SAE G9 Meeting May 1, 2013

Hexavalent Chromium Sealant Alternatives

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Government

Industry

Academia

Key Team Members

Paul Robinson/Casey Yeary	**AMCOM G4**
Kent DeFranco/Zachary Powell/Tony Phillips	**Lockheed Martin**
Alp Manavbasi/Kevin Baranowski	**Metalast**
Diane Klienschmidt	**NAVAIR**
Kurt Kessel	**NASA**
Erich Schoch/Steve Davidson	**Northrop Grumman**
Dayna Lamb/David Pinsky	**Raytheon**
Greg Morose – TEAM LEAD	**TURI, UMass Lowell**
Alan Fletcher	**USAF**

Several additional team members played significant roles in various activities at each OEM/Agency/Company/Institution and made this project possible.

Thanks to everyone for their hard work!!!

Purpose

- Polysulfide sealants containing soluble hexavalent chromium (Cr6+) compounds are used in various aerospace manufacturing applications including:

  Butt joints Faying surfaces Wet installation of fasteners

  Sealing over the heads of fasteners Brush coating on a flat surface
- All above applications are prohibited under the DFARS rule on Cr6+ minimization
- The established industry and military specification testing criteria was determined insufficient to differentiate between hexavalent chromium containing and hexavalent chromium free sealant used in various applications where damage is expected.
  - Test vehicle and parameters based on MIL-PRF-81733 with variations primarily to induce damage , stress and to represent hardware applications
- Testing was intended to provide screening level data necessary to influence the following individual decisions regarding how to proceed with DFARS compliance.
  - Pursue Additional Screening Testing
  - Pursue Qualification Level Testing
  - Request exemptions

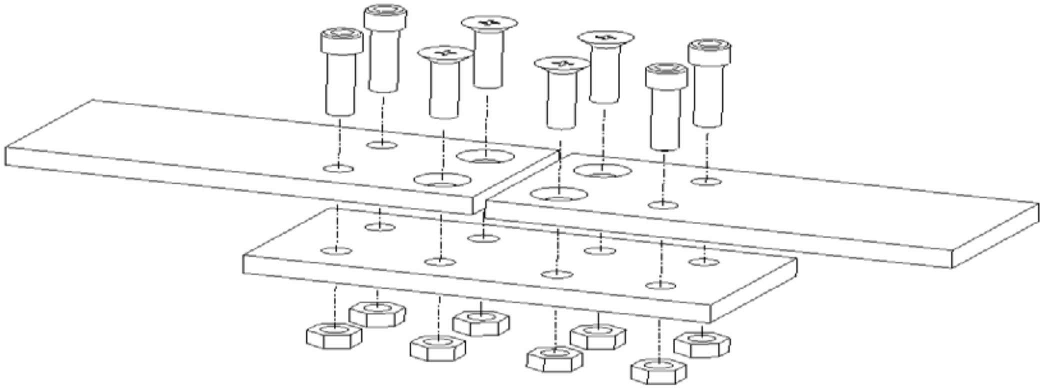
Material Selection

- Numerous sealants were considered for evaluation in the study, main criteria used in selection:
  - Contains hexavalent chromium (Y/N)
  - Alternative contains a corrosion inhibitor package (Y/N)
  - Chemistry of the corrosion inhibitors
  - Alternative qualified to a military or industry specification (Y/N)
  - Application time
  - Cure Time to 30 Shore A
  - Shore A, full cure
  - Chemical Class (polysulfide, polythioether, silicone, etc.)
- Due to limited funding the selection limited to 3 alternatives and 1 baseline

Vendor	Vendor PN	Specification	Chemistry	Corrosion Inhibitor
PPG Aerospace	PS-870	MIL-PRF-81733D Type II Class 1 Grade A	Polysulfide	Hexavalent chromium
3M	AC-735	MIL-PRF-81733D Type II Class 1 Grade B and AMS 3265 Class B	Polysulfide	Zinc phosphate
PPG Aerospace	PR-1775	AMS 3265 Class B	Polysulfide	Ammonium phosphite
PPG Aerospace	PR-2001	AMS 3277 Type II, Class B	Polythioether	None

Test Vehicle (TV) Assembly Drawing

- A single test vehicle design was developed to evaluate 5 different bonding applications (similar to MIL-PRF-81733)
  - Butt Gap
  - Faying Surface
  - Wet Installation of Fasteners
  - Sealing over Fastener Heads
  - Brush coating on a flat surface
- Each TV had 3 metal plates with matching non-threaded holes (8 per TV) through which threaded fasteners were inserted and then held in place by nuts.



Aluminum plates: 2” x 4.5” x 0.25” (alloys 6061 and 7075)

Test Vehicle Preparation

- TV materials procured and machined by TURI/UMASS Lowell
  - A286 ¼” Fasteners; NAS1102E4-14 (flat head), NAS1351N4-14 (socket head)
- Hexavalent chromium chemical conversion coated panels
  - Processed at **Northrop Grumman Linthicum, MD**
  - MacDermid Iridite 14-2
  - MIL-DTL-81706 Type I Class 1A Form II Method C
- Trivalent Chromium chemical conversion coated panels
  - Metalast TCP-HF HPA 100 panel preparation performed by **Metalast**
  - Processed at Metalast International in Minden, NV
  - Not qualified to MIL-DTL-81706

