ARMY RESEARCH LABORATORY

A Tandem Wheel Attachment to Improve M198 Howitzer Mobility

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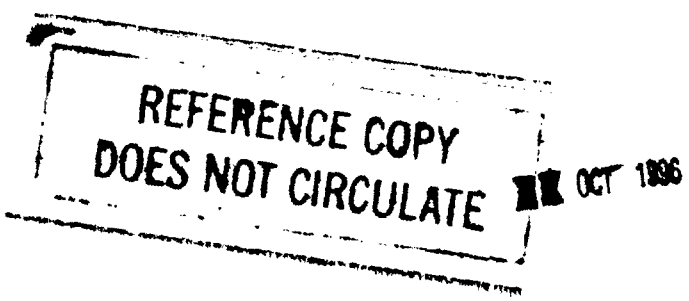
John L. Thompson

ARL-MR-245 August 1995



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An M198 wheel attachment has been designed and fabricated to meet the increased requirement for responsiveness and survivability demanded by future M198 combat missions. The wheel is composed of a dual pneumatic swivel caster that attaches to the left trail end by a spade-like lug. It is secured to the trail by the spade key. This tandem wheel supports the trails in both the towed and stowed configurations allowing the M198 to be easily maneuvered. The current capability of towed howitzers would be increased by simplifying the handling and stowage during ground and air transportability/mobility. It removes some of the dependence on material handling equipment and prime movers while providing labor savings, time savings, and increased safety to the soldiers. The primary functions of the wheel would be to facilitate the loading and unloading of a stowed M198 into a cargo carrier aircraft, moving a stowed or towed M198 around a motorpool/airstrip/tactical environment, used during air assault operations for quick emplacement, and obtaining M198 weight and center of balance measurements before air movements.

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1. INTRODUCTION

The M198 towed 155-mm Field Artillery Howitzer (see Figure 1) is a medium weight weapon weighing approximately 16,000 lbs (7,257 kg) [ST 6-50-19, March 1989]. Operated by an 11 man crew, this weapon is designed to provide general support and direct support artillery fire for infantry and air assault divisions and in the corps general support battalions. It is also used to increase light infantry division capabilities as required by specific missions. The M198 is used by both the U.S. Army and the U.S. Marine Corps units, active and reserve.

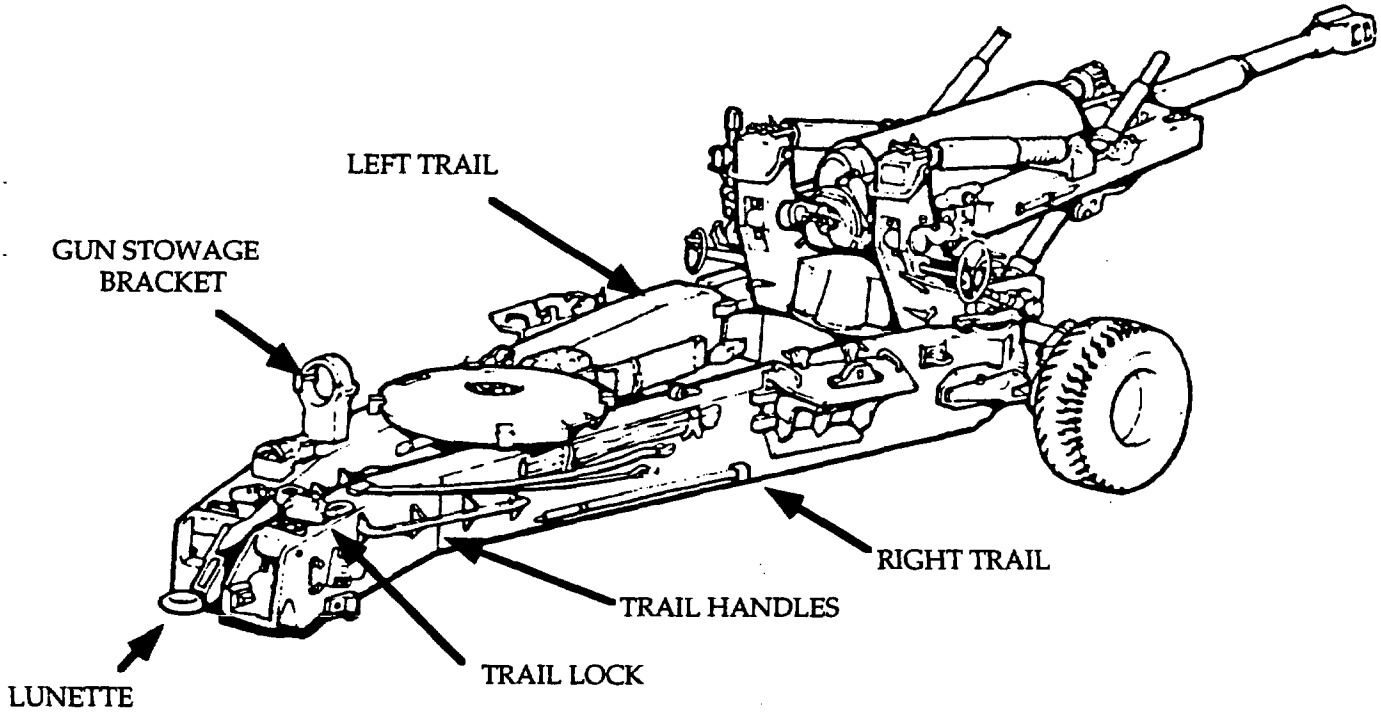
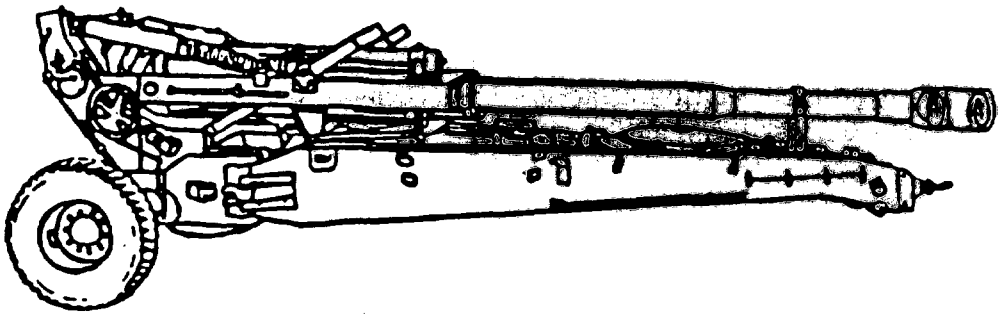


Figure 1. 155-mm M198 towed howitzer

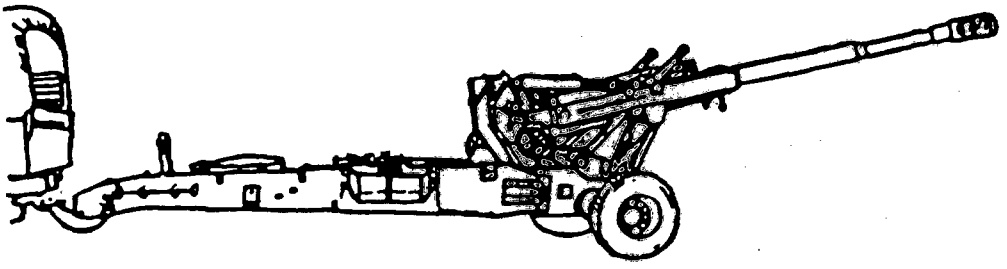
Currently there are four methods of transporting the M198: air, ground, water, and rail [TM-55-1025-211-14, Sept 89]. These methods fall into two general areas of transportability: tactical mobility and strategic deployability. Furthermore, strategic deployability can either be a tactical or nontactical movement. The type of movement is based on the urgency of the situation. Nontactical movements emphasize economical use of the aircraft cargo space when enemy interference or contact is not anticipated. Tactical movements are facilitated when a tactical mission is to be accomplished. Unit integrity becomes the primary consideration in this movement.

