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19.5 ton Electric Drive Future Combat Vehicle (E.D.F.C.V.) < https://tanks-encyclopedia.com/19-5-ton-electric-drive-future-combat-vehicle-e-d-f-c-v/>

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p> USA (1984-1987)

Combat Vehicle – models only

a commission was formed to look into the potential for electric drive systems for a 40-ton (36.3 tonnes) (tank) and 19.5-ton (17.7 tonnes) (APC/IFV) platform.

The US Army's Tank Automotive Command (TACOM) issued a contract to General Dynamics Land Systems for this project – to evaluate existing electric drive technologies to use in future vehicles. This contract was given the number DAAE07-84-C-RO16 and was divided into 2 phases – a third phase was added later under contract modification P00006.

The goal was roughly that of evaluating the 'new' (electric drive for vehicles predates armored vehicles themselves) technology available across a variety of platforms for what it may offer for further development. What it actually generated was the realization that electric-drive fighting vehicles were not only possible but had some valuable features worth exploring, especially with regards to a series of heavy IFV platforms. However, like so many other studies, this work faded away and the design work was abandoned. To this day, in 2020, the M2 Bradley remains in service with a conventional power plant along with numerous other armored vehicles in the US inventory. Despite the billions of dollars spent, to date, the US military has yet to capitalize on the potential of electric-drive vehicles.

The beginning

Work on a future electric drive combat vehicle was to consist of three phases of work:

- **Phase I**: A survey of existing technology (document JU-84-04057-002)
- **Phase II**: Generation of concept vehicles with electric drive
- **Phase III**: A parametric study and evaluation with a selection of 3 recommended concepts for further

x 6 wheeled, 15-ton (13.6 tonnes) Electric Vehicle Test Bed (EVTB) it had paid for itself in order to test and validate electric drive. It also had an Advanced Hybrid Electric Drive (AHED) 8 x 8 vehicle in the 20-ton class using lithium-ion batteries.

General Dynamics Advanced Hybrid Electric Drive (AHED) 8 x 8. Source: DiSante and Paschen

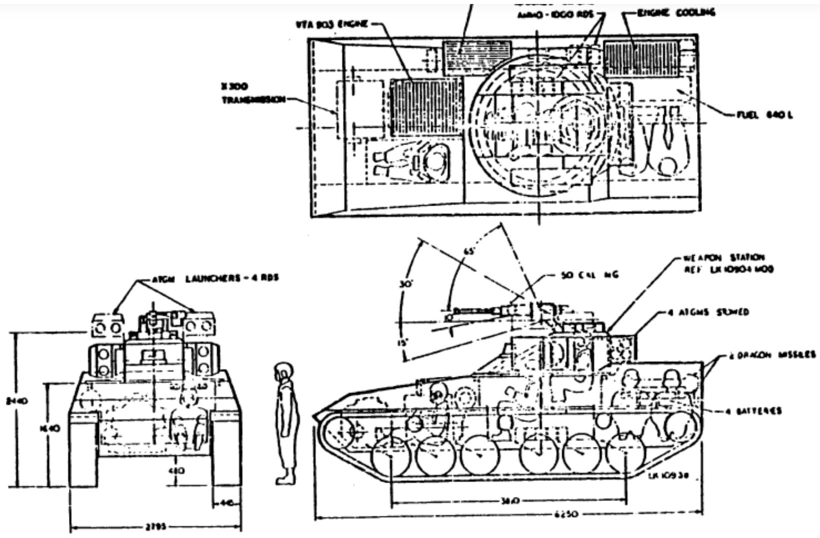
The timetable for the project called for Phase I to be concluded by the end of 1984. In the end, the report on this phase was finished in July 1984 and then published in January 1985. By this time, the second phase was already underway, with an expected conclusion date in the latter half of 1985 followed by another report and, starting in the middle of 1986, Phase III running through into the start of 1987.

Why Electric Drive?

The potential of electrical drive systems for tanks was recognized and experimented upon as far back as WW1. An electrical transmission offered the designer a significant freeing up of the internal layout of an armored vehicle, as the drive motors did not have to be next to the engine, and the ability to deliver continuous, reliable power in preference to mechanical systems. This is primarily because an electrical drive system has far fewer moving parts and bearing surfaces than a mechanical system. There are also major advantages, not the least of which being volume. An electrical system could be smaller than the equivalent mechanical system and a smaller volume meant more internal volume in a vehicle for other things and/or a reduction in the amount which needed to be protected by armor – that means less weight too. Electrical transmissions are also quieter due to the absence of gearing and driveshafts and offer the not insignificant potential to provide electrical power for the vehicle's systems.

One of the biggest advantages of e-drive over a conventional powertrain (liquid-fuel burning engine connected to a mechanical transmission) is that the engine, generators, and motors do not have to be

Some 38 possible concepts across the 19.5 (17.7 tonnes) and 40-ton (36.3 tonnes) vehicles were considered over four basic vehicle considerations. Various companies and one university submitted concept plans for the program, namely: Westinghouse, ACEC (*Ateliers de Constructions Electriques de*



19.5 ton (17.7 tonnes) Baseline Vehicle Concept. Source: GDLS

Baseline Vehicle Description

The baseline vehicle was a departure from the rather large body of the M2 Bradley. The essential layout, however, was very conventional. Riding on six wheels attached to what appear to be suspension arms, it appears to have torsion bar suspension, with the track running on these 6 sets of road wheels on each side which were divided into two groups of three and supported on the top with a trio of return rollers.

A driver sat in the front left with the power plant alongside on the right. Behind this was the fighting and troops' space with a turret set slightly back from the center. The two-man turret carried all of the armament for the design, consisting of a single .50 caliber (12.7 mm) heavy machine gun with an elevation range of -15 to +30 and 1,000 rounds of ammunition. On each side of the turret was a pair of Dragon anti-tank guided missile (ATGM) launchers with another 4 missiles stowed at the back of the turret.

Finally, the troop space at the back, as can be imagined from a relatively small vehicle with a turret, was also small. Although only two men are shown drawn in the vehicle, it is probable that another two would be seated opposite for a troop space of 4 men, although how happy they would be to know that they were sat atop the 640-liter fuel tank is anybody's guess.

It is important to remember though that the vehicle shown in the drawing, whilst more than a mere doodle of a viable armored personnel carrier (APC), should only be taken as an illustration of a possible future APC. The power plant work could just as legitimately be refitted to another vehicle as the key part of the study was not this APC per se, but a study to evaluate these power systems for AFV propulsion.

Potential Configurations for Electric Drive for 19.5 (17.7 tonne) and 40-ton (36.3 tonne) vehicles			
Configuration	**Detail**	**Advantage**	**Disadvantage**
I	Engine driven alternator Individual traction motors at each drive sprocket	Separate track control improves handling Regenerative steering Offers least complex vehicle	Electrical load during regeneration can be over 3 times the duty ratings
IA	As above but with the traction motors and gearboxes mounted inside two rear drive sprockets and two front drive sprockets	Lowest volume of components under armour	Increase in complexity over Configuration I
II	Engine-driven generator powering one motor coupled to a cross drive with a second motor and cross shaft for steering	Single high-power motor Steering by means of a separate motor	Each drive sprocket requires a 2-speed gearbox Cross drive shaft and steering cross shafts reduce design flexibility
III	Similar to Config. I with the addition of a mechanical feedback path on the steering motor to regenerate power for it. Engine-driven alternator motor at each final drive.		
IV	Electro-mechanical system with electrical and mechanical power working together to provide drive	Improved efficiency over a system using just traction motors (Cong.I and IA)	

19.5-ton (17.7 tonne) Vehicle Concepts

With four (five including one minor amendment) configurations being considered, the design task was simplified by the specification of the engines to be used. The 19.5-ton (17.7 tonne) vehicle would use the Cummins VTA-903T generating 500 hp. The engine would then drive generator/s to provide power to various configurations of motors with a goal of a road speed of 45 mph (72.4 km/h).

Dimensions were set with a ‘datum’ concept vehicle with a hull height of 72” (1.83 m), an overall height

vehicle concepts used an ‘engine forward’ arrangement leaving a large space in the rear of the vehicle suitable for carrying troops or other payloads. Armament was likewise the same on all of the 19.5-ton (17.7 tonnes) concepts: a single heavy machine in the small turret flanked on each side by a fire of anti-tank guided missile (ATGM) launchers.

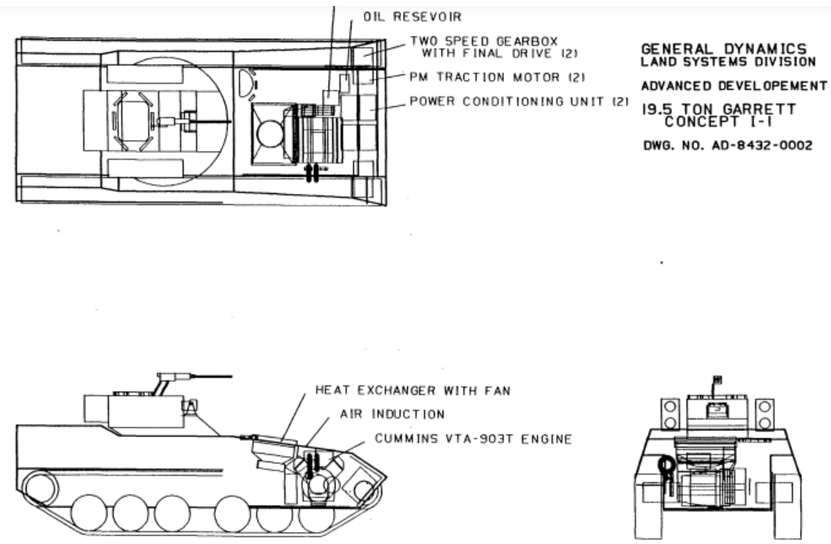
selected to go forward from theoretical design to a drawing stage were all allocated a drawing number starting AD-8432-xxxx.

Summary of 19.5 ton (17.7 tonne) Vehicle Concepts							
Concept	Designer	Drawing No.	Automotive Components from 500 hp Cummins VTA-903T				Drive
			Generator	Motors	Gear-boxes	PCU	
Basic Concept	Concept Datum	0001	n/a	n/a	n/a	n/a	n/a
Configuration I Vehicles							
I-1	Garrett	0002	AC	PM traction motors x 2	2-speed x 2	2	Front
I-2	Westinghouse	0003	AC	Induction motors x 2	2-speed x 2	2	Front
I-3	Westinghouse	-	AC	PM traction motors x 4	2-speed x 2	2	Front
I-4	ACEC	-	AC	DC traction motors x 2	2-speed x 2	-	Front
I-5	ACEC	0023	AC	DC traction motor x 2	2-speed x 2	-	Front
	Note: The drawing number here is non-sequential. It appears to have been issued with a number after the 40-ton concepts were drawn.						
I-6	Garrett	0004	DC hompolar	DC traction motors x ?	1-speed x 1	?	Front
I-7	Westinghouse	-	AC	PM traction motors x 2 (speed and torque)	1-speed x 2	-	Front
I-8	University of Michigan	-	AC hompolar	AC traction motors x 2	2-speed x 2	-	Front
I-9	Unique Mobility	0005	AC	PM traction motors x 2 /	1-speed x 2	-	Front
I-9A	Unique Mobility	0006	AC	PM traction motors x 2	1-speed x 2	-	Rear
I-10	Garrett	0007	AC	PM traction motors x 2	2-speed x 2	0	Front
	Note: This design is a revision of I-1 to avoid the use of PCUs						
Configuration IA Vehicles							
IA-1	Garrett	0008	AC	PM traction motors x 4	2-speed x 4	4	Front and Rear
IA-2	Jarret	-	AC	Variable Reluctance motors x 4	1-speed x 4	-	Front and Rear
IA-3	Jarret	0009	AC	Variable Reluctance motors x 4	1-speed x 4	-	Front and Rear
Configuration II Vehicles							
				steering motor			
II-3	ACEC	0010	AC	DC traction motor with PM steering motor	2-speed and 1-speed x 1	2	Front

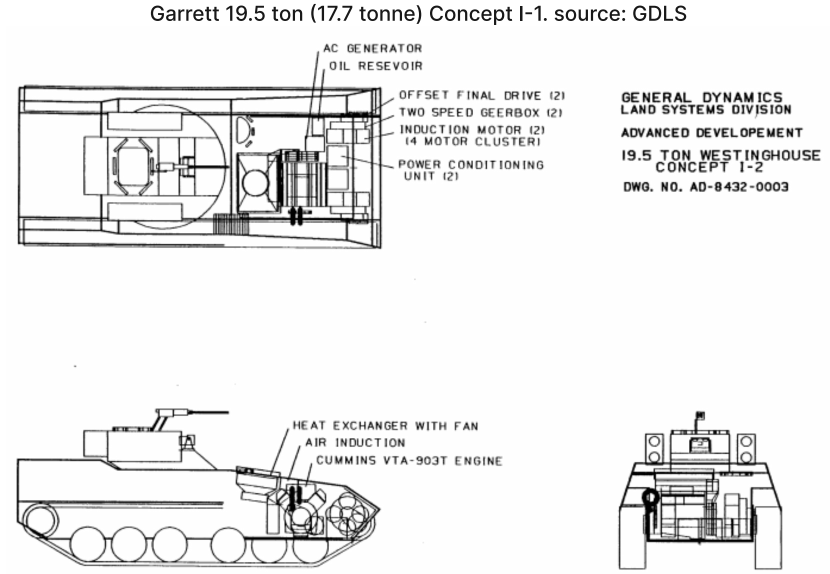
				motor / gearbox	reduction gearbox x 2		
Configuration III Vehicles							
III-1	Garrett	-	-	PM traction	2-speed x 2	≥2	-
				motors x 2 PM steering motor	and a reduction gearbox		
III-2	ACEC	0012	PM	DC traction motors x 2 PM steering motor	2-speed x 1 and a reduction gearbox	1	Front
III-3	Unique Mobility	0013	PM	PM traction motors x 2 and steering motor	1-speed x 2	≥2	Front
Configuration IV Vehicles							
IV-1	Garrett	-	PM	PM traction motors x 2	2-speed x 2	2	-
IV-2	Unique Mobility	0014	PM	PM traction motors x 2	1-speed x 2	-	Front
IV-3	ACEC	0015	PM	DC traction motors x 2	2-speed x 2	-	Front
Notes: PM - Permanent Magnet AC - Alternating Current DC - Direct Current PCU - Power Conditioning Unit							

Having outlined various conceptual vehicles, those which were successful were authorized to be drawn and, of those, five 19.5-ton (17.7 tonnes) vehicle concepts were selected on the basis of an efficiency scoring system that assessed a variety of factors such as weight, volume, the efficiency of the system, and technological ease. Despite it being a heavier system than the others, it was the Belgian ACEC system that was selected as being the best of all of the possibilities for the new vehicle. One proviso to this was that the Jarret system was received late in the assessment process and potentially could have been better than the ACEC – the design team recommended it receive further development too.

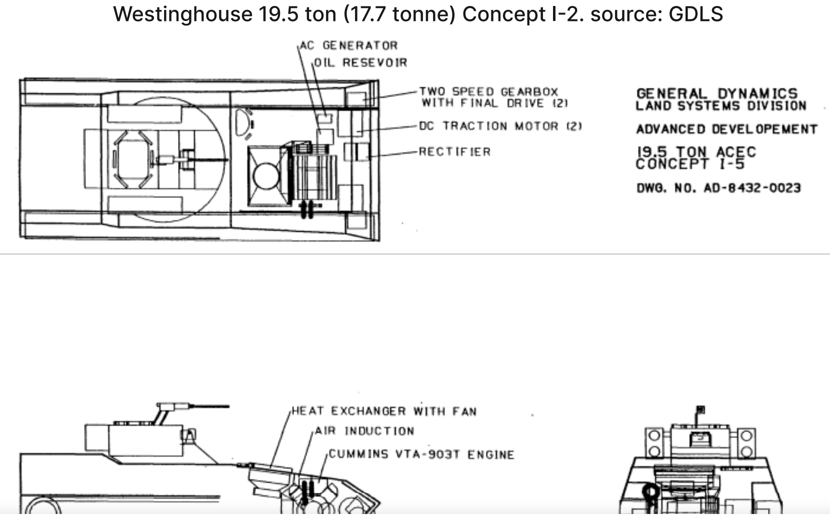
Selected 19.5-ton (17.7 tonne) Vehicle Concepts				
Ranking	**Concept**	**Designer**	**Overall Rating out of 1000**	**Rating Percentage**
1	I-5	ACEC	826	82.6 %
2	IA-3	Jarret	806	80.6 %
3	IV-2	Unique Mobility	787	78.7 %
4	I-10	Garrett	779	77.9 %
4	I-9	Unique Mobility	779	77.9 %

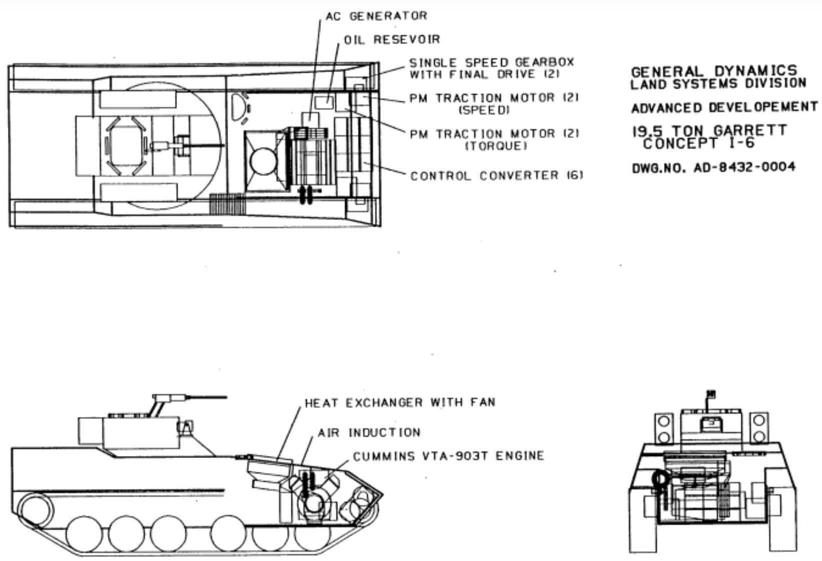


Garrett 19.5 ton (17.7 tonne) Concept I-1. source: GDLS

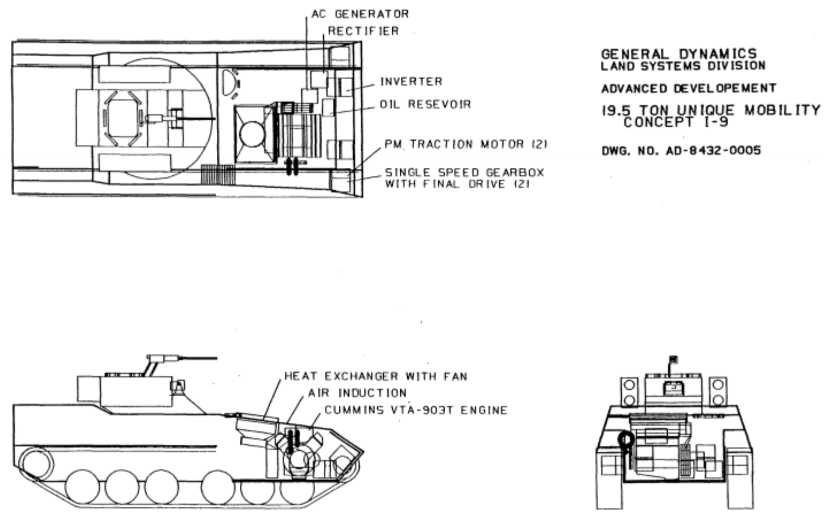


Westinghouse 19.5 ton (17.7 tonne) Concept I-2. source: GDLS

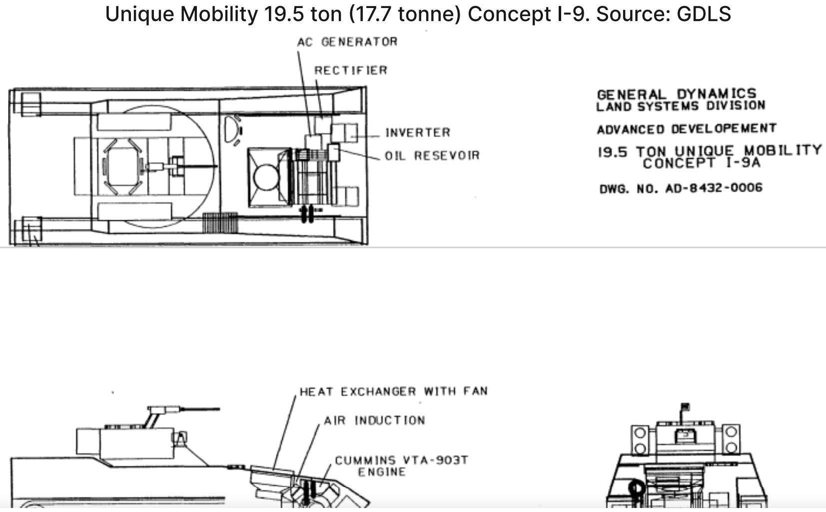


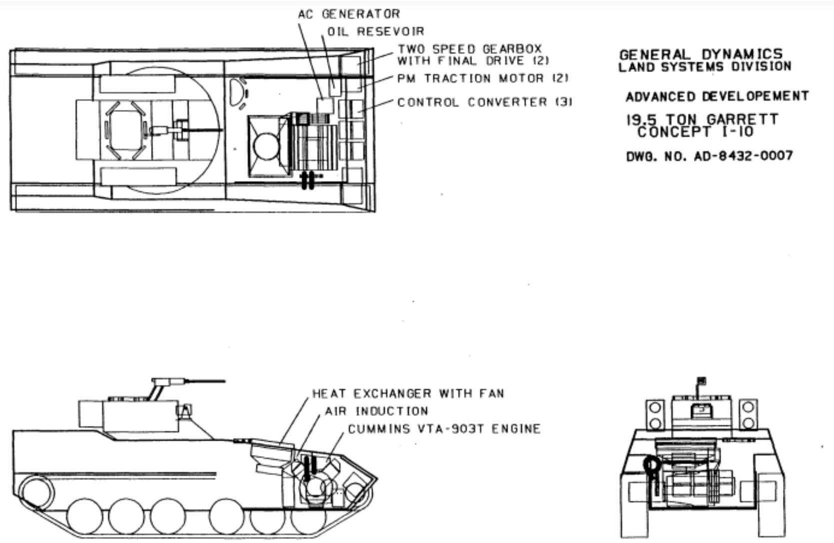


Garret 19.5 ton (17.7 tonne) Concept I-6. Source: GDLS

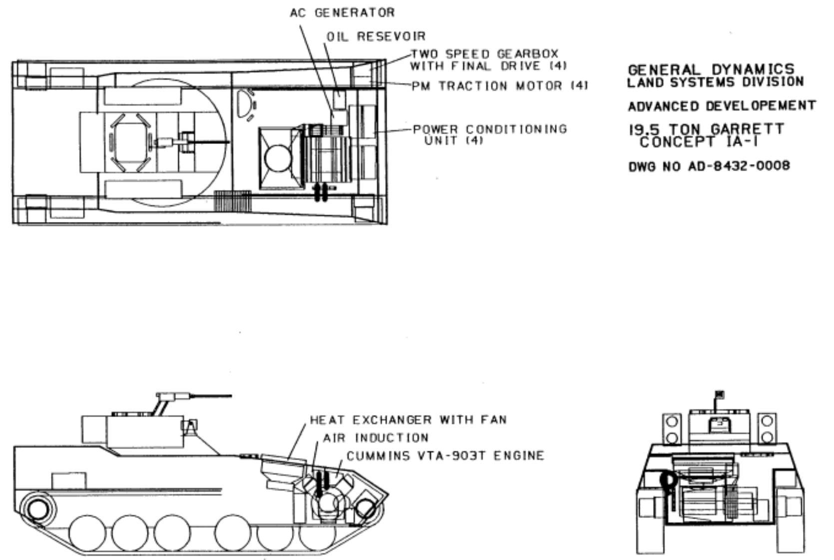


Unique Mobility 19.5 ton (17.7 tonne) Concept I-9. Source: GDLS

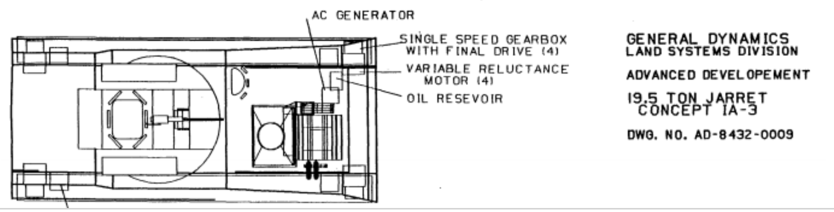


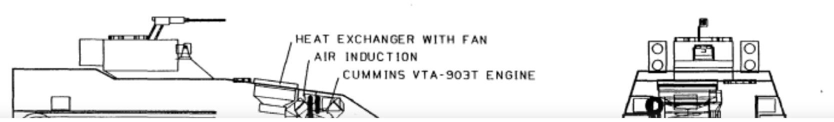


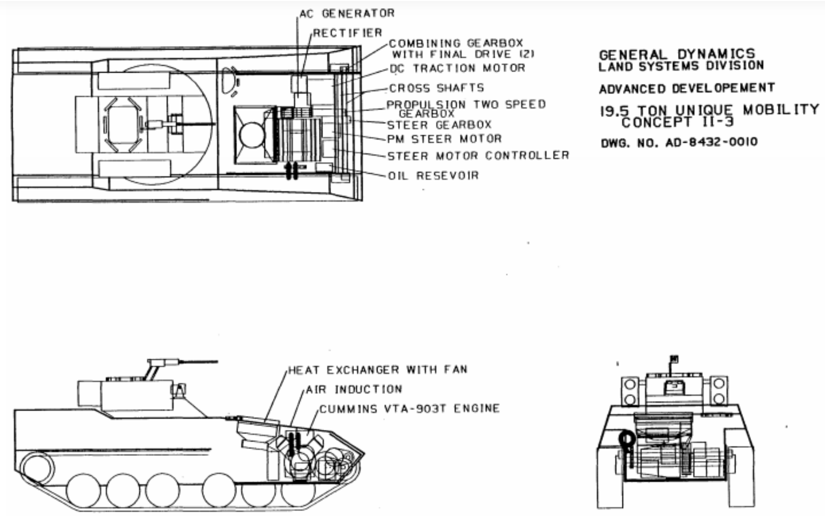
Garrett 19.5 ton (17.7 tonne) Concept I-10. Source: GDLS



