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COSTECH REPORT 70-4
FEBRUARY 1970

COST & TECHNICAL INFORMATION REPORT

M520, (GOER) 8 TON TRUCK SYSTEM

James Morrison



For information to the public, agencies only:
26 OCT 1971
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**COST ANALYSIS DIVISION
COMPTROLLER & DIRECTOR OF PROGRAMS
U.S. ARMY TANK-AUTOMOTIVE COMMAND
WARREN, MICHIGAN 48090**

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JAMES MORRISON
U. S. ARMY TANK-AUTOMOTIVE COMMAND

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ABSTRACT

This report summarizes the system history and the development, investment, and operating costs of the High Mobility (GOER) vehicles. Development of these vehicles, called the (GOER) occurred from 1960 to 1965. The M520, 8-Ton GOER Cargo Truck, and the M559, GOER Tanker were type classified (STD-A) in May 1966. The XM553, 10-Ton Wrecker is scheduled for type classification FY 1970.

The (GOER) vehicles are in the final phase Advance Production Engineering; this is presently being done under the Advance Production Engineering Contract prior to a planned procurement of these vehicles in FY 1971.

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I. INTRODUCTION

The objective of this report is to present the development, investment and operating costs associated with the 8-Ton Cargo Truck, M520 GOER family of vehicles.

Costs for this study are derived from prior RDT&E contracts, Technical Development Plans and the Program Master Plan at Product Manager, M520 Office, USATACOM.

Hardware estimates are taken from the December 1969 GOER Cost Study conducted at USATACOM.

The M520 vehicle is not in production and the operating costs utilized are from the REVAL WHEELS Cost Study. This source is used to provide operating cost estimates on the M520 vehicle.

A requirement exists to provide combat areas and supporting units with wheeled vehicles of vastly improved ground mobility and logistical support for combat operations. The objective of this project is to provide wheeled vehicles with a degree of cross-country mobility for tactical and logistical support elements commensurate with the future concept of widely dispersed operations.

II. SYSTEM DESCRIPTION

The origin of the GOER concept dates back to mid-1954. In general, this concept involved a vehicle or family of vehicles, which possessed all terrain all weather performance possibilities.

From mid-1954 through late 1958 several "evolutions" took place. A 5-Ton Cargo Unit was built, tested and a 15-Ton Vehicle was studied. Then, in 1959 a 16-Ton GOER family was brought into existence, followed by an 8-Ton Family in early 1960.

The concept 8-Ton Vehicle exemplified the following initial ideas: Large diameter, low pressure tires, positive articulated steering, exoskeletal body frames, mechanical simplicity achieved through elimination of complex suspension systems, vastly improved ratios of payload to - gross weight.

The M520 Vehicle is an 8-Ton payload rated four-by-four all-welded steel cargo truck consisting of the prime mover (cab) and cargo trail unit. The vehicle is powered by a six-cylinder liquid cooled diesel engine, driving through a power shift transmission, transfer gears, limited-slip differentials and planetary final drives. The transmission provides six forward speeds and one reverse speed, manually selected by the operator.

Front and rear wheels are engine driven through limited slip differentials. An oil disconnect clutch is provided for the rear wheel drive. A positive powered, wagon-type steering is used with the 8-Ton GOERS. With this type of steering, the front wheels do not turn in relation to the front axle. Steering is by means of two double acting hydraulic cylinders, with one end of each cylinder attached to the power unit and the other to the hitch.

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The vehicle is designed for use over all types of roads, highways and cross-country terrain, it possesses a swimming capability, and is air transportable. The vehicle does not use a suspension system and is dependent solely on large tires as a suspension.

During the testing of the first 8-Ton cargo prototypes, more evolutions took place. Two different transmissions were tested and evaluated. Because of simplicity and ruggedness, the Caterpillar built power shift transmission was selected.

The Caterpillar D333 Engine became the power plant of the 8-Ton GOER Family.

Utilizing the same principles and power train as the first 8-Ton Cargo vehicles the 10-Ton GOER wreckers emerged in April 1963 followed by the 2500 Gallon GOER tankers in October 1963.

