



Collective Mind:



Continuous, Automatic Learning to Improve Equipment Maintenance

DoD Great Ideas Competition
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Self-Sustainment Requirement

- 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

- 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

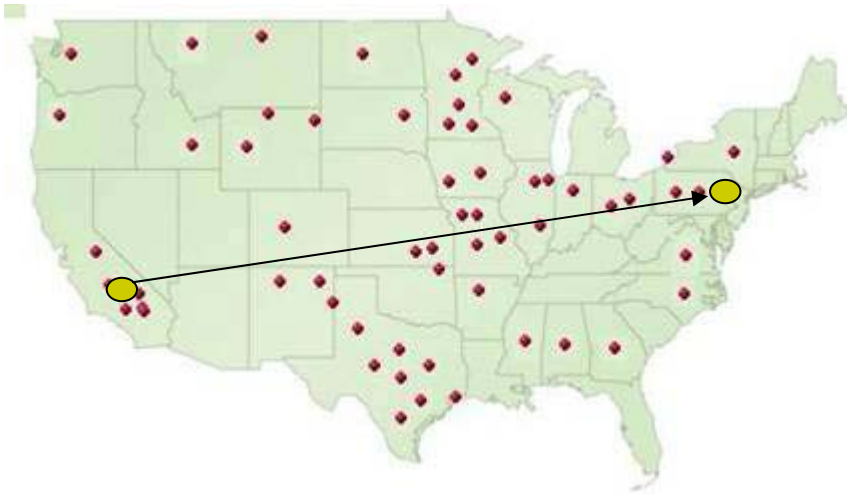
- Discover similar units
 - Peers form a Collective
- Evaluate unit under consideration using experience of peers
- Improve discovery and evaluation based on mission success
 - Learning in the Collective results in “Collective Mind”
- Do everything automatically

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

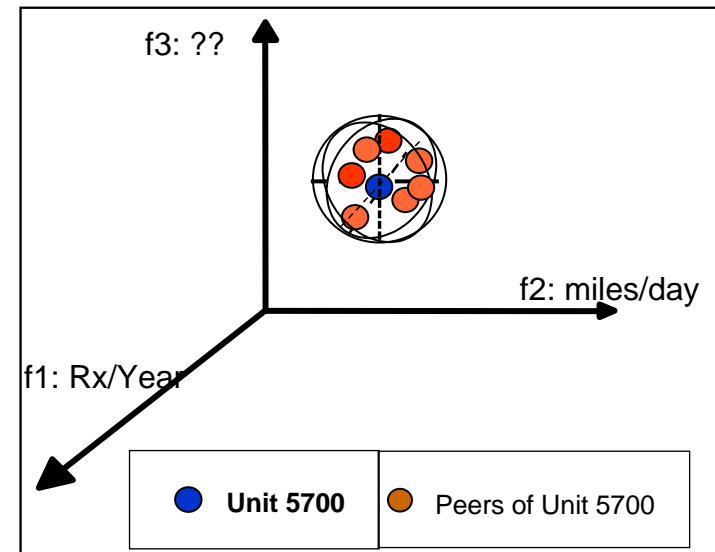
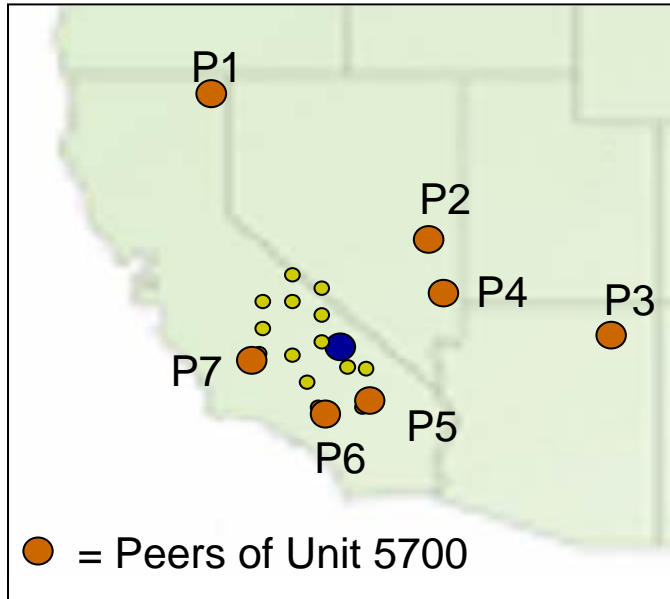
Time elapsed since last repair

