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The GM 3500 HD Its Design & Development

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GM Truck & Bus

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ABSTRACT

The GM 3500 HD is a new class 4 truck being introduced this fall. Complementing GM's successful introduction of the 11,000 lb and 12,000 lb cab/chassis in 1990, this truck will have a GVW rating of up to 15,000 lbs.

The design and development of this truck began in late 1987 and utilized selected common parts from GM's light duty pickup truck and commercial forward control chassis.

Several features unique to the class 4 market were incorporated for increased customer satisfaction. Among these are low loading heights, three cab/axle offerings, large brakes, increased cooling, and large frame sections with straight flat rails behind the cab.

A description of the vehicle features and how the design evolved and developed will be detailed. In addition, significant performance criteria that were met or exceeded will be summarized to establish the high level of vehicle performance achieved.

INTRODUCTION

The GM 3500 HD began as a natural extension of the new 1990 cab/chassis program that GM launched in the fall of 1989. This series of cab chassis was based on the full size Chevrolet and GMC pickup trucks that have been in production since 1987. The cab/chassis versions introduced in the 1990 model year have met with tremendous success in the marketplace and outstanding customer acceptance.

This paper will describe how the GM 3500 HD evolved from these 1990 products. The objectives of the GM 3500 HD will be detailed, including the general history of the program and its development. A review of the market segment the vehicle is intended to fill will be given. Along with this, a review of the vehicle design will be described and significant performance objectives will be provided.

TEXT

In the beginning of 1987 GM recognized the need to fill a market segment that had for many years been vacant in the commercial truck market. This segment bridges the gap that has existed between traditional weight classes of light duty cab/chassis and the higher GVW medium duty market. Figure I shows the niche market that the 3500 HD will fill. This niche mandates a GVW rating of between 14,000 and 16,000 lbs with higher front and rear axle ratings than have been available in traditional light duty trucks in recent history. Surrounding this market segment are other GM offerings which have provided acceptable choices to the customer. Changes in tax laws and the increasing cost of medium duty trucks, as well as increasing competitive interest in this market, led GM to seriously look at designing and developing the new 3500 HD.

GMC 3500 HD

Class 3-4-5 Commercial Segment

- **GVWR/GCWR Capacity and Cab Preference**

	GCWR (Lbs.)		
	Class 3 10,000–14,000	Class 4 14,001–16,000	Class 5 Up 16,000 Up
Conven. Cab	R/V Chassis Cab 10–11K GMT-535 10–12K		GMT-530
Forward Control	G Cutaway G/P Cutaway Isuzu (W4)	G/P Cutaway Isuzu (W5)	Isuzu (W6 & 7) (GMT-535)

FIGURE I

Our estimates that this market is somewhere around 30,000 to 40,000 units per year could be conservative once customers recognize the potential use of these vehicles in their operations.

These vehicles are traditionally supplied as cab/chassis that get fitted by after market body upfitters to serve specific customer requirements. The 3500 HD should be widely used by customers that upfit with service bodies, stake rack platforms, wreckers, van bodies, etc. Figure II is an indication of how the market should break down for this class of vehicles.

Most Common Body Types

- **Flatbed** 41%
- **Roll Back Wrecker** 14%
- **Utility** 12%
- **Wrecker** 10%
- **Van** 9%

FIGURE II

PROGRAM OBJECTIVES

The 3500 HD had some specific program objectives that needed to be met during the design and development phase. These were established, reviewed with members to the NTEA (National Truck Equipment Association), and modified as necessary. Figure III is a list of the basic program assumptions that were made at the beginning of the program.

Assumptions

- **Utilize Proven Components**
- **Commonize with 1990 P/U and Cab/Chassis**
- **Low Egress and Ingress**
- **Low Frame Height**
- **Common Appearance with P/U**
- **Straight Frame Rails 34" Wide**
- **Superior Ride and Handling**
- **Multiple Gas Engines**
- **HD Transmissions**

FIGURE III

Because of the low volumes involved, the economics of using existing designs were widely sought. In addition, these components offered proven customer reliability, a high priority. This, however, did not prevent the design and development of new components where required to meet customer demands.

