 2 alternatives with equivalent performance, no heavy metals and lower phenol content



# TURI: Cr6+ Free Sealant Study

- Polysulfide sealants containing soluble hexavalent chromium (Cr6+) compounds are used in various aerospace manufacturing applications including:
  - Butt joints, Faying surfaces, Wet Installation & Sealing over head of Fasteners
- Established industry/military specification testing criteria determined insufficient to differentiate between Cr6+ & non- Cr6+ sealants applications with damage
- Test vehicle design modified from MIL-PRF-81733 to include
  - damage
  - stress
  - real world hardware applications

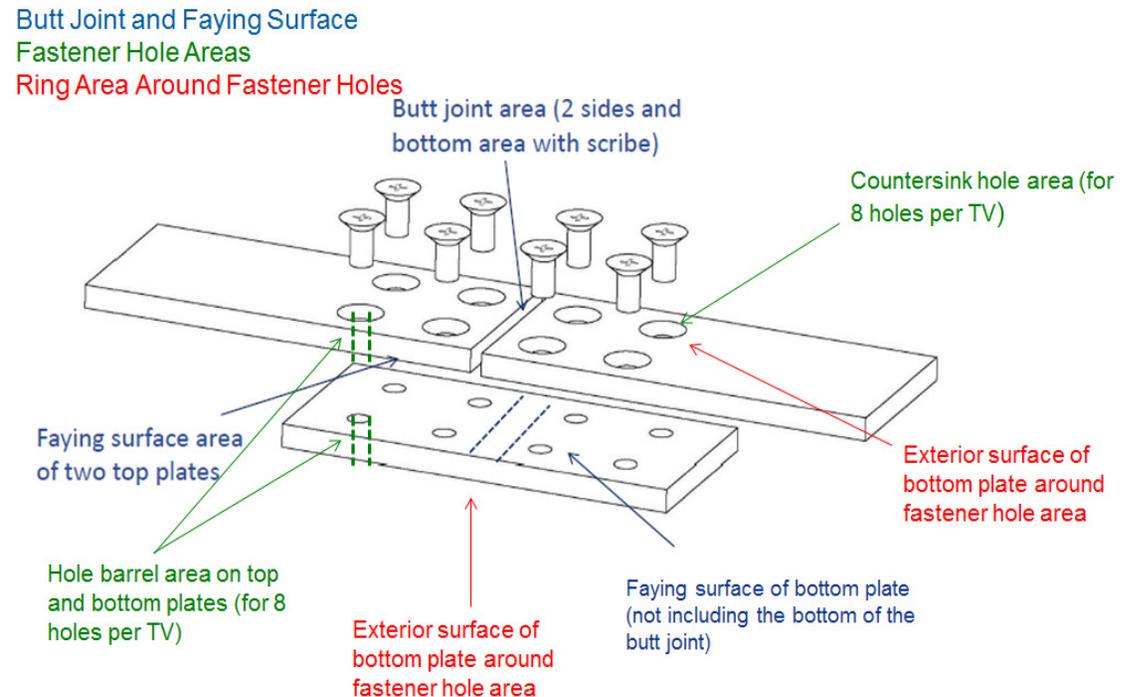


**Academia**

# TURI Cr6+ Free Sealant Study – Materials and Test Vehicle

Vendor	Vendor PN	Specification	Purpose	Chemical Class	Corrosion Inhibitor
PPG Aerospace	PS-870	MIL-PRF-81733 Type II Class 1, Grade A	Baseline	Polysulfide	Hexavalent Chromium
3M	AC-735	MIL-PRF-81733 Type II Class 1, Grade B and AMS 3265 Class B	Alternative Sealant	Polysulfide	Zinc Phosphate
PPG Aerospace	PR-1775	AMS 3265 Class B	Alternative Sealant	Polysulfide	Phosphite Salt
PPG Aerospace	PR-2870	MIL-PRF-81733 Type II Class 2 Grade B	Alternative Sealant	Polythioether	Phosphite Salt
Flamemaster	CS 5500N CI	Not yet qualified	Alternative Sealant	Polysulfide	Molybdates
PPG Aerospace	PR-1440	AMS-S-8802 Type 2 Class B	Negative Control	Polysulfide	None

Vendor	Model	Coating Type	Spec
MacDermid	Irridite 14-2	Chemical Conversion Coating	MIL-DTL-5541 Type I, CI 1a
PPG Aerospace (Deft Inc.)	44GN098	Primer	MIL-PRF-85582 Type I, CI N
PPG Aerospace (PRC-Desoto)	Kit: 8211F378 86MPY22 K	Topcoat	MIL-PRF-85285 Type I



