CORROSION POLICY AND OVERSIGHT

OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR MATERIEL READINESS

SLIDES ONLY

NO SCRIPT PROVIDED

Product Support and CPC Planning

September 2022

DoD Enterprise Corrosion Impact

What's the Corrosion Problem ?

Since 2003, the Department spends over $20B annually on corrosion, representing over 20% of the total maintenance cost, 24 million hours of downtime at $833 per down-time hour.

Current Examples of Operational Impacts of ineffective CPC implementation :

- F-22 Reliability and Maintainability Maturation Program total funding requirement has ***increased 100% ($664M to $1.3B) to correct unplanned corrosion issues***.
- ***83% of F-35 corrosion issues are common across all variants***, impacting approximately 75% of global fleet impacting MC rates , thus readiness
- F/A-18 Service Life Modification program (SLM) is experiencing ***a backlog of work in progress because of unplanned corrosion issues***; resulting in a backlog of jets waiting to get inducted into SLM.

Discussion Items

- What motivates PMs to select SMEs to support their Acquisition Program?
  - Where does CPC planning fit?
- Maintenance Planning and CPC
  - Reliability
  - Maintainability (preventive and corrective maintenance)
- CPC Planning Resources
  - DoD CPC Planning Guidebook
  - Where does CPC expertise reside?

What motivates PMs to select SMEs to support their Acquisition Program?

Where does CPC Planning Fit?

Acquisition Drivers

Acquisition Program Drivers	CPC Planning impact: positive (+), negative (-), or neutral(~)	Typical Support "-ilities"
Cost	-	Prog Mgr Financial Mgr Analysts
Schedule	~ or -	Prog Mgr Analyst
Performance	~ or +	Engineering, Technical Expertise

Performance Element Breakdown

Performance Element /Driver (Per JCIDS Manual)		CPC Planning impact: (+,- ,~)	Typical Support "-ilities"
KPPs **KSAs** **APAs**	Sys Performance Attributes Note: System Dependent ; will be multiple elements	**~ or +**	Sys Engr Mech Engr Elec Engr S/W Engr Ind Engr
MKPP	Energy	**~**	?
MKPP	System Survivability	**~**	?
MKPP	Force Protection	**~**	?
MKPP	Sustainment	**+**	Product Support Logisticians

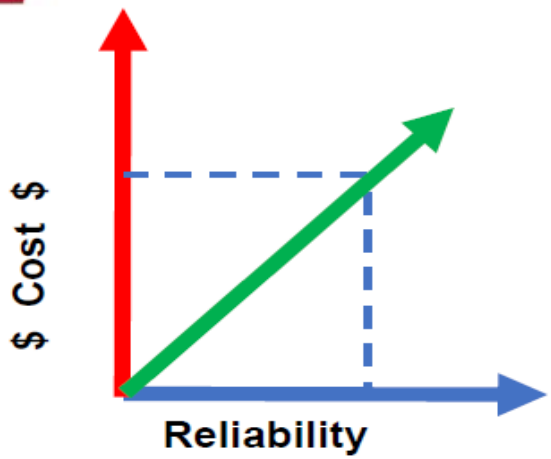
Sustainment Element Breakdown

Sustainment KPP Element (Per JCIDS Manual)	CPC Planning impact: (+,- ,~)	Typical Support "-ilities"
Materiel Availability	+	Logistician
Operational Availability	+	Logistician
Reliability		
Mission	+	?
Logistics	+	Logistician

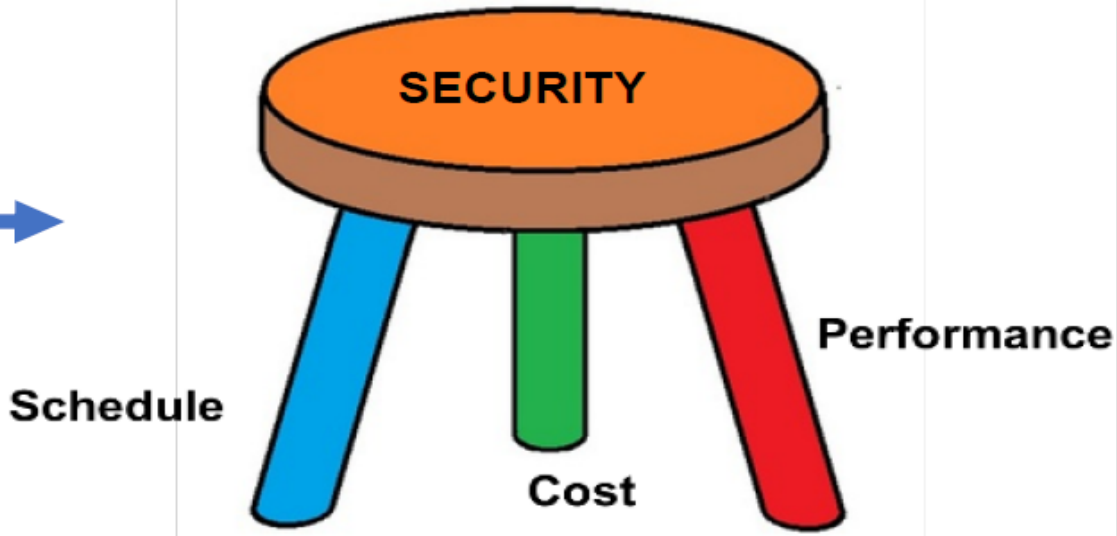
Sustainment Element Breakdown

Sustainment KPP Element (Per JCIDS Manual)	CPC Planning impact: (+,- ,~)	Typical Support "-ilities"
Maintainability		
Maintenance Burden	+	Logistician
Corrective Maintenance	+	Logistician
All Failure	+	Logistician
Mission Failures	+	Logistician
Built-In-Test	~ or +	Logistician
O&S Cost	+	Logistician Budget Analyst

