Analyzing Big Data: Using Lessons Learned to Influence Future Reliability Testing

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Agenda

- Purpose
- Historical RAM Analysis Lessons Learned
- Recent RAM Testing Lessons Learned
- Using Lessons Learned to Influence Future Reliability Testing

Purpose

To provide an overview of lessons learned from analyzing historical reliability testing and examine the potential of using the data to influence future reliability test planning and evaluation

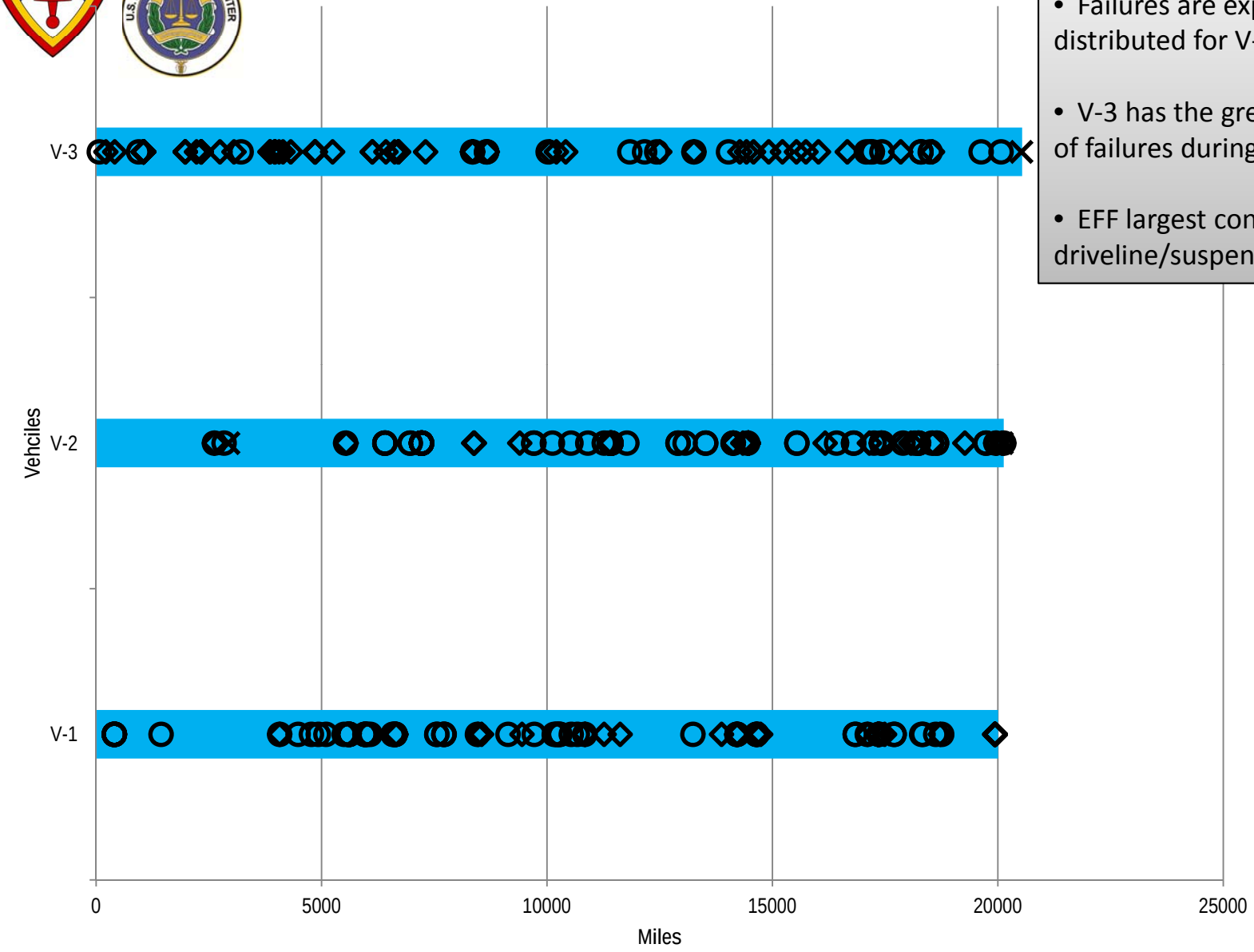
Historical RAM Testing: Data Set #1

- Vehicle reliability testing consisted of three vehicles tested for 60,000 miles
  - Two vehicles tested at APG
    - Vehicle-1 (V-1): 20,005 miles; 41,000 lbs
    - Vehcile-2 (V-2): 20,131 miles; 40,740 lbs
  - One vehicle tested at YPG
    - Vehicle-3 (V-3): 20,540 miles; 40,850 lbs
- Testing conducted to support a Full Material Release
- AEC RAM conducted analysis on historical data to determine previous failure rates and modes

