Amphibious High Water Speed Focus Area Forum



Vehicle and Personnel Survivability, Materials, and Structures Technology Area


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Agenda

- Operational Environment
- Lessons Learned
- Current State-of-the-Art
- Technology Challenges

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Operational Environment

- Amphibious vehicle structure/material requirements
  - 20 year service life – hull structure specific
  - Derived requirements
    - Mobility, stowage/lifting/towing, shock/vibration
  - Corrosion prevention and control
    - Maintain full capability over service life and Operational Mode Summary/Mission Profile (OMS/MP)
    - Corrosive seawater/salt spray & high humidity
  - Maintain structural integrity post force protection threat events
    - Roadside and under vehicle IED
    - Penetrating direct fire
    - Water tight and buoyant
  - Climate and terrain
    - Extreme temperature variations
    - Coastal to Desert, Rainforests to Mountainous
    - Amphibious operations
    - Transportability

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Operational Environment

Vehicle Threat Environment

- Armor
  - Direct and indirect fire (heavy machine gun, rocket propelled grenade/anti-tank guided missile, artillery)
  - Mine/IED (roadside/underbody/underwater explosions, blast/fragmentation/explosively formed projectile)
  - Mitigate behind armor debris (e.g. spall liner)
- More widespread use of optics and sensors
  - Signature Management
- DEW (Directed Energy Weapons) effects mitigation
- HEMP (High-Altitude Electromagnetic Pulse) effects mitigation
- NBCCS (Nuclear, Biological, and Chemical Contamination Survivability)

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Lessons Learned

- Weight limitations are driving factor in all design decisions– need to float
  - Protection capability limited due to weight limitations.
    - Amphibious capability (low or high water speed) mandates lightweight material solutions.
    - Increasing protection, if necessary, is accomplished by applying kits once ashore.
- Material and manufacturing costs can be expensive
  - Armor, structure, joining and mechanical components
- Use of dissimilar materials and lightweight expensive materials create corrosion concerns
- Management of fuel and materials to maintain fire survivability
  - E.g., Exterior vs. Interior fuel tanks highly influence survivability designs
- Managing high output engine exhaust in sea water environment
  - Sea water quenching during amphibious operations significantly degrades material life expectancy of exhaust system (initial submerging drop from Navy amphib, high water speed seawater and sea spray, plunging surf of final beach assault)

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EFV Lessons Learned

- Modified Space Frame (13,000 lb. Hull Weldment + 8000 lb. Armor)
  - Enabled program to change light armor solutions should threat requirements change or should a lighter/affordable armor system become available
- FSP (Friction Stir Processing)
  - Leveraged ManTech programs and Industry capabilities to optimize fabrication processes
  - Allows for use of materials with reduced arc weld strength and overall weight savings
- Extensive Paint Process and Material Development
  - Titanium fasteners/components (Many of the bolts/fasteners were individually machined and unique to the EFV.)
  - Ceramic coated Titanium inserts used to reduce corrosion effects
  - Parker seals to maintain seal against sea water intrusion
- Investigated various casting and alternate material initiatives
- Limited internal volume and increased payload requirements
  - Limited clearance of occupant seating and leg protection
  - Limited space for armor and protective systems

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EFV Lessons Learned

- AFES (Automatic Fire Extinguishing System)
  - Essential to reduce effects of overmatching threats
- Fire Survivability
  - Flammable Fluids, Material and component ignitability, Tires
- BDAR (Battle Damage Assessment and Repair)
  - Complex and multi-material structures increase difficulty to assess condition after damage
- Survivability systems/components/appliques SWAP-C (Size, Weight and Power – Cost)
  - Missile Countermeasure, Active Protection, Camouflage Nets & Signature Management
  - Mine Countermeasure
- Paint processes and material selections to manage corrosion can be costly
  - Paint processes were fairly rigid and allowed for minimal flexibility or deviation without significant degradation to corrosion prevention performance

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Current State of the Art

- Composite/ceramic lightweight armor systems
  - Light armor system ranks very high with respect to light armor designs.
- Hull designs influence under vehicle protection capability
  - Buoyancy, Dynamic Lift, Land Mobility and UBB mitigation requirements compete with each other during vehicle design
  - UBB protection designs typically include increased ground clearance and structural shaping – “V-shaped” hull designs for example
  - "V-shaped" hull solutions do not generate lift to achieve high speed semi-planing operations.
  - Flat bottoms provide hydrodynamic lift.
- Occupant centric protection approach
  - Energy absorbing seats
  - Energy mitigating flooring applications

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Ongoing Projects

PM AAA survivability related Initiatives

- Using the SBIR process
  - Phase III light armor; Fuel Tank; Laser Protection; Exhaust; Cooling Exhaust Nozzle; Quiet Cooling Fans; High Efficiency Heat Exchanger; High Temperature Armor; Desktop Survivability and Ray Trace Software; Materials/Castings
- UNDEX effects on wheeled vehicles
- Heavy machine gun armor challenge
- Leveraged efforts from studies for the Amphibious Assault Vehicle (AAV)
  - Survivability upgrade program
  - Enhanced Applique Armor Kit (EAAK) program and sustainment effort
  - Armor aging study of AAV hull and effects on ballistic performance
  - Corrosion effects on hull life and ballistic performance

ONR-30 material/survivability related Initiatives

- ACV-Scale affordable light armor development
  - Scaling up a lighter threat armor design for ACV applications

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Technology Challenges

Material Challenges

- Unique material needs: high strength, weldable, & good ballistic properties (High Strength Alloys)
- Weight is critical
  - Amphibious operations mandate lightweight AND affordable materials
- EMI mitigation
  - Non Galvanic and Galvanic
- Concerned about hazardous and green materials
  - Using the National Aerospace Standard (NAS) 411 standard that presents challenges for corrosion prevention and material selection
- Extended Service Life
  - Inspection and Preventive Maintenance
- Under vehicle mine/IED protection
  - Hydrodynamic requirements constrain protection provided through increased ground clearance and structural shaping.

