



Fluid Optimization Testing for Predictive Sustainment

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Overview

- **No overlooked conditions.** Degraded or contaminated fluid and early wear are identified before they become failures.
- **No wasted tasks.** Fluid changes and component pulls happen when the data calls for them, not by calendar or habit.
- **A data trail.** Every reading becomes a record that feeds trend analysis and predictive models.

Summary

Fluid Optimization testing gives Army maintainers objective, on-the-spot data on the condition of oils, greases, coolants and hydraulic fluids, and on the wear of the components they lubricate. This paper is addressed to the Sustainment Future Capability Directorate (S-FCD) to introduce this capability and request a path to a field and depot demonstration. It turns today's look-and-feel fluid checks into measured, criteria-based decisions, directly supporting **LOE 1: Advanced Manufacturing & Maintenance through predictive sustainment.**

York Laboratories proposes introducing Fluid Optimization testing at Field and Depot level using portable sensors such as PocketLab 2.1. Readings are taken at the point of maintenance, compared against defined limits, and written into the governing procedures.

- Historically inefficient and wasteful fluid replenishment tasks are guided by data in the hands of maintainers to drive optimized tasks.
- Component replacements are driven by data trends, and unnecessary repairs based on "conservative" strategies or subjective observations are instead triggered by action targets.
- Autonomous systems will not have pilot and operator feedback inputs for potential issues; fluid data becomes more critical to assess drone and driverless vehicles in the coming battlefield.

The problem: fluid checks are subjective

Most fluid inspection at the unit and depot today relies on a maintainer's eyes, nose and fingers: color, clarity, smell, feel, level. The outcome depends on who is looking, available lighting, and experience.

That creates two costly failure modes:

- **Missed conditions.** Water ingress, fuel dilution, oxidation, coolant breakdown and early wear debris are often invisible until damage is done. The first sign is a failed component, a deadlined vehicle, or a parts request.
- **Unnecessary work.** Fluids are drained on fixed intervals regardless of condition, and components are pulled on suspicion. Good fluid, labor hours and parts are consumed with no readiness gain.



Lab oil analysis exists, but turnaround is measured in days and results rarely reach the maintainer at the moment of decision. In a 2022 audit, the DoD Inspector General found the Department had [not fully implemented predictive maintenance on any weapon system](#) (DODIG-2022-103), leaving opportunities in the fundamental guidance of CBM+ unaddressed.

What Fluid Optimization testing is

Fluid Optimization treats every lubricant and working fluid as a sensor already installed in the equipment. Measuring the fluid tells you both its own health and the health of the parts it touches. York Laboratories' Industrial Fluid Optimization approach covers three areas:

Area	Questions it answers	Typical measures
Fluid Sampling	Where and how must the fluid be queried to provide accurate data? This applies both to liquid samples removed from the system and the method and location of installed sensors.	Contamination (water, fuel, dirt, wrong fluid), oxidation and degradation, viscosity change
At-machine Sensor Analysis	Is the lubricated component healthy? Is the fluid free of contaminants and debris? What is the true remaining life of the fluid? When should samples be sent to a laboratory for more detailed analysis and to pinpoint the cause and location of an identified issue?	Both in-line sensors for gearboxes and other oil lubricated components, and at-machine sensors for testing greases are evaluated for wear, physical properties and contaminant levels, and in the case of grease, consistency changes.
Laboratory Fluid Analysis	What is the source of contamination? What wear modes are present, how severe, and where in the machine? Is the existing maintenance process sufficient for maximum reliability and fluid life?	Wear particle analysis; lubricant chemistry changes due to oxidation, contamination, thermal stresses; contaminant sources and fluid chemistry mixing.

Portable sensors such as the PocketLab 2.1 put these measurements in the maintainer's hands. A small sample is tested at the vehicle, aircraft or component, and results are available in real time instead of days later from a lab. Lab analysis remains the reference for confirmation and calibration.

PocketLab 2.1. The kit combines three portable instruments that together show bearing and gear wear, grease degradation, contamination and mixing of greases ([product details](#)). Grease samples are taken with the Grease Thief sampler or Pick-Pocket tool, which need only about 1 gram of grease and reach into openings as small as ¼ inch in diameter.



Instrument	What it measures	Key specifications
FerroQ*	Ferrous wear debris in grease (ASTM D7718 sampling)	Result in under 10 seconds; automatic range up to 200,000 ppm; battery or 12 VDC power; Bluetooth or USB data; calibrated with certified Grease Thief standards
GT Colorimeter*	Grease color at fixed pathlength, compared to new-grease reference, for degradation, contamination and mixing	Spacers (0.005, 0.010, 0.035 in) create fixed pathlength for optical absorption for greases of varying opacity; Bluetooth tablet app with logging and cloud sync capabilities; liquid cell for liquid oils and coolants
GTA Mini-1.1	Consistency change of in-service grease relative to new grease	Thin-film deposition by Die Extrusion method; film split into substrate sections of ~0.25 g each for follow-on RULER, elemental spectrometry, FTIR and analytical ferrography

*Units currently in use at AOAP Laboratory Redstone Arsenal. Samples from field testing with the PocketLab can be repackaged and sent on to Redstone for detailed analysis and action.