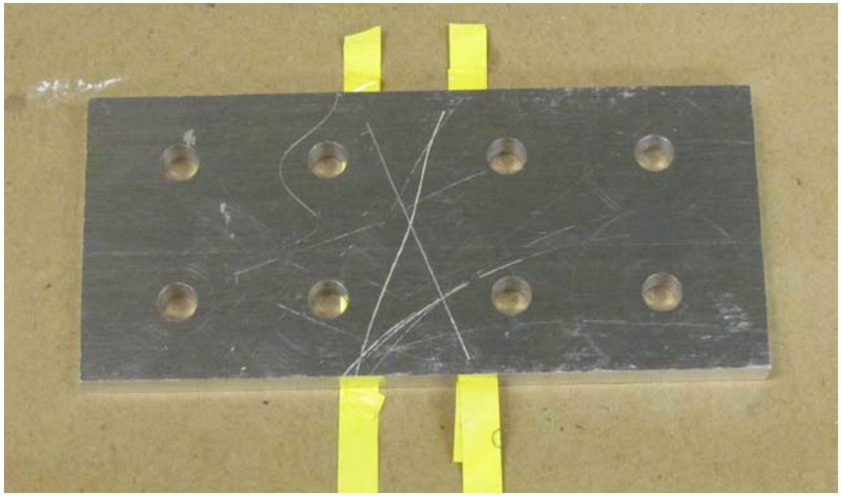
Stages	Type	Concentration	Temperature (°F)	Time (min)
Cleaner	METALAST Cleaner 1000	45g/L	120	5.0-10.0
Rinse	RO water	-	Ambient	1.0
Rinse	RO water	-	Ambient	1.0
Surface Activation	Deox 3300 (A) + *Nitric Acid	45g/L + 20% v/v	Ambient	0.5
Rinse	RO water	-	Ambient	1.0
Rinse	RO water	-	Ambient	1.0
METALAST TCP-HF HPA 100	-	30% v/v	Ambient	5.0
Rinse	RO water	-	Ambient	0.1
Dry	Forced Air	-	Ambient	-

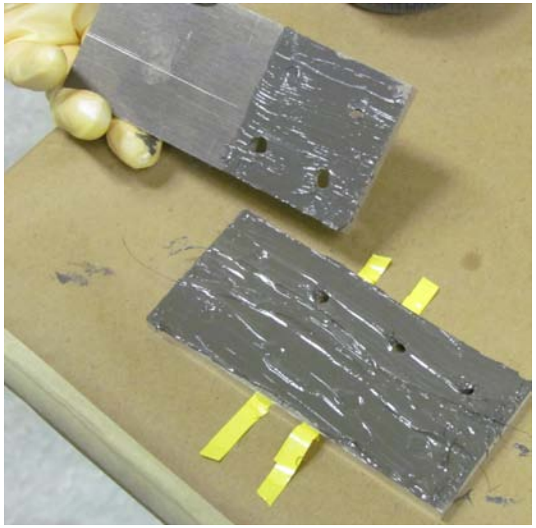
Iridite 14-2 conversion coating applied at Northrop Grumman; Linthicum, MD

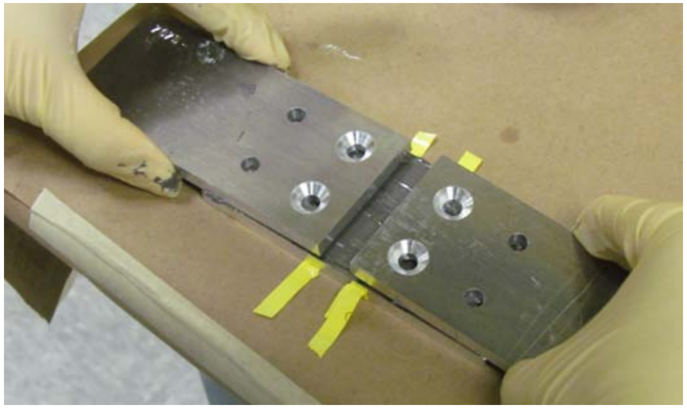
TVs Assembly Process

1. Butt Joint Scribe: Scribed the top side of the bottom plate with an "X"
2. Faying Surface: Applied approximately 0.005 inch of sealing compound to one side of each of the 3 mating TV panels with an orange stick, glass rod or equivalent. Add 0.005 inch wires to control the bond line.
3. Threaded Fasteners: Evenly coated the entire surface area of the fasteners with the appropriate sealing compound and then inserted into the freshly mated panels. Installed nuts and torqued to 40 in-lbs.
4. Butt Joint: Applied sealing compound to the butt joint with an orange stick, glass rod or equivalent to completely fill the gap, smoothed with squeegee.
5. Wiped clean excess sealant from the entire TV prior to proceeding.
6. Fastener Heads: Completely covered over and around two of each type of fastener head, on each TV, as well as the corresponding nuts.
7. Flat Plate Surface: Applied two strips of 0.005 to 0.007 in thick tape approx 0.025 in apart on the opposite side of the butt gap between the recessed fasteners. Filled the area between the tape with sealant, smoothed with a squeegee.
8. Curing: Allowed entire TV to cure for 48 hours at room temperature.
9. Prime and Paint: Applied primer and topcoats to the test vehicles according to manufacturer instructions.

