

Zeus builds prototype for Marines

The **U.S. Office of Naval Research** (ONR) has enlisted prime contractor **Zeus** to design and build a small ground vehicle to be evaluated for light strike/medical evacuation capabilities for the **U.S. Marine Corps**. Called the Light Strike Medical Evacuation Vehicle (LS-MEV), the compact, high mobility, off-highway vehicle is designed to fit within the tight cargo compartment of the **Bell Boeing V-22 Osprey** vertical takeoff and landing aircraft.

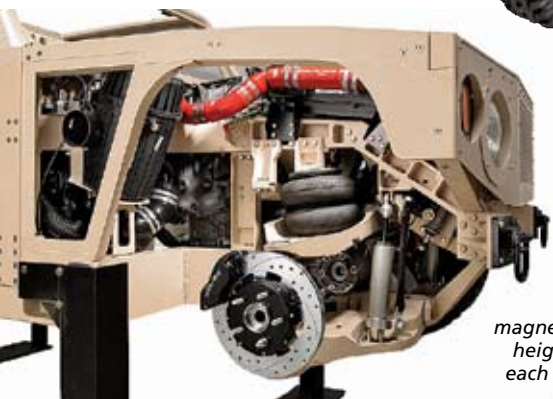
The program is intended to demonstrate various innovative technologies to be used in future combat vehicles. "To do so, we attempted to take a fresh look at each system in the vehicle and consider out-of-the-box solutions where appropriate," said Will Myers, Zeus Director of Design, and the LS-MEV Project Manager. Elements of the design could apply



The Zeus Light Strike Medical Evacuation Vehicle is designed to fit within the cargo compartment of the V-22 Osprey vertical takeoff and landing aircraft.



The LS-MEV's custom-designed radiator is installed in a near-horizontal position with a large electric fan mounted under it.



The LS-MEV chassis features magnetorheological shock absorbers, ride height controlled by varying pressure in each air spring, and four-wheel steering.

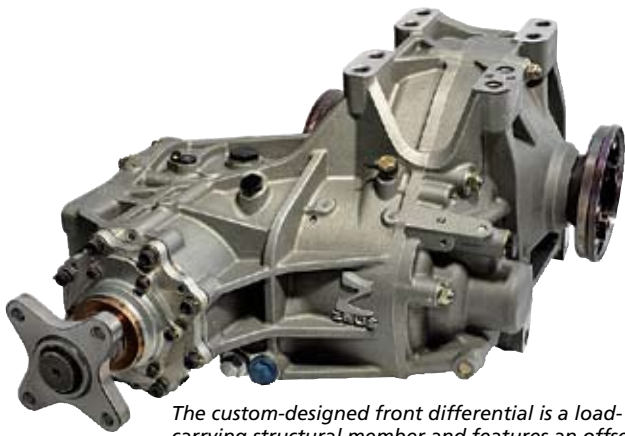
to various existing and future military vehicles, he added. "For example, Zeus was recently granted an additional contract to design a potential suspension for the Joint Light Tactical Vehicle [JLTV] slated to replace the HMMWV [High Mobility Multipurpose Wheeled Vehicle]. This work will be based on the LS-MEV's variable ride height, self-adjusting suspension."

The Zeus vehicle is thought to incorporate a unique set of design solutions for vehicles this size, achieving a significant improvement in projected mission performance vs. competitive options. Since staffing is fairly lean at Zeus, each engineer working on the program is responsible for several systems from concept through the build process. They design and perform analysis on the parts for which they are responsible, coordinate design space and load paths with the other designers, and coordinate purchasing, perform quality inspections on vendor-supplied parts, and coordinate assembly of the parts on the vehicle with technicians. In addition to their design-related duties, one engineer is responsible for purchasing all machined parts, another for purchasing all sheet metal parts, and another for purchasing fasteners. The advantage of doing this at a small company is that the engineer responsible for each specialty is more knowledgeable about that system than any other person and is more cost-effective at making decisions about that system than any other person, said Myers.