PocketLab 1.1: FerroQ and GT Colorimeter (left). PocketLab 2.1: adds the GTA Mini-1.1 (right)

Fluids in scope: engine and gear oils, greases, coolants and hydraulic fluids.



Case Studies: 1-Grease sampling and analysis were utilized to evaluate existing maintenance intervals on the Chinook CH-47 fleet in a Boeing study performed for Chinook Worldwide Owner's Workshop (CWOW) for US Army, RNLAf, RCAF, and UK Squadron. Existing maintenance directives for depot-level grease replacements ranged from 50 flight hours (swashplates) to 250 flight hours, and contributed significantly to sustainment costs. The Lubrication Optimization Study (LOS) used grease analysis data to optimize these intervals according to 7 testing parameters, increasing (mostly) and decreasing intervals according to testing data. The result (adopted by the US Army and other participants) extended the shortest intervals by 140%, resulting in documented **sustainment cost savings of \$100 million annually** across the Chinook fleet.

Case Studies: 2-US Army contractor providing rotating radar units has deployed seven PocketLab units for field testing of grease-lubricated gear sets that allow prognostic evaluation of gear wear and grease condition, including effects of field encountered contaminants that can accelerate wear and reduce readiness of critical assets. Grease samples are obtained using a modified kit compliant with ASTM D7718 standard for inservice grease sampling. Samples are evaluated for wear levels measured against time-on-grease, to determine wear rate trends and overall levels. Colorimetry is utilized to monitor grease condition for the presence of contaminants (dirt, sand, moisture) and mixing with incorrect greases.

Case Studies: 3-PocketLab sensors are utilized at Redstone Arsenal by the US Army Oil Analysis Program (AOAP) to evaluate grease samples submitted for analysis. While grease analysis is not routine in Army procedures, it is utilized in crash analysis, and as requested by the units in response to observed conditions during maintenance activities, and unexpected events involving grease-lubricated components. The PocketLab sensors are situated in the AOAP PMO Lab at Redstone alongside existing oil analysis equipment, and the samples screened using these instruments can be further prepared in some cases to be tested using oil analysis instrumentation, such as FTIR using a magnetic clamshell sample adapter, and after dilution with a suitable solvent, other instruments such as elemental spectroscopy with the Rotating Disc Electrode spectrophotometer.

Alignment to LOE 1: Advanced Manufacturing & Maintenance

Fluid Optimization supplies the ground-truth condition data that predictive sustainment depends on, at the echelon where maintenance happens. S-FCD is one of nine Future Capability Directorates formed under the [Futures and Concepts Command](#) to turn concepts into fielded capability. Army Materiel Command leadership has described the target state as a maintenance system that is [predictive, precise, and prepared](#), built on sensor data and analytics that anticipate failures.

LOE 1 points	How Fluid Optimization contributes
Keep combat power forward through predictive sustainment, point-of-need production and agile maintenance	Wear debris and fluid degradation trends flag component long before it fails; repairs are planned instead of reactive. Real-time readings let maintainers decide at the vehicle or aircraft. Wear trends tell planners which parts will be needed and when, giving an earlier, more accurate demand signal.



LOE 1 points	How Fluid Optimization contributes
Expand additive manufacturing and modern maintenance concepts at echelon	Criteria-based fluid testing is a modern maintenance concept that is portable and needs no lab, so it can be fielded at every echelon from unit motor pool to depot. The same written limits apply at each level, and every test is a record that can feed Army systems of record and readiness views such as G-Army, AOAP Oasis, and Weapon System 360.
Increase equipment availability and reduce dependence on distant depots	Catching faults early and skipping unneeded fluid changes and part pulls keeps more equipment mission capable. Field-level data shows which items can be fixed forward and which truly need depot repair, cutting unnecessary evacuations. At the depot, readings at induction scope the repair accurately and shorten turnaround.

It also supports the Army Transformation Initiative line of effort to eliminate waste, by cutting maintenance tasks that add no readiness. (See Chinook Case Study)

Application at Field and Depot level

The same sensors and criteria serve both levels of maintenance; what changes is the decision each reading informs.

	Field level	Depot level
Where	Unit motor pools, flight lines, forward maintenance sites	Organic industrial base depots and repair lines
When tested	During PMCS and scheduled services; after operation in harsh conditions	At induction, during teardown and inspection, at final test before return to the force
Decisions informed	Change or keep fluid; continue operating, monitor or evacuate the item	Scope of repair at induction; confirm root cause of wear; verify fluid fill and system cleanliness at release
Main payoff	Fewer missed faults and fewer unneeded fluid changes forward	Better repair scoping, less over-repair, verified quality of returned assets
Data use	Trend per vehicle or aircraft; alerts to maintainers and leaders	Fleet-level trends that feed back to engineering, technical manuals and intervals



