

Populations, Activity and Emissions of Diesel Nonroad Equipment in EPA Region 7

PSU 1 PAMS Purchase Recommendation Memos Appendix O

Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Prepared for EPA by
Eastern Research Group, Inc. (ERG)
EPA Contract No. EP-C-06-080



MEMORANDUM

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To: Connie Hart, Jim Warila, Carl Fulper (USEPA)
From: Sandeep Kishan (ERG)
Mike Sabisch (ERG)
Date: March 6, 2007
Re: **Recommendations for purchase of PAMS and auxiliary equipment**

The purpose of this memorandum is to report on findings of research conducted on candidate portable activity measurement systems (PAMS) to be used in conducting Work Assignment 0-1 of EPA Contract No EP-C-06-080. Cost and conformance with Appendix C (PAMS Specification) of this Work Assignment were used as the primary basis for evaluation, with additional consideration given to factors such as qualitative assessment of overall product design and anticipated responsiveness and support of the PAMS supplier.

Methodology

To begin this review, a matrix was developed which individually listed all Appendix C requirements, allowing a basis for comparison among various PAMS. Market research was then conducted in order to identify the universe of candidates from which the most suitable units could be selected. A number of manufacturers were identified that provide products intended to communicate with heavy-duty and light-duty computer data streams on electronically-controlled vehicles and equipment (i.e., all light-duty and heavy-duty communication protocols specified in Appendix C, which we'll generically refer to as "OBD/CAN" systems). However, many of these manufacturers did not provide equipment to log data, but rather only to receive and interpret data and provide bi-directional communication with a vehicle's OBD/CAN system. These "communication-only" systems were excluded from consideration. Similarly, equipment intended to be used to communicate location, speed or other parameters to a remote database ("In-Network Vehicle Monitoring") but without "local" memory storage capabilities (such as flash memory) were also excluded from consideration.

Although we were unable to identify any PAMS which conform entirely to the PAMS Specification, several candidates were identified which did satisfy a number of the requirements, especially with respect to "core" units. Once these units were identified, primary consideration was given to factors such as unit cost, ability to automatically shift into "sleep" mode and auto-initiate, ability to operate using the vehicle/equipment's power source with minimal electrical current drain, OBD/CAN datastream communication capabilities, availability of additional analog and digital input channels for auxiliary sensor inputs, and ability to be placed into service without the need to develop acquisition and configuration software (i.e., units are provided with suitable graphical user interface). Although units meeting only the "core" specification



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requirements were also considered during our search, emphasis was placed on those units that could be expanded into "comprehensive" units. In this way, the PAMS selected for this study may also be used in future studies with different requirements.

Nine systems were identified which appeared to meet a number of the critical PAMS Specification requirements. Each of these units was investigated to assess overall conformance with the specification. Manufacturers and distributors were contacted in order to obtain technical information, cost information and demonstrations of interfaces and capabilities. Once this review was completed, each of these units was assigned an assessment rating of "A" (good candidate), "B" (not on the "short list"), or "C" (doesn't appear to be a candidate), based on how well each unit satisfied the PAMS Specification requirements, with particular emphasis toward those features previously described (cost, sleep mode, power, OBD/CAN, auxiliary inputs, and user interface). Out of these nine units, four were assigned an "A" rating. However, the manufacturer of one of these units discontinued this model after the assessment was complete (or during the assessment process), reducing the number of "A" candidates to 3. A summary of each on each of these three "A" candidates is provided in the following section, and details are provided in Appendix A. Appendix B lists details for the remaining 6 candidates, including the discontinued model.

Recommendations:

Table 1 provides a summary of each of the three candidates, as well as a recommendation on how many units should be purchased for this work assignment. "Optional" recommendations are also shown in Table 1, to supplement the base recommendation. As can be seen, the base recommendation is for purchase of Corsa EZII dataloggers. EPA has already purchased two of these units, and one has been provided to ERG for evaluation. Our recommendation assumes the two EPA units will be available for use in this study. Although our evaluation of the Corsa unit was not as comprehensive as a full field deployment, it did indicate that this unit would be well suited for this work assignment, as it is somewhat "ruggedized" and weather proofed, small, relatively easy to set up, and equipped with software which makes it fairly easy to configure and operate. Wireless configuration and data retrieval are additional features that will facilitate field deployment of the Corsa unit. Orders of five or more units are eligible for a 25% discount, which is reflected in the costing shown in Table 1.

Note that although OBD/CAN data collection is not required as part of this work assignment, we are recommending (as an option) collecting this information when available, based on conversations with EPA. Therefore, we are also recommending the purchase of 6 Corsa CAN/OBD modules for use with computer-controlled vehicle/equipment (SAE J1939 protocol only). Until field deployment commences, we are unable to predict the # of instrumented pieces which will be computer controlled (using a system employing the SAE J1939 communication protocol), but we do anticipate this number will be less than six, the number of OBD/CAN modules recommended for purchase. This number may be adjusted based on budgetary restrictions.



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Both the Isaac V8 Sealed and the Hemdata DAWN-LOG16 dataloggers also appear to be very suitable PAMS for this and future studies. However, since we have not had test units to evaluate, as we did with the Corsa EZII datalogger, we are hesitant to recommend bulk purchases of either of these units at this time. We do, however, recommend purchasing one of each of these units, as this would offer an excellent opportunity to do an “in-field” evaluation and comparison of each of the three PAMS systems (Corsa, Isaac, and Hemdata). Since “in-field” evaluations provide a very thorough evaluation opportunity, information gathered during this study could be beneficial in helping guide future equipment purchase decisions. Both the Isaac and Hemdata units are reportedly capable of collecting all heavy-duty communication protocols (SAE J1708 and SAE J1939). Because of the non-standardized hardware associated with the SAE J1708 protocol, however, acquiring signals from these systems can be problematic. An “in-field” study might provide an opportunity to assess the percentage of SAE J1708-controlled equipment from which we can truly acquire this signal (datastream).

Details on these three systems are provided in Appendix A. Details on the other six excluded candidates are provided in Appendix B. Again, *these costs are estimates only*. Exact purchase costs will be available when the purchase orders are submitted.

Once an order is finalized for PAMS, we recommend consideration of the purchase of protective cases in which to house these units during in field use. The exact type and dimensions of these cases will be established once the PAMS order is final and the cases are approved, and we estimate the cost to range between \$50 and \$75 per case. These are included as an optional cost in Table 1.



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Table 1: Recommendation for Purchase of “Core” PAMS

Product	Estimated Cost	Qty	Tot Est Cost	Comments
Corsa EZII Datalogger	\$ 3150	14	\$ 44,100	Price estimate includes 25% discount.
EPA’s Corsa EZII Datalogger	\$ 0	2	\$ 0,00	These are the two units already purchased by EPA
Miscellaneous wiring, harnesses, and supplies	\$ 1000	1	\$ 1,000	Specifics unknown at this time
<i>Subtotal Base Cost</i>			\$ 45,100	
<i>Tax / S&H</i>			\$ 4,510	
<i>ODC Loading (% 14.62)</i>			\$ 6,594	
<i>Total Base Costs</i>			\$ 56,204	
Optional Purchase Recommendations				
Corsa CAN/OBD Module	\$ 3075	6	\$ 18,450	Recommended for installations of J1939 controlled equipment. Price includes 25% discount (we need to confirm this is available for this module).
Isaac V8 Sealed	\$ 3326	1	\$ 3326	Note that auxiliary sensors and aux sensor wiring would be required.
Isaac V8 Sealed CAN/OBD Module	\$ 800	1	\$ 800	CAN/OBD apparently available with both HD SAE protocols (J1708 and J1939).
Hemdata DAWN-LOG16	\$ 6500	1	\$ 6500	\$4500 for core unit (which includes both HD SAE protocols (J1708 and J1939), plus \$1900 for software packages and HD cable (\$100) – Several notes: <ul style="list-style-type: none"> • auxiliary sensors, aux sensor wiring, and CF card not included in estimate • 4.5% discount for 2-5 units, 14% for 6-10 units, 22% for 11-20 • \$1900 software package may be used with multiple units
Protective Cases	\$75	14	\$ 1050	
<i>Subtotal</i>			\$ 30,126	
<i>Tax / S&H</i>			\$ 3,013	
<i>ODC Loading (% 14.62)</i>			\$ 4,404	
<i>Total Optional Costs</i>			\$ 37,543	

