Thank you for signing in early

The webinar will begin promptly at
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SERDP and ESTCP Webinar Series

- The webinar will begin promptly at 12:00 pm ET, 9:00 am PT
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  - Listen to the broadcast audio if your computer is equipped with speakers
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    - (669) 900-6833 or (929) 205-6099
    - Required webinar ID: 503-901-313
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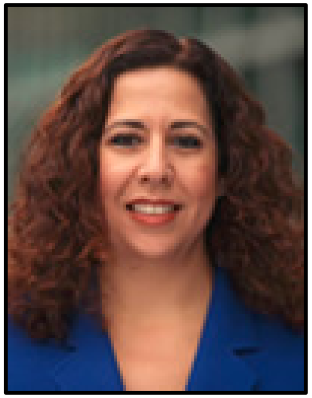
Developing and Demonstrating Non-Toxic and Sustainable Coating Systems for Military Platforms

October 31, 2019

Welcome and Introductions



Rula A. Deeb, Ph.D.
Webinar Coordinator

SERDP DOD • EPA • DOE | ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Robin Nissan, SERDP and ESTCP
- **Impact of Cleaning Tools on Wear of Biofouling Control Coating Systems and Copper and Zinc Release** (25 minutes + Q&A)
  Ms. Elizabeth Haslbeck, Naval Surface Warfare Center
- **Advancing Coating Systems for Army Tactical Assets** (25 minutes + Q&A)
  Mr. John Escarsega, U.S. Army Research Laboratory
- **Final Q&A session**

In Case of Technical Difficulties

- Use a compatible browser (Firefox, IE or Edge)
- If material is not showing on your screen or if screen freezes
  - Key in Ctrl + F5 to do a hard refresh of your browser
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  - Click the arrow next to the "*Join Audio*" button
  - Select test "*Speaker and Microphone*"
  - Follow prompts
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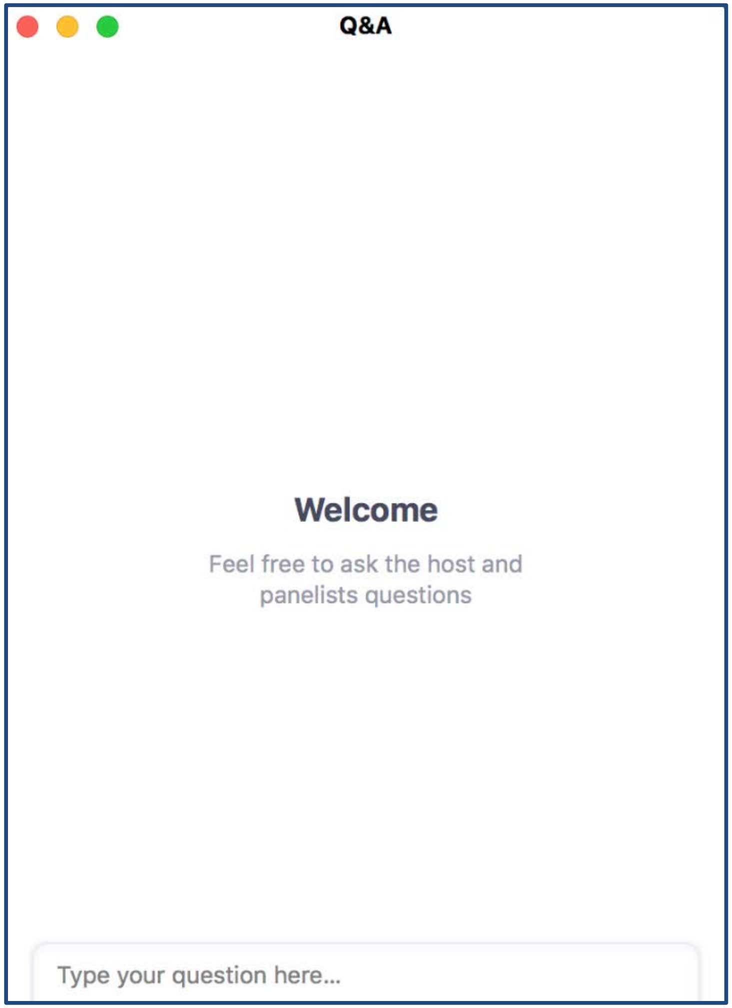
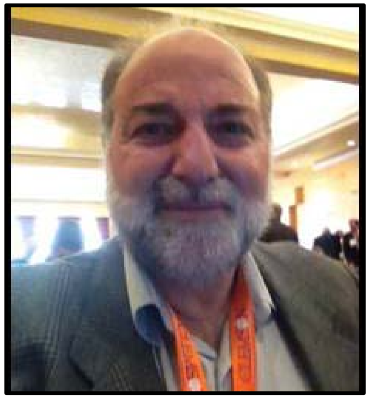
- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview



Robin Nissan, Ph.D.
SERDP and ESTCP

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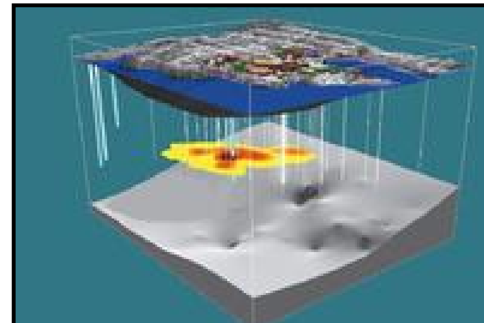
SERDP

- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas



- Environmental Restoration
- Installation Energy and Water

- Munitions Response

- Resource Conservation and Resiliency
- Weapons Systems and Platforms

Weapons Systems and Platforms

- Major focus areas
  - Surface engineering and structural materials
  - Energetic materials and munitions
  - Noise and emissions
  - Waste reduction and treatment in DoD operations
  - Lead free electronics

SERDP and ESTCP Webinar Series

Date	Topic
November 7, 2019	Overview of SERDP and ESTCP Environmental Restoration PFAS Efforts
December 12, 2019	Monitoring and Remediating Groundwater Contaminated with Chlorinated Solvents

- A list of 2020 webinars with registration information will be released soon at http://serdp-estcp.org/Tools-and-Training/Webinar-Series

Save the Date

SERDP • ESTCP SYMPOSIUM

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

December 3-5, 2019

Washington Marriott Wardman Park

Registration is open!

Impact of Cleaning Tools on Antifouling Coatings

Elizabeth Haslbeck
Naval Surface Warfare Center

SERDP
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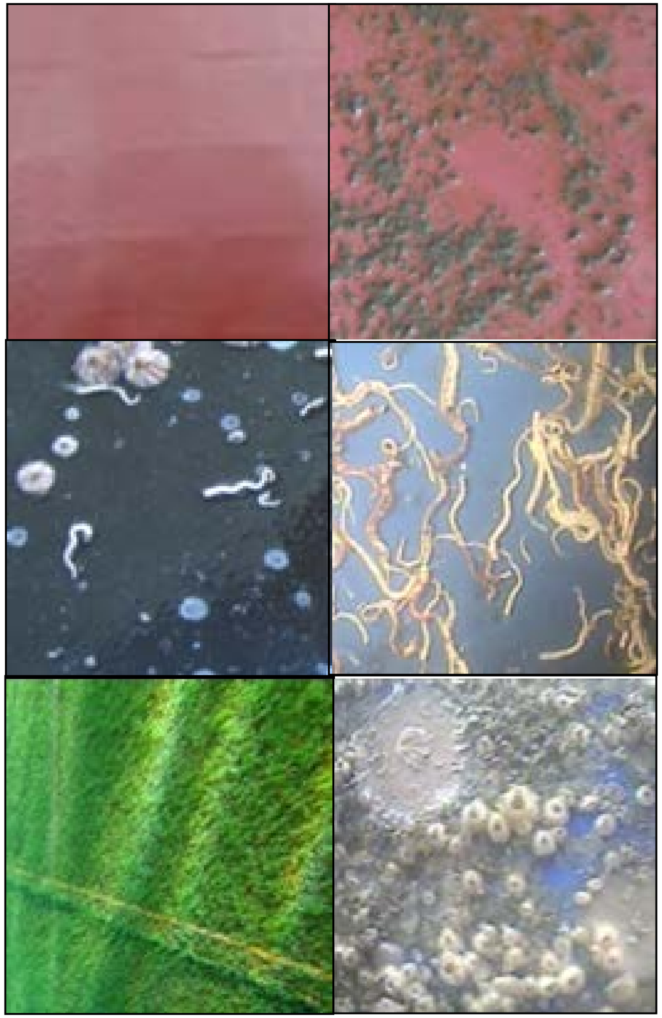
Agenda

- Biofouling and current management
- Biofouling impacts on DoD
- Hull cleaning technologies
- Data gaps
- Need for screening tool
- Standardized device development
- Conclusions

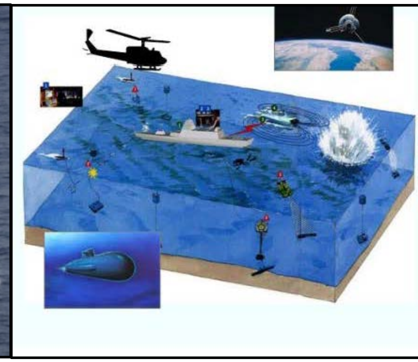
Biofouling and Current Management

- Attachment and growth of organisms on immersed, man-made objects
- DoD uses biocides
  - Copper ablative underwater hull coating systems
- Effectiveness of coating
  - Biofouling coverage of a few % results in significant, measurable impact
- Biofouling on ships
  - Drydock ship and replace coating
  - In-water cleaning
    - “Reactivates” coating surface
    - Abrades coating
    - Debris settles in water column