The dimensional constraints imposed by the ONR—60-in (1520-mm) width, 60.2-in (1530-mm) height, and 200-in (5080-mm) length—pose considerable challenges to the packaging and stability re-

Zeus LS-MEV Highlights

- High power density turbocharged 164-hp (122-kW) diesel engine
- Two speed, four-wheel drive
- Four-wheel independent suspension
- Four-speed electronically controlled automatic transmission
- Compact offset drive front differential
- Four-wheel steering with 20-ft (6.1-m) turning radius
- Air suspension with variable ride height
- Constant ground clearance regardless of payload
- Computer-controlled magnetorheological damper system
- Lightweight aluminum frame and body construction with fold-down windshield
- Helicopter-transportable, internally and externally
- 50° approach angle
- 45° departure angle
- 13° breakover angle
- 115-in (2920-mm) wheelbase
- 177-in (4495-mm) overall length
- Designed for 10 g vertical, 8 g fore and aft, and 5 g lateral accelerations at gross weight



The custom-designed front differential is a load-carrying structural member and features an offset input shaft that allows the front of the engine to be placed directly behind the differential while maintaining low vehicle height.

quired in a vehicle of this type, according to Myers. For example, if the engine were placed between the front wheels, suspension travel would be virtually eliminated due to the width constraint. If it were to be located above the suspension, driver visibility, vehicle stability, and height become an issue. To maintain a low center of gravity for stability and a high approach angle for off-highway driving, the engine was located as low as possible just aft of the front suspension. This solution presents a challenge with drivetrain and suspension packaging. So Zeus worked with its gearbox supplier to develop a proprietary, narrow track, offset input differential, which acts as a structural member of the frame. This solution has proven to be cost-effective without compromising suspension travel or drivetrain integrity.

Zeus chose **Iveco Motors** of North America, a **Fiat** Powertrain Technologies company, to provide the power for the prototype. The 3.0-L HPI diesel engine was chosen for its light weight and high power rating. The four-cylinder diesel produces 164 hp (122 kW) at 3500 rpm and has a mass of 463 lb (210 kg). The engine features four valves per cylinder, double overhead camshafts, an aluminum cylinder head, and common-rail fuel injection. It is mated to a **General Motors** four-speed automatic transmission.

One of the key features of the prototype is its suspension, which was designed and optimized for high performance over rough off-highway terrain. The suspension control arms were machined from 6061-T651 plate to reduce unsprung weight. By using an air suspension with variable ride height and magnetorheological (MR) shocks, both the spring and damping rates are variable, allowing for the optimum suspension control independent of payload or terrain.

The design process for the suspension including use of state-of-the-art software (from **SolidWorks**, for instance) with extensive use of a proprietary in-house design program. The kinematics and dynamics of the suspension were simulated using Visual Nastran 4D. The MR damping system was optimized for ride and handling through the use of these simulations. FEA was performed on individual suspension components using **Algor** software. The drivetrain was also designed in SolidWorks and modeled using in-house software. Proprietary software was also used to tune transmission shift characteristics.

Zeus chose a unique approach for design of the frame and body in an attempt to reduce weight and offset large *g* loading at gross weight. Several concepts were considered, and the final selection is very similar to highly loaded structural beams and frames in an aircraft fuselage. The 6061-T651 alu-

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minum alloy used has welded joints designed to be used in their as-welded condition. The frame assembly is composed of bolted subassemblies for ease of manufacturing and replacement. Most of the parts in the frame and body are self-locating.

The vehicle is assembled in a simple fixture attached to the frame and floor and remains in the fixture until it can rest on its tires. The fixture replaces much more expensive prototype

Terex loader backhoes offer versatility

Developed to increase productivity, **Terex** backhoes combine the versatility of a wheel loader with the functionality of an excavator in one machine.

At the heart of Terex's backhoe family is the TX760B, which is powered by a 4.4-L, 86-hp (64-kW) **Perkins** turbo induction engine. With a mass of 15,151 lb (6872 kg), its standard lift capacity is 7604 lb (3449 kg). The backhoe has a standard dig depth of 14.7 ft (4.5 m) and a maximum digging depth of 19.3 ft (5.9 m), as well as a straight-wall dig position on the bucket and a power dig position.



Terex's TX760B loader backhoe is powered by a 4.4-L 86-hp (64-kW) Perkins turbo induction engine.



The TX970B offers all-wheel steer, including crab steer, as well as a long backhoe boom for increased, 24-ft (7.3-m) reach and 20.3-ft (6.2-m) digging depth.