Focused RAM Investigation on Historical Data Set #1

- Investigate driveline/suspension failure modes during historical testing
  - When are they happening?
  - Unique to terrain, courses, climate, test site?
- Start analysis with failure mode timeline and failure rate plots
  - Assumptions hold?
  - Investigate gaps in data
  - Determine if failures are happening in distinct groupings
- Historical analysis approach will show areas of interest while planning future reliability testing
  - How long to test? Where to test?
  - What failure modes do we expect to encounter?

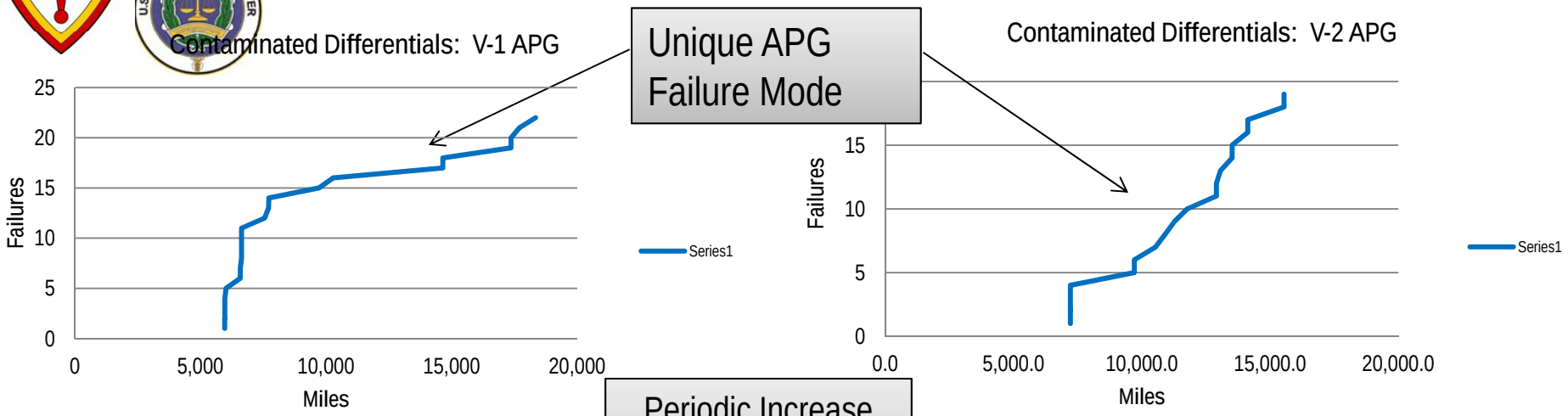
Data Set #1
Vehicle Driveline/Suspension Failures