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FIGURE 1

TRUCK, CARGO: 8 Ton, 4x4, M520

FIGURE II
CARGO TRUCK, M520
M559 FUEL, XM553 WRECKER
TECHNICAL CHARACTERISTICS

	<u>M520</u>	<u>M559</u>	<u>XM553</u>
Curb Weight	23,500 lbs	27,590 lbs	38,220 lbs
<u>Dimensions</u>			
Overall Length	385 in	391.2 in	401.3 in
Height	132 in	132 in	132 in
Reducible Height	97 in	97 in	118 in
Width	108 in	108 in	108 in
Wheel Base	235 in	235 in	235 in
Ground Clearance at Axles	23.3 in	23.3 in	23.3 in
Ground Clearance at Midship	30.1 in	30.1 in	30.1 in
Angle of Approach	35°	35°	35°
Angle of Departure	41°	33°	34°
<u>Engine</u>	<u>Transmission</u>	<u>Transfer Case</u>	
D333 B Engine, Diesel 6 cyl in line 525 cu in Displ HP213 (Gross BHP)	Caterpillar 6 speed Powershift with torque converter	Single Speed Integral with Transmission	
<u>Performance Characteristics</u>			
Max Speed	30.2 MPH		
Fuel Capacity	110 GAL		
Fuel Consumption	2.13 MPG AVG		
<u>Suspension System</u> - Large Tires act as the suspension.			
<u>Brakes</u> - Mechanical, on Transmission Case			
<u>Steering</u> - Hydraulic w/Mechanical follow-up.			
<u>Tires</u> - 18.00 x 33 10 ply tubeless			

FIGURE II

TECHNICAL CHARACTERISTICS
(continued)

Electrical System - 24V 100 AMP

Body Type - Medium and High strength Steel.

Crew Space - 2

Fording Depth -

Buoyant at approximately 70 inches with full load
swimming speed 3 MPH.

III. SYSTEM HISTORY

In June 1960, Caterpillar Tractor Co., Peoria, Illinois was awarded Contract DA-11-022-ORD-3491 to design, develop, and fabricate the 8-Ton GOER Vehicle. In August 1961, the first two 8-Ton GOER Units were shipped to Aberdeen Proving Grounds for test evaluation. Six additional cargo units were subsequently built and successfully tested. A prototype acceptance meeting was held in Peoria, Illinois in July 1961.

After reviewing several Caterpillar proposals, USATACOM established the basic configuration using an all mechanical drive to the power unit wheels and a mechanical assist to the rear wheels in the form of a clutch controlled drive shaft going through the articulation hitch. The steering was limited to 60 degrees both right and left.

In August 1961, a decision was made to equip six cargo vehicles with a hydraulically actuated planetary-gear transmission with torque converter; and two cargo units with a conventional truck type, constant mesh spin-gear transmission.

The Caterpillar D333 basic engine was selected for use in all vehicles. Performance evaluation of the first two test vehicles with different transmissions was begun at Aberdeen Proving Grounds in August 1961.

In June 1962, a meeting was held in Peoria to discuss design and component selection of the second configuration, the 10-Ton Wrecker, which would become a part of the 8-Ton GOER Family. It was decided that the basic power unit and power train with the planetary torque converter transmission of the initial 8-Ton Cargo version would be utilized in the 10-Ton Wrecker. A Review Point meeting was held in Peoria and the Wrecker demonstrated in April 1963.

The design and configuration of the third version of the 8-Ton GOER Family, the 2500-gallon tanker, was discussed at a meeting in August 1963.

The cargo basic power unit and power train with planetary-torque converter transmission was also utilized in the 2500-gallon tanker. The bulk-fuel tank trailer and all dispensing equipment was designed to specification contained in RDPD 60-31E. The vehicle was built and demonstrated in October 1963 - eight 8-Ton Cargo Units, two 10-Ton Wreckers, and two 2500-gallon Tankers were built and underwent engineering and service tests. Test sites included extreme environmental conditions, ranging from Alaska to Panama.

In May 1963, Caterpillar was awarded a contract to build 23 updated versions of the three models in the 8-Ton GOER Family. These units were shipped to the Seventh Army in West Germany for troop-test in April 1964, to prove their reliability, durability and maintainability.

