



Product Information – Powertrain

Subject: **Competitive Analysis of Eaton Ultrashift PLUS®** Date: November 24, 2009

This document is a competitive analysis of the **Volvo I-Shift AMT-D** series and the **Eaton Ultrashift PLUS®** Linehaul and Performance automated transmissions. Both the I-Shift and Ultrashift PLUS are available in either direct drive or overdrive models.



Eaton Ultrashift PLUS



Volvo I-Shift

Specification Overview

Designation	Eaton Ultrashift® PLUS				Volvo I-Shift		
	LAS		MHP	MXP	AT2612D	ATO2612D	ATO3112C
Type	2-Pedal AMT Direct Drive	2-Pedal AMT Overdrive	2-Pedal AMT Overdrive	2-Pedal AMT Overdrive	2-Pedal AMT Direct Drive	2-Pedal AMT Overdrive	2-Pedal AMT Overdrive
Torque Capacity (lb-ft)	1450-1550 ¹	1450-1650 ¹	1450-1850	2250 ²	1900	1900	2350
Max GCW (lbs)	80,000	80,000	150,000	Unlimited ³	110,000*		143,000*
Weight w/clutch(lbs)	915	915	995	995	712	712	726
Oil Drain Interval (miles)	500,000**		180,000		500,000**		
Gear Selector Positions	R-Reverse, N-Neutral, D-Drive, Manual, Low				R-Reverse, N-Neutral, D-Drive, M-Manual		
Overall Ratio	15.42:1	17.53:1	16.84:1	18.95:1	14.94:1	15.04:1	15.04:1
Forward Gears	10		13	18	12		
Reverse Gears	2		2		4		
	¹ +200 lb-ft in top 2 gears		² Pending 2010 Release		[*] Higher GCW with application approval		
			³ Application Approval Required		^{**} Linehaul operations @ 80,000 GCW		

LAS = Linehaul Active Shifting, MHP = Multipurpose High Performance, MXP = Multipurpose Extreme Performance

Torque Capacity

Eaton Ultrashift PLUS

- LAS = 1850 lb-ft (top 2 gears, 1650 lb-ft otherwise)
- MHP/MXP = 2250 lb-ft (pending 2010 release)

Volvo I-Shift

- AT2612D = 1900 lb-ft
- ATO2612D = 1900 lb-ft
- ATO3112D = 2350 lb-ft

Eaton advertises that they have the highest torque capacity in the industry. While 2250 lb-ft capacity is impressive, the 2350 lb-ft rating of the Volvo I-Shift for the D16 engine is higher by 100 lb-ft. In fact, it's the only transmission which can be used behind Volvo's 700 HP D16 Euro V engine, with 2323 lb-ft (3150 N-m). No matter the model of the I-Shift transmission, the same robust internal gears are used and the transmission will always meet or exceed the torque rating of the engine with which it is paired.



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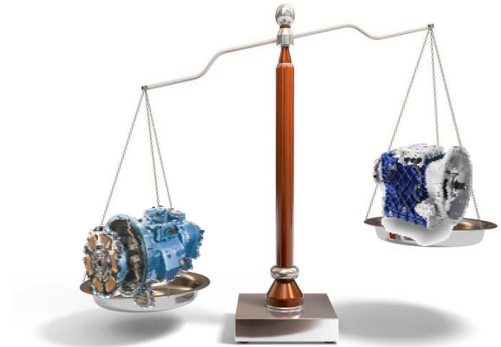
Weight (including clutch package)

Eaton Ultrashift PLUS

- LAS = 915 lbs
- MHP/MXP = 995 lbs

Volvo I-Shift

- AT2612D = 712 lbs
- ATO2612D = 712 lbs
- ATO3112D = 726 lbs



Weight is extremely critical in today’s truck market, especially with the installation of additional components to meet EPA’10 emission levels. In comparison of the transmission weights, the Volvo I-Shift is almost 200 pounds lighter. When comparing the below engine and transmission combinations, the Volvo engine and I-Shift together are approximately 600 pounds lighter.

Cummins ISX Engine and Ultrashift PLUS = 3879 lbs.