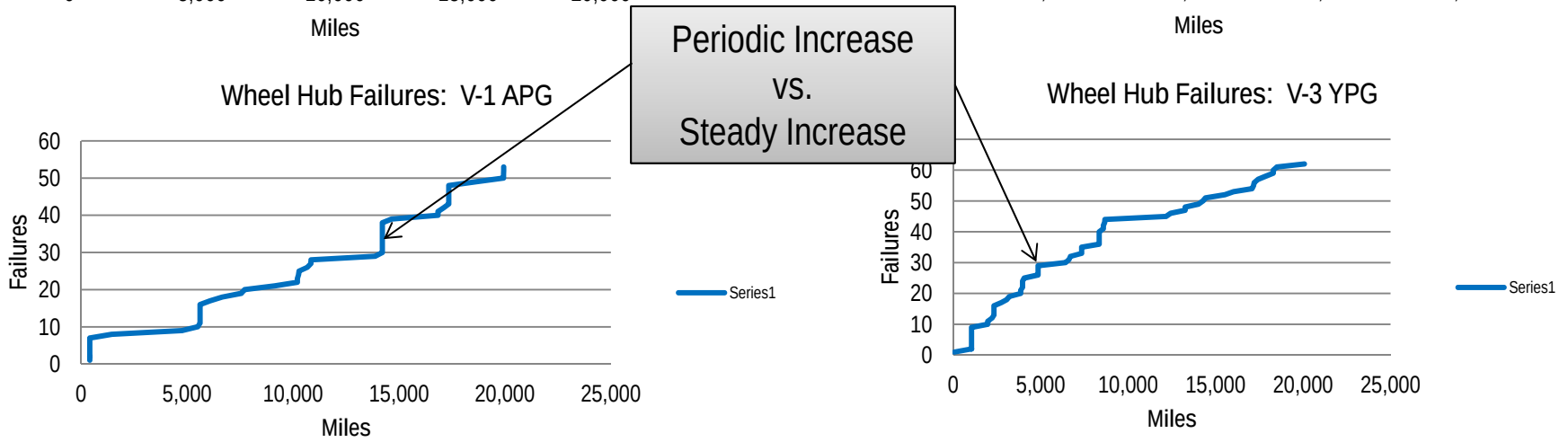


- Failures are exponentially distributed for V-3
- V-3 has the greatest amount of failures during PVT
- EFF largest contributor to driveline/suspension failures