Biofouling Impacts on DoD

Negatively impacts mission, readiness, capability, environment

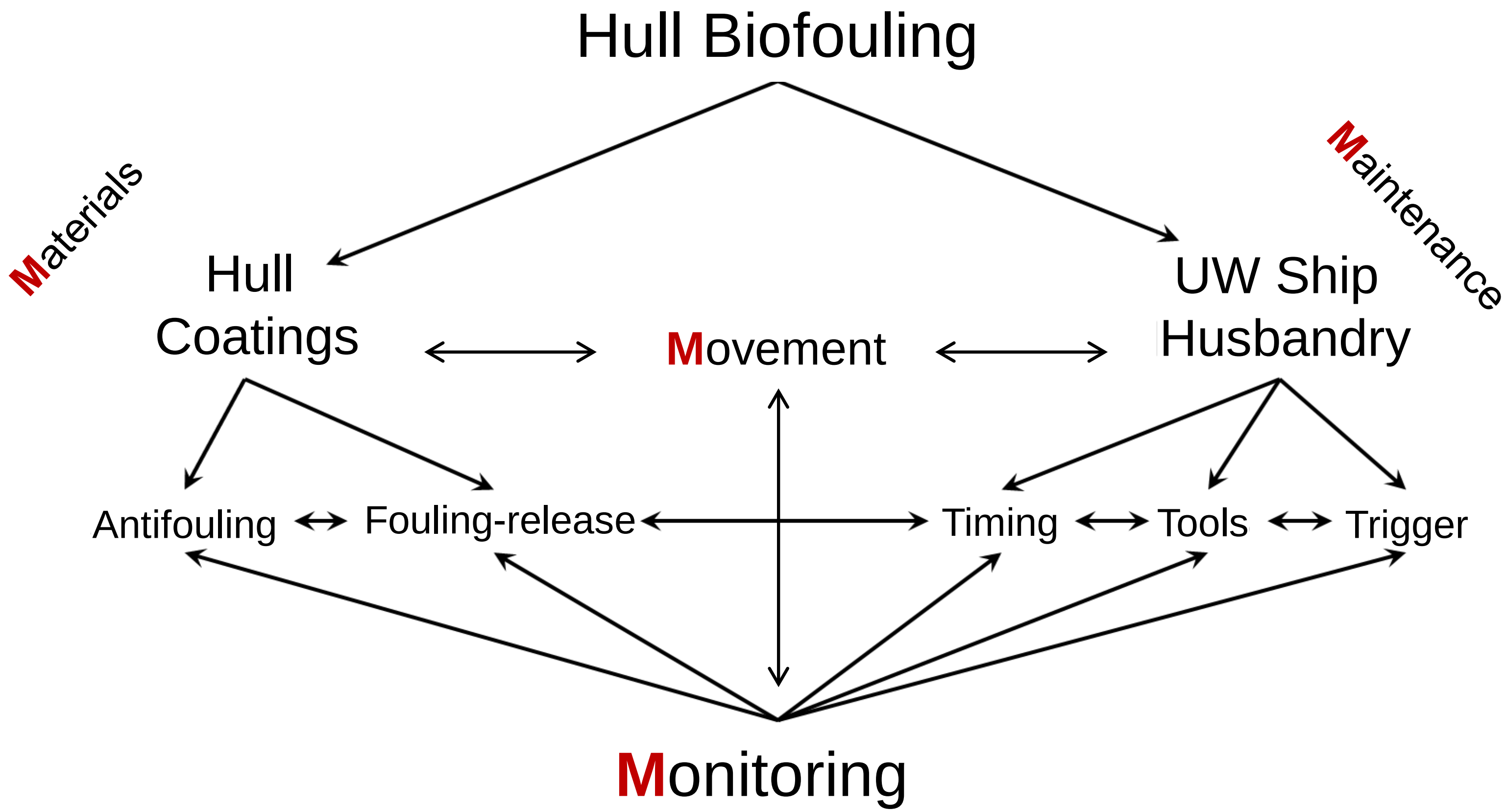


Speed/Range/Maneuverability **Signature** **Projected Power/Mission**

Maintenance/Safety **Readiness** **Air/Water Quality**

Single biggest factor affecting DoD fleet fuel efficiency

Interdependencies



Characterizing performance, service life, benefits, and costs is challenging

Biofouling Control

Coatings

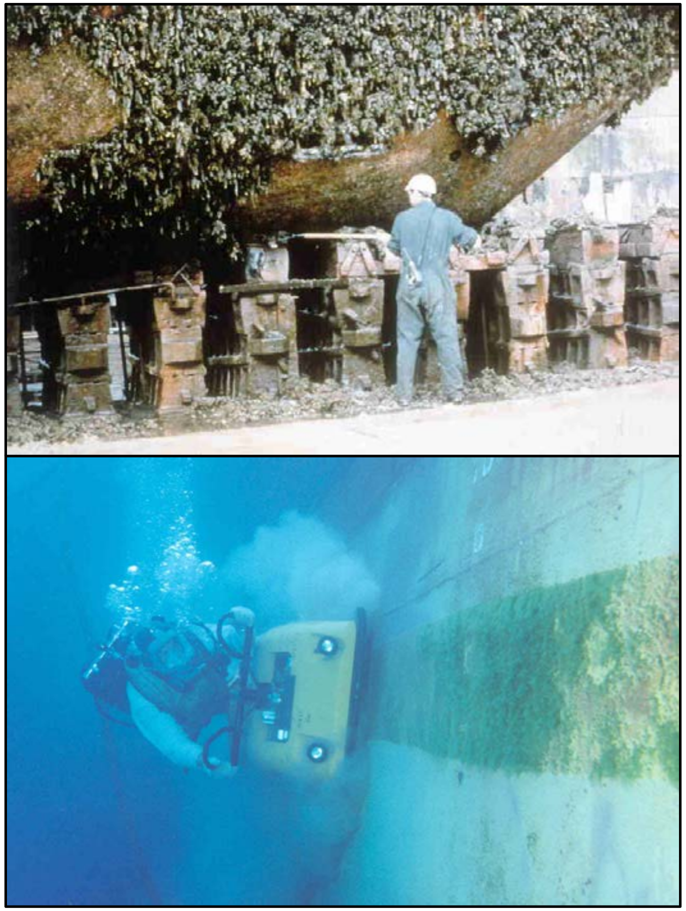
- Biocide-containing
  - Heavy metal
  - Organic
- Biocide-free
  - Fouling-release
- Hybrid coatings

Problems

- Regulatory concerns
  - Volatile organic content biocide inputs
- Coating performance
  - Operational profile
  - Operational area
  - Niches

Hull Cleaning When Coating Fails

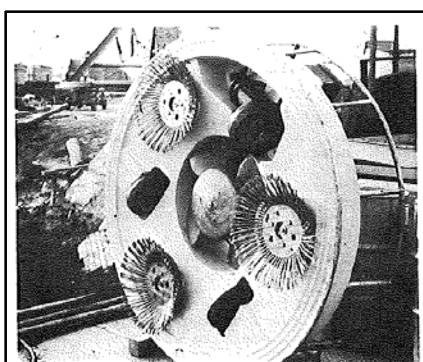
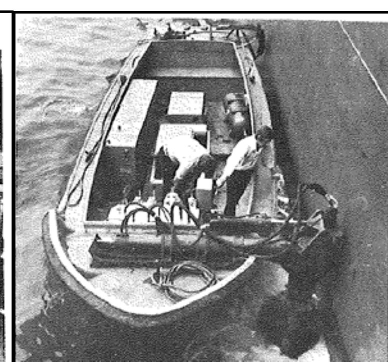
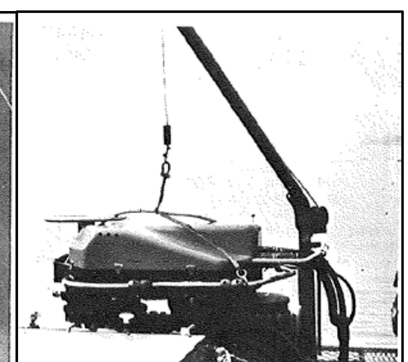
- In drydock
  - Expensive
  - Time consuming
  - Limited dock availability
- In water
  - Less expensive
  - Quick



History of In-Water Cleaning

U.S. Navy Experience

- 1970s and 1980s
  - Vinyl copper-based coatings
  - 1 → 3+ years
  - Rotating brush tools
  - Removes cupric salts/compounds
- 1980s and 1990s
  - Ablative copper-based coatings
  - 3-5 → 8-12 years
  - Rotating brush tools
  - Removes leached layer
  - Extended time between drydocking

In-Water Cleaning Practices

U.S. Navy Experience

- Rotating brush
- Limited use of waterjets
- Biannual inspections
- Cleaning triggers
  - Antifouling coatings
    - 40 rating over 20% of hull
  - Fouling-release coatings
    - 50 rating over 10% of hull

Fouling Rating	Organisms
10-20	Slime/diatom
30	Soft macrofouling
40-50	Small calcareous
60-100	Larger forms and/or mixed forms

