Performers Information Package (PIP)

for

ONR BAA Announcement Number _08-016

Development of a Variable Load & Ride Height Suspension System for the USMC LAV

19 May 2008

Approved for public release; distribution is unlimited.

ONR BAA-08-016 PIP
USMC Light Armored Vehicle (LAV)

The LAV is a family of 8x8 wheeled, diesel-powered, lightly-armored vehicles combining speed, mobility and firepower to fulfill a variety of missions for the U.S. Marine Corps. The versatile LAV brings Marines to the fight on land and in water while also providing a weapons platform for anti-tank missiles and mortars, functioning as a command and control vehicle, or performing logistical and recovery tasks. LAVs are equipped with twin aft propellers and rudders and can make 6.5 mph in calm waters of rivers or for fording streams.

The LAV-25 has a two-man turret, which provides ballistic protection equivalent to the base chassis. The vehicle provides the vehicle commander and gunner with full 360° visibility in the closed hatch mode via periscopes. The primary armament is the electrically powered M242 25mm automatic chain gun, the same as on the M2/M3 Bradley Fighting Vehicle, which can fire single shot, 100 or 200 rounds per minute. The LAV-25 has a crew of three and carries six Marines inside.

The LAV entered the Marine Corps in 1983 with a service life expectation of 2005. As of 2007, the Marine Corps Light Armored Vehicle (LAV) has been in service for more than 24 years and is now projected to remain in service until at least 2024. Through programs of service life extension, upgrades to armor and armament, along with survivability and capability enhancements, the LAV remains fully ready for the battlefields of the 21st century.

LAV Specifications and Performance

Length	20.96 ft (6.39 m)
Width	8.20 ft (2.50 m)
Height	8.83 ft (2.69 m)
Weight	14.1 tons (12.8 m-tons)
Engine	Detroit Diesel 6V53T 275 hp diesel
Transmission	Allison MT653 5 fwd, 1 rev
Drive	(8x8) Rear two axles full time, front two axles selectable
Differentials	Four for wheeled axles, two for water propellers
Armament (LAV-25)	M242 Bushmaster 25mm automatic chain gun Two M240 7.62mm medium machine guns Two 4-barrel grenade launchers
Ammunition (LAV-25)	210 ready rounds and 420 stowed rounds of 25 mm 200 ready rounds, 800 stowed rounds of 7.62mm 8 ready rounds and 8 stowed rounds of smoke grenades

Max speed (highway)	60 mph
Max grade	60%
Max side slope	30%
Acceleration	0-20mph, < 10 sec.
Vertical step capability	18 inches
Cruising range	400 miles
Ground clearance	14 inches
Air transportable	C130 Hercules, CH53E Sea Stallion

LAV Configurations

There are more than 700 LAVs in the Marine Corps 2007 inventory, fielded in one of seven different model variants or configurations:

LAV-25, base model, armed with an M242 25mm chain gun

LAV-AT, Antitank, equipped with TOW missile system

LAV-C2, Command and Control (C2)

LAV-L, Logistics vehicle, providing cargo and maintenance capacity

LAV-M, Mortar 81mm Mortar carrier

LAV-R, Recovery vehicle

LAV-MEWSS, Mobile Electronic Warfare Support System

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LAV Mission Profile

Operational Mission Profile

Surface	RMS Range (in)	%
Primary Roads	0.1 to 0.3	10%
Secondary Roads	0.3 to 1.0	20%
Trails	1.0 to 3.4	30%
Cross-country	1.5 to 4.8	40%

6.1. Duty Profile/Mission Cycle.

The following definition describes the U.S. Marine Corps LAV duty profile/mission cycle. Unless otherwise specified, performance shall be demonstrated on surfaces such that 10% is completed on Primary Roads, 20% on Secondary, 30% on Trails, and 40% Cross Country. The Government has defined duty profile mission cycle percentages and RMS values for surface roughness. The wave number spectrum formulas are based on the following: Example Formula: Gxx(n) = 1.4 x 10-8(n)-2.5Wave Number Spectrum: Gxx(n) = spectral of the road elevation in ft2/cycle/ft n = wave number in cycle/ft1.4 x 10-8= roughness coefficient (amplitude of spectrum at 1 cycle/ft)-2.5 = slope of the wave number spectrum. 50% of the mileage shall be with towed load. 90% of the mileage shall be at GVW.