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

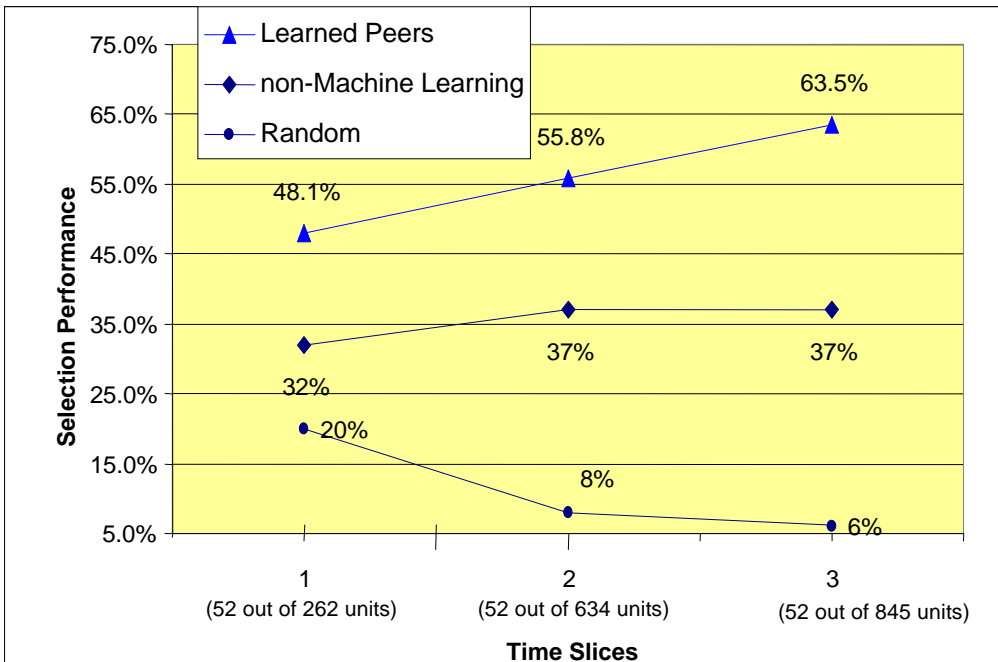
Learning: Similarity measure updated by accuracy of MR Rank

State of the Practice: non-Machine Learning

Selection Criteria	% of Correctly Classified Units: Top 20% (Sample Performance)
Lowest Mileage	17%
Newest Units	18%
Random	20%
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%

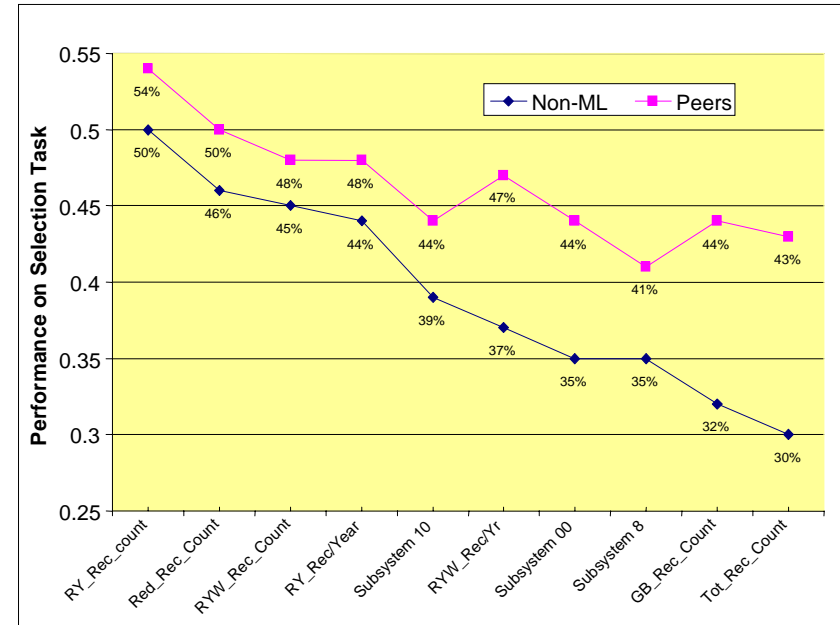
Accuracy and Robustness of the Peer Approach