In-Water Hull Cleaning

Benefits

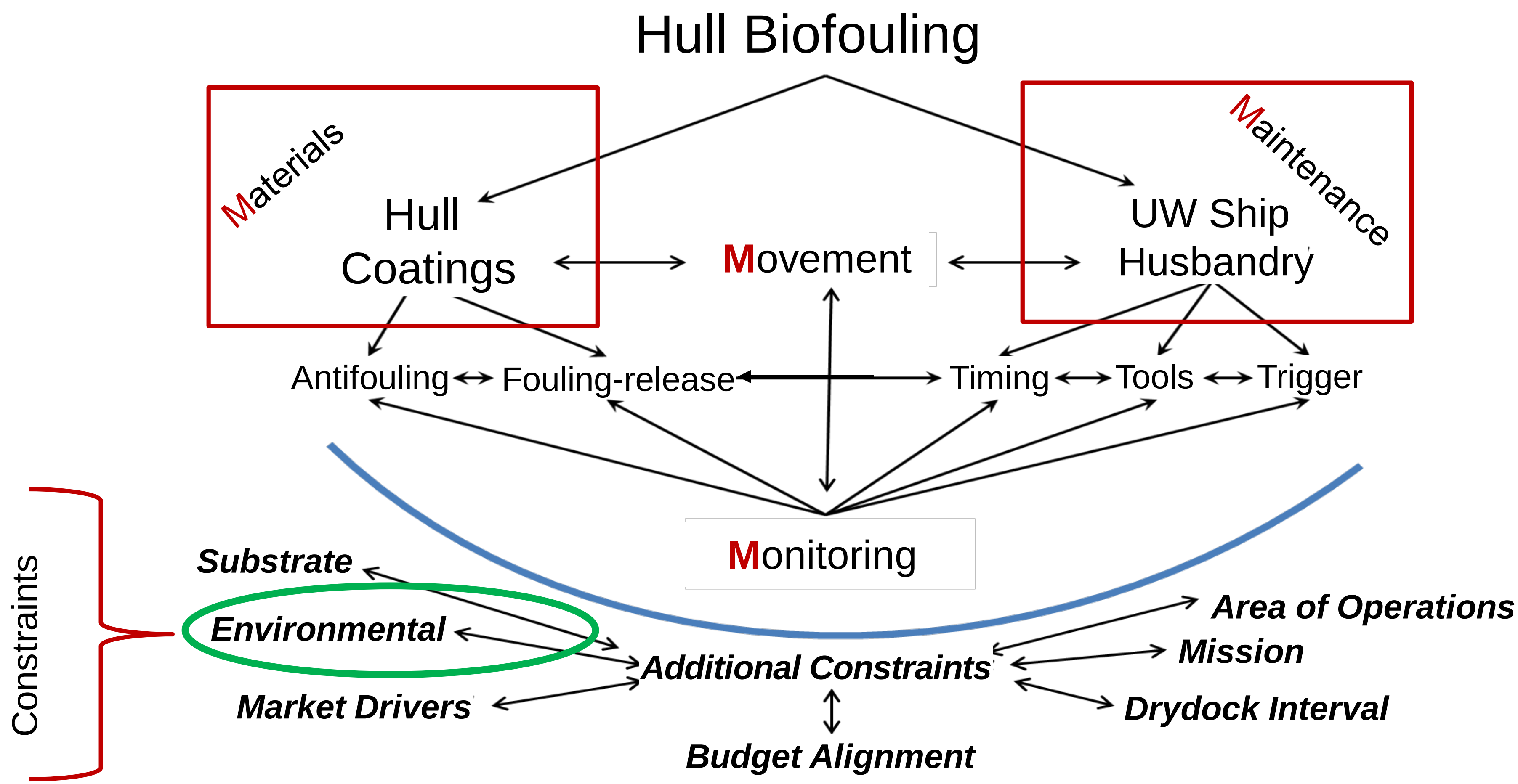
- Cost-effective for vessel operating efficiency
- Restores coating efficacy


Technodive-hellas.com

Consequences

- Discharge of paint components
- Impact coating integrity
  - Paint thickness
  - Surface properties
- Release of attached biofouling
- Regulatory scrutiny

Finding the Right Solution



Knowledge and Capability Gaps

- Lack understanding of in-water cleaning
  - Environmental inputs
    - o Chemical
    - o Biological
  - Impact on coatings
    - o Thickness
    - o Damage
    - o Subsequent efficacy
  - As affected by
    - o Coating type
    - o Cleaning tool
    - o Cleaning strategy
- Need standard testing and impact measurement

Options for Testing

Elcometer Washability Tester

- ASTM D2486, D4828, D4213, D3450
- DIN, ISO methods
- Advantages
  - High quality data, reproducible
- Disadvantages
  - Architectural focus
  - Limited for relevant cleaning tools
  - Cannot measure environmental inputs

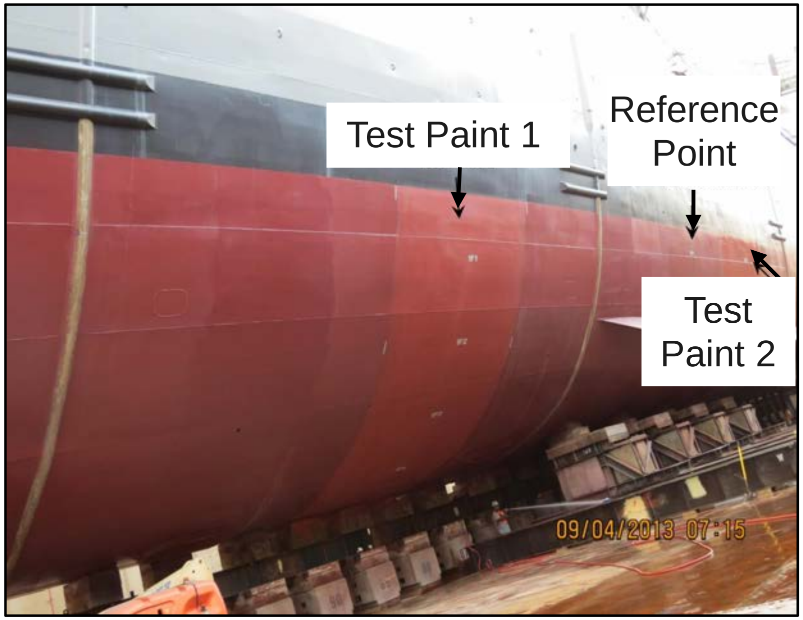
Source: https://www.elcometer.com

Notes: ASTM = American Society of Testing and Materials; DIN = German Institute for Standardization; ISO = International Standards Organization

Options for Testing

Non-Standard Methods: On-ship Evaluation

- Quantify paint thickness decrease
- Advantage
  - Application of full-scale tool
- Disadvantages
  - Cannot resolve small changes
  - Limited environmental inputs measurement
  - High risk to ship – coating failure



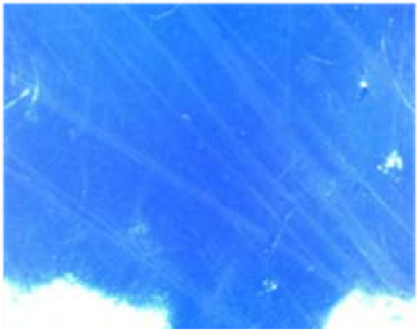
Options for Testing

Non-Standard Methods: Raceway Test

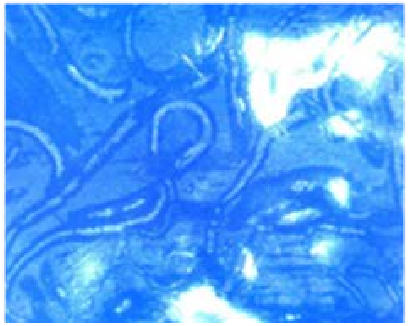
- Panel tests – mounted coated panels
- Advantages
  - Application of full-scale tool
  - High data quality
  - No risk to a ship
- Disadvantages
  - High cost
  - Limited ability to measure environmental inputs

Cleaning damage test – cleaning w-brushes **damaged paint**

Macroscopic damage



Microscopic scratching (50x)



Calcareous tubeworm residue (50x)

Source: NSWCCD, Florida Institute of Technology

Options for Testing

Non-Standard Methods: Raceway Test

Panel Tests

Options for Testing

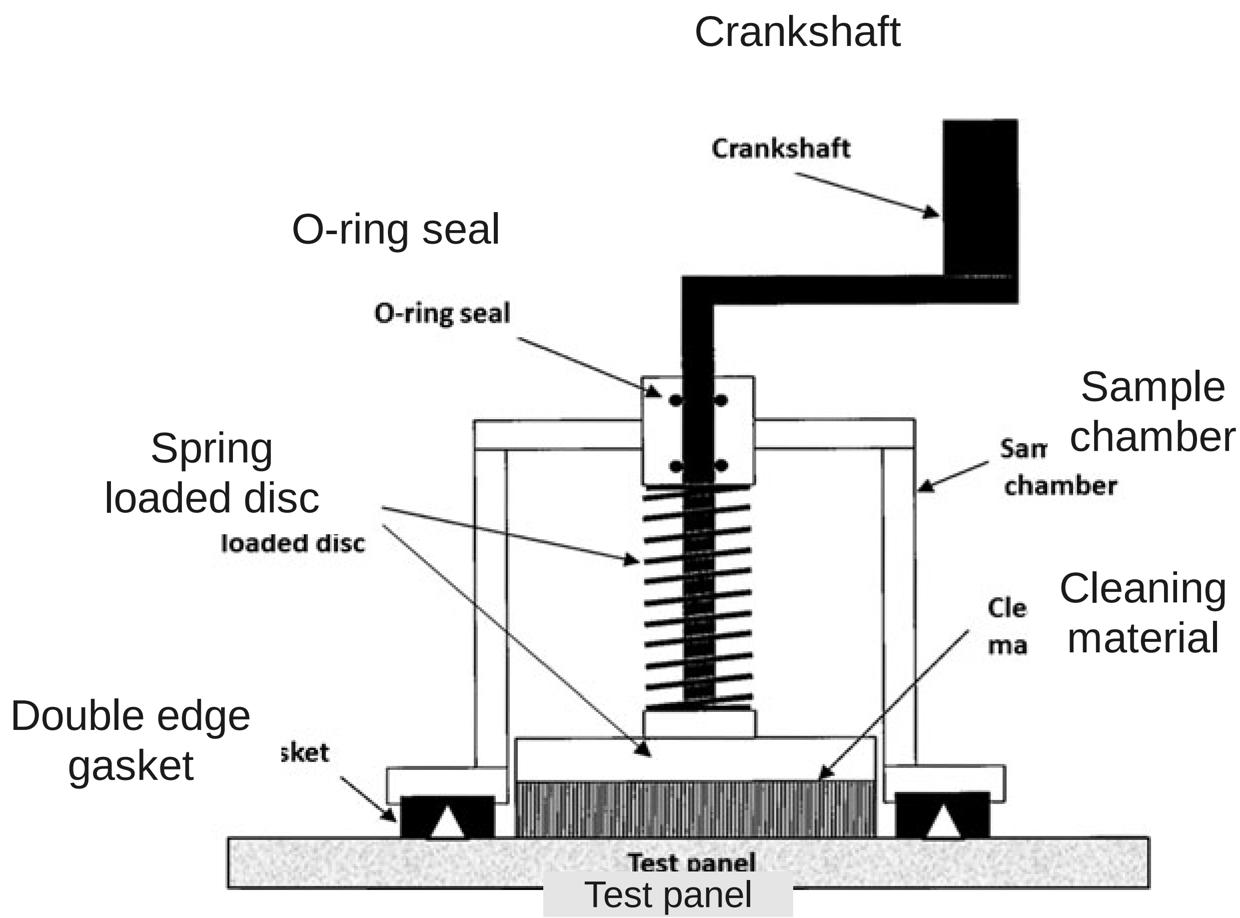
Non-Standard Methods: Diver Handheld Tool