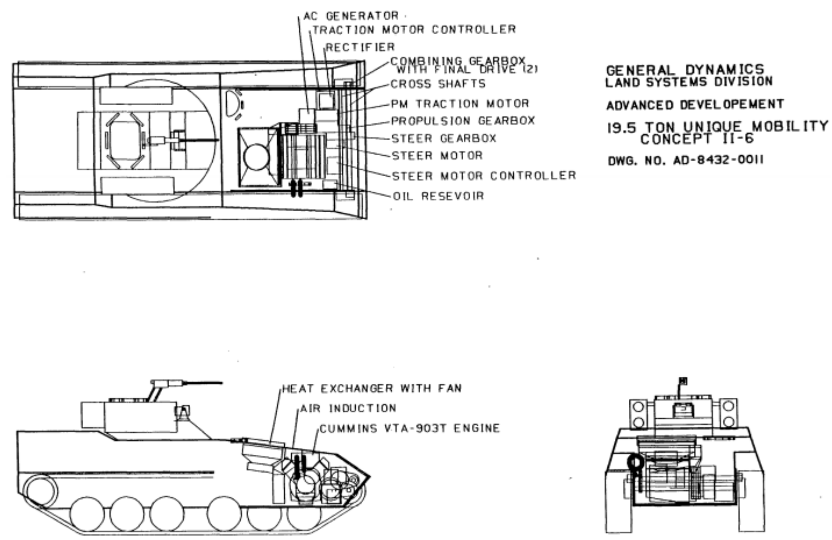
Garrett 19.5 ton (17.7 tonne) Concept IA-1. Source: GDLS



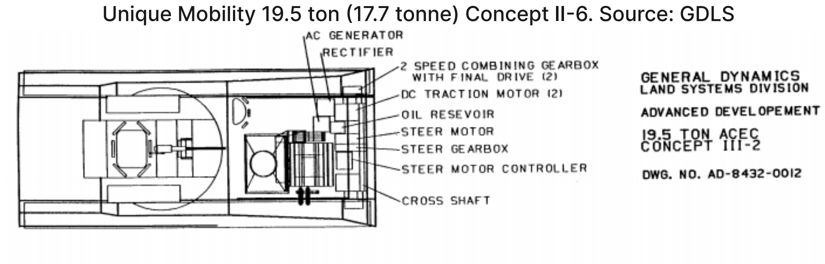


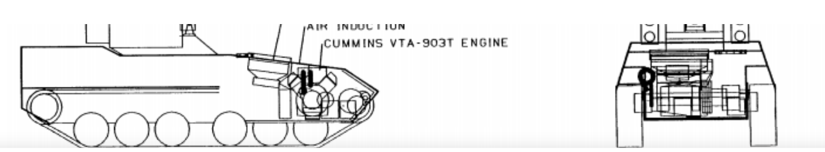


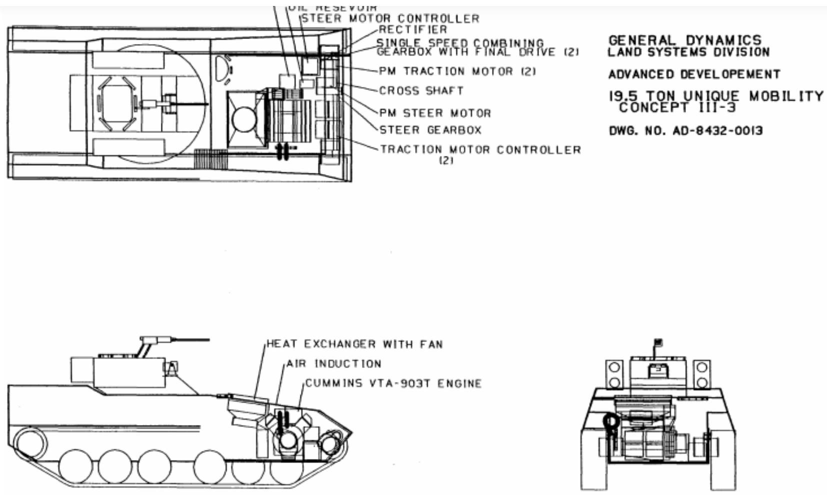
Unique Mobility 19.5 ton (17.7 tonne) Concept II-3. Source: GDLS



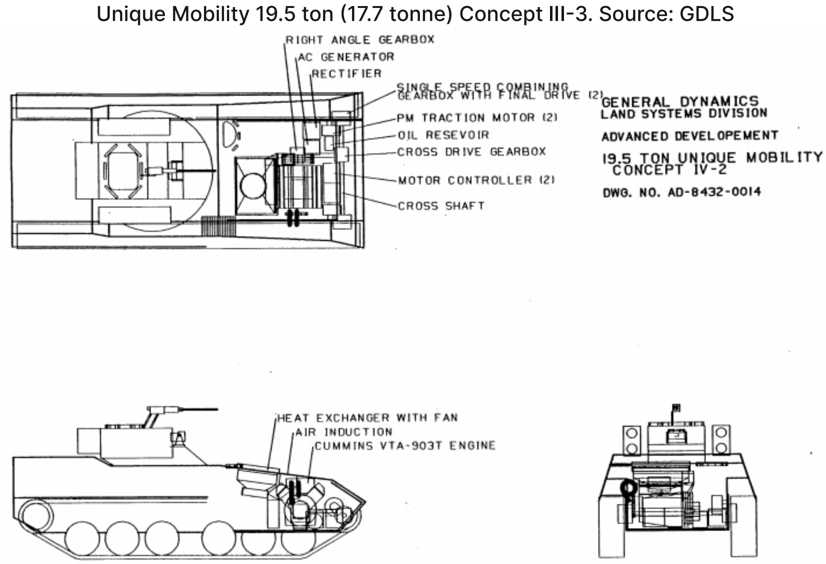
Unique Mobility 19.5 ton (17.7 tonne) Concept II-6. Source: GDLS



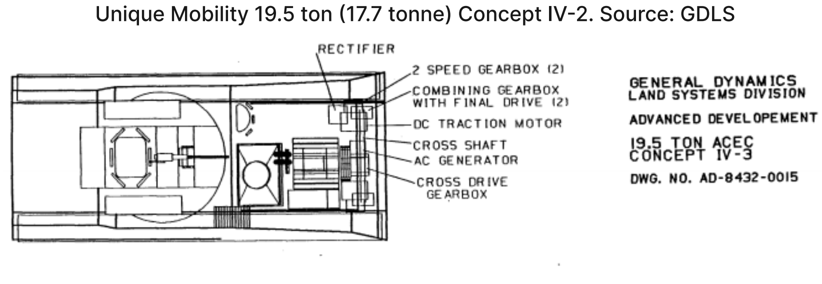


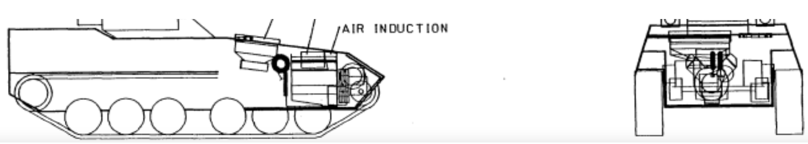


Unique Mobility 19.5 ton (17.7 tonne) Concept III-3. Source: GDLS



Unique Mobility 19.5 ton (17.7 tonne) Concept IV-2. Source: GDLS





Production study

With the ACEC winning out, a production study was conducted as to problems and costs. The 192 hp DC motor in the design was not an issue, as it was already a well established piece of technology. It had already been used experimentally on a Belgian AFV called the **ACEC Cobra < https://tanks-encyclopedia.com/cobra-ifv>** several years before.

Although the ACEC system had already been used on the Cobra some years beforehand, there were significant differences. The study had selected the 500 hp Cummins VTA-903T whereas the Cobra used the 190 hp Cummins VT 190.

The 417 hp rare-earth metal permanent magnet (PM) generator (a Garrett design) used in the concept study was a problem. The generator required Samarium Cobalt (SmCo – a type of rare-earth magnet), and Inconel (a nickel alloy), an ingredients list which used strategic materials – specifically cobalt, a material which was difficult to work with in manufacturing, as it required special handling to prevent it from being damaged.

The result was that the cost of the drive-system without considering the final drives and cooling was estimated per vehicle at 1985US$19,500 (nearly US$47k in 2020 values) with a projection that the drives for the planned 400 vehicles would cost over 1985US$165,000 (just under US$396,000 in 2020 values).

Alternative Engines

Although the 500 hp Cummins VTA-903T was selected for the purposes of the study, it was accepted that other engines were available. In the end though, other than the possibility of switching to a petrol-turbine, the existing diesel engines were the only technology mature enough to be considered.

Alternative Engine options for the 19.5 ton (17.7 tonnes) and 40-ton (37.7 tonnes) E-Drive Vehicles			
Engine Options	**Type**	**Advantages**	**Disadvantages**
Cummins VTA-903T	90-deg. V-type diesel	Good growth potential. Excellent fuel consumption. Low production costs.	Limited potential for growth compared to other options.
Cummins L10	6-cyl. Inline diesel		
MTU 880 Series	90-deg. V-type diesel		
Deere Rotary Engines*	Spark ignition stratified charge		
AD1000	diesel		
AVCO AGT800	Petrol Turbine	Volume efficient. Excellent growth potential.	High fuel consumption. High cost.
Garret GT601			
		transmission.	
Lithium-Air Fuel cells	Chemical energy storage cell.	Little waste heat. Low thermal signature. No transfer case or generator needed.	Experimental technology not yet mature enough for use.

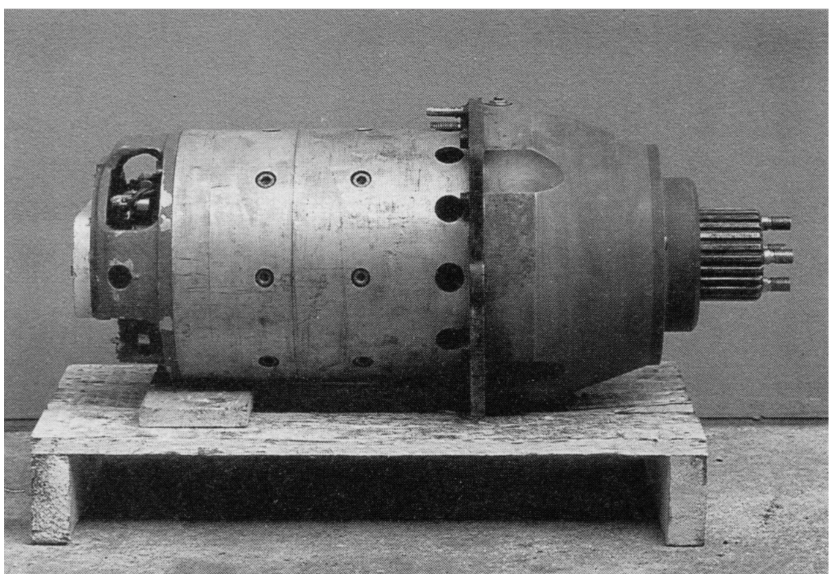
Of the 38 possibilities, three systems suitable for the 19.5-ton vehicle were identified. Concept I-5, from the Belgian firm of ACEC, came with the conventional DC (Direct Current) traction motor driven by a permanent magnet AC generator. The second was concept I-10 from the firm of Garrett which used its own AC permanent magnet drive, and finally, from the firm of Unique Mobility was concept IV-2 which used a dual-path AC permanent magnet drive system.

Other systems were considered as showing potential, even though they were not selected. These were the Jarret variable reluctance drive (using a single seed gearbox saving a lot of weight and volume with 84% efficiency) and the Westinghouse DC Homopolar drive (an extremely simple system albeit heavier than the equivalent mechanical system).

ACEC Drive System Detailed

The ACEC drive system consisted of a single 417 hp rare-earth self-excited metal permanent magnet (PM) generator (a Garrett design) operating at 18,000 r.p.m. This oil-cooled generator had an efficiency of 93.5% and a rating of 370 kVA. Connected to the 500 hp Cummins VTA-903T, it required a ratio transfer case operating at a ratio of 6.9:1 to raise the relatively slower rotating speed inside the engine to match that needed by the generator.

This sounded simple enough but the output from the generator was 3-Phase Alternating Current (AC) and had to be rectified into Direct Current for the ACEC motors. This was done using an oil-cooled 6 thyristor rectifier bridge allowing for bi-directional power flow and also for close control over the voltages. Operating at 747 Volts DC, this rectifier was 98% efficient.

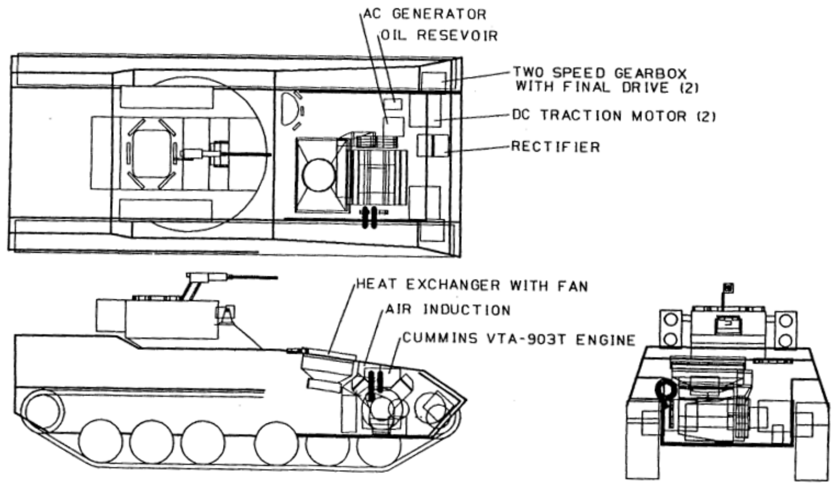


ACEC DC traction motor as used on the ACEC Cobra. Source: Janes

which allowed for steering and braking with the power generated fed back into the system and adding to the power of the generator. The motors were very compact too, just 2.35 cu.ft. (0.07 m3) each, with a diameter of 430 mm, length of just 460 mm, and a weight of just 700 lbs. (317.5 kg). Operating at 1,887 r.p.m. the motors could work at a maximum of 5,660 r.p.m. (for 20 seconds) operating at 420 Volts DC

These motors, on their own, were insufficient to provide all the power required to meet the desired road speed of 45 mph (72.4 km/h), so a two-speed 3:1 ratio oil-cooled gearbox was added with a constant mesh gear and clutch system of a type similar to that used in the X-1000 series transmission on the M1 Abrams.

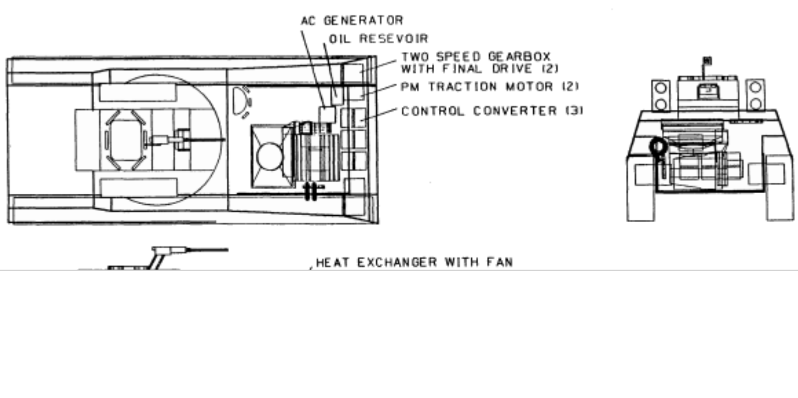
The final element in the drivetrain was the 4:1 reduction ratio heavy-duty planetary drive coupled to the drive sprocket. For the ACEC-system vehicle, a maximum heat rejection of 3,677 BTU/Min (3,879 KJ/Min) was needed.



ACEC Concept I-5 for the 19.5 ton (17.7 tonne) electric drive vehicle. Source: GDLS

Garrett Drive System Detailed

The Garrett system (I-10) consisted of a permanent magnet AC traction motor rated at 444 hp, also with a 2-speed gearbox and final drives. The AC generator itself was an oil-cooled unit of Garrett design using the rare-earth magnets to supply the field flux and operating at 747 Volts RMS at 18,000 r.p.m. with an efficiency of 93.5 %. As with the ACEC system, a ratio transfer case operating at a ratio of 6.9:1 was needed to raise the relatively slower rotating speed inside the 500 hp Cummins VTA-903T engine to match that needed by the generator.



Garrett Concept I-10 for the 19.5 ton (17.7 tonnes) electric drive vehicle. Source: GDLS

The system from Garrett added an oil-cooled rectifier to provide feedback to the control system for the oil-cooled motors, like the motors from ACEC, were capable of operating at up to 300% capacity and running at 18,500 rpm for up to 20 seconds.

The AC traction motors delivered speed across a 4 to 1-speed range but once more, like the ACEC system, was insufficient on its own to provide the necessary top speed desired. This system too was therefore also supplemented by an oil-cooled 2-speed gearbox, once more using a similar gear meshing and clutch system as used on the X-1000 series transmission of the M1 Abrams. Finally, the Garrett system used a 4:1 reduction ratio heavy-duty planetary gear driven by the output from the 2-speed gearbox to move the sprockets.

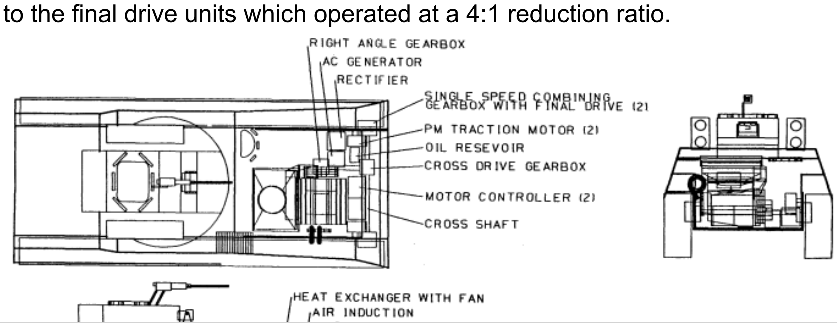
Cooling was an important factor in all of the system and calculations for the Garrett systems (both I-10 for the 19.5 ton and I-3 for the 40-ton) were calculated. For the 19.5 ton (17.7 tonnes) vehicle, a maximum heat rejection of 4,565 BTU/Min (4,816 KJ/ Min) was needed.

Unique Mobility Drive System Detailed

The drive system from Unique Mobility (UM) was different from the other systems in that it used two different paths for the delivery of automotive power, one mechanical and one electrical. The electrical system alone delivered power for speeds from 0 to 15 mph (24 km/h) and, when more power was needed to go above that, the mechanical system was unlocked and coupled to the electrical system. The control unit then controlled the power between these two units.

The electrical power was provided by a permanent magnet AC generator driven by the engine rectified to DC and then inverted in order to provide power to the traction motors. The generator was an oil-cooled Garrett-type rated at 400 hp and rotated at 18,000 rpm with 93.5% efficiency. The oil-cooled rectifier for this system operated at 685 Volts DC at 98% efficiency and connected to a 284 Volt AC inverter operating at 96% efficiency.

The traction motors used rare-earth metal magnets made from neodymium which removed the problem of the cobalt-type magnets, as the US had adequate stocks of neodymium. The cost of 400 of these power units was estimated to be 1985 US$145,000 (just under US$350,000 in 2020 values). The Garrett traction motors delivered 192 hp each and were able to operate at 200% for up to 30 seconds and deliver power to the final drive units which operated at a 4:1 reduction ratio.



