



# Collective Mind:



## Continuous, Automatic Learning to Improve Equipment Maintenance

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DoD Great Ideas Competition  
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Rensselaer





# Self-Sustainment Requirement

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- Army Future Force units in 2020
  - “The UA is self-sustainable for 3-7 days of operations and maintains combat power with dramatically reduced theater stockpiles.”

[The Army in 2020 Functional Area White Papers](#)

**Critical Capability: Prognostics**



# Challenges for Prognostics

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- Lack of Physics of Failure models
- Missing sensor suites
- Low equipment-utilization rates
- etc.

## But Maintenance Crews

- Have the ability to improve reliability of their equipment over time
- Share what they have learned with other crews

# Claim: Existing field experience can be used to improve Prognostics

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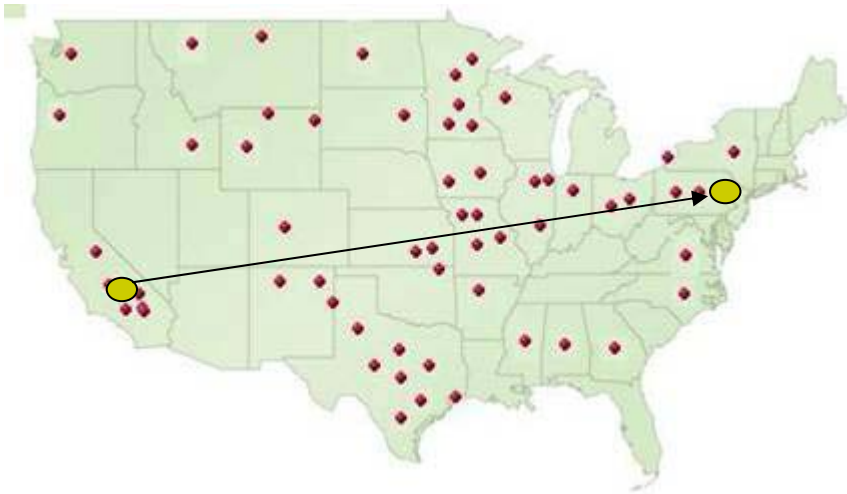
- Discover similar units
  - Peers form a Collective
- Evaluate unit under consideration using experience of peers
- Improve discovery and evaluation based on mission success
  - Learning in the Collective results in “Collective Mind”
- Do everything automatically

**Key Technology: Statistical Machine Learning**

# Example: Locomotive Selection

## The Mission:

Select 12 Locomotives  
to go from CA to PA



Data from GE Transportation

## Decision Support Data:

200+ Basic Parameters

### Design and Configuration

*Type*

*Electrical System*

...

### Utilization Information

*Age*

*Mileage*

*Average miles/day*

...

### Maintenance Information

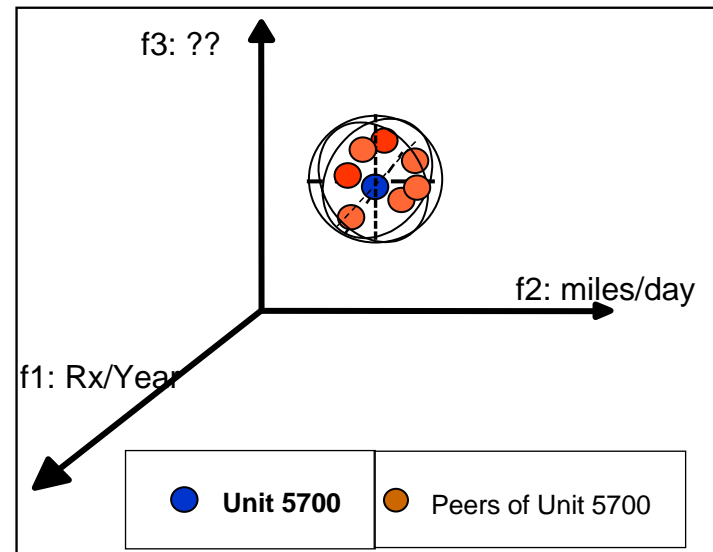
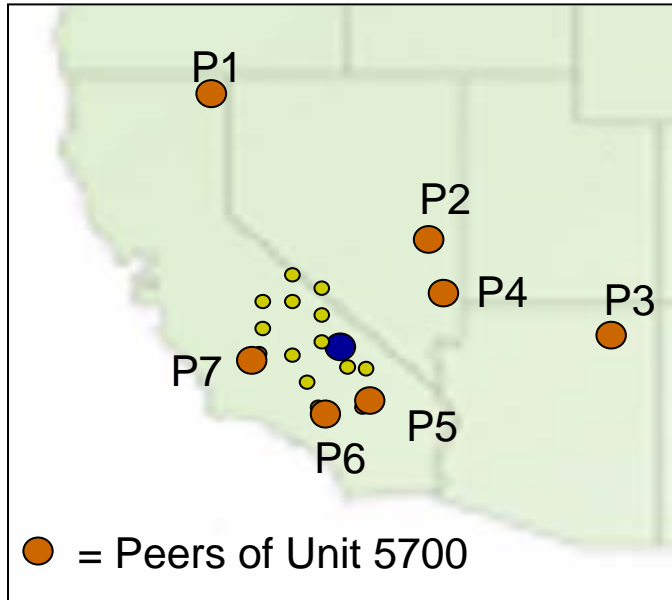
*Time elapsed since last repair*

*Median time between repairs*

*Median time from repair to next  
recommendation (Rx)*

...