- In-water hull cleaning sampling device
- Quantify biocide inputs following “surface refreshment”
- Advantages
  - Quantify biocide inputs
- Disadvantages
  - Does not utilize diver-operated tools
  - Does not replicate true impact to coating

Source: Earley et al. (2014) Biofouling 20:41-68

Options for Testing

Non-Standard Methods: Diver Handheld Tool

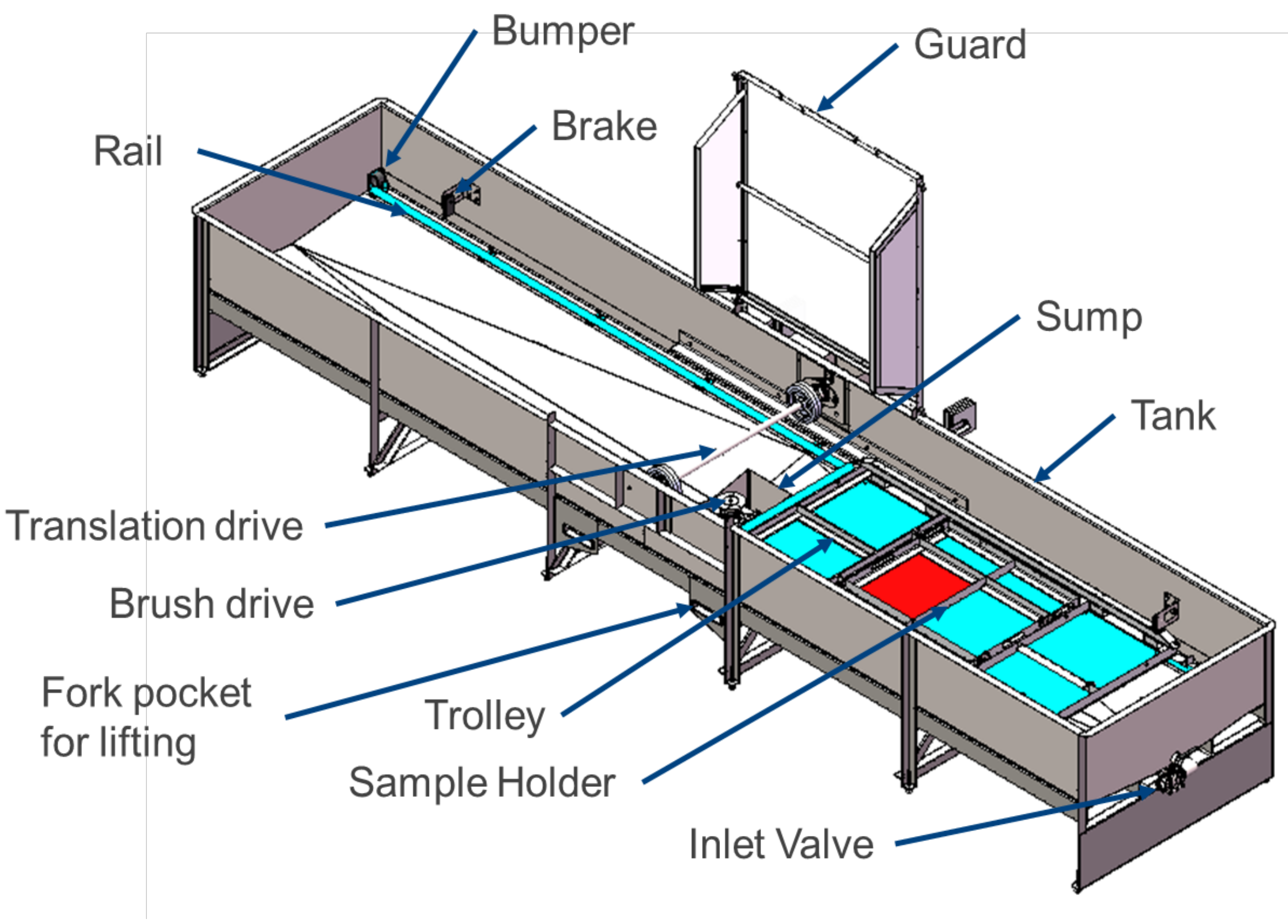


Source: Earley et al. (2014) Biofouling 20:41-68

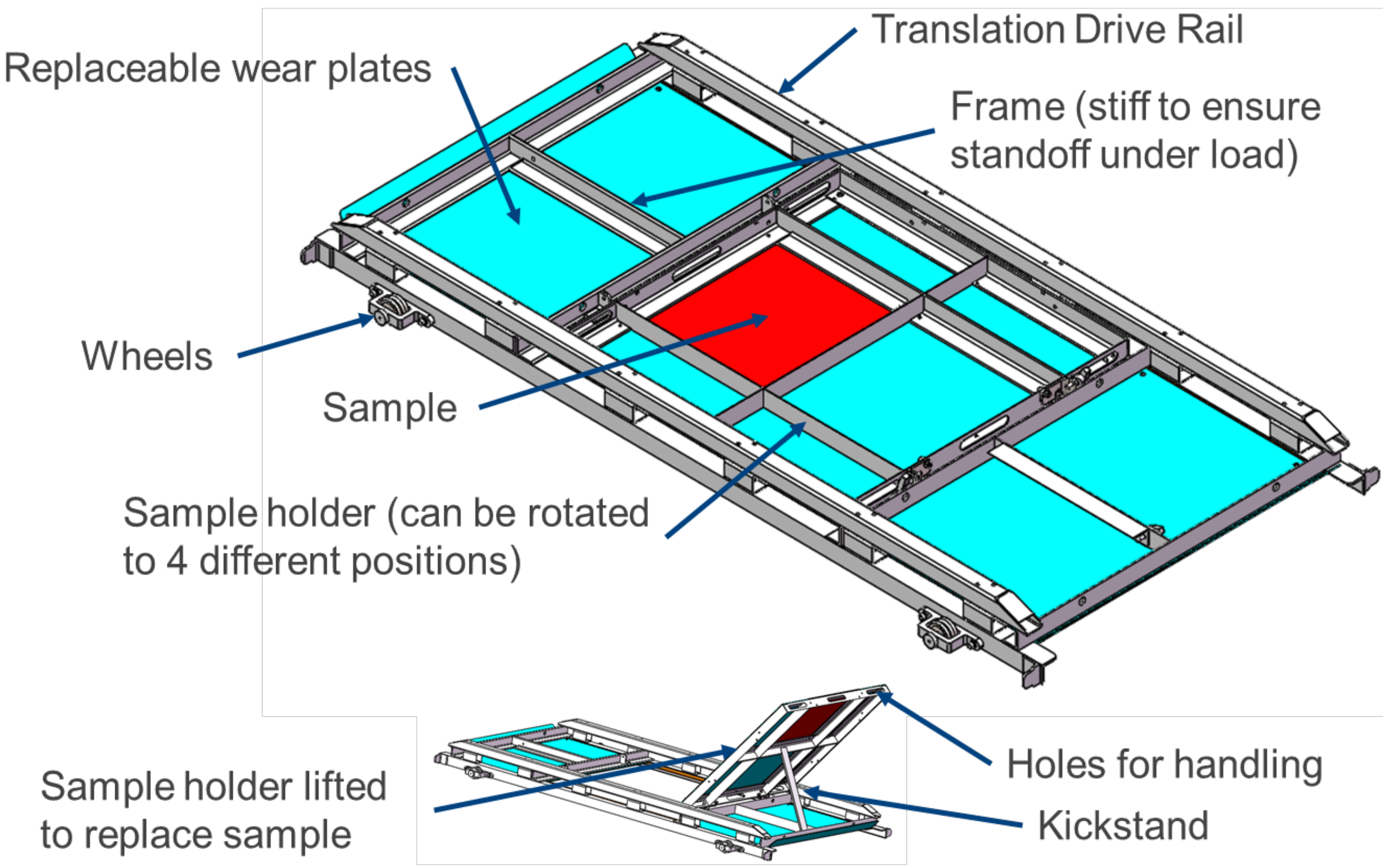
Standardized Device and Method

- Evaluate in-water cleaning tool impact on hull paint
- Address weaknesses of other methods
- Cleaning tools applied to test surfaces
- Match operational characteristics as used in field
  - Transit speed
  - Rotation rate, shear force
  - Normal force
- Materials to minimize interfering chemicals into sample water
- 20+ detailed design requirements including
  - Logging operational parameters
  - Easy swapping of cleaning brushes and hydraulic motors

