OFFICE OF THE SECRETARY OF DEFENSE
1700 DEFENSE PENTAGON
WASHINGTON, DC 20301-1700

OPERATIONAL TEST
AND EVALUATION

OCT 26 2012

The Honorable Howard P. "Buck" McKeon
Chairman
Committee on Armed Services
United States House of Representatives
Washington, DC 20515-6035

Dear Mr. Chairman:

I have enclosed a response to Committee Report 112-479, May 11, 2012 requesting a briefing addressing Test and Evaluation of Materials Degradation. In the briefing I have provided background information on corrosion mitigation, prevention, and control; addressed recent problem areas and lessons learned in the test and evaluation community; present actions taken by DOT&E; and recommendations and considerations for other agencies.

Should the Committee require additional information, my point of contact is Mr. Greg Barlow. He can be reached at greg.barlow@osd.mil, or 703.590.2999.

J. M. Gilmore

J. Michael Gilmore
Director

Enclosure:
As stated

cc:
The Honorable Adam Smith
Ranking Member

Test and Evaluation of Materials Degradation

Corrosion Prevention, Mitigation, & Control

Briefing Prepared in Response to:
HASC Report 112-479, NDAA for FY2013
May 11, 2012

Overview

- *Corrosion Prevention, Mitigation, and Control (CPM&C) Background*
- *CPM&C Considerations*
- *Observed Problem Areas*
- *Operational Test and Evaluation CPM&C Observations*
- *Recent Lessons – F-22A*
- *F-22A Lessons Learned Applied to F-35*
- *DOT&E Actions and Considerations*
- *Additional Considerations*
- *Recommendations*

General Background

- Corrosion prevention, mitigation, and control (CPM&C)
  - Is a subset of overall system reliability, maintainability, and availability. CPM&C considerations influence both design and development activities as well as life cycle sustainment programmatic decisions.
- Success in meeting CPM&C qualification/specification criteria through system design and development is largely dependent on:
  - Robustness of the selected design
  - Understanding of the materials properties to be used in the system design
  - Rigor of the system design reviews conducted by the program management teams
  - Completeness of the systems engineering processes and developmental testing
- Similarly, successful CPM&C management across the life cycle of a given system is largely dependent on:
  - A funded CPM&C sustainment program that complements and supports the system as designed throughout the operational environments and expected service life of the system
  - The ability to address and resolve unanticipated CPM&C shortfalls that were not realized during system design, development, or pre-fielding test and evaluation

CPM&C Considerations

- Corrosion is not a new phenomena; CPM&C is one of many life cycle suitability considerations across all weapon systems

- CPM&C is a continuous process from system initial design, development and testing through life-cycle system sustainment:
  - Combination of system design considerations, as well as life cycle sustainment (prevention, inspection, maintenance, repair, replacement) of the system
  - Trade offs are made during system development phases with the intent of designing corrosion resistance and prevention properties that enable the system to function in the intended operational environment consistent with the program's planned CPM&C sustainment posture (inspection, maintenance, repair, replacement).
  - Sustainment is predicated on the "prevention and control" caveats – which drives inspection, repair, and (depending on the system) replacement of affected components and/or subsystems based on a given system's operational maintenance construct, sparing and replacement programs, and depot maintenance - all part of a weapon system's life cycle cost posture

Observed Problem Areas

- When systems fail to meet qualification/specifications prior to operational testing/fielding, root causes include:
  - Science and technology; inadequate design – *less than perfect understanding of the design/materials and physical integration processes; application of inappropriate/non-effective materials integration technologies*
  - Qualification testing – incomplete, non-robust systems engineering and/or developmental test and evaluation
    - *Inadequate direct government participation/oversight of corrosion testing*
    - *Non-robust environmental (climatic) qualification testing*
    - *Insufficient justification to verify closeout of corrosion control requirements*
    - *Limited ability to equate component-level accelerated corrosion test results to full-scale dynamic system performance over an expected 20-30 year service life*

- Post-Initial Operational Test and Evaluation problems occur with fielded systems when:
  - The robustness of the fielded system design doesn't support the program's planned CPM&C sustainment posture (inspection, prevention, repair, replacement) or vice versa. When this happens, consequences can include: reduced availability; increased manpower and resources costs, accelerated inspection/maintenance/repair/replacement, costly post-fielding retrofits or design changes, and increased life cycle costs

Operational Test and Evaluation CPM&C Observations

- DOT&E has not observed instances where CPM&C requirements have been “traded away” in the requirements development process.