With a mass of 15,964 lb (7241 kg), the TX860B offers 94 hp (70 kW) as well as slightly more hydraulics than the 760B, 42 vs. 37 gal/min (159 vs. 140 L/min). The backhoe, which is almost identical to that of the 760B, offers a standard dig depth of 14.7 ft (4.5 m) and a maximum digging depth of 19.3 ft (5.9 m). The 860B loader offers more lift capacity, 8700 vs. 7600 lb (3946 vs. 3447 kg) for the 760B.

The TX870B, with a front end that is similar to the 860B, offers a 15.8-ft (4.8-m) backhoe, which provides a slightly longer reach and depth. The 16,986-lb (7705-kg) 870B has larger tires, as well—20 in on the front and a full 30 in on the rear, which allows the machine to work in very soupy conditions. It also allows for increased ground clearance and flotation.

The TX970 features all-wheel steer, which provides good highway and high-speed stability; crab steer is also included. The 17,663-lb (8012-kg) 970B is similar to the 870 in performance, power, and loader capacity. The 970B's 15-ft (4.6-m) class backhoe provides a 24-ft (7.3-m) extended reach and

assembly tooling normally used for vehicles of this type. This is rather unusual construction for a wheeled vehicle but was found to be very efficient for this application.

Zeus developers will soon brief ONR officials on their work. After reviewing the vehicle and performing preliminary tests at Zeus facilities, plans call for the ONR to further evaluate the vehicle at one of its facilities.

Kevin Jost

20.3-ft (6.2-m) digging depth. Wheels are 24 in for both the front and rear. A switch inside the cab allows the operator to switch between two-wheel and all-wheel steel, and a front steering axle helps to reduce the turning radius, yielding tight maneuverability.

The TX870 and TX970B both have a standard lift capacity of 8783 lb (3984 kg), a standard dig depth of 15.9 ft (4.8 m), and a maximum dig depth of 20.3 ft (6.2 m).

All models feature powershift transmission for clutch-less operation. The 760B, 860B, and 870B models have 4F/4R speeds and a single-stage torque converter with 3.01:1 stall ratio. The 970B has 4F/4R and a single-stage torque converter with 2.60:1 stall ratio. High tractive effort is available in first and second gears on all models for high loader performance.

A front counterweight provides greater fore and aft stability for the 760B and 860B models, and the stabilizer legs include lock-out valves in the circuit so they remain down and provide better stability during operation. The 133-in (3378-mm) center-to-center width across the stabilizer pads provides sufficient stability for heavy loads such as concrete.

The backhoe end features advanced piloted controls that help the machine operate like an excavator. Its closed center, sharing control valve gives operators a smooth, multifunction performance while ensuring fine control for accurate trenching and grading applications. The narrow backhoe boom and 24-in (610-mm) bucket ensure excellent visibility while digging into a trench. The bucket linkage design allows operators to drive into a pile and roll back 45°, and the machine is able to dump at 57° for greater fill capacity and better discharge.

The loader features a single, center-mounted loader dump cylinder for fewer wear and lubrication points, and a large, 1.32-yd³ (1.01-m³) bucket. A single bucket cylinder on the front end minimizes wear and reduces the number of pins and bushings that require maintenance.

All Terex loader backhoes feature an ergonomically designed joystick with adjustable armrests for enhanced operator comfort and visibility. Controls are set to either side of the seat to ensure an unobstructed view of the work area, and a joystick override switch allows operators to stand and look down into the trench while operating the backhoe. A control pattern change valve on the joystick allows the operator to select an **SAE** or **ISO** operating pattern.

A rear-tilting hood gives operators easy, ground-level access to the engine and transmission. All serviceable components are located on the left-hand side of the machine for quick and easy daily maintenance checks.

Terex positions its TRAC rod steering system on the back side of the axle so it can be mounted high enough to maintain a workable ground clearance, which helps to avoid damage to the undercarriage when working on less-than-ideal terrain. Transport is simplified by legs that fold up and lock into position inside the width of the tires.

Darlene Fritz

Gradall introduces its largest-ever excavator

Gradall Industries recently expanded its excavator line for construction markets with the addition of the XL 5100 III excavator—the company's largest production model to date.