Standardized Device and Method



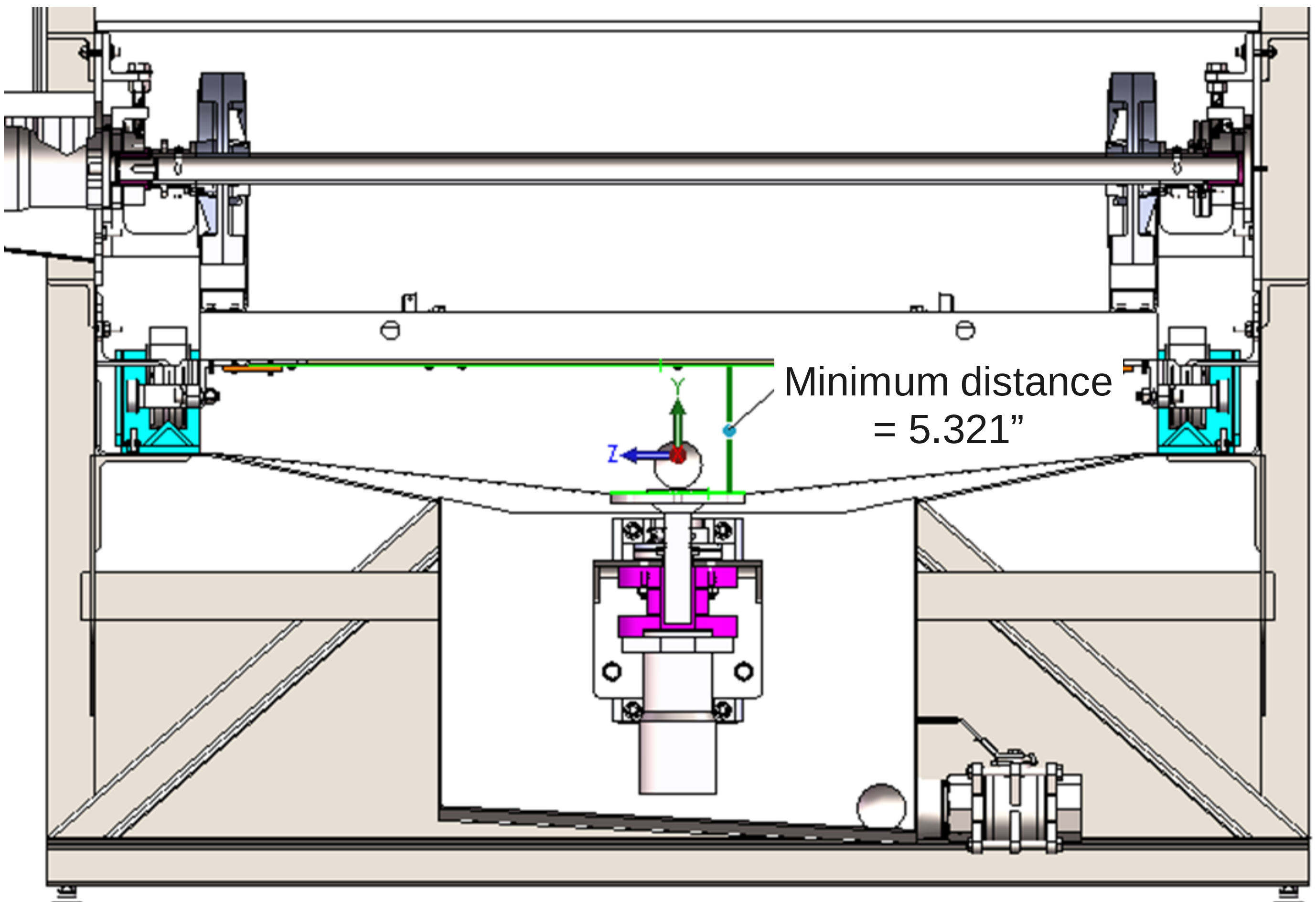
Standardized Device and Method



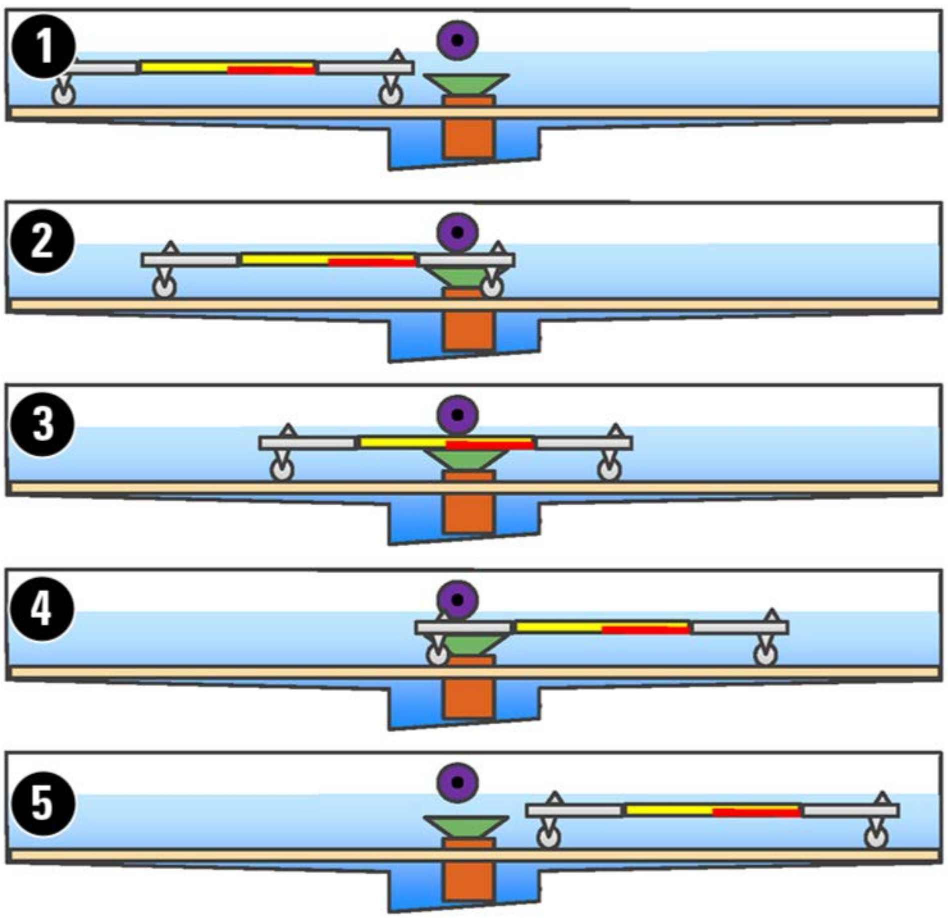
Standardized Device and Method

- Single pass of coated test panel over cleaning tool
  - Cleaning head for multiple tools types
  - Currently configured to handle brushes
  - 7 brushes in initial test (U.S. Navy qualified)
- Quantify changes in paint thickness or surface properties
- Sample for water quality
  - Dissolved metals
  - Particulate matter
  - Copper, zinc
- Screening test – compare legacy to emerging technologies
  - No analysis of biological inputs
    - Would need lengthy exposure time in order for coatings to develop biofouling

Standardized Device and Method



Standardized Device and Method



Conclusions

In-Water Hull Cleaning

- Cost-effective coating restoration
  - Coating regulations may conflict with cleaning regulations
  - Need benefit-cost balance
- In-water cleaning impacts coatings
- Poor understanding of:
  - Paint thickness
  - Coating system service life
  - Environmental inputs
- Improved understanding may aid regulators, technology developers, and end users
- A standardized tool and method may help inform the problem
- Could evaluate environmental biological material inputs
  - Efficacy and post-cleaning survival
  - Impact of in-water hull cleaning/biofouling removal on biological oxygen demand

Benefits to DoD

- Standardized method closes critical knowledge and capability gaps
  - Reduce risk
    - New coating transition
  - Predict coating system service life
  - Assess the use of in-water cleaning as a biofouling mitigation strategy
- Underpins key environmental quality concerns
  - Air quality
    - Solvents and combustion emissions
  - Water quality
    - Hull coating leachate, in-water cleaning, non-indigenous species

Acknowledgments

- Naval Surface Warfare Center, Carderock Division, Bethesda, Maryland
  - Biofouling control and coatings expertise
  - CTTD design
  - Method development
  - Full-scale validation
- Naval Information Warfare Center, San Diego, California
  - Environmental/water quality expertise
  - Seawater test rack (panel exposure/hydration)
  - Cleaning Tool Test Device (CTTD) design and "home"
  - Method development
  - Test execution - water chemistry, cleaning tool impact
- Battelle, Columbus, Ohio (Derek Michelin, Nathan Gabriel, Chris Baer)
  - CTTD design and build

For additional information, please visit
https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/WP18-5194

Speaker Contact Information

Elizabeth.Haslbeck@navy.mil; 301-227-4784

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Q&A Session 1

Advancing Coating Systems for Army Tactical Assets

John Escarsega
U.S. Army Research Laboratory

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Agenda

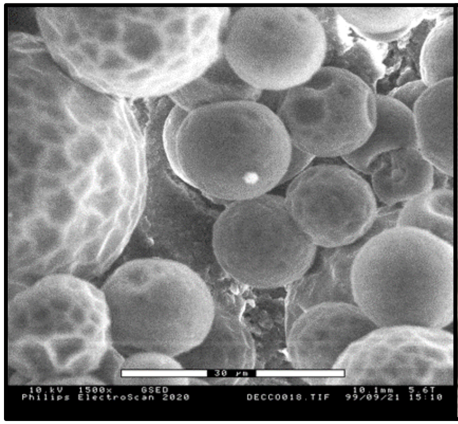
- Background
- Implementation
- Pretreatments
- Primers
- Topcoats
- Data collection
- Corrosion modeling
- Benefits to DoD
- Conclusions

ARL Coating Contribution

- Armaments
- Ground vehicles
- Facilities
- Soldier systems
- Aviation
- Missiles
- Munitions