Design for Support

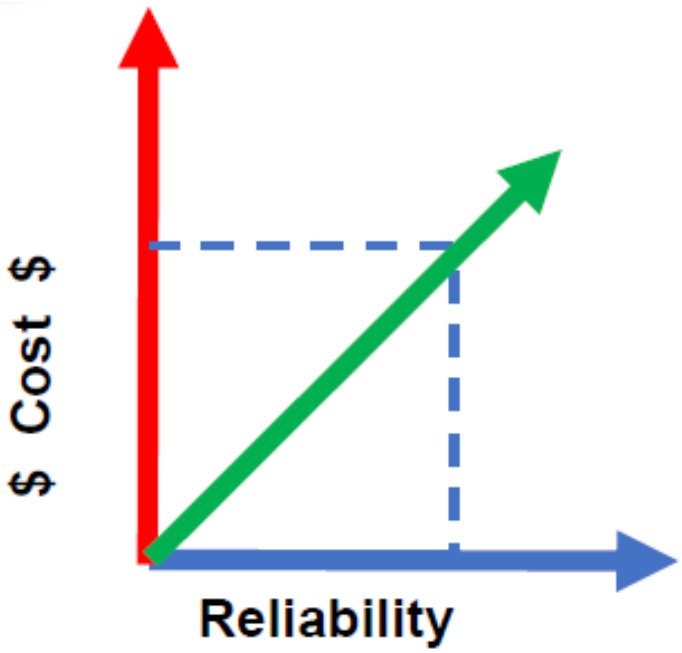


Trade Space Analysis



Derived from RAM-C Report Manual

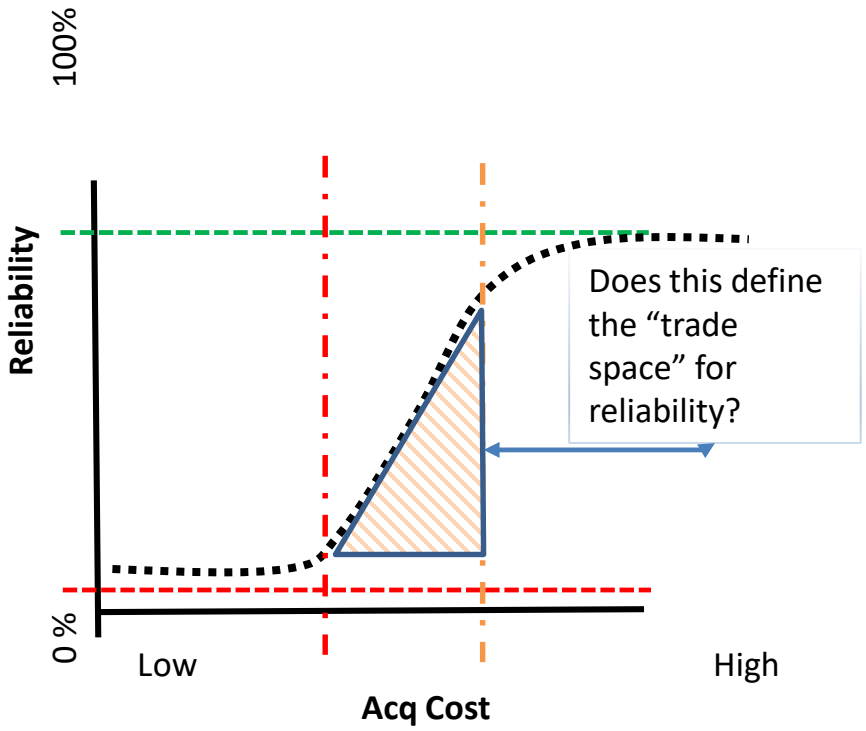
Acquisition Cost vs Reliability (idealistic representation)



- Why is cost versus reliability presented in an idealized linear relationship?
- We know from experience that:
  - High Acq Costs can yield High Reliability
  - While at the same time, it is also true that Acq High Costs can yield Low Reliability
- Would it be better to present the approach differently?

