Roscommon Equipment Center Program

Project No. 53A

M-561 "GAMMA GOAT"

An Analysis of the Vehicle for Wildfire Use

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Northeast Forest Fire Supervisors

In Cooperation with

Michigan's Forest Fire Experiment Station

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INTRODUCTION

The Gamma Goat is a 6-wheel drive articulated (jointed) U.S. Military vehicle. The payload rating is 5/4 ton. Two versions exist: the M-561 Cargo Truck and the M-792 Ambulance. The vehicle is a dual bodied truck with tractor (cab/engine) and carrier (trailer) portions.

The Roscommon Equipment Center Program, because of the interest of various wildfire agencies, had its eye on the Gamma Goat for evaluation as a pumper unit for some time. High quality M-561 trucks became available through the Federal Excess Personal Property program in late 1986. Through the help of the Pennsylvania Bureau of Forestry, a vehicle was obtained for REC's use in January, 1988. The Northeast Forest Fire Supervisors (NFFS) Equipment Development & Testing Committee recommended and approved testing and pumper development of this vehicle as an REC project. Because of the special nature of this vehicle, it was decided to break the project into two parts. The first part contained within this report provides information on the Gamma Goat that could be reported quickly, so agencies could start making decisions as to the possibilities this vehicle may have for their use. Project No. 53B provides a sample design for modification of the Gamma Goat for forest fire use.

VEHICLE CHARACTERISTICS

Military Name:	M-561, Truck, Cargo, 1-1/4 Ton 6x6 M-792, Ambulance, 1-1/4 Ton 6x6
Tractor Section:	2 Axles 2 Seats (driver plus passenger)
Trailer Section:	1 Axle Cargo Area
Construction:	Aluminum Alloy Unibody
Engine:	Detroit Diesel 3-53 3 Cylinder, Liquid Cooled, In-line, Two Cycle
Transmission:	Manual - 4 forward, 1 reverse Synchromesh action in forward gears, except first.
Transfer System:	High and low range. Two or six wheel drive. PTO for trucks with winch.
Tires:	Tubeless Nondirectional 11x18, 6 ply. Pressure - 22 psi highway; 18 psi cross country.
Electrical System:	24 volt negative ground. 24 volt 60 amp alternator.
Steering:	4 Wheel Steering - front and rear. Wheels turn in opposite direction with turn of steering wheel.
Brakes:	Hydraulic service brakes. Hand operated park brake.

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Turning Diameter: 58 feet outside.

Truck Weights: (M-561 Cargo Truck) in pounds.

	Curb Weight	GVWR
Payload and Crew		2,960
Front Axle	2,620	2,960
Center Axle	3,125	4,045
Rear Axle	1,700	3,540
TOTAL	7,445	10,545

Road Speed: (MPH) at curb weight.

	Transfer	
Gear	High	Low
4	55	32
3	32	19
2	15	9
1	8	4
R	8	4

LOADING AND DESIGN CONSIDERATIONS

The Gamma Goat's Gross Vehicle Weight Ratings (GVWR) as of 1979 is listed above. The military no longer gives a cross country and highway GVWR, instead, ratings found on the dashplate and in the manuals are for the more conservative cross country use. It is hard to imagine a specialized vehicle, such as the Gamma Goat, being used for any other end use than off-the-road. Hence, the user should not exceed the GVWR listed.

There are some limiting factors for loading the Gamma Goat. The rear axle is located far to the rear of the carrier. This means centering payloads, such as a water tank, over the rear axle where most of the payload capability is available, is not possible. Much of a water tank load will fall on the center axle which is already heavily loaded with the engine.

For our tests, we modified an M-715 slip-on tank (see REC Project No. 34). The front deck of this tank was shortened by four inches in order to fit into the rear of the carrier. The capacity of this mild steel tank is 200 gallons. Lighter weight materials for the tanks, such as aluminum or fiberglass, could be used if increasing the water capacity is desired.

The difference between the front axle weight rating and the curb weight of the front axle is only 400 pounds. This is nearly the weight of the driver and occupant. Approximately 70 percent of the driver and occupant's weight will rest on the front axle. Addition of a cab top and limb protection would add additional weight on the front axle. It will be difficult to add a cab or accessories on the front without exceeding the front axle rating. Using aluminum for the cab construction may be necessary.

Adding a hard top cab and brush protection poses a few more problems than just the added weight on the front axle. The Gamma Goat has no doors; the occupants must step up over the side panels in order to slip into their seats. The top of any cab or roll cage must be high enough to provide entrance for the occupant.