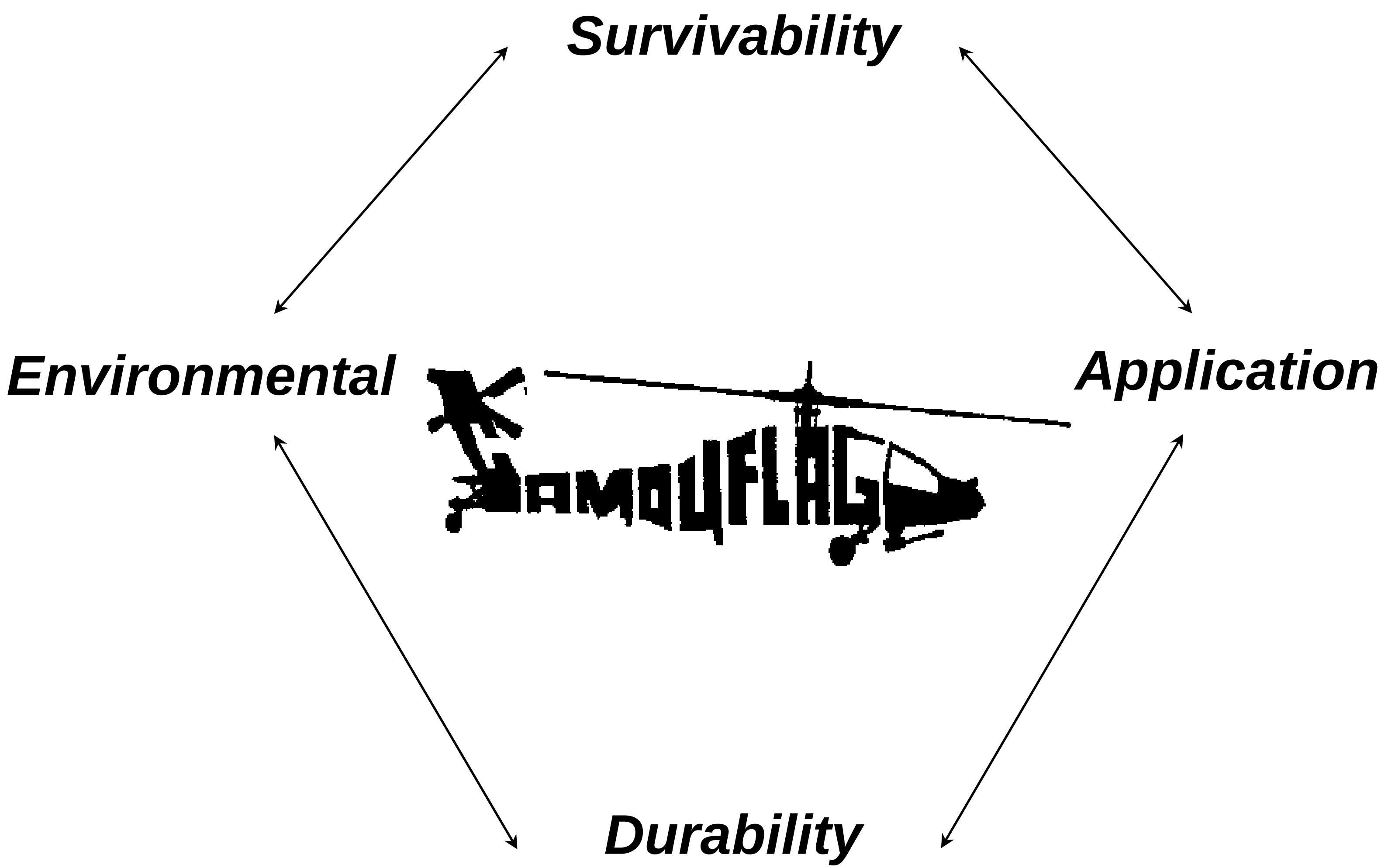
ARL Authority and Leadership for CARC

- Lead DoD technical authority
- DoD commodity item manager
- Key specification owner



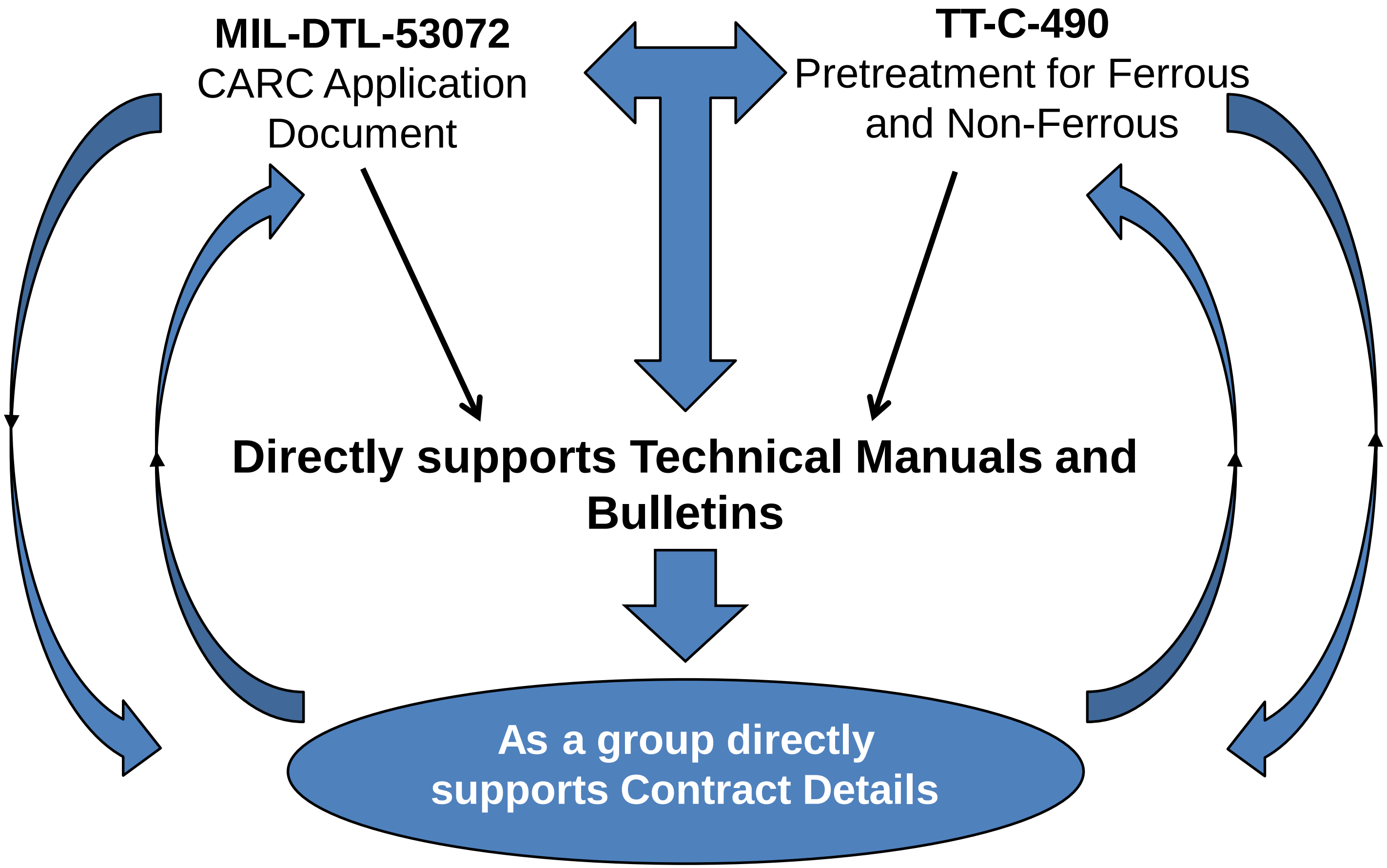
Note: CARC = chemical agent resistant coatings

Guiding Principles



Expressway to Implementation

Over-Arching Specifications



Coating System

Today

Polyurethane Topcoat

- **Visible**
- **Silica extender**
- **Regulated solvents**

Epoxy Primer

Chemical Conversion Coating

Substrate

- Ferrous
- Nonferrous

Tomorrow

Tailored Coating

- **Functional pigmentation**
- **Controlled roughness**

Functional Primer

- **Corrosion protection**
- **Texture**

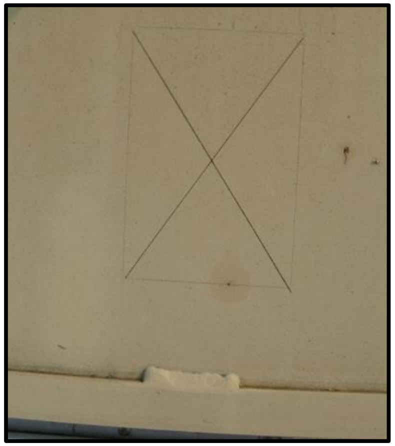
Advanced Corrosion Protection Layer

Substrate

- Ferrous
- Nonferrous
- Polymer composite

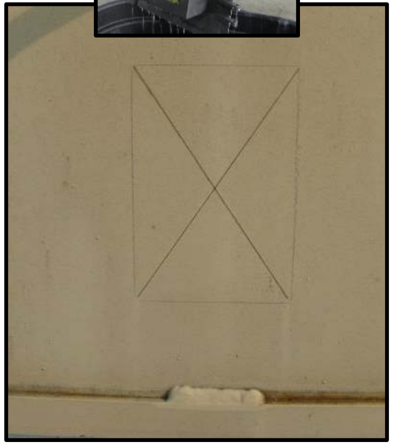
Spray Application Pretreatments

WP-200906



DOD-P-15328 Pretreatment

Alternative Pretreatment



Some corrosion bleed-out along skip welds

24 months of outdoor exposure of MRAP doors demonstration: Only minor corrosion in scribes of either door