The principal method of transport is by ground using its prime mover, a 900 series 5-ton cargo truck. This vehicle is organic to the unit and transports the section personnel, ammunition, equipment, and the M198 in the stowed or towed A-frame position configuration. The prime mover is equipped with a rear pintle hook that attaches to the M198's lunette. Towing in the towed A-Frame

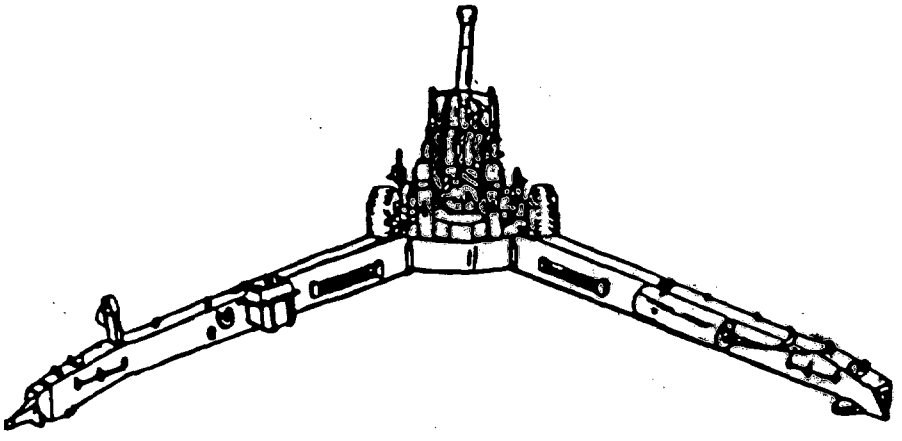
configuration is recommended in tactical situations because towing in the stowed configuration usually requires removal of the muzzle brake. The M198 has a total of three operational configurations for handling and stowage. They are shown in Figure 2.



STOWED OR CUBED POSITION



TOWED A-FRAME POSITION



FIRING POSITION

Figure 2. Operational configurations

During combat operations, it may be necessary for the commander to quickly move his fire support assets forward to engage targets that are beyond the weapons range capabilities and then quickly move them back to support the close battle. To conduct these missions, the commander would use the heavy lift assets within the Corps to airlift the howitzers on an artillery raid.

The primary method of air transport is the CH-47D, or larger, heavy lift helicopter. The howitzer is externally rigged for air transport with lifting hardware attached to the four lifting eyes. The howitzer is in the A-frame configuration during air transport. The crew, ammunition, and equipment are secured within the helicopter. Once the aircraft reaches its destination, it drops off the howitzer, crew, ammo, and equipment and then departs. There currently is no method of moving the howitzer once it is has been positioned by the helicopter, since the 900-series 5-ton truck is not air-liftable.

A C-130, or larger, fixed wing aircraft is the other form of air transport for this weapon. Used during strategic deployment, this method of airlift transportation is accomplished with a stowed M198 loaded into the aircraft by material handling equipment or a modified 2-1/2 ton truck. Upon arrival to its destination, the M198 can be unloaded and placed. The M198 can also be palletized and rigged for airdrop during Airborne missions that do not require the plane to land.

To meet the increased requirement for responsiveness and survivability demanded by the broad range of future combat missions, towed howitzers must have the capability to be rapidly and accurately emplaced, conduct fire missions, and move to a new location. A howitzer upgrade package is being developed by the Army Research Laboratory (ARL) System Performance Branch (SPB) to afford towed field artillery the speed and flexibility that a state of the art automated digital fire control system and materials handling equipment can provide. This modified M198 package, known as the Advanced Towed CAnnon System (ATCAS), is being designed as an analytical, engineering, and operational test bed to determine the required capabilities of the next generation towed howitzer. A tandem wheel has been identified as a candidate for future implementation.

The overall objective of the tandem wheel is to improve M198 handling and stowage during transportability and mobility operations. Users, like the Marine Corps and XVIII Airborne Corps Artillery, have requested that ARL design such a labor and time-saving modification for the M198. The wheel would serve several functions: to facilitate the loading and unloading of a stowed M198 into a cargo carrier aircraft, ship, or landing craft; to move a stowed or towed M198 around a motorpool/airstrip/tactical environment; to emplace during air assault operations; and to obtain M198 weight and center of balance measurements before air movements.

2. TANDEM WHEEL DESIGN

2.1 Customer Requirements

It was essential that an easy attachment scheme be employed. If the wheel requires more time to place into operation than the time saved in using it, artillery sections will revert to operating in the old way. Therefore, the operation of attaching the wheel was intended for just two or three people. In addition, due to

the nature of environments and abuse encountered in a military setting, a ruggedized design was also required.

There are some M198 physical limitations that restrict the size and weight of the wheel. The overall wheel assembly weight was capped at 191 lbs (86.7 kg). That corresponds to the weight of the spade, which is already difficult to lift and maneuver with the two people assigned to its attachment. The overall device height was restricted to 24 inches (58.4 cm). That corresponds to roughly 30 inches (73.7 cm) at the lunette. This would yield at least 1 inch of clearance since the pintle height on the prime mover measures 32 inches (81.3 cm) or higher to its top (see Figure 2). With the M198 in the towed configuration and its lunette resting on the pintle, it would allow the wheel to be rolled underneath the trails and be easily attached. The static load at the lunette when in the towed and stowed configurations are approximately 400 lbs (181 kg) and 4,000 lbs (18,150 kg), respectively. The load capacity of the wheel assembly with some factor of safety was planned to be 5,000 lbs (2,270 kg) at a minimum.

2.2 Design Concept

Like most designs, this one has been evolving and continues to be improved. There are three major parts to the current tandem wheel assembly. The parts include a receiver, an interface plate, and a caster wheel. The receiver is modeled after the spade-like lug attachment (see Figure 3). It is constructed of steel and inserts into the recess of the bottom rear end of the left trail. On these end surfaces is a square hole for inserting the spade key that secures the wheel to the trail. This setup allows for easy attachment/disconnect to only one trail. Since the right trail is secured to the left one by the trail lock and the trail retaining pin, all weight rests on the left trail. Even when the howitzer is stowed, its cannon is bracketed to the left trail. Again, all of the cannon's weight is placed on the left trail.