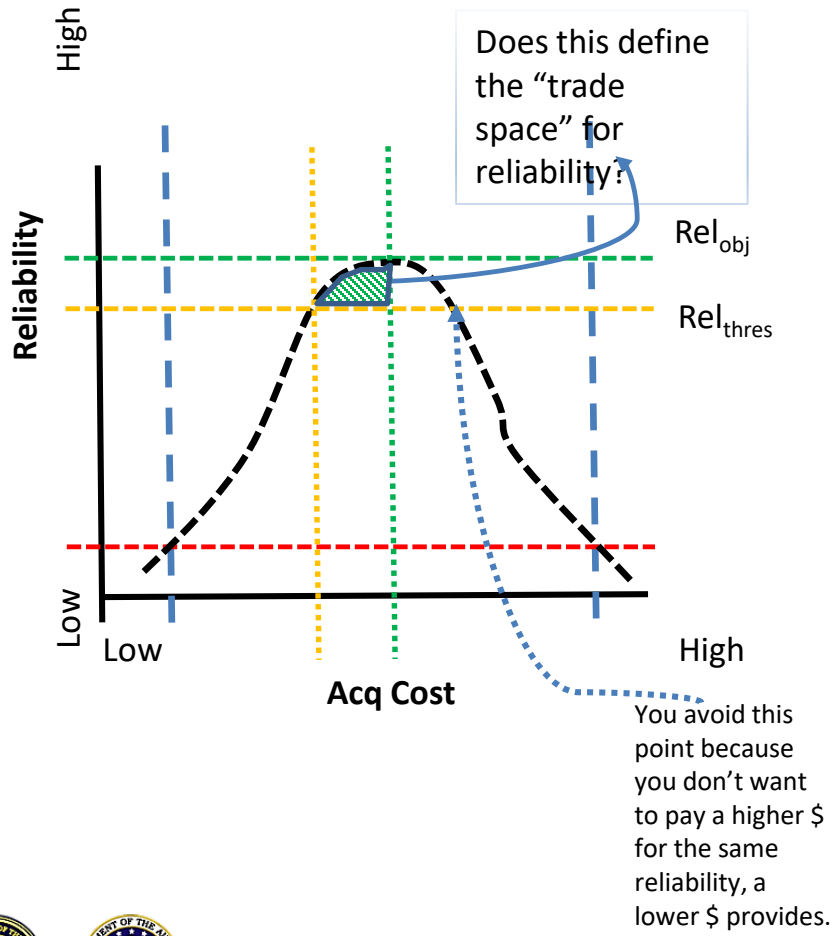
Reliability vs Acquisition Cost (Better Theoretical Representation)

- If we agree the following statements are true possibilities:
  - High Costs/Investment can yield High Reliability
  - High Costs/Investment can yield Low Reliability
  - Theoretically 100% reliability is not achievable
  - Theoretically 0% reliability does exist
- Would this graph be a more realistic representation?



Reliability vs Acquisition Cost (More Realistic Representation)

- If we agree the following statements are true possibilities:
  - High Costs/Investment can yield High Reliability
  - High Costs/Investment can yield Low Reliability
- Would this graph be a more realistic representation?
  - One may reasonably assume the there would only be one point of optimizing reliability as a function cost, and not a multi-modal function.
- Therefore, this would imply there is an optimization of reliability in relation to cost/investment.
- Another approach would be to represent it in Production Possibility Frontier (PPF) graphical format.



Corrosion Impact on Operational Availability

- Weapon System Operational Availability, A_o

$$A_o = \frac{MTBM}{MTBM + MDT}$$

- What's a simpler approach to look at for some given time period:

$$A_o = \frac{Up\ Time}{Total\ Time} = 1 - \frac{Down\ Time}{Total\ Time}$$

$$Total\ Time = Up\ Time + Down\ Time$$

So, how does Availability behave?

A_o increases if Down Time decreases;

A_o decreases if Down Time increases

Corrosion Impact on Availability

- What factors impact system Down Time, how much does it cost, and how does Corrosion impact it?
  - Inventory (INV) covers items such as:
    - Supply Chain Items, i.e. spare parts and availability of parts
    - Redundant weapon systems (mostly used to maintain MC rates)
  - Operational Expenses (OE) covers items such as:
    - Direct Maintenance Labor
    - Direct Maintenance Materials
    - Storage
    - Time (value of non-availability)

- These are resources needed to determine Maintainability
  - Preventive Maintenance?
  - Corrective Maintenance?

DoD Enterprise – Maintenance Outcomes

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DoD Weapon System Enterprise	Total Maintenance Expenditure	Preventive Maint allocation	Corrective Maint allocation	CostNeither Allocation	Preventive as % of Total	Corrective as % of Total	CostNeither as % of Total
FY10-FY19 Averages	$64,990,683	$18,946,222	$40,311,692	$5,732,331	29%	62%	9%
Std Deviation	$3,429,151	$1,888,493	$1,738,466	$792,960	2%	1%	1%

DoD Aviation Enterprise	Preventative as % of Total Maintenance Expenditure			Corrective as % of Total Maintenance Expenditure			Other Mx as % of Total Maintenance Expenditure		
	Army	Navy/USMC	Air Force	Army	Navy/USMC	Air Force	Army	Navy/USMC	Air Force
10-11 Yr Average	33%	31%	28%	62%	66%	67%	6%	4%	5%
Standard Deviation	4%	4%	2%	4%	4%	2%	2%	1%	2%