In order to meet the requirements of a “core” PAMS, engine speed (in units of RPM) must be acquired. Although engine speed is available through SAE J1708 or SAE J1939 datastreams, we anticipate this datastream will not be available for some instrumentations performed during this work assignment. Therefore, in addition to purchase of the PAMS units and CAN/OBD modules



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listed in Table 1, ERG recommends the purchase of auxiliary equipment that would allow acquisition of engine speed for both PEMS and PAMS instrumentations. Several alternatives exist for collecting this information, some of which are listed below:

- **Electrical Tap** - Tap into a voltage signal proportional to RPM (for instance, tap into an ECU tachometer output or a fuel-injection control lead on an electronically-controlled engine)
- **Optical LED** - Use an optical sensor mounted near to and pointed at a rotating object (such as an engine pulley or harmonic balancer) upon which reflective tape is affixed
- **Infrared** – Use an infrared sensor mounted near to and pointed at a rotating object (such as an engine pulley or harmonic balancer) upon which contrasting surfaces are affixed
- **Piezoelectric (fuel-rail pulse signal generator)** - Use a piezoelectric signal generator affixed to a fuel line to capture a signal proportional to RPM
- **Magnetic or inductive pickup** - Use a hall-effect or magnetic pick-up mounted near a rotating object (such as an engine pulley or harmonic balancer) on which a ferrous or magnetic object is mounted, or near a flywheel or flexplate with teeth. A signal proportional to RPM is captured as each tooth or ferrous/magnetic object passes near the pickup
- **Alternator pickup (AC signal processor)** - Use pick-up coil mounted on the outside of the engine's alternator to sense its rotating field during operation
- **Tach-gen (internal magnetic sensor)** - Use a rotary magnetic pickup device that is tied to an engine's injector pump shaft by way of a small flexible shaft or coupler shaft

The viability of each of these methods is largely dependent on the equipment being instrumented. From past experience, we recognize field collection of engine speed can be problematic (especially over a long-duration study). For example, centrifugal forces tend to detach ferrous objects mounted on rotating pulleys, contaminants can obscure lenses of optical sensors, and OBD/CAN datastreams may be lost during a testing. Therefore, in order to increase the likelihood of successfully collecting valid engine speed information throughout all testing, we recommend acquiring an assortment of sensors that could be used to acquire valid RPM signals on many different engine configurations. Doing so will provide field team members the best opportunity for RPM collection, regardless of the type of installation. In addition, we also recommend RPM signals be collected for each installation using two different systems whenever possible. Although this can pose some challenges during data analysis in the case of differing signals, we feel the benefit of increasing our chances of acquiring at least one continuous valid signal throughout the test outweighs the incremental cost increase and data processing challenges. Redundant acquisition increases the likelihood that at least one valid RPM signal is available throughout the test data.

Table 2 lists ERG's recommendations for purchasing RPM acquisition devices, including optional purchase of alternator signal sensors. Although costly, we recommend purchase of



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these sensors as they are expected to greatly simplify gathering RPM data on a number of PAMS and PEMS installations. The costs listed in this table are estimates only. Manufacturer information and exact purchase costs will be available upon approval of final recommendations, at which time the most suitable vendors will be identified and purchase orders will be submitted.

Table 2: Recommendation for Purchase of Auxiliary Sensors

Sensor Type	Qty	Est Cost (each)	Tot Est Cost	Comments
Electrical Tap	60	\$5	\$ 300	One-time use wire and tap such as a 3M™ Scotchlok™
Optical LED	8	\$ 200	\$ 1600	Comparison between this and infrared
Infrared	8	\$ 250	\$ 2000	Comparison between this and optical
Piezo (fuel-rail pulse signal generator)	0	N/A	\$ 0	Search for suitable manufacturer underway
Magnetic or inductive pickup	4	\$ 100	\$ 400	Limited use, as centrifugal forces tend to detach ferrous triggers and equipment configurations may obscure flywheel teeth
Tach – gen (internal magnetic sensor)	0	\$ 250	\$ 0	None at this time, until we can evaluate equipment configs that could utilize this
Subtotal			\$ 4,300	
Tax / S&H			\$ 430	
ODC Loading (% 14.62)			\$ 629	
Total Base Costs			\$ 5,359	
Optional Purchase Recommendations				
Alternator Pickup (AC signal processor)	9	\$ 1100	\$ 9,900	8 for PAMS, 1 for backup
Alternator Pickup (AC signal processor)	1	\$ 1100	\$ 1,100	For acquiring RPM on the SEMTECH DS PEMS
Subtotal			\$ 11,000	
Tax / S&H			\$ 1,100	
ODC Loading (% 14.62)			\$ 1,608	
Total Optional Costs			\$ 13,708	

Memo Appendix A: Details on Recommended PAMS Units

Please note that costs are only estimates used for evaluation. Actual costs to be provided after purchase orders are placed

Core Unit Requirements	Requirement Comments	Corsa EZII Datalogger	Corsa Comments
Date / Time Stamp		Yes	
Engine on / off	May be via RPM	Yes	
RPM		Yes	
Engine Module Requirements	Comments		
RPM	N/A, in core	Yes	
exhaust temperature (°C)		Yes	
humidity (% r.h.)		possible	Not part of existing package, but one could be easily used
barometric pressure (kPa)		Yes	Eric indicates Corsa does have a barometer they can provide
ambient temperature (°C)		Yes	
date/time stamp	N/A, in core	Yes	
GPS Module Requirements	Comments	Not currently	<i>Corsa is developing a WAAS-enabled GPS module for use with the Ezlogger. <5 m will be OK, the <0.1 m on altitude will be difficult to achieve. This is not currently available from Corsa.</i>
longitude (<5 m accuracy)			
latitude (<5 m accuracy)			
altitude (<0.1 m accuracy)			
vehicle speed (distance/time)			
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Not currently	<i>Not currently, but 1939 module could be adapted to accommodate LD CAN, and Corsa says they could make a LD module that would work on the EZ logger if provided the spec</i>
ISO 14230	LD (KWP 2000)	Not currently	
ISO 9141-2	LD (KWP 2000)	Not currently	
ISO 11898	LD (CAN)	Not currently	
ISO 15765	LD (CAN) (not in spec)	Not currently	
SAE J1587 / J1708	HD (earlier)	No	<i>Corsa decided to focus on 1939, rather than 1587/1708 which it replaces</i>
SAE J1939	HD (later)	Yes	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	yes	1 Gb +

Core Unit Requirements	Requirement Comments	Corsa EZII Datalogger	Corsa Comments
Sleep and power-up on signal		yes	
Power off vehicle, < 1% output increase		Yes	11-18 V input
< 1 % output increase from power draw		Yes	300 mA typical
Record power draw			
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		Yes	
Core Weight < 10 lbs		Yes	8.7 oz
Core dimensions < 1'x1'x6"		Yes	4.5" x 3.4" x 1.3",
Comp Weight < 20 lbs		Yes	
Comp dims < 1.5'x1.5'x1'		Yes	
Water/dust resistant		Yes	
-40 to 40 C Temp Range		No	32F to 140F
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		20+, 40 w/ CAN	
Wiring harnesses included/available?		Yes	
Company accessibility		Great	Michigan
Order turnaround time			

Core Unit Requirements	Requirement Comments	Corsa EZII Datalogger	Corsa Comments
Core Cost		\$4,200	
Engine Module Cost		\$1,000	est
GPS Module Cost		??	
CAN/ECM Module Cost		\$4,100	
Other costs (i.e., harnesses)		included	
Total <i>Estimated</i> Cost		approx \$10000	est - Eric indicated order of 5 or more will receive a 25% dealer discount, discounts on other larger orders may be negotiated on a case-by-case basis
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		A	Local presence (Michigan), rugged, sealed, numerous cables and adaptors available, meets nearly all our needs, company intends on or is capable meeting additional needs (GPS and LD OBDII) (small flexible company). Downside: high cost, but orders greater than 5 get discount. Carl F recommends order full shipment, but have them ship partial as it becomes available.