Failures of Interest

Data Set #1

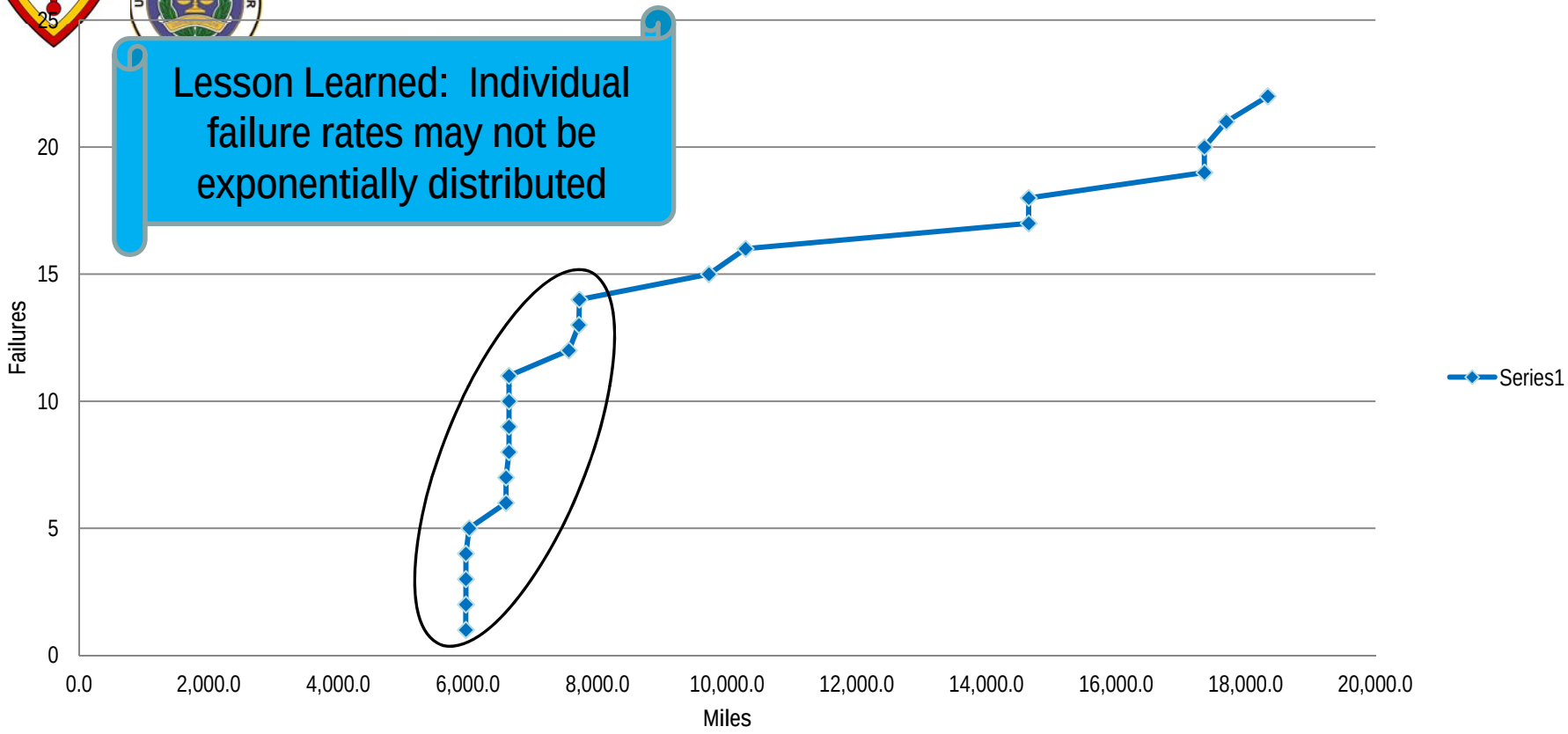




Develop lessons learned from Data Set #1

Data Set #1

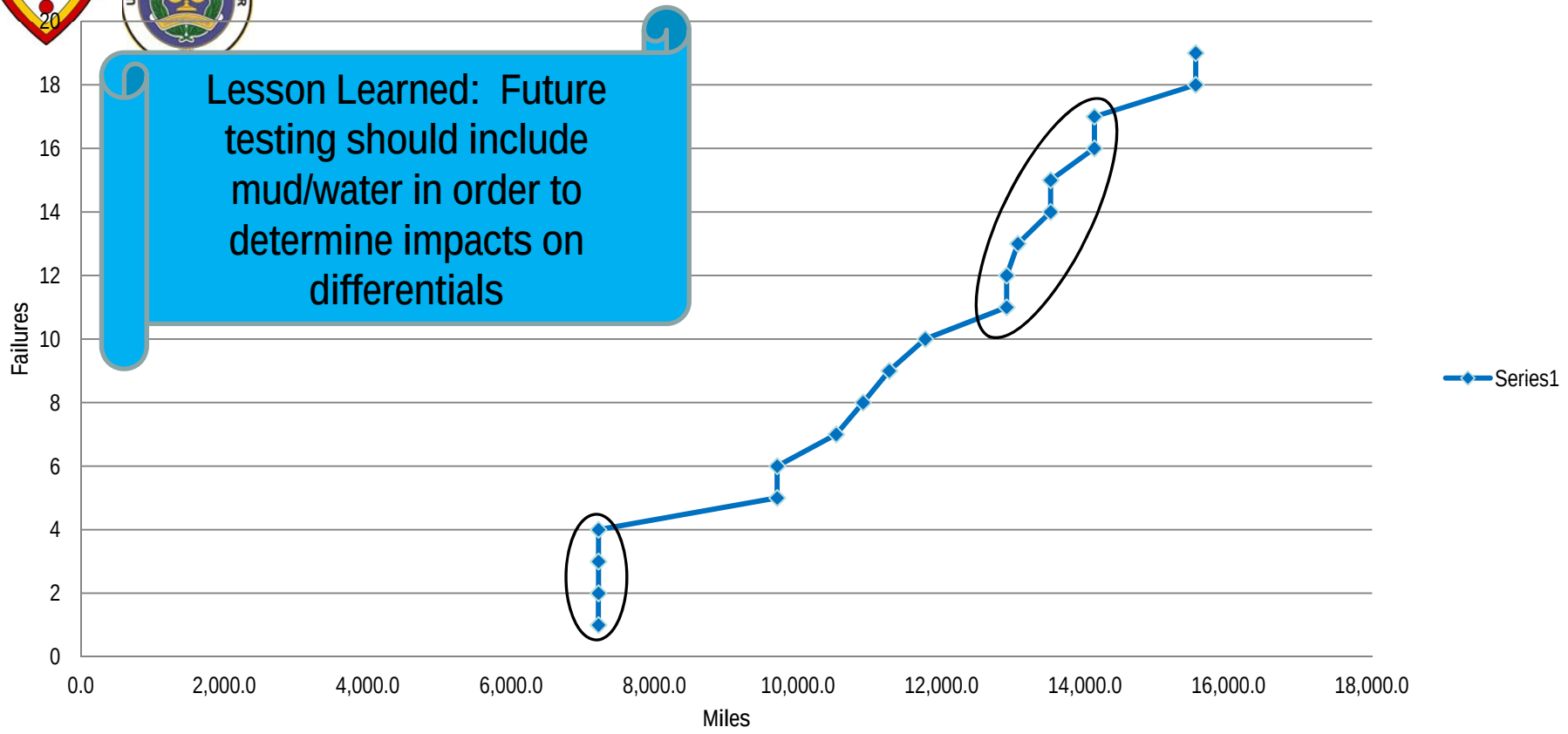
Contaminated Differentials: V-1 APG



- Drastic increase in contaminated differential oil contamination occurring between 6,000 and 8,000 miles
- Failure rate increases again at 18,000 miles

