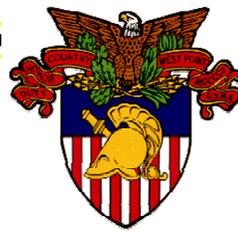


Army Lubrication Program Analysis

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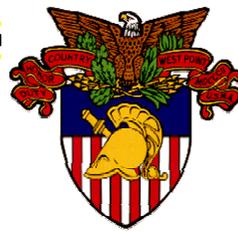


Agenda

- **Background**
- **Design of experiment**
- **Data collection and verification**
- **Method of analysis**
- **Candidate analysis results**
- **Candidate comparison**
- **Current status of study**

Where I
entered the
process.

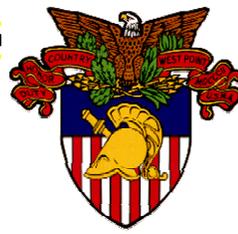




Background

- **Conflicting reports on lubricant performance in OIF**
- **Tasker for lubricant evaluation**
- **Review CLP spec, revise if necessary**
- **Test all available candidates against spec**
- **Add qualified candidates to QPL**
- **Insufficient time for traditional spec development, CLP spec found to be valid**





Design of Experiment

- **Define operationally based requirements**
 - Environmental factors (sand, dust, heat)
 - Round count
- **Conduct pilot tests (M4)**
- **Use pilot results to refine testing standards for M16**
- **Evaluate fielded products for baseline**
 - 10 weapons per product (new or newly refurbished)
 - 7 cycles per weapon (1 cycle = 4 magazines = 120 rounds)
- **Dust/fire cycle**
- **Randomization of magazines to weapons**



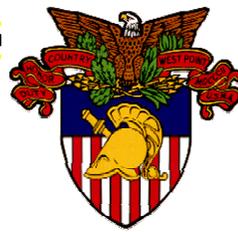


Photo #1: Weapon & magazine placement in dust chamber



Photo #3: First 10sec of dust cycle

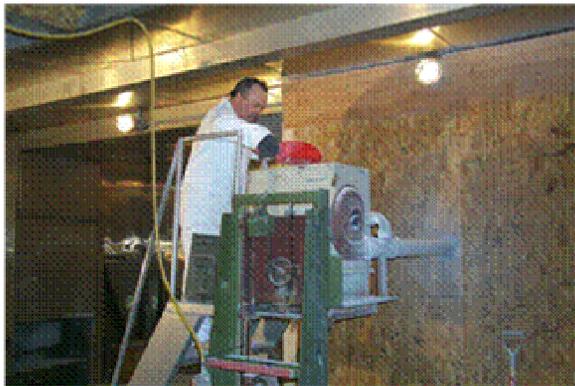
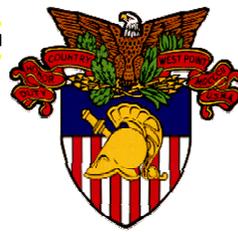


Photo #2: Silica Flour loaded into hopper of dust blower



Photo #4: Post-dust firing from standard test mount

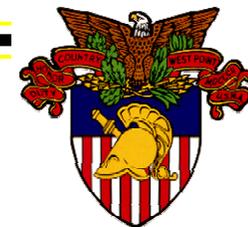




Data Collection/Verification

- For each weapon fired, failures recorded as: FFD, FFR, FXT, FBR
- Data recorded on a per round basis for each weapon
- Failures annotated by type and cycle/magazine/round count
- Data entered into Microsoft Excel

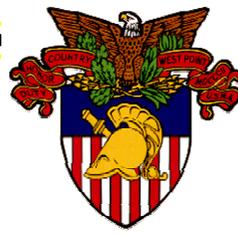




Candidate Data

DESERT LUBRICANT - PHASE 2							
<u>M16A2 Rifle</u>				<u>Mag.</u>	<u>Mag.</u>		
<u>Wpn. No.</u>	<u>Cycle</u>	<u>Malf.</u>	<u>Mag. No.</u>	<u>Seq. No.</u>	<u>Rd. No.</u>	<u>Test Rd.</u>	<u>Remarks</u>
31	1	FXT	2	2	4	34	Lube 2
		FXT			5	35	
		FXT			7	37	
		FXT			9	39	
	3	FFD	16	4	1	331	
		FXT			4	334	
	7	FFD	31	2	1	751	
		FFD			2	752	
		FFD			4	754	
		FFD			5	755	
		FFD			6	756	
		FFD			7	757	
	Total	7 FFD	Class 1			840	
		5 FXT	Class 2				
32	5	FFD	7	2	1	511	
	6	FFD	39	1	3	603	
	7	FFD	17	1	3	723	
	Total	3 FFD	Class 1			840	