The new XL 5100 III, with a mass of just over 55,000 lb (24,948 kg), represents new Gradall-engineered advantages over the XL 5100 it replaces. The new excavator reflects a new design philosophy that delivers increased performance and a shorter carrier for easier highway mobility and a shorter rear swing.

Unlike its predecessor XL 5100, which used two **Cummins** engines, the new XL 5100 III uses just one **Detroit Diesel Mercedes OM906** Tier 3 industrial engine. Conserving fuel while producing great power, the new four-cycle, six-cylinder engine operates both the truck carrier and the upper structure and boom. The turbo/charge air aftercooled, electronically controlled engine achieves 275 hp (205 kW) at 2200 rpm, and 811 lb-ft (1100 N·m) at 1200 rpm.

The simplified powertrain, with only one electrical system, one radiator, one set of filters and other non-redundant features, also helps to reduce vehicle maintenance costs. An **Eaton** Roadranger RTX-14609B transmission provides nine forward and two reverse speeds. The operator can drive the excavator at highway speeds as high as 53 mph (85 km/h). Noise levels are suppressed by such features as a variable vis-



Gradall's new XL 5100 III excavator features a simplified yet more efficient powertrain and a shorter carrier for easier mobility.

cus fan clutch system, while the new chassis benefits from a stronger new axle, standard low-profile radial tires, and hub-piloted disk wheels.

While the old model required two fuel tanks, the new engine is paired with a single 100-gal (379-L) tank. The new engine also offers a longer warranty, with standard 600-h service intervals rather than the 250-h intervals required by the former engines.

XL 5100 III models are available in 6x4 and 6x6 configurations, painted in the new Gradall color scheme of gray with red trim and dark gray cabs, similar to the XL 3000 and XL 4000 models. At 8.5 ft (2.6 m) wide, the XL 5100 III carriers are 6 in (152 mm) narrower than the models they replace, so they now

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can be driven on highways without an over-width permit. The undercarriage has a 14.3-ft (4.4-m) wheelbase and is 24.2 ft (7.4 m) long.

A newly designed counterweight is mounted higher to minimize its impact on operator vision. The counterweight is also more compact, which helps to reduce swing clearance by 18 in (457 mm) and the total length of the undercarriage by 6 in (152 mm). The shorter swing clearance enables the machines to deliver improved performance in tighter quarters, and to reduce interference with moving traffic during highway demolition and repair work.

The new upper-structure cab is located on the left side of the machine, a familiar location for operators of Gradall XL 4100 and XL 3100 highway speed models. From this cab, the operator can reposition the carrier and operate the powerful telescoping and tilting Gradall boom. The new model offers greater control over the carrier positioning speed using a two-speed switch in the upper cab. The cab has a large, adjustable modular seat with electronic joysticks—one for hoist and bucket control, one for telescope and swing control—built into armrests. A quick-change joystick pattern switch on the instrument panel allows operators to switch from Gradall to an **SAE** or **Deere** joystick pattern. Standard features include AM/FM radio, air conditioning, and a work light package.

The upper-structure swing speed has been increased by 33%, providing greater productivity for truck loading and unloading, and allowing the Gradall to compare favorably with conventional high-performance excavators. Bucket breakout force has been increased from 21,900 to 24,900 lb (97,416 to

110,761 N), and the boom crowd force has been increased from 23,390 to 24,500 lb (104,044 to 108,981 N).

The boom movement hydraulics system uses a single load-sensing axial piston pump. The system automatically adjusts boom power for high-productivity excavating, ditching, loading, and demolition or standard grading, sloping, and finishing. The convenient and productive load-sensing feature also allows for fuel savings. Operators of the new model also have the option of reducing engine rpm from 1900 to 1700 using a new switch in the cab.

The new XL 5100 III's boom movements are designed to extract full productivity from a wider range of attachments. Unlike conventional booms that require significant overhead clearance to operate, the Gradall boom benefits from a telescoping action that allows it to work under bridges, trees, signage, top-down excavations, and on the ground floors of many multi-story construction projects. Also unlike conventional booms, the telescoping action delivers consistent power throughout the entire digging cycle.