Concept IV-2 from Unique Mobility. Source: GDLS

19.5 ton (17.7 tonne) E-Drive Vehicle Overall Efficiencies					
Concept	**Designer**	**Transmission Efficiency**	**Regenerative Efficiency**	**5- 45 mph (8.0 - 72.4 km/h) Efficiency**	**Overall Efficiency**
I-5	ACEC	83 %	79 %	83 %	82 %
IA-3	Jarret	-	-	-	-
IV-2	Unique Mobility	87 %	86 %	87 %	86 %
I-10	Garrett	78 %	-	78 %	-
I-9	Unique Mobility	-	-	-	-
X300 (Mechanical Transmission)		-	-	83 %	-

19.5 ton (17.7 tonne) E-Drive Vehicle Performance					
Concept	**Fastest Acceleration Time (Seconds)**		**Max Speed mph (km/h) on Grade**		
	0 - 20 mph (0 - 32 km/h) Forward	**0 - 10 mph (0 - 16 km/h) Reverse**	**10 %**	**20 %**	**60 %**
I-5 ACEC	4.5	1.17	22.0 (35.4)	13.5 (21.7)	5.5 (8.9)
I-10 Garret	5.12	1.36	21.0 (33.8)	12.5 (20.1)	5.4 (8.7)
IV-2 Unique Mobility	4.85	1.11	24.0 (38.6)	15.0 (24.1)	5.6 (9.0)
DDA X300-4A (Mechanical Transmission)	7.5	-	21.0 (33.8)	12.5 (20.1)	4.8 (7.7)

19.5 ton (17.7 tonne) E-Drive Concepts compared to Mechanical Transmission		
Concept	**Weight lbs (kg)**	**Volume ft3 (m3)**
I-5 ACEC	1,960 (889.0)	9.5 (0.27)
IV-2	1,240	9.3
Transmission)	(907.2)	(0.57)

Switching to an electrical transmission from a mechanical one could have provided several key benefits. It was more efficient, produced less heat through friction, and took up less than half the volume of the mechanical system. Half the volume meant more space available inside for fuel, weapons, and men, or just a smaller vehicle which therefore needed less armor and could be lighter.

With the transmission decoupled from the location of the engine and no drive shafts needed, the designers for the vehicle were free to make some radical layout changes if they wanted. This they did not do for this concept, as the layout remained rather ordinary. It is perhaps that which was the biggest failing of the study, as the vehicle shape and size were dictated from the start, meaning the single biggest freedom provided to the designers was gone. Instead, electric drive could only compete in terms of weight and volume and perhaps it was this 'dictating the terms of the contest' which was the main factor in why it was not adopted.

By working their way through the possible vehicle power options, the concept study team had made a clear choice. A relatively small diesel engine and the ACEC DC system were the most efficient and effective e-drive options for a new generation of vehicles in the 19.5-ton (17.7 tonnes) class.

Despite this, however, the idea was destined for obsolescence by the conventional diesel engine and mechanical powertrain on the M2 Bradley. The Belgians had made their ACEC motor-powered APC and even a light tank on the platform, but this American project fizzled out and more than 30 years later the idea of a diesel electric-powered APC has yet to be exploited to its full potential.

Side profile of the EDFCV. While the outside layout of the vehicle was quite interesting, the heart of the project lay within: The hybrid drive. Illustration by Rhictor Valkiri, funded by our Patreon campaign.

3/4 view of the EDFCV, showing the impressive armament and optics. Illustration by Rhictor Valkiri, funded by our Patreon campaign.

Specifications 19.5 ton (17.7 tonne) Concept

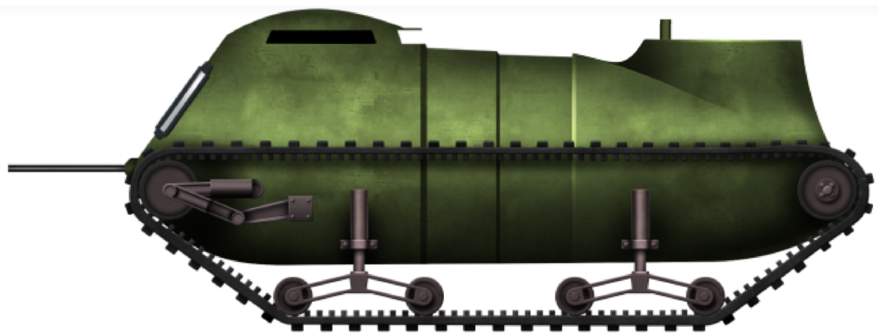
Dimensions (L-W-H)	246” (6.25 m) overall, 92.52” (2.35 m) from front wheel to rear (centers) x 110” (2.79 m) x 72” (1.83 m) hull, 96” (2.44 m) overall
Tracks	17.52” (0.45 m) wide, 150” (3.81 m) length ground contact
Total weight	19.5 tons (17.7 tonnes)
Crew	??
Propulsion	500 hp Cummins VTA-903T with electric drive
Speed	5 mph (8 km/h) to 45 mph (72.4 km/h)
Armament	Single 0.50 calibre (12.7 mm) heavy machine gun with 1,000 rounds, pair of twin Dragon ATGM launchers with 4 spare missiles

Sources

GDLS. (1987). Electric Drive Study Final Report – Contract DAAE07-84-C-RO16. US Army Tank Automotive Command Research, Development and Engineering Center, Michigan, USA
DiSante, P. Paschen, J. (2003). Hybrid Drive Partnerships Keep the Army on the Right Road. RDECOM Magazine June 2003
Khalil, G. (2011). TARDEC Hybrid Electric Technology Program. TARDEC

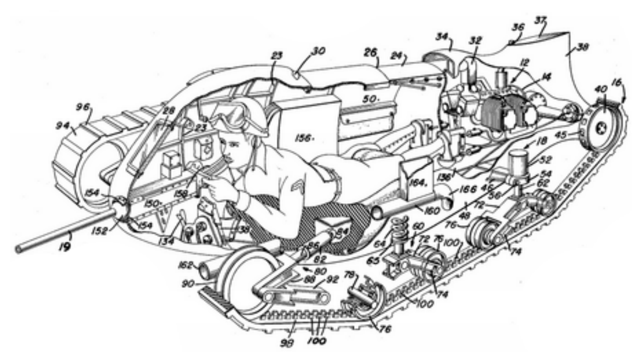
COLDWAR AMERICAN PROTOTYPES < HTTPS://TANKS-ENCYCLOPEDIA.COM/CATEGORY/COLDWAR-AMERICAN-PROTOTYPES/>

Baldine One-Man Tank < https://tanks-encyclopedia.com/baldine-one-man-tank/>



< https://tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> USA (1951-1958)
Light Tank – Design only

On 2nd April 1951, James Joseph Baldine (20/12/1910 to June 1974) of Hubbard, Ohio, USA, submitted a design for a one man tank and, like so many other one-man tank designs, Baldine's had all the advantages of protecting a single soldier behind armor but also all the same disadvantages of a lack of fightability, observation, and vehicle control. He had, however, carefully considered the control aspect of the one-man tank and devised a foot-pedal control system which would allow the soldier inside to manage the steering and propulsion of the vehicle entirely with his feet allowing him to keep his hands free to operate a weapon. Baldine was no doubt influenced by current events, as the design was submitted at the time of the Korean War (1950-1953) but showed what can only be described as naive thinking in military terms, especially in a post-World War II era. Nonetheless, the design was a thorough one, producing probably the best of all of the one-man tanks and showing how many of the challenges for such a concept could be overcome.



Baldine's one-man tank of 1951. Source: US Patent 2722986

Automotive

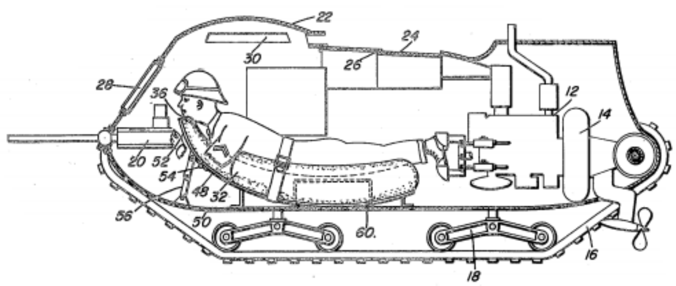
Baldine's tank did not separate the engine from the operator (this is what Baldine called the sole crewman), but placed it directly behind him, with the control pedals for steering/braking at his feet. The engine is described only as a four-cylinder, air cooled aviation type motor behind which was a conventional fluid transmission connected to the final drive for the tracks and a power-take-off with a small propeller allowing the vehicle to be propelled in water. Exhaust gases were vented directly out of the top but, with no provision for a fan, the operator would quickly become very tired from the proximity of this hot engine (despite the presence of a bulkhead between the operator and the engine) inside such a small machine. Directly under the crotch region of the pad, under the operator, was the petrol tank for the engine. The tracks for Baldine's tank are not specified but he describes them only as *"an endless track"* with suspension of a 'shock absorbing' type.

Armament

secondary weapon, in the form of a forward firing rocket launcher sticking out of the front, was located to the left of the operator. Fed from a magazine at the rear, the purpose of the rocket launcher is unclear as to whether it was for smoke or anti-tank or other purposes. The exhaust gas from the rocket was although presumably any soldier inside would also have their personal weapon as well, such as a submachine gun or handgun.

Layout

The tank itself was somewhat more complex than many other one-man tank concepts and also a lot larger. Unlike others, where the operator lacks enough space to sit up, Baldine proposed a taller vehicle with a pronounced dome directly over the soldier. Provided with ventilation slots, this dome would provide air and comfort for the solder but was not used for observation. Instead, all observation was conducted through the single large bulletproof glass window located directly to the soldier's front over the main armament. Access to the tank was gained via a small sliding hatch located midway down its length on the roof, meaning the soldier would be exposed to enemy fire if/when the machine became stuck.



Cross-sectional view of Baldine's one-man tank showing the location of the large pad on which the operator lay and the fuel tank (60) underneath him. Source: US Patent US2823393

The Pad

A common flaw in the one-man tank concept is the issue of comfort for the soldier crewing the vehicle. The operator is already very busy having to command, steer, and fight from the tank and obviously this is made harder if they are uncomfortable. Taking a prone position, where the soldier is lying on his front, can become very tiring after a while, particularly after travelling over rough country and having to lift their head up in order to see and fight, which produces additional strains. Baldine's additional idea to assist his one-man tank concept was the addition of a specially designed sponge-rubber pad on which the soldier could lay.

Specially shaped, this pad would hold the operator in a steady position, providing support for his arms and chin as well as a wedge shaped block on which his crotch would rest. This crotch-block would prevent the solder from slipping down the mattress and raised edges on the sides and base would stop him from sliding laterally as well.

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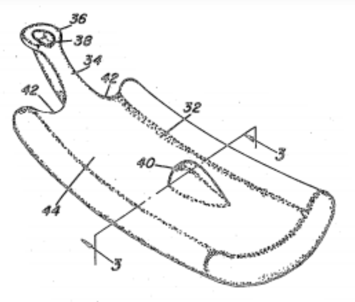

The unusually shaped sponge-rubber pad on which the operator would lay showing the crotch block (40) and chin-rest (36/38)US Patent US2823393

Conclusion

The one-man tank idea, something first proposed decades earlier and something which had never seen any successful mass production or use, was a dead idea by the 50's. It can be surmised that Baldine was motivated by seeing the War in Korea and wanting to do his part for his country and to save the lives of soldiers or maybe just opportunism to try and make some money from an idea. Regardless of his motivations though, the design itself was not a terrible one by any means. As far as the concept goes, the design certainly had merit for the control of the machine and the layout, but the concept of a one-man tank was just fundamentally a bad one. A single soldier would be unable to adequately command, control and fight from the vehicle and the features of the vehicle inherent within the design, such as the low profile, giving low visibility, prevent such an idea being viable. As such, his one-man tank design might have been a very good one-man tank design but the concept was simply a flawed one. As such, his design suffered from those flaws and despite his best efforts could not overcome them. That ended his one-man tank idea.

Baldine also submitted a patent for a game teaching apparatus in January 1951. In 1963, he also designed a portable incinerator for a motor vehicle, designed as a means of disposing of cigarettes and paper items which could be fitted to a standard saloon car for disposing of litter on the move. Neither of those two designs were perhaps as adventurous as his one man tank idea, but Baldine had moved on anyway. It is not known whether Baldine received any financial benefit from his patents, but his one-man tank idea certainly went nowhere. His political career, as Mayor of Hubbard, was far more successful though, serving six consecutive terms. He died in office in 1974.

Sources

US Patent US2823393(A) Cushion pad for one-man tank, filed 2nd April 1951, granted 18th February 1958

Hubbard News, 19th June 1974 – Mayor Baldine: an era has ended

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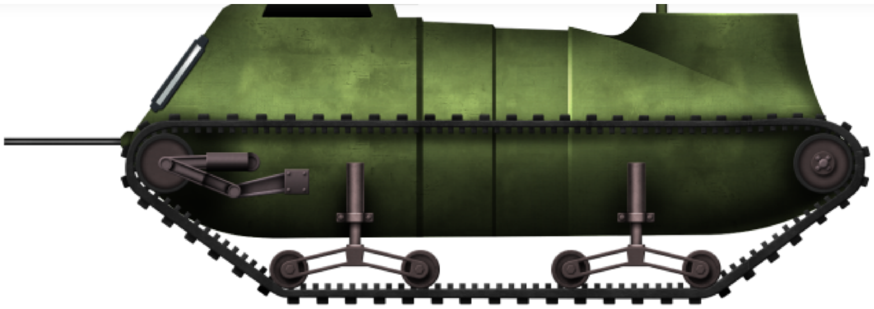

Illustration of the Baldine one-man tank, by Yuvashva Sharma, funded through our Patreon campaign.

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FMC Howitzer Improvement Program (HIP) < https://tanks-encyclopedia.com/fmc-howitzer-improvement-program-hip/>

By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

September 29, 2020 < https://tanks-encyclopedia.com/fmc-howitzer-improvement-program-hip/>

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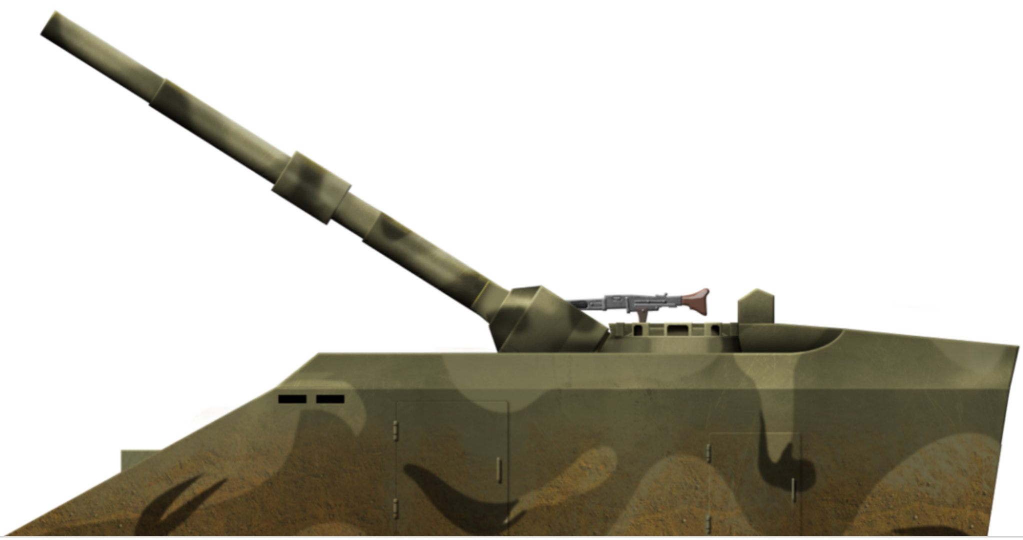

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< https://www.tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> USA (1979-1983)
Self-propelled gun – Project only

FMC HIP design. Source: Janes

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(SPG's) in service were not suitable for a potential Cold War showdown with the Soviet Union, which had a more modern SPG force. Early development work took place under the program names Division Support Weapon System (DSWS) and Direct Support Armored Cannon System (DSACS). The DSWS

All of these programs were also grouped under the general name of the Howitzer Improvement Program (HIP). This development was to take multiple strands. One was work commissioned from the firm of Norden to study improvements to the existing **M109 fleet < https://tanks-encyclopedia.com/coldwar/US/M109_Paladin.php>** as well as an examination of foreign systems in use or development. This included the **French GCT < https://tanks-encyclopedia.com/coldwar/France/gtc-155mm>** and the multinational SP-70 project. The M109, a system developed in the 1950s and first fielded in 1963, was a prime candidate for upgrading or replacement. In 1980, the replacement for the M109, incorporating elements of the other programs, was underway and after 3 years of work several alternatives for replacement or modernization of the M109 had been evaluated as part of the Howitzer Improvement Program known as HIP.

HIP outline

With the multitude of acronyms involved before work had even begun, it is easy to become confused, but the HIP program laid general principles a future system would have to meet to be acceptable. Firstly and most importantly, the caliber was defined. It had to be a 155 mm gun with a barrel length not less

the crew down to a nominal 4 with some optimism that it could be reduced to 3 and operated in an emergency by just 2 men.

Not less than 50 rounds were to be carried with a target of up to 75 shells which, working with the consideration was a ‘halfway house’ of a semi-automatic system rather than manual or fully automatic with an estimated rate of fire of between 4 and 8 rounds per minute. The desire was for a state of the art system to meet the RAM (Reliability, Availability, Maintainability) requirements with computer-controlled and monitored systems. Fire control was to be by means of an onboard ballistic computer and computer-controlled gun motors. This combination allowed the system to fire, relocate to avoid counter-battery fire, and then fire again in under 1 minute. The ability to avoid enemy counter-battery fire was a significant improvement and step forward.

Protection was to be just of an ‘improved’ type over what (presumably) there already was in comparison on the M109 and the vehicle had to have an NBC overpressure system fitted as standard. A further note was that for self-defense the vehicle would be provided with a single .50 caliber heavy machine gun on the commander’s cupola. For mobility, the HIP required a new powerful engine capable of delivering not less than 20 horsepower per ton capable of propelling the various vehicles based on this chassis to a road speed of 60-75 km/h, to a maximum operational range of between 400 and 600 km. All vehicles had to be capable of transportation via a C-130 transport aircraft.

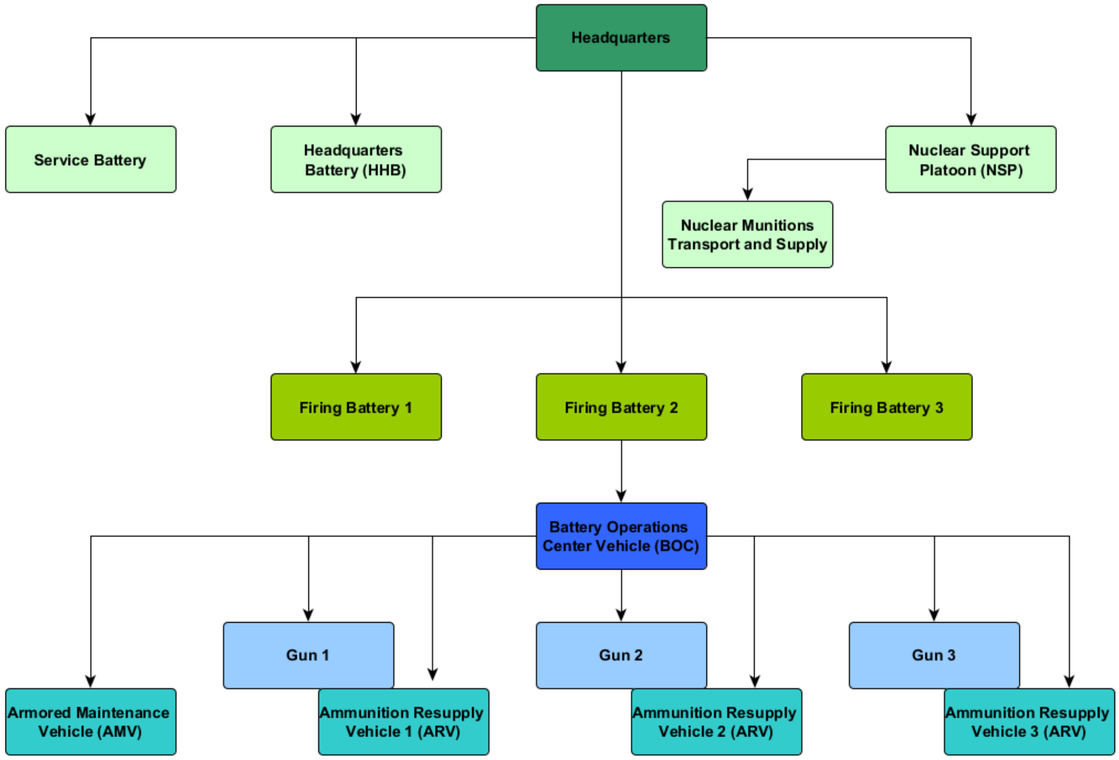
HIP Chassis family

Each SPG would have an associated and dedicated Ammunition Resupply Vehicles (ARV) with between 80 and 150 additional rounds of ammunition. This vehicle was to be based on the same chassis as the SPG itself, with a crew of 3 or 4 and the same level of protection.

Another vehicle would be the Battery Operations Center (BOC) also based on the chassis with a crew of 7 (in two shifts) and an Armored Maintenance Vehicle (AMV) with a crew of 2 (and 4 mechanics). Each AMV would carry spares, tools, and even a complete spare power pack for the chassis. The vehicles were to be assigned to a battery at the rate of one AMV per battery.

A battery would therefore consist of 3 SPG’s, 3 ARV’s, 1 BOC and 1 AMV for a total of 3 guns, up to 675 x 155mm shells, and between 28 and 45 men.

HIP was to be an integrated part of all Army divisions replacing the vehicles already in service at a rate of one battalion to each Army brigade



Battalion makeup for the HIP program. Source: Author

The FMC Proposal New Start

By 1984, FMC (Food Machinery Corporation) had made their own proposal to meet the demands of the HIP program as specified under the name 'DSWS New Start.' The basic arrangement of the proposal was an unusual-looking vehicle with a completely fixed superstructure on the rear of the chassis. The engine was mounted in the front and the ammunition (in drums) sat at the top rear of the casemate. The 155 mm gun mounted into this superstructure was not completely fixed and had the ability to move up to 5 degrees left or right. The driver sat forwards of the casemate, in a raised structure that extended back along the hull into the casemate. This would permit him to come back into the fighting space rather than be isolated in the driving position. The chassis itself was mounted on 7 road wheels with 4 return rollers and drive to the tracks delivered by a front-mounted sprocket. Power would be provided by an unspecified 700 hp engine.

weapon which was under development at Watervliet Arsenal. The range required was 25km (30km with rocket assistance) but this FMC proposal gave the maximum range with standard (non-rocket-assisted) projectiles as 23km.

including fuze setting which was incorporated into the breach and was fully compatible with the existing 1 to 8 zone bag charge propellant system or the then newly proposed 5-zone modular propellant. Shells would be reloaded via the Ammunition Resupply Vehicle via two large hatches in the rear of the gun.

The end of the new start

The DSWS project was canceled by 1983. It was seen as being too expensive and too complicated. The focus would instead be on modernizing the existing M109 fleet and the HIP project would roll on sucking in more cash. For their part, FMC had produced a capable design whose biggest flaw was probably not the cost but the lack of a turret. They had met almost all of the requirements set by HIP and would try their hand at the M109 modernization instead, rolling much of their development work into a new M109.

Conclusion

Like many of these multi-year huge contracts in the US, this one is an enormous project of overlapping requirements. The HIP program didn't end with the cancellation of the FMC DSWS New Start concept, it was still going on into 1991. This was the date by which the vehicles were meant to have been entering service yet development hadn't even finished and only 8 prototype improved vehicles had even been made by 1989. The project was simply too large and phenomenally expensive. In 1989 alone, for example, the HIP program cost nearly US$28.5million and nearly US$10.5million the following year. It didn't matter anyway for FMC. All work on a complete replacement for their project was terminated by 1984 with the decision being made at the time to simply modify the M109 fleet with new ammunition stowage and a longer range gun instead. The project was overall somewhat of a failure, no new vehicle was produced and a huge amount of money was spent. The opportunity for a new and more capable platform producing a new family of vehicles was lost.