Volvo D13 Engine and I-Shift = 3262 lbs.

Customizable Software Packages

I-Shift can be custom tailored to each customer’s operation through six fully featured software packages. Individual features may even be enabled or disabled within those packages.

The Ultrashift PLUS transmission does not have this feature.

Features	I-Shift Transmission Electronics Feature Packages					
	Basic Shifter (Family 1)			Premium Shifter (Family 2)		
	Basic	Enhanc Basic	Fuel Econ	Performance	Comprehen	GentleShift
Ergonomic seat mounted shifter	X	X	X	X	X	X
Basic Shifter type without manual controls	X	X	X			
Premium Shifter type with manual controls				X	X	X
Manual gear shifting in Drive mode				X	X	X
Manual gear shifting in Manual mode	Hold only	Hold only	Hold only	X	X	X
Manual selection of start gear				X	X	X
Idle Governor driving mode		X	X	X	X	X
Manual selection of Idle driving gears				X	X	X
Economy mode	X	X	X	X	X	X
Performance/Performance Plus (P+) mode				X ^{A, D}	X ^A	X ^A
Kick-Down		X ^B	X ^B	X ^B	X ^B	X ^B
Eco-Roll			X ^C		X ^C	X ^C
Engine Brake Performance mode	X	X	X	X	X	X
Auto Neutral when parking brake applied	X	X	X	X	X	X
Auto Neutral at key-off if gear engaged	X	X	X	X	X	X
Hill Start Assist	Optional	Optional	Optional	Optional	Optional	Optional
STD PTO features	X	X	X	X	X	X
Enhanced PTO features	Optional	Optional	Optional	Optional	Optional	Optional
Feature upgradeability	Unlimited within family and between families with gear shifter change					
Engine Torque upgradeability	Unlimited by clutch, transmission and prop shaft					
Functionality of features programmable per customer preference:						
^A 1. Available 2. Available with auto return to Economy 3. Available with Performance Bonus Reward 4. Not available						
^B 1. Available 2. Available in Economy mode only 3. Available with Performance Bonus Reward 4. Not available						
^C 1. Available 2. Not available						
^D 1. The P+ mode includes various functions that adapt gearshifts and gear selection to poor or hilly driving conditions (EPA’10 only)						

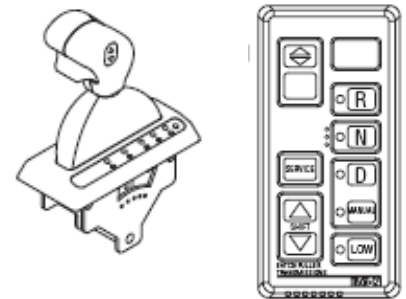


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Gear Selector Unit

The Ultrashift PLUS transmission is available with either a lever type or push button shifter depending on the OEM. The shifter is mounted to the side of the driver’s seat. Operating modes are:

- Reverse
- Neutral
- Drive
- Manual
- Low – selects lowest gear available and holds that gear
- Up and Down arrow buttons to allow the driver to override the transmission



The I-Shift transmission is equipped with an ergonomic lever type shifter which is available in either a Basic or Premium level, depending on the software feature package selected. The shifter is mounted to the side of the driver’s seat. Operating modes are:

- Reverse
- Neutral
- Drive – Economy or Performance (Premium Shifter)
- Manual
- Limp Home – can be activated if a serious fault occurs

I-Shift Basic Shifter

The Basic shifter is used for the Basic, Enhanced Basic and Fuel Economy software packages. This shifter limits the amount of driver interface with the transmission, allowing it to remain in Economy mode and operate in the most efficient manner at all times. I-Shift can be trusted to provide the right gear for the right conditions every time. The Basic shifter has no +/- buttons and prevents the driver from operating the vehicle in the way he is used to “hearing it sound”.



I-Shift Basic Shifter



I-Shift Premium Shifter

I-Shift Premium Shifter

The Premium shifter is used for the Performance, Comprehensive and Gentle Shift software packages. When equipped with the Premium shifter, I-Shift comes with two selectable personalities - Economy and Performance/P+ modes. The shifter also adds the feature of manual shifting capabilities to the transmission and is recommended for Owner Operators, Vocational and Heavy Duty applications where additional driver interaction may be desired.