MODEL LINEUP

The model lineup for the 3500 HD is shown in Figure IV. The vehicle will be offered in three wheelbases and corresponding three cab/axle dimensions. The C310 model will have a 135.5" wheelbase with a cab/axle dimension of 60". The C314 model will have a 159.5" wheelbase with a cab/axle dimension of 84" and the C318 model, which will be unique to this market, will have a wheelbase of 183.5" with a cab/axle dimension of 108".

3500 HD Cab/Chassis

Model	Wheelbase	Cab/Axle
C31003	135.5"	60"
C31403	159.5"	84"
C31803	183.5"	108"

FIGURE IV

Dimensionally, the vehicle has the same interior dimensions as a Chevrolet or GMC light duty pickup truck, thus offering the same generous interior comfort and convenience of these offerings. These are shown in Figure V. The exterior dimensions are shown in Figure VI. To meet one of the program objectives of low ingress and egress, the vehicle was configured with the lowest frame height in its class. The rear frame sits 30.3" from ground at curb weight without an after market body and only 27.5" from ground at GVW. This should allow convenient loading and unloading of the cargo configurations as well.

3500 HD Cab/Chassis

	3500 HD		
Model	310	314	318
Headroom (in.)	40.0	40.0	40.0
Leg Room (in.)	41.1	41.1	41.1
Shoulder Room (in.)	66.0	66.0	66.0
Hip Room (in.)	60.7	60.7	60.7

FIGURE V

3500 HD Cab/Chassis

	3500 HD		
Model	310	314	318
Frame HT @ Curb (in.)	30.3	30.3	30.3
Frame HT @ Load (in.)	27.5	27.5	27.5
Overall Length (in.)	224.1	248.1	272.1
Axle-Frame (in.)	51.0	51.0	51.0
Thread Width F (in.)	69.7	69.7	69.7
Thread Width R (in.)	66.7	66.7	66.7
Cab Height (in.) @ Curb	75.7	75.7	75.7

FIGURE VI

The frame section modulus is the largest of any cab/chassis produced to date at 10.6 lbs/in-in. This translates into robust stiffness and strength to match the vehicle rating of 15,000 lbs.

DESIGN FEATURES

The vehicle design features are many. The cab is identical to a light duty pickup truck. The high gloss enamel used on the medium duty truck will also be applied to the 3500 HD.

The vehicle will be offered in the same eight (8) colors as our medium duty trucks plus two *new* unique metallic colors. The color offerings are shown in Figure VII.

Engineering Color Name	GM Code
Yellow White	12
Lamp Black	19
Ocean Blue	23
Med Blue Met	24
Dark Blue	29
Dark Green	46
Tan	61
Red Orange	71
Standard Red	72
Gray Met	90

FIGURE VII

The interior trim will be a base system in either cloth or vinyl or a med level offering in cloth or vinyl. No uplevel trim will be offered for the 1991 model year.

FRAME

The frame is all new. The frame rails rearward of the cab are completely straight and 34" wide. In the side view the frame rails rearward of the cab are flat. This will allow simple and direct mounting of nearly all after market bodies without rework. The design also concentrated on keeping other chassis components from protruding above the frame rails. The frame construction is a combination of welded and riveted processes. All front crossmembers are welded except for the transmission crossmember which will be bolted in for the service of powertrain components. All rear crossmembers are riveted. The entire frame is wax coated for enhanced corrosion protection.

The frame is being completely assembled in a new manufacturing facility near our final assembly plant. The frame assembly process involves extensive weld fixturing and robotic welding to ensure the highest reliability.

FRONT SUSPENSION

The front suspension consists of a new "I" beam axle with a FGAWR of 5000 lbs. This axle is based on our "P" model stripped chassis, which has been in production since 1985. The axle has an offset of 114 mm which contributes to the ability to package the vehicle and achieve a low ingress and egress height.