Illustration of the FCM New Start Howitzer Improvement Program, showing the forward placed driver compartment connected to the rear fixed superstructure. Illustration by Yuvnashva Sharma, funded by our Patreon campaign.

Specifications required for Future Self-Propelled Artillery System

Propulsion	Advanced new engine delivering at least 20 hp/t
Top speed	60 to 75kmh (road)
Operational maximum range	400-600km
Armor	Unspecified 'improved' armor

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FMC proposal 'DSWS New Start'	
Armament	155 L45 main gun, one cupola mounted .50 cal heavy machine gun
Ammunition	50 rounds in two 25 round drums with fully automatic feed capable of firing unassisted projectiles to 23km

Sources

GAO Report AD-A141 422 M109 to M109A5 Report, March 26th 1984
Janes Armour and Artillery 1984-5 < https://www.amazon.com/gp/product/0710608004/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=0710608004&linkId=62d8880173b70c2f50b713cc5311762d>
US Army Tank Automotive Command Laboratory Posture Report FY 1982, US Army
Research Development and Evaluation Army Appropriation descriptive summaries, January 1990, US Army Congressional Report
Report ARLCD-CR-81053, Demonstration Prototype Automated Ammunition and Handling System for 155mm Self-Propelled Howitzer Test Bed, December 1981, US Army ARRADCOM

COLDWAR AMERICAN PROTOTYPES < HTTPS://TANKS-ENCYCLOPEDIA.COM/CATEGORY/COLDWAR-AMERICAN-PROTOTYPES/>

M-70 Main Battle Tank < https://tanks-encyclopedia.com/m-70-main-battle-tank/>

By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

July 20, 2020 < https://tanks-encyclopedia.com/m-70-main-battle-tank/>

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< https://tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> USA (1962 – 1963) – MBT – None built

In 1962, the US Armor Association launched a competition for the design of a next generation of Main Battle Tanks (MBTs) to replace the M60 Gun Tank in light of advanced Soviet vehicles which were being developed. The goal was to gather ideas as to how people thought the tanks of 1965-1975 might look and left the various designers a lot of freedom in terms of armament and propulsion. Many designs were sent in from around the world but one very close to home came from a serving US soldier, David Bredemeir, based at Fort Knox, the home of the US School of Armor at the time. This design was to eschew conventional suspension, layout, and armament and produce a missile carrier capable of destroying any future Soviet threat. Named the 'M-70' (no connection to the MBT-70), presumably for the anticipated in-service date, this vehicle provides a semi-professional glimpse at some of the thinking of the era.

U.S. Army

PFC David

Layout

The basic layout of the M-70 was a long slender tank. The engine, a “long slender gas turbine”, was positioned alongside the driver at the front. The turbine would power the front-mounted transmission.

Armament

The M-70 was not to be a conventional gun tank. Bredemeir eschewed the conventional cannon approach for his design and put the offensive capability for the tank in the hands of anti-tank guided missiles. This design choice was based upon the logic that it would be able to fire before an enemy tank could and to ensure a first-round hit each time. The result was that the tank was to carry a battery of 8 anti-tank guided missiles (ATGM) in each ‘fender’, the sponsons along each side above the tracks. As the missiles traveled slower than a conventional shell, they could be fired in the general direction of the enemy even without aiming, with this process then being picked up by means of the guidance as the vehicle stopped. There would then be time to guide the missile onto its target before the corresponding

in the turret.

Various types of missiles were proposed, including smoke, chemical, heat-seeking, and even atomic rounds, guaranteeing these missiles were capable of taking on even the heaviest of enemy armor. The

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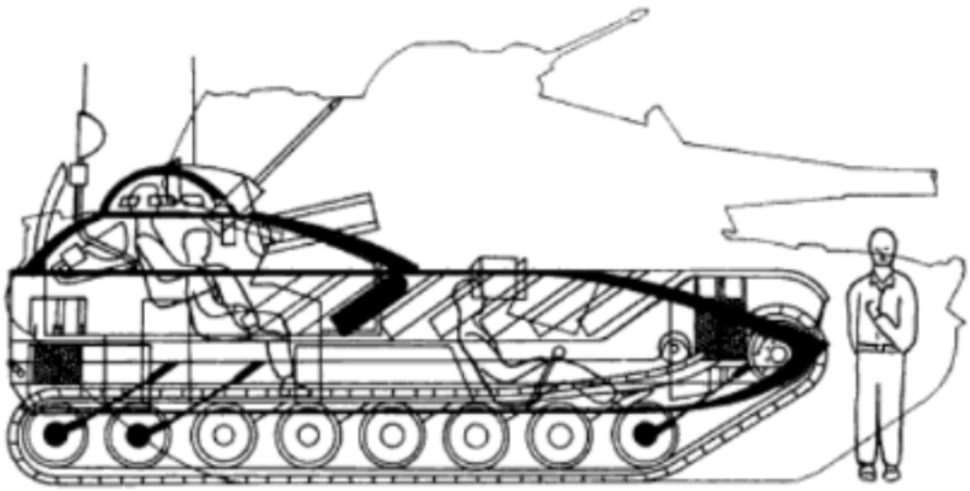
Crew

The M-70 was to use a three-man crew consisting of commander, gunner, and driver, although the gunner also served as a radar operator. When the gunner was busy loading the missile tube, the commander could take over his duties. Of the three crew, the driver would be at the front, leaving the commander and gunner in the turret at the back. The gunner, situated on the left, would be able to operate the missile launch-tube centrally as well as the radar, and when he was otherwise engaged, the commander could take on the gunner's duties. The commander sat in the turret on the right-hand side and had his own cupola with a machine gun.



Bredemeir's M-70 tank design relied upon its low profile for protection and missiles for its firepower. Source: Armor Magazine

Armor

Being lower than the M60 Gun Tank < https://tanks-encyclopedia.com/coldwar/US/M60_Patton.php> would give the M-70 a higher chance of survival on the battlefield, as it would be less likely to be hit. It also meant a lighter and more maneuverable tank but it still needed armor. The result was that the M-70 was to be made out of aluminum. This, in turn, would keep the overall weight down to 20 to 25 tons (18.14 to 22.70 tonnes)

Suspension

The suspension for the M-70 was a 'two-stage' system, with the tracks and road wheels divided in half and connected together via a single leaf-spring holding them to a beam that ran the full length along

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road wheels would spread the weight of the tank along its track and also serve to keep the overall height of the vehicle down.

During the 1960s, faced with the enormous growth in power of anti-tank guided missiles, many were speculating it meant the end of the conventional tank. Likewise, the potential of ATGMs outstripped the anti-armor potential for large caliber guns with the advantage of being significantly smaller and lighter. Many countries would consider and even develop ATGM-based tanks during the Cold War, but just like the US Army, they were constrained by budgets, thinking, and a conservative attitude of trying to keep developments relatively simple. The M-70 offered superior firepower to the M60 in a much smaller vehicle but in 1962, this gun-launched missile concept was already underway on the M551 Sheridan. It was never to work satisfactorily for that tank and the M-70 offered little to warrant development.

Illustration of the M-70 Main Battle Tank by Andrei 'Octo10' Kirushkin, funded by our Patreon Campaign

Sources

Armour Magazine January-February 1963

M-70 Specifications

Propulsion	Petrol turbine (fuel tanks under turret at the back)
Armament	ATGM launchers, 50-60 shells (incl. 20 in turret)

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Lockheed/Forsyth Tank < https://tanks-encyclopedia.com/coldwar-usa-lockheed-forsyth-tank/>

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By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

June 1, 2020 < https://tanks-encyclopedia.com/coldwar-usa-lockheed-forsyth-tank/>

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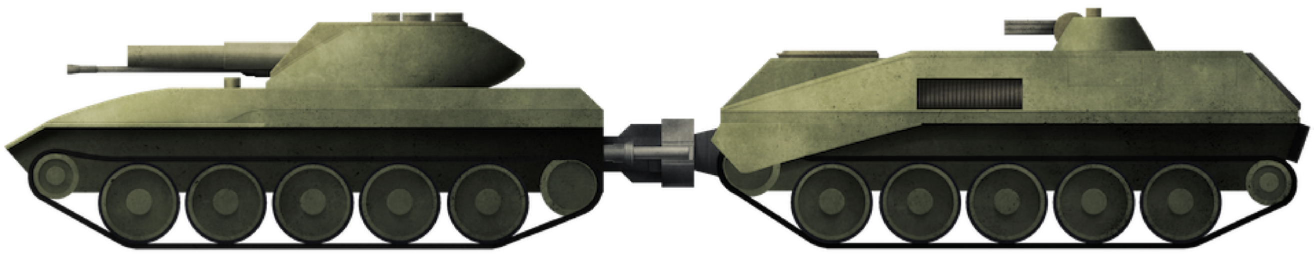

U.S.A. (1962-67)
None Built

Post World War 2, the United States had a glut of tanks including large stocks of **M4 Shermans < https://tanks-encyclopedia.com/ww2/US/M4_Sherman.php>** and new designs such as the **M26 Pershing < https://tanks-encyclopedia.com/ww2/US/M26_Pershing.php>**. There was, as a result, little impetus for new vehicles, even though design work, if anything, increased apace at this time.

Throughout the 1950's, US tank designers were looking at every aspect of the problems of tank technology, from armor to propulsion and armament. Whereas a lot of development had made great strides during this time in other areas, armor was still fundamentally based upon large steel castings. Various ideas though had been tried, including compositions with glass in armor cavities and even work on bar armor to defeat incoming projectiles and the increasingly common HEAT-type warheads.

By the early 1960s though, even with a new generation of Main Battle Tanks (MBTs) at hand, the US was short of a light modern tank that was air-transportable, amphibious, well-armed, and well protected. Obviously, this is a holy grail of tank design, light-enough weight to be air-transportable but with enough armor protection to be useful in direct battle rather than just scouting or skirmish roles. The tank which was to become the **M551 Sheridan < https://tanks-encyclopedia.com/coldwar/US/M551_Sheridan.php>** was in development but this was not the only

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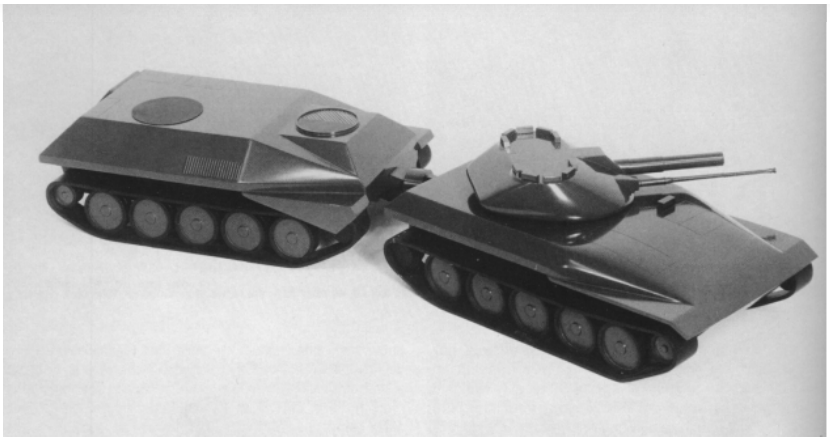
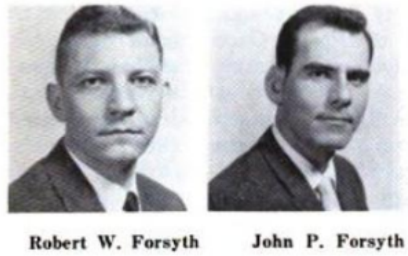


The model from Robert and John Forsyth, which won the US Armor Association tank design competition in 1962. Source: Hunnicutt

Designers

The first thing to address in looking at this design are the designers, John and Robert Forsyth. John and Robert were brothers who were engineers living in California and worked at the Vehicle Systems for cars to travel in and various forms of unusual traction machines including a tri-wheeled amphibious vehicle and articulated machines.



The Forsyth brothers. Source: Armor Magazine

Whether their tank design was already being considered prior to the Armor competition of 1962 is not clear, but it was certainly submitted, meaning it must have been ready before the end of August 1962.

The Need For a Light Tank

Despite a multitude of light tank designs considered during various conferences during the 1950s, it was not until January 1959 that work had begun in earnest of a new light combat vehicle under the designation AR/AAV (Armored Reconnaissance/Airborne Assault Vehicle). The specifications demanded of that design were presented in July 1959 by Ordnance Tank Automotive Command (OTAC). That vehicle was going to have to replace the existing stock of **M41 light tanks < https://tanks-encyclopedia.com/coldwar/US/M41_Walker_Bulldog.php>**, the **M56 self-propelled gun < https://tanks-encyclopedia.com/coldwar/US/m56-scorpion-spat.php>** and supplement/work alongside the existing main battle tanks and armored personnel carriers in service.

To meet this demand, a pilot vehicle was prepared by Aircraft Armaments Incorporated (AAI) with a 3-man crew tank in the 10-ton (9.1 tonne) class. Another company, Cadillac, designed a vehicle with a four-man crew and a little heavier. Neither of those vehicles though, as obvious by the incredibly low weight, had any reasonable protection outside of against small arms. Even so, the Cadillac proposal, although selected for development, was still woefully under-protected even outside the weight limit imposed. As a result, the allowance for weight was increased to 15 tons (13.6 tonnes) and was designated AR/AAV XM551, the progenitor of the M551 Sheridan. What that design sacrificed in height and size it made up for in armament, with a 152 mm main gun capable of firing a large HEAT (High Explosive Anti Tank) round as well as the Shillelagh missile with a HEAT warhead. Both of those weapons were capable of taking on even the heaviest contemporary Soviet armor and also provide fire support for airborne troops. Other weapons under consideration at the time were a conventional 76 mm, 90 mm, 105 mm, and even 152 mm guns, ENTAC (ENgin Téléguidé Anti-Char) (to supplement any conventional gun), TOW (Tube-launched, Optically-tracked, Wire-guided), or POLCAT missiles.

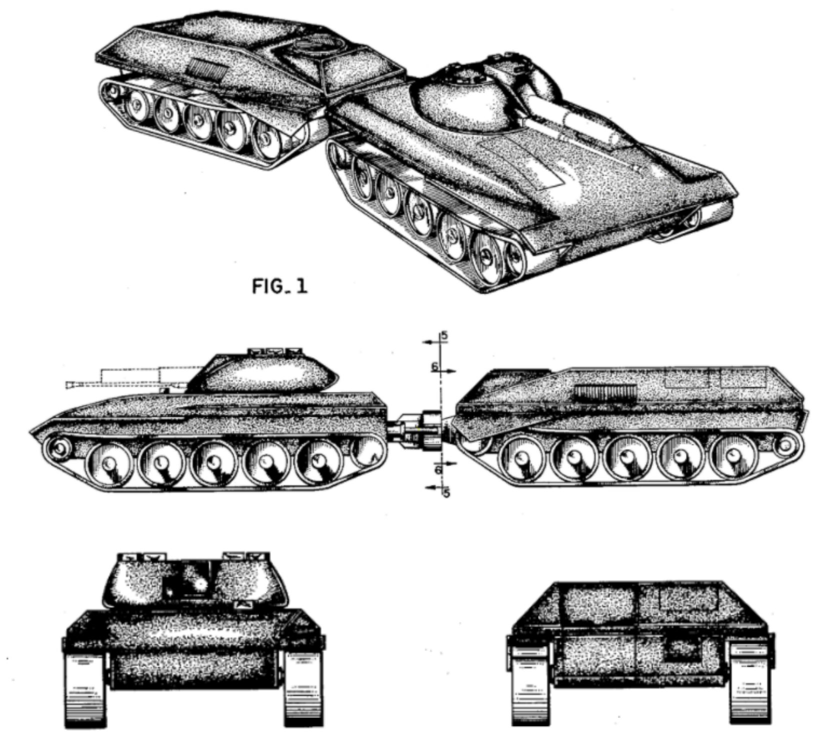
The first pilot XM551s were delivered in June 1962 for testing, with more pilots following in 1963, 1964,

A contemporary design though, offered some solutions to what became the flaws in the M551 Sheridan, whilst at the same time adding another layer of complexity to meet the demand to replace the old and obsolescent M41 Walker Bulldog < https://tanks-tank class vehicle at a significantly reduced weight, this design was supposed to add mobility as it could go places a conventional tank, light or otherwise could not go.

Basic Layout

Having won the tank design competition with their design at the end of 1962, the Forsyth brothers and Lockheed Aircraft Corporation were anxious to secure and market the idea. The result was an embodiment in the patent application filled in January 1963, but there was nothing in that application other than the layout.

What it showed was a small tank with 5 road wheels on each side, topped with a low-profile rounded turret. Inside that turret can be seen one large caliber gun and a smaller secondary armament. Most striking in that design though is what is behind the tank, a trailer. Not just a trailer in fact, but another tracked hull, with 5 road wheels but where the armored body is taller, reaching nearly the height of the turret of the preceding vehicle. The two sections connected together through an articulated joint. The details of the articulated design would be made clear in a following application filed in July that year.



The basic design of Forsyth and Forsyth's tank concept for Lockheed, as shown in US Patent 196779 of January 1963, illustrates a novel articulated vehicle.

the two sections as well as movement sideways (as encountered when steering) and vertically (as encountered when climbing or descending).

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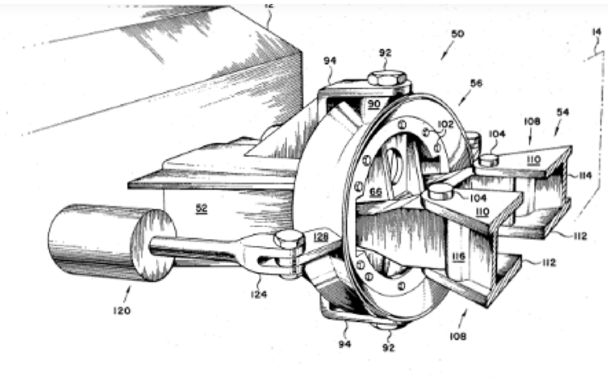
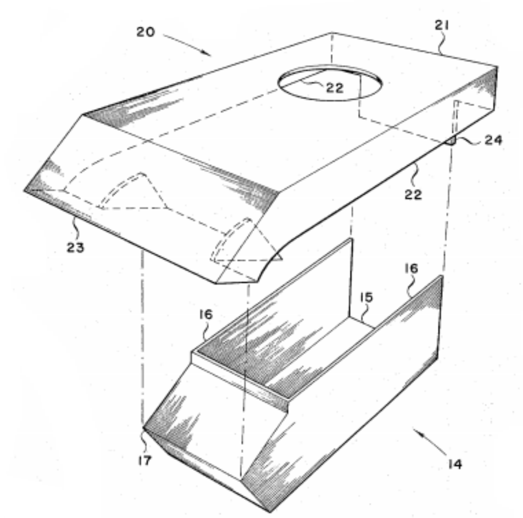


The coupling between the two sections. Source US Patent 3215219



The whole construction was simple, just two fabricated sections forming a top and a bottom half of the hull fastened together. US Patent 3351374

Armor

The armor in the 1962 Armor competition was described as a steel and aluminum alloy with a maximum thickness of 76 mm to 150 mm (3 to 6 inches). This was clearly subject for more thought and the focus of the design submitted for patent in July 1963 was the armor. Instead of relying on a homogenous steel plate that was face hardened and was heavy and vulnerable to shaped charges, the Forsyth brothers envisaged a new system. This system consisted of a series of layers, a first and second layer of rigid armor spaced apart from each other which the cavity between them filled with a multitude of different armor panels, which were themselves held apart by a filler material proposed to be cellular or a foam-

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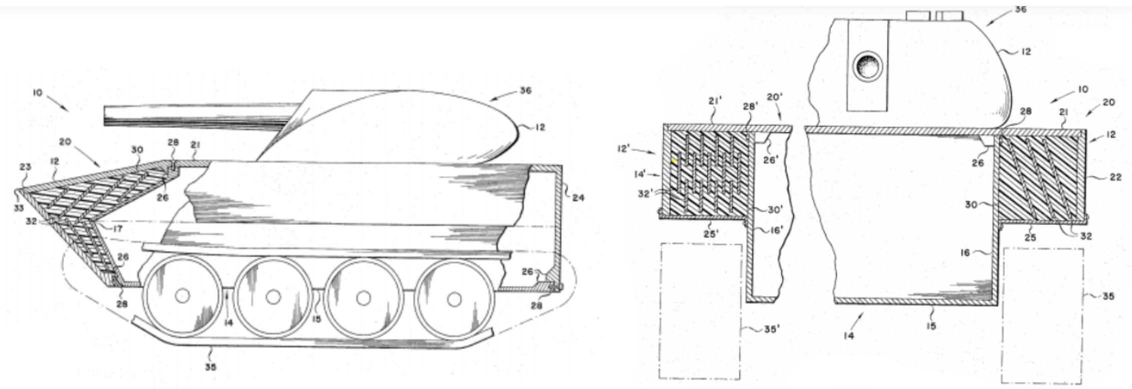
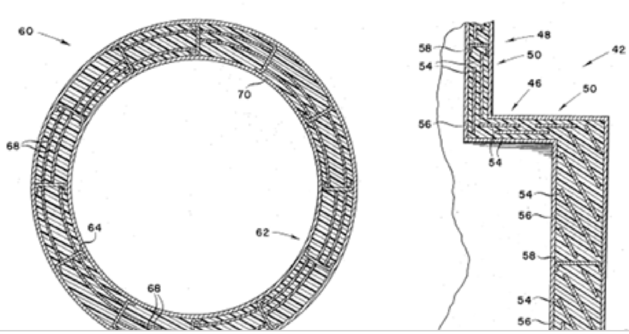


Distribution of armor per US Patent 3351374. The armor is concentrated on the front and upper sides, where enemy fire is most likely to be received. This is repeated on the following unit for the tank as well. Note that in this drawing the tank has only 4 wheels.

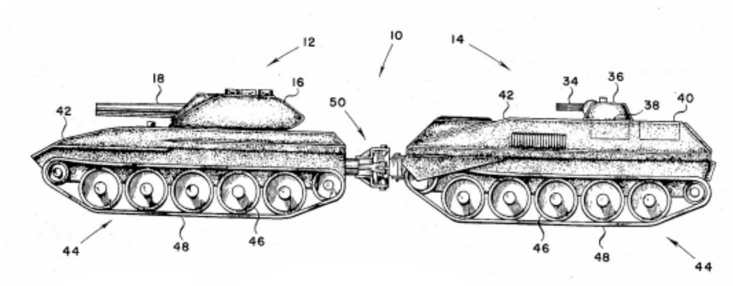
The panels inside the armor cavities were suggested as being made from a variety of possible materials, including glass-fiber or metal fabric laminated together, coated with flexible epoxy-urethane resin. Other epoxy resins, polyurethane and plastics could also be substituted. The filler material between those panels served to hold them apart and offer rigidity and was to consist of polyurethane resin too. The difference between this resin filler and the other resin used was that this filler-resin was also to contain cyclohexylstearate or dimer acid, and a lead, cadmium, or boron compound (i.e. lead oxide, cadmium oxide, boric oxide) as protection against neutron radiation. In other areas where this filler did not need to be used throughout the cavity, it was to be substituted with foam, as this was a good thermal insulator and provided buoyancy.