Note: MRAP = Mine-Resistant Ambush Protected Vehicle

Spray Application Pretreatments

WP-200906

24 months
Alternative
Pretreatment

Initial Deployment

24 months
Wash Primer

24 months of outdoor exposure of generator trailer at CCAFS

Note: CCAFS = Cape Canaveral Air Force Station, Florida

Spray Application Pretreatments

Ground

Cleaner Technologies

Zinc Phosphate Line

Alternative Line

Spray Application Pretreatments

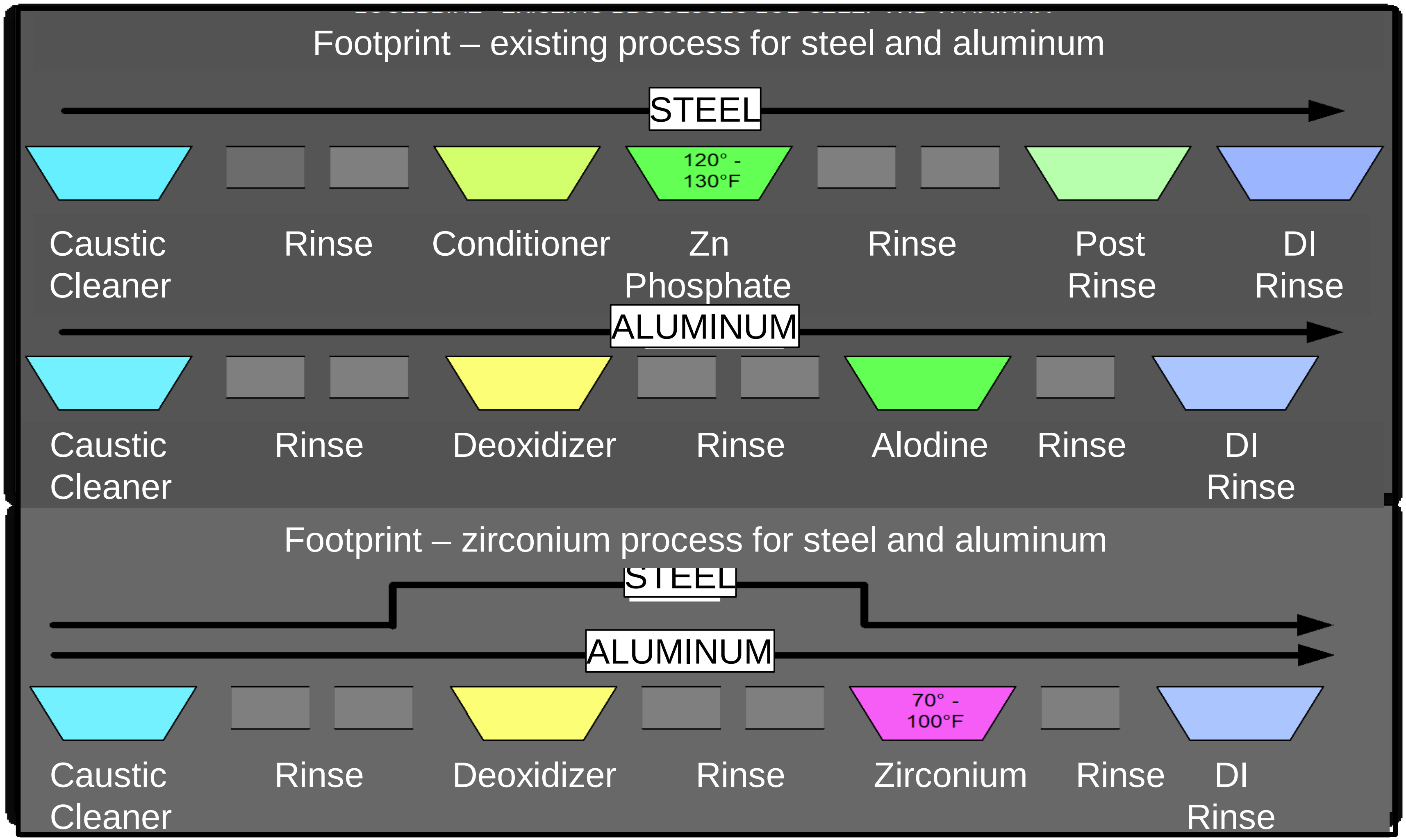
Ground

	Zinc Phosphate 125°F (52°C)	Iron Phosphate 125°F (52°C)	Advanced Pretreatment 70°F (21°C)
Chemical Cost	$100	$100	$100
Heating Energy	$100	$100	$70
Electric Energy	$100	$86	$71
Rinsing Water	$100	$100	$40
Waste Disposal	$100	$35	$17
Maintenance	$100	$25	$15
Total	**$600**	**$446**	**$313**

Greener pretreatment processes do not cost more than legacy processes

Immersion Pretreatments

WP-201318



Immersion Pretreatments

WP-201318

Steel Parts

	Zinc Phosphate ($ZnPO_4$)	Zirconium (Zr)
Crystal Size	2-10 mm	~0.1 mm
Coating Weight	150 – 300 (mg $ZnPO_4$) / square foot	~5 (mg Zr) / square foot
Thickness	2-5 mm	20-80 nm
Heavy Metal	Nickel	None
Chrome Sealer	Yes	No
Bath pH	3.2	4.8
Temperature	120º F	Ambient
Sludge?	Considerable	Minimal

Aluminum Parts

	Chrome Conversion Coat	Zirconium
Crystal Size	Amorphous	~0.1 mm
Coating Weight	~50 mg / square foot	~5 (mg Zr) / square foot
Thickness	0.5-1.5 mm	20-80 nm
Heavy Metal	Cr^{6+}	None
Bath pH	1.6	4.8
Temperature	Ambient	Ambient

Note: Cr^{6+} = hexavalent chromium

Liquid Primers

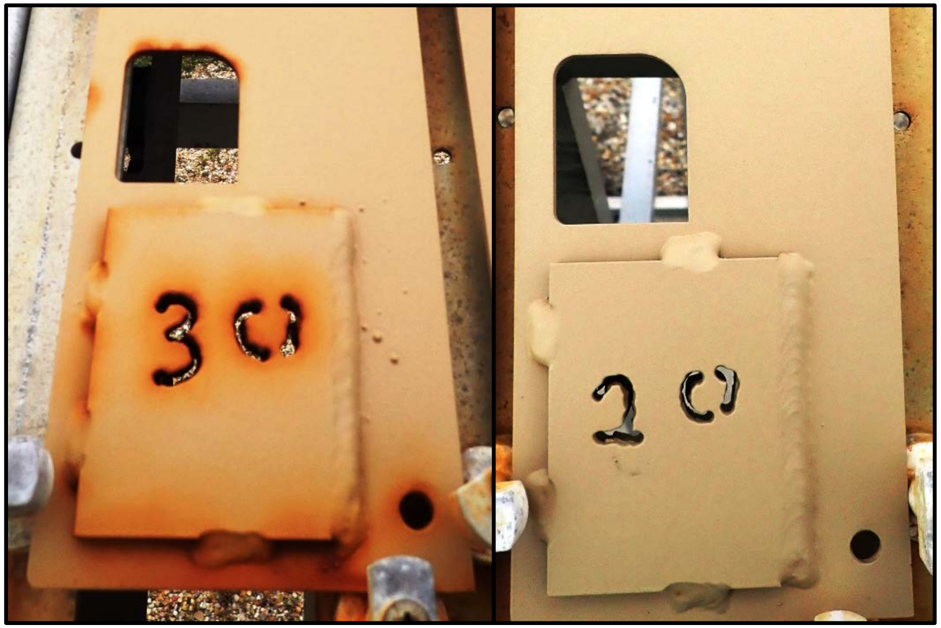
- Specification changes
  - Cancel underperforming products
  - Eliminate VOHAPs and reduce VOCs
  - Drive performance based requirements
- Novel resins
- Novel corrosions Inhibitors
- Exempt solvents

Notes: VOCs = volatile organic compounds; VOHAPs = volatile organic hazardous air pollutants

Electrocoat Primers

WP-201620

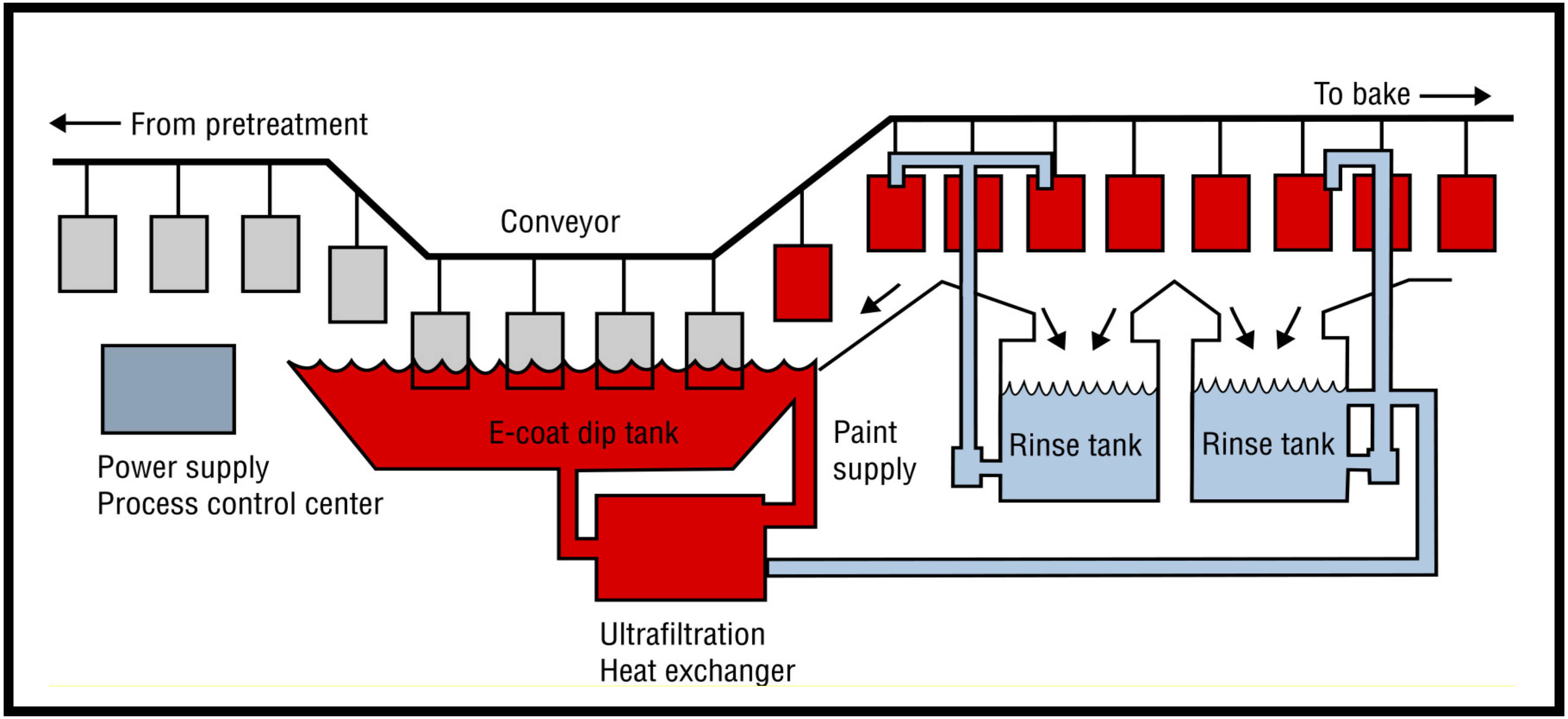
- Scalable systems for production requirements
- Able to coat complex parts better than spray coatings
- Excellent edge retention
- Zero VOHAPs
- Extremely low VOCs, minimal material waste