Learned Peers show better performance & continuous improvement



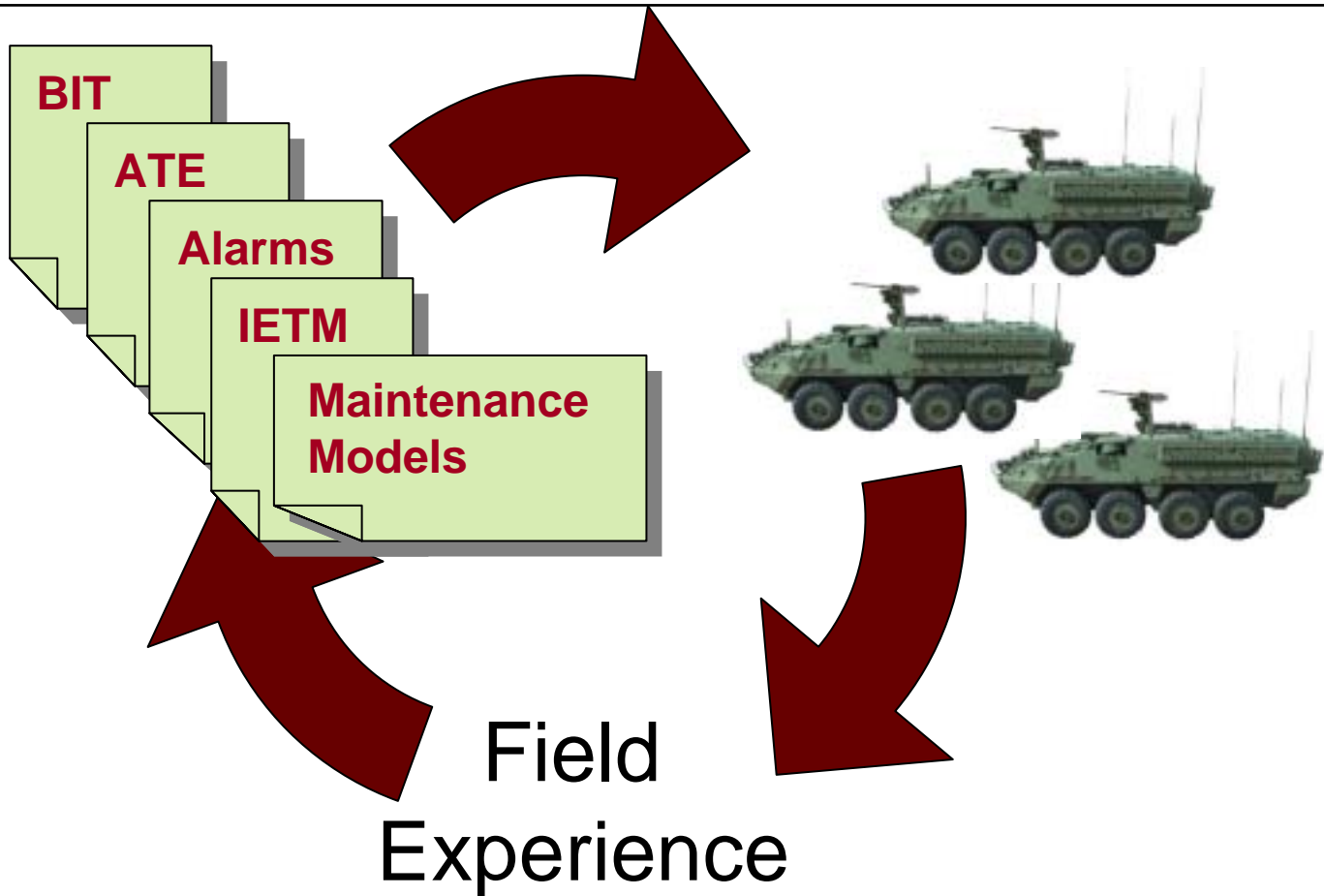
Excellent Performance with Existing Sensors on Legacy Systems

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?



Collective Mind

Continuously Improving Equipment Maintenance

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