Core Unit Requirements	Requirement Comments	Isaac V8	Isaac Comments
Date / Time Stamp		Yes	"time-based recording" -
Engine on / off	May be via RPM	Yes	
RPM		Yes	
Engine Module Requirements	Comments		
RPM	N/A, in core	Yes	\$128 for spark detector, \$185 for optical, \$90 for magnetic
exhaust temperature (°C)		Yes	\$101 for exhaust temp thermocouple
humidity (% r.h.)		Yes	\$165 for RH sensor
barometric pressure (kPa)		Yes	\$200 for abs pressure sensor
ambient temperature (°C)		Yes	\$ 183 for thermocouple
date/time stamp	N/A, in core	Yes	
GPS Module Requirements	Comments	Yes	\$314 for GPS module
longitude (<5 m accuracy)		Yes	<3 m, \$314 for GPS module
latitude (<5 m accuracy)		Yes	<3 m
altitude (<0.1 m accuracy)		No	<3 m
vehicle speed (distance/time)		Yes	<3 m
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Yes	
ISO 14230	LD (KWP 2000)	No	Not available
ISO 9141-2	LD (KWP 2000)	Yes	
ISO 11898	LD (CAN)	Yes	
ISO 15765	LD (CAN) (not in spec)	Yes	
SAE J1587 / J1708	HD (earlier)	Yes	1708 is apparently available
SAE J1939	HD (later)	Yes	
Other Requirements	Comments		

Core Unit Requirements	Requirement Comments	Isaac V8	Isaac Comments
3-months data acquisition for core	(> 128 Mb)	Yes	4 Mb memory
Sleep and power-up on signal		Yes	
Power off vehicle, < 1% output increase		Yes	11 to 18 V input
< 1 % output increase from power draw		Yes	0.5 W typical max
Record power draw			
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		Yes	"Analyzer V8" for Win XP or 2000, for data analysis, system config, and real-time display
Core Weight < 10 lbs			
Core dimensions < 1'x1'x6"		Yes	4 x 4.75 x 1.75
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant		Yes	
-40 to 40 C Temp Range		Yes	-25/40 to 85 C
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		4 / 4	4 digital / 4 analog, each expandable through the addition of the MODCAN module
Wiring harnesses included/available?		Yes	standard cable CBLST7 provided for power and accessories
Company accessibility		Good	Company from Canada, but they have a sales rep in

Core Unit Requirements	Requirement Comments	Isaac V8	Isaac Comments
			Dearborn, Michigan
Order turnaround time		30 days	30 days for 1 to 9 units, 60 days for 10 to 24 units
Core Cost		\$3,326	USD
Engine Module Cost		\$834	
GPS Module Cost		\$314	
CAN/ECM Module Cost		\$1,142	\$802 for 1708 and 1939, plus 340 for all LD protocols
Other costs (i.e., harnesses)			
Total Estimated Cost		\$5,616	USD - For one complete unit sensors, perhaps some additional harnesses would be needed, not sure.
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		A	Overall this looks a lot like what we need. Additional investigation is warranted. US Sales rep has offered to provide a web demonstration. Note to Mike: Ask sales associate (Brent) about feasibility of the Datron dataloggers (Ipetronik or 2D) as alternatives.

Core Unit Requirements	Requirement Comments	Hemdata DAWN-LOG16	Hemdata Technologies Comments
Date / Time Stamp		Yes	
Engine on / off	May be via RPM	Yes	
RPM		possible	We would have to acquire our own RPM sensors
Engine Module Requirements	Comments		
RPM	N/A, in core	Possible	We would have to acquire our own sensors. Drew and HEMDATA don't sell these sensors. However, the AVIT does have 16 analog input channels.
exhaust temperature (°C)		Possible	
humidity (% r.h.)		Possible	
barometric pressure (kPa)		Possible	
ambient temperature (°C)		Possible	
date/time stamp	N/A, in core		
GPS Module Requirements	Comments	Yes	GPS conforming to NMEA0183 GPS communication standard, Rick says Delou GPS, but he doesn't know accuracy or resolution. Website states 2m accuracy (see http://www.deluogps.com/).
longitude (<5 m accuracy)		yes	
latitude (<5 m accuracy)		yes	
altitude (<0.1 m accuracy)		no	
vehicle speed (distance/time)		Yes	
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Yes	ISO9141 requires an additional optional module (the Mongoose) for \$300, otherwise the HEMDDATA AVIT does all LD and HD protocols.
ISO 14230	LD (KWP 2000)	Yes	
ISO 9141-2	LD (KWP 2000)	Yes (optional)	
ISO 11898	LD (CAN)	Yes	
ISO 15765	LD (CAN) (not in spec)	Yes	
SAE J1587 / J1708	HD (earlier)	Yes	
SAE J1939	HD (later)	Yes	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	yes internal CF	to 16 GB

Core Unit Requirements	Requirement Comments	Hemdata DAWN-LOG16	Hemdata Technologies Comments
Sleep and power-up on signal		Yes	AVIT has power-up on signal
Power off vehicle, < 1% output increase		Yes	6-26/7-36 Volt allow input
< 1 % output increase from power draw			
Record power draw			
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		Yes	DAWN Master Windows Software, \$1900 for each datalogger (individually-configured software package must be purchased for each datalogger) plus \$400 for viewer and export software, \$2300 total
Core Weight < 10 lbs			
Core dimensions < 1'x1'x6"		1.25"H x 9.5"D x 5.25"W	
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant		Somewhat	Not like the Corsa. This has been "ruggedized" for long-term testing by Allison, but this would probably require additional housing and sealing.
-40 to 40 C Temp Range		-40 to + 85	
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		16	12 bit each
Wiring harnesses included/available?			Unit comes standard with 25 pin DB cable which may be attached to aux sensors. Other harnesses would need to be custom made if needed. We'd have to make our own harnesses for this application
Company accessibility		Good	Michigan
Order turnaround time			2-8 weeks depending on quantity and when order is placed

Core Unit Requirements	Requirement Comments	Hemdata DAWN-LOG16	Hemdata Technologies Comments
Core Cost		\$4,500.00	
Engine Module Cost			Sensors would have to be acquired separately from another company
GPS Module Cost		\$375.00	
CAN/ECM Module Cost		\$500.00	All Included in system except for ISO 9141, which requires the "Mongoose" adaptor (additional \$300). \$200 for the J1962 and J1939 cables.
Other costs (i.e., harnesses)		\$2,300.00	For software. Also, possibly some additional costs with accessory wiring harnesses
Total <i>Estimated</i> Cost		\$7,675.00	Price includes WIFI communication (\$300), but no engine module accessories (approx \$1000) or wiring harness for engine module accessories. Price does not include CF Card.
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		A	Appears to have a lot of what we need, but fairly pricey and doesn't include engine module accessories or harnesses. Sales person (Rick Walter) indicates DOE has 24 units, is ordering more, Rick can provide DOE reference regarding product. Houston Metro also has some, EPA is considering ordering (another group).