In May 1965, one of each model Cargo, Tanker and Wrecker were returned from Germany to Caterpillar Tractor to be reworked in order to incorporate the latest design changes and/or corrections prior to confirmatory testing at Fort Knox subsequent to type classification as STD-A.

In February 1966, USATACOM was directed to ship all the latest hardware versions of the GOER Family to S.E.A. for service used by our troops in the theatre.

In March 1966, Caterpillar Tractor was awarded Contract DA-20-113-AMC-09867, wherein the family concepts were to be engineered into a competitive production package. The Advance Production Engineering provided for conversion of the development drawings to military format and create the required technical data, quality control provisions, and inspection aids to enable competitive procurement and mass production of the products.

This project required to fabricate ten pre-production prototypes; three each, M559 and M520 and four each, XM553. There were no major difficulties encountered in R&D prototypes which had to be resolved in the pre-production prototypes. The items covered by the project are: Truck Wrecker, 10-Ton, 4x4, XM553 (Code "B"); Truck, Cargo, 8-Ton, 4x4, M520 (Code "A"); Truck, Tank, Fuel Servicing, 2500-gallon, 4x4, M559 (Code "A").

IV. DEVELOPMENT COSTS AND ANALYSIS

On 29 June 1960, a development contract DA-11-022-ORD-3491 was awarded to Caterpillar Tractor Co., Peoria, Illinois in the amount of \$363,000.

The contract was for services and property required for the design, development, fabrication, and test support of one prototype and seven pilot models of the Truck, Cargo Logistical, High Mobility, 8-Ton, 4x4, XM520E1.

The Engineering work was to be accomplished in ten phases, beginning with concept study and investigation to determine the basic components and configuration and completed with Phase X; the Modification and Drawing Revisions.

There were a total of 18 modifications to the basic contract. The cost increases to the RDT&E contract were the result of increasing the number of pilot vehicles built to twelve 8-Ton GOER vehicles: eight 8-Ton Cargo Units (XM520), two 10-Ton Wreckers (XM553), and two 2500-gallon Tankers (XM559).

Other modifications were to include the design, development and fabrication of arctic kits for application on the XM520E1 and front mounted winch kit for application on the XM520E1 Vehicle.

All R&D activities on the GOER Vehicles were completed in the 2nd Quarter, FY 1965.

TABLE I
ACTUAL M320 DEVELOPMENT COST
R&D PHASE

<u>FY</u>	<u>DESCRIPTION OF WORK</u>	<u>TOTAL</u>	<u>CUM TOTAL</u>
1960	Development & Engineering	363,000	363,000
1961	"	78,000	441,000
1962	"	551,000	992,000
1963	"	111,000	1,103,000
1964	"	144,613	1,247,613
1965	"	<u>33,310</u>	<u>1,280,923</u>
TOTAL R&D COSTS		<u>1,280,923</u>	<u>1,280,923</u>