Primary Roads.

There are three types of primary roads, high quality paved, secondary pavement, and rough pavement. All may consist of two or more lanes, all weather, maintained, hard surface (paved) roads with good driving visibility used for heavy and high density traffic. These roads have lanes with a minimum width of 108 inches, road crown to 2 degrees and the legal maximum GVW/GCW for the county and state is assured for all bridges. (a) High quality paved roads have surfaces having an average Root Mean Square (RMS) value of 0.1 inches. (b) Secondary pavement has an average RMS of 0.2 inches and can include significantly degraded concrete, macadam concrete or asphalt pavements (potholes, alligator cracking, freeze/thaw breakup) (c) Rough pavement has two categories that consist of two lane roads with degraded shoulders, and marginal subgrades which produce long wavelength swells and additional degradation of the surface. Rough pavements have an average RMS of 0.3 to 0.5 inches RMS & severely degraded pavements have an average RMS of 0.5 to 0.7 inches RMS.

Surface	Wave Number Spectrum	% Total Miles
High Quality Paved Road	$G_{xx}(n)=1.4 \times 10^{-8}(n)^{-2.5}$	3%
Secondary Pavement (Two Lane Paved Road)	$G_{xx}(n)=1.9 \times 10^{-7}(n)^{-2.5}$	3%
Rough Pavement (Degraded Paved Road)	$G_{xx}(n)=8.0 \times 10^{-7}(n)^{-2.5}$	3%
Rough Pavement (Highly Degraded Pavement)	$G_{xx}(n)=3.0 \times 10^{-6}(n)^{-2.0}$	1%

Secondary Roads.

There are three types of secondary roads; loose surface, loose surface with washboard and potholes, and Belgian block. These roads are one or more lanes, all weather, occasionally maintained, varying surface (e.g., large rock, crushed rock and gravel) intended for medium-weight, low-density traffic. These roads have no guarantee that the legal maximum GVW/GCW for the county and state is assured for all bridges. These roads are surfaces having a RMS value varying between 0.3 inches to 1.2 inches. The wave number spectrum equation, percentages of total travel, and average travel speed for the three levels of pavement roughness are as follows:

Surface	Wave Number Spectrum	% Total Miles
Loose Surface	$G_{xx}(n)=3.0 \times 10^{-5} (n)^{-2.0}$	8%
Loose Surface with Washboard & Potholes	$G_{xx}(n)=4.0 \times 10^{-6} (n)^{-2.4}$	10%
Belgian Block	$G_{xx}(n)=4.0 \times 10^{-1} (n)^{-1.4}$	2%

(1) Loose surface with washboard roads have a peak amplitude of 5.0 x 10-3 ft^2/cycle/ft at 0.3 to 0.5 cycle ft (2 to 3-foot wavelengths). Loose surface roads with a high density of potholes have a peak amplitude of 9.0 x 10-3 ft^2/cycle/ft at 0.1 to 0.2 cycle/ft (5 to 10 foot wavelengths). Generally, washboard occurs in operational areas that are dry, whereas pothole gravel roads occur in wet operational areas.

(2) Belgian Block secondary roads have a peak amplitude of 8.0 x 10-2 ft^2/cycle/ft at.083 cycle/ft (12 foot wavelengths) and these wavelengths are 180^o out-of-phase left to right which produces a racking input to the vehicle. The cobblestone blocks dominate the amplitude of the wavelengths at 1 cycle/ft.

Trails.

One lane, unimproved, seldom maintained loose surface roads, intended for low density traffic. Trails have no defined road width and can include large obstacles (boulder, logs, and stumps) and no bridging. These are surfaces having a RMS value varying between 1.0 inches and 3.4 inches. The wave-number spectrum equation for the trail roughness is as follows:

Surface	Wave Number Spectrum	% Total Miles
Trails	$G_{xx}(n)=4.6 \times 10^{-1} (n)^{-1.9}$	30%

Cross-Country Terrain.