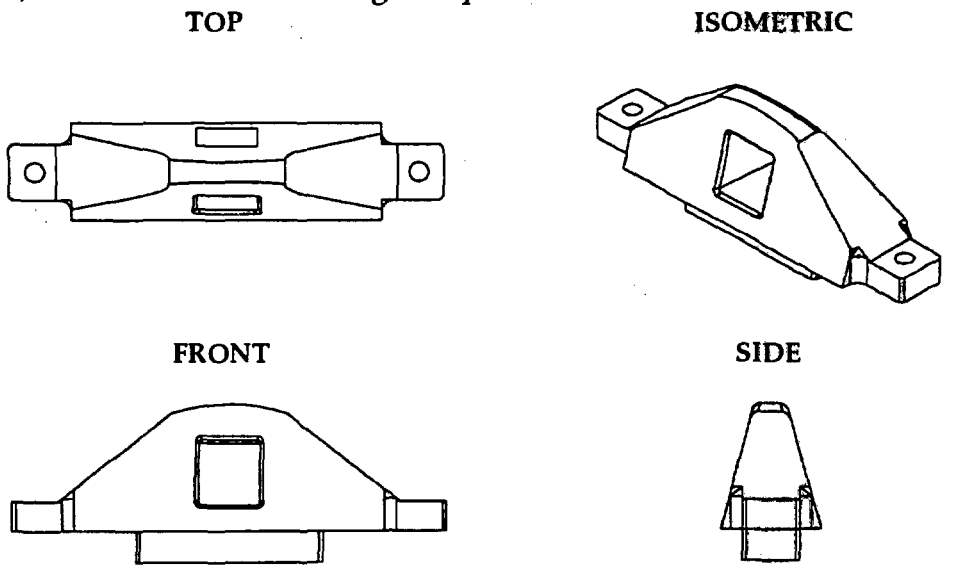


Figure 3. Receiver drawing

The interface plate acts as the union between the receiver and the caster (see Figure 4). The plate is fabricated from heat-treated aluminum so that it is strong yet relatively lightweight. The plate has a keyway, in which the receiver bottom inserts, and also two built-in handles. Two bolts affix the receiver to the plate at the tabs and two bolts thread directly into the receiver body. A finite-element modeling approach, using the IDEAS Master Series software package from Structural Dynamics Research Corporation (SDRC), was used to perform a stress analysis on the plate. The structural integrity of the plate was verified to withstand the applied compressive loads it would experience under static conditions.

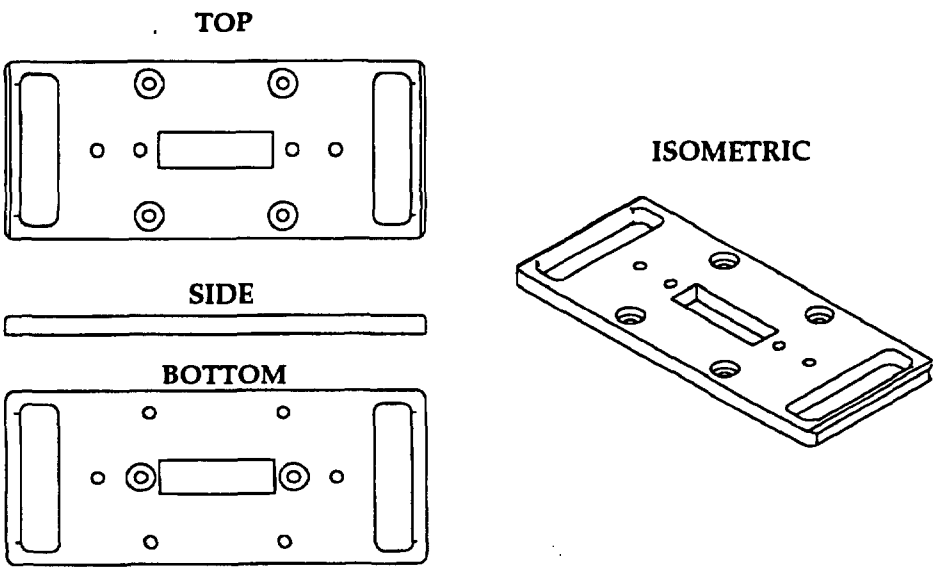


Figure 4. Interface plate drawing

The plate is then bolted to the dual-pneumatic caster wheel (see Figure 5). Figure 6 shows the complete tandem wheel assembly supporting the M198. To save time and costs, an off-the-shelf caster wheel, manufactured by Albion Industries, that met most of the design criteria was located. It is comprised of a top plate, a swivel caster thrust bearing with hardened ball bearing race, two steel forks bridged by an axle, and two pneumatic tires mounted on wide base rims. The rims are bolted to the hubs for extra strength and are fully demountable. This wheel is designed for heavy-duty material handling applications. Table 1 lists the specifications of the current wheel design.