- The overwhelming bulk of corrosion test and evaluation is accomplished early in system design and throughout the program’s systems engineering processes and developmental test and evaluation.
  - Given the relatively short duration of Initial Operational Test and Evaluation, it is unlikely that shortfalls in a system’s CPM&C capabilities may be fully discovered.
  - Notably, should significant CPM&C shortfalls be discovered in Initial Operational Test and Evaluation (IOT&E), there is little to no schedule margin to correct deficiencies. CPM&C problems realized in IOT&E may render the system not operationally effective or suitable.

- Incomplete knowledge of CPM&C shortfalls and/or reduced scope of environmental and corrosives testing during system development transfers the risk of discovery to IOT&E where there’s little if any opportunity to affect solutions

Recent Lessons – F-22A

- Prioritization of low observable requirements led to acceptance of other corrosion risks during system development
- Program implemented silver-filled conductive gap filler and paint in direct contact with aluminum structures – well known corrosive risk
  - No risk mitigation through increased testing during development; no trade studies to identify long-term costs of corrosion
- Performance-based acquisition approach:
  - Contractor corrosion testing without direct government participation; government accepted the risk and cost of failure
  - Insufficient justification to verify closeout of corrosion control requirements
- Environmental and occupational health concerns drove use of non-chromated outer mold line primer that didn't provide the needed corrosion protection; this led to additional corrosion issues in the field

Recent Lessons – F-22 *(continued)*

- Aircraft signature considerations drove design change in the number and size of drainage ports
  - Reduced from 201 initial design to 27 drainage ports
  - Remaining drainage ports proved insufficient in removing water and other corrosive liquids from aircraft cavities
  - Water intrusion issues at deployed locations led to post-fielding drain port redesign/retrofits
- Reduced scope climatic lab testing during developmental test and evaluation
  - Reduction from 6 to 3-month period
  - No severe wet weather testing
  - 2008 operational unit deployment to Guam experienced severe water intrusion and associate corrosion; forced redesign/addition of cockpit drain port
- No field test of final low observable coating system prior to Initial Operational Capability
  - 5-year Low Observables Over Time (LOSOT) testing from 2005-2010 necessary to determine stability, durability, and maintainability
- All operational testing in desert southwest environment
  - Operational units (Langley VA, Tyndall FL, Elmendorf AK) experienced additional corrosion issues not seen in desert southwest environmental
- <u>Consequences</u>: *Significant redesign/retrofit costs incurred post-IOT&E ~$228M; increased manpower; reduced system operational availability*

F-22A Lessons Learned Applied to F-35

- Fewer outer mold line seams; gap filler less galvanically dissimilar from aluminum; less aluminum in outer mold line
- Early corrosion testing of conductive gap filler in representative operational environment
- Testing of full stack-up panel seams with simulated damage exposed to accelerated and outdoor (beach) exposures
- Sufficient internal drainage system
- Climatic lab testing planned to incorporate severe weather testing
- Flight testing in operational environments other than desert southwest ~3-4 years prior to IOT&E (Edwards CA, Eglin FL, Patuxent MD)

Overall Lessons Learned – F-22 to F-35

- Low observable aircraft CPM&C poses unique developmental and design challenges
  - Signature requirements must be balanced with evolving technologies
  - Trade-offs have consequences: signature vs. corrosion; signature versus drainage; optimum LO designs may be less than optimum for CPM&C considerations
  - Environmental considerations (e.g. non-chromated versus chromated primers) may result in unintended consequences that adversely affect CPM&C performance