Vehicle operations over terrain not subject to repeated traffic. No roads, routes, well-worn trails, or man-made improvements exist. (This definition does not apply to vehicle test courses that are made to simulate cross-country terrain.) In addition, cross-country terrain can consist of tank trails with crushed rock or having large exposed obstacles (rocks, boulders, etc). These are surfaces having a RMS value varying between 1.5 inches and 4.8 inches. The wave-number spectrum equation for the cross-country roughness is as follows:

Surface	Wave Number Spectrum	% Total Miles
Cross-Country	$G_{xx}(n)=9.2 \times 10^{-1} (n)^{-2.1}$	40%

(1) Road Left and Right Track Correlation. Fixed frequency, RMS, and half-round obstacles shall include roughness or events where the left and right wheel paths are shifted longitudinally up to +/- 45 degrees (approximately 6 1/2-ft (2m)). (6) Roughness Tolerances. The random roughness' expressed through the straight-line wave number spectrum relationships are average values and actual road roughness will naturally contain variability. The upper and lower limits for the random portion of the road roughness have a +/- 3 db envelope.

6.2. Road Roughness.

Spectral characteristics of road surface measured and analyzed in terms of wave-number spectra.

6.3. Root Mean Squared (RMS).

A measurement used to describe the roughness of a terrain.

6.4. Washboard Effect.

A periodic component in space that appears in the wave-number spectrum as a sharp peak at a wave-number corresponding to the reciprocal of the 'washboard' wavelength. Generally, washboard roads occur in operational areas that are dry.

6.5. Wave-Number Spectrum

Represents road roughness data as a straight-line relationship on a log-log plot with ft2/cycle/ft on the y-axis (wavelength in feet or spatial frequency of the distance between the bumps). Technique for measuring and monitoring long sections of various terrain types, including paved roads and off-highway durability test courses, that can be used to describe all potential deployment areas of a vehicle. Wave-number spectrum provides a vehicle and speed independent measure of the roughness of a road. An example of the equation for wave-number spectrum is as follows: Gxx (n)+ 1.66 X 10-6(n)-2.0 Where: Gxx (n): wave-number spectrum of the road elevation in ft2/cycle/ft; n: wave number in cycle/ft; 1.66 X 10-6: roughness coefficient (amplitude of spectrum at 1 cycle/ft where the wave-number spectral density of the road roughness is an equivalence among road roughness spectrum with different slopes); -2.0: Slope of the wave-number spectrum.

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Front LAV Wheel End/Suspension Photographs

Rear LAV Wheel End/Suspension Photographs

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Front (Stations 1 & 2) LAV Suspension Components from the Technical Manual