Manual Shift Buttons



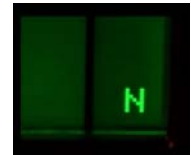
E/P Mode Switch



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Driver Interface

The Ultrashift PLUS transmission comes equipped with a dash indicator (OEM dependent) showing the present gear, and clutch abuse warnings. There are also indicator lights on the shifter assembly and beep tones used to alert the driver if the transmission is unable to make a requested shift.



The I-Shift transmission communicates through the Driver Information Display (DID) in the instrument cluster. All of the needed information is right in front of the driver in an easily readable format. Information displayed is as follows:

- Gear selector position
- Present gear
- Available gears – up or down
- Economy or Performance mode
- Engine Brake position
- If Eco-Roll enabled

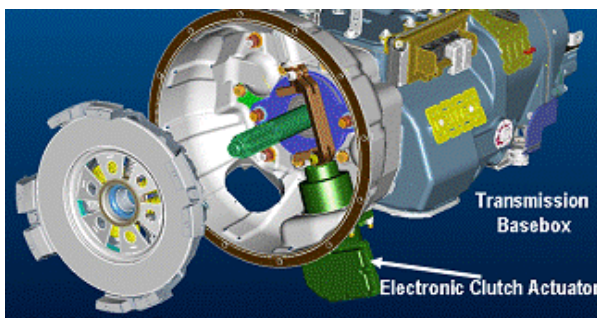


The Volvo I-Shift lets the driver know the number of steps that can be taken up or down based on present conditions, *BEFORE* the shift is attempted, not an audible signal to indicate the shift has failed *AFTER* it has been attempted.

Clutch Package

The Ultrashift PLUS transmission utilizes an Eaton 15½ inch twin plate, pull-type, ceramic faced self-adjusting clutch.

The I-Shift transmission uses a 17 inch single plate, push-type organic faced clutch. The spring-cushioned organic friction facings ensure the smoothest possible clutch engagement. The combination of this non-aggressive facing and I-Shift's ability to minimize heat during clutch engagement results in longer clutch life and reduced flywheel wear compared to cerametallic faced clutches.



Ultrashift PLUS Clutch Package



I-Shift Clutch Package



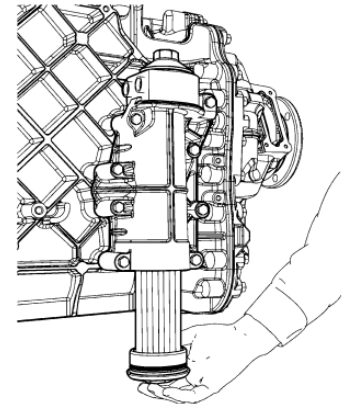
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Maintenance

The Ultrashift PLUS and the I-Shift both offer extended oil drain intervals. With a linehaul application rated at 80,000 lbs. or less, the interval is 500,000 miles for both transmissions. Vocational and heavy haul applications require more frequent service intervals.

An additional important feature of the I-Shift is an integrated oil filter which also must be changed with the oil. The filter will catch any foreign particles which could possibly enter the transmission.

Both the Ultrashift PLUS and the I-Shift feature an external sight glass for visually inspecting fluid levels. The clutch housing on the Ultrashift PLUS must also be greased every 25,000 miles or 3 months for linehaul applications and every 250 hours or 1 month for vocational. There is no maintenance for the I-Shift clutch actuator since it is a sealed maintenance free unit.