As an aside, Forsyth and Forsyth also considered that this armor was suitable for consideration on ships and submarines. The projected weight for both parts was just 21 to 22 tons (19.00 to 19.96 tonnes) for the steel/aluminum armor version and fro, 24 to 32 tons (21.77 to 29.03 tonnes) for the composite armored version, depending on the exact composition. The composite armor-option was a significant improvement over the original steel and aluminum option and provided the design with substantially more protection than that of the Sheridan against both kinetic energy and shaped charge munitions.

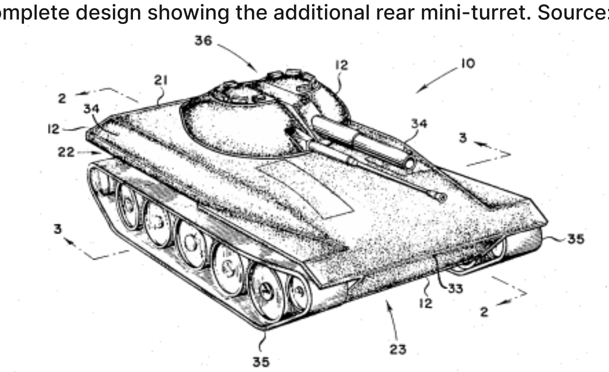


The armor arrangement as outlined for the tank but used for a submarine (left) and boat (right). Source: US Patent 3351374

As shown in the patents, there were two weapons mounted on the tank, and later, a third weapon mounted on the following unit. The tank's weapons consisted of a single large-caliber gun of an undisclosed size in the patent, although it bears a close resemblance to a gun like that on the M551, the 152 mm. Bearing in mind the requirements from the army, as stated before, included 76 mm, 90 mm, 105 mm, and even 152 mm guns, ENTAC (to supplement a conventional gun), TOW, or POLCAT missiles, one of those would have been chosen and what is shown is too large for either the 76 mm or 90 mm guns. In their competition entry, the Forsyth brothers were clear that they planned a 155 mm gun as the primary weapon, capable of firing rocket-assisted projectiles. The secondary armament, as it appears in the patents, appears to be a cannon, but is only described as the secondary armament for anti-personnel purposes. No mention is made of the third gun at the back, which could be assumed to be a machine gun. In their competition entry, the secondary gun is confirmed as a 20 mm Hispano-Suiza HSS 820 automatic cannon in the front vehicle and the small turret at the back is confirmed to take a 7.62 mm Vulcan-type machine gun.



Side view of the complete design showing the additional rear mini-turret. Source: US Patent 3215219

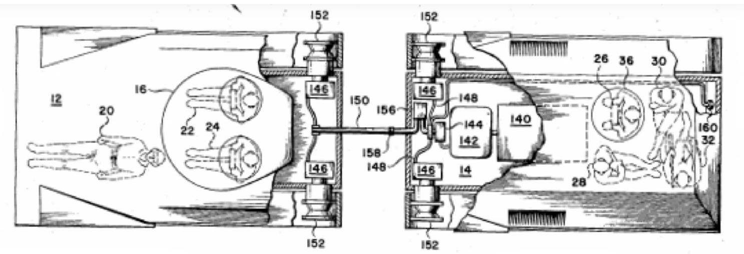


Front ¾ view of the design showing the two turret hatches and the armament. Source: US Patent 3351374

Crew

The M551 was to have a crew of four, as the use of a three-man turret was seen as having value in combat. The design from Lockheed though went away from that idea and back to a three-man crew with

acted as a small armored personnel carrier team attached to the main tank and accessed it via a door at the back. They could egress the vehicle to fight or carry out tasks dismounted, and in the final patent publication's drawings, this following unit had gained a small turret with a gun so as to provide additional firepower. As part of a platoon of such tanks, the men in the rear sections would end up being a unit 15

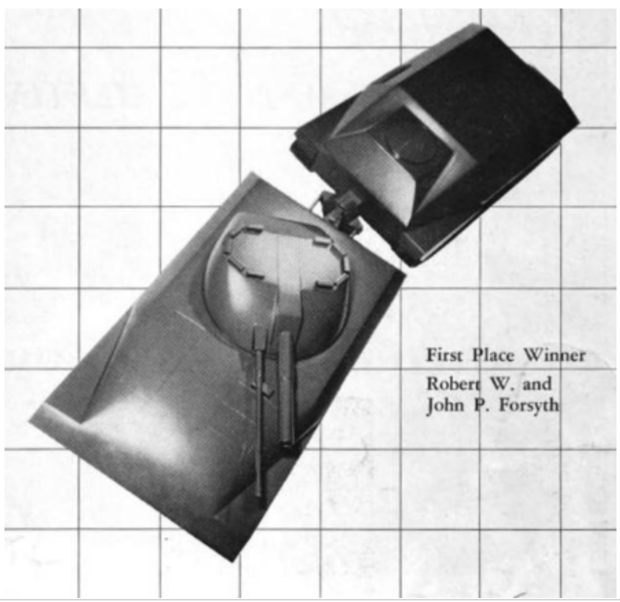


Layout of automotive elements and crew from US Patent 3215219

Automotive and Suspension

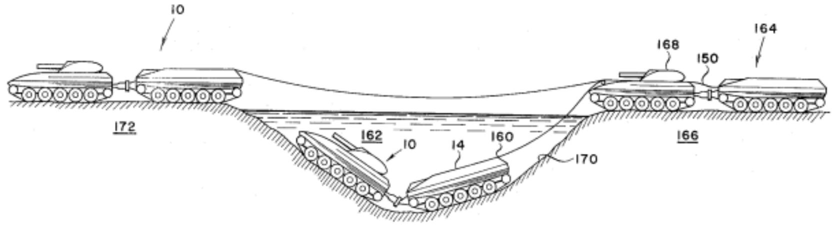
The engine for this first section of the vehicle was located in the front right of the hull and centrally in the second section. It is described only as "a piston unit [conventional petrol or diesel engine] or a gas turbine" which drove an A.C. electrical generator. That electrical power was then delivered to the back of the tank (in the case of the lead unit) where traction units drove the sprockets. On the trailing unit, the same system was used except that the electrical traction units and sprockets were at the front. Steering was electro-hydraulic, able to adjust power to the tracks on each side of each section to vary the turning moment applied but also allowed for steering forces to be applied through the coupling hydraulically.

Suspension for both sections was by means of a flat band track mounted on long-pitch, large-diameter road wheels, although the designers did suggest that if tracks were not suitable that a multi-axle wheel system could be substituted instead.

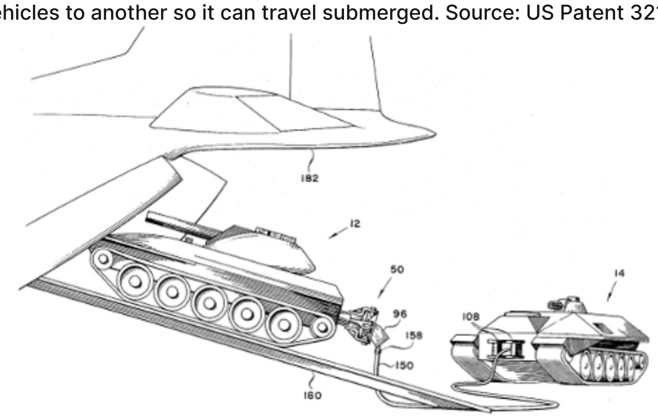


unit failed or broke, the other could push or pull it along, reducing the chances of the design becoming stuck or crippled. Further though, the independence of the electrical transmission provided additional benefits. The sections could be split and have power sent from one half to the other via cable even

[Maus in WW2 < https://tanks-encyclopedia.com/ww2/nazi_germany/panzer_maus.php>](https://tanks-encyclopedia.com/ww2/nazi_germany/panzer_maus.php). It made loading onto aircraft for transport easier too.



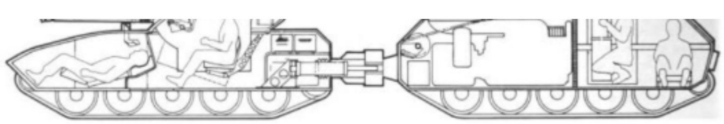
Working alone or in pairs, the design was flexible enough to allow power to be sent from one vehicle or pair of vehicles to another so it can travel submerged. Source: US Patent 3215219

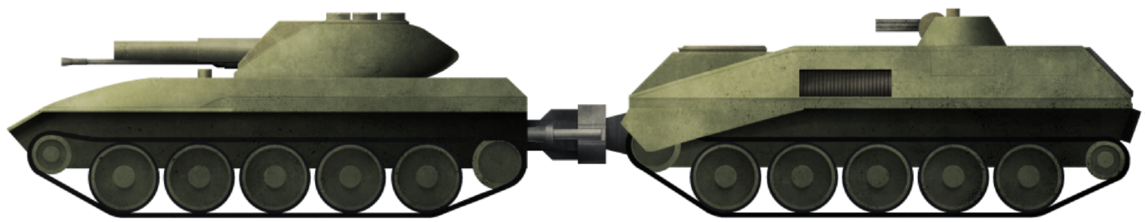


At just 21 to 22 tons (19.00 to 19.96 tonnes) (steel/aluminum armor version) to 24 to 32 tons (21.77 to 29.03 tonnes) (composite armored version) in total, the vehicle was air-portable and was able to split in half to easily self-load into an aircraft. Source: US Patent 3215219

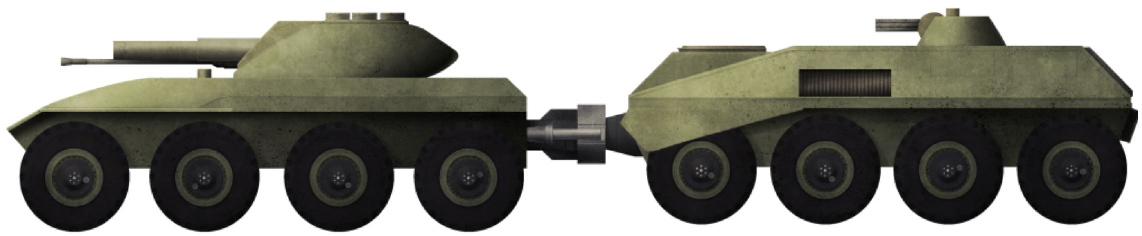
Conclusion

The design from Messrs. Forsyth and Lockheed was, in many ways, ahead of its time. During the early 1960s, the concept of using composite armor was still new thinking. There were, however, serious problems to overcome. The coupling concept was not new, ideas for coupled tanks date back to 1915, and although the coupling in 1962/3 was undoubtedly better designed than the ones from 1915, it was still not a perfected technology. Lighter than the M551, this design offered increased protection and capability and the potential for improved firepower, but it was unlikely to have ever received serious consideration. By the time the first patent was filed, the US Army's eyes were on the XM551 project, which offered a lot of what they wanted without having to use new and as of yet unproven technologies. The potential offered by this design was thus lost, it received no orders and was never built. Coupled vehicles would continue to be examined by a variety of countries for a variety of purposes, as would coupled tanks and electric drive and composite hulls. This design, however, seems to be the first design to combine all of these elements in one.





The tracked version of the Lockheed/Forsyth Tank



The wheeled version of the Lockheed/Forsyth Tank

These illustrations were produced by Andrei Kirushkin, funded by our Patreon campaign.

Specifications

Dimensions	1.83 m (72") high
Mass	21 – 22 tons (19.00 – 19.95 tonnes) (aluminium/steel armor version) up to 24 and 32 tons (21.77 to 29.03 tonnes) (composite armor version) depending on armor selected.
Crew	3 (Driver, Commander/Gunner, Gunner/Loader) + 4
Prop	
Armament	155 mm main gun firing rocket-assisted projectiles (24 rounds), 20 mm Hispano-Suiza HSS 820 automatic cannon (200 rounds), 7.62 mm Vulcan-type machine gun (2500 rounds)

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Sources

Armor Magazine. (July-August 1962). Tank Design Contest.
Armor Magazine. (January-February 1963). The Winning Tank Designs.
US Patent 196779 ' Tank Unit', field 28th January 1963, granted 5th November 1963
US Patent 3351374 'Armor Construction', filed 1st July 1963, granted 7th November 1967
US Patent 3215219 'Articulated Vehicle', filed 22nd July 1963, granted 2nd November 1965
Hunnicutt, R. (1995). Sheridan: A History of the American Light Tank. Presidio Press, California < https://www.amazon.com/gp/product/1626542538/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=1626542538&linkId=7d4cb369ce54d22e21019b10f3dd9346>
Hunnicutt, R. (1990). Abrams: A History of the American Main Battle Tank. Presidio Press, USA < https://www.amazon.com/gp/product/1626542554/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=1626542554&linkId=b3832096b6acb9793e134a615128e721>

COLDWAR AMERICAN PROTOTYPES < HTTPS://TANKS-ENCYCLOPEDIA.COM/CATEGORY/COLDWAR-AMERICAN-PROTOTYPES/>

120mm Gun Tank M1E1 Abrams < https://tanks-encyclopedia.com/coldwar-usa-120mm-gun-tank-m1e1-abrams/>

By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

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Following the failure of the MBT-70/KPz-70 joint project, the need for a new tank for West Germany and the USA (amongst others) had not gone away. One of the main points of value for those projects was the interchangeability of parts and, even after the joint project had been terminated, the desire for more interchangeability continued. In 1974, a memorandum of understanding (MOU) was signed between the as possible between the two tank programs. This was followed, in 1976, by an addendum to that 1974 MOU in which the components to be standardized were identified.

It was here that the decision was made to select the German 120 mm smoothbore gun for both tanks, although it was apparent that the first series of **M1 Abrams < https://tanks-encyclopedia.com/coldwar/US/M1_Abrams.php>** entering production would have to be armed with the M68 105 mm gun (an American-made copy of the British L7 rifled gun) instead, as the 120 mm was not ready. In 1976, the project to up gun the M1 with this 120 mm smoothbore gun was already set out, naming this first variant as the M1E1 (E = official Experimental version).

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Experimental Model Number 1

Not only was this first experimental modification of the M1 Abrams going to mount and test the German 120 mm smoothbore, but there were other plans too. Every vehicle has a certain amount of 'growth potential' – the amount which it can reasonably be expected to take and accept changes, modifications, adaptations etc. to meet future threats and stay up to date. The same is also true with the M1. Although M1E1 plans had been started in 1976, it was not until February 1979 that this growth potential investigation began with the M1E1 Block Improvement Program starting. This four-point plan was to investigate armor improvements to the front of the turret, a hybrid NBC system incorporating a micro-climate crew cooling system, weight reduction, and upgrades to the suspension and final drives. It was debated about adding an independent thermal imaging sight (CITV – Commander's Independent Thermal Imager) for the commander for the M1E1.

Adding a CITV would have given the M1E1 commander the ability to adopt an independent hunter-killer mode, able to hunt for targets even whilst a target was already being engaged by the gunner. Due to the expense involved with thermal imagers, this idea was dropped to save money. A circular port was planned to be added to the roof though so that a thermal imager could be added at a later date. The rest of the work was approved in May 1982 for work to proceed with the first M1E1 expected in 1985. The first 2 of the 14 M1E1s were delivered for testing in March 1981, ahead of the actual implementation date of the product improvement program.

> *"The M1 is now in procurement, with a small amount of development and testing yet to be accomplished. We have procured over 780 tanks as of the end of 1982. Fielding began in 1981 and will continue for a decade or more. The 120mm-gun-equipped M1E1 is now in development. The first production model M1E1 will be produced in 1985. In addition, the Army is pursuing a product development program to assure the M1 maintains its competitive position through the 1980s and beyond"*

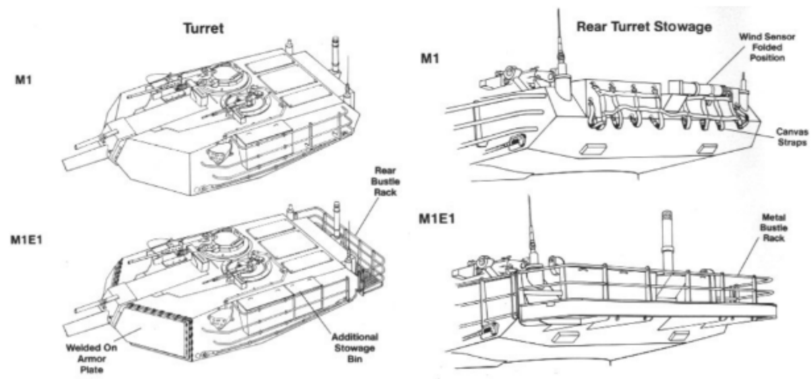
– US Dept. of the Army, 1983

M1E1 first pilot model built in March 1981. Note the wide ring fitted around the rear sprocket in an effort to prevent it from throwing tracks. Source: Hunnicutt

Blocks

Upgrades made to the basic M1 for the new M1E1 were identified as Blocks. Block I was to consist of the 120 mm gun and NBC system. Block II, which included further improvements in survivability and fire control, would not be done until the M1A1 was in service.

armament, as the United States' major NATO allies, Great Britain and Germany, were already fielding 120 mm guns (rifled and smoothbore, respectively) on their new main battle tanks. The brand new US tank was, therefore, going to end up being fielded with the cheap and effective 105 mm and was thus going to be under-armed. More to the point though, the M1 was not going to meet the requirements of incorporate some other, smaller changes too. Firstly, the amount of stowage was improved with an additional stowage box added to the turret side. The second stowage improvement was the addition of a full turret bustle rack on the back in which items could be stowed. This replaced the original canvas strap system which was slow and cumbersome to use. The final change to the turret, other than the gun and armor, was the wind sensor. On the M1 turret, the wind sensor, in the middle of the turret at the back, could be folded down. It was now fixed in place on the M1E1 turret.



Visual changes between the M1 and M1E1 turrets. Note that this graphic shows a 3-section ammo blow-off panel on the M1 rather than the original 4-piece panel. Source: Mesko

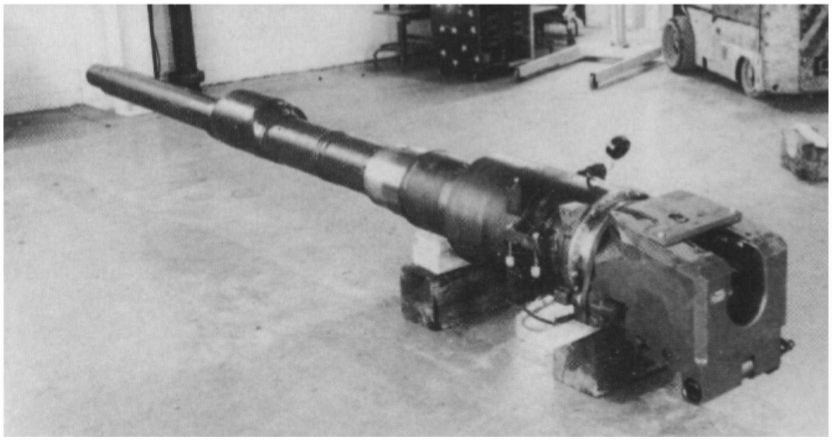
Armament M1 to M1E1

The M68A1 105 mm gun was cheap and reliable and the M1 carrying that gun could carry 55 rounds of ammunition between the hull and turret compartments. Upgrading to a larger gun, as had been considered, would reduce the amount of ammunition which could be carried. With Great Britain and Germany fielding powerful 120 mm guns on their new main battle tanks (**Challenger < https://tanks-encyclopedia.com/coldwar/UK/FV-4030_Challenger-I.php>** and Leopard II, respectively), this left the US in the position of not just using a less powerful gun but having no cross-compatibility in terms of ammunition with either NATO partner.

The German 120 mm smoothbore, made by Rheinmetall, had suffered from some development issues and was not delivered for testing to Aberdeen Proving Grounds until the first half of 1980, where it was designated as the XM256. Plans for an American-designed breech for the gun were still on the table, as it was felt that the German breech was too complex and the source of some additional problems. Those new-breech plans were abandoned as unnecessary and the German breech would be used instead, as the problems were steadily overcome and simplified. Following successful trials of the XM256 in 1980, the first 14 M1s were retrofitted with this gun replacing their 105 mm rifled guns. As such, these vehicles were designed M1E1 to test the new gun mount and other improvements. When the XM256 120 mm smoothbore gun was accepted for service for the M1A1, it was redesignated as the M256.

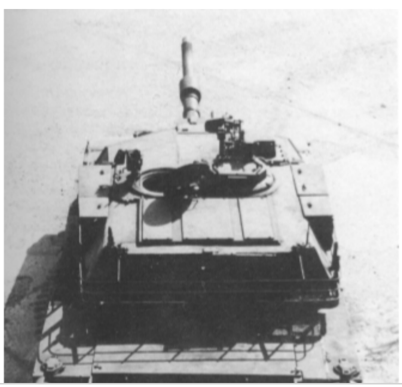
of the M68A1 105 mm gun, and which could tolerate a much higher internal pressure. When the problems with the 120 mm XM256 were resolved, there was no need for this improved 105 mm gun and the plan for it was dropped for both the M1E1 and **IPM1 < https://tanks-encyclopedia.com/105mm-gun-tank-m1-abrams-improved-performance-m1ip/>** . The XM256 was accepted for use in

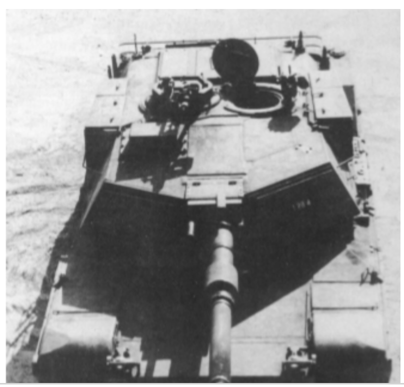
As the turret had been designed from the beginning for this larger gun, mounting it in the turret was not a big problem, although the amount of ammunition would be reduced to just 44 rounds.



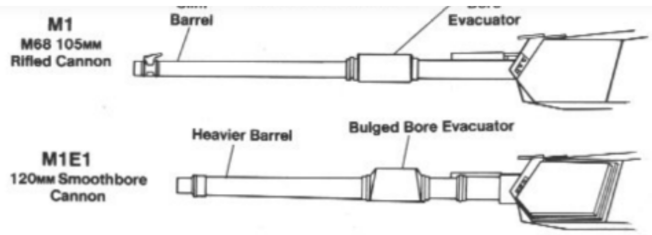
The German 120 mm smoothbore adopted for trials as the XM256. This gun is using the German breech which was initially felt to be too complex. The idea of a simpler American-designed breech was dropped and this gun was adopted later as the M256. Source: Hunnicutt

These 44 rounds were planned to be divided amongst the turret bustle (34) and hull rear (6), with an additional 4 ('ready rounds') in an armored box on the turret floor – a hangover from the M1. With the size of these unitary 120 mm cartridges though, those extra 4 were eliminated, leaving just 40 rounds for the tank. The hull stowage (6 rounds) was retained in the rear of the hull (accessed by a small door in the bottom right of the turret basket), albeit with a new size rack for the larger rounds and an improved hatch on the armored door. In the turret, the ammunition rack also had to be changed for the new, larger rounds with the shells divided into three sections in the bustle. Each of the outer sections could hold 9 rounds and the center section, divided from the other two alongside it by a bulkhead, held the main stock of rounds, with 16 more. The original blow-off panels above this ammunition store consisted of four rectangular sections on the first M1s, changed to a three-section panel, with two narrow sections surrounding a slightly wider center panel, on the M1E1. When the M1E1 was adopted as the M1A1, this 3-section panel was dropped and replaced with a simpler 2-section blow-off panel instead.