# TURI Cr6+ Free Sealant Study - Collective Process



Test plan development  
All participants



Test vehicle CAD design  
Raytheon



Aluminum plate machining  
NASA



Conversion Coating  
(MacDermid Iridite 14-2)  
Northrop Grumman



Test Vehicle Assembly\*  
Raytheon



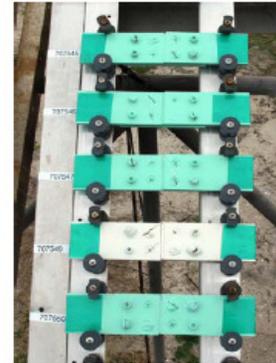
Test Vehicle Preconditioning  
U.S. Navy

\*Fasteners for the test vehicle provided by **Bombardier**

# TURI Cr6+ Free Sealant Study – Collective Process



Accelerated Corrosion Test  
1,000 hours  
SO<sub>2</sub> Salt Fog, ASTM G85 Annex 4  
(24 Test Vehicles)  
Lockheed Martin



Long-term Corrosion Test  
1 year duration  
(6 Test Vehicles)  
NASA



Sealant Removal  
TURI, UMass Lowell



Corrosion Inspection &  
Analysis  
Lockheed Martin



Statistical Analysis &  
Write Paper  
TURI, UMass Lowell

## TURI Cr6+ Free Sealant Study – Conclusions

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The Phase II Design of Experiments appears robust for the following reasons:

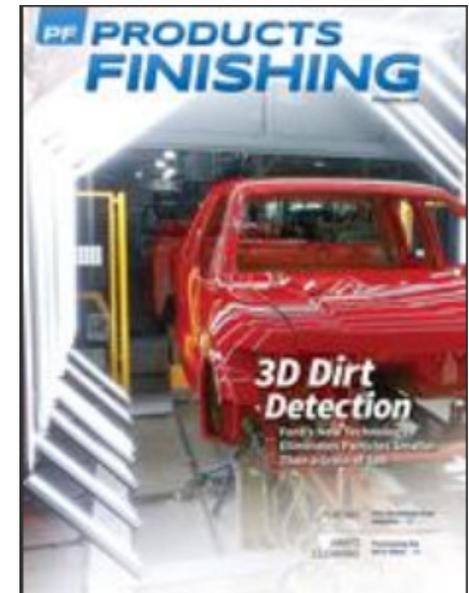
- **Experiment Power:** There were four replicates provided for each sealant type. This provided statistical differences for each of the three inspection areas.
- **Sealant Application Differentiation:** There were differences in the corrosion results for the different sealant applications (e.g. butt joint, fastener holes, etc).
- **Sealant Product Differentiation:** There were statistical differences between the corrosion inhibiting performance of the various sealant products for each of the three inspection areas.
- **CI Additive:** The sealant with no corrosion inhibitor additive had the lowest or second lowest corrosion protection for each of the three inspection areas.
- **Induced Damage:** The sealant overcoat and scribed areas had more corrosion than the sealant and un-scribed areas.
- **Sealant Protection:** The areas with sealant overcoat and no scribes had less corrosion than areas with no sealant and no scribes.