**Memo Appendix B: Details on PAMS Units Evaluated but Not
Recommended for Purchase for this Work Assignment**

Core Unit Requirements	Requirement Comments	Drew Technologies AVIT	Drew Technologies Comments
Date / Time Stamp		Yes	
Engine on / off	May be via RPM	Yes	
RPM		Yes	
Engine Module Requirements	Comments		
RPM	N/A, in core	Possible	We would have to acquire our own sensors. Drew doesn't sell these sensors. However, the AVIT does have 16 analog input channels.
exhaust temperature (°C)		Possible	
humidity (% r.h.)		Possible	
barometric pressure (kPa)		Possible	
ambient temperature (°C)		Possible	
date/time stamp	N/A, in core		
GPS Module Requirements	Comments	Possible	
longitude (<5 m accuracy)			A USB GPS antenna may be attached using one of the AVIT's 2 USB ports. The USB antenna is not sold by Drew Tech.
latitude (<5 m accuracy)			
altitude (<0.1 m accuracy)			
vehicle speed (distance/time)			
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Yes	ISO9141 requires an additional optional module (the Mongoose) for \$300, otherwise the AVIT does all LD and HD protocols.
ISO 14230	LD (KWP 2000)	Yes	
ISO 9141-2	LD (KWP 2000)	Yes (optional)	
ISO 11898	LD (CAN)	Yes	
ISO 15765	LD (CAN) (not in spec)	Yes	
SAE J1587 / J1708	HD (earlier)	Yes	
SAE J1939	HD (later)	Yes	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	yes internal CF	to 16 GB
Sleep and power-up on signal		Yes	AVIT has power-up on signal

Core Unit Requirements	Requirement Comments	Drew Technologies AVIT	Drew Technologies Comments
Power off vehicle, < 1% output increase		Yes	6-26/7-36 Volt allow input
< 1 % output increase from power draw			
Record power draw			
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		NO	Runs linux and requires user to develop a C/C++ application to develop laptop configuration software to control unit as a datalogger. Note that the "HEMDATA" DAWN package includes the AVIT and the operating software for configuration, operation, post-processing, and download of data.
Core Weight < 10 lbs			
Core dimensions < 1'x1'x6"		1.25"H x 9.5"D x 5.25"W	
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant		Somewhat	Not like the Corsa. This has been "ruggedized" for long-term testing by Allison, but this would probably require additional housing and sealing.
-40 to 40 C Temp Range		-40 to + 85	
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		16	
Wiring harnesses included/available?			Unit comes standard with 25 pin DB cable which may be attached to aux sensors. Other harnesses would need to be custom made if needed.
Company accessibility		Great	Michigan
Order turnaround time			Immediately (for a few) to a few weeks for a large order
Core Cost		\$2,000.00	(AVIT is \$1800 w/o WiFi)

Core Unit Requirements	Requirement Comments	Drew Technologies AVIT	Drew Technologies Comments
Engine Module Cost		N/A	Sensors would have to be acquired separately from another company
GPS Module Cost		N/A	N/A, GPS would have to be acquired separately from another company.
CAN/ECM Module Cost		\$300.00	All Included in system except for ISO 9141, which requires the "Mongoose" adaptor (the additional \$300).
Other costs (i.e., harnesses)			25-pin DB std. Cost on other wiring would depend on needs and configuration.
Total <i>Estimated</i> Cost		\$2,300.00	excluding software, aux harnesses, gps, and engine module (temps, pressure, humidity, etc.)
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		B	Good price, much of the functionality we need, but it would take some time to piece all this together, develop the software, etc. This is not an "out of the box" solution.

Core Unit Requirements	Requirement Comments	Squarell ILogCAN	Squarell Comments
Date / Time Stamp		Yes	
Engine on / off	May be via RPM		
RPM		Yes	(does have analog voltage sensor input box)
Engine Module Requirements	Comments		
RPM	N/A, in core	No	<i>These could probably be collected thru their analog input, but that capability looks pretty limited. This seems to be primarily targeted toward collecting PCM info.</i>
exhaust temperature (°C)		No	
humidity (% r.h.)		No	
barometric pressure (kPa)		No	
ambient temperature (°C)		No	
date/time stamp	N/A, in core	No	
GPS Module Requirements	Comments		
longitude (<5 m accuracy)		Yes	<10 m
latitude (<5 m accuracy)		Yes	<10 m
altitude (<0.1 m accuracy)		Yes	<10 m
vehicle speed (distance/time)		Unk	
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	No	
ISO 14230	LD (KWP 2000)	No	
ISO 9141-2	LD (KWP 2000)	No	
ISO 11898	LD (CAN)	No	
ISO 15765	LD (CAN) (not in spec)	No	
SAE J1587 / J1708	HD (earlier)	Yes	Appears to require a converter / adaptor to achieve 1708
SAE J1939	HD (later)	Yes	Apparently this layer integral with the logger
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	Yes	website says 6 months, but only lists up to 512 Mb. Not sure if this can be increased with a CF.

Core Unit Requirements	Requirement Comments	Squarell ILogCAN	Squarell Comments
Sleep and power-up on signal		Yes	
Power off vehicle, < 1% output increase		Yes	10-50 V DC Input
< 1 % output increase from power draw		1 watt	when live
Record power draw			
Adjustable acquisition rate		yes	
Acquisition rate 1 Hz capable		Unk	
User-friendly GUI		Unk	
Core Weight < 10 lbs		yes	123 grams
Core dimensions < 1'x1'x6"			100 mm x 63 mm x 29 mm
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant			
-40 to 40 C Temp Range		-40 to 90 C	
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		6	Devices are available which make 2 analog and 4 digital signal inputs possible
Wiring harnesses included/available?		Some available	Some cables for vehicle CAN, but we'd probably need to develop harnesses for external sensors that don't come with the unit.
Company accessibility		Poor	HQ and sales in Netherlands, costs given in Euros.
Order turnaround time			
Core Cost		\$1,500	(USD) 6600-36 iLogCAN 512 MB
Engine Module Cost		Unk	

Core Unit Requirements	Requirement Comments	Squarell ILogCAN	Squarell Comments
GPS Module Cost		\$610	(USD) GPS to CAN DA DR
CAN/ECM Module Cost			
Other costs (i.e., harnesses)		\$40	(USD) Volvo/Renault Adaptor
Total <i>Estimated</i> Cost			
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		B	Fairly affordable, but probably not too attractive of an option since the product appears to be tailored for PCM input and logistics of no local (US) support, and we'd have to do a lot of development for the system we need.