I-Shift Integrated Filter

Transmission Warranty (excludes clutch)

Eaton Ultrashift PLUS

- LAS = 5 years / 750,000 miles
- MHP/MXP = 5 years / 500,000 miles

Volvo I-Shift

- *Normal Duty* ≤ 1750 lb-ft = 5 years / 750,000 miles / 15,000 hours
- *Normal Duty* > 1750 lb-ft = 3 years / 500,000 miles / 12,500 hours
- *Heavy Duty* = 3 years / 250,000 miles / 6,250 hours
- *Severe Duty* = 1 year / 100,000 miles / 3,250 hours

Clutch Warranty

Eaton Ultrashift PLUS

- LAS = 3 years / 350,000 miles
- MHP/MXP = 3 years / 350,000 miles

Volvo I-Shift

- *Normal Duty* = 3 years / 300,000 miles / 7,500 hours
- *Heavy Duty* = 3 years / 250,000 miles / 6,250 hours
- *Severe Duty* = 1 year / 100,000 miles / 3,250 hours



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Available Features

	Ultrashift PLUS	I-Shift
Grade Sensor	X	X
Load Sensor	X	X
Skip Shifting	X	X
Low Speed Operation	X	X
Hill Starting Assistance	X	X
Auto Neutral	X	X
Electronic Clutch Actuation	X	X
Intelligent Shifting	X	X
Forced Lubrication		X
Kick-Down		X
Economy and Performance Modes		X
Integration into Performance Bonus		X
Eco-Roll		X
Brake Mode		X
Enhanced PTO Functions		X
Ability to Rock Free		X
Power Launch		X
Runaway Control		X
Avoid Shifts in Drive Mode		X
Greatest Possible Downshift		X
Upgradeability Allowed		X
Full OEM Integration		X

Grade Sensor

The Ultrashift PLUS has a newly introduced grade sensor, similar to what the I-Shift has been using since its introduction. The grade sensor allows the transmission to sense what grade the vehicle is operating on and alter gear shifts accordingly.

Load Sensor

The Ultrashift PLUS has a newly introduced load sensor, similar to what the I-Shift has used since its introduction. This load sensor allows the transmission to calculate the GCW of the vehicle and adapt gearshifts for higher overall weights.

Skip Shifting

Utilizing the grade and load sensors, both transmissions are able to calculate when to skip shift gears. This allows the transmission to quickly get into the upper gears to maximize fuel economy. But I-Shift, with 12 speeds, can reach top gear in Economy mode using just five upshifts.

Low Speed Operation

The Ultrashift PLUS uses a Creep Mode to allow the vehicle to operate at low speeds. In drive and reverse, there is a slight creeping ability, but creep may exit and the clutch will open if the engine speed drops slightly below idle. In manual and low, the system enters Creep Mode and will stay engaged until the brake is pressed. The transmission will not shift to a higher gear.

The I-Shift utilizes the Idle Driving mode, which is engaged by the driver removing their foot from the accelerator and allowing the vehicle to idle along. The transmission automatically selects the gear which best suits the speed. The vehicle speed can be adjusted without the accelerator by using the plus (+) or minus (-) buttons on the Premium shifter (if equipped) which slightly raises the engine speed for the transmission to shift up, or slows the vehicle down with a downshift. When the Basic shifter is utilized, slightly pressing the accelerator or brake pedal will change engine speed to facilitate an upshift or downshift.



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Hill Starting Assistance

The Ultrashift PLUS has a Hill Start Aid feature identical to the I-Shift's Hill Start Assist feature. These Hill Start options will hold the vehicle on a hill by applying the service brakes allowing the driver three seconds to move their foot from the brake pedal to the accelerator. When an accelerator input is detected, the brakes are released and the vehicle can drive off. This is a safety feature, keeping the vehicle from rolling backwards and also saves wear on the drivetrain.

Auto Neutral

The Ultrashift PLUS transmission will automatically shift to neutral if the vehicle is left in drive and the parking brakes are set. It is very important to not shut the vehicle down if still in gear and the parking brake is not applied as this could "Torque Lock" the system and result in a No-Start condition.

Since the I-Shift transmission has authority over the engine, it makes sure it is in neutral, regardless of the brake position, before allowing the engine to shut down to ensure it will never get stuck in gear. To protect the clutch release bearing, the I-Shift will automatically shift to neutral if left in gear with the parking brake applied for four minutes.

Electronic Clutch Actuation

The Ultrashift PLUS transmission has an Electronic Clutch Actuator (ECA), which replaces the standard clutch pedal. The clutch is closed when the vehicle is launched and is automatically opened when coming to a stop. The ECA also has the opportunity to open the clutch when shifting. The ECA mounts to the bottom of the clutch housing.