TV Assembly Process Photos

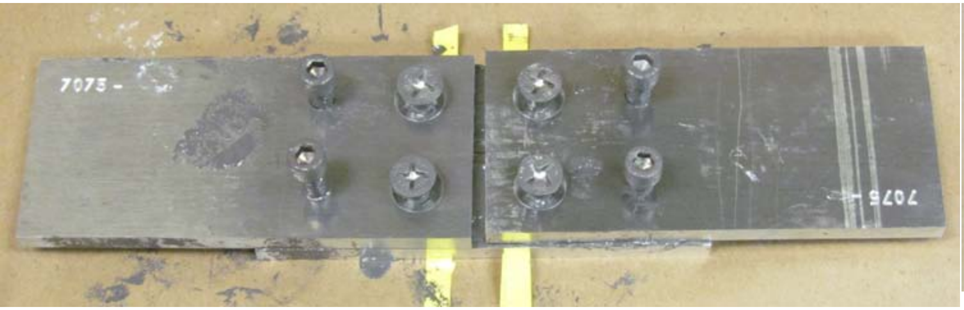


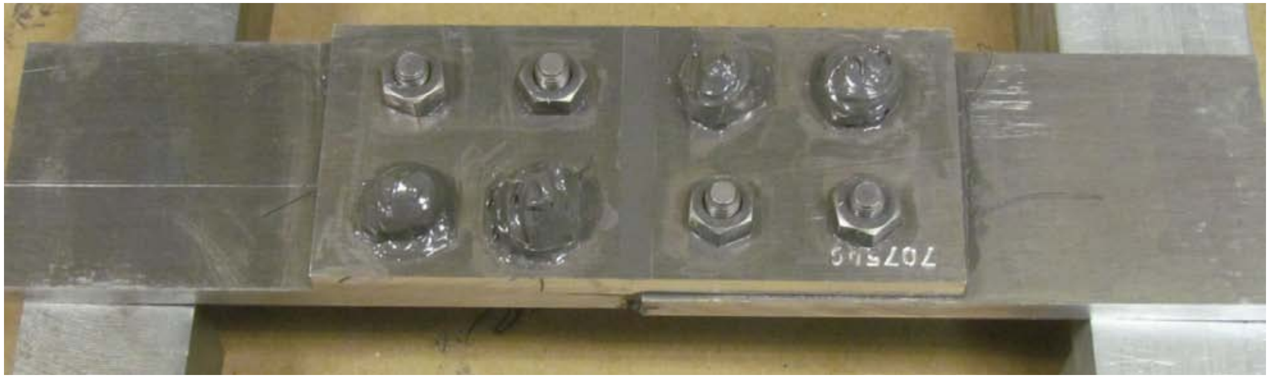




TV Assembly performed at Raytheon Missile Systems; Tucson, AZ

TV Assembly Process Photos

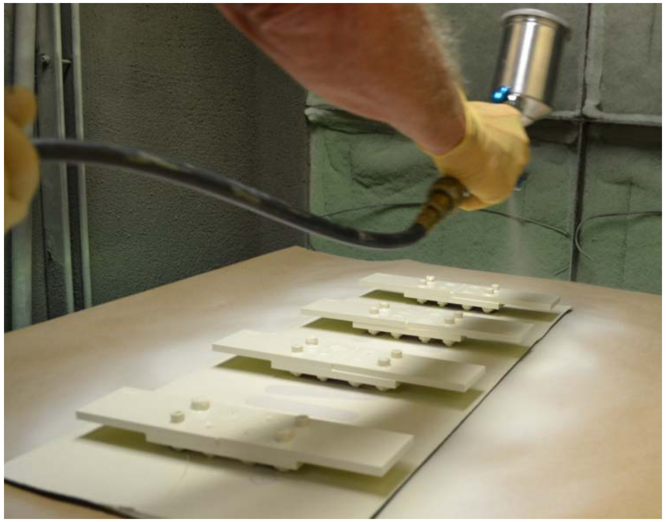




TV Assembly performed at Raytheon Missile Systems; Tucson, AZ

Priming and Painting

Vendor	Model	Primer/ Topcoat	Specification	Hexavalent Chromium Containing
Akzo Nobel Aerospace Coatings	10P20-13 High solids epoxy primer + EC-213 HS epoxy primer cure solution	Primer	MIL SPEC PRF 23377, Type 1, Class C	Yes
Deft Inc.	44GN098 1GK base and catalyst	Primer	MIL SPEC PRF 85582, Type 1, Class N	No
PRC-Desoto of PPG Aerospace	CA8211, 8211F37886MPY 22K	Topcoat	MIL SPEC PRF 85285, Type 1	No



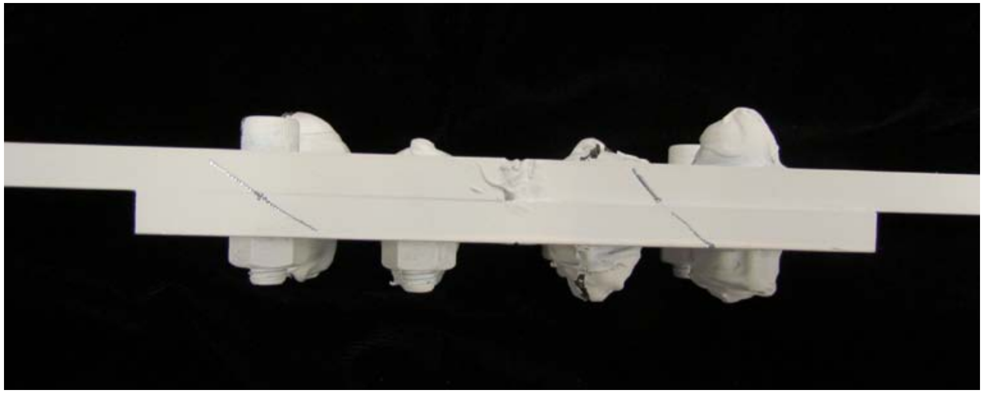
In order to get complete coverage of the areas with sealant and prevent exceeding the maximum thickness requirements for the entire TV, hand priming and painted was performed over the sealant areas prior to spray application to the manufacturers instructions.

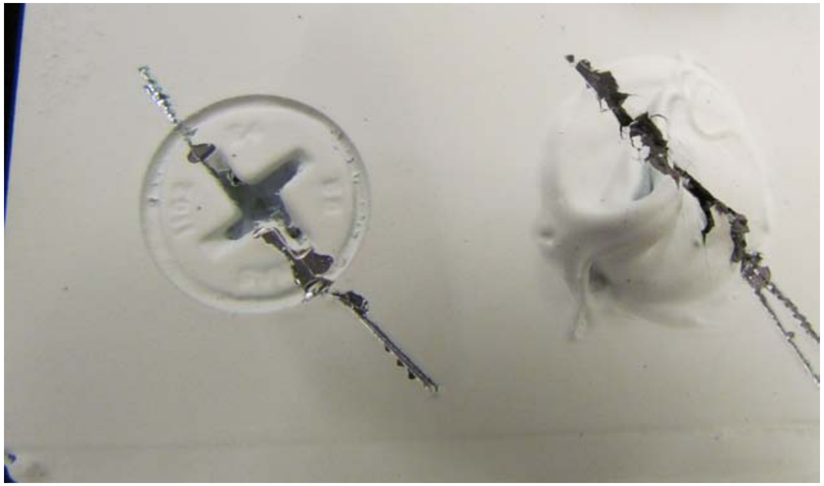
Induced Damage – Scribing

One of the major differences with this test plan and MIL-STD-81733 is that there is damage induced to the specimens.

Scribed Test Vehicles:

- Scribes were generated by an Erichsen Scratch Stylus acc to Sikkens Model 463 with a 1 mm wide carbon tip.
- Scribed an “X” at the base of butt gap prior to addition of butt gap sealant material.
- Scribed through the primer/topcoat at edge of test vehicle in four locations.
- Scribed along brush coat area on the bottom plate flat surface area.
- Scribed over four fastener heads (two flush heads and two protruding heads) and two nuts on each test vehicle.