Core Unit Requirements	Requirement Comments	ACR Smartreader Plus 7 Datalogger	ACR Comments
Date / Time Stamp		Yes	
Engine on / off	May be via RPM	Yes	(through RPM)
RPM		Yes	
Engine Module Requirements	Comments		
RPM	N/A, in core	Possible	We would have to acquire our own sensors. Microdaq doesn't sell these sensors.
exhaust temperature (°C)		Possible	
humidity (% r.h.)		Possible	
barometric pressure (kPa)		Possible	
ambient temperature (°C)		Possible	
date/time stamp	N/A, in core	Possible	
GPS Module Requirements	Comments		
longitude (<5 m accuracy)		No	
latitude (<5 m accuracy)		No	
altitude (<0.1 m accuracy)		No	
vehicle speed (distance/time)		No	
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	No	
ISO 14230	LD (KWP 2000)	No	
ISO 9141-2	LD (KWP 2000)	No	
ISO 11898	LD (CAN)	No	
ISO 15765	LD (CAN) (not in spec)	No	
SAE J1587 / J1708	HD (earlier)	No	
SAE J1939	HD (later)	No	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	Yes (up to 1.5 Mb)	1.5 Mb = 1,048,000 readings

Core Unit Requirements	Requirement Comments	ACR Smartreader Plus 7 Datalogger	ACR Comments
Sleep and power-up on signal		No	
Power off vehicle, < 1% output increase		N/A, independent	1 amp-hour battery, plus supplemental battery (BP101), 5 to 10 microamp draw.
< 1 % output increase from power draw		N/A	
Record power draw		N/A	
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		Yes	Apparently, through "Trendreader" software
Core Weight < 10 lbs		Yes	4 oz
Core dimensions < 1'x1'x6"		Yes	4x3x1
Comp Weight < 20 lbs		N/A	
Comp dims < 1.5'x1.5'x1'		N/A	
Water/dust resistant		No	
-40 to 40 C Temp Range		Yes	-40 to 70 C
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		8	7 voltage/current, 1 internal temp
Wiring harnesses included/available?		No	
Company accessibility		OK	New Hampshire
Order turnaround time			
Core Cost		\$1,850	\$ 1600 for 1.5 MB (1100 for 128k), plus \$200 for software and \$50 for additional battery pack required for 1 Hz acquisition.
Engine Module Cost		N/A	
GPS Module Cost		N/A	

Core Unit Requirements	Requirement Comments	ACR Smartreader Plus 7 Datalogger	ACR Comments
CAN/ECM Module Cost		N/A	
Other costs (i.e., harnesses)		Unk	Have do to our own
Total <i>Estimated</i> Cost		> \$1850	plus sensors - assuming software can run more than one unit, this would drop cost/unit down at least \$150
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		B	Meets some base unit needs, but we'd have to modify power to provide signals from RPM and other sensors as needed (battery pack insufficient). No auto shutoff/start either. Actually may be too much \$\$ for us, since it doesn't meet a number of our requirements.

Core Unit Requirements	Requirement Comments	Drew Technologies CarDAQ	Drew Technologies Comments
Date / Time Stamp		Yes	
Engine on / off	May be via RPM	Yes	
RPM		Yes	
Engine Module Requirements	Comments		
RPM	N/A, in core	no	We would have to acquire our own sensors. However, the CARDAQ does have 6 analog input channels.
exhaust temperature (°C)		no	
humidity (% r.h.)		no	
barometric pressure (kPa)		no	
ambient temperature (°C)		no	
date/time stamp	N/A, in core		
GPS Module Requirements	Comments	Yes (thru CF)	
longitude (<5 m accuracy)			GPS thru CF port using CF GPS card on CARDAQ,(units have 2 CFs).
latitude (<5 m accuracy)			
altitude (<0.1 m accuracy)			
vehicle speed (distance/time)			
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Yes	C/C++ Programming would be reqd to let the CarDAQ read HD protocol, but Drew could do this for us (or Mike Smith). ISO9141 requires an additional optional module (the Mongoose) for \$300.
ISO 14230	LD (KWP 2000)	Yes	
ISO 9141-2	LD (KWP 2000)	Yes (opt)	
ISO 11898	LD (CAN)	Yes	
ISO 15765	LD (CAN) (not in spec)	Yes	
SAE J1587 / J1708	HD (earlier)	No	
SAE J1939	HD (later)	No	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	yes (CF 16+Gb)	to 16 GB

Core Unit Requirements	Requirement Comments	Drew Technologies CarDAQ	Drew Technologies Comments
Sleep and power-up on signal		No	<i>The CarDAQ always stays running</i>
Power off vehicle, < 1% output increase		Yes (verify)	6-26/7-36 Volt allow input
< 1 % output increase from power draw			
Record power draw			
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		No	Runs linux and requires user to develop a C/C++ application to develop laptop configuration software to control unit as a datalogger. Other suppliers can provide the software application.
Core Weight < 10 lbs			
Core dimensions < 1'x1'x6"		1.8 x 6.5 x 4	
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant		Not extremely	
-40 to 40 C Temp Range		0 to 70C	
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		6	
Wiring harnesses included/available?			Unit comes standard with 25 pin DB cable which may be attached to aux sensors.
Company accessibility		Great	Michigan
Order turnaround time			
Core Cost		\$2,500.00	
Engine Module Cost		N/A	Not available from Drew Technologies
GPS Module Cost			

Core Unit Requirements	Requirement Comments	Drew Technologies CarDAQ	Drew Technologies Comments
CAN/ECM Module Cost		N/A	Included in system
Other costs (i.e., harnesses)			
Total <i>Estimated</i> Cost			
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		C	Unit stays running all the time, has fewer inputs than the Drew AVIT, and cannot do HD. The Drew AVIT or the HEMDATA package which includes the software with the AVIT hardware is a better soln.

Core Unit Requirements	Requirement Comments	Dearborn Group Gryphon	Dearborn Group Comments
Date / Time Stamp		Yes	Per 5.3 of User's Manual
Engine on / off	May be via RPM	No	Only thru PCM feed
RPM			
Engine Module Requirements	Comments	No	I don't see analog inputs possible. An optional
RPM	N/A, in core	No	I/O module allows 2 digital inputs only.
exhaust temperature (°C)		No	
humidity (% r.h.)		No	
barometric pressure (kPa)		No	
ambient temperature (°C)		No	
date/time stamp	N/A, in core		
GPS Module Requirements	Comments	No	
longitude (<5 m accuracy)		No	
latitude (<5 m accuracy)		No	
altitude (<0.1 m accuracy)		No	
vehicle speed (distance/time)		No	
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Optional	3 1850 modules listed, Ford, GM, Chrysler
ISO 14230	LD (KWP 2000)	Optional	
ISO 9141-2	LD (KWP 2000)	Optional	
ISO 11898	LD (CAN)	Optional	
ISO 15765	LD (CAN) (not in spec)	Optional	
SAE J1587 / J1708	HD (earlier)		
SAE J1939	HD (later)	Optional	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	Yes	CF Card capability

Core Unit Requirements	Requirement Comments	Dearborn Group Gryphon	Dearborn Group Comments
Sleep and power-up on signal		Apparently	Per C.6 and C.10 of user's guide, CAN and KWP protocol provide "wakeup" signals
Power off vehicle, < 1% output increase		Yes	6-32 V input capable
< 1 % output increase from power draw		Yes	< 1 amp
Record power draw			
Adjustable acquisition rate		Yes	Per section 5.4 of user's manual
Acquisition rate 1 Hz capable		Yes	Per section 5.4 of user's manual
User-friendly GUI		Yes	(Optional Hercules software)
Core Weight < 10 lbs			
Core dimensions < 1'x1'x6"		yes	2" x 9" x 5"
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant			
-40 to 40 C Temp Range		yes	-40 C to 85 C
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?			
Wiring harnesses included/available?			
Company accessibility			
Order turnaround time			
Core Cost		\$3,390	Gryphon logger is \$1395, and the software (Hercules) is \$1995. Individual software required for each logger.
Engine Module Cost		N/A	
GPS Module Cost		N/A	
CAN/ECM Module Cost		\$325 to \$2,000 +	Not clear how many modules would be reqd.
Other costs (i.e., harnesses)			CAN and OBDII cables appear to be extra
Total Estimated Cost		>\$4K	