NOTE: Weigh each converted vehicle's axle with a full complement of water and equipment before use to check if the GVWR has been exceeded.

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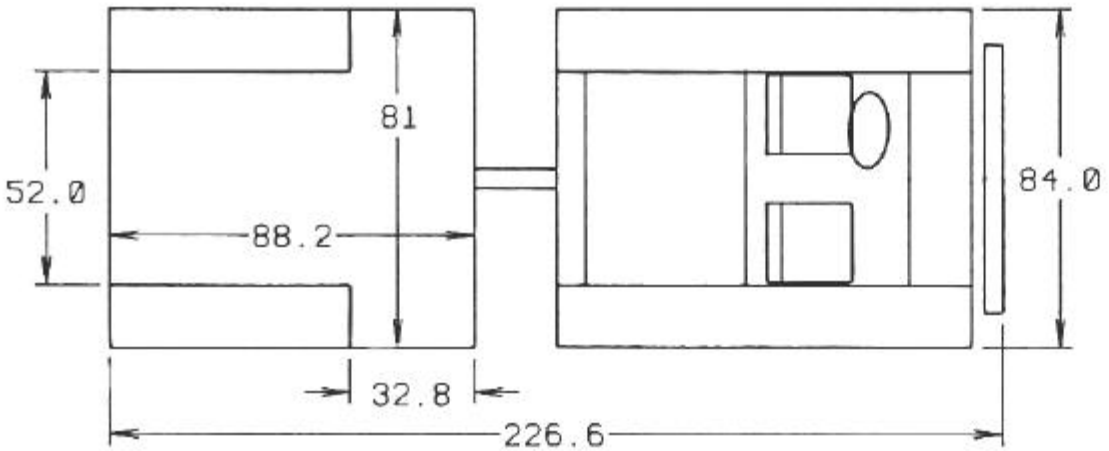
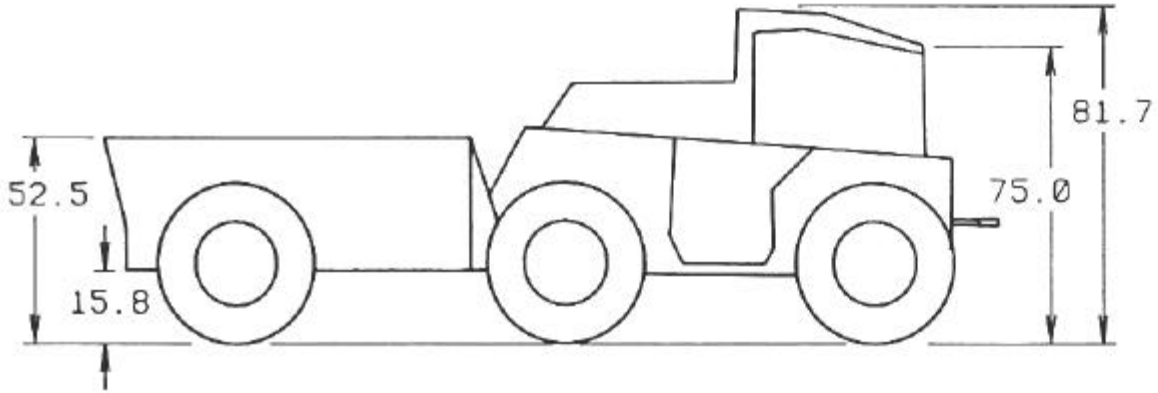


Length w/ winch:	226.6"
Length w/o winch:	231.7"
Width:	84.0"
Grd. clearance:	15.0"
Height:	81.7"



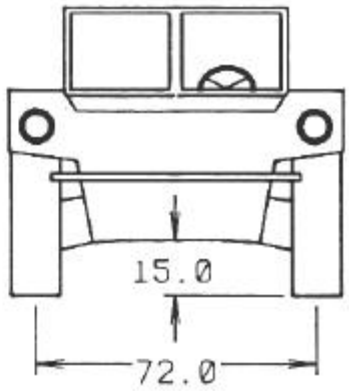


Fig. 1: VEHICLE DIMENSIONS M-561 GAMMA GOAT

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VEHICLE TESTS

At the project's beginning we felt the M-561 characteristics might be right for use in rugged, steep, rocky terrain, or possibly in marsh or bog areas. It would appear that other military 6x6's and 4x4's can readily handle most situations, other than these. Other military vehicles are simpler and more familiar to drivers than the Gamma Goat.