Method of Analysis

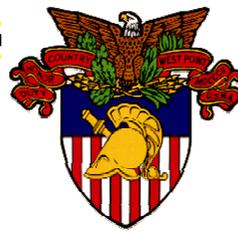
- **Nonparametric model for recurrence data, outlined by Meeker and Escobar (1998)**
- **Mean Cumulative Function (MCF) is defined as the expected number of failures over the variability of each system**

$$MCF = \mu(t) = E[N(0,t)] \text{ Where,}$$

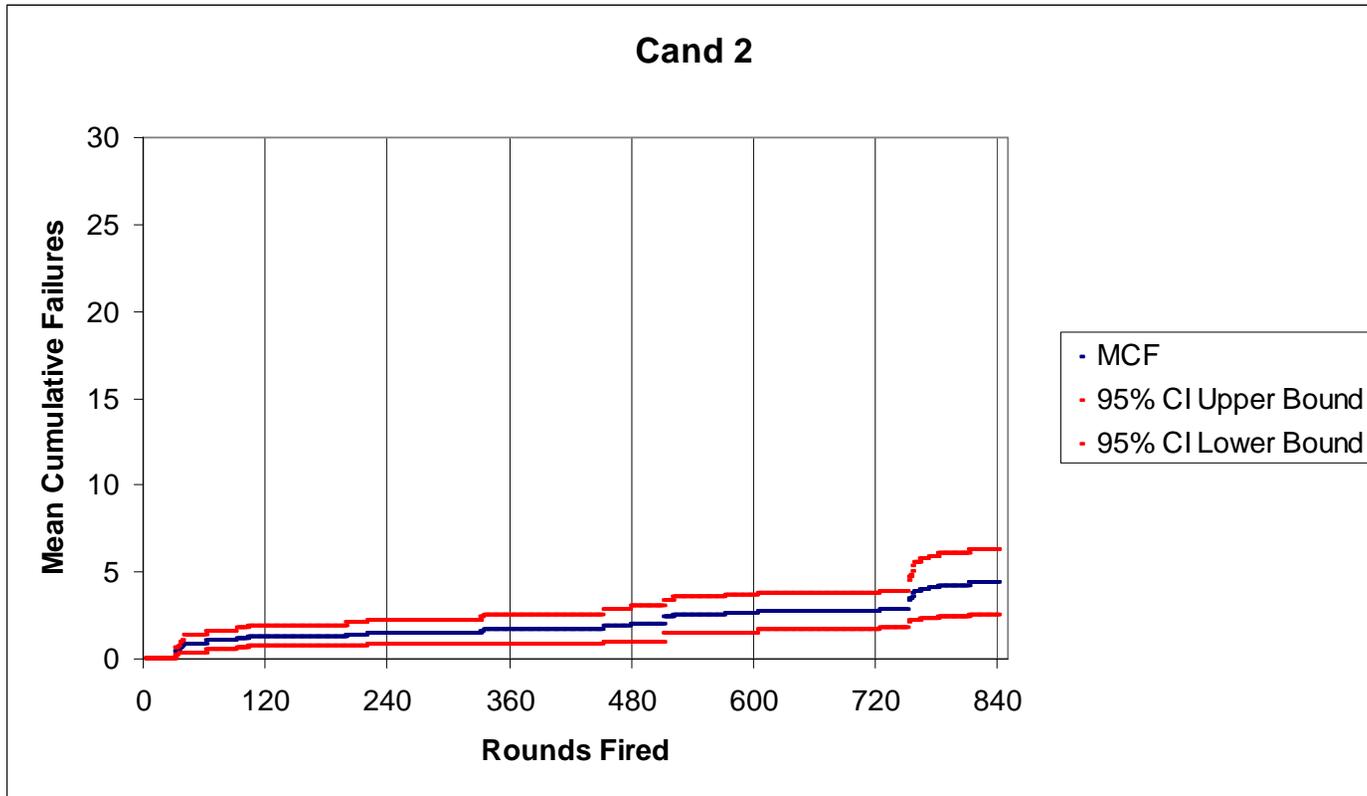
$N(0,t)$ = the cumulative number of occurrences (weapons failures) in the system for age interval $(0, t)$

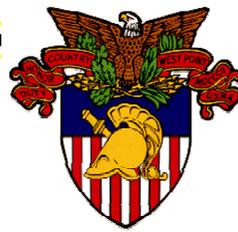
- **The estimate $\hat{\mu}(t)$ is a step function with jumps at recurrence times**
- **A variance estimate for $\hat{\mu}(t)$ is also provided in Meeker and Escobar (1998)**