SOURCE: Program Data Sheets from RDT&E, Project GOER Project
No. 10543006D402

TABLE II

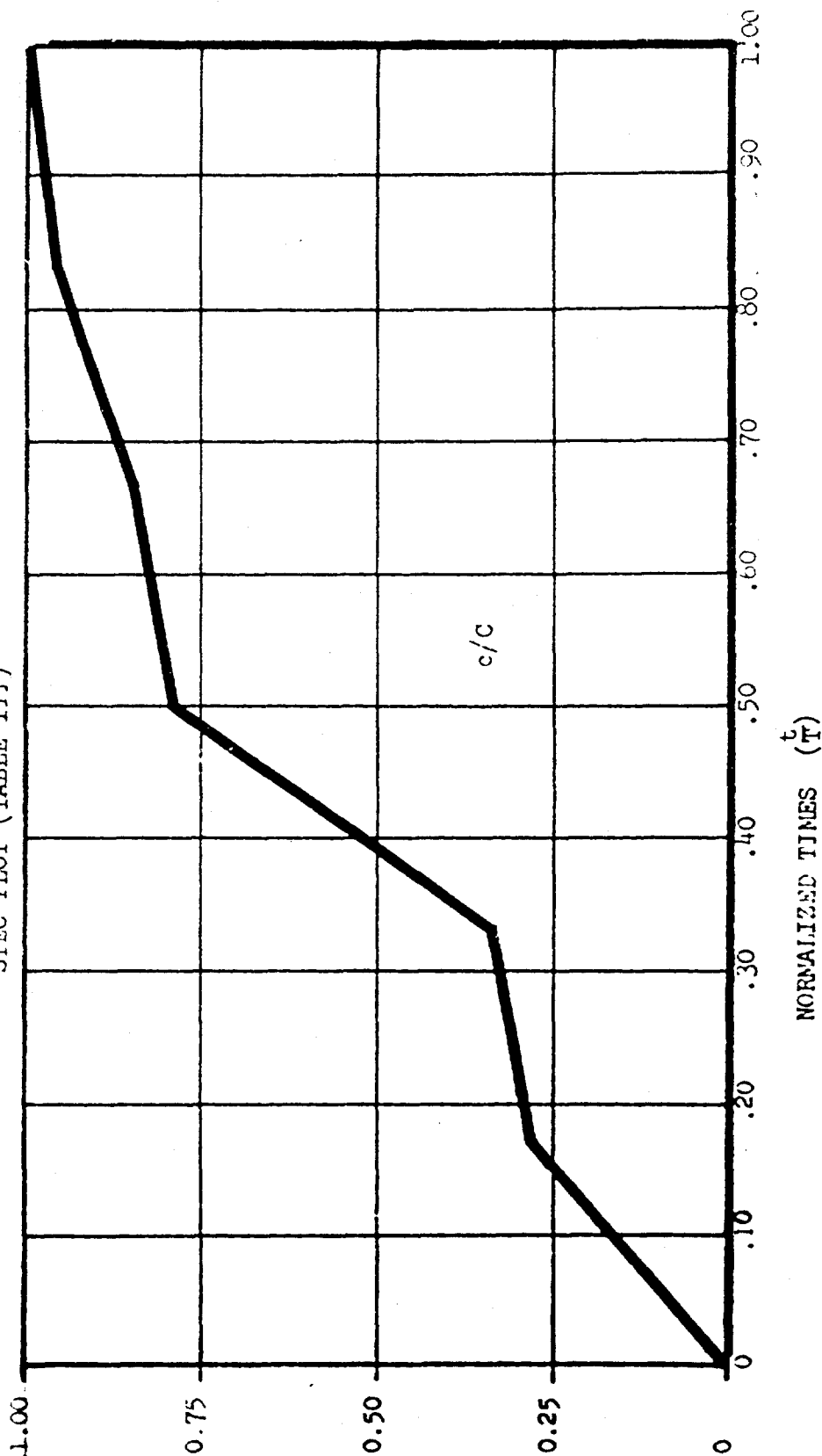
STEC PLOT DATA: M520 (GOER FAMILY)
(MILLIONS OF DOLLARS)

FY	t	ACTUAL RDT&E COSTS		ESTIMATED TOTAL RDT&E		c/C	e/C*	t/T
		Annual \$	Cumulative \$ (c)	COST MADE AT TIME t (e)				
1959	0	0	0	0	0	0	0	0
1960	1	.363	.363		.29			.17
1961	2	.078	.441		.34			.33
1962	3	.551	.992		.78			.50
1963	4	.111	1.103		.86			.67
1964	5	.144	1.247		.97			.83
1965	6	.033	1.280		1.00			1.00

Source: 1. Project Manager Master Plan.
2. Program Data Sheets for RDT&E, Project (GOER) 1D543006D402.

*Records of fiscal estimates for the RDT&E, (GOER) dated 7 June 1960 indicates amount of funds required not available for M553 & M559 vehicles. Total estimate incomplete, therefore not used.

M520 (GOER)
STEC PLOT (TABLE III)



SYMBOLS:

- c - Cumulative RDT&E actual costs up to time t (Dollars).
- T - Time period from date of initial RDT&E estimate to completion of RDT&E phase (Years).
- e - Estimate of total RDT&E costs made at time t (Dollars).
- C - Total amount of actual RDT&E costs final (Dollars).