TV Assembly scribing performed at Raytheon Missile Systems; Tucson, AZ

Preconditioning

- The purpose of this testing was to simulate the severe operating environment of various aerospace/defense applications
  - Provides mechanical and thermal preconditioning to stress the sealant joints prior to salt fog testing

- Preconditioning executed IAW MIL-PRF-81733D Section 4.8.9.3.1 Cyclic Loading for Class 1 materials
  - -65°F soak for 30 min with no load, followed by cyclic loading between 0 & 5,000 lbs.
  - 250 cycles per each test vehicle

Preconditioning performed by NAVAIR at Patuxent River, Maryland facility

Salt Fog Testing at Lockheed Martin

SO2 Salt Fog IAW ASTM G85 Annex 4

- 6 hr cycles in an environmentally controlled chamber

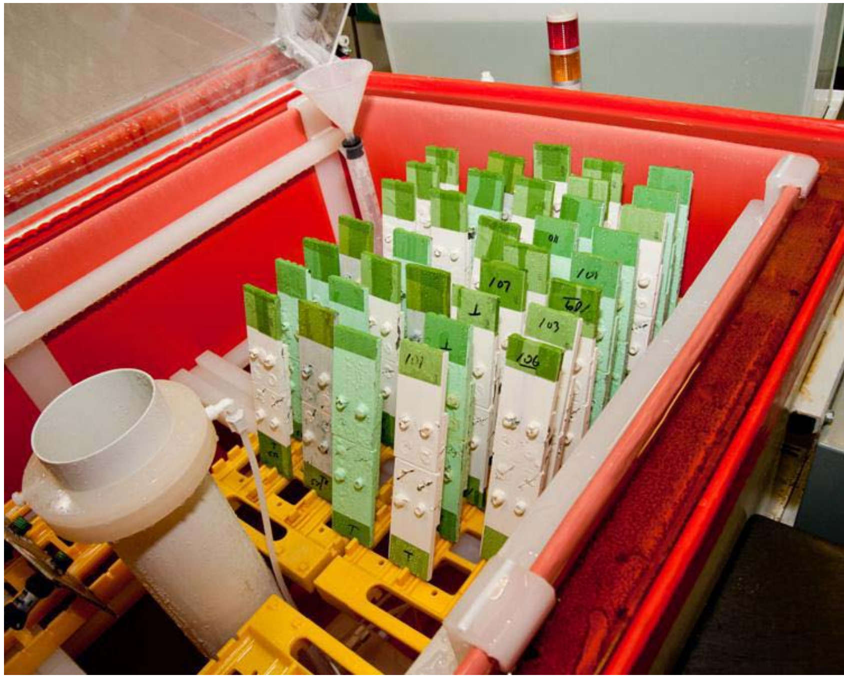
- 5% NaCl solution (aq) was constantly sprayed into the chamber for all 6 hours of the cycle at a collection rate of 1-2 ml/hr

- After the first 5 hrs of the cycle, SO2 gas was introduced into the chamber for 1 hr to complete the cycle

- 6 hr cycle was continuously repeated for 1008 hours

- Chamber kept at 95 +/- 3 °F and the temperature in the air saturator tower was kept at 117 +/- 2 °F

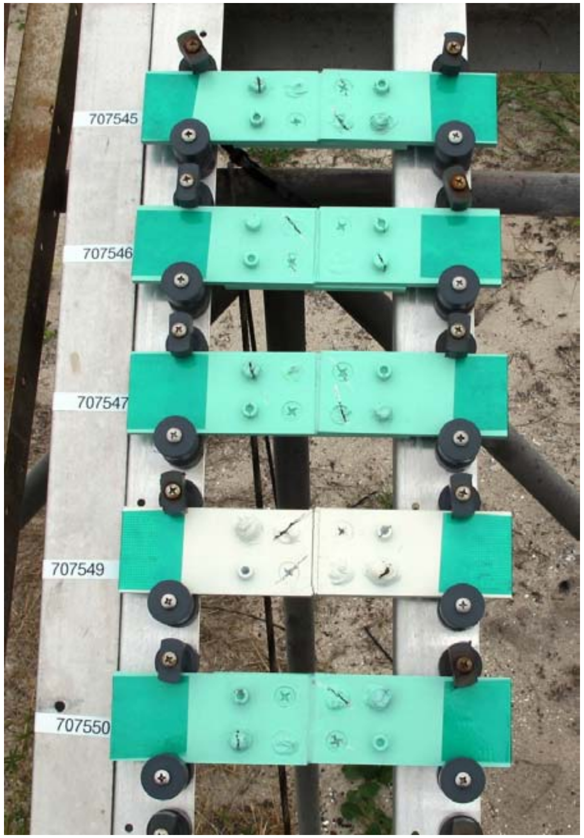
- pH kept in the range of 2.5 -3.2, controlled by adjusting the flow rate of SO2 gas



SO2 Salt Fog Chamber at Lockheed Martin Aeronautics Company, Fort Worth, TX

NASA Beachfront Testing

- Five test vehicles are currently at NASA Beachside Atmospheric Test Facility, Kennedy Space Center, FL
- Provides real-time corrosion experiments and remote monitoring of surrounding weather conditions including wind speed and direction, and rainfall.
- The results of the beach testing are not included in this report, but will occur over a 12 month duration. To be completed in November, 2013.



Number	Alloy	Sealant	Conversion Coating	Secondary Finish	Test
45	7075	P/S-870	Iridite 14-2	HCF primer only	Beachfront
46	7075	AC-735	Metalast	HCF primer only	Beachfront
47	7075	PR-1775	Metalast	HCF primer only	Beachfront
49	7075	P/S-870	Iridite 14-2	HCF primer only + Topcoat	Beachfront
50	7075	PR-2001	Metalast	HCF primer only	Beachfront