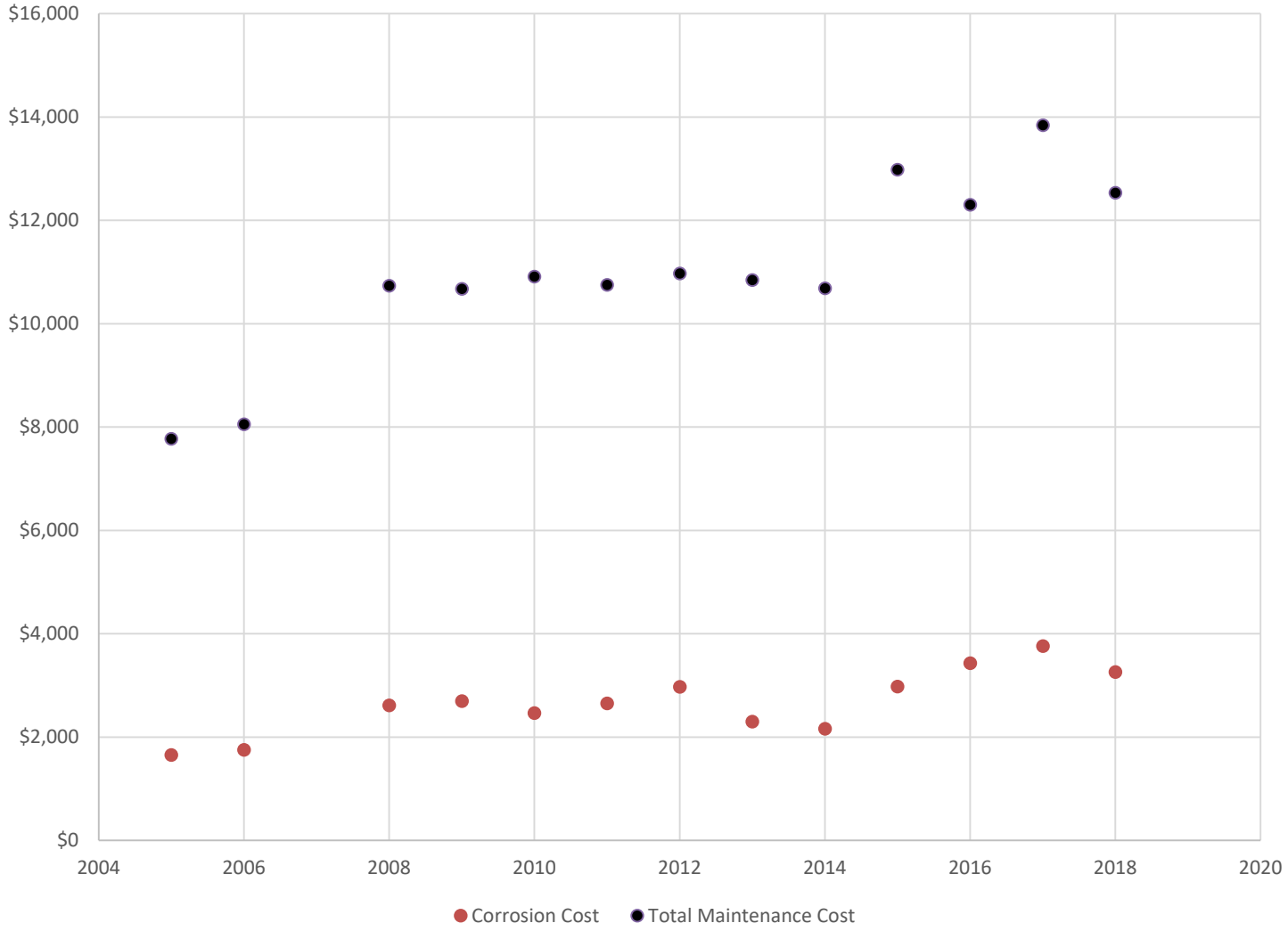
DoD Ground System Enterprise	% Preventative of Total Maintenance Expenditure		% Corrective of Total Maintenance Expenditure		% Other Mx of Total Maintenance Expenditure	
	Army	USMC	Army	USMC	Army	USMC
10-11 Yr Average	37%	26%	54%	42%	10%	32%
Standard Deviation	6%	12%	6%	18%	5%	29%

Macro-analysis of Historical Maintenance Expenditure Data Indicates DoD Sustainment Culture Accepts a Reactive Maintenance Posture over a Planned Maintenance Posture

Corrosion Outcome: Example 1

Consideration 1:
Corrosion Costs as a Percentage of Maintenance Cost

Example 1: Are Costs Increasing? A_o?



Corrosion Percentage of Costs vs Time

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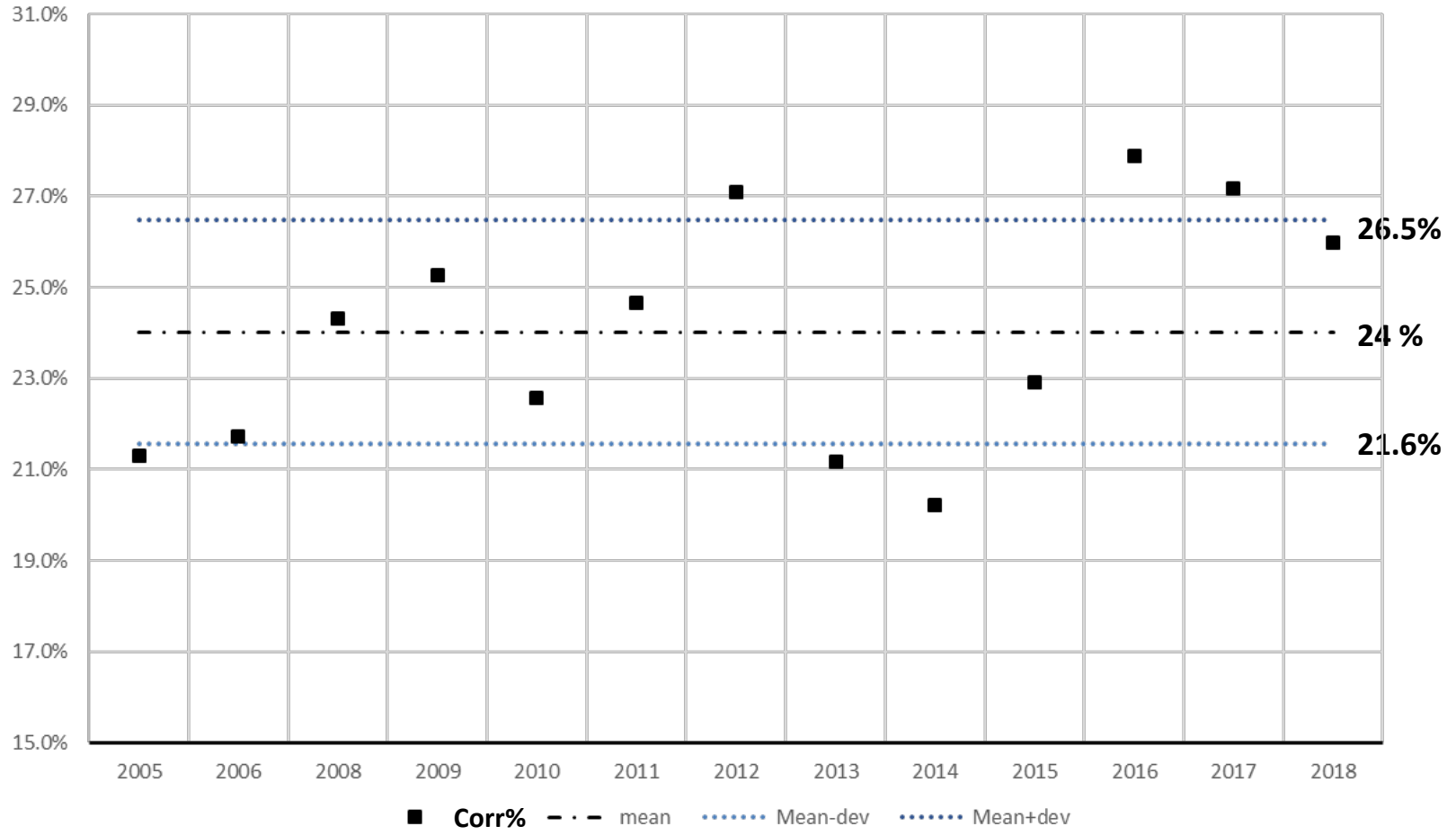