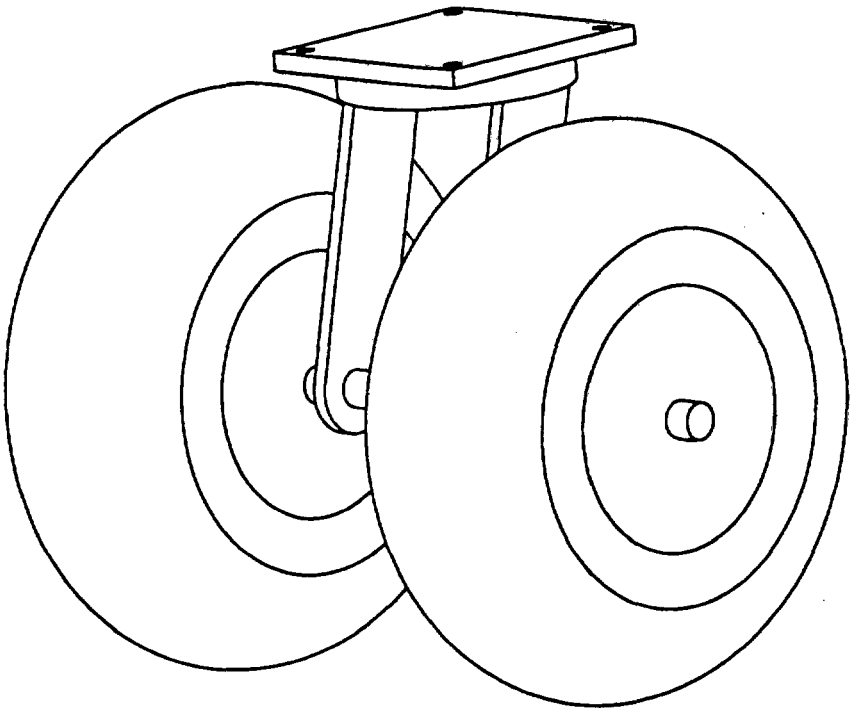


Figure 5. Swivel caster wheel

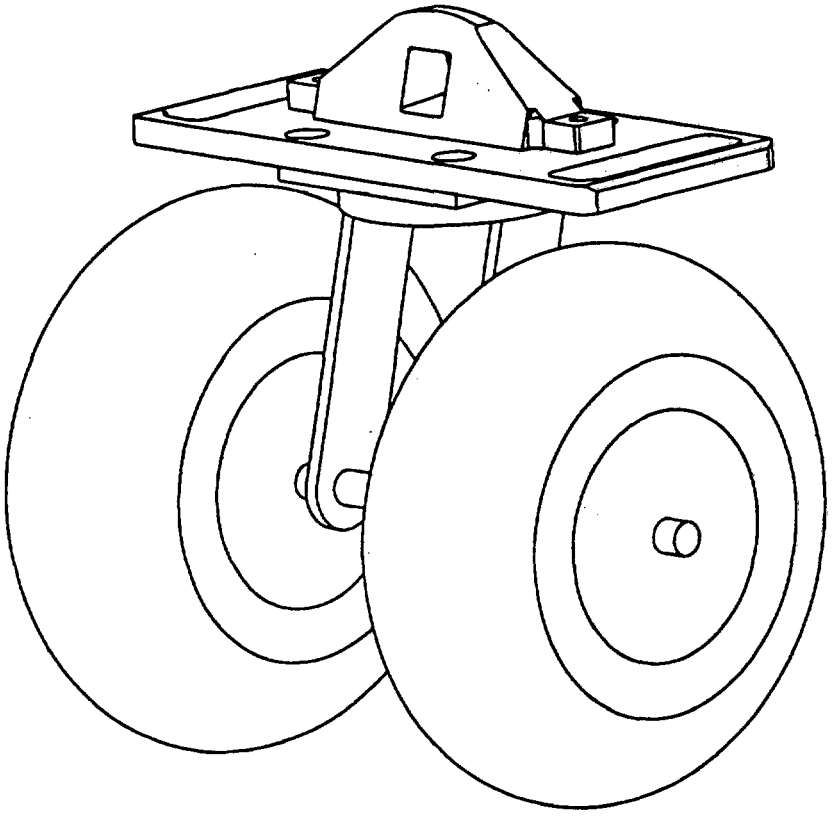


Figure 6. Tandem wheel assembly

Table 1. Tandem Wheel Specifications

Component	Weight lbs (kg)	Height in (cm)
Receiver	20 (9)	
Interface plate	20 (9)	
Caster wheel	130 (59)	
Total	170 (77)	24 (61)

Tire Description	
Tire Size	6.9/9 - 21 in (53.3 cm) diameter
Manufacturer	Goodyear
Ply Rating	10
Air Pressure	100 psi (689 kPa)
Tire Capacity	4,840 lbs (2,200 kg) @ 5 mph 3,020 lbs (1,370 kg) @ 55 mph

3. WHEEL FUNCTIONS

The wheel can be utilized in a variety of missions. The following sections briefly describes the current operating procedures and how they might be simplified by a tandem wheel.

3.1 Moving an M198 Around a Motorpool/Airstrip/Tactical Environment

Because of its high tongue weight, which must rest on the vehicle's pintle, only two vehicles and the rough terrain forklift are authorized to tow, or move the M198. With the addition of a tandem wheel supporting the trails and a tow-bar providing the connection between the M198 and its mover, much smaller vehicles like pickup trucks and HMMWV's will be able to move the M198 around a motorpool or airfield at relatively low speeds and near level terrain (see Figure 7). A steel connector box with a built-in pintle hook was made to allow the M198 lunette to easily hook up to the existing inventoried tow-bar (NSN 4910-00-433-7094 or similar) (see Figure 8). The lunette is inserted into the steel box and is fastened by a steel pin inserted through an aluminum cylinder and secured with a cotter pin for safety. The pintle hook attaches to the eyelet of the tow-bar. The other end of the tow-bar attaches to the vehicle's shackle brackets. Otherwise, a specialty tow-bar could be fabricated that has a pintle already built into its end instead of an eyelet. A kit is currently being developed by the Project Management Office, Family of Medium Tactical Vehicles, to modify the 2-1/2 ton truck with such a front-mounted bumper tow pintle.

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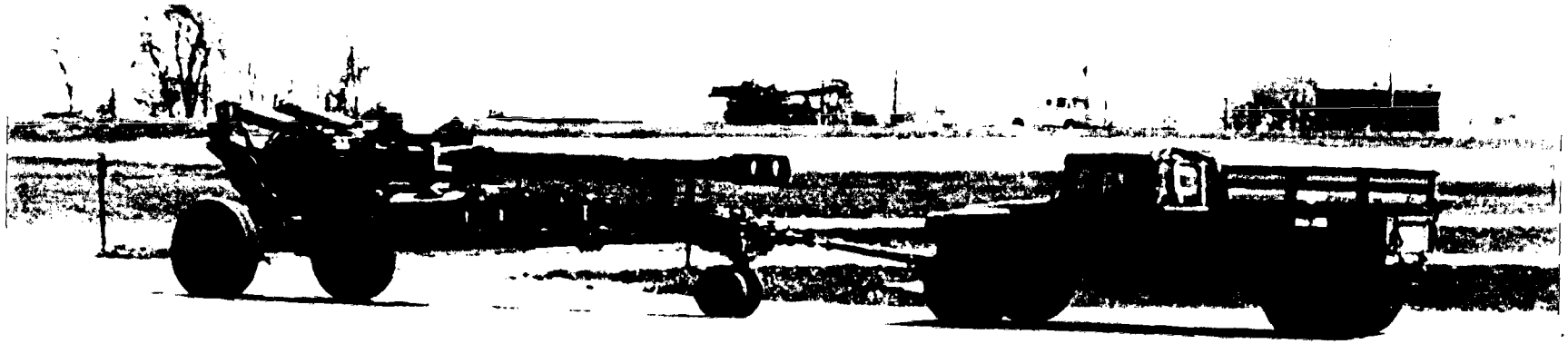