- *Trades early in F-22 program (signature priority) resulted in adverse CPM&C consequences and significant retrofit costs post fielding*
  - *Potential problem areas were not highlighted in design reviews*
  - *Lack of government involvement and oversight of developmental qualification testing was a contributing factor – Total System Performance Responsibility (TSPR) contract type for both F-22 and F-35*

- Post-IOT&E CPM&C testing of low observables
  - 5-year F-22 Low Observables Stability Over Time (LOSOT) testing invaluable in assessing long-term system CPM&C durability, suitability, and maintainability
  - *Similar long-term testing approach for F-35 in work*

DOT&E Actions and Considerations

- Actions that DOT&E can, will, and does take to consider material degradation due to corrosion and associated impacts on operational effectiveness and suitability include the following:
  - Limitations (system quantities, test duration, basing, security, test range locations, and others) preclude testing in every possible operational environment. However, DOT&E conducts and will continue to conduct operational test and evaluation across the range of operational environments available during IOT&E periods. IOT&E – as a period of performance confirmation at the end of system development – cannot identify all unforeseen CPM&C shortfalls.
  - Where progress and results from developmental test and evaluation indicate potential shortfalls and challenges in CPM&C, DOT&E will include CPM&C in formal Operational Assessments prior to IOT&E.
  - Similarly, should progress in meeting CPM&C design specifications at programmatic milestone decision points prior to IOT&E indicate shortfalls in testing, or when novel materials and coatings are utilized (*e.g. low observables materials for aircraft*) DOT&E will require demonstration that system specification requirements are met as entrance criteria prior to IOT&E.
  - Where warranted based on system performance during developmental test and evaluation, DOT&E will direct additional CPM&C inspections and maintenance evaluations be incorporated into operational test and evaluation plans approved by the DOT&E.
  - For systems utilizing unique and novel materials and coatings (e.g. F-22 and F-35 low observable systems) experience has shown that conducting long-term testing over time has provided invaluable insight into the durability, maintainability, and sustainability of fielded systems. As was the case with the F-22 post-IOT&E 5-year Low Observables Stability Over Time operational test, DOT&E will continue to require such testing in the interest of informing such fielded systems' long-term operational effectiveness and suitability requirements are met.
  - In cases where CPM&C shortfalls are identified in IOT&E, DOT&E will require focused formal follow-on test and evaluation to determine the efficacy of CPM&C mitigation strategies implemented to address such shortfalls.

Additional Considerations

- Operational Test and Evaluation, occurring at the end of system development, affords only a limited duration in which to assess CPM&C characteristics of a given system. Accordingly, corrosion testing is primarily a function of early systems engineering design and developmental testing prior to IOT&E. As such, experience with recent systems (e.g. the F-22A & F-35) suggest actions that the Acquisition Community and Developmental Test and Evaluation agencies should implement to include:
  - Ensure government oversight and active participation in CPM&C qualification testing early during initial systems engineering design and component and subsystem developmental test and evaluation. Delegating CPM&C design and developmental decisions to contractors without government participation or oversight can have adverse consequences (e.g. F-22A outer mold line corrosion issues and post IOT&E retrofit costs).
  - Robust climatic laboratory environmental and corrosives testing during system development is crucial to identifying potential shortfalls and problems. Reducing the scope of climatic laboratory testing to accommodate near-term program budget and schedule challenges can result in unplanned and unbudgeted fielded system redesign or retrofit costs.
  - During developmental test and evaluation, conduct full system-level testing in diverse environments representative of those in which the fielded system will operate should be considered to provide insight into CPM&C capabilities and limitations.
  - Programs utilizing unique and novel materials and coatings (e.g. F-22A and F-35 low observable systems) should plan and program for post-operational fielding, long-term testing over time to ensure CPM&C stability, suitability, and maintainability features meet life-cycle performance requirements.

Recommendations

Early, informed, and complete design, systems engineering, and developmental test and evaluation with direct government involvement and oversight afford the best opportunity to mitigate CPM&C shortfalls and associated risks.

Development efforts must encompass such practices, and be informed by lessons learned across similar development efforts.