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V. INVESTMENT COSTS AND ANALYSIS

In October of 1962, the contractor was requested to submit a proposal on the basis of a cost-plus-fixed-fee type contract to initiate Phase I (Troop Test) of the Advance Production Engineering on the GOER program.

This contract was to run concurrent with the R&D contract as a coordinate phase of R&D effort with the Advance Production Engineering.

In May 1963, Contract DA-11-022-AMC-409(T) was awarded to Caterpillar Tractor Company in the amount of \$2.7 million to proceed on Phase I of the Advance Production Engineering of the GOER Vehicles.

The basic contract-scope required the contractor to perform engineering services as required for 13 each Cargo M520; 8 each Tanker M559; 2 each Truck Wrecker XM553; accessories (tools, manuals, spare parts, 23 Slave Cable Kits, 23 Power Unit Winch Kits and modifications as directed by USATACOM).

There were a total of forty modifications to Contract DA-11-022-AMC-409(T), with the largest cost increase to cover Engineering Test-Service Tests in Europe and S.E.A.

The above tests costs provided for technical representatives to USATACOM and USAREUR and S.E.A.; together with OVE, more repair parts and changes in scope of work.

Troop tests for the 8-Ton GOER Vehicle Family were conducted in Europe from 15 May 1964 to 15 February 1965.

GOER type vehicles were mixed with standard vehicles to provide a basis for comparison. During June 1966 ten 8-Ton Cargo, six 2500-gallon Tanker and one 10-Ton Wrecker were inspected and repaired and shipped to South Vietnam to form a GOER provisional company for tests in S.E.A. areas.

In May 1966, the M520, 8-Ton GOER Cargo Truck, and the M559, 2500-gallon GOER Tanker were type classified as Standard (STD-A).

Contract DA-11-022-AMC-409(T) was completed by December 1968 with a total value of \$3.583 million.

In March 1966, a cost-plus-fixed-fee contract, DA-20-113-AMC-09867(T) was consummated with Caterpillar Tractor Company to continue Advance Production Engineering on the GOER Vehicles.

Advance Production Engineering was to provide for conversion of the developmental drawings to military format and create required technical data, i.e., quality control, provisions and inspection aids to enable competitive procurement and mass production of the products essential for the fabrication of pre-production prototypes.

This project required the contractor to fabricate ten pre-production prototypes; three each, M520; three each, M559; and four each, XM553. There were no major difficulties encountered in R&D prototypes which had to be resolved in the pre-production prototypes.

As of January 1970, a total of forty-seven modifications have been added to APE Contract DA-20-113-AMC-09867(T) which brought the total contract value to \$6.637 million. Most of the cost increases were to incorporate all design changes made to the original 23 GOER Vehicles which were tested in USAREUR and made product improvements to an additional ten pilot vehicles.

The APE contract on the GOER program has not been completed and is to continue through the 4th Quarter of FY 1970.

In April 1966, a Product Improvement Project was initiated to investigate other Engine/Transmission alternates for adaptation in the GOER with the intent of reducing weight and to eliminate proprietary Engine and Transmission, which are currently being used in the GOER Vehicles. The total investment in the project was \$2.06 million shown in Table IV.

The GOER Vehicles are not in production, but an USATACOM in-house hardware estimate was made for a projected procurement in FY70. The GOER hardware estimates assumed a multi-year procurement of 1300 vehicles consisting of 807 Cargo, 371 Tanker and 122 Wrecker Vehicles with production in yearly quantities of 100, 400, 400 and 400. The estimated manufacturing costs are shown on Table V.

TABLE IV

M520 INVESTMENT NON-RECURRING COSTS

	FY70 & PRIOR
Advanced Production Engineering	
Phase I (Troop Test)	\$ 3,583,253
Phase II (Continuation of APE)	7,500,000
Alternate Engine Program	2,062,000
Tooling & Start-Up	<u>4,300,000</u>
Total Investment Non-Recurring	\$17,445,253
SOURCE: USATACOM Project 44712 and 44232 Project Management Master Plan (PM ₂ P) Contract No. DA-11-022-AMC-409(T).	