Data Set #1

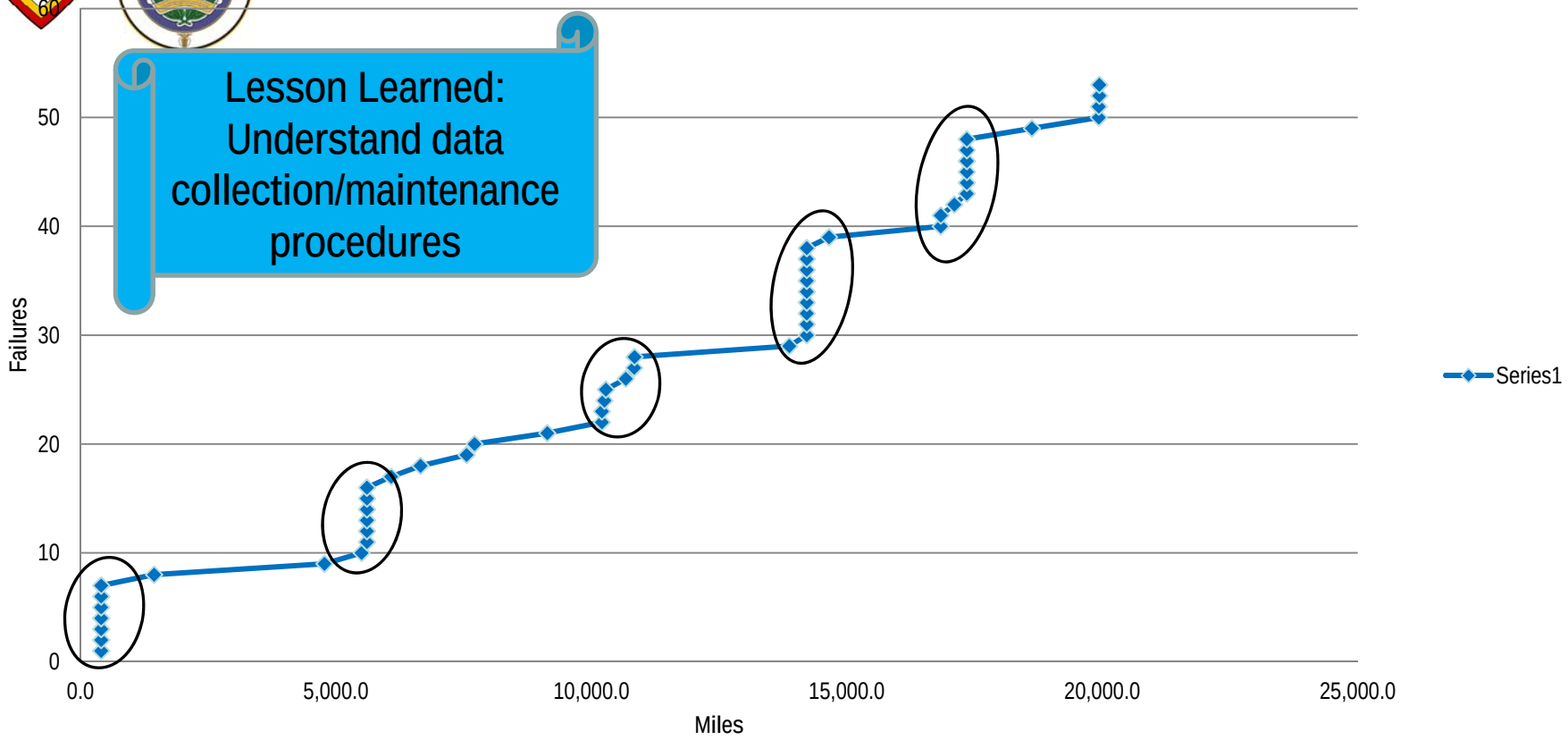
Contaminated Differentials: V-2 APG



- Contaminated differential oil did not occur until ~7,200 miles
- Steady increases after 10,000 miles