The axle is supported by new tapered leaf springs that are 57" long. The springs have a rate of 571 lbs/in which when tuned to the rate of the rear suspension give a front to rear ride balance ratio of 1.3:1. This contributes to the outstanding ride of the vehicle compared to its competitors. The springs are spaced 841 mm apart, which when combined with the use of a front stabilizer bar provide low roll gain values in the neighborhood of 7–8 deg/g @ .3g lateral acceleration. The front suspension also has a lateral track bar to add lateral compliance stiffness and thereby enhance directional control and feel. The shock absorbers are 35 mm diameter for increased dampening potential.

REAR SUSPENSION

The rear axle is an 11,000 lb Rockwell International axle with a ring gear diameter of 12-1/8". The vehicle will be offered with axle ratios of 4.56:1 and 5.13:1. This axle is similar to the axle used in our "P" model stripped chassis where it has had good reliability for many years.

The rear springs are a conventional multi-leaf design. The design is new with spring lengths of 58". This short spring length will allow the frame to be shortened for use in wrecker service. The springs have a first stage rate of 771 lbs/in and a second stage rate of 2000 lbs/in. All of the vehicle handling goals were met without a rear stabilizer bar, and as such, none is available. The rear shock absorbers are also 35 mm diameter to match the front.

BRAKE SYSTEM

The vehicle will have front and rear disc brakes identical to the system used on our "P" model stripped chassis. The front disc diameters are 14.25", and the rear disc diameters are 13.75". The piston diameter is 3.375". The use of these large disc brakes was necessitated because the vehicle was required to meet all light duty brake performance criteria at the GVW of 15,000 lbs. To package this size of brake, the wheels needed to be 19.5" diameter which is beyond normal light duty size.

The park brake is propshaft mounted and has a size of 9" x 3". This brake is the same as used with GM's medium duty school bus chassis. The activation system was modified to allow the use of a pedal common with the full size pickup truck. The system uses a manual adjustment turnbuckle to compensate for brake shoe wear.

The service brake system is activated via a hydraboost system, which is energized by the power steering pump.

The system will also incorporate brake height sensing proportioning. This will allow the load/height of the vehicle to provide a split proportioning of the brake pressures between front and rear brake systems.

POWERTRAINS

Figure VIII is a chart depicting the powertrain lineup that will be available sometime during the 1991 model year. We have purposely only scheduled the 7.4L 4-speed automatic powertrain combination to be available for the start of the 1991 model year to allow our assembly plant to accelerate up to full capacity with a minimum number of engines and transmissions, thereby focusing on high quality.

3500 HD Powertrains

	5-Speed Manual		4-Speed Auto.	
	4.56	5.13	4.56	5.13
5.7L	X	X	NA	NA
7.4L	X	X	X	X

FIGURE VIII

The base engine will be a 5.7L with a new 5-speed manual transmission. This combination will not be available initially. The 5.7L engine will have internal enhancements to meet the duty cycle of the 3500 HD.

The uplevel engine will be our new 7.4L Mark V gas V8. This engine has been redesigned for 1991 with attention paid to increased reliability and serviceability. The 7.4L engine will be matched with our new 4-speed HD auto for the start of the 1991 model year. The engine will also be available later with the new 5-speed manual. Both engines will be offered with the 4.56:1 and 5.13:1 axle ratios.

The 5.7L V8 will have a rating of 190 hp at 4000 rpm. The torque output will be 300 ft-lbs at 2400 rpm. The 7.4L V8 will have a rating of 230 hp at 3600 rpm and a torque output of 385 ft-lbs at 1600 rpm. Both engines will utilize throttle body fuel injection.