Figure 7. HMMWV moving the M198 howitzer with tandem wheel attached

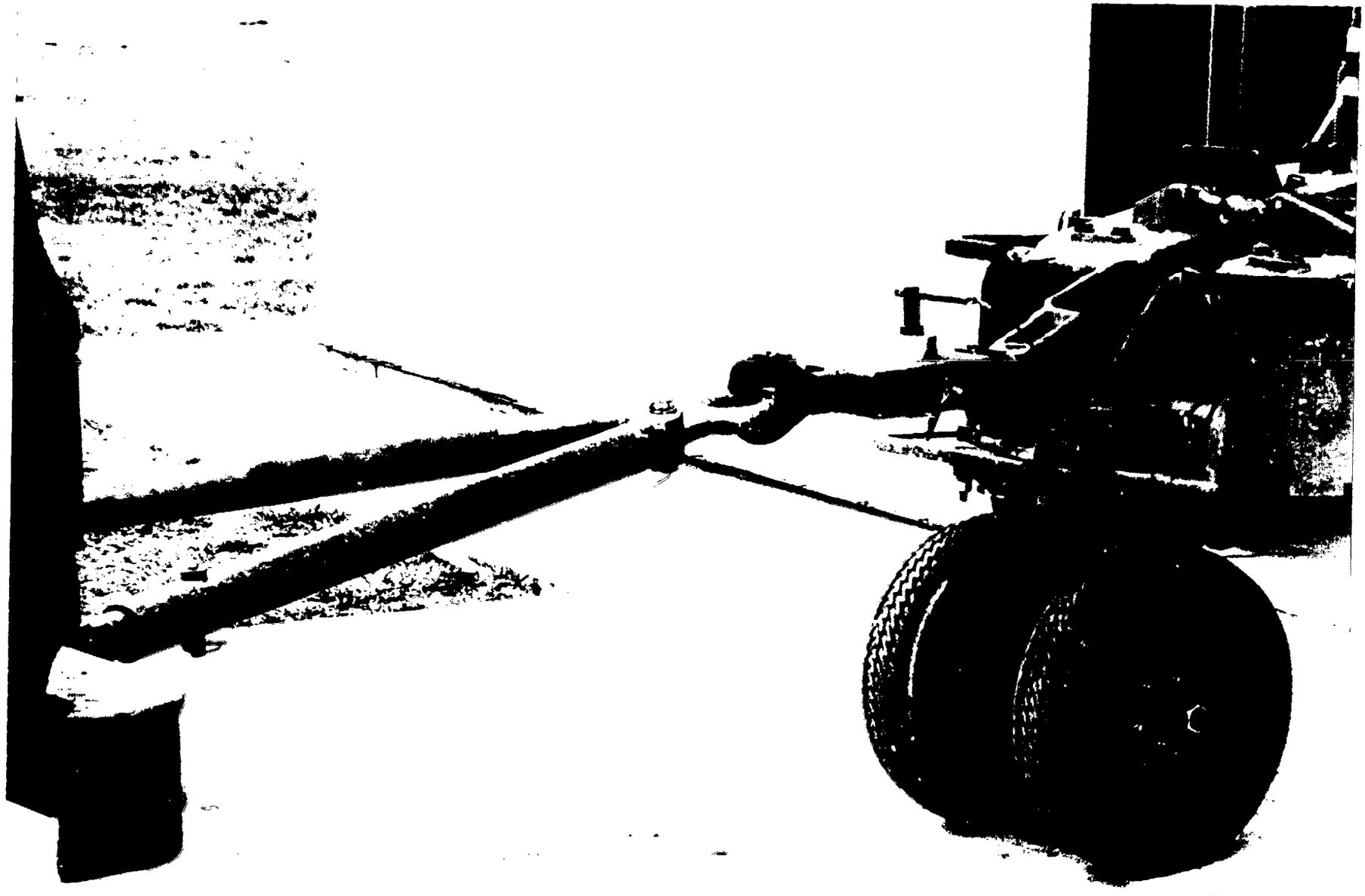

Figure 8. Connector box and tow-bar

Using the wheel in a tactical scenario could arise when only a small area in a tactical environment was available for placing a battery of M198's by air assault. With the wheel attached to the howitzer it could be pushed by soldiers, or, if a HMMWV were available, it could pulled into a tree line as they were placed by the helicopter. Currently, a much larger piece of land, big enough for the entire battery to fit, is required. Enemy forces are trained to target the large open area land masses and ignore those that are small.

3.2 Weighing and Obtaining Center of Balance for Air Lift Missions

Each cargo's actual load center of balance (CB) and weight must be determined to keep the total cargo weight within the aircrafts center of gravity (CG) limits and allowable cabin load (ACL). Current procedures for measuring tongue weight, overall weight, and CB are cumbersome and timely. A jackstand is needed to raise the lunette off the pintle and support the weight while the tongue weight is measured. The lunette is then placed back onto the pintle and the jack is removed. The M198 is moved forward until it is fully centered on the scale. The jack is then repositioned under the lunette and taken off the pintle. The total weight is then measured. With a tandem wheel attached, the trails are already supported, allowing the truck to quickly pull the M198 into the desired positions with the tow-bar, detach the bar, and clear the scale without use of the jack. The measurement can then be easily taken. This saves time, manpower, and is a much safer operation.

3.3 Loading/Unloading onto a C-130

There are some flight restrictions when load planning wheeled and bulk cargo onto aircraft due to limits on ACL, CG, dimensions, and floor strength (see Table 2). The ACL depends on many varying factors, such as distance to be flown, fuel load, weather, and winds. The ACL of the C-130 is generally 25,000 lbs (11,360 kg). This restriction does not allow for the material handling equipment or prime mover to travel with the M198. Therefore, the M198, prime mover, and material handling equipment would be loaded into separate C-130s. Upon arriving at their destination, the M198 would be unloaded from the C-130 and reunited with a prime mover. This entire process can be a difficult as well as a time-consuming process. It is possible to fit an M198 and HMMWV onto one C-130 without exceeding its ACL and dimensions. The HMMWV could just be used for loading/unloading and moving it around the airfield. This would free up valuable space on other C-130s, allowing more artillery to enter a combat zone or when securing an airport with limited number of tactical flight missions.

The current C-130 loading procedure requires the howitzer to be attached to a front pintle on the material handling equipment [TO 1C-130A-9]. A 2-1/2 ton truck or RT4000 rough terrain forklift with a fork-mounted pintle hitch are the only authorized vehicles for this application. The loading vehicle pushes the howitzer into the airplane. It takes a lot of time for even experienced drivers to position his/her vehicle and M198 so that they line up perfectly with the narrow aircraft hull

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and ramp. Once inside, the M198 is placed at the appropriate station. The handbrakes are set and safety chains installed. A jackstand assembly (NSN 1025-01-210-3688) is then placed under the lunette eyelet and raised until it clears the truck's pintle. Safety shoring is positioned under the trails. The trails are then lowered onto the safety shoring. The pin is then removed from the pintle and the truck is backed out. Finally, the trails are raised off the safety shoring. Once it is determined that the howitzer is safely supported by the jack, the shoring is removed. Having a tandem wheel should simplify the loading procedure by removing many of the steps.

When loading a rolling object, like the howitzer with tanden wheel, the following limitations must not be exceeded: pounds per square inch (psi), pounds per linear foot (plf) axle weight, and wheel weight. The formula for computing pounds of pressure per square inch exerted on the aircraft floor for a tire pad is as follows [FM 55-9, Chapter 6, p 8]. The axle weight is divided by the length times width of the tire pad times 0.785 times the number of tires on the axle. The formula for the the tandem wheel floor pressure becomes:

$$\text{pressure} = \text{axle weight}/(\#\text{ of tires})(0.785)(\text{length})(\text{width}).$$

The pressure footprint of the tandem wheel with the M198 in a cubed configuration can be calculated to be:

$$\text{pressure} = 4{,}000\text{ lb}/(2)(0.785)(8.5\text{ in})(5\text{ in})$$
$$= 60\text{ psi (410 kPa)}.$$

Planking may be needed under the tires to decrease the load on the flooring to 50 psi (340 kPa) as required by the flight limitations in Table 2. All other requirements for cargo are met. The procedure upon arrival would also be simplified when time is critical. The truck or HMMWV simply pulls up to the M198, attaches the tow-bar, and then pulls the M198 out of the aircraft. If the HMMWV traveled on the C-130, it would simply pull out of the C-130 with the M198 in tow.

Another loading/unloading scenario makes use of the C-130's internal winch. The winch, if connected to the lunette, would have ample strength to pull the cargo into the aircraft's cargo compartment. It would also provide the necessary constraint and control when unloading the cargo back down the aircraft ramp. (This technique would require the winches to be in good working condition)

Currently, only two 24-inch (61-cm) wide ramps are needed to support the loading vehicle's axle (see Figure 9, auxiliary ground loading ramps). At least four auxiliary ground loading ramps would be required so that the tandem wheel and loading vehicle could overcome the height of the ramp. The other two auxiliary ramps are usually stored inside the aircraft, but are readily available when needed.