NASA Beachside Atmospheric Test Facility, Kennedy Space Center, FL

Design of Experiments

Number	Alloy	Sealant	Conversion Coating	Secondary Finish	Test
1	6061	PS-870	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
2	6061	PS-870	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs
3	6061	AC-735	Metalast TCP	HCF Primer & Topcoat	Salt fog 1,008 hrs
4	6061	AC-735	Metalast TCP	HCF Primer Only	Salt fog 1,008 hrs
5	6061	AC-735	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
6	6061	AC-735	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs
7	6061	PR-1775	Metalast TCP	HCF Primer & Topcoat	Salt fog 1,008 hrs
8	6061	PR-1775	Metalast TCP	HCF Primer Only	Salt fog 1,008 hrs
9	6061	PR-1775	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
10	6061	PR-1775	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs
11	6061	PR-2001	Metalast TCP	HCF Primer & Topcoat	Salt fog 1,008 hrs
12	6061	PR-2001	Metalast TCP	HCF Primer Only	Salt fog 1,008 hrs
13	6061	PR-2001	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
14	6061	PR-2001	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs

Design of Experiments

Number	Alloy	Sealant	Conversion Coating	Secondary Finish	Test
15	7075	PS-870	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
16	7075	PS-870	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs
17	7075	AC-735	Metalast TCP	HCF Primer & Topcoat	Salt fog 1,008 hrs
18	7075	AC-735	Metalast TCP	HCF Primer Only	Salt fog 1,008 hrs
19	7075	AC-735	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
20	7075	AC-735	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs
21	7075	PR-1775	Metalast TCP	HCF Primer & Topcoat	Salt fog 1,008 hrs
22	7075	PR-1775	Metalast TCP	HCF Primer Only	Salt fog 1,008 hrs
23	7075	PR-1775	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
24	7075	PR-1775	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs
25	7075	PR-2001	Metalast TCP	HCF Primer & Topcoat	Salt fog 1,008 hrs
26	7075	PR-2001	Metalast TCP	HCF Primer Only	Salt fog 1,008 hrs
27	7075	PR-2001	Iridite 14-2	HCF Primer & Topcoat	Salt fog 1,008 hrs
28	7075	PR-2001	Iridite 14-2	HCF Primer Only	Salt fog 1,008 hrs

Design of Experiments

Number	Alloy	Sealant	Conversion Coating	Secondary Finish	Test
29	7075	PS-870	Iridite 14-2	HC Primer & Topcoat	Salt fog 1,008 hrs
30	7075	PS-870	Iridite 14-2	HC Primer Only	Salt fog 1,008 hrs
31	7075	AC-735	Iridite 14-2	HC Primer & Topcoat	Salt fog 1,008 hrs
32	7075	AC-735	Iridite 14-2	HC Primer Only	Salt fog 1,008 hrs
33	7075	PR-1775	Iridite 14-2	HC Primer & Topcoat	Salt fog 1,008 hrs
34	7075	PR-1775	Iridite 14-2	HC Primer Only	Salt fog 1,008 hrs
35	7075	PR-2001	Iridite 14-2	HC Primer & Topcoat	Salt fog 1,008 hrs
36	7075	PR-2001	Iridite 14-2	HC Primer Only	Salt fog 1,008 hrs

Early Failure Analysis & Beachfront Testing

Number	Alloy	Sealant	Conversion Coating	Secondary Finish	Test
37	7075	PS-870	Iridite 14-2	HCF Primer Only	Salt fog 336 hrs
38	7075	AC-735	Metalast TCP	HCF Primer Only	Salt fog 336 hrs
39	7075	PR-1775	Metalast TCP	HCF Primer Only	Salt fog 336 hrs
40	7075	PR-2001	Metalast TCP	HCF Primer Only	Salt fog 336 hrs
41	7075	PS-870	Iridite 14-2	HCF Primer Only	Salt fog 672 hrs
42	7075	AC-735	Metalast TCP	HCF Primer Only	Salt fog 672 hrs
43	7075	PR-1775	Metalast TCP	HCF Primer Only	Salt fog 672 hrs
44	7075	PR-2001	Metalast TCP	HCF Primer Only	Salt fog 672 hrs
45	7075	PS-870	Iridite 14-2	HCF Primer Only	Beachfront
46	7075	AC-735	Metalast TCP	HCF Primer Only	Beachfront
47	7075	PR-1775	Metalast TCP	HCF Primer Only	Beachfront
50	7075	PR-2001	Metalast TCP	HCF Primer Only	Beachfront

Note: Test vehicle numbers 48 and 49 are spares – 49 used for Beachfront testing

Results/Inspection

Non-destructive Inspection Results

- Inspections used to examine the outer appearance of the test vehicles
- Performed on all of the test vehicles at the following intervals of exposure to the salt fog:
  - ➢ 168 hours (1 week)
  - ➢ 336 hours (2 weeks)
  - ➢ 672 hours (4 weeks)
  - ➢ 1,008 hours (6 weeks)
- Inspection provided valuable information regarding the outside appearance of the test vehicles

Destructive Visual Inspection Results

- TVs were dismantled to conduct the destructive inspection so that the amount of corrosion could be recorded
- Performed on
  - ➢ 4 TVs after 2 weeks
  - ➢ 4 TVs after 4 weeks
  - ➢ 36 TVs after 6 weeks
- TVs were dismantled by removing the fasteners, separating the plates of the test vehicles, and stripping sealant with toluene to reveal the inner surfaces that were protected by sealant

Results/Inspection

The test vehicles were divided into three categories

1) 6061 aluminum alloy with hex-chrome free (HCF) primer
2) 7075 aluminum alloy with HCF primer
3) 7075 aluminum alloy with hex-chrome (HC) primer

Within the three categories of test vehicles, there were two areas of interest: (6 groups total)

1) butt joint and faying surface related areas
2) fastener countersunk related areas

Ratings for the amount of corrosion in each area of interest were recorded as a percentage

0% = no corrosion was present 100 % = complete corrosion

Corrosion was only recorded if there was deterioration of the metal (pitting).