Data Set #1

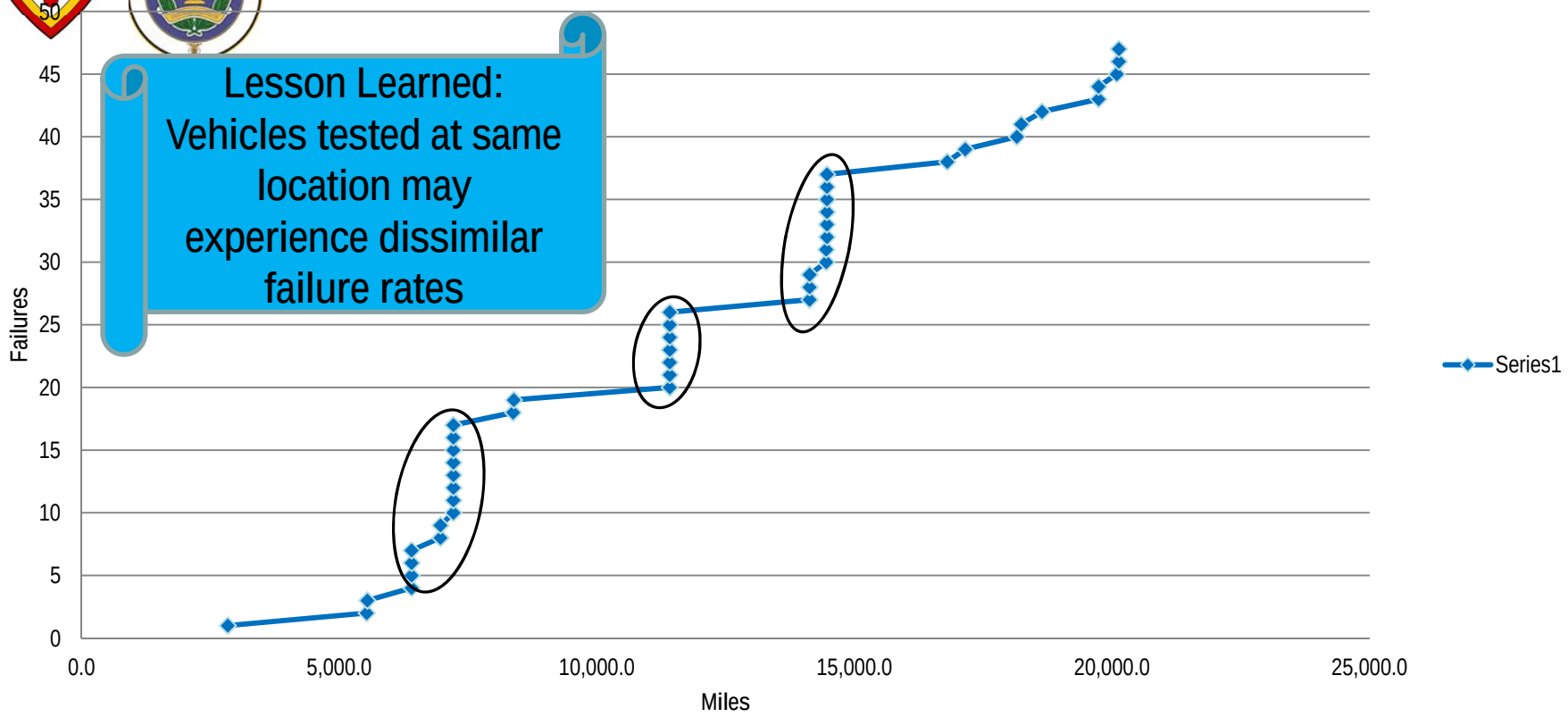
Wheel Hub Failures: V-1 (APG)



- ~5,000 mile increments between wheel hub failures
- It appears that the failure grouping increments may become closer after 15,000 miles, possibly indicating faster wear out of wheel hub hardware
- Not all failures result in replacing wheel hub assembly