To capitalize on the XL 5100 III's full range of capabilities, Gradall offers buckets designed for excavating, pavement removal, dredging, ditching and trenching. Grapples, hammers, grading blades, and boom extensions are also available, as well as a tree limb shear and a live boom that can reach over obstacles and dig straight down. All attachments are interchangeable with Gradall XL 4100 II models.

Within the carrier cab, drivers can monitor engine performance with new gauges for oil pressure, coolant temperature, air tank pressures, fuel level, voltmeter, speedometer with odometer, and tachometer with an hour meter. The cab also has a new air suspension seat as well as indicator lights and controls for front axle engagement on 6x6 models and rear axle differential lock.

Darlene Fritz

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Stone adds new Rhino dirt roller

A new combination of power and performance is now available from **Stone Construction Equipment** with the introduction of the Rhino 66X Vibratory Dirt Roller. This ride-on 66-in (1676-mm) roller joins the 43-in (1092-mm) and 54-in (1372-mm) models currently in the Rhino line.



Stone Construction Equipment's new Rhino 66X vibratory dirt roller is available in smooth or padfoot configurations.

The 10-ton (9.1-t) Rhino 66X is powered by a 110-hp (82-kW) **Cummins** water-cooled diesel engine and heavy-duty **Sauer-Danfoss** hydraulic components. The machine also features dual amplitude with a choice of high or low compaction forces of up to 22,500 lb (100 kN) for optimum compaction on any soil. Dual speeds give the roller added maneuverability. The drive system is hydrostatic with a **Dana** no-spin differential axle.

The Rhino 66X is available in either smooth or padfoot configuration. A smooth drum roller with the optional padfoot drum conversion kit is also available, which offers the versatility of two rollers in one. Although tractor-type tires and turf tires are available for the 43-in (1092-mm) and 54-in (1372-mm) models, the 66X uses compaction tires.

Standard features of the Rhino 66X include removable roll-over and fallover protection structures (ROPS/FOPS), an extra-large cooling system, and 45-gal (170-L) hydraulic and fuel tanks. A lift-up fiberglass hood reduces noise and provides maximum access to all service points.

The operator's platform is ergonomically designed for operator comfort, easy operation, and high visibility. The safety-seat features flip-up armrests and a seatbelt that is adjustable in three ways. The control console includes a four-in-one control lever with forward, reverse, and neutral positions; a vibration activation button; and speed and amplitude control buttons.

The Stone Rhino 66X also lowers overall lifetime costs with serviceability features that reduce downtime and maximize up-



The Rhino 66X is ergonomically designed for operator comfort, easy operation, and high visibility.

time. Features like extra-large hydraulic tanks, extended service intervals for engine oil and filter change, maximum access to all service components, same-day parts response and no-parts minimum help to keep the Rhino on the job, not in the shop.

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New cab crowns latest Manitowoc mobile crane

Manitowoc Crane Group recently expanded its Grove mobile crane family with the launch of the Grove GMK4100, the company's newest all-terrain crane.

Rated at 100 t (110 ton), the GMK4100 (GMK4115 in the U.S.) offers a 52-m (171-ft) six-section boom. The boom incorporates MegaForm shaping for rigidity and Grove's Twin-Lock pinning system for a lighter design. The main boom has a telescoping time of less than 7 min.

The boom can be further extended with a 10- to 17-m (33- to 56-ft) bi-fold swingaway jib and up to two additional 5-m (16.4-ft) inserts. With the jib attached, the crane can achieve a maximum tip height of 82 m (269 ft). As with all Groves all-terrains, the jib is able to hydraulically luff under load.

A 295-kW (395-hp) **Mercedes-Benz** engine powers the crane's carrier, and a Mercedes transmission provides 16F/2R gears, combined with a two-stage transfer case. The carrier's standard 8x6x8 drive allows independent rear and crab steering, and an optional 8x8x8 drive is available.

The superstructure is powered by a four-stroke, direct-injection Mercedes OM 904 LA diesel engine, which offers a power rating of 110 kW (147 hp).

Riding on 16.00 R25 tires, the GMK4100 can travel below 12 t (13.2 ton) per axle when carrying a 6.3-t (6.9-ton) counterweight, together with the bi-fold swingaway jib and a 16-t (17.6-ton) hook block. In other configurations, the crane can accommodate up to a maximum 26.1-t (28.8-ton) counterweight.