The Gamma Goat was tried in as great a variety of situations as the Roscommon area would allow. It had good power and will go almost anywhere that it has traction. We found it had difficulty in loose sand on about a 20 percent grade. In second gear-low, the vehicle did not have enough power to climb the grade; in first gear-low, it had plenty of power, but all six wheels were spinning. On the same grade, with three wheels on a loose sod mat, it climbed the grade easily. According to military tests the maximum grade for a full load in first-low is 60 percent.

We found some success running the vehicle in a leatherleaf bog. However, the Gamma Goat succumbed to the same problem as most wheeled vehicles: somewhere within the bog it found a place where the root structure was thin enough to allow the wheels to cut through the mat into the moss below. In most bog situations the Gamma Goat will soon be sitting on its bottom plate, unless it hits a hard structure before using all of its 15 inch ground clearance.

The Gamma Goat does not appear to have a future in muck fire use, although its agility and high ground clearance may allow it to travel through leatherleaf bogs when they are dry and the leatherleaf is thick. The most likely use for the Gamma Goat is in the rocky areas and areas of steep slope. Its 15 inches of ground clearance is twice that of current production 4x4 truck units. The angle of approach is 60 degrees; angle of departure is 43 degrees. The hinged nature of the vehicle gives it great flexibility. It travels over hummocks easily and comfortably. It can likely traverse shallow stream beds and rocky areas and will certainly get into places that no pickup would be able to travel.

ROADABILITY TEST

The Gamma Goat was taken on a 10 mile course, which included two long grades and a traffic light. The course was 8-1/2 miles of blacktop road and 1-1/2 miles of gravel. During the 1978 REC Unimog Equipment Evaluation, an International 1700 4x4 tanker with 500 gallons of water averaged the course in 17 minutes. The Gamma Goat took 19-1/2 minutes. Top highway speed obtained on blacktop level surface was 53 MPH without water and about 48 MPH at maximum GVWR. The highway speed seems adequate; acceleration is slow.

As delivered to the military; the noise level is high enough to require ear protection. We added an insulated cab which reduced the noise from the midship engine. The operator still experienced an unpleasant, high whining noise from the transmission, especially when in fourth gear-high on the highway. The vehicle handles reasonably well on the highway; however, it would not be recommended to travel at highway speeds for long periods (more than 45 minutes).

The Gamma Goat originally came with a canvas top and no doors. Because of the unibody construction, we were limited in providing the operator an adequate opening for entering the cab. The hardtop cab design of the Forest Fire Experiment Station is, in fact, higher than we desired, solely to provide a bigger door opening for the operator. It is a clumsy machine for the operator to enter. Tall or stocky built drivers may find considerable difficulty seating themselves. Getting into the passenger seat is easier because there is no steering wheel obstruction.

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The inside turning radius of the Gamma Goat is about 20 feet. This compares to about 22 feet for an International 1700 4x4; 18-1/2 feet for a GMC or Chevrolet pickup truck; and 25-1/2 feet for a REO 2-1/2 Ton 6x6. The Gamma Goat steering utilizes both the front and rear axles in tandem.

FIELD EVALUATION

As of spring 1988, four northeast fire agencies have tried the Gamma Goat for fire use. They are Michigan, Minnesota, New Jersey, and Pennsylvania. A total of five vehicles are on trial within these four agencies and they have been on a total of 45 fire runs. A survey was made of the vehicle operators to obtain a quick field evaluation; the comments are summarized below. Tank capacities vary from 100 to 250 gallons. One of Pennsylvania's units was a 100 gallon fiberglass tank; they also used the rear carrier for transporting personnel and tools. New Jersey chose aluminum to construct a 250 gallon tank. The other tanks were 200 gallon mild steel. Four of the five units were fitted with some type of tubular frame sheet metal clad cab.

Operators were pleased with the vehicle's mobility, ability to climb grades and move through terrain with difficult approaches, such as ditches. None of the operators appreciated the high noise level and there was mention of the vulnerability of the fuel line underneath the vehicle. U-joints were the most cited maintenance problem. Tire availability is also poor. Because of the odd rim size, other tread and tire widths are not available.