Data Set #1

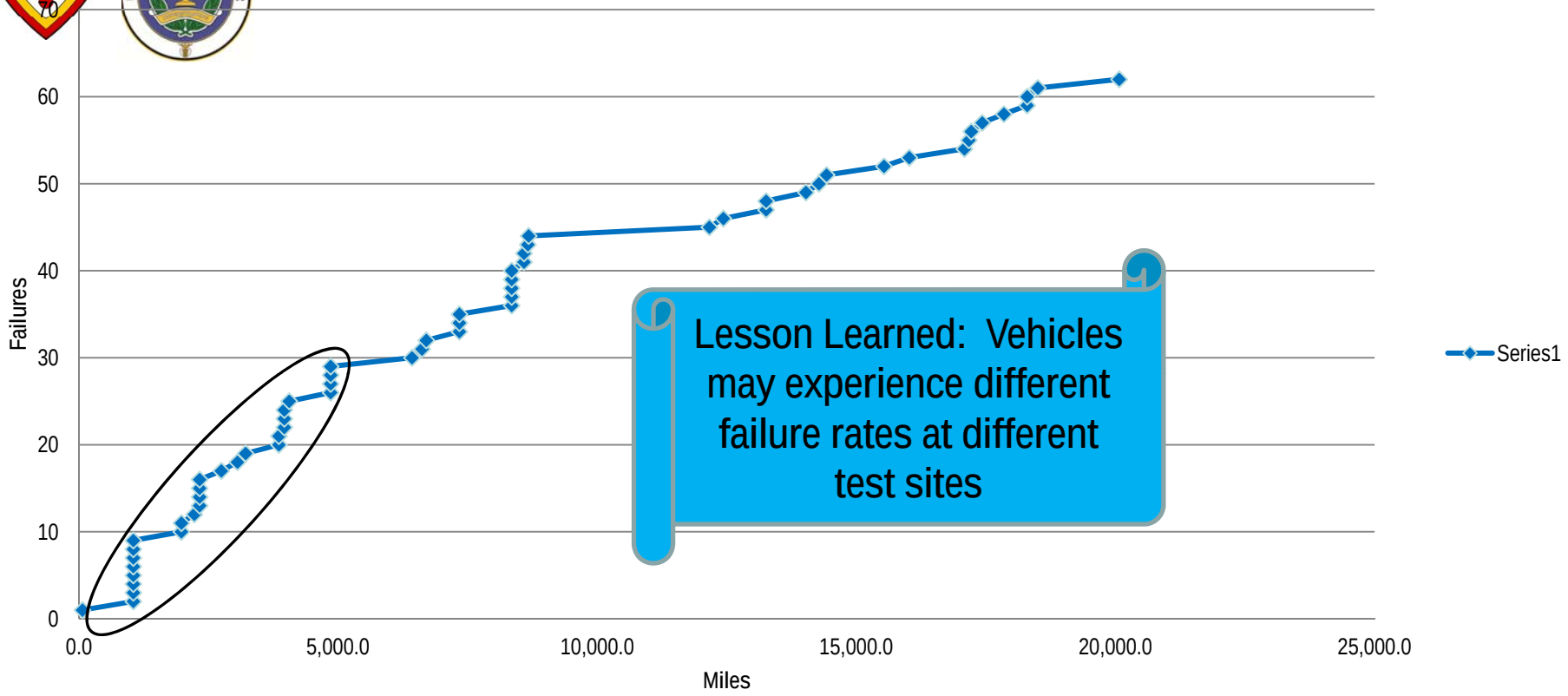
Wheel Hub Failures: V-2 (APG)



- Wheel hub failure trends at APG appear to be almost identical
- Groupings centered around maintenance intervals
- Increased amount of failures found after 5,000 miles, possibly indicating increased wear out rate of wheel hub hardware

Data Set #1

Wheel Hub Failures: V-3 (YPG)