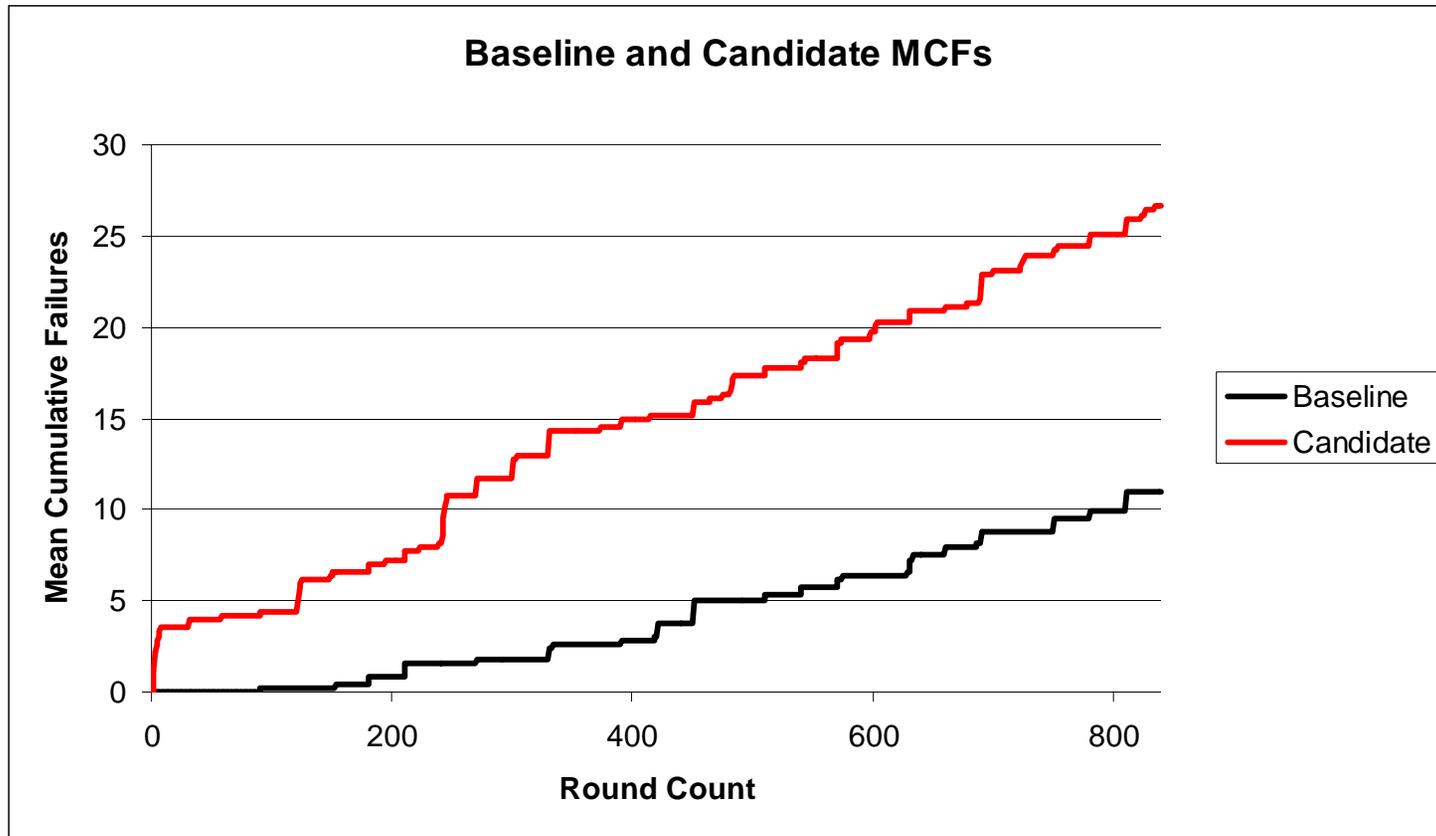


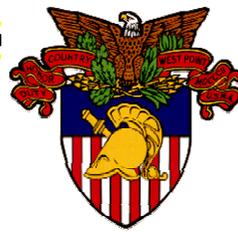
Candidate MCF



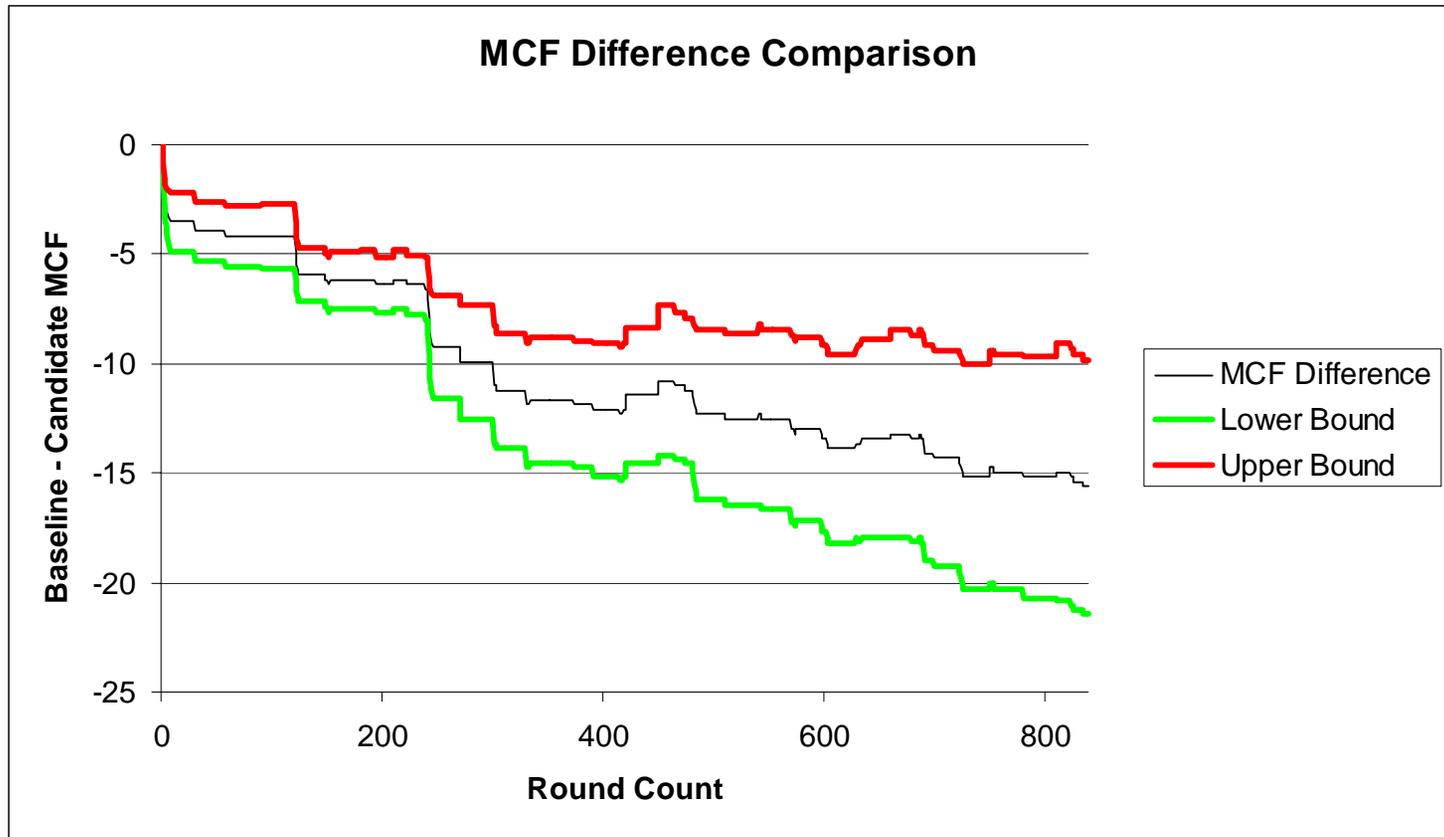


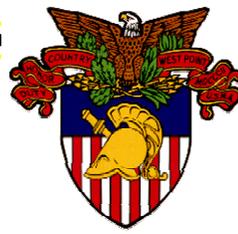
Example MCF Comparison





MCF Difference

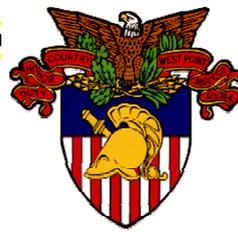




Program Update

- **19 of 23 candidates fired to date**
- **Laboratory testing complete on all candidates**
- **Testing delayed – safety, dust machine**
- **Potential conflict in future firing due to range availability as well as resource availability**
- **Planning for firing other weapon types, using qualified candidates**

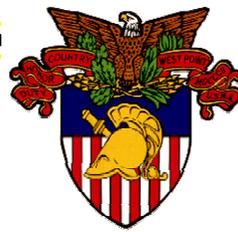




Performance Risks

- **Long-term performance risk; no endurance testing to investigate potential long-term adverse effects on weapon life**
- **Special desert lubricants may not have cleaning or corrosion protection features, increasing user burden and logistics**
- **No operational test due to troop availability, schedule, cost**





Questions?