For duplicate TVs, the corrosion values were averaged

The primary performance indicator of sealant corrosion inhibition was determined to be the butt joints and faying surfaces category; due to the large amount of surface area the sealant was required to protect

Results

Butt Joints and Faying Surfaces (TVs 1-14)		
6061 with HCF Primer		
Sealant	Surf. Prep.	Average Corrosion
PS-870	Iridite	0.5%
PR-1775	Iridite	0.8%
PR-1775	Metalast	1.0%
AC-735	Iridite	1.0%
PR-2001	Iridite	2.7%
AC-735	Metalast	3.7%
PR-2001	Metalast	12%

Countersink Areas (TVs 1-14)		
6061 with HCF Primer		
Sealant	Surf. Prep.	Average Corrosion
PR-2001	Metalast	0.8%
PR-2001	Iridite	1.0%
PR-1775	Metalast	1.1%
PR-1775	Iridite	1.4%
PS-870	Iridite	1.4%
AC-735	Iridite	2%
AC-735	Metalast	2%

Butt Joints and Faying Surfaces (TVs 15-28)		
7075 with HCF Primer		
Sealant	Surf. Prep.	AverageCorrosion
AC-735	Iridite	1.8%
PR-1775	Iridite	2.0%
PS-870	Iridite	2.2%
PR-2001	Iridite	4.2%
PR-1775	Metalast	29%
PR-2001	Metalast	63%
AC-735	Metalast	75%

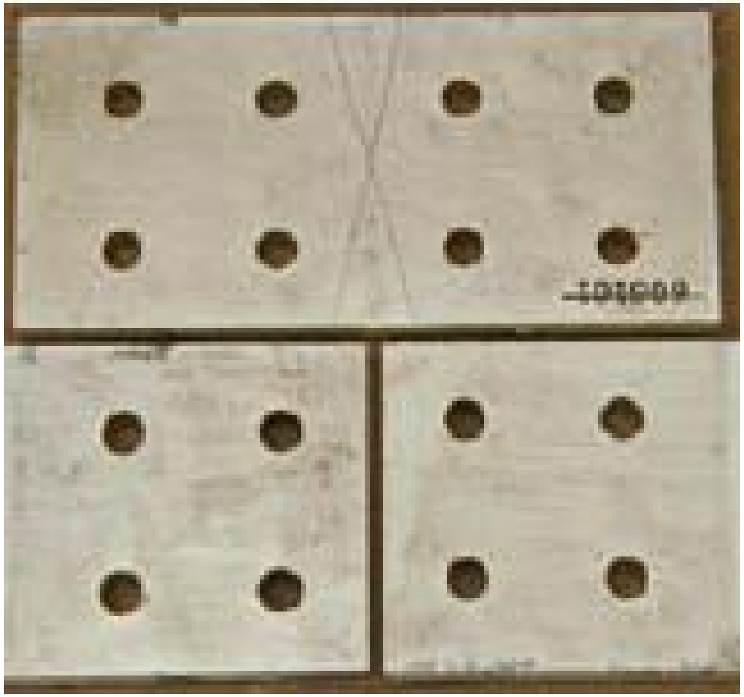
Countersink Areas (TVs 15-28)		
7075 with HCF Primer		
Sealant	Surf. Prep.	Average Corrosion
PR-1775	Iridite	31%
PR-1775	Metalast	48%
PS-870	Iridite	48%
PR-2001	Metalast	58%
PR-2001	Iridite	58%
AC-735	Iridite	68%
AC-735	Metalast	86%

Butt Joints and Faying Surfaces (TVs 29-36)		
7075 with HC Primer		
Sealant	Surf. Prep.	Average Corrosion
AC-735	Iridite	1.5%
PR-1775	Iridite	2.0%
PS-870	Iridite	2.8%
PR-2001	Iridite	3.3%

Countersink Areas (TVs 29-36)		
7075 with HC Primer		
Sealant	Surf. Prep.	Average Corrosion
PR-1775	Iridite	22%
PS-870	Iridite	48%
PR-2001	Iridite	62%
AC-735	Iridite	78%

Destructive inspection results for TVs that completed 1008 hours of SO2 salt fog exposure

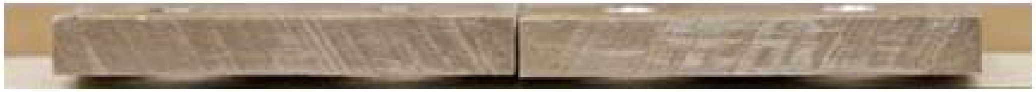
Results



Faying Surface

Countersunk holes

1008 hours
6061 alloy
Iridite 14-2
HCF primer + topcoat
P/S 870



Faying Surface

Statistical Analysis

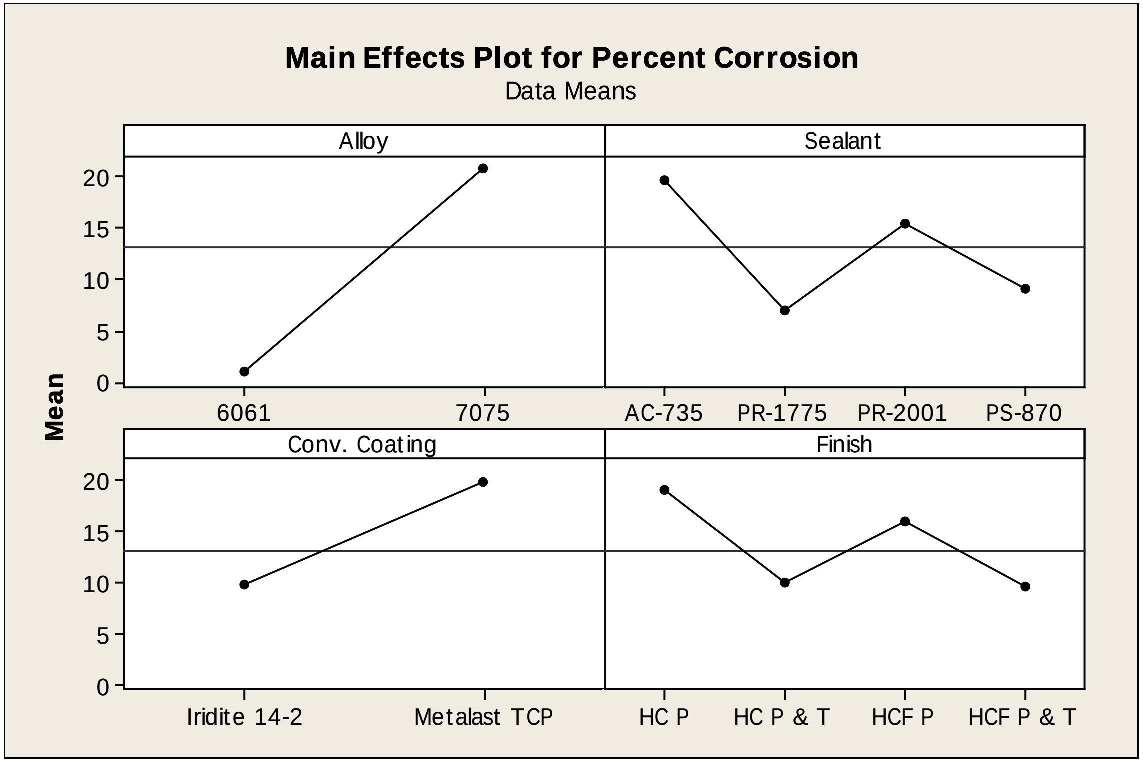
The Analysis of Variance (ANOVA) results can be used for hypothesis testing. The null hypothesis used for this research is that the corrosion values for different factor/level combinations within the experimental design are the same for each combination. The alternative hypothesis is that the expected corrosion values for different factor/level combinations within the experimental design are not the same.