Left: MIL-DTL-53022 Type IV primer
Right: MIL-DTL-53084 E-coat

Electrocoat Primers

WP-201620



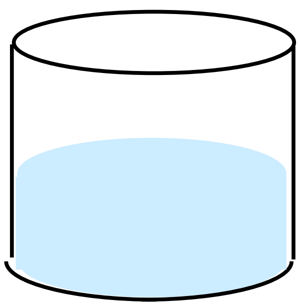
Powder Coat Primers

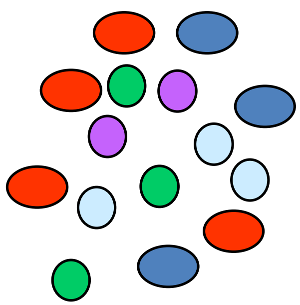
- Development of CARC powder topcoats (WP-2207 and WP-2234) drives the powder market
- Able to uniformly coat parts/ equipment
- Zero VOHAPS, zero VOCs, minimal material waste

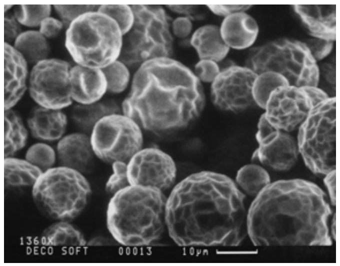
Advances in Topcoats

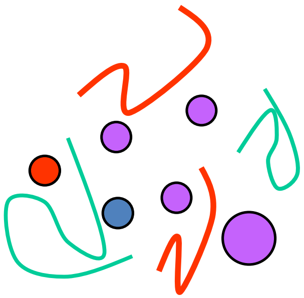
Raw Material Selection

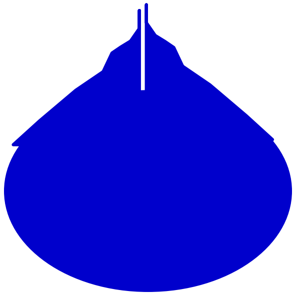
- Resin
- Pigments
- Polymeric flattening agents
- Additives
- Solvents









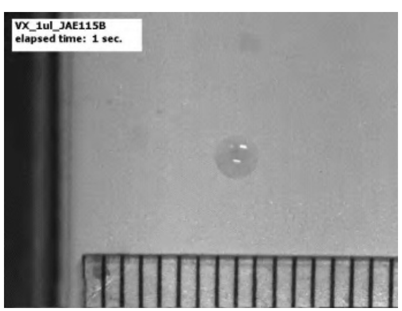


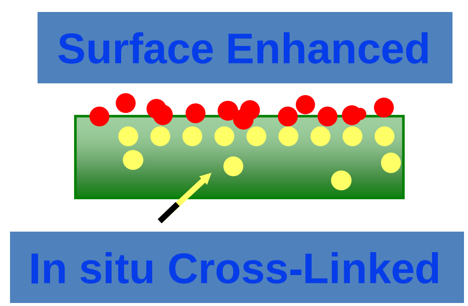
We may advance any one or group of raw material to advance the technology

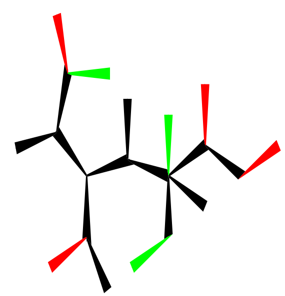
Advances in Topcoats

Following Tailored Coating Application

- Non isocyanate resins (polysiloxane)
- Low solar absorbing pigmentation
- Hydrophilic or phobic additives
- Flattening agents
- Plate like or suspension agents
- Carrier or reactive solvents



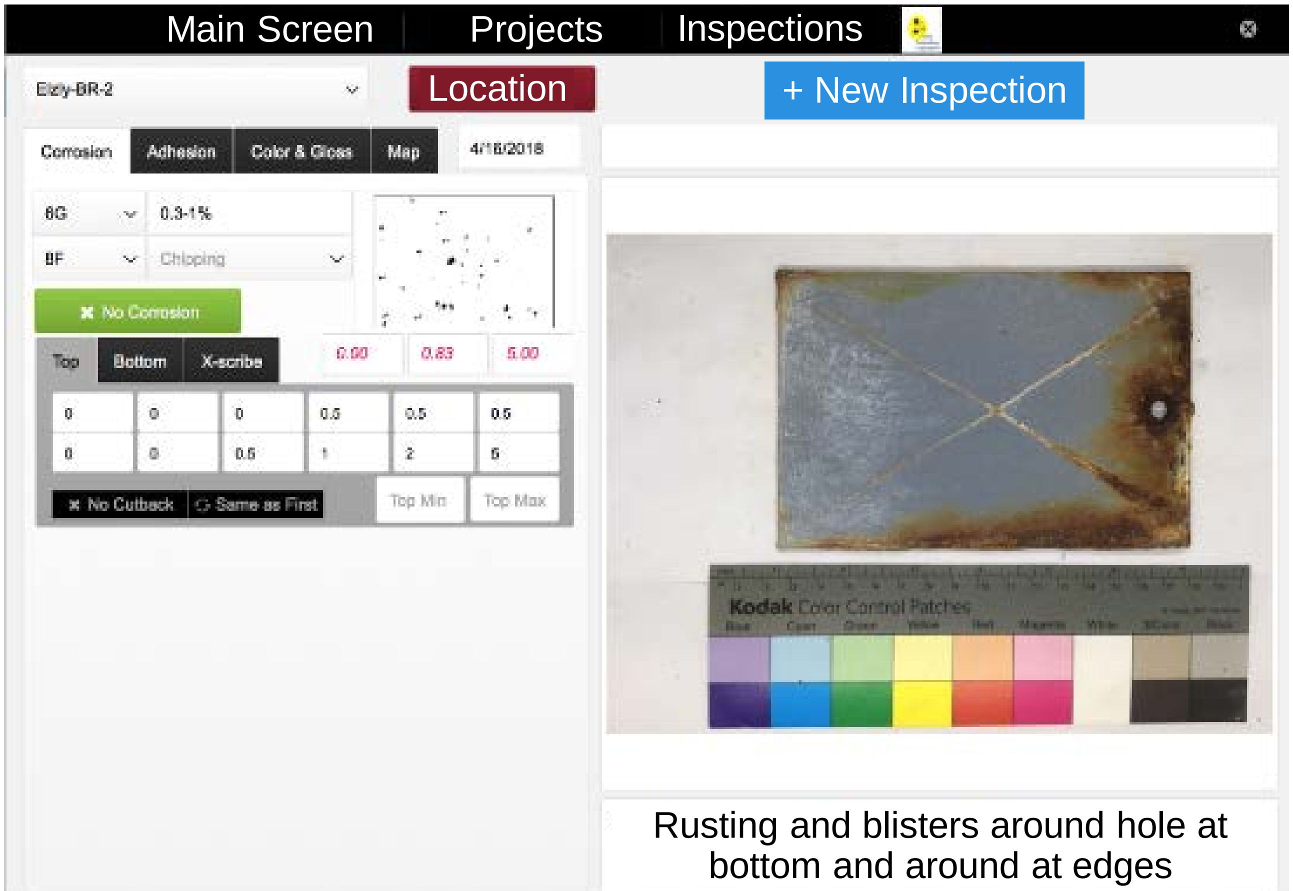




Data Collection Moderation

- Implement use of networkable tablets
  - Photographs
  - Corrosion ratings
  - Adhesion testing
  - Color and gloss
- Scanable bar codes for easy identification
- Geo-tagging
- Integrated with database
  - Access to large scope programs

Data Collection Moderation

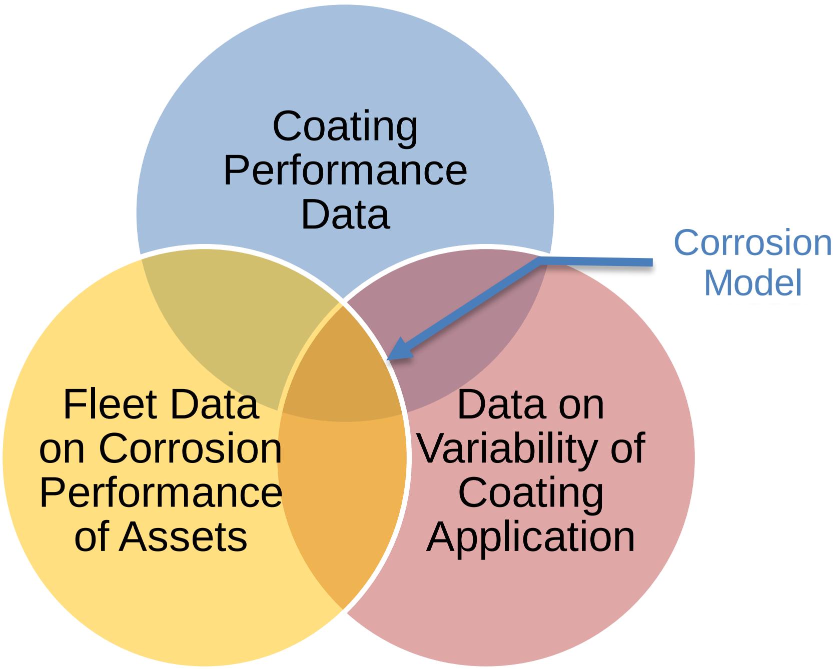


No more pen and paper!

Predictive Corrosion Model

WP19-1208

- Predictive Bayesian model
  - Based on available data
    - Historical CARC information
    - Army fleet surveys
- Supplementary data for mechanistic information
- Additional data for base condition
  - Process
  - environmental
- Robust predictive model
  - Representative of real world



Conclusions

- ARL owns specifications to facilitate coating technology transition
- Greener coatings do not mean reduced performance
- Advances in data collection/interpretation aid in advances

Benefits to DoD

- Advanced coating systems that provide environmental compliance and enhancements without negative impact to performance requirements
- ARL CARC commodity management facilitates coating technology transition which cultivates collaboration with industry, academia and government

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Surface-Engineering-and-Structural-Materials/Coatings/WP-201620

https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Surface-Engineering-and-Structural-Materials/Coatings/WP-201318

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Q&A Session 2

The next webinar is on November 7, 2019

Status of SERDP and ESTCP Efforts on PFAS and Innovative Approaches for Treatment of Waste Derived from PFAS Subsurface Investigations

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends

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