(2019 algorithm)

Enterprise Cost Based Corrosion Approach

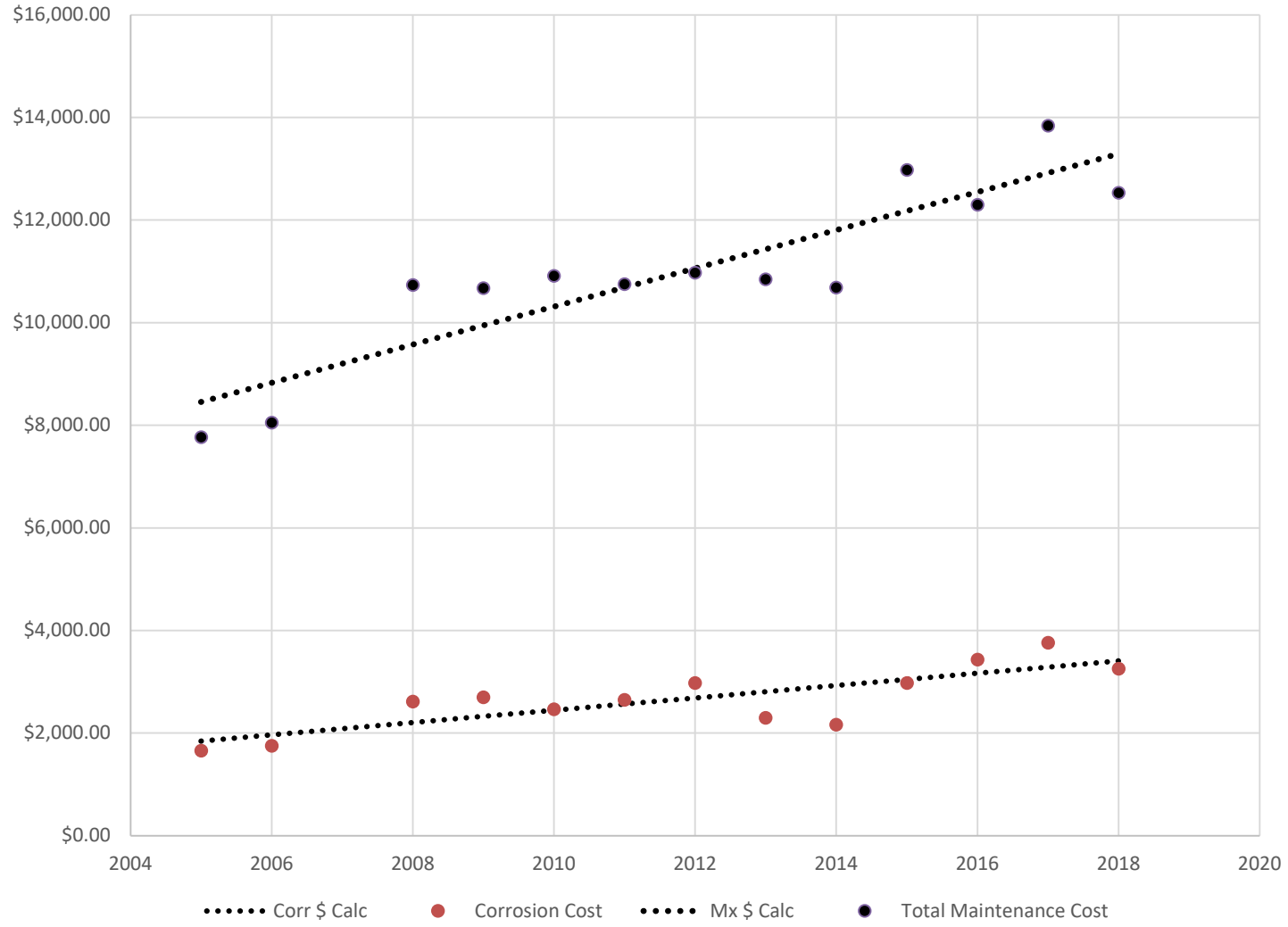
Assumption 1: An Inherent Availability was established on some estimate of INV and OE based upon Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) at fielding; therefore let's define those as baseline INV and OE (annual fixed costs)