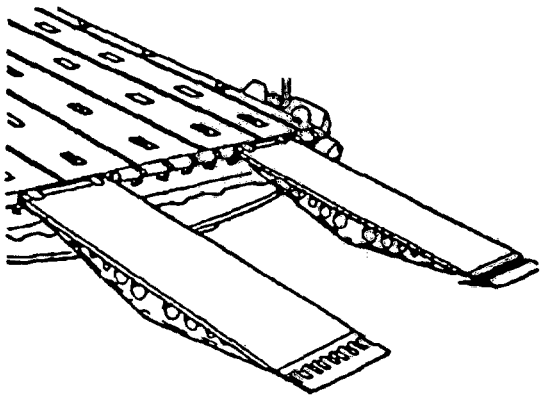

Figure 9. C-130 auxiliary ground loading ramps

Table 2. C-130 Flight Limitations Chart

	FUSELAGE STATION(IN)	245-337		337-682		682-737		737-869 (Ramp)	
		TREAD-WAYS	BETWEEN TREAD-WAYS	TREAD-WAYS	BETWEEN TREAD-WAYS	TREAD-WAYS	BETWEEN TREAD-WAYS	TREAD-WAYS	BETWEEN TREAD-WAYS
BULK CARGO	Concentratated Load (PSI)	50		50		50		50	
	Running Load (PLF)	1400		3000	1600	1400		500	
WHEELED CARGO	Tongue Load (LBS)		2000		2000		2000		2000
	Max Axle Load (LBS)	6000	5000	13000	5000	6000	5000	2500	1200
	Max Wheel Load (LBS)	3000	2500	6500	2500	3000	2500	1250	600
	IN - inches PSI - pounds per square inch PLF - pounds per linear foot Pneumatic Tires - 100 PSI max pressure								

3.4 Air Drop of Palletized M198

The procedure used to ready an M198 for an air drop mission involves palletizing and rigging. Material handling equipment is readily available during this stage. Currently, at least 15 soldiers are needed to lift the trails, roll the M198 off the palletized platform, and keep it level at the destination site. If the tandem wheel was included in the package, it would greatly simplify this task by supporting the weight of the trails and cannon allowing maneuverability and mobility at the destination site.

3.5 Emplacing the M198

Moving the trails from the A-frame configuration into the firing position is an arduous undertaking as each trail weighs about 1,000 lbs (454 kg). The following method describes the emplacement procedure. With the trail lock open, each trail is lifted one at a time by trail handles and spread until the trail contacts the stops on the carriage. The stops control the maximum spread of the trails. The trails are then raised and the spades are attached. With the wheel available and attached to the left trail, the right trail can be easily pushed by one person until locked. The trail is suspended in air so that the spade can be easily attached. The left trail can then be rolled until it also locks. Either the mover, the jack, or a few soldiers can support the trail so the wheel can be removed and the second spade attached. The trail can then be emplaced. Significantly less effort is involved with emplacing/displacing in this manner. Safety would improve as crewman would be less suspectable to back injury or fall while lifting and pushing/pulling. As part of the ATCAS, ARL has designed an hydraulic elevation assist device that further simplifies this task. Only two people would be needed to raise and then split the trails.

4. DISCUSSION

Wheel selection has been a difficult part of creating the tandem wheel. Solid wheel casters support a lot of weight, but they are typically used on relatively flat and hard surfaces. They work best on industrial concrete floors and are not suited for outside terrain encountered by M198's. Even the smallest of obstructions can stop a solid wheel from rolling. Therefore, a pneumatic tire has been selected for its off-road capability, larger footprint, and inherent shock absorption. Pneumatic tires lack load capacity when compared to solid ones and can deflate, but in this circumstance they are the better choice.

Filling the pneumatic tire with foam to prevent deflation was an option considered. However, this would add an extra 15 lbs (7 kg) per tire so that it is no longer manageable for two people to lift.

Other wheels, like those found on aircraft landing gear, were considered. For the most part, their pursuit was a difficult one. They are very costly and would need major modifications to the axle to be adapted. It may be possible for just the wheels, that meet the constraints mentioned earlier, to be adopted into the existing caster assembly if a wider footprint or stronger wheel is required.

5. SAFETY CERTIFICATION

On 27 April 1995 a safety certification test was conducted at the Slopes Area of the Munson Test Course, APG, by the Aberdeen Test Center (ATC), formerly the U.S. Army Combat Systems Test Activity (CSTA), of the U.S. Army Test and Evaluation Command (TECOM). Towing, maneuverability, and loading tests were conducted to determine potential problems before the tandem wheel can be placed

in operational testing scenarios. The test plan called for the tandem wheel to be attached to an M198 and pulled up/pushed down at least a 15° incline thereby simulating a C-130 ramp. The 20% grade (11.3°) and then the 30% grade (16.7°) slopes at the Munson Course were utilized to simulate the C-130 ramp. Although the lengths of the slopes were approximately 100 ft (30 m) long, which is much longer than the 12-ft (3.7-m) C-130 ramp, they were the closest way to imitate the ramp. The 16.7° angle and much longer slope would guarantee a more severe environment than what would actually be experienced in the field. The M998 model HMMWV was loaded with a 2,500 lb (1,140 kg) plate to obtain its 7,700-lb (3,490-kg) gross vehicle weight (GVW). This would give more traction to the tires and decrease the mass ratio between the M198 and M998 from 3:1 to 2:1.

The M198 weight measurements were taken just prior to testing. An overall weight of 16,320 lbs (7,420 kg) was measured for this ATCAS-modified M198 with tandem wheel and tow-bar attached. The axle weight at the tandem wheel was measured to be 4,460 lb (2,030 kg).

A 5-ton truck with winch cable was used as a safety precaution. The cables were attached to the front M198 lifting eyes and slack was given. The truck resided just past the crest of the hill. The tow-bar was connected to the bottom part of the HMMWV's front shackle brackets. This allowed the driver to have a clear view of the M198 and have eye contact with person signaling instructions. The test sequence was to push the M198 up the 20% grade slope and back it down. The test was successful and we proceeded with the 30% grade (Figure 10). This test was also successful. The wheel was visually inspected for signs of damage after each test. No signs of damage were evident.

As part of the 30% grade test, a load cell was then connected between the tow-bar and the lunette. It indicated 4,200 lbs (18,700 N) of force was required by the vehicle to push/pull the M198 up a 30% grade incline. 900 lbs (4,000 N) of force was required on flat terrain. A scale was also placed under the tandem wheel to measure the downward load exerted on the wheel during the 30% grade test. The reading was measured to be 5,200 lbs (2,360 kg). A limited safety release was granted by TECOM and relevent wheel sections can be found in Appendix A, 3c, 4f, and 5e.