Core Unit Requirements	Requirement Comments	Dearborn Group Gryphon
<p>Overall Assessment</p> <p>A = good candidate</p> <p>B = not on the short list</p> <p>C = doesn't appear to be a candidate</p>		<p>Dearborn Group Comments</p> <p>Review of literature and talk with sales person, this appears to be more suited to specific lab and OEM applications pertaining to PCM development rather than a generic datalogger. Doesn't appear to fit out needs. It's possible the Dearborn Group has another logger better suited, but this is what the salesperson said would be best for our needs. Review of website also seems to show lab, OEM and repair industry target market</p>

Core Unit Requirements	Requirement Comments	Si-Gate, VDL-1000	Si-Gate Comments
Date / Time Stamp		Yes	real-time clock with battery backup
Engine on / off	May be via RPM	Yes	
RPM		possible	We would have to acquire our own RPM sensors
Engine Module Requirements	Comments		
RPM	N/A, in core	Possible	We would have to acquire our own sensors
exhaust temperature (°C)		Possible	We would have to acquire our own sensors
humidity (% r.h.)		Possible	We would have to acquire our own sensors
barometric pressure (kPa)		Yes	Internal
ambient temperature (°C)		Possible	We would have to acquire our own sensors
date/time stamp	N/A, in core	Yes	
GPS Module Requirements	Comments	Yes, NMEA protocol	
longitude (<5 m accuracy)		Not listed	
latitude (<5 m accuracy)		Not listed	
altitude (<0.1 m accuracy)		Not listed	
vehicle speed (distance/time)		Not listed	
CAN/ECM Module Requirements	Comments		
SAE J1850	LD (VPW and PWM)	Yes (optional)	
ISO 14230	LD (KWP 2000)	no	
ISO 9141-2	LD (KWP 2000)	no	
ISO 11898	LD (CAN)	no	
ISO 15765	LD (CAN) (not in spec)	no	
SAE J1587 / J1708	HD (earlier)	no	
SAE J1939	HD (later)	Yes	
Other Requirements	Comments		
3-months data acquisition for core	(> 128 Mb)	Yes, CF card	128 Mb standard, larger available

Core Unit Requirements	Requirement Comments	Si-Gate, VDL-1000	Si-Gate Comments
Sleep and power-up on signal		Yes	
Power off vehicle, < 1% output increase		200 mA at 12 V	
< 1 % output increase from power draw		9-16 V DC	
Record power draw			
Adjustable acquisition rate		Yes	
Acquisition rate 1 Hz capable		Yes	
User-friendly GUI		Somewhat	<i>Vantage (VDL 1000 software configuration tool) Setup doesn't appear as friendly as some, requires programming language configuration and deciphering of processed files.</i>
Core Weight < 10 lbs		500 grams	
Core dimensions < 1'x1'x6"		120 x 130 x 135	
Comp Weight < 20 lbs			
Comp dims < 1.5'x1.5'x1'			
Water/dust resistant		No	
-40 to 40 C Temp Range		-40 to 85 C	
-40 to 0 C Thermal Shock Range			
Shock/Vibration Resistant			
1 year warranty w/ 5- day turnaround			
# open input channels?		12 analog/ 4 digital inputs	
Wiring harnesses included/available?		No	<i>Unit comes with a DB-44 connector for vehicle interface, power input, and analog/digital inputs. Cables/harnesses not included.</i>
Company accessibility		Good	Michigan (but manufacturer is in Germany)
Order turnaround time		N/A	No Longer Available!!!
Core Cost		1200 + ?	MINIMUM PURCHASE OF 5 UNITS!!! Includes J1939 and CF-storage datalogger. LD J1850, accelerometer, GPS, barometric pressure, and wireless interface extra (we're awaiting costs from Jamie at DGE).

Core Unit Requirements	Requirement Comments	Si-Gate, VDL-1000	Si-Gate Comments
Engine Module Cost			
GPS Module Cost			
CAN/ECM Module Cost		1939 included in core unit, J1850 optional	
Other costs (i.e., harnesses)			
Total Estimated Cost			
Overall Assessment A = good candidate B = not on the short list C = doesn't appear to be a candidate		N/A	This appears to be an attractive option (cost and meets many functionality requirements). Disadvantages: requires weatherproofing, configuration and file processing somewhat complex, requires min order of 5 units, and requires creation of harnesses and supplemental sensors. We may want to just try to loaner unit, then place order if warranted. Mfr in Germany so possibly slow turnaround. 2/22 Update: Model Discontinued, no longer available.



MEMORANDUM

Eastern Research Group, Inc.
5608 Parkcrest Drive, Suite 100
Austin, TX 78731-4947

To: Connie Hart, Jim Warila, Carl Fulper (USEPA)
From: Sandeep Kishan (ERG)
Mike Sabisch (ERG)
Date: March 8, 2007
Re: **Revised Recommendations for purchase of PAMS and auxiliary equipment**

This memo is a clarification of the March 7 memo that presented revised recommendations for purchase of portable activity measurement systems (PAMS) to be used while conducting testing in PSU 1 of Work Assignment 0-1 of EPA Contract No EP-C-06-080. This memo replaces the March 7th memo, and all relevant information from the March 7th memo is included or revised herein. Details of each PAMS evaluated for this work assignment, methodology for reviewing PAMS candidates, and details regarding the various RPM signal pickups considered for use in this study, may be found in the original March 6 memo.

Recommendations:

Based on the March 7 conference call between ERG and EPA, ERG is recommending reducing the purchase to only those units needed to perform testing in the first PSU (6 activity tests, plus possible concurrent testing during emissions testing, and a backup unit). Table 1 provides a summary of purchase recommendations. Note that this approach allows a more comprehensive assessment to be made regarding each unit, prior to a second purchase order being placed. This recommendation for a split order carries a slightly higher risk of insufficient PAMS being available for the second phase of the study (PSU 2). However, we feel this risk is minimized if the order is placed before the end of PSU 1 testing is complete. The three PAMS suppliers appear to be able to meet this shortened timeline. We are including a recommendation to purchase OBD/CAN modules with the Corsa systems. These costs are estimates only. Exact purchase costs will be available when the purchase orders are submitted.

Once an order is finalized for PAMS, we recommend consideration of the purchase of protective cases in which to house these units during in field use. The exact type and dimensions of these cases will be established once the PAMS order is final and the cases are approved, and we estimate the cost to range between \$50 and \$75 per case. These are included in Table 1.



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Table 1: Recommendation for Purchase of PAMS for PSU 1

Product	Estimated Cost	Qty	Tot Est Cost	Comments
Corsa EZII Datalogger	\$ 3150	5	\$ 15,750	Price estimate includes 25% discount.
EPA's Corsa EZII Datalogger	\$ 0	2	\$ 0	These are the two units already purchased by EPA, on currently at ERG
Miscellaneous wiring, harnesses, and supplies	\$ 500	1	\$ 500	Specifics unknown at this time
Corsa CAN/OBD Module	\$ 3075	5	\$ 15,375	Recommended for installations of J1939 controlled equipment. Price includes 25% discount.
Corsa CAN/OBD Module	0	2	\$ 0	EPA has at least one (currently in ERG's possession) perhaps two
Isaac V8 Sealed	\$ 3326	1	\$ 3,326	Note that auxiliary sensors and aux sensor wiring would be required.
Isaac V8 Sealed CAN/OBD Module	\$ 800	1	\$ 800	CAN/OBD apparently available with both HD SAE protocols (J1708 and J1939).
Hemdata DAWN-LOG16	\$ 6500	1	\$ 6,500	\$4500 for core unit (which includes both HD SAE protocols (J1708 and J1939), plus \$1900 for software packages and HD cable (\$100) – Several notes: <ul style="list-style-type: none">• auxiliary sensors, aux sensor wiring, and CF card not included in estimate• 4.5% discount for 2-5 units, 14% for 6-10 units, 22% for 11-20• \$1900 software package may be used with multiple units
Protective Cases	\$75	9	\$ 675	
Subtotal			\$ 42,926	
Tax / S&H			\$ 4,292.60	
ODC Loading (% 14.62)			\$ 6,276	
Total			\$ 53,494	