# Identifying Peers



**Collective:** Peers are units with similar operational & maintenance profiles

Peer experience forms Mission Reliability (MR) rank

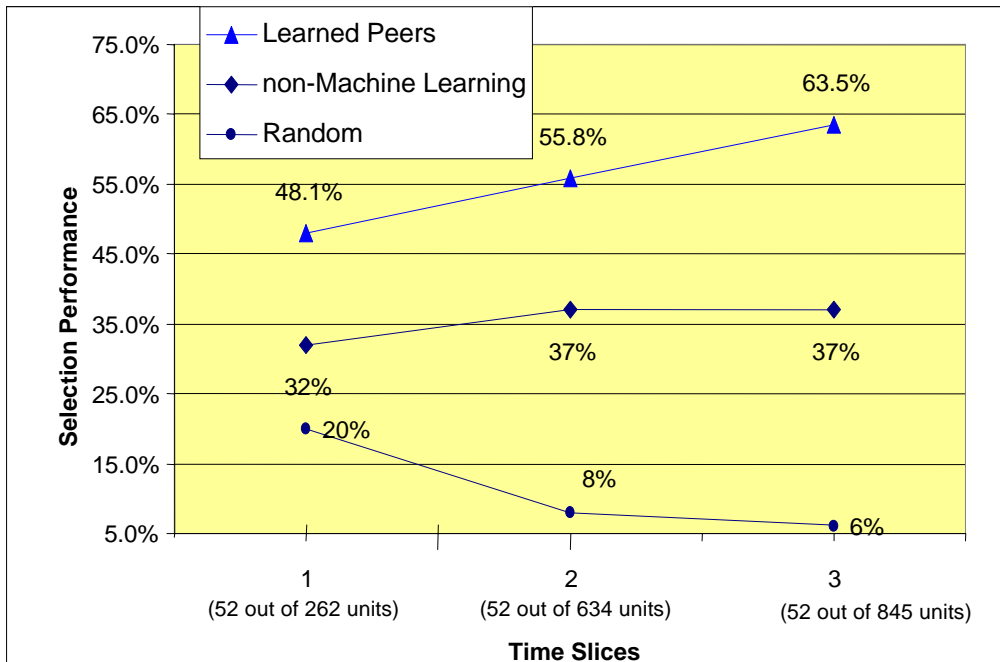
**Learning:** Similarity measure updated by accuracy of MR Rank

# State of the Practice: non-Machine Learning

Selection Criteria	% of Correctly Classified Units: Top 20% (Sample Performance)
Lowest Mileage	17%
Newest Units	18%
<b>Random</b>	<b>20%</b>
Highest Energy (MWHRS) generated	24%
Highest Miles/ Hours Moving	26%
Highest Percentage Hours Moving	29%
Lowest Percentage of Failures in Most Critical Subsystem	38%
Lowest Ratio: Recommendations / Age	49%

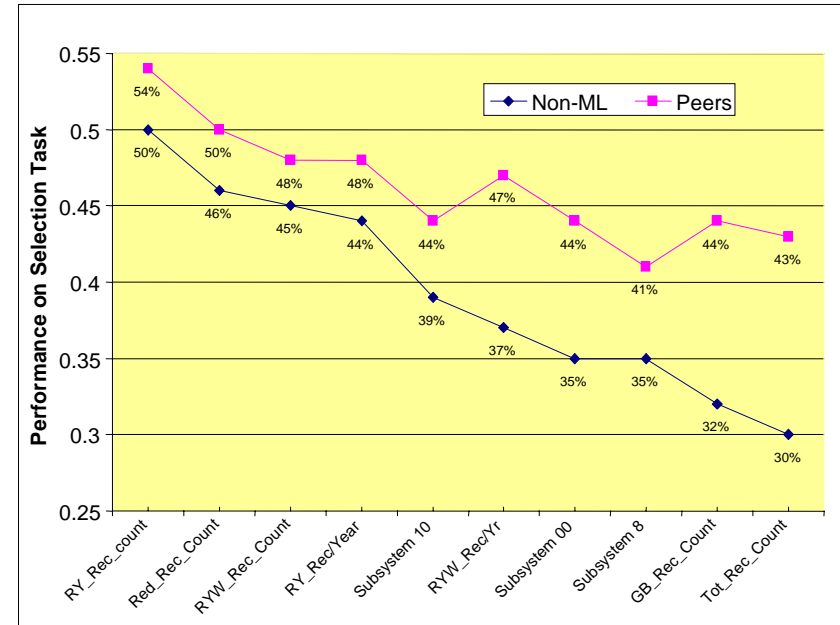
# Accuracy and Robustness of the Peer Approach