A P-value is a measure of how much evidence we have against the null hypotheses about the population. P-values represent the probability of making a Type 1 error, or rejecting the null hypothesis when it is true.   The smaller the P-value is, then the smaller is the probability that you would be making a mistake by rejecting the null hypothesis.

For the purposes of this research, if the P-value is 0.05 or less, then the corrosion results were considered to be significantly different and likely to support the alternative hypothesis.

P-Value	Designation
0 - 5%	Significant
> 5%	Not Significant (NS)

Destructive Inspection: All Applications



All applications:
butt joint, faying surface, countersunk area, and barrel area

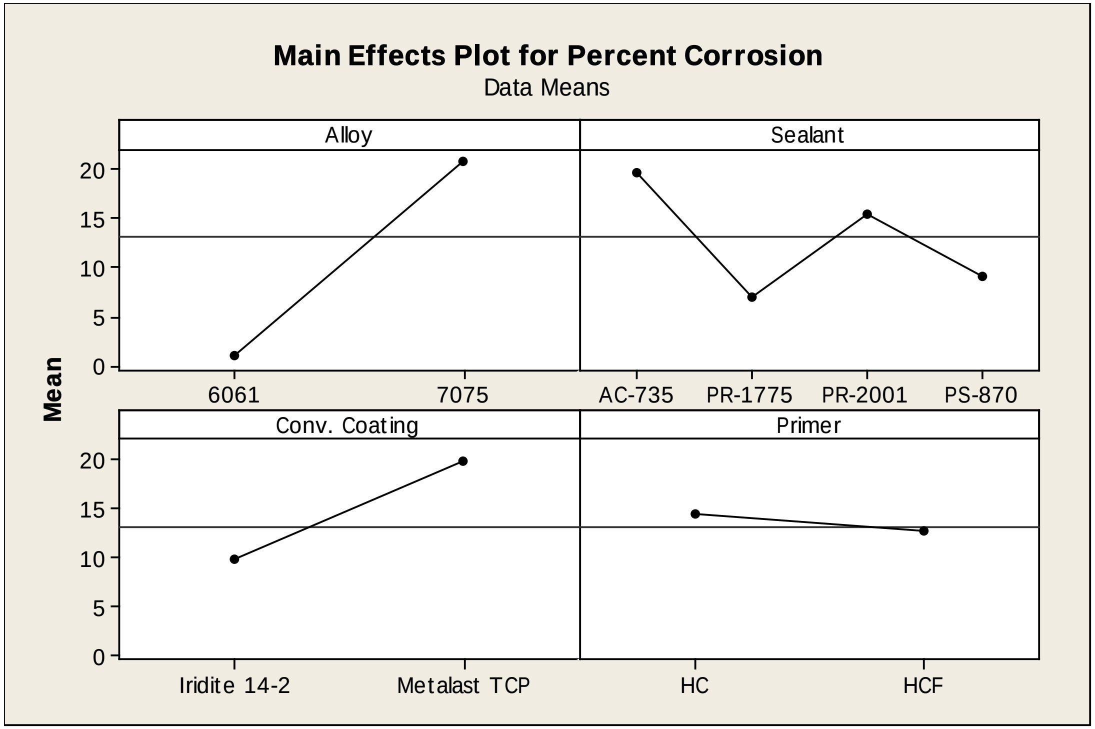
Type of alloy is significant.
(P value = 0.00)

Conversion coating is significant.
(P value = 0.008)

Analysis of Variance for Percent Corrosion, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Alloy	1	3372.8	3854.8	3854.8	33.89	0.000
Sealant	3	1029.8	845.3	281.8	2.48	0.083
Conv. Coating	1	1264.3	918.0	918.0	8.07	0.008
Finish	3	541.2	541.2	180.4	1.59	0.216
Error	27	3070.9	3070.9	113.7		
Total	35	9279.0				

Destructive Inspection: All Applications



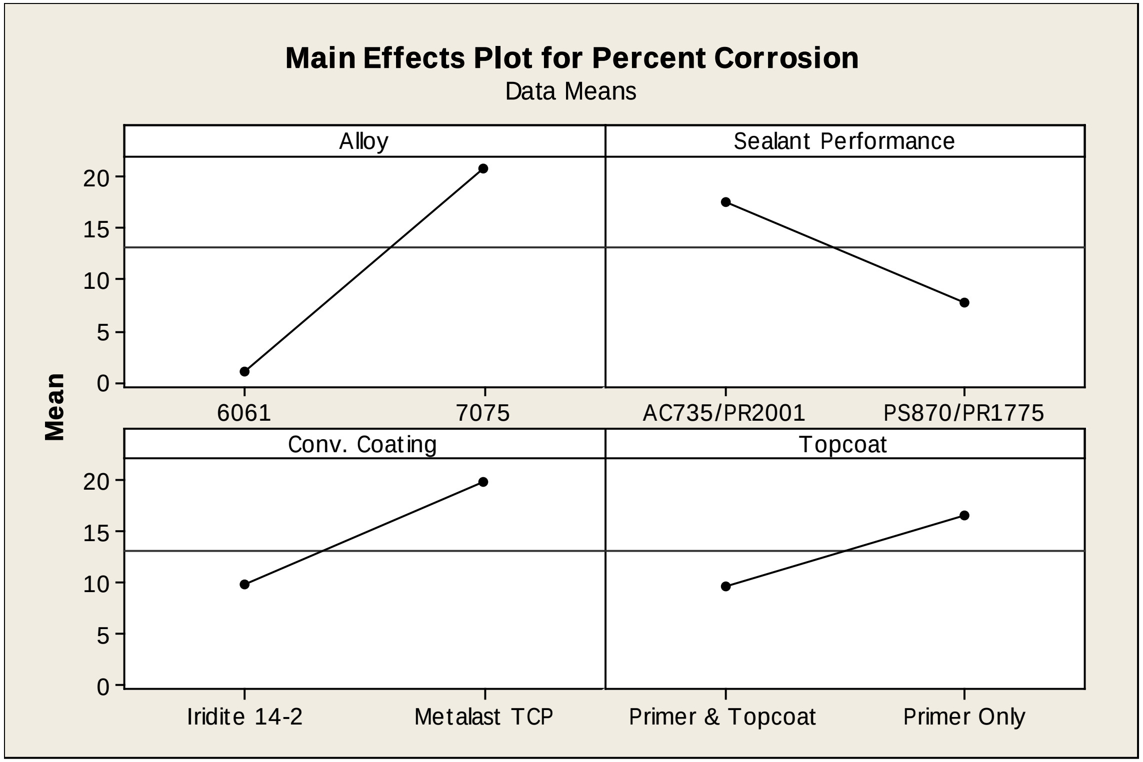
Type of primer is not significant.
(P value = 0.379)