TABLE V

M520 INVESTMENT RECURRING
(Thousands of Dollars)

	FY 70	FY 71	FY 72	FY 73	FY 74	TOTAL
Mfg.	\$5,544	0	\$21,623	\$21,676	\$21,676	\$70,519
Contract	(Qty 100)		(Qty 400)	(Qty 400)	(Qty 400)	(Qty 1300)

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VI. OPERATING COSTS

Table VI provides the operating costs estimates by cost categories and cost data references. These factors have been derived from REVAL WHEELS cost studies.

TABLE VI
OPERATING COST FACTORS (ESTIMATED)

POL	\$187/veh/yr
Maintenance Personnel ¹	180/veh/yr
<u>Depot Overhaul</u> ²	
Total End Item	\$17,540
Engine	2,200
Transmission	990
<u>Crew</u> ³ - 2 men (E4)	\$2,164/veh/yr
Repair Parts ⁴	6.39% x hardware cost/veh/yr
Repair Parts Transportation ⁴	\$ 73/veh/yr
Line Item Management ⁵	\$453,241
<u>Operating Factors</u>	
Estimate useful life of ea. unit	12 years
Average miles per year	4,000
SOURCE:	
¹ AMC REVAL WHEELS Update, 13 May 1969 with maintenance personnel pay rate adjustment of \$3.22/hr (DA Comptroller, Cost Analysis Data)	
² TACOM REVAL WHEELS Update, 13 February 1969.	
³ FY70 Army Audit Agency pay rate of \$5.41/yr for driver (200 operating hrs per year - AMC REVAL WHEELS Update, 13 May 1969.	
⁴ AMC REVAL WHEELS Update, 10 March 1969.	
⁵ AMC REVAL WHEELS Update, 13 May 1969 with Federal pay raise adjustment of 8.9%.	

SYSTEM TITLE:

GOER TRUCKS

M550 Truck, Cargo

M553 Truck, Fuel

M559 Truck, Wrecker

SECTION VII
FINANCIAL SUMMARY

TABLE VII

Amounts in Thousands of Dollars)

Description of Work	Cost By Fiscal Year					
	FY 1970 & Prior	FY1971	FY1972	FY1973	FY1974	TOTAL
Development & Engineering	\$1,281*					\$ 1,281*
TOTAL RDT&E	1,281*					1,281*
Production Base Support						
Advance Production Eng'g	11,083*					11,083*
Tooling & Start-up	4,300					4,300
Other Engine Alternate	2,062*					2,062*
Total Non-Recurring	17,445					17,445
A. Manufacturing (Vehicle)	5,544		21,623	21,676	21,675	70,519
B. Provisioning						3,806**
C. Kits						1,997**
D. Documentation						102**
E. Contractor (PEC)						7,690**
F. In-House						1,278**
TOTAL RECURRING						85,392
TOTAL PROGRAM COST						\$104,118

* Amounts shown with single asterisk are actual amounts spent. All other amounts are estimates.

** Amounts shown with double asterisk are estimates for total program. Yearly cost breakout is not available.

VIII REFERENCES

1. RDT&E Project No. 1D543006D402 (GOER VEHICLES).
2. Contract DA-11-022-ORD-3491 Development Contract with Caterpillar Tractor Company.
3. Project Management Master Plan (PM₂P) for (GOER) Trucks.
4. Technical Development Plan Trucks, High Mobility (GOER) 4x4, January 1969.
5. USATACOM Project 44712 APE (GOER).
6. USATACOM Project 44232 (Alternate Engine Program).
7. Advance Production Engineering Contracts DA-11-022-AMC-409(T), DA-20-113-AMC-09867(T).
8. "REVAL WHEELS" cost studies data - February, March and May 1969.
9. GOER Production Cost Analysis Report USATACOM, dated 12 December 1969.
10. "Macrobehavior of Development Costs and Estimates (STEC PLOTS)" Unclassified, Major Horace Schow II. Technical Report 68-2, Systems and Cost Analysis Division, HQ, USAMC, September 1968, AD674653.