The 1991 model year will see the introduction of a new 4-speed heavy duty automatic from GM's Hydramatic Division. Figure IX is a summary of the specifications for this new transmission. The unit will have electronic controls to allow cleaner more precise up shifts and down shifts. To increase the fuel economy the unit will have a .75:1 overdrive 4th gear. The electronic controls will also contribute to the improved fuel economy. The unit specific to the 3500 HD will also use spiral cut gearsets for improved strength and durability.

The 1991 model year will also see the use of a new 5-speed manual transmission engineered by New Venture Gear. This unit has a 6.34:1 low gear for heavy duty use and a 5th gear overdrive of .73:1. The shift effort and feel have been improved to approach the feel of a light duty manual transmission. The unit is built by top loading all of the mechanicals to provide an extremely compact layout. This transmission will have PTO access from both the driver and passenger sides of the vehicle.

Both transmissions will be unique to the 3500 HD in order to allow the mounting of the propshaft mounted parking brake system to the units.

Hydra-matic 4L80-E Transmission Specifications

Engine torque capacity of 597 N·m

Gross combined vehicle weight of 20,000 lbs.

Transmission Drive
Rear Wheel Drive
4-Wheel Drive

Transmission Type
4L80-E = 4-Speed, Longitudinal Mount, High Torque Capacity, Electronically Controlled
Automatic Overdrive with Torque Converter Clutch Assembly

Control Systems
Shift Pattern— Solenoid Control
Shift Quality— Force Motor Control
Torque Converter Clutch— Pulse Width Modulated Solenoid Control

Gear Ratios

1st:	2.482
2nd:	1.482
3rd:	1.000
4th:	0.750
Rev:	2.077

Maximum Engine Torque
597 N·m (440 lb-ft)

Maximum Gearbox Torque
1,200 N·m (885 lb-ft)

The maximum torque limits are only to be used as a guide and may not always be applicable under certain conditions.

Maximum Shift Speed

1-2	6,000 RPM
2-3	6,000 RPM
3-4	6,000 RPM

The maximum shift speed allowed in each engine application must be calculated.

Maximum Gross Vehicle Weight
7,484 kg (16,500 lb)

Maximum Gross Combined Vehicle Weight
9,072 kg (20,000 lb)

Transmission Fluid Type
Dexron® II

Converter Sizes Available
310 mm—4 Element (Dual Stators)
—3 Element (Single Stator)

Converter Bolt Circle Diameters
292.1 mm (Reference—6 Lugs)

Converter Stall Torque Ratio Range
2.1 to 3.5

Converter "K" Factor Range
87 to 125

Not all "K" Factors are applicable across the entire range of Converter Stall Torque Ratios.

Transmission Fluid Capacities
Bottom Pan Removal: 7.3L (7.7 qt)
Dry: 12.8L (13.5 qt)

Transmission Weight
Dry: 107 kg (236 lb)
Wet: 118 kg (260 lb)

Transmission Packaging Information*
Engine Mounting Face to Rear of Case
660.7 mm (Reference-Less Extension)
Engine Mounting Face to Rear of Case Extension
800.2 mm (Base Reference)
824.2 mm Heavy Duty (Reference)
Engine Mounting Face to Rear of Output Shaft
817.3 mm Base (Reference)
811.3 mm Heavy Duty (Reference)
736.8 mm 4 x 4 (Reference)
838.8 mm Long Heavy Duty (Reference)
Engine Mounting Face to Converter Lug
22.7 mm (Recommended Position)
One-Piece Case with Separate Extension

7 Position Quadrant
(P, R, N, OD, D, 2, 1)

Pressure Taps Available
Line Pressure

Drain Plug Available

*All dimensions shown are nominal.

Information may vary with application. All information, illustrations and specifications contained in this brochure are based on the latest product information available at the time of publication approval. The right is reserved to make changes at any time without notice.