Elevated front and rear view of the pilot model M1E1, providing an excellent view of the changes to the blow-off panels and stowage on the turret. Note that, at this time, the circular panel where a thermal imager could be fitted had not yet been added. Source: Hunnicutt



Visual differences between the turret front and armament of the M1 compared to M1E1. Source: Mesko

The switch to this new, heavier and larger caliber gun also meant changes to the fire control system were needed. A new gearbox for elevation and depression of the gun, software upgrades and electronics were added in order to make this new gun workable. The coaxial gun needed some minor modifications, with a new mount for the ammunition box, feed and ejection chute, and a box to collect spent ammunition and links.

Ammunition for the XM256/M256				
Name	**Type**	**Weight (Shell / Projectile)**	**Muzzle-Velocity**	**Note**
M829	APFSDS-T	18.7 kg / 7.0 kg (41 lbs / 15 lbs)	1,700 m/s (5,577 fps)	Type classified in FY1985 as the standard combat round
XM827	APFSDS-T	19.1 kg / 4.5 kg (42 lbs / 10 lbs)	1,650 m/s (5,413 fps)	Type classified as M827 early 1983 (FY1983). Features a one-piece DU penetrator
XM830	HEAT-MP-T	24.2 kg / 13.5 kg (53 lbs / 30 lbs)	1,140 m/s (2,740 fps)	Type classified FY1985 as M830
XM859	HEAT-MP-T	*24.2 kg / 13.5 kg* (53 lbs / 30 lbs)	*1,140 m/s* (2,740 fps)	Planned follow-on round for XM830
XM865	TPCSDS-T*	19 kg / 3.2 kg (42 lbs / 7 lbs)	1,700 m/s (5,577 fps)	Type classified July 1984 (FY1984) for gunnery practice
XM866	TPFSDS-T*	*19 kg / 3.2 kg*(42 lbs / 7 lbs)	*1,700 m/s* (5,577 fps)	Interim training round
XM831	TP-T*	24.2 kg / 13.5 kg (53 lbs / 30 lbs)	1,140 m/s (2,740 fps)	Type classified April 1983 (FY1982) as standard training round version of XM830/M830
Note: All ammunition was made by Honeywell Defense Systems * Denotes training rounds Figures in italics are estimates				

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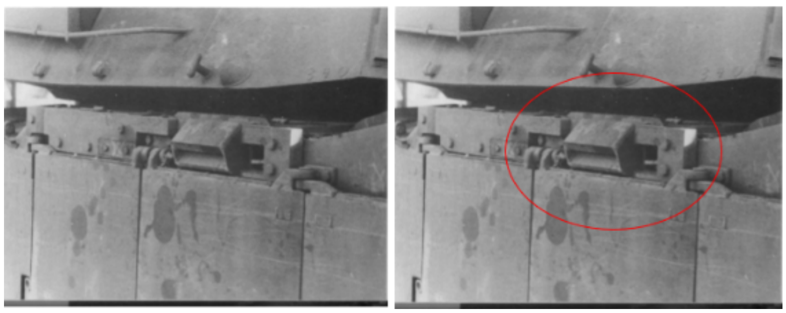
Mobility

attempt to reduce the weight of the primary construction elements of the tank. There would, in later years, be numerous 'lightenings' of components for the Abrams throughout its life to save a little weight here and there, but in 1985 the idea was to take the single largest and heaviest element, the hull, and make it lighter. The hull, which was of an all-steel welded construction, offered few options for lightening, The other mobility upgrades were dictated by the increased weight. Improved final drives and transmission for the M1E1 would increase reliability and deal with the additional load. Further, new suspension shock absorbers were fitted to the front to increase the damping effect. Less obvious was the adoption of a slightly modified road wheel with a thinner rubber tyre and wider cross-section (132 mm to 145 mm).

NBC

Somewhat surprisingly for a modern main battle tank designed to fight a modern war in Europe, which was highly likely to involve the use of nuclear, chemical, or biological weapons, the M1 Abrams had no NBC filtration system. The crew, instead, would have to wear their personal protective equipment, such as gloves and respirators, whilst fighting in the tank – an enormous encumbrance for them which would reduce their fighting ability. A key goal of the M1E1, therefore, was the addition of an NBC system which would create an overpressure within the tank to keep out contaminants and poisons, with filters being used to scrub the air being drawn in.



Port for the NBC system trialed on the M1E1, as it appears on the left side of the hull. Note: the turret is turned to the rear in the photo. Source: Hunnicutt

One M1E1 was modified for these purposes and for testing at the Natick Laboratories in Maryland. Fitted with the M43A1 detector and AN/VDR-2 radiac (mounted on the turret floor), even very low levels of chemical or nuclear agents could be detected. The M13 filtered air system, which delivered air directly to the crew's face masks as was used on the original M1, was retained as a backup system.

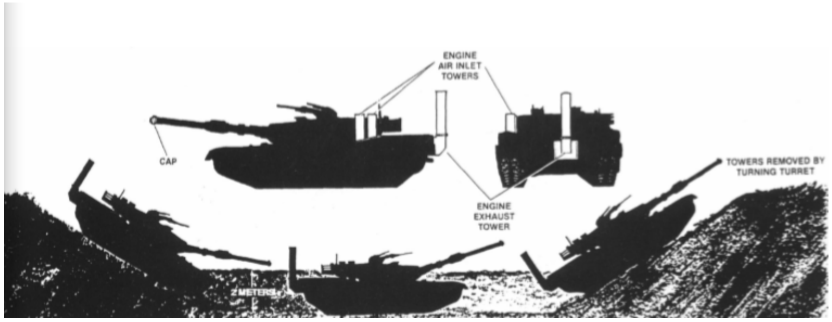
The system was to use an all-vehicle air conditioning system (macroclimate) instead of the alternative of using individual crew cooling systems (microclimate). This macro system would keep the crew comfortable inside the tank as well as filter the air coming in. However, this cooling system proved to be bulky, as it had to filter, cool, and circulate the air around the tank. The crews who took part in the testing (two crews from 2nd Battalion 6th Cavalry) were positive about the need for the new air system, but in light of the bulk and expense involved, it was decided to abandon the tank-climate system and revert to the earlier idea of a microclimate individual crew-cooling vest instead.

Other

harnesses. Minor changes continued in the turret, with a rerouting of the electrical harnesses and alterations to the commander's seat and a new knee guard for the gunner.

With a new and improved M1 underway for the Army (which would enter service as the M1A1), it was

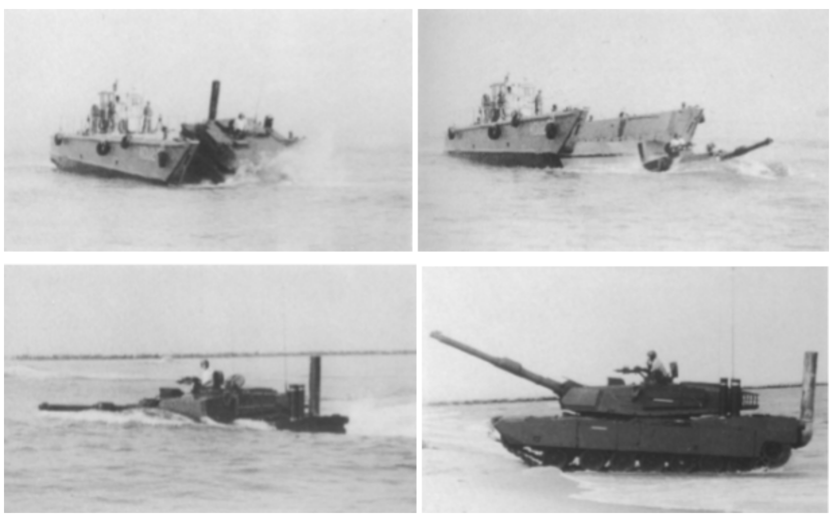
This meant that a deep water wading kit had to be designed, fitted, and trialed on the M1E1. These trails were carried out in October 1984.



Design for a deep water wading kit for a USMC version of the M1A1 which was evaluated on the M1E1. Note: after leaving the water the turret would be traversed and knock off the towers over the air inlet and exhaust. Source: Hunnicutt

Trials

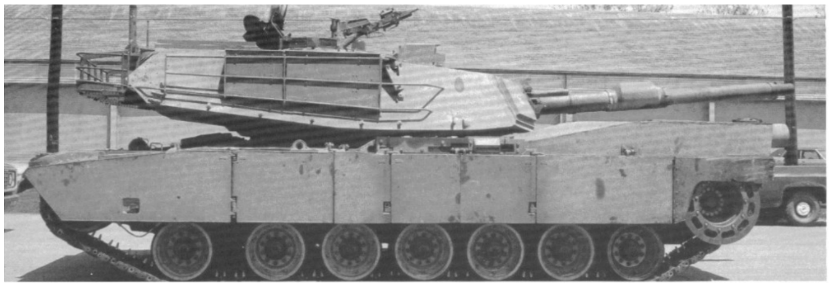
By 1984, the M1E1 was undergoing Development Test II and Operational Test II, making sure it met the requirements of the Army. The M1E1 was expected to enter production in 1985, when it would be renamed from M1E1 to M1A1. At the same time, the Army was also pursuing a program of continuing product improvement with an eye to changes and development of the M1 Abrams as a platform to meet future threats.



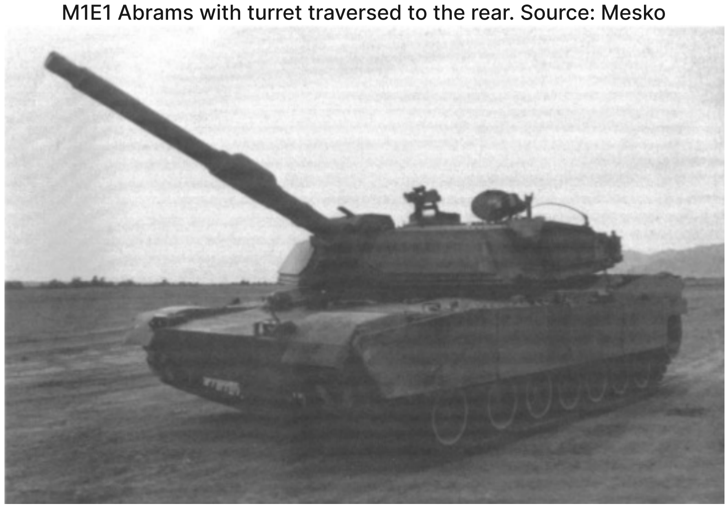
Montage image of M1E1 with deep wading kit fitted during trials in October 1984. Source: Hunnicutt

Before these trials were over, the Improved Performance version of the M1, known as the M1IP, was

A sequence of shots showing an M1E1 from above during tropical trials in Panama. Source: US National Archives



M1E1 Abrams with turret traversed to the rear. Source: Mesko



One of the 14 M1E1s as fitted with the XM256 120 mm smoothbore gun and other improvements, including substantial slabs of steel welded to the hull and turret front to mock up the weight of a new armor package. Source: Mesko

apparent. Source: Zaloga

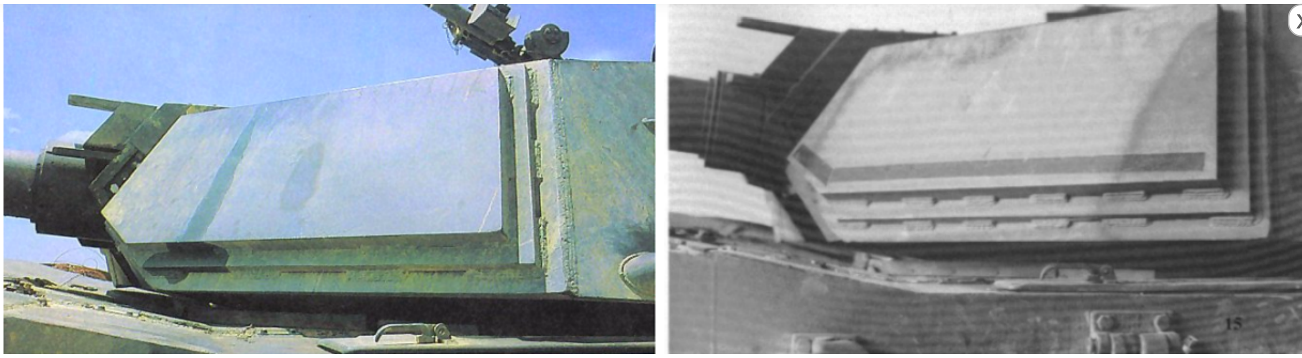
X

Armor M1 to M1E1

The most obvious changes to the M1E1 from the M1 are the new, larger gun and the large slabs of steel welded to the front of the turret. It is important to note that although these were large slabs of steel welded to the front that they were not actually additional armor in of themselves. They were added simply as weight to simulate the additional weight of the new composite armor modules being added behind the original ‘skin’ on the front of the turret. The structure and arrangement of this armor is known, although the exact composition of those special armor arrays is not. The composition of the armor is still classified, although it is known that, at this time, the Abrams was not using Depleted Uranium (DU) within the armor. This was not added until later. Nonetheless, the ‘special’ armor provided significantly better protection (weight for weight) than conventional cast-steel or rolled steel armor, making use of composite materials and spacing within the arrays. This was particularly effective against High Explosive Anti-Tank (HEAT) ammunition and less so against Kinetic energy ammunition (APFSDS – Armor Piercing Fin Stabilised Discarding Sabot).

A careful look at the front of the turret of one of the first M1E1s being evaluated clearly shows that these slabs (eventually three-thick) were added incrementally to the design during evaluation. With all of the modifications to the turret and hull, the new gun, and the additional armor, the M1E1 weighed 62 tonnes. The M1 would get even heavier throughout its life in service, far exceeding the original goals of the 1970s.

X



Two views of two of the 14 M1E1s fitted with the XM256 120 mm smoothbore gun and other improvements, including substantial slabs of steel welded to the hull and turret front to mock up the weight of a new armor package. Note that the application of welds differs for each vehicle. Source: Mesko (right) and unknown (left)

Conclusion

The M1E1 was a very successful trial project. Even though not all of the systems proposed or tested, such as the commander's independent thermal sight, were adopted on the M1A1, the M1E1 marked the step into what the M1 was supposed to be in the first place – a superior tank in all aspects to the Soviet tanks it faced for the 1980's in Western Europe. The M1 ceased production in January 1985, as new vehicles would be of the new M1A1 standard. The only aberration to the story of the M1E1 is the appearance of the IPM1, a stopgap M1 to meet the urgent need for more protection.

The M1E1 also marked the first step in what was to be a significant gain in weight for the Abrams, a trend which has continued since then, as the demand for protection has increased as the threats the tank faces change. The M1E1 is not a well-known variant of the Abrams and it never saw combat. Just 14 were made for testing and none are known to survive.

Illustration of the 120mm Gun Tank M1E1. Produced by Tank Encyclopedia's own David Bocquelet.

Specifications

Dimensions (L-W-H)	9.83 x 3.65 x 2.89 meters 113.6" h (1984 memo) 311.68" long (1984 memo) – L W H all identical to M1 hull 143.8: wide (1984 memo)
Total weight, battle-ready	62,000 kg (62.9 US tons -1984 statement) 63 tons – 1984 memo
Crew	4 (Commander, Gunner, Loader, Driver)
Propulsion	Avco-Lycoming Turbine (Petrol) 1,500 hp (1,119 kW)
Maximum speed	41.5 mph (67 km/h) governed
Suspensions	High-hardness-steel torsion bars with rotary shock absorbers
Armament	120 mm XM256 smoothbore gun 12.7 mm M2HB QCB heavy machine gun 2 x 7.62 mm MAG58 general-purpose machine guns
Armor	Hull: Welded steel with special armor inserts in the front. Composite side skirts. Turret: Welded steel with special armor inserts on the front and sides
Production	14

Sources

Hunnicutt, R. (1990). Abrams – A History of the American Main Battle Tank. Presidio Press, California, USA < https://www.amazon.com/gp/product/1626542554/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=1626542554&linkId=2e7aac5f41f3dbdaed81c76fc2bf3bb7>

Mesko, J. (1989). M1 Abrams in Action Squadron/Signal Publications, USA < https://www.amazon.com/gp/product/0897472225/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=0897472225&linkId=c1af2f5cf73fa7072077efebe84b5b22>

Janes Armour and Artillery 1985-86, Janes Information Group < https://www.amazon.com/gp/product/0710608209/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=0710608209&linkId=64e8972a452b6a9dd9a664e2572adc3c>

Lucas, W., Rhoades, R. (2004). Lessons from Army System Developments Vol. II – Case Studies. UAH

Prototype Air-Vest Microclimate Cooling system. United States Army Medical Research and Development Command, Natick, Maryland, USA

US Dept. of the Army. (1983). 1983 Weapon Systems. US Dept. of the Army, Washington D.C., USA

US Dept. of the Army. (1984). 1984 Weapon Systems. US Dept. of the Army, Washington D.C., USA

Zaloga, S. (2018). M1A2 Abrams Main Battle Tank, Osprey Publishing, England < https://www.amazon.com/gp/product/1472831780/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=1472831780&linkId=077c4c55dc83df314a918d5372b5ec20>

COLDWAR AMERICAN PROTOTYPES < HTTPS://TANKS-ENCYCLOPEDIA.COM/CATEGORY/COLDWAR-AMERICAN-PROTOTYPES/>

LVTP-77 Cybernetically Coupled Amphibian & Articulated LVT < https://tanks-encyclopedia.com/colwar-usa-lvtp-77-cybernetically-coupled-amphibian/>

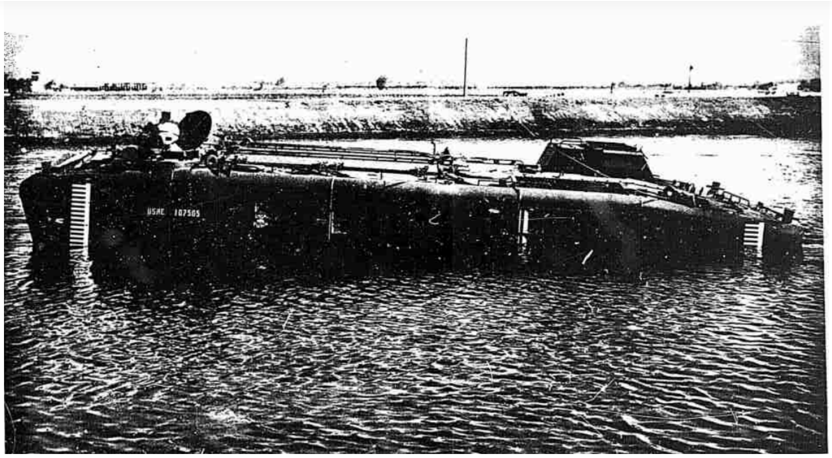
By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

April 23, 2020 < https://tanks-encyclopedia.com/colwar-usa-lvtp-77-cybernetically-coupled-amphibian/>

No Comments < https://tanks-encyclopedia.com/colwar-usa-lvtp-77-cybernetically-coupled-amphibian/#respond>

< https://www.tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> U.S.A. (1966)
Research Vehicle – 1 Built

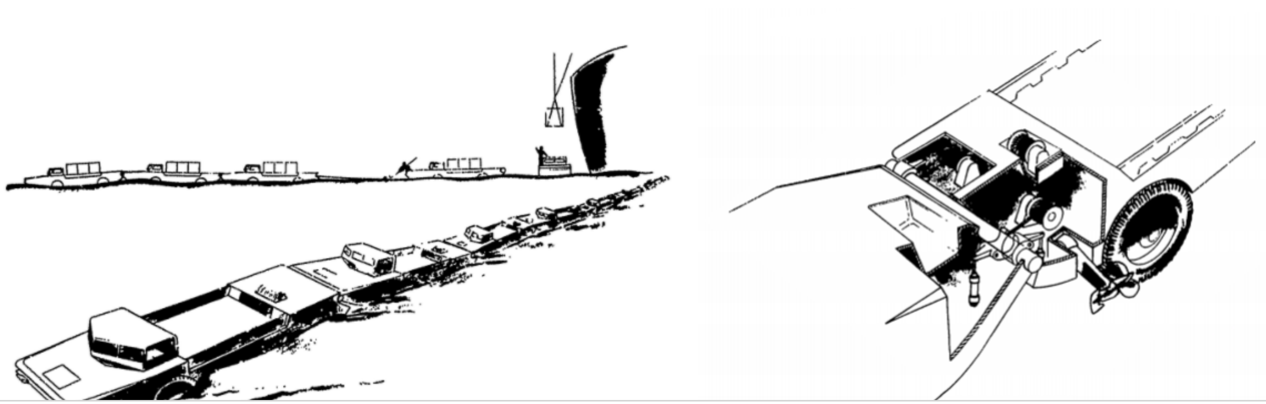
Ideas about coupling vehicles together and of an articulated body for fighting vehicles are as old as tanks themselves. Coupling two vehicles together offers the designer some significant benefits for mobility and design for a variety of roles, one of which was with amphibian tanks.



Unladen LVTP-5 in the water showing her trim line, later a coupled LVTP-5 was attempted. Source: Dyck and Ehrlich

Amphibian tanks, which can operate on land or in water, have unique challenges to overcome. They have to be buoyant enough to float and yet armored sufficiently to protect the troops and then they still have to deal with the difficult transition from water to land. A coupled or articulated vehicle has the advantage of being long enough to straddle this boundary between water and land and potentially, of being able to cross bigger obstacles than a single-hulled vehicle.

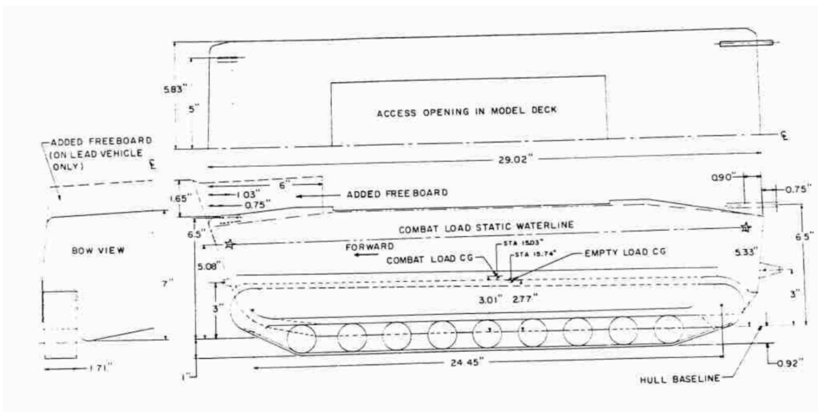
With that in mind, the US Navy started work as early as 1966 studying the effects, benefits, and costs associated with coupling amphibian vehicles together. That study followed work between 1956 and 1958 focusing solely on improving water speeds for amphibian vehicles although due to time and financial constraints it was limited only to wheeled vehicles. Although those tests were inconclusive the one bright light from them was the testing of the 'Sea-Serpent' (not to be confused with the amphibian flame-thrower vehicle of the same name). Sea-Serpent was the name given to a multi-vehicle amphibian train of up to eight vehicles coupled together which managed a combined speed double that of one of the single vehicles.