# TURI Cr6+ Free Sealant Study

## Conclusions / Publication

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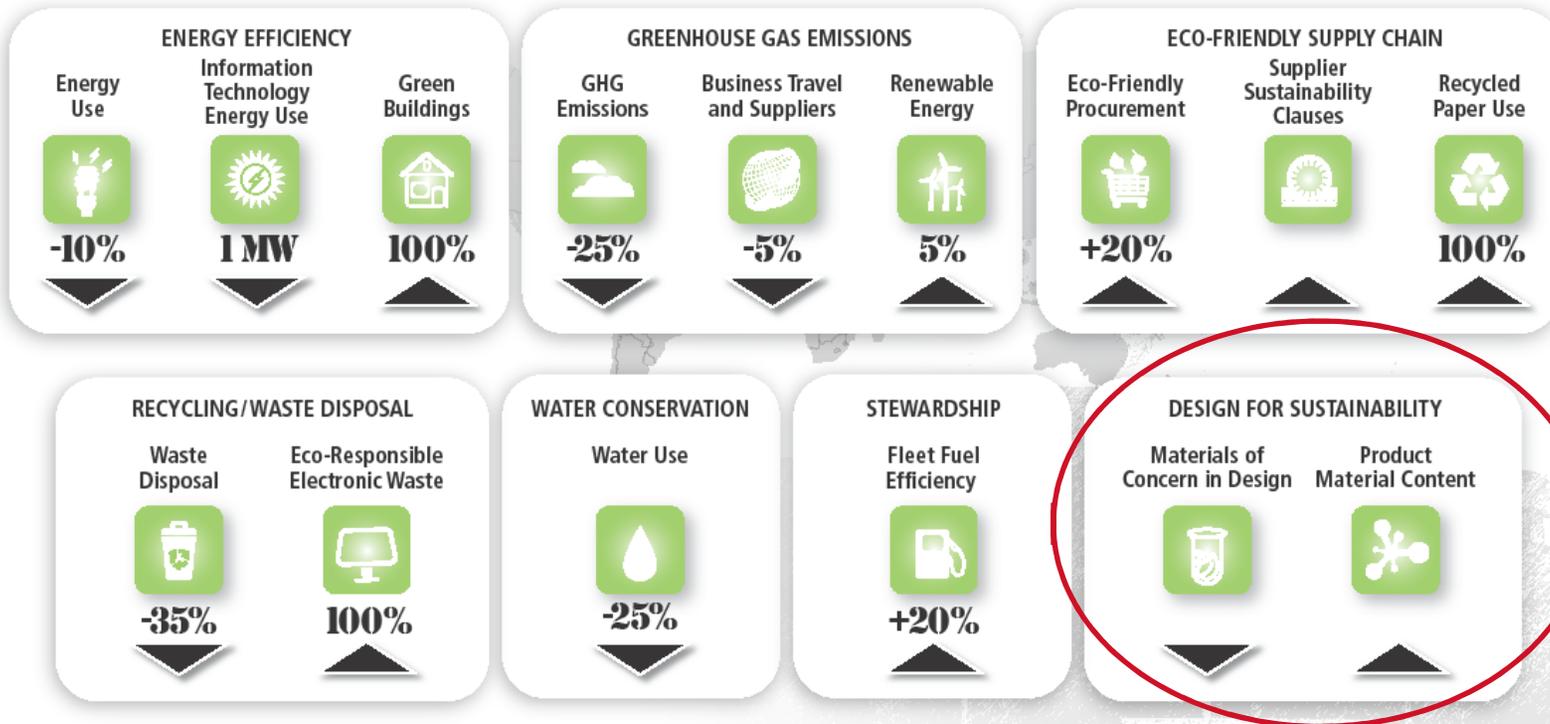
- Faying surface/butt joint areas: four alternative sealants containing non-hex chrome corrosion inhibitors provided equivalent corrosion prevention performance to the baseline sealant PS-870
  - AC-735
  - PR-1775
  - PR-2870
  - CS 5500N CI
  
- Fastener holes and ring around the fastener areas: three alternative sealants containing non-hex chrome corrosion inhibitors provided equivalent corrosion prevention performance to the baseline sealant PS-870
  - AC-735
  - PR-1775
  - PR-2870



<http://www.pfonline.com/articles/hex-chromium-free-sealants-for-defense-and-aerospace>

# Raytheon Corporate Sustainability

## 2015 SUSTAINABILITY GOALS



OUR COMMITMENT TO FUTURE GENERATIONS

# Raytheon Global Substances Program

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- Corporate-wide, cross-functional effort that addresses:
  - Substance management and compliance
  - Alternatives implementation
  - Reliable and responsible sources of supply
- Manages Design for Sustainability Goals
  - Materials of Concern and Product Material Content
  - Design for Sustainability Training
- Provides program and enterprise collaboration for REACH, Conflict Minerals, Specialty Metals, Rare Earth Elements and other product-related substance requirements



# Materials of Concern (MoCs)



**Materials of Concern in Design:** Eliminate/reduce in new and existing product design

- Minimize in Existing/Legacy Design
- Eliminate from New Design
- Current MOCs are Hexavalent Chromium (Cr6+), Cadmium (Cd)
  - Expand implementation of alternatives
  - Align Raytheon MoC process with emerging DoD/industry standards
  - Quantify MoC usage



Cadmium Bloom

<del>cadmium 48 <b>Cd</b> 112.41</del>	<del>chromium 24 <b>Cr</b> 51.996</del>
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# What is Design for Sustainability

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## Design for Sustainability

Integrated, systems-based design methodology which incorporates innovative technologies into our products and process throughout the entire lifecycle to protect our environmental and natural resources, enhance our performance, systems safety, energy security and economic vitality while preserving mission assurance



- Raytheon DfS encompasses all our activities, from hardware to software, from systems to electrical and EVERYTHING in between.
- DfS training available online or through an instructor lead course

# Summary

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- Raytheon Participates in Numerous Collaborative Activities in the Realm of Sustainability.
  
- Through Collaboration Raytheon Achieves...
  - Valuable Knowledge
  - Lessons Learned
  - Cost Sharing
  - Schedule Reduction
  - Respect and Visibility from our Customers
  - Increased Influence over Suppliers
  - Lasting Partnerships that Crosses Sectors
  
- With International and Domestic Collaboration, Raytheon Increases it's Ability to Design, Build and Support Anywhere.



**The secret is to gang up on the problem, rather than each other.**

—Thomas Stallkamp

# Questions

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