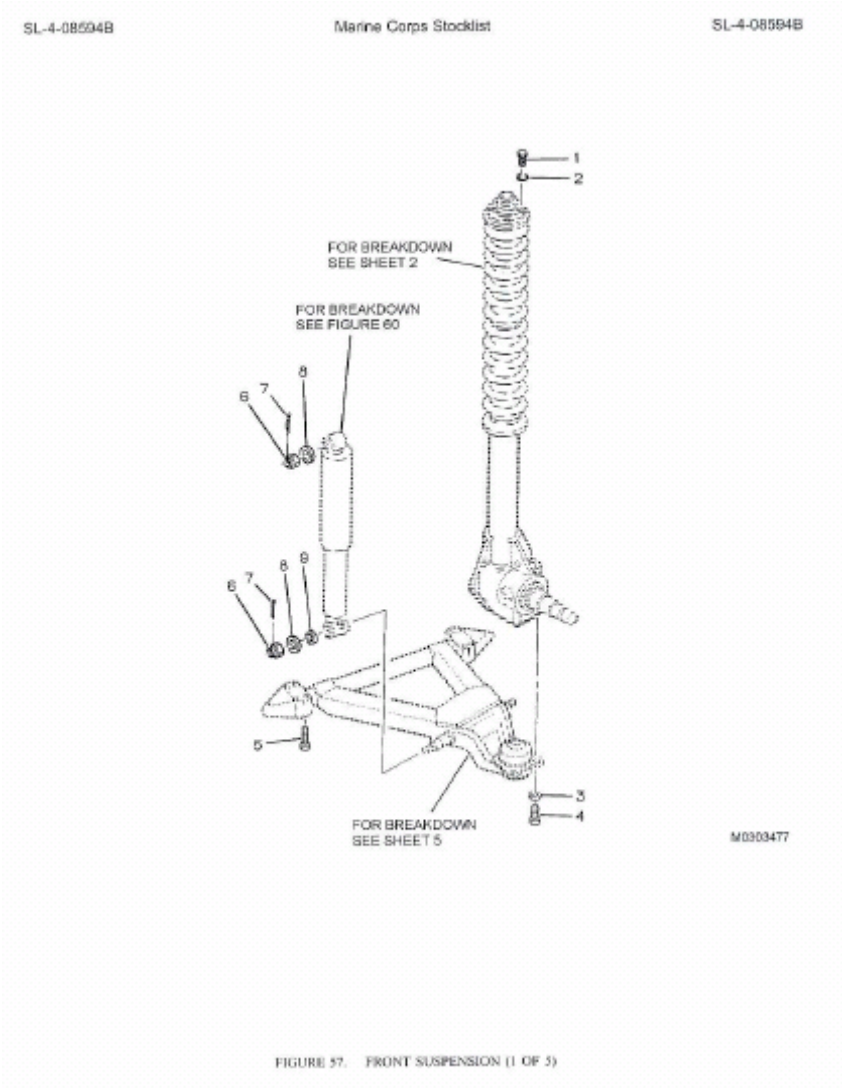

FIGURE 57. FRONT SUSPENSION (1 OF 5)

Rear (Stations 3 & 4) LAV Suspension Components from the Technical Manual

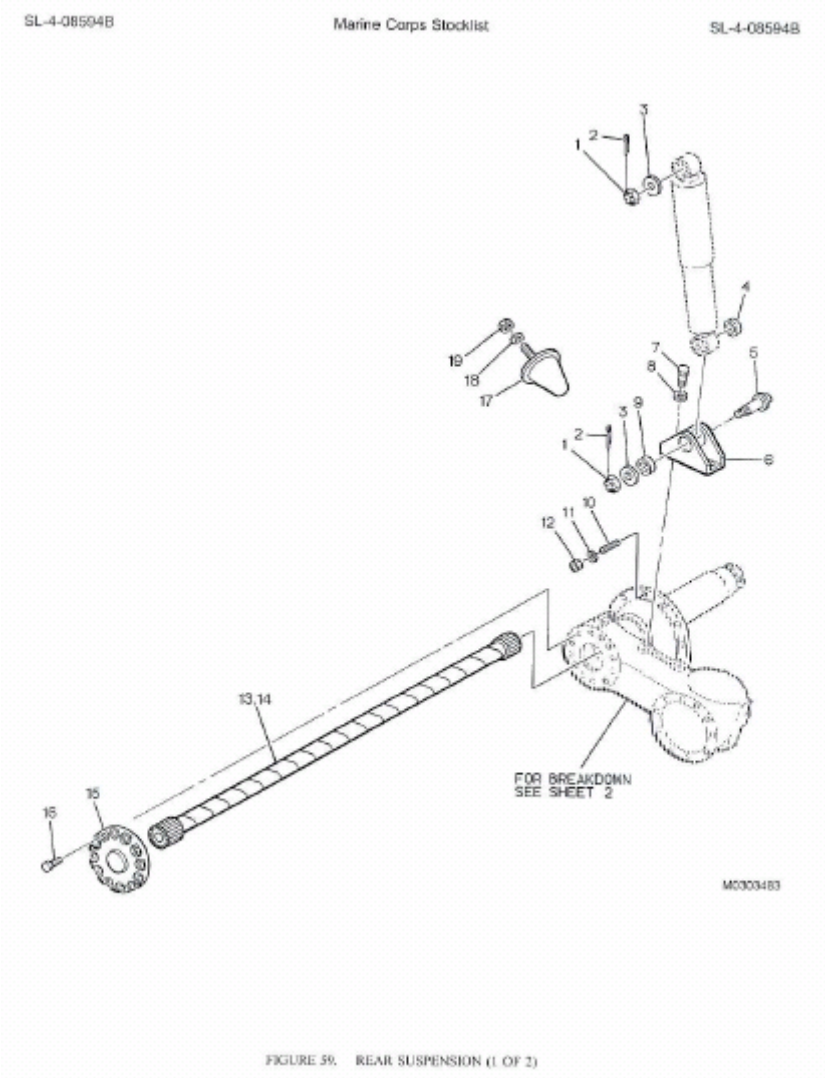

FIGURE 59. REAR SUSPENSION (1 OF 2)