**Learned Peers show better performance & continuous improvement**



**Excellent Performance with Existing Sensors on Legacy Systems**

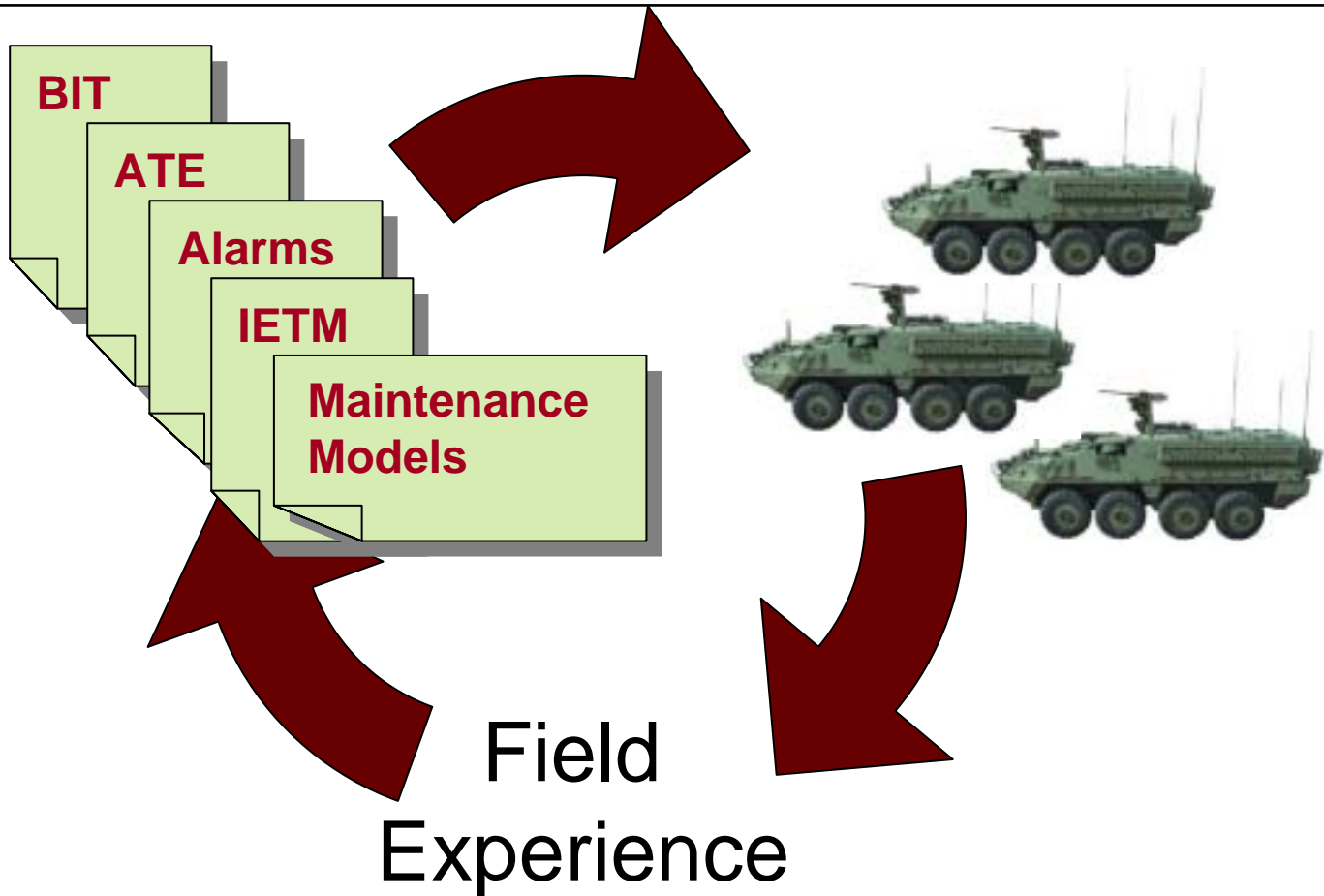
**Highest contributing parameters assumed missing**



**Robust to Missing Sensors**



# Claim: Machine Learning applies throughout Maintenance



# Vision: New Paradigm for Maintenance Decision Support

**Objective: Actively Manage the Maintenance Process**

- Operating at All Levels, All Phases of Operations
- Continuously Improve Planning, Response, and Execution

Linking all Elements into a Living, Distributed, Global Maintenance System

## Technical Approach

Basic Building Block:  
Self-Aware Platform



**Collective Mind:**

Communities of  
Self-Aware  
Platforms



Sense and Respond  
Maintenance Network



**Global Community of Continuously Improving Equipment**



# Questions?



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## Collective Mind

### Continuously Improving Equipment Maintenance

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