The I-Shift transmission features a light weight and maintenance free ConAct clutch actuator which is a completely pneumatic device controlled electronically by the I-Shift. Combining the functions of clutch actuator, release fork, clutch bearing, transmission quill and various bushings/pivot points into a single integrated unit, the wear points and resulting inaccuracies of operation are virtually eliminated. No hydraulics are involved, and the concentric in-bell housing design eliminates undercarriage ground clearance restrictions of "catapult fork-type" setups.

Forced Lubrication

Every I-Shift comes with a lube oil pump that pressurizes the distribution of lubricant through drilled passageways, similar to the oil pump in an engine, to ensure lubrication under arduous conditions. A standard lube oil filter will remove any contaminants.

The Ultrashift PLUS transmission does not have this feature.

Kick-Down

The I-Shift Kick-Down feature maximizes acceleration. When engaged via the switch under the accelerator, the transmission will downshift if it calculates that it will help bring the vehicle to the desired speed faster than remaining in the current gear.

The Ultrashift PLUS transmission does not have this feature.

Economy and Performance Modes

When selecting the Premium shifter and an upper level software package with an I-Shift transmission, the Economy and Performance features are also available through a push button switch on the shifter. In Economy mode, the transmission operates to maximize fuel economy and driveability. In Performance mode, the transmission operates in a mode to maximize engine power. Selectable parameters allow the transmission to be defaulted back to Economy mode if maximum performance is no longer needed. Performance Plus (P+) mode is designed to provide additional performance for vocational and heavy haul vehicles.

The Ultrashift PLUS transmission does not have this feature.





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Integrated into Performance Bonus Feature

Volvo's Performance Bonus software, which encourages the driver to operate the engine for better fuel economy, can integrate certain I-Shift features for even better functionality.

Both the Kick-Down feature and the E/P switch can be enabled/disabled as a reward for driving the engine in the sweet spot.

The Ultrashift PLUS Transmission does not have this feature.

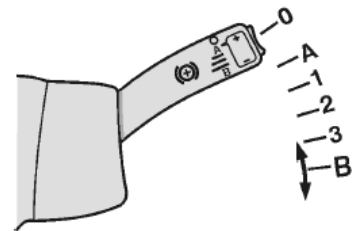
Eco-Roll

The Eco-Roll feature of the I-Shift transmission is aimed at doing one thing; saving fuel. This feature is engaged automatically when the Engine Brake stalk is in 'A' position and allows the transmission to go to neutral during certain conditions such as moderate rolling hills, maximizing the kinetic energy of the vehicle. The transmission goes to neutral in the splitter part during Eco-Roll, leaving the clutch and the main transmission still engaged, which allows a quick re-engagement of the driveline as soon as the driver touches the foot brake, accelerator or engine brake.

The Ultrashift PLUS transmission does not have this feature.

Brake Mode

I-Shift is perfectly integrated into the Volvo Intelligent Engine Brake (I-VEB) control. In the 'A' position, 'Brake Blending' occurs as the I-VEB is operated at 50% level with the application of the footbrake. Position 'A' also enables Eco-Roll to come on when coasting during the proper conditions. Positions 1, 2, and 3 operate the I-VEB at 40%, 70%, or 100%. When the Brake Mode (B) is activated, the I-VEB comes on 100% and the transmission automatically downshifts to maximize the performance of the engine brake. I-Shift will continuously downshift in Brake mode as the speed decreases in order to maintain maximum retardation. The function then becomes less aggressive in the lower six gears to protect the driveline and improve comfort.



The Ultrashift PLUS transmission does not have this feature.

Enhanced PTO Functions

The I-Shift comes standard with Basic PTO functionality, but is available with Enhanced PTO Functions. These include the following:

- Pre-defined split positions – defines which split gear (low or high) to use when the PTO is engaged
- Gear selection adaptation to engine speed limits – limit engine speed when PTO's are used
- Auto neutral
- Reverse inhibit
- Split box engagement

The Ultrashift PLUS transmission does not have this feature.

Ability to Rock Free

In situations where wheel spin occurs and a vehicle becomes stuck, the I-Shift transmission has the ability to rock