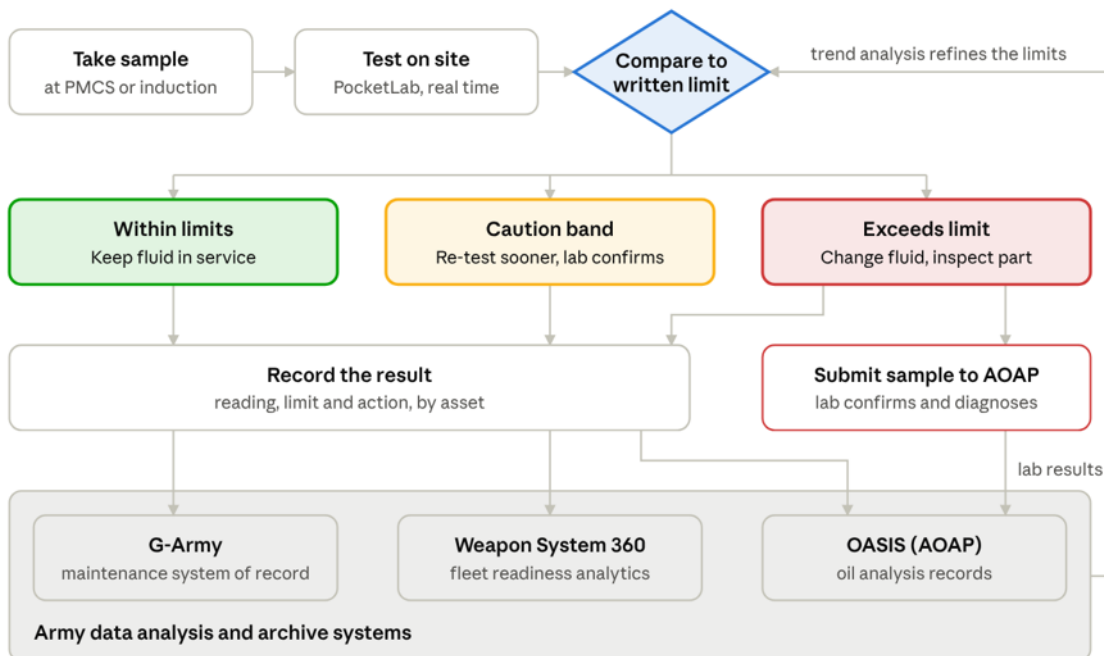
Used together, field readings tell the depot what condition an asset arrives in, and depot findings tighten the limits used in the field.

From subjective inspection to criteria-based decision points

Each fluid check in a governing procedure (technical manual, PMCS table, depot work instruction) becomes a measured test with a written limit and a defined action. Two maintainers testing the same item reach the same decision.

Every reading leads to a written action and an Army record

Replaces the color, smell and feel judgment in the governing procedure



The limits are set per fluid and platform from OEM and technical manual values, confirmed against lab analysis, and refined as trend data accumulates, utilizing machine-learning algorithms. Caution-band results are where predictive value lives: they show a component trending toward failure while there is still time to plan the repair. Data is shared across the Army data analysis and archive systems, including input into G-Army to drive repairs, correlation to AOAP oil analysis data, and status updating for logistics planning to Weapon System 360.



Expected benefits and how to measure

The benefits below should be baselined and measured during a pilot rather than assumed; the table names the measure for each.

Benefit	Measure for the pilot
Higher equipment availability	Operational readiness rate and non-mission-capable days of the test fleet vs. a control fleet
Fewer unexpected failures	Unscheduled removals and lubrication-related failures per 1,000 operating hours
Less unnecessary maintenance	Fluid changes and component pulls avoided when readings were within limits
Lower fluid and parts cost	Gallons of fluid and parts dollars consumed per asset
Faster decisions	Time from sample to maintenance decision vs. lab turnaround
Consistent inspections	Agreement between maintainers on the same item (criteria vs. subjective call)
Better depot repair scoping	Repair scope changes after teardown; repeat repairs

Proposed next steps:

York Laboratories requests an introductory engagement with S-FCD to scope a demonstration at one field unit and one depot.

1. **Introductory briefing** with S-FCD to confirm fit with LOE 1 priorities and identify a sponsor.
2. **Select platforms and sites:** one field maintenance unit and one depot repair line, with a matched control fleet.
3. **Set the criteria:** agree test parameters and action limits per fluid and platform, referenced to OEM and technical manual limits and confirmed against lab analysis.
4. **Demonstrate:** run portable testing alongside current procedures for an agreed period and collect readings in the unit's existing records.



5. **Assess:** report results against the measures above and recommend changes to procedures and intervals.
6. **Scale:** draft procedure language and training for wider adoption, and define the data hand-off to Army systems of record.

Open questions for S-FCD

- Which platforms and fluids carry the highest maintenance burden today?
- Which systems of record should receive test data in a pilot?
- Is there an existing CBM+ or predictive sustainment effort this should join?
- What is the required data output format (i.e. Jailbreak, Screen Display, App for screen or smartphone)?

Contact: Rich Wurzbach, 717-324-5921, York Laboratories, LLC dba MRG Labs, mrgcorp.com,
rwurzbach@mrgcorp.com · [Request a fluid analysis](#)

Sources

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