The Grove GMK4100, Manitowoc Crane Group's newest all-terrain crane, offers an extendable 52-m (171-ft) boom and sleek new operator cab.

One of the most noticeable upgrades to the crane is its new operator cab, which boasts a modern design based on functionality, ergonomics, and comfort. Manitowoc is introducing the new cab with the GMK4100, but it will eventually appear on other Grove models. The cab offers superior all-around visibility, thanks to a panoramic windscreen and heated, curved rearview mirrors. Clearly readable instrument dials have been fitted inside the straightforward, functional dashboard, and air-suspension seats offer a new level of operator comfort. A control unit allows the operator to use the same pedal for braking or accelerating, alternating between the two functions by switching a lever next to the steering wheel.

The new operator cab also makes use of Grove's ECOS electronic control system. Carrier settings, such as suspension, differentials, steering, and level can be easily adjusted using the ECOS panel. Operators can also monitor oil and water temperature, engine speed, and fuel and battery levels.

Complementing the standard GMK4100 is a long-boom version—the GMK4100-L. In addition to offering all of the same features as the standard model, this version offers a 60-m (197-ft) seven-section main boom.

Darlene Fritz

Sennebogen multihandler offers hi-rise visibility

With its North American introduction of the new green line 305 Multihandler C Series, **Sennebogen** presents a versatile new unit that is suitable for material handling needs in scrap handling, waste transfer station, and forestry industry applications.

Sennebogen engineered the 305 Multihandler to provide improved visibility and greater maneuverability combined with the company's signature compact, ergonomic design. It features a hydraulic hi-rise operator's cab with an eye level of 13.3

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The hi-rise cab on the 305 Multihandler provides an eye-level view of 13.3 ft (4.1 m) and gives the operator a clear view of where the load is going.



The 305 Multihandler's bucket and extendible arm give the operator additional reach into a pile.

ft (4.1 m). Capable of reaching a lifting height of 24 ft (7.3 m), the 305 C also offers a real maximum load-bearing capacity of just over 11,000 lb (4990 kg) and is outfitted with a 100-hp (75-kW) diesel engine.

The 305 Multihandler measures 15.7 ft (4.8 m) long, 8.2 ft (2.5 m) tall, and 8.1 ft (2.5 m) wide. This gives the Multihandler the ability to work in areas and markets that previously Sennebogen would not have been able to enter.

The ability to raise and lower the cab reduces operator guesswork and facilitates more precision work, allowing operators to clearly see where they are going, what they are moving, and where they are taking it. In addition to high all-round visibility, the cab also features an ergonomically designed workstation, joystick control, and an adjustable steering column.

An optional two-part XL telescopic boom provides the operator with an extended reach and lift height of 30 ft (9.1 m). With greater reach and loading ability, 305 Multihandler operators can access heights and dump materials that are beyond the reach and ability of traditional telehandlers or forklifts.

The XL version is well suited for container loading as well as shoveling or lifting operations that require extra reach. The quick-change mechanism with extra-wide quick-change plate has a widened 45° tip-back angle, offering optimal shovel control and a tip-out angle from 34 to 142°. The larger tip-back angle ensures clean, fast, and efficient tipping with minimal debris left in the bucket.

The compact 305 Multihandler features hydrostatic all-wheel drive for optimized maneuverability. The unit is equipped with three different steering systems including crab steering, all-wheel steering, and front-wheel steering. The outer tires reach a radius of 140 in (3560 mm) and the inner tires an extreme radius of 35 in (890 mm), resulting in a tight turning capability that allows the operator to maneuver in and around tight spaces.

The 305 Multihandler features an efficient load-sensing hydraulic system as well as a power-governed axial piston pump. The unit also comes with a combined brake and inching pedal plus a selective 100% locking differential.

Operators can perform daily maintenance and fluid-level checks at ground level. The unit is equipped with a reversing fan for cleaning out the cooling system, which helps to minimize downtime and keep the engine running at optimum operating temperature.

Sennebogen offers a complete line of attachments for the 305 Multihandler, including an orange peel, attachable forks, timber grab, sweeper, and various buckets. The attachable forks are also available with sideshift, and buckets are available with and without teeth or grippers. Attachments are designed for quick and easy change.

Darlene Fritz



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