Building on this finding for such a novel vehicle, in 1966, Davidson Laboratory (DL) looked at the problem from the point of view of tracked amphibians and concluded that it was feasible to couple together up to five **LVTP-5s < https://tanks-encyclopedia.com/coldwar/US/LVTP-5.php>** and that this military advantage and clearly this success meant there would be further work in this area to expand on this.

The DL experiments did not use actual LVTP-5 but instead accurately shaped and weighed models in a test tank with them connected together by means of simple pin connections at the height of the center-of-gravity (CoG) of the vehicles.

One problem identified during these 1966 tests was that the increased vehicle speed produced an increased sized bow-wave with a consequent increased risk of swamping of the lead vehicle (as there is no bow wave for any of the following vehicles). To counter this, a freeboard shield would be required to be fitted to the lead vehicle of any LVTP-5 train regardless of length (Tests conducted during the 1970's with **coupled < https://tanks-encyclopedia.com/coldwar-us-m226-coupled-research-vehicle/> M113 < https://tanks-encyclopedia.com/coldwar/US/M113_APC.php>** s also showed this additional freeboard shielding used). Additionally, as a larger freeboard shield was required for any length of LVTP-5 train, it was also found this had the side benefit of itself reducing drag in the water by 5%. In calm water, it required zero freeboard at 7.1 mph (11.4 km/h) and 12 inches (305 mm) at 7.6 mph (12.2 km/h). At 8.3 mph (13.4 km/h) however, she would need 20 inches (508 mm) of freeboard – the same amount as required unladen at 10 mph (16.1 km/h).



Schematics of the 1/12 scale model used for the coupled LVTP5 trials showing the size of the additional freeboard protection required. Source: Dyck and Ehrlich

Spacing

Vehicles used in an amphibian train had to be carefully positioned to reduce drag and the ideal gap between vehicles was found to be 1 foot (300 mm) compared to the original 6 feet (1.8m). This close-coupling reduced drag in the water by 15% and thereafter all testing was done with little or no gap between vehicles. Even with the drag reductions and freeboard changes though, the entire train was still effectively limited to a safe speed of 9.2 mph (14.8 km/h) in the water to provide a margin of safety for

more than 25 degrees, their train broke apart. Obviously, in a real-world situation, this would have proven extremely hazardous.

The 1966 experiments ended with strong recommendations to pursue this modeling to the prototype

M113 CCRV project during snow trials. The vehicle could be controlled from either front or rear vehicle.
Source: TACOM/TARDEC

A Project Reborn

The work in 1966 had shown the potential for coupling for amphibians but also highlighted the lack of knowledge in coupled-vehicle systems. As a result, in 1972, money was put aside by Congress for work on cybernetically coupled technologies with positive feedback controls to tray and leverage this coupling technology. The following year (1973), two M113's were modified and coupled together to form the **M226 Cybernetically Coupled Research Vehicle (CCRV) < https://tanks-encyclopedia.com/coldwar-us-m226-coupled-research-vehicle/>** . That work showed, once more, great potential. Combined, the two vehicles exhibited greater mobility off-road than an individual vehicle, particularly when it came to obstacle crossing, and used a more controlled system for the coupling compared to the rather crude pin-attachment in the 1966 experiments. This time, instead of an uncontrolled pin vulnerable to excess pitch (in the water) and excess yaw (on land or in the water), the M113 CCRV connector limited movement to a maximum articulation of +/-45 degrees and a yaw of +/-30 degrees.

Control for the system was by means of a simple joystick with positive feedback in all cases, except for pitching where the feedback caused some problems. A simple movement of the driver's joystick would control the hydraulic arms on top of the vehicle to move the two hulls relative to each other as well as providing stiffness preventing too much pitch and yaw.

The conclusion of the trials in 1974 had proven the experiments in 1966 to be partially correct. A coupled vehicle did exhibit manoeuvrability benefits over the single hull system. Some specific recommendations and findings about the coupled-vehicle system came out of the project including the reduction of water resistance for amphibious vehicles and assisting amphibious assault vehicles in breaching defences.

LVTP-7's

Irmin Kamm, from the Stevens Institute of Technology and one of the lead authors for TACOM on cybernetically coupled vehicles had already worked on amphibian trains coming up with the Sea-Serpent

study saying "the advantages [of a coupled vehicle] exceed the drawbacks, it is recommended that existing vehicles be coupled and tested to establish their operational capacity". The end-user was being clearly identified as the US Marine Corps just like before but the requirements had changed a little. Instead of a coupling permitting +/-45 degrees and a yaw of +/-30 degrees as on the M113 CCRV, this

Instead of the A-frame drawbar connected to a ball and two hydraulic actuators, this time, the system would be simpler. That older system had to be connected manually but with a new cone-into-cone system, the vehicles could connect or detach on sea or land without having to stop and get out. Each vehicle would simply have a 'male' convex cone on the front and a 'female' concave cone on the rear, with both located at the center of gravity line. This system was much more versatile. Instead of a master-and-slave unit, as with the M113 CCRV, this time any vehicle so equipped with a coupling cone could connect to any other on sea or land adding a new level of capability to the idea.

Just as before, control over pitch and yaw was performed by either lead or following vehicle by means of a joystick (although a steering wheel was also considered in the study) and the engines would be synchronized to produce the same output. Transmission and braking was to be changed manually though.

With two LVTP-7's coupled together in this system, the expected performance increases were impressive at a price of additional weight of controls and fittings and a reduction in the internal space in each vehicle. Another note was that the coupled vehicles presented a slightly larger target to enemy fire although from the front the area exposed would obviously be the same. Coupled together, the vehicle would also get a new name. It was to be the LVTP-77.

Comparison between LVTP-7 and LVTP-77 (on land)				
Vehicle	**Trench**	**Step**	**Short slope negotiation**	**Cross-Country Speed**
LVTP-7	8 feet	3 feet	39°	nominal
LVTP-77	14 feet	7 feet	100°	+75%

Comparison between LVTP-7 and Coupled LVTP-77 (in water)				
Vehicle	**Drag from water**	**Max. speed in water (calm)**	**Max. speed in Water - Sea State 2 (waves)**	**Pitching in Sea State 2 (waves) at 4 - 6 mph**
LVTP-7	nominal	7 mph	6 mph	nominal
LVTP-77	-75%	>7 mph (up to estimate 11 mph)	10 mph	-50%

Articulated LVT

The name 'LVTP-77' appears here for the first time as it is two LVTP-7's coupled together and rather than sum the two 7's to make LVTP-14, akin to what was done adding together the '113' part of the two other concept investigated by Kamm as an alternative. This was an articulated vehicle made from multiple-units comprising a single vehicle rather than two or more vehicles combining.

This articulated vehicle would have two sections of 14 feet (4.27m) and 19 feet (5.80 m) respectively fore and aft with a single 890 gross horsepower engine and weighing 54,000lbs (24.5 tonnes). The fore-section contained the engine and transmission and the rear section contained all of the crew, and an auxiliary engine.

Kamm articulated LVT compared to LVTP-7 and LVTP-77 on land				
Vehicle	**Trench**	**Step**	**Short slope negotiation**	**Cross-Country Speed**
Articulated LVT	14 feet	4 feet	58°	+75%
LVTP-7	8 feet	3 feet	39°	nominal
LVTP-77	14 feet	7 feet	100°	+75%

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The 1979 study had concluded that a coupled amphibian was not only possible and beneficial but also desirable, as was an articulated LVT. The recommendation going forwards was to design, install and test a suitable coupling on either a pair of LVTP-7's or LVTPX-12 vehicles.

Coupling the LVTP's

With the M226 CCRV, it was simple. It was just a test rig so it did not really matter if the combat capabilities, such as the troop space, were severely hampered. For the actual project with LVTP-7's or others, the rear ramp and emergency exits had to be kept clear, as would the cargo hatch. Unlike the M226 CCRV, the coupling had to be remotely connectable and disconnectable on land or water and each vehicle had to be able to operate as either the master or the slave. For an articulated LVT, the vehicle was to be limited to 33' (10.06 m) and had to be equipped with a rear exit ramp and top cargo hatch. The restriction of just one driver was not a problem, but the articulated vehicle was also supposed to be able to dump one part of itself and be able to operate independently on land if needs be. Hence, the reason for the auxiliary engine in the aft unit of the articulated LVT design.

There were 12 separate coupling systems suggested for the coupled LVTP, but only a single viable design for the articulated LVT. The types of connections considered were ball joint, off-center ball joint, symmetrical yaw, symmetrical yaw with independent pitch control, dependent pitch and yaw, dependent pitch and yaw with coupling frame, yaw – no roll, pitch only, turntable, trunnion mount, trunnion mount-

remote coupling. In keeping with articulated and coupled vehicles though, the turning radius was large, 35' (10.7 m), over twice as big as a single LVTP-7 but substantially less than either the coupled M113CCRV or the LVTP-77.

Turning radii of single and coupled vehicles compared to articulated LVT concept	
Vehicle	**Turning radius**
Single M113	24’ (7.3m)
M113 CCRV (M226)	40’ (12.1m) to 41’ (12.5m) (1979 data)
LVTP-7	15’ (4.6m)(1979 data) 16 ½ ‘ (5.0m)
LVTP-77	61’ (18.6m)
Articulated LVT	35’ (10.7m)

All of the pitch and yaw controls were completely contained within the vehicle with steering by the simple means of yaw control from the driver. The front unit’s 850 ghp engine would be supplemented by a 100 hp auxiliary engine in the back providing some very limited mobility in the absence of the lead unit or if it became damaged by enemy fire. In the normal situation though, this 100 hp engine was used only for driving the pumps for moving the actuators for the coupling.

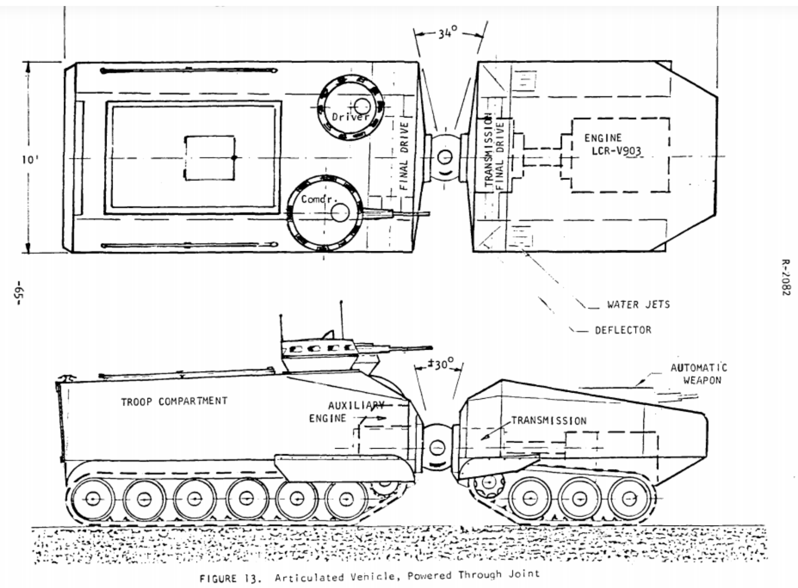
Power in the water was to be provided by water jets enclosed in the fore sections powered from the main engine. Although it would be more efficient in water-drive terms to have them in the rear section, it was a more efficient use of weight and space to have them in the front. Steering in the water was by means of water deflectors in the jets which moved in conjunction with the yaw of the vehicle for efficient steering. The articulated vehicle would only need one driver who was required to be in the rear although was ideally to be in the front section for visibility. The coupled vehicle concept, on the other hand, would require a driver in both sections to ensure smooth operation and obviously would not need to couple up remotely. In an emergency, it could decouple from the front unit by means of an explosive bolt – in this was the driver did not have to get out at all.

Having conducted various analytical work on the concepts for arrangements of the LVTP-7 and **LVTPX-12 < https://tanks-encyclopedia.com/coldwar-us-assault-amphibian-personnel-carrier-lvtpx-12/>** models, trials were carried out and once more confirmed the efficiency of coupling an amphibian. Unlike the coupled LVTP-5, which does not appear to have gone further than the concept stage, there was work carried out between 1979 and 1980 on the LVTP-7 project.

The Articulated LVT

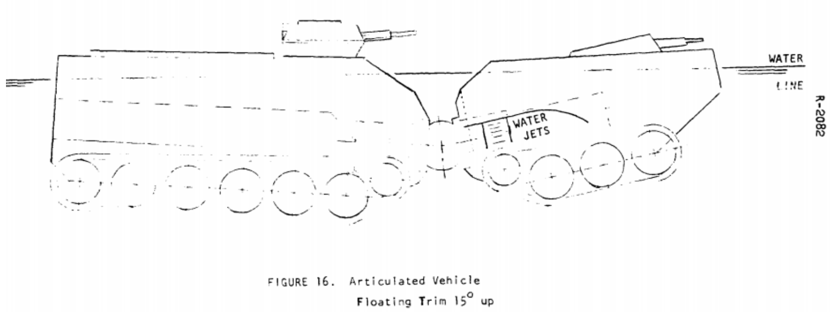
The other part of the project which seems to have gained no traction was the Articulated LVT. Despite being better in many regards than the M226 and LVTP-77, simpler, no remote coupling or uncoupling, a single driver, etc., the project simply did not get anywhere yet was a fairly straightforward design. Two sections, engine at the front with the crew at the back, it could pitch through +/- 30 degrees and yaw to

through the water just as well as the LVTP too. An added advantage was that this fore-section would also be the first part coming out of the water to draw enemy fire but, being completely unmanned, did not matter. Instead, it actually served to provide substantial protection for the aft section and in the event of



Drawings of the proposed Articulated LVT. Source: Kamm and Nazalwicz

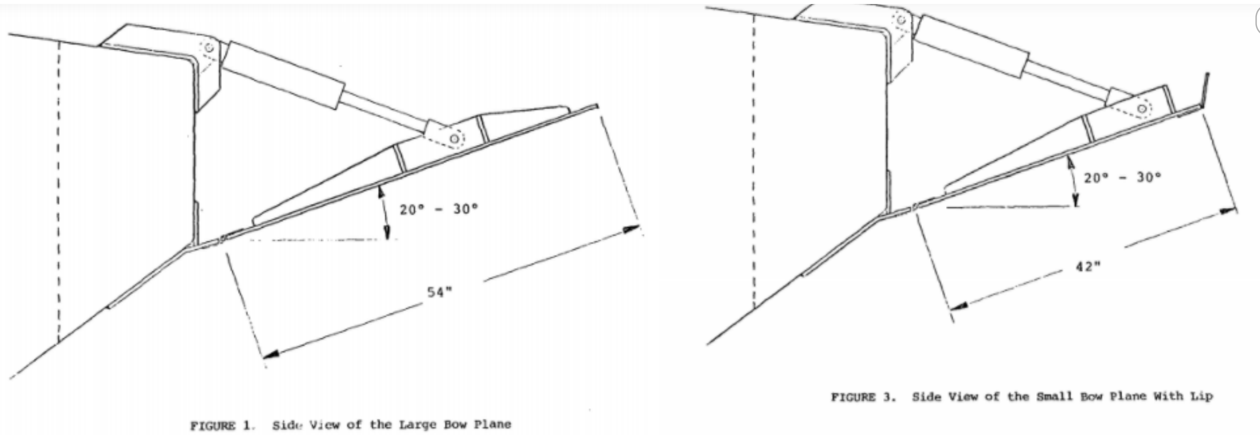
Floating in the water, the fore section with the water jets tilted upwards sharply directing the water jets down whilst the main vehicle was relatively level behind it. Poking out just above the water from this fore section was another weapon, remotely operated and forming the primary weapon for the design specified only as an 'automatic weapon'.



Drawings of the proposed Articulated LVT. Source: Kamm and Nazalwicz

Putting the LVTP-77 Concept Into Reality

(152.4 mm) lip. The vehicles were tested for speed at Courthouse Bay and at the Battalion Maintenance Pier followed by open water tests in the open ocean off Onslow Beach, all at Camp Lejeune, compared to an unmodified vehicle and a 'jury-rigged' coupling between two LVTP-7s.



Arrangements of the experimental bow planes tested on LVTP7s at Camp Lejeune 1979-1980. Source: Kamm and Nazalwicz

Results of LVTP7 tests at Camp Lejeune 1979-1980	
Vehicle	**Max speed in calm water without swamping**
Unmodified LVTP-7	6 mph (swamped at 6.5 to 7 mph included water entry in driver's hatch)
54" bow plane	6 mph - reduced swamping
42" bow plane	6 mph - reduced swamping
42" bow plane with 6" lip	6 mph - reduced swamping
Coupled vehicle (LVTP-77) with normal bow plane (both vehicles driven)	7.5 mph (with or without bow plane)
Coupled vehicle (LVTP-77) with normal bow plane (only rear vehicles driven)	7 mph (with or without bow plane)

The results showed that the increased bow planes did not directly affect speed by reducing drag, but did reduce swamping which allowed for a small increase in speed. Regardless, however, the coupled LVTP-77 was faster by about 0.5 mph (0.8 km/h) in all conditions even without a bow plane and the method of coupling was inadequate with the vehicles too far (about 24 inches / 610 mm) apart, something known to increase drag. Had the coupling been properly constructed and fitted no doubt further improvement could have been made.

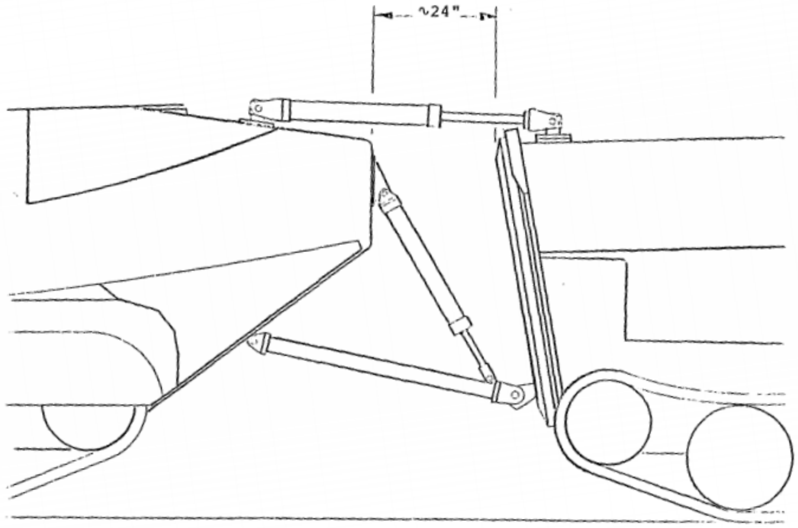


FIGURE 4. Side View of the Coupling Mechanism

Experimental coupling tested at Camp Lejeune for two LVTP7's. Source: Kamm and Nazalwicz

Very poor quality image showing the two LVTP-7's coupled together during open water testing. Source: Kamm and Nazalwicz

The tests concluded that a new bow plane should be designed and made for the LVTP-7A1 to reduce the swamping experienced at even 6.5mph in calm waters and further work should be done on the coupled LVTP idea. The gap between the vehicles was going to be a problem though, the requirement for the ramp to still lower guaranteed the vehicles had to be too far apart to make complete use of the extra efficiency when in the water.

coupling were simply returned to USMC service straight after the trials. The articulated LVT was even less successful. Despite being the logical solution to the coupling development, it never got past the proposal stage. The LVTP-7 was serviceable and available and budgets, seemingly, were better spent elsewhere rather than on a relatively small improvement to an existing vehicle.

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Illustration of the LVTP-77 Cybernetically Coupled Amphibian produced by Tank Encyclopedia's own David Bocquelet

Specifications (LVTP-77)

Total weight, battle ready	103,968lbs (47.2 tonnes) to 106,500lbs (48.3 tonnes)
Crew	Minimum 1 (driver), ideally 2 (one in each vehicle)

Specifications (Articulated LVT)

Dimensions	33 ft x 14 ft x 19 ft (10.06m x 4.27 x 5.79 meters)
Total weight, battle ready	54,000lbs (24.5 tonnes) fore section 15,200lbs (6.9 tonnes), and aft section 38,800lbs (17.6 tonnes)
Crew	Minimum 1 (driver)
Propulsion	main engine LCR-V903 890hp, auxiliary engine 100hp
Armament	primary automatic weapon in fore section controlled remotely, secondary weapon on commander's turret on aft section

Sources

Cybernetically Coupled Research Vehicle. (1974). Ronald Beck and Irmin Kamm, Stevens Institute of Technology, USA

Irmin Kamm and Jan Nazalwicz. Ship Research and Development Center, Office of Naval Research, Department of the Navy.

Drag Studies of Coupled Amphibians. (1966). R.L. Van Dyck and I. R. Ehrlich. Office of Naval Research,

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Analysis of Obstacle Negotiation by Articulated Tracked Vehicles: The State of the Art. (1981). Peter Brady. Naval ship Research and Development Center, Office of Naval Research
High Speed Wheeled Amphibian: A Concept Study. (1969). C. J. Nuttall and Irmin Kamm. Davidson Laboratory, Stevens Institute of Technology, USA
An Evaluation of the Coupled LVT Concept. (1979). Irmin Kamm, Peter Brown, and Peter Brady. David Taylor Naval Ship Research and Development Center, Stevens Institute of Technology, USA

COLDWAR AMERICAN PROTOTYPES < HTTPS://TANKS-ENCYCLOPEDIA.COM/CATEGORY/COLDWAR-AMERICAN-PROTOTYPES/>

Ridlon's Main Battle Tank < https://tanks-encyclopedia.com/coldwar-us-ridlon-main-battle-tank/>

By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

April 17, 2020 < https://tanks-encyclopedia.com/coldwar-us-ridlon-main-battle-tank/>

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< https://www.tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> U.S.A. (1962-1963)
Main Battle Tank – None built

By 1962, the 105 mm Gun Tank M60 < https://tanks-encyclopedia.com/coldwar/US/M60_Patton.php> was still a new tank in service with the US Army but, just like any current system, was already being considered for future replacement, redevelopment

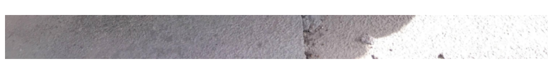
an open competition for the design of a new tank. Of the designs submitted, some were clearly better thought-out and practical in terms of production, cost, and combat effectiveness than others.

Nonetheless, the competition formed part of one means by which the US Army could assess new and electrical engineer by trade. He submitted a quad-track tank with a crewless turret propelled by a hybrid-drive system based on the M60.

Everett Ridlon 26/7/1934 – 9/7/2011. The designer of the tank. Source: Armor Magazine

Suspension

Probably the most obvious thing about Ridlon's design is the suspension. Six wheels on each side divided into groups of three with a strong angling at the front and back respectively. Assuming the raised wheel at the front of the lead unit and rear of the rear-most unit were the drive sprockets this provided a strong degree of redundancy in the design so that should one unit become damaged by enemy fire or a land mine or accident, the vehicle would not be immobilised. Each wheel was held on a single arm providing a good degree of movement and is reminiscent of the suspension arms of the M60. If it was just like those on the M60, then the arms would be hydraulically damped in their movement.

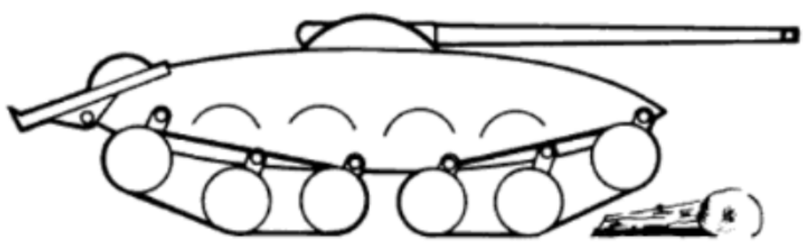


Viewed from the front of the tank the curved lower hull of the M60 is clearly similar in style to that envisaged by Ridlon and shows how these suspension arm units would have to project from a curved body.