Analysis of Variance for Percent Corrosion, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Alloy	1	3372.8	3854.8	3854.8	31.80	0.000
Sealant	3	1029.8	845.3	281.8	2.32	0.096
Conv. Coating	1	1264.3	918.0	918.0	7.57	0.010
Primer	1	96.7	96.7	96.7	0.80	0.379
Error	29	3515.4	3515.4	121.2		
Total	35	9279.0				

Due to multiple variables and few duplicates this approach may only offer limited insight

Destructive Inspection: All Applications



PS-870/PR-1175 sealants versus AC735/PR-2001 is significant. (P value = 0.023)

Presence of topcoat is significant. (P value = 0.055)

Analysis of Variance for Percent Corrosion, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Alloy	1	3372.8	4026.0	4026.0	36.75	0.000
Sealant Perf.	1	940.4	626.5	626.5	5.72	0.023
Conv. Coating	1	1135.0	1135.0	1135.0	10.36	0.003
Topcoat	1	435.0	435.0	435.0	3.97	0.055
Error	31	3396.0	3396.0	109.5		
Total	35	9279.0				

Destructive Inspection Summary

Factor	Butt Joint	Counter-sunk Area	Faying Surface	Barrel Area	All Applications	Conclusion
Alloy	Significant (6061)	Significant (6061)	Significant (6061)	Significant (6061)	Significant (6061)	6061 better than 7075
Sealant	NS	Significant (PR-1775 best results)	NS	NS	*NS	Overall, PS870 & PR1775 better
Conversion Coating	Significant (Iridite)	NS	Significant (Iridite)	Significant (Iridite)	Significant (Iridite)	HC (Iridite) better than HCF except for counter sunk areas
Finish	**NS	Significant (HCF P &T)	NS	NS	NS	No difference HC to HCF, except butt joint

* PS870 & PR1775 performance is significant versus AC735 & PR2001 performance.

** Type of primer is significant with HC better than HCF primer

Conclusions

- Testing not performed to any military or industry standard specification - developed by the Team as a screening level test approach specifically for differentiating between Hex Cr containing and Hex Cr free sealants in field applications subject to a corrosive environment where damage can be expected
- Testing was modeled after MIL-STD-81733, but modified
- Included a large number of variables, a limited number of test vehicles, and very few replicates
- Not enough data to derive statistically significant results for the many variables
- ***Results and conclusions are based on the conditions of this limited testing effort and are not intended to be an endorsement or disapproval of the various products included in the test***

SEALANTS

Butt Joints and Faying Surfaces

When tested with an Iridite 14-2 Hex Cr containing conversion coating, regardless of primer type or alloy type, the corrosion inhibiting performance of the AC-735 and PR-1775 Hex Cr free sealants was comparable to the PS-870 Hex Cr containing sealant

Countersink Areas

When tested with an Iridite 14-2 Hex Cr containing conversion coating, regardless of primer type or alloy type, the corrosion inhibiting performance of the PR-1775 hexavalent chromium free sealant was comparable or better to the PS-870 Hex Cr containing sealant

General Conclusions

Alloys - 6061 Al consistently exhibited better corrosion resistance compared to 7075 Al when similar conversion coatings and sealants were used

Especially evident in the countersink areas of the test vehicles - an expected result of the inherent corrosion resistance differences in the alloys themselves

Conversion Coatings - In general Hex Cr containing Iridite 14-2 conversion coating provided the better corrosion resistance results when compared to Metalast TCP-HF HPA 100, with the exception of the countersink areas on the 6061 Al.

Primer - In general there was no significant difference in corrosion resistance observed regardless of alloy or conversion coating if a Hex Cr containing primer or Hex Cr free primer was used

Topcoat – In general there was improved corrosion resistance overall in the TVs when a topcoat was used regardless of the primer, conversion coating, alloy or sealant

This was more evident in the 7075 alloy over the 6061

Lessons Learned

- Tried to do too much with too little – ideally should have more replicates and fewer variables for better statistical results

- Stick to original plan of DFARS only - eliminate TCP conversion coating, and chromate primer from the Design of Experiments

- Include a negative control for subsequent testing efforts
  - We did not have a polysulfide with no corrosion inhibitor – only a polthioether without a corrosion inhibitor (different polymer chemistry)

- Large variability in countersink data; holes not threaded which is not a typical scenario

NEXT STEPS………

SAVE THE DATE

Tuesday September 24, 2013 – Aerospace/Defense Supply Chain

This will be a meeting with representatives across the aerospace/defense industry supply chain to review the use of toxic chemicals in products and manufacturing processes. The objective is to identify collaborative research and training opportunities to address the use of the toxic chemicals.

This meeting will be held in Sturbridge, MA at the Sturbridge Host Hotel & Conference Center.

TURI will be posting more information (at www.turi.org) about this meeting and the registration process during the May 2013.

For questions about this meeting, please contact Greg Morose at Gregory_Morose@uml.edu or 978-934-2954.