Coordination between ARL and PEO Tactical Wheeled Vehicles, Tank Automotive Command (TACOM) led to this same safety test being performed with the medium tactical vehicle (MTV) 5-ton truck from the family of medium tactical vehicles (FMTV). The MTV is slated to replace the current M900 series 5-ton truck and become the next M198 prime mover. According to Air Force flight limitations on a C-130, the MTV with the M198 attached to its front pintle, overloads the floor pressure. This corresponds to the front axle being 1,500 lb (680 kg) above its allowable limit. With the tandem wheel attached, it could meet their axle requirement by supporting the 4,000 lbs (1,810 kg) at the M198 trails. This test was also successful on the 30% grade slope. A safety certification was also granted for the MTV to push the M198 up a 17° incline with the tandem wheel attached.

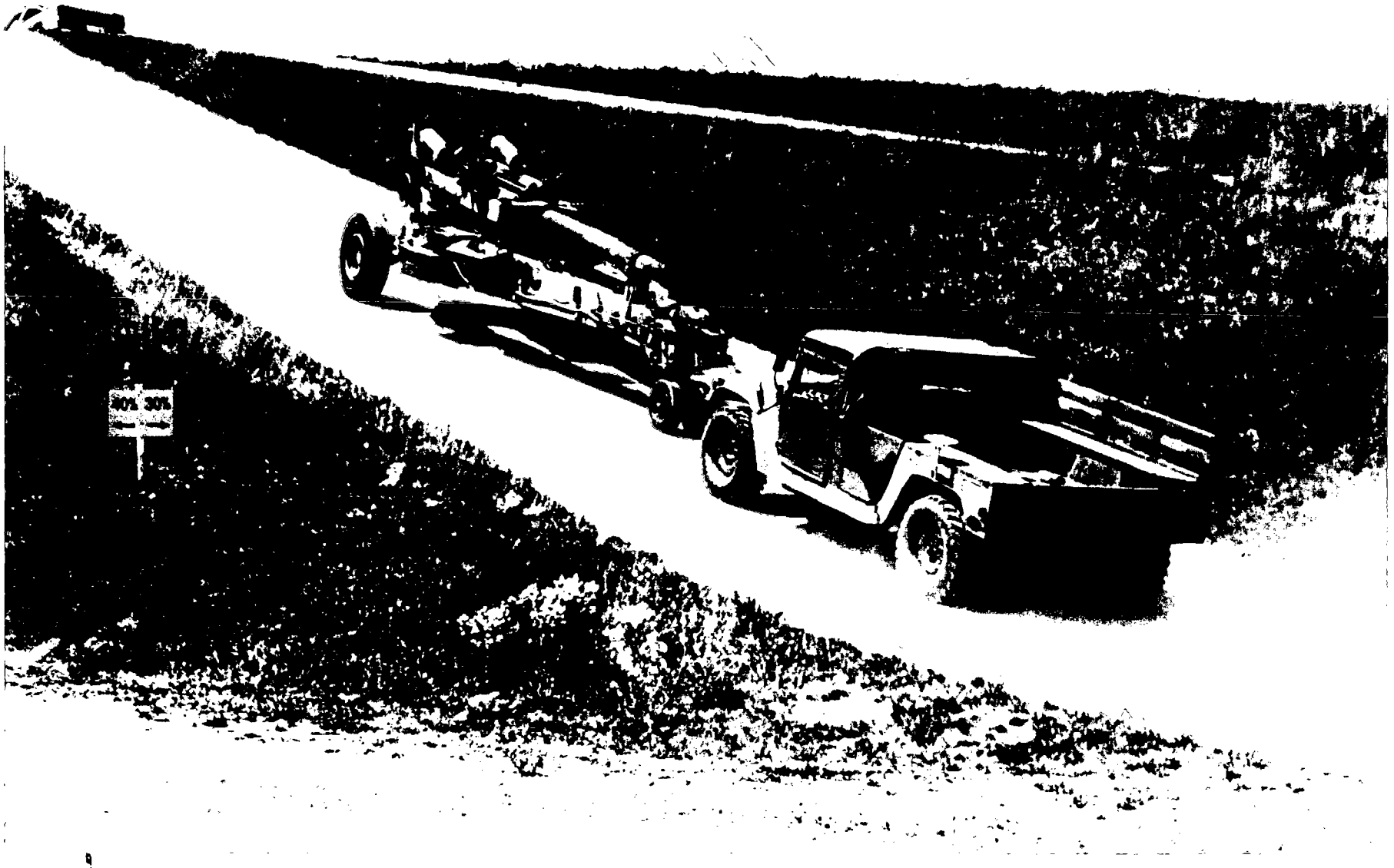

Figure 10. HMMWV pushing M198 with tanden wheel up a 16,8° slope

6. FUTURE PLANS

To further decrease the weight of the tandem wheel, the receiver can possibly be welded directly to the caster wheel top plate. Steel handles would be used and welded to either side of the top plate. This configuration could cut about 20 lbs (9 kg) from the wheel's total weight, yet maintain sufficient strength to transfer the static and dynamic forces. There is also a need to locate a wider tire to avoid the use of planking on the aircraft's floor.

The operational procedures for the tandem wheel are continuously being developed since a similar piece of equipment does not exist in the inventory and the wheel has not been tested to any large degree in the environments/terrains it will encounter. Further testing and evaluation with the artillery and Air Force community will take place during the summer of 1995 at Ft Bragg, North Carolina.

7. CONCLUSION

A tandem wheel has been developed that easily attaches to the M198 trail. It could simplify the M198 handling and stowage in at least five different ways: moving, weighing, loading, emplacing, and air dropping an M198. Impact of this wheel would be immediate, greatly reducing the dependence on material handling equipment and prime movers, and increasing the efficiency of maneuvering the M198 by saving valuable time. It would also allow the FMTV to meet Air Force requirements when loading an M198 into a C-130.

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REFERENCES

Field Artillery Cannon Weapon Systems and Ammunition, US Army Field Artillery School, ST 6-50-19, Chapter 7, pp 1-3, 1 March 1989.

Unit Air Movement Planning, FM 55-9, Chapter 2, pp 1-8, Chapter 6, pp 7-8, 5 April, 1993, updated 14 October 94.

Cargo loading manual, USAF Series C-130 Aircraft, TO 1C-130A-9, 16 June 1980.

Technical Manual Transportability Guidance for Transporting the Howitzer, Medium, Towed, 155-MM, M198 By AIR, Highway, Water, Rail, TM-55-1025-211-14, Sept 1979, updated 25 Jan 84, 1 Sept, 87.

Operator's Manual for High Mobility Wheeled Vehicle, Army TM 9-2320-280-10, Chapter 6, pp 99-103, June 91.

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APPENDIX: TECOM Limited Safety Certification

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005-5055

REPLY TO
ATTENTION OF

AMSTE-TA-L (70-10p)

15 MAY 1995

MEMORANDUM FOR Director, U.S. Army Research Laboratory, ATTN: AMSRL-WT-WF (MSG Thompson), Aberdeen Proving Ground, MD 21005

SUBJECT: Limited Safety Release of the Modified M198 Towed Howitzer

1. References.

a. Meeting between ARL, MSG Thompson, and TECOM, MAJ Prendergast, 5 May 95, subject: schedule and requirements for the Fort Bragg testbed.

b. Memorandum, CSTA, STECS-AA-TA, 11 May 95, subject: Recommendation for Limited Safety Release for the Modified M198 Howitzer, TECOM Project No. 2-CO-160-00-065.

c. Memorandum, TECOM, AMSTE-TA-L, 11 Jun 93, subject: Limited Safety Release for Aiming and Pointing System (APS).