Assumption 2: Some percentage of corrosion sustainment cost was built in the fixed "costs" for the Inherent Availability of the system

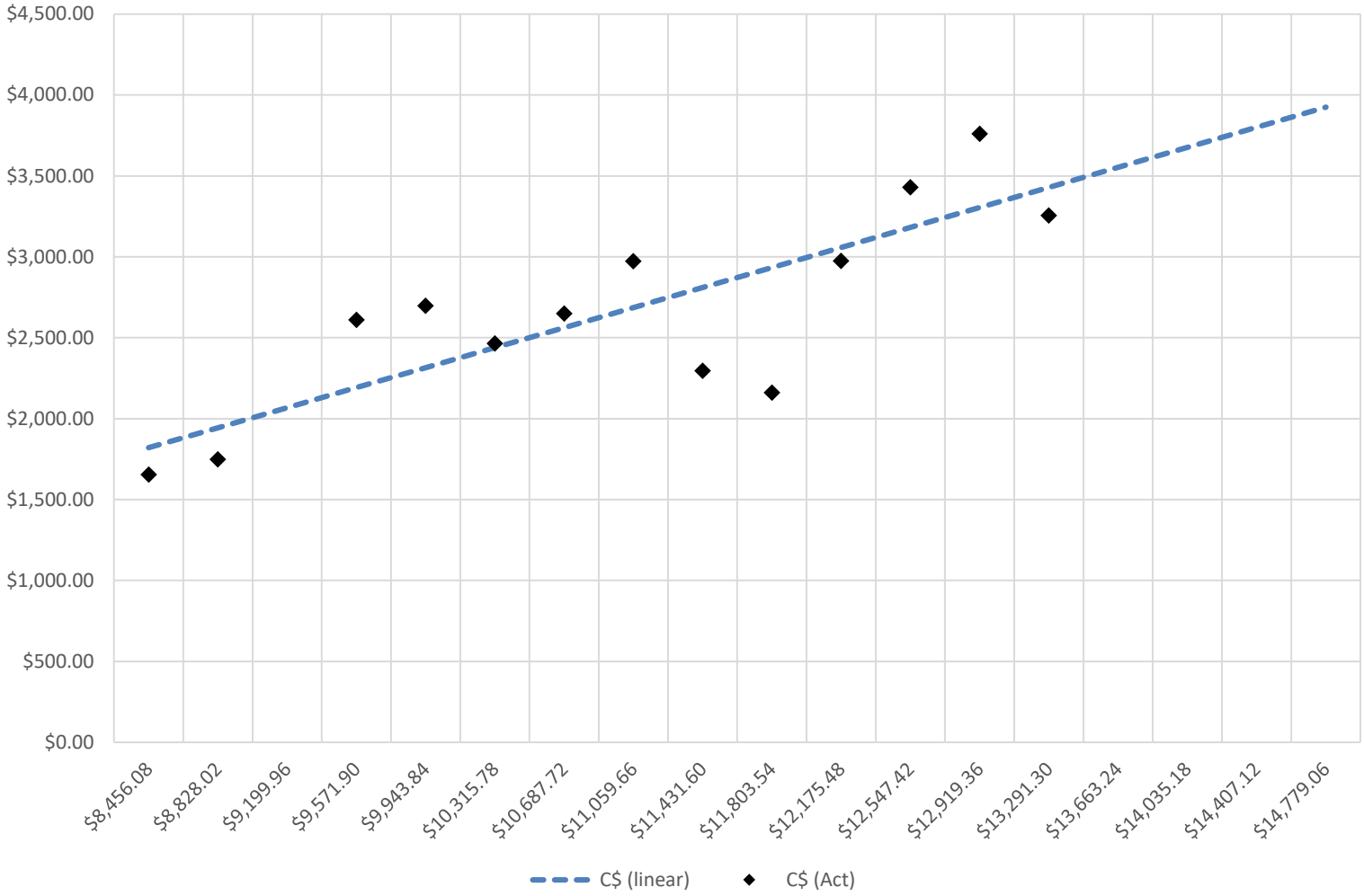
- Based upon the available data:
  - The effective assumed fixed corrosion costs is ~24 % of the total maintenance costs
  - The Standard Deviation or Variation in corrosion cost ~ +/- 2.5%
- What does that mean?
  - The Average Annual Maintenance Cost = $11,002M per year
  - Planned Corrosion Cost = $2,640M +/- $275M

Consideration 2: Corrosion and Maintenance Cost Modeling

Linear Regression Modeling



Linear Regression: Corrosion Vs Mx Costs



Modeling Based Corrosion Approach

Assumption: An Inherent Availability was established on some estimate of INV and OE based upon Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) at fielding; therefore, let's define those as baseline INV and OE (annual fixed costs)