The performance of each of the types of PAMS in during PSU 1 fieldwork will be used as a basis for purchasing PAMS necessary for the remainder of the study (PSUs 2 through 5). Table 2 lists two options for this future PAMS order. An order may be made which differs from these two options, but we feel these provide low-end and high-end cost estimates for planning purposes. The Hemdata DAWN-LOG16 cost drops from \$6500 (Table 1) to \$4800 (Table 2) since the software necessary to configure and operate the datalogger will not need to be purchased for the second order (\$1900 cost reduction), but compact flash memory storage cards will need to be purchased for each unit (\$200 cost increase).



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Table 2: Anticipated Purchase Options for PAMS for PSUs 2 through 5

Product	Estimated Cost	Low Cost Option	High Cost Option	Low Cost Estimate	High Cost Estimate
Corsa EZII Datalogger	\$ 3150	6	0	\$18,900	\$0
Corsa CAN/OBD Module	\$ 3075	1	0	\$3,075	\$0
Isaac V8 Sealed	\$ 3326	0	0	\$0	\$0
Isaac V8 CAN/OBD Module	\$ 800	0	0	\$0	\$0
Hemdata DAWN-LOG16	\$ 4800	0	6	\$0	\$28,800
Protective Cases	\$75	5	5	\$375	\$375
Subtotal				\$22,350	\$29,175
Tax / S&H				\$2,235	\$2,918
ODC Loading (% 14.62)				\$3,268	\$4,265
Total				\$27,853	\$36,358

Table 3 lists recommendations for purchasing auxiliary equipment in order to acquire RPM data for PEMS and PAMS installations. ERG feels the ease of installation benefit offered by the alternator signal pickups offsets the higher costs of these units. This can be evaluated during PSU 1 testing, at which time a decision may be made regarding equipment to order for PSUs 2 through 5. ERG recommends attempting to acquire RPM signals using two different methods on as many tests as possible. This is reflected in Table 3 order quantities. This order may be reduced accordingly if dual-signal collection is not attempted.

Manufacturer information and exact purchase costs will be available upon approval of final recommendations, at which time the most suitable vendors will be identified and purchase orders will be submitted.

Table 3: Recommendation for Purchase of Auxiliary Sensors for PSU 1

Sensor Type	Qty	Est Cost (each)	Tot Est Cost	Comments
Electrical Tap	10	\$5	\$50	One-time use wire and tap such as a 3M™ Scotchlok™
Optical LED	4	\$ 200	\$800	Comparison between this and infrared
Infrared	4	\$ 250	\$1,000	Comparison between this and optical
Piezo (fuel-rail pulse signal generator)	0	N/A	\$0	Search for suitable manufacturer underway
Magnetic or inductive pickup	2	\$ 100	\$200	Limited use, as centrifugal forces tend to detach ferrous triggers and equipment configurations may obscure flywheel teeth
Tach – gen (internal magnetic sensor)	0	\$ 250	\$0	None at this time, until we can evaluate equipment configs that could utilize this
Alternator Pickup	8	\$ 1100	\$8,800	AC signal processor
Subtotal			\$10,850	
Tax / S&H			\$1,085	
ODC Loading (% 14.62)			\$1,586	
Total Costs			\$13,521	



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The ability to collect RPM data via each of the types of RPM pickup units during PSU 1 fieldwork will be used in determining which types of RPM signal collection devices to purchase for the remainder of the study (PSUs 2 through 5). Table 4 lists two options for the RPM pickup device purchase for PSUs 2 through 5. An order may be made which differs from these two options, but we feel these provide low-end and high-end cost estimates for planning purposes.

Table 4: Anticipated Purchase Options for RPM Pickups for PSUs 2 through 5

Product	Estimated Cost	Low Cost Option	High Cost Option	Low Cost Estimate	High Cost Estimate
Electrical Tap	\$5	50	50	\$250	\$250
Optical LED	\$ 200	8	0	\$1,600	\$0
Infrared	\$ 250	0	0	\$0	\$0
Magnetic or inductive pickup	\$ 100	2	2	\$200	\$200
Alternator Pickup (AC signal processor)	\$ 1100	2	10	\$2,200	\$11,000
<i>Subtotal</i>				\$4,250	\$11,450
<i>Tax / S&H</i>				\$425.0	\$1,145.0
<i>ODC Loading (% 14.62)</i>				\$621.35	\$1,673.99
<i>Total</i>				\$5,296	\$14,269

Table 5 lists total quantities of equipment (by type) to be in EPA inventory based on the various ordering options, at various stages of this work assignment. Again, some combination of the low/high cost equipment orders for PSUs 2-5 may be placed, so the final EPA inventory may differ from that shown in Table 5.

Table 5: Summary of EPA PAMS and Associated Purchases

Product	Original EPA Inventory	Purchase for PSU 1	Purchase for PSUs 2-5 (low cost)	Purchase for PSUs 2-5 (high cost)	Final WA01 Inventory (Low Cost)	Final WA01 Inventory (High Cost)
Dataloggers w CAN	2	7	1	6	10	15
Dataloggers w/o CAN	0	0	5	0	5	0
Protective Cases	0	9	5	5	14	14
Electrical Tap for RPM	0	10	50	50	60	60
Optical LED for RPM	0	4	8	0	12	4
Infrared for RPM	0	4	0	0	4	4
Magnetic/Inductive for RPM	0	2	2	2	4	4
Alternator Pickup for RPM	0	8	2	10	10	18



MEMORANDUM

Eastern Research Group, Inc.
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To: Connie Hart, Jim Warila, Carl Fulper (USEPA)
From: Sandeep Kishan (ERG)
Mike Sabisch (ERG)
Date: August 22, 2007
Re: **Recommendation for purchase of Additional PAMS and auxiliary equipment for Work Assignment 0-1 under Contract EP-C-06-080**

This memo is a follow-up to the March 7 memo in which ERG presented recommendations for purchase of portable activity measurement systems (PAMS) to be used while collecting activity data in the first phase (PSU 1) of Work Assignment 0-1 of EPA Contract No EP-C-06-080. In the March 7th memo, ERG recommended purchasing only a sufficient number of units needed to perform testing in the first PSU (6 activity tests, plus possible concurrent testing during emissions testing, and a backup unit). This recommendation was made to provide the team an opportunity to evaluate various brands and types of PAMS prior to submitting a second, final order that would be needed for the subsequent phases of the study (in which 12 activity tests would be performed concurrently). This current memo provides a brief overview of the performance of each of the PAMS used during PSU 1, along with a recommendation for purchase of additional PAMS, auxiliary sensors, and other equipment and consumables necessary to perform activity tests throughout the remainder of this work assignment.