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Technology Challenges

Corrosion Challenges

- Material selection
- Design
  - Dissimilar alloys – failure to isolate effects
  - Drainage
  - Joining issues – avoidance of crevices, alloy dilution
- Environment (Temp., seawater, dust, abrasives, etc)
- Improper, inadequate corrosion prevention/control
  - Lack of good surface preparation
  - Poor selection of conversion coating, primer, or coating
  - Poor coating application
  - Lack of inspection criteria/ inspection timing
- Manufacturing and Workmanship
- Inadequate maintenance

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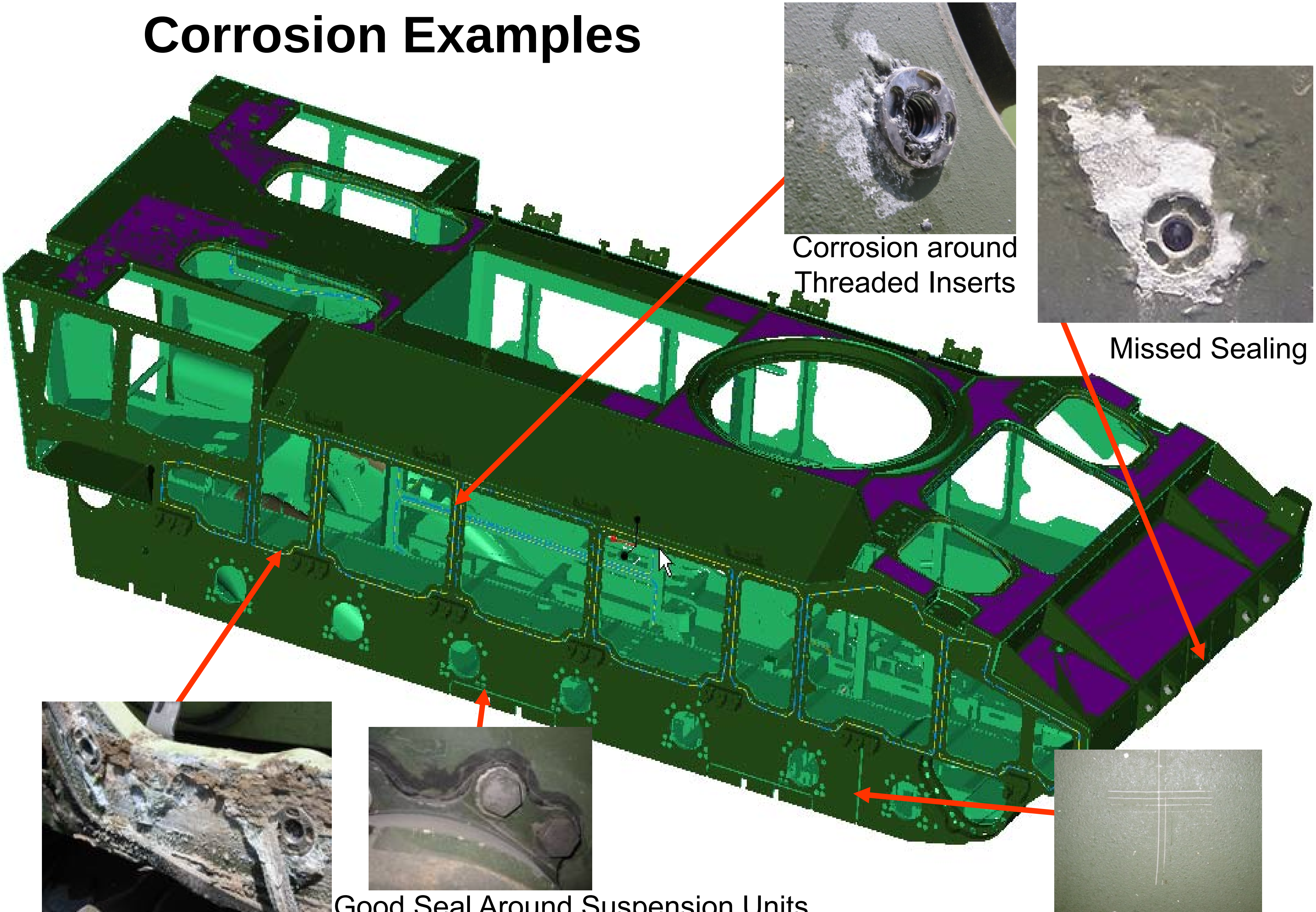
Corrosion Examples



Corrosion around Threaded Inserts

Missed Sealing

Corrosion Under Armor

Good Seal Around Suspension Units

Non Galvanic / No Crevice

Technology Challenges: Summary

- Lightweight, more affordable armor
- Lightweight, durable, corrosion resistant structures, materials and components
  - Corrosion prevention, control and joining
- Occupant protection technologies
- Active protection and countermeasure systems
- Add-on/modular protection technology for under vehicle and direct fire threats
- Protected ammunition and infantry weapon stowage
- Fuel tank to maintain mobility and force protection
- Fire survivability
- Battle Damage Assessment is difficult with complex and multi-material structures

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