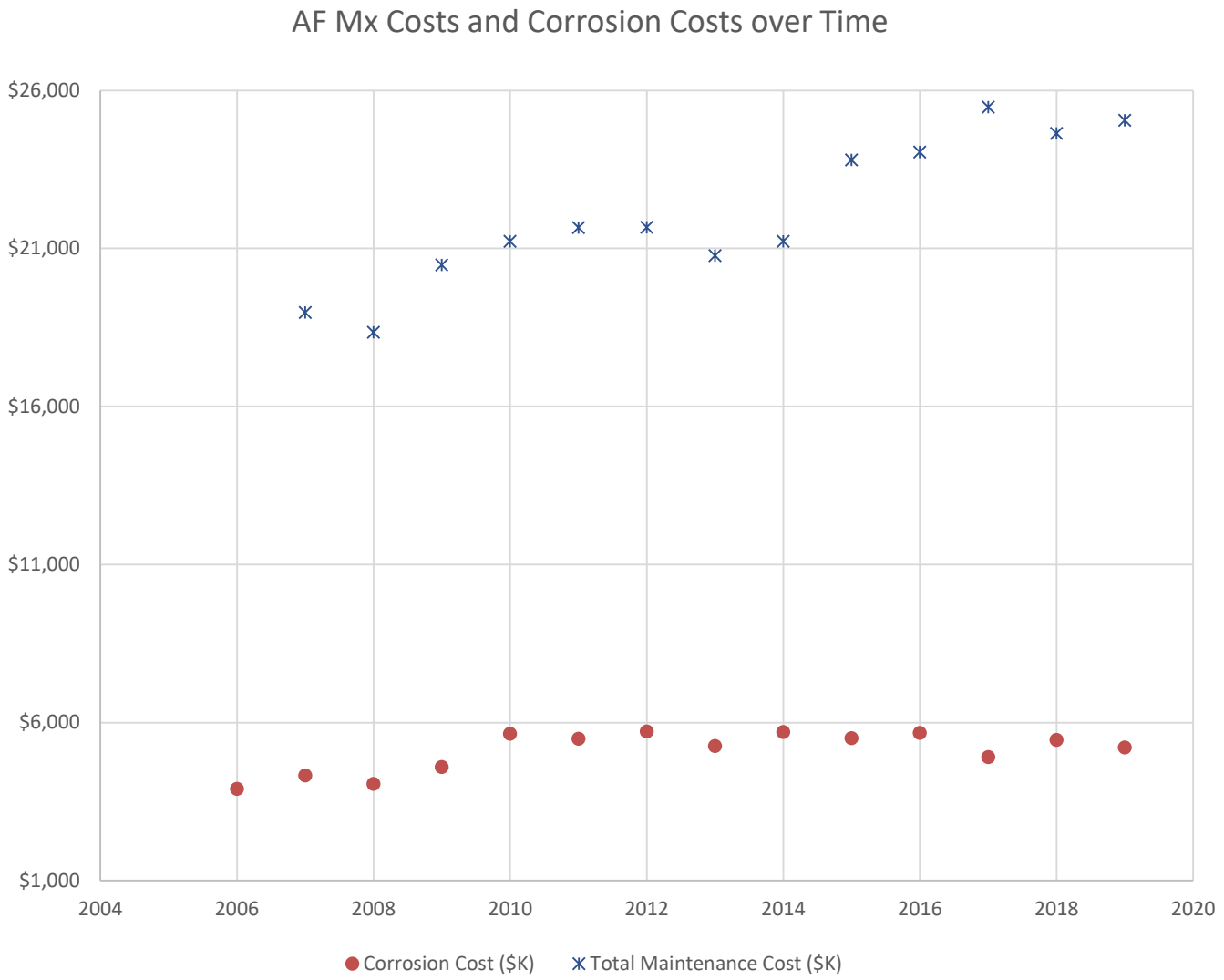
Assumption 2: Some percentage of corrosion sustainment cost was built in the fixed "costs" for the Inherent Availability of the system

- Based upon the available data:
  - The effective assumed fixed corrosion costs is ~33 % of the total maintenance costs
- What does that mean?
  - The Average Annual Maintenance Cost Increase = $379M per year
  - Planned Corrosion Cost Increase = $125M