2. Purpose. The purpose of this limited safety release is to allow trained cannon crews to operate specially-modified M198 howitzers at Fort Bragg, Fort Sill, Fort Polk, and Camp Lejeune during training and operational testing from 1 Jun to 31 Dec 95. Primary crew trainers will be trained by U.S. Army Research Laboratory (ARL) personnel prior to operating the systems. All crews will be certified IAW installation range safety regulations prior to deployment for field exercises. The purpose of the training and testing is to provide data for system improvements and to prepare for Advanced Warfighting Experiment (AWE) Warrior Focus at Fort Polk in Nov 95.

3. System Description. The modified M198 consists of the following components: standard M198 towed howitzer, digital fire control system (FCS), hydraulic power-assist kit (HYPAK), and trail-mounted tandem wheel. All modifications use existing bolts/bolt holes or fabricated brackets and do not affect the howitzer's structural integrity.

a. The digital FCS was incorporated to augment the M198's optical fire control system. The FCS provides position, azimuth, and gun tube elevation, and computes the ballistic solutions. It has demonstrated mean errors of 0.61 mils in azimuth and 0.14 mils in elevation during engineering tests. The FCS is composed of the aiming and pointing system (APS), the lightweight howitzer computer (LWHC), the Lear Astronics Mk5 muzzle-velocity radar, and a power supply/distribution unit (PSDU).

(1) The APS consists of a ring laser gyro, a Chief of Section (COS) display unit, and gunner and assistant gunner display units. The ring laser gyro is mounted on the right trunnion of the M198 howitzer. Its function is to determine the azimuth and elevation of the gun tube. Prior to APS initialization, UTM coordinates are entered into the ring laser gyro via the COS unit or GPS receiver (on-board or PLGR). After two and one-half minutes of initialization, the gun tube azimuth and elevation are displayed on the COS unit.

(2) The LWHC is a standard ruggedized computer, developed at ARL, which computes ballistic solutions for the M198 and provides the input/output functions for interfacing with the APS, communication systems, and sensor systems. It has an integrated GPS receiver to provide position and altitude.

(3) The Mk5 muzzle-velocity radar is a Doppler-type radar, mounted in the standard muzzle velocity radar mount on the M198 to provide muzzle velocity for each round. The LWHC processes the velocity readings and includes them to compute the subsequent ballistic solutions.

(4) The PSDU provides a 24-volt DC power source for the howitzer support equipment. It is mounted on the left trail of the M198 and consists of two commercial batteries, circuit breakers, power conditioning unit, and a transformer - all enclosed in an aluminum protective enclosure. The system includes a NATO slave connector.

b. The HYPAK is a DC-powered hydraulic pump and is standard equipment on the M1 tank. It is mounted on the M198 carriage, providing powered raising and lowering of the wheels and speed-shift platform. It is powered by PSDU.

c. The tandem/jockey wheel is attached to the left trail, to allow limited movement without the prime mover in either the travel or stowed configuration. It was primarily designed to assist loading operations on cargo aircraft.

4. Requirements and Background.

a. Firing will include live ammunition authorized for use with the M198. Field exercises may include limited airmobility testing, to be conducted under the supervision of a representative from the Airdrop Systems Division (Natick), and an aircraft-loading operation using the tandem/jockey wheel, in support of the Family of Medium Tactical Vehicles (FMTV) program.

b. The Combat Systems Test Activity (CSTA) tested the modified M198 howitzer from Nov 94 to Jan 95. Tests included firing shock at temperatures from $-10^{o}F$ to $120^{o}F$, using M203A1 and M4A2 propelling charges. The modified M198 was also subjected to 200 miles of towing over various road conditions, to gather shock and vibration data.

c. CSTA performed a number of accuracy and firing tests of the APS from Mar 92 to Jan 93, including firing shock using M203A1 charge 8. No unusual safety hazards were noted, and the maximum system error recorded was less than one mil. TECOM issued a safety release of the APS for operational testing at Fort Sill, Jun-Dec 93 (reference 1c).

d. The Mk5 muzzle-velocity radar is one of five NDI systems that were involved in a competitive evaluation by TECOM in 1993-94. No unusual safety hazards were noted during the CSTA evaluation. The Army Environmental Hygiene Agency (AEHA) conducted radiation tests of the five systems during the CSTA test. Due to the low intensity and short duration of the radiation emissions, AEHA determined that the risk of radiation overexposure is minimal, with normal operator precautions.

e. CSTA also tested the HYPAK from Mar 92 to Mar 94. Tests included a number of emplacements and displacements of the M198 using the HYPAK. No safety issues were noted during testing.

f. The tandem wheel was subjected to mobility testing on various surfaces and slopes up to 30 percent. No unusual safety hazards were noted. A simulated cargo-aircraft loading operation was performed on a 30-percent slope, using a HMMWV with tow bar and a lunette adapter, and using the FMTV vehicle with a fabricated front-pintle push bar. The tandem wheel should operate safely on slopes up to fifteen degrees (C-130 ramp), and at speeds up to five miles per hour.

5. Conclusions and Recommendations. Subject to the following precautions and limitations, and the guidance contained in TM 9-1025-211-10, Operator's Manual for the M198 Howitzer, the modified M198 howitzer is considered safe for use by MOS-trained soldiers during training and testing at Fort Bragg, Fort Sill, Fort Polk, and Camp Lejeune.

a. An ARL representative will provide training to the primary crew trainers prior to any operational exercise. Training will include the precautions and limitations listed in this paragraph. Crews must be certified IAW installation range safety regulations prior to any firing exercises.

b. Use of the LWHC and APS for position, weapon lay, and ballistic solutions does not relieve the Position Commander of any of the safety duties as prescribed in the installation range regulations. The azimuth of fire must be verified and visual indicators (safety stakes or tape) should be used to ensure that rounds fall within the prescribed safety limits.

c. All hardware and electrical cables should be secured to the M198 frame to prevent tripping and falling hazards, and should be inspected for serviceability and secure connections prior to transport or use.

AMSTE-TA-L 15 MAY 1995
SUBJECT: Limited Safety Release of the Modified M198 Towed Howitzer

d. The Mk5 radar must be installed only after power to the FCS is turned off. Personnel should not be forward of the radar head when the FCS is on.

e. Maneuver with the tandem wheel should be limited to a maximum speed of five mph on paved surfaces and two mph on gravel, and to a maximum slope of fifteen degrees.

f. Any further modifications to the M198 or the attached components must first be approved by this office.

g. This safety release supplements the existing range safety regulations, applicable technical manuals, and unit standard operating procedures.

6. The points of contact for this action are MAJ Tim Prendergast, AMSTE-TA-L, DSN 298-1381, and Mr. Pete Kamenik, TECOM Safety Office, DSN 298-1307.

FOR THE COMMANDER:

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Chief, Safety Office

ALAN L. YANKOLONIS
Chief, Artillery, Aviation and
Live Fire Division
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