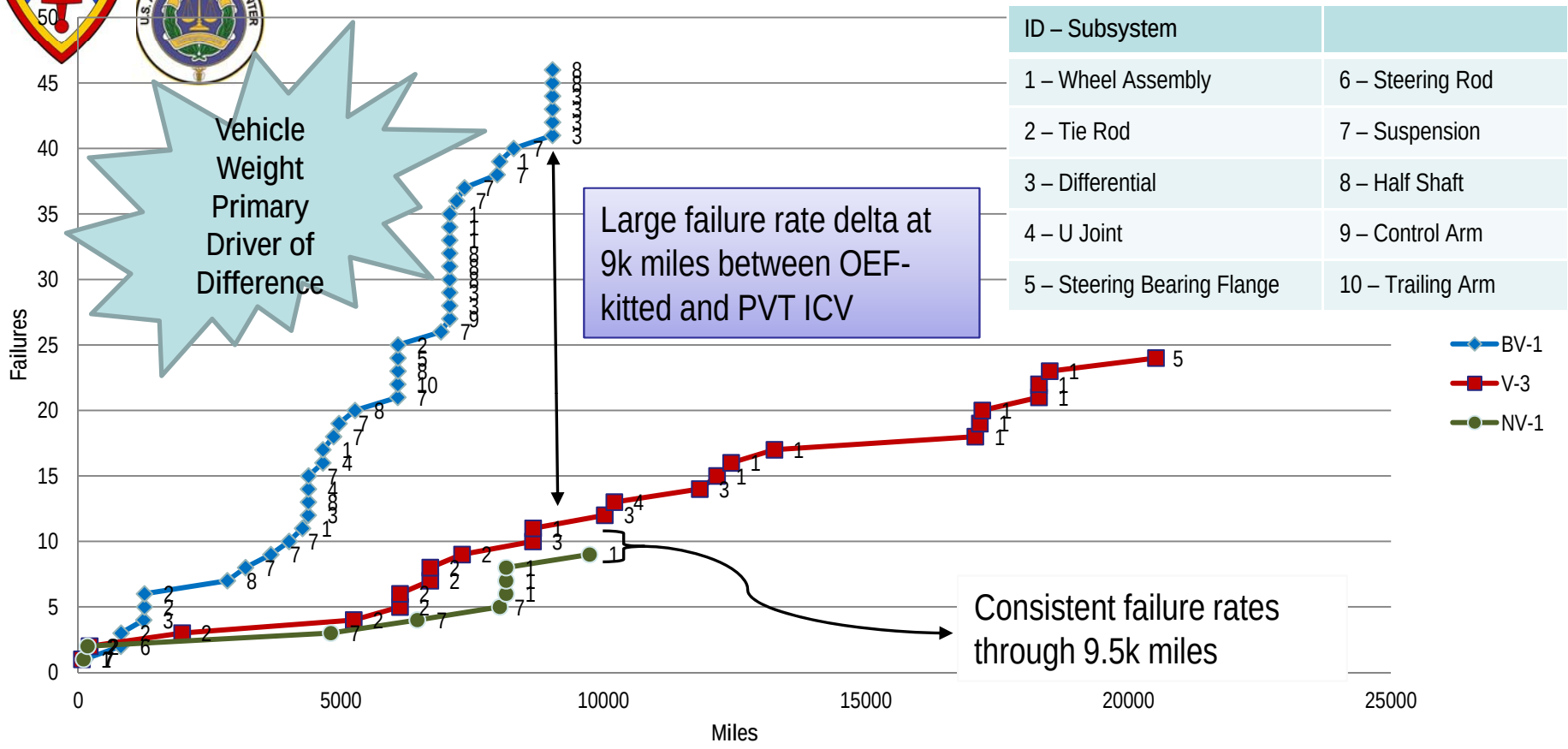
- YPG experienced more rapid increase to failure rate prior to 5,000 miles
- YPG wheel hub failure data differs from APG
  - No major groupings around 5,000 mile increments
- Wheel hub failures don't appear to be connected to maintenance intervals
- Wheel hub failures may be attributed to YPG terrain

Recent RAM Testing: Data Set #2

- Recent RAM testing conducted on new vehicle configuration
  - One vehicle is up-weighted version from what was tested in Data Set #1
  - One vehicle new design: upgraded driveline and suspension
  - 9,000 miles accumulated on both vehicles
- RAM testing conducted at YPG
- Compare Data Set #1 and #2

Data Set #1 & #2

Driveline/Suspension Failure Rate Plot



ID – Subsystem	
1 – Wheel Assembly	6 – Steering Rod
2 – Tie Rod	7 – Suspension
3 – Differential	8 – Half Shaft
4 – U Joint	9 – Control Arm
5 – Steering Bearing Flange	10 – Trailing Arm

LESSONS LEARNED:

New driveline/suspension components performing similarly to historical data set #1.

Up-weighted baseline vehicles experienced many more driveline/suspension failures

Applying Lessons Learned to Influence Future RAM Test Planning

- By analyzing historical data future reliability testing can be made more efficient
  - Reduce testing by identifying failure mode risk areas, focusing RAM testing on known areas of concern
  - Develop a plan to leverage M&S capabilities
    - M&S used to fill evaluation gaps
    - Extrapolate existing test data to supplement RAM evaluation

GOAL: Use lessons learned to "right size" RAM testing with appropriate risk