Corrosion Outcome: Example 2

Consideration 1:
Corrosion Costs as a Percentage of Maintenance Cost

MaintenanceCosts and Corrosion Costs over Time



Corrosion Percentage of Maintenance Costs vs Time

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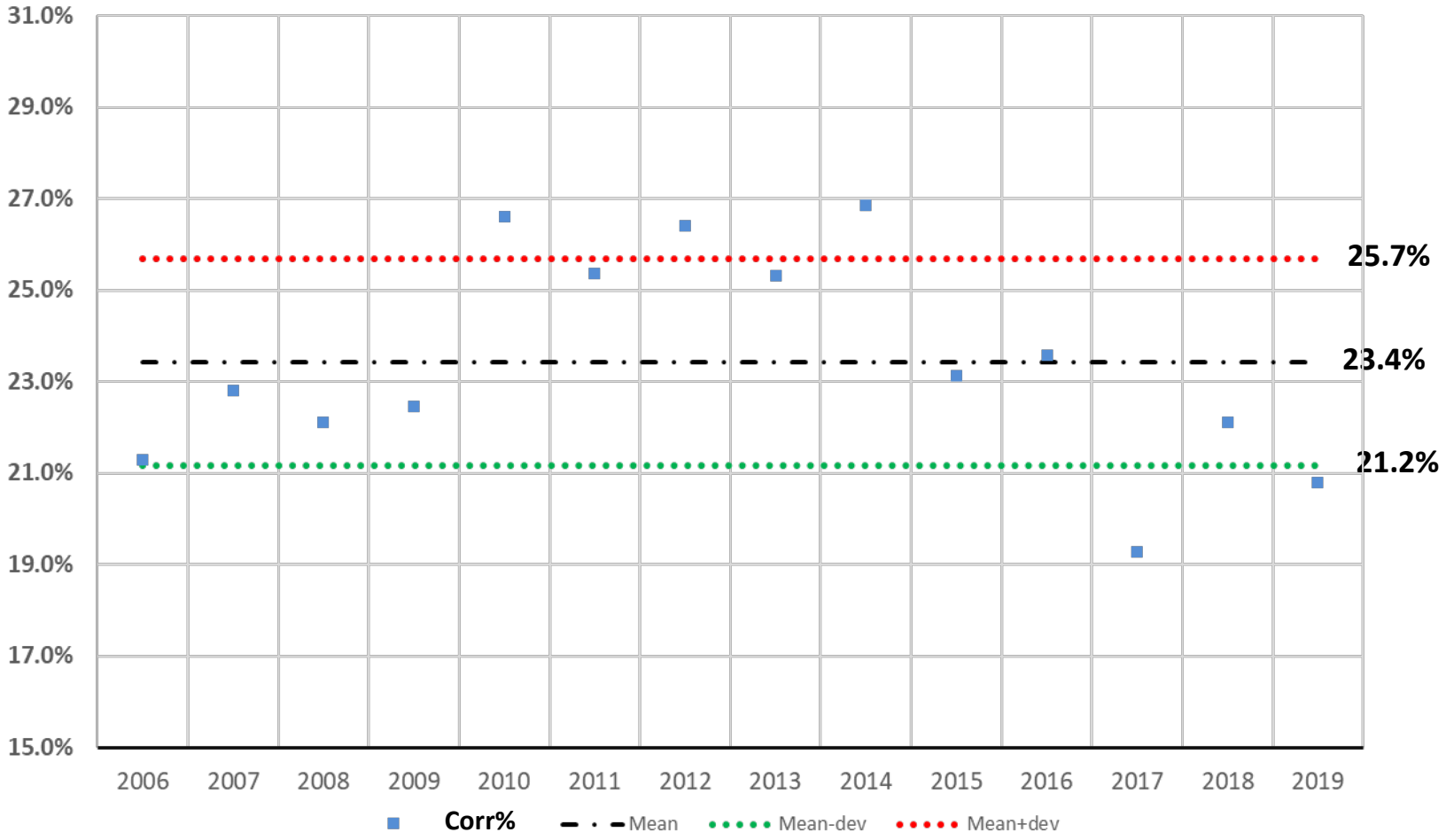

Enterprise Cost Based Corrosion Approach

Assumption: An Inherent Availability was established on some estimate of INV and OE based upon Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) at fielding; therefore let's define those as baseline INV and OE (annual fixed costs)

Assumption 2: Some percentage of corrosion sustainment cost was built in the fixed "costs" for the Inherent Availability of the system

- Based upon the available data:
  - The effective assumed fixed corrosion costs is ~23 % of the total maintenance costs
  - The Standard Deviation or Variation in corrosion cost ~ +/- 2.3%
- What does that mean?
  - The Average Annual Maintenance Cost = $21,838K per year
  - Planned Corrosion Cost = $5,022K +/- $116k

Consideration 2: Corrosion and Maintenance Cost Modeling

Regression Modeling

CPC Planning Resources

DoD CPC Planning Guidebook

Recently Revised to cover:

- CPC Planning by Acquisition (AAF) Pathway and Phase

- Functional Area:
  - Program Management
  - Engineering
  - Life Cycle Sustainment
  - Test & Evaluation

Action	Program Phase				
	MSA	TMRR	EMD	P&D	O&S
Life Cycle Sustainment Back to Document Overview					
Include corrosion-related sustainment and maintenance considerations and acceptance criteria in the TEMP.		✓	✓		
Define CPC requirements to include in the product support solution.		✓	✓		
Flow CPC requirements down to PSIs and PSPs, as appropriate.				✓	✓
Include corrosion metrics in the RAM-C rationale report.		✓	✓	✓	✓
Support the materiel availability (A_m) and operational availability (A_o) KPPs in the CPC solution (design, materials selection, corrosion protection, etc.): • Does the CPC solution offer adequate protection between maintenance intervals? • Does corrosion reduce mean time between failure (MTBF)? • Will corrosion-related maintenance cause excessive mean down time (MDT)?		✓	✓	✓	✓
Specifically address CPC as a topic during independent logistics assessments (ILAs) and sustainment reviews (SRs); find related risks and opportunities to reduce the effect of corrosion on cost and system availability.		✓	✓	✓	
Update the LCSP (and CPCP, if used) as the system design matures to reflect changes in the following: • Test, modeling, and simulation results • CONOPS • Intended operating and storage environments, and ESOH regulations			✓	✓	✓
Include CPC requirements in performance-based logistics (PBL) agreements and contracts.			✓	✓	✓
Include CPC-related technical considerations, field experience, and costs in operational sustainment reviews.				✓	✓
Determine the necessary CPC-related training for operators and maintainers.		✓	✓	✓	✓
Test and Evaluation Back to Document Overview					
Include a corrosion SME on the T&E Working Integrated Product Team (WIPT).		✓	✓	✓	

Where does CPC expertise reside?

	Organization	R&D	Systems Engineering and Design	Acquisition Support	Materials Testing	Standards and Specifications	Training
Army	CCDC ARL	X		X	X	X	
	CCDC GVSC	X	X	X	X	X	X
	CCDC AvMC	X	X	X	X	X	X
	CERL	X	X		X	X	X
Navy	NRL	X	X	X	X	X	
	NSWC	X	X	X	X	X	X
	NAWCAD	X	X	X	X	X	X
	NUWC		X	X	X	X	
	NAVFAC EXWC	X	X	X	X	X	X
	NIWC	X	X	X	X		X
Air Force	AFRL	X		X	X	X	
	AFCPCO		X	X		X	X
	CAStLE	X	X	X	X	X	X