PARTS AVAILABILITY

Because the Gamma Goat is a unique vehicle, designed exclusively for military purposes, it has many special components and parts. Most of these are not available through commercial sources. It is, however, a relatively new design compared to some other vehicles that have been available through excess property. Sources at the Army Tank Command in Warren, Michigan, have informed us that the supply of parts from the manufacturer to the military has become a problem. This was caused by the change in ownership of the primary manufacturer, Consolidated Diesel. Because the military is phasing out the Gamma Goat for most purposes, they are now anticipating using cannibalization as a method of parts supply. This has two ramifications:

1. Parts availability through MILSTRIP sources may be limited.

2. Gamma Goats available through Federal Excess Personal Property may already have been stripped of some parts.

Whether this has any affect on the number of high quality Gamma Goats available for Federal Excess Personal Property, remains to be seen.

Checks by USFS State & Private Forestry in Broomall, have already noticed a shortage of supply of technical manuals for these vehicles. The two primary technical manuals are:

1. TM 9-2320-242-10-1, Sept. 180
   "Operation, Installation and Reference Data"
   Truck, Cargo: 1-1/4 ton, 6x6, M-561
   (NSN 2320-00-873-5407)
   Truck, Ambulance: 1-1/4 ton, 6x6, M-792
   (NSN 2320-00-832-9907)

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2. TM 9-2320-242-20P, March 1985
   "Organizational Maintenance, Repair Parts and Special Tools Lists"
   Truck, Cargo: 1-1/4 ton, 6x6, M-561
   (NSN 2320-00-873-5407)
   Truck, Ambulance: 1-1/4 ton, 6x6, M-792
   (NSN 2320-00-832-9907)

Because these manuals are either not available or available in limited quantities, the Broomall Office is exploring ways to get manuals reproduced for those who may need them.

The New Jersey Forest Fire Service has reported difficulty in obtaining tires. The tires are apparently a special design for the Gamma Goat and are not available through commercial channels. Gamma Goat tires are available through MILSTRIP and we should expect that to continue until the military cleans the vehicles out of the system. There apparently is one private supplier who has a stockpile of these tires in Delaware. Since the vehicles' wheel size is unusual, there are no options for changing tire treads or width.

The military insists that the Gamma Goat has no peculiar maintenance demands, that any problems began early in production have been resolved. One look, however, tells an observer that these are not like the family car and maintenance and repair will be somewhat different, if not more complicated, than most agencies are currently used to. Do not expect the local garage to repair one of these vehicles. The enclosed undercarriage often makes repair access difficult.

SUMMARY

Our present limited testing has indicated that the Gamma Goat is best suited for rugged, rocky terrain and steep slopes. We can see no advantage that the Gamma Goat has over 6x6's or 4x4's in sandy areas or level terrain. It does not appear significantly better than any other military vehicle in muck, peat, or bog areas. Therefore, we have concluded that its most likely use would be in applications where its high ground clearance, unusual agility and great power will perform better than common equipment.

Although the Gamma Goat has shortcomings in operator comfort on the highway, it is not uncomfortable at slow speeds when working off the highway. In fact, it is much more comfortable in hummocks or rugged terrain than other vehicles, this is because the body twists and turns and has tremendous flexibility.

Summary of Advantages:

- High ground clearance (15 inches).
- Excellent gradability.
- Superior traction in rugged terrain.
- Excellent underbody protection (except fuel line).
- High fording level.
- Good riding comfort in rough terrain.
- High mobility.

Summary of Disadvantages:

- Difficult for operators to enter.
- High noise levels (hearing protection required).
- Poor availability of parts and operator's manuals
- Limited cab and operator protection options due to front axle load limits.
- Maintenance and repair different than common vehicles.

We feel the Gamma Goat has limited potential for most wildfire use in the northeast, but in areas where more common all-wheel-drive vehicles cannot traverse, the M-561 offers a possibility that is financially attractive because of the Federal Excess Personal Property program. We expect that many more will be available in the upcoming years as the Department of Defense switches to new vehicles such as the HUM-V. The Gamma Goat will remain in the U.S. Army system in limited numbers to carry a special mobile radar system. This may help parts availability in the future.

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Figure 2 - If its front deck apron is reduced by four inches, the 200 gallon REC design M-715 slip-on tank fits into the Gamma Goat. It also loads the vehicle properly.

Figure 3 - The Gamma Goat traverses part of a wet leatherleaf bog. Eventually the tires cut the root mat and towing was needed.

Figure 4 - The side of this ditch was too steep for the Gamma Goat to cross; however, it backed out easily. The water depth was about 3 feet and the ditch was 6 feet deep.

Figure 5 - The weight of cab top and brush protection can easily exceed the payload capability of the front axle. This is discussed in the report.

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