Comparison of PAMS units:

Three types of PAMS were ordered for use / evaluation in PSU 1, the Corsa EZII CF (with external compact flash), the Isaac V8 Sealed, and the HEMDATA DAWN. Five Corsa units were ordered, along with one each of the Isaac and HEMDATA. The Corsa and Isaac dataloggers were each found to meet the PAMS specification requirements sufficiently to warrant consideration for an additional purchase to complete the remainder of the study. However, we encountered several obstacles that prevented our use of the HEMDATA unit during the first PSU. These convinced us that the HEMDATA would not be appropriate for use in the field by multiple operators. Examples of these obstacles are:

- **System Setup Problems:** An auxiliary sensor wiring harness was not available for purchase with the HEMDATA datalogger. The system requires fabrication of a custom connector. Although our team was able to develop a harness using a standard 25-pin connector, this delayed installation of the unit in the field. Also, the wiring harness was not moisture resistant (as are the harnesses on the Corsa and Isaac units). A quick Internet search did not identify any harnesses that could both be modified in the field and would be resistant to conditions in the engine compartments of off-road equipment.



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- **Auxiliary Sensor Problems:** Our team was unable to operate any auxiliary sensors with the HEMDATA datalogger, despite working with the manufacturer to incorporate custom software modules provided specifically for this study to allow this feature. Also, electrical output power appeared to be insufficient to excite the auxiliary sensors (such as the optical RPM sensor).

- **Software Problems:** The user interface necessary to setup the HEMDATA datalogger is an icon-based programming module. While this type of user interface tends to offer great programming versatility, it also is much less intuitive than menu-based or other more tightly defined user interface modules. For the purposes of this study, we feel this type of user interface is less favorable than a menu-driven interface.

For these reasons, we do not recommend ordering any additional HEMDATA dataloggers for this work assignment. We will continue to work with HEMDATA to resolve the issues for the datalogger we've purchased.

Next, we compared the Corsa EZII and the Isaac V8 Sealed PAMS using criteria such as price, apparent quality of data, datalogger reliability and durability, customer service from supplier, size of unit, ease of use, and other features. The following table provides a brief summary of our comparison. These results could be somewhat biased due to our limited familiarity with each datalogger (this was our first field deployment using either type of datalogger), and the fact that the comparison was based on one use of one Isaac unit vs. use of six Corsa units. Also, we were unable to acquire CAN signals from the equipment we instrumented, so our evaluation is based only on use of each datalogger's capability with auxiliary inputs. We were unable to evaluate each unit's ability to collect CAN data.

Table 1: Comparison between Corsa EZII CF and Isaac V8 Sealed PAMS

Evaluation Criteria	ERG's preference for			Comments
	Corsa EZII	Isaac V8 Sealed	No Pref	
Price	Y			Corsa base unit (with 1 Gb removable compact flash) cost is \$4200, but reduces to \$3150 with purchase of 5 or more units. Adding CAN capability, Corsa cost is \$8300 (\$6225 for 5 or more). Isaac base unit is approximately \$5325 (with 512 Mb internal memory). Although the Isaac base unit is more expensive than the Corsa base unit, CAN is now integral with the Isaac base unit (included in base \$5325 cost).
Quality of data		Y		We encountered several issues with the Corsa data, including multiple data files created during setup, large "lockout" files that consumed the memory card (but contained no valid data), and several "corrupted" (but repairable) datafiles. Some of these issues may have resulted from incorrect installation or operation procedures (such as incorrect shutdown procedures, faulty power leads, etc.). The Isaac data was contained in one clean datafile.



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Table 1: Comparison between Corsa EZII CF and Isaac V8 Sealed PAMS

Evaluation Criteria	ERG's preference for			Comments
	Corsa EZII	Isaac V8 Sealed	No Pref	
Reliability and Durability		Y		Although installation teams attempted to prevent exposure to harsh elements, this was not always entirely possible, and both brands appeared to be reliable under adverse conditions (high dust, high moisture, oil/grease exposure, high vibration, and high temperatures). One Corsa unit quit functioning during the study, but diagnosis indicated the compact flash card had been exposed to water (the unit is water resistant, but the CF card region is not). Corsa repaired and returned the unit free of charge (warranty).
Customer Service	Y			Because of several issues, one of which being the number of units in use during PSU 1, installation team members frequently worked with Corsa in resolving issues (both hardware and software). Corsa was always responsive and helpful in resolving all issues. Installation personnel initially had difficulty establishing laptop communication with the Isaac datalogger. Team members were unable to reach Isaac tech support, but were able to resolve their problem (by using another laptop). No other customer service attempts were made for Isaac.
Unit size	Y			The Corsa unit is somewhat smaller than the Isaac unit. However, the CAN module is integral in the Isaac unit, which increases its base size (this is a separate module on the Corsa datalogger). Both units are acceptably small.
Ease of use			Y	Both units are acceptably easy to use. The Isaac appears to have more software features that make it appear somewhat more complex. However, installation team members did report that the Isaac unit was quite intuitive and easy to use.
Other features			Y	The Corsa we used is supplied with an RF transmitter box, which makes remote configuration and diagnosis possible. This is a nice feature, but remote (RF) download of datafiles is not possible, due to the time required for large file downloads. The removable CF card on the Corsa unit allows memory flexibility, but the Isaac is limited to 512 Mb max memory. However, Isaac's internal memory prevents moisture and contamination problems as encountered with the Corsa unit, and the Isaac software has a feature which allows acquisition rate and duration to be tailored for the of memory available. Both units are relatively well sealed to elements (with the exception of the Corsa CF card reader).

Recommendations:

Based on our experience with each of the types of dataloggers, in particular the intuitive nature of the Isaac software and the apparent cleanliness of the data, ERG recommends purchasing additional Isaac V8 Sealed dataloggers to conduct the remainder of this work assignment. Since our experience with the Isaac is still somewhat limited, use of additional Isaac units during the remainder of this work assignment will allow us to more thoroughly evaluate the overall performance of this unit, for consideration in future studies. Similarly, we will continue to work with the Corsa units we currently have in order to resolve any issues identified with these units.



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Table 2 provides a summary of purchase recommendations. Isaac reports that they will be able to provide a 2 to 4 week order fulfillment, which would meet the Phase II testing timeline. Table 2 also includes our recommendations for purchase of auxiliary equipment and sensors necessary to conduct the remainder of the work assignment. Due to the performance of the Capelec RPM detection devices during PSU 1, we do not recommend purchasing additional Capelecs for the remainder of the study. Instead, we will rely on optical RPM sensors as our primary RPM acquisition source, and continue to explore other options to facilitate RPM data acquisition. A line item is included in Table 2 to cover the future purchase of alternative RPM detection devices, should they be identified.

Table 2: Recommendation for Purchase of PAMS Equipment for PSUs 2-5

Product	Estimated Cost	Qty	Tot Est Cost	Comments
Isaac V8 Sealed logger	\$5,400	5	\$27,000	Units now provided with integral CAN acquisition capability. Cost listed also includes 512 Mb internal memory upgrade.
Optical RPM Detector	\$250	8	\$2,000	These will be used for primary RPM acquisition, based on performance during PSU 1
Magnetic RPM Detector	\$125	4	\$500	Backup in case optical not feasible
Miscellaneous wiring harnesses and extensions	Misc	Misc	\$1,000	Various harnesses and extensions which may be needed for all dataloggers
Alternative RPM detection	\$1,000	5	\$5,000	ERG is continuing to explore other sources for RPM detection devices which use principles similar to that employed by the Capelec sensor
Miscellaneous installation accessories	Misc	Misc	\$500	Consumables such as reflective tape, cleaners, fuse holders, in-line electrical taps, spool wire, & other
Protective Cases	\$75	12	\$900	If needed. These weren't feasible in PSU 1, will be explored further for additional installs
Unloaded Subtotal			\$36,900	Does not include S&H or other fees

All costs in Table 2 are estimates only. Upon EPA's approval of our recommendations, suitable vendors will be identified and purchase orders will be submitted. Exact purchase costs will be available after submission of the purchase orders.