Hull

The design of this vehicle was not going to need a new tank hull, as Ridlon simply planned to reuse the lower hulls from the M60. He proposed stripping out of the original drive components and fitting a new engine and the motors. On each side in the middle, where the two track units were closest to each other, the road wheels would be on the ground, creating a large empty space above them. This meant that the new upper hull of the M60 donor tank was going to need to bulge out across the side to improve the ballistic protection in that area.

Within the hull would sit the two crew along with the myriad of engines and motors proposed. In amongst all of this would be compartmentalised storage for fuel, compressed air, hydraulic fluid, water, fire extinguishers, and other items which were seen as being able to add to the protective structures around the crew.



Ridlon's crude and un-detailed sketch of a future main battle tank. Source: Armor Magazine

Armor

The lower hull would be that of an M60, but the upper half would be remade to feature a large curved section across the top half bulging out at the sides to make use of the low section above the ends of both track units on each side. Further, Ridlon wanted the armor to be made in sections so that, as it was hit by enemy shells, the outer sections would break away on impact. To accomplish this, he wanted the outer sections of the armor to be made 'soft', with 'hard' armor on the inside, in what he describes as a "live" system. Further, he stated "the outer armor is composed of ribbed interlocking plates which give greater depth of armor and less weight as well as catch the projectile higher on the sides and thus disperse impact energy over a larger surface area". The whole plan was not practical in that sense, but it could be considered as modular as each damaged section could at least be replaced.

Firepower

The drawing of the turret and main armament is almost comically poor, with an impossibly small turret

Ridlon also proposed rocket tubes should be placed in the upper hull, capable of attacking ground or airborne targets.

Ridlon, somewhat preciently for a US Main Battle Tank, proposed the use of a very small 'gas turbine', that is, a turbine-type engine running on petrol. This engine was not to directly drive the tank though, but was to drive a series of small high-speed homopolar generators. Each of these generators would be spread around the vehicle to minimize the chance of a single one becoming damaged and incapacitating the vehicle. Ridlon envisaged this system being duplicated for all military vehicles, as the humble **Jeep < https://tanks-encyclopedia.com/ww2/US/Willys_Jeep_MB.php>** would need just a pair of these small generators, a truck three and eight for a tank. Ridlon proposed eight small turbines working together to deliver power to thirty-two motors which powered the four sprockets which drove the tracks. The idea was that, by increasing the number of possible drive options, it would be impossible to be crippled by the loss of any one drive unit, motor or generator. The chances of all of those elements being made to work without something breaking seems highly optimistic even though it is the best part of his design considering elements of protective redundancy in the drive units to avoid being crippled and vulnerable to enemy fire. Rearranging the automotive elements of the tank to multiple small motors and generators would have made significant changes to the internal layout possible but that was beyond Ridlon's skills as a designer, which perhaps explains why the drawing was so poor and the ideas on armor so poorly conceived.

Conclusion

Ridlon's design took third place in the Armor Association's competition, behind the **Forsyth brothers' coupled-tank < https://tanks-encyclopedia.com/coldwar-usa-lockheed-forsyth-tank/>** and **Eischen's MBT < https://tanks-encyclopedia.com/coldwar-usa-luxembourg-eischens-main-battle-tank/>**, yet is drawn and described very crudely. The design appears utterly impractical with multiple complex systems, yet was held in high regard by the Armor judges. The question is why?

Perhaps it was a combination of novelties of the ball unmanned ball turret, the hybrid drive, the compartmentalization or some or all of those, but whereas the Forsyth design was a competent and well-thought-through design, this vehicle was simply impractical and an example of fantastical thinking for the time. There was no likelihood this vehicle would ever have been built and its inclusion in third place seems surprising given other better thought out designs. Ridlon did better than his tank design did, by 1970 he was teaching at a technical college before retiring in 1992. He died of lung cancer in 2011.

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Specifications

Crew	2
Propulsion	Petrol-Electric (8 Petrol turbine driving 32 high speed homopolar generators)
Armament	2 machine guns, cannon, surface to air/ground missiles

Sources

Armor Magazine January-February 1963
Hibbing Daily Tribune, 12th June 2011 'Everett Philip 'Babe' Ridlon

COLDWAR AMERICAN PROTOTYPES < HTTPS://TANKS-ENCYCLOPEDIA.COM/CATEGORY/COLDWAR-AMERICAN-PROTOTYPES/>

Composite M2 Bradley IFV < https://tanks-encyclopedia.com/coldwar-usa-composite-m2-bradley-ifv/>

By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

April 10, 2020 < https://tanks-encyclopedia.com/coldwar-usa-composite-m2-bradley-ifv/>

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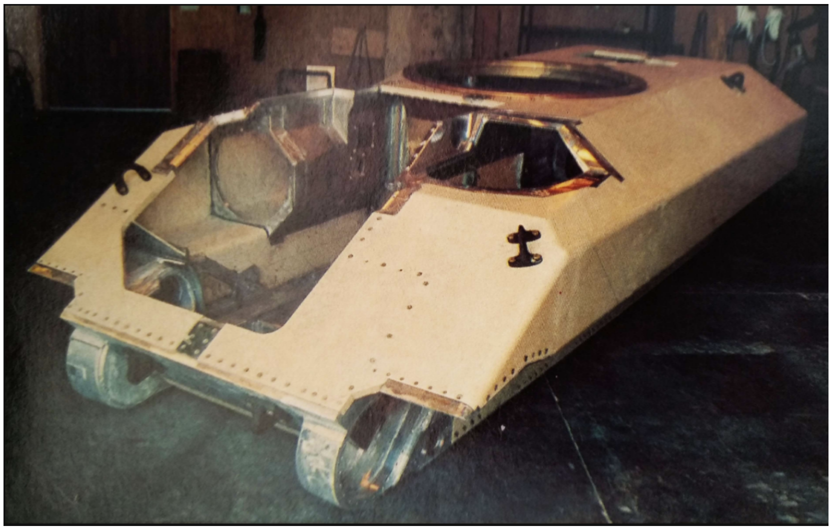
< https://www.tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> U.S.A. (1983-92)
Infantry Fighting Vehicle – 1 Turret & Hull Built

reducing protection, they come with an often very steep price tag as well as other problems. One idea from the early 1980s was the possibility of using a new generation of fiber-reinforced plastics to form the hull of armored fighting vehicles, which led to the creation of a **composite body < https://tanks-encyclopedia.com/coldwar-us-m113-grp-hull-feasibility-demonstrator/> M113 Armoured Personnel Carrier (APC) < https://tanks-encyclopedia.com/coldwar/US/M113_APC.php>** . Whilst the M113 was already obsolete and being replaced with the M2 Bradley Infantry Fighting Vehicle (BIFV), the glass fiber composite technology had shown the potential of not just reducing weight of the new APC but also of increasing protection at the same time. The composite used on the M113 was rather basic and would be improved with the first generation of integrated ceramics to provide improved ballistic protection.

Composite-hulled M2 Bradley Infantry Fighting Vehicle with non-composite turret. Source: Pilato and Michno

At the same time, Food Machinery Corporation (FMC) of San Jose, California, the parent firm for the M113, undertook the development of a composite turret for the Bradley with the project starting in 1983, manufacturing 5 turrets by the middle of 1987. Unlike the 'double sandwich' of the hull used on the M113, this turret composite was a single layer of polyester bonded S-glass. Overall, the turret was identical in shape and layout to the standard M2 Bradley turret except that it was made in two halves with the resin impregnated glass fiber cloth and then joined together with a metal frame. Making the turret out of S-2 glass fiber/polyester resin composite saved 15% over the weight of the original turret structure with similar levels of ballistic protection. This turret design was then sent for firing trials at Camp Roberts, California, in Autumn 1986. These appear to have been successful, as, by September that year, FMC was awarded a further contract from the US Army Materials Technology Laboratory (M.T.L.), Watertown, Massachusettes to develop this idea further with a composite hull for the entire vehicle.

This hull is referred to technically as Glass Reinforced Polyester (GRP) hull, but often shortened simply to 'plastic'. The structure of this vehicle was essentially the same as that of the composite turret, consisting of just a polyester bonded S-2 glass fibre, and fabricated in two halves (with the floor panel as a single piece rather than having a seam) which were then joined together using an aluminium alloy frame. Unlike the early tests of the composite M113, this was simpler to produce, lacking the 'sandwiching' of the earlier trials. Metal was not eliminated completely either from the prototype, as the turret ring remained metal, as did many of the fittings and the whole rear ramp arrangement. The aluminium frame providing the stiffness for the hull and to which the halves were attached also served saving of 25% over the original metal structural panels. Work on the composite turret would be less successful and indicate that switching out just the aluminium-armour parts for composites could result in a weight saving of 15.5%.



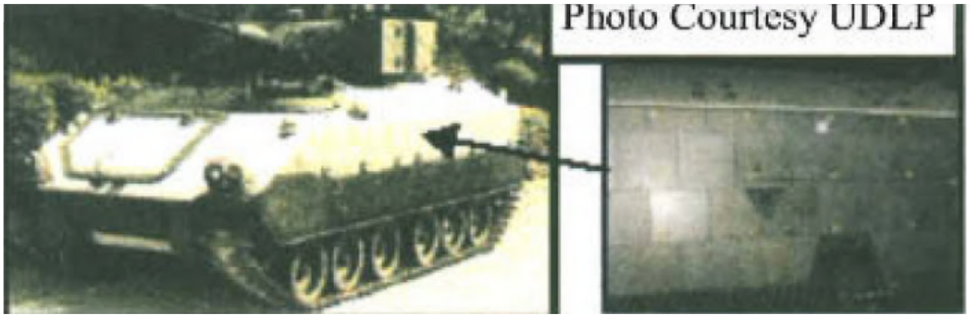
The fabricated hull showing the composite construction. Source: Army Research Development and Acquisition Bulletin, 1990

Unlike the marginal improvements with the M113 composite hull, the weight saving for the Bradley composite was large, 27% lighter than the standard hull, even with the additional ceramic exterior tiles as applique armor.

Just like the turret, the hull was tested ballistically too. In terms of protection, it was more resistant against explosive blasts and more resistant to spalling than the standard M2 Bradley. The tests had been successful and significant savings in weight could be made, although the cost of mass production of such hulls, not to mention longevity issues, were still to be addressed. One additional advantage of the plastic hulled vehicle was that it had better thermal properties than the metal hull. It stayed cooler and was less prone to overheating, providing better insulation. On paper at least, it was successful enough that in 1992 a new project was started known as the **Composite Armored Vehicle (CAV) < https://tanks-encyclopedia.com/composite-armored-vehicle-advanced-technology-demonstrator-cav-atd/>** , intended to develop the technologies needed to produce a range of composite hulled military vehicles. That project was developed by United Defence as the third generation of their program of ceramic composite armor development with the Bradley constituting generation 1 and the M8 AGS, generation 2.

Protection

With the majority of the aluminium hull replaced with the S-2 glass fibre composite, the vehicle had structure but lacked the ballistic protection required to protect against the Russian 14.5 mm round. As a result, the vehicle was designed to take special ceramic tiles bolted to the outside. These tiles were made from TiB_2 (titanium diboride), an extremely hard material (1800 Knoop, a hardness test unit for very thin or brittle materials) with a high melting point (2970 Celsius) and high density (4.52 g/cm3). Compared to steel with a density of 7.85g/cm3 and aluminium 5083 armor with a density of just 2.66g/cm3, TiB_2 lay half way between the two materials but was more than ten times harder than aluminium (1800 Knoop vs 109 Knoop). These rectangular tiles were overlaid with each other in a 'brick'



Tile pattern on side of the BIFV. Source: McCauley et al

Composite-hulled M2 Bradley Infantry Fighting Vehicle with non-composite turret. Source: Richard Eshleman

Problems

Ignoring issues with the weight, there was a more fundamental problem with the composite body for the M2 Bradley. Just as was found during the same tests with the composite body for the M113, the new plastic hulls exhibited significant longitudinal twisting during testing. In comparative testing though, the small M113 came out better than the larger M2 Bradley in this regard. When fitted with engine, hatches and equipment etc., it simply showed less twisting along the longitudinal axis. Both designs showed themselves equally good at absorbing vibrations, with the plastic hull better than the metal versions.

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Rear view of the testbed vehicle circa 1989. Source: Army Research Development and Acquisition Bulletin, 1990

The completed FMC Composite M2 Bradley Infantry Fighting Vehicle (BIFV) was shown off to 200 assorted military, media, and FMC representatives in June 1989 when it was unveiled by General Louis Wagner, then head of the US Army's Materiel Command. From this public unveiling, it was taken to Camp Roberts in California for 6,000 miles (9,656 km) testing under real-world conditions. Optimistically at the time, the composite BIFV was seen as being able to deliver a 25% weight saving along with improvements to vibration, noise reduction (10dB), reducing spall, lower radar signature, improved thermal efficiency, improved protection against mines and a 20% saving in the cost of manufacture along with lower life-cycle costs. Certainly, these were very exciting potential benefits and they were, overall, somewhat successful. The composite M2 BIFV never went into production though, the hull could still be improved, the external ceramic tiles were too vulnerable to damage and, as with all composites, the issues of repair and multi-shot resistance were not addressed. Instead, a new project was started in 1992 – the Composite Armored Vehicle (CAV) program. This would require the manufacture of a completely new vehicle as a demonstrator test-bed for composite armors known as the Advanced Technology Demonstrator (ATD) as part of the US Army's Thrust program. More than one company submitted bids for a new composite hulled vehicle platform for the US Military but the program faded out. The work on proving the technology on the M113 and then on the M2 Bradley was to evolve and find use in the CAV-ATD program, but the Composite M2 was not adopted. The fate of the prototype M2 Composite hull is not known.

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Unveiling and examination of the composite hulled Bradley at AUSA. Source: Richard Eshleman'

Illustration of the Composite M2 Bradley modified by Pavel Alexe based on work by David Bocquelet, funded by our Patreon campaign.

Sources

Bradley: A history of American fighting and support vehicles. (1999) R.P. Hunnicutt, Presidio Press < https://www.amazon.com/gp/product/1626541531/ref=as_li_tl?ie=UTF8&tag=tankencyclope-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=1626541531&linkId=f4b8a70501c4e93dcdeb7216b1471f34>

Modal Analysis of the M113 Armored Personnel Carrier Metallic Hull and Composite Hull. (1995). Morris Berman. Army Research Laboratory

Aluminium 5083. (2018). ASM Aerospace Specification Metals Inc.

Ceramic Armor Materials by Design. (2012). James McCauley, Andrew Crowson, William Gooch, A. Rajendran, Stephen Bless, Kathryn Logan, Michael Normandia, Steven Wax. Ceramic Transactions Series No 134

Army Research, Development and Acquisition Bulletin, January-February 1990
Advanced Composite Materials. (1994). Louis Pilato, Michael Michno, Springer-Verlag, Berlin

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Eischen's Main Battle Tank < https://tanks-encyclopedia.com/coldwar-usa-luxembourg-eischens-main-battle-tank/>

By **Andrew Hills < https://tanks-encyclopedia.com/author/vollketten/>**

February 22, 2020 < https://tanks-encyclopedia.com/coldwar-usa-luxembourg-eischens-main-battle-tank/>

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< https://www.tanks-encyclopedia.com/coldwar/US/cold_war_american_tanks.php> USA/Luxembourg (1962)
MBT – None built

In 1962, the Cold War was at a peak, with the two great power blocks of the Soviet Union/Warsaw Pact and the United States/NATO facing off across Central Europe. By the 1960s, the Soviets had made significant strides forward in their armored vehicles and possessed both a numerical and, in many regards, a technical advantage over the NATO forces seeking to safeguard Europe.

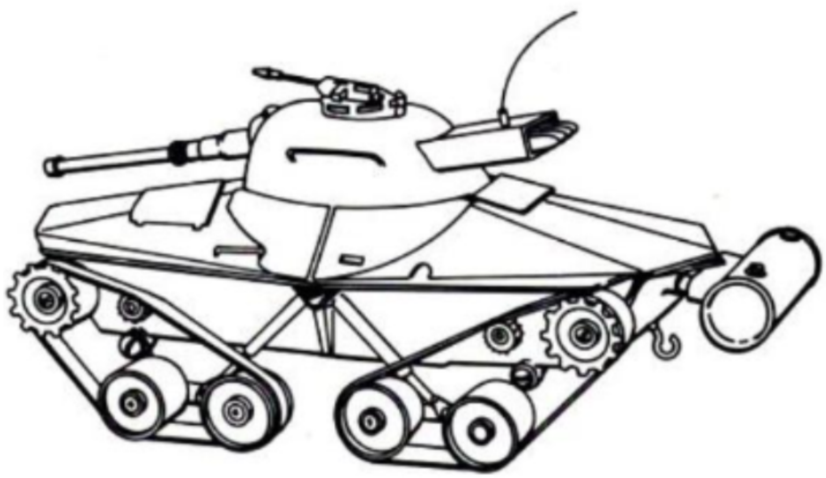
The US was still maintaining large stocks of obsolete weapons including many from WW2 and had, by the late 1950s, realized the need for a new light tank. That program eventually led to the M551 Sheridan < https://tanks-encyclopedia.com/coldwar/US/M551_Sheridan.php> . When the first prototype of that vehicle was published in the summer of 1962, it appears to have spurred some further thought battlefields of Europe from 1965 to 1975. The US Armor Association issued a design competition one month after the appearance of the M551 for exactly this purpose, to design a new tank.

Sgt Gustave L. Eischen

The designer, Sgt. Gustave L. Eischen. Source: Armor Magazine

One of the men who answered the call and submitted a design was Gustave L. Eischen. Eischen is described by the Magazine of the US Armor Association only as being from Luxemburg, with no other details. In the photo above, his uniform and cap badge appear to indicate that he was a member of the Army of Luxembourg and his rank is given as a Sergeant. The Army of Luxembourg at the time was contributing a brigade-sized force to NATO in Europe, with little prospect of beginning its own tank production.

In a newspaper article in Luxembourg published on 7th December 1962, it states that Eischen, a soldier for 8 years and a mechanic in the Luxembourg Air Force, resigned to pursue other opportunities.



Eischen's unusual tank of 1962 showing the distinctive shape of the front and rear and the rear-turret mounted missiles. Source: Armor Magazine

Date

Eischen submitted a sketch and a model and claimed to have been working on his idea for several months prior to the competition being announced, meaning it would date to around January or February 1962 at the earliest. He had to submit it by the deadline of August 1962, so it is clearly not later than this

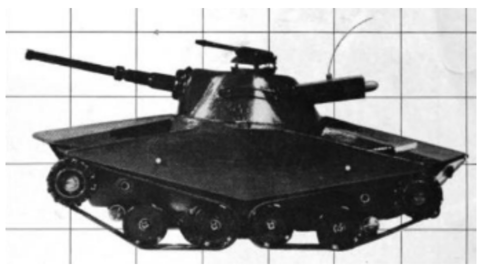
Technical details

The design, at first glance, is quite unusual, with four sets of tracks and a steeply angled front and rear in what could be thought of as two half-tanks joined together. This is because the design was to use a pair of air-cooled engines and two drivers, one in each half. Mounted on top of the four two-roadwheel track units, the height of the tank could be varied hydropneumatically.

Having one driver at each end allowed for the vehicle to be driven at high speed safely in either direction without having to turn around. Along with the variable height of the suspension, this would allow a good deal of off-road mobility and a range *"triple that of the* ***M60 < https://tanks-encyclopedia.com/coldwar/US/M60_Patton.php>*** *"* by virtue of the several 'special' fuel cells arranged around the vehicle.

The shape had one more critical advantage too. It allowed for extremely good visibility from the turret both fore and aft and for the vehicle to be equally fightable in each direction.

At just 6 meters long and 3 meters wide, the vehicle would have been almost exactly the same size as the WW2-era **M24 Chaffee < https://tanks-encyclopedia.com/ww2/US/M24_Chaffee.php>** , albeit slightly heavier at between 24 and 32 US tons (21.8 tonnes to 29 tonnes) depending on the armor thickness selected.



Side view of Eischen's tank showing the pair of track units on each side and the diamond-shaped hull.
Source: Armor Magazine

Armament

The armament was to consist of either a conventional 75 mm or 90 mm gun, which would provide excellent general-purpose firepower against vehicles and infantry support. For contact with heavier tanks, against which the gun would not be adequate, it was supplemented by a pack of 'self-homing' [guided anti-tank] missiles. In order to keep the silhouette as small as possible, Eischen took the unusual step of simply placing the gun and missiles at opposite ends of the turret, facing in different directions. Thus, should a heavier target need to be attacked, the gun would have to be fully rotated to fire the missile. On the drawing submitted, a machine gun, fitted to what is assumed to be the commander's cupola on the turret roof, is also shown.

Armor

Given the low weight – less than 30 tonnes – even at its heaviest, protection would be modest. The M24 Chaffee, a comparative-sized vehicle, had conventional welded steel armor up to 38 mm thick in places. Given the additional weight of the missiles, additional driver's station and second engine, the Eischen cells to increase protection for the vehicle, but whatever details he might have provided were not included in the article concluding the competition.

Epilogue

Eischen appears to have got nowhere with his design. It won second place in the Armor competition in 1962, behind the **articulated tank concept of the Forsyth brothers < https://tanks-encyclopedia.com/coldwar-usa-lockheed-forsyth-tank/>** . His military career did not pan out either, but a lingering trace of him exists in a patent for a self-supporting element used in the manufacture of prefabricated houses filed in 1971 in Germany. There his home town is given as that of Ettelbruck in Luxembourg.

Conclusion

Eischen's design featured the significant novelty for 1962 as hydropneumatic suspension for 4 separate track units. The two-driver idea was not particularly new as many armored cars had featured a second (backward) driver before this for the same reason, the ability to withdraw at speed. The armament offered little in the way of novelty too, a conventional 75 mm gun was by 1962 a hopeless concept for anything other than the lightest of armored targets. Even consideration of a 90 mm gun would likely have been of little use against modern Soviet tanks which is why he had added missiles. It is the missiles which are the most interesting novelty of the design as they faced backward, an unusual yet simple solution to a complex problem of mounting a missile battery on a tank.

Illustration of Eischen's Main Battle Tank produced by Andrei Kirushkin, funded by our Patreon Campaign

Specifications

Dimensions (L-W)	6 x 3 meters
Total weight, battle-ready	21.8 tonnes – 29 tonnes)
Crew	4 (front driver, rear driver, commander, gunner)
Propulsion	x2, unknown type
Armament:	75 mm or 90 mm gun supplemented with anti-tank guided missiles, machine gun

Sources

Armor Magazine. (July-August 1962). Tank Design Contest.
Armor Magazine. (January-February 1963). The Winning Tank Designs.
Carter, D. (2015). Forging the Shield: The US Army in Europe 1951-1962. Center of Military History, US Army, Washington DC < https://amzn.to/2uld8sR>
d'Letzeburger Land 7th December 1962 'Ideen machen sich bezahlt Gusty Eischens Spielzeug-Panzer'
German Patent DE2135276 'Selbsttragendes, plattenariges wandelment' filed 15th July 1971, granted 25th January 1973

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