FIGURE IX

FUEL SYSTEM

The fuel system on the 3500 HD will be common with the system used on the lower GVW cab/chassis offerings introduced in 1990. The base fuel tank, mounted midship between the frame rails, will have a capacity of 22 gallons. Extra long filler neck hoses will be assembled into the vehicle to allow after market upfitters to tailor the hose lengths for each application. The optional fuel tank will be mounted between the rear frame rails rearward of the axle. This tank will have a capacity of 30 gallons. At this time the two tanks will not be available as a coupled system.

EXHAUST SYSTEM

The exhaust system will be stainless steel for improved resistance to high temperature. The pipe size will be 3" diameter for low engine exhaust back pressure. The majority of the system is common with the 1990 cab/chassis.

STEERING SYSTEM

The steering system is completely new. The linkage is a modified Haltenberger. The steering gear ratio is 14:1 packaged into the same housing as a full size pickup truck. The power steering pump output pressure was increased by 6 percent to allow lighter steering effort when the vehicle is loaded to its front axle weight rating of 5000 lbs. A steering system damper was also included in parallel to this link to reduce system loads and assist in reducing wheel feedback under uneven road inputs. The entire vehicle has a minimum curb to curb turning diameter of 46 ft for the C310 model.

The vehicle was developed to meet specific handling criteria. Figure X shows the handling parameters obtained with the system developed. The result is a 15,000 lb GVW truck that handles and feels more like a light duty pickup truck.

GMT 455 Handling Parameters

	Roll Gain (Deg/g)		Understeer (Deg/g)
	@ .36	@ .15g	@ .5g
Goals	<10.0	3.5	Constant
C31403	8.6	5.3	6.9

FIGURE X

TIRES AND WHEELS

To package the larger brakes, the same wheels used on our "P" model chassis were used. These are 19.5" by 6". To allow for the larger wheel diameter, and still meet our low egress and ingress height, a low profile tire was chosen. The tire size is 225/70 R19.5 "F." This tire will be supplied by Goodyear and is of steel cord construction for premium reliability. The rear and front wheels were commonized, but the rear wheels use 10 attachment nuts per side while the front wheels use 5 attachment nuts. The spare tire is available as an option, shipped strapped to the back of the frame rails. All tire and wheel combinations maintain the same balance specification as our light duty models for improved quality. These specifications require that all tire and wheel assemblies received at the assembly plant be no more than 6 oz out of balance prior to final correction to 0 oz of imbalance.

COOLING SYSTEM

The duty cycle of the 3500 HD is such that increased cooling is required to carry the increased payloads and to enhance component durability. A radiator size of 19" × 34" × 2-1/8" was packaged. To increase the airflow into the radiator, a front lower grille extension was added below the existing base full size pickup grille. The size of this opening is 37" × 3-1/4". This combination will cool the vehicle, even under idle soak conditions, without the use of an auxiliary coolant boost fan.

SYSTEM PERFORMANCE

The philosophy of creating a new vehicle with unique components was driven by designing and developing the vehicle to performance criteria identified with the usage of the 3500 HD. Enhancements in low loading heights, performance, braking, powertrain reliability, ride and handling, fuel economy, launchability, and cooling were obtained relative to our competition.

SUMMARY

The 3500 HD was created to capture sales in a completely new market niche, which until recently, had not been targeted. By combining a total systems approach, utilizing the available technology of current reliable GM designs and creating unique and robust new components, the 3500 HD will push the criteria for vehicles in this class. Without ignoring pleaseability, the vehicle has achieved new levels of performance without "re-inventing the wheel." This should allow outstanding levels of longevity and widespread customer acceptance.

The vehicle began limited production in June of 1990 at a separate facility next to our Janesville, Wisconsin, medium duty truck plant. Prior to production we tested 20 prototypes for over one third of a million miles of testing. We have had five field test vehicles in customer hands since March of 1990, providing early customer feedback.

The work force has had extensive training by building numerous prototypes in a near production environment. All of which will lead to accelerated production in the fall of 1990 toward full production capacity in early 1991.

Working closely with the NTEA and other customers has lead to what we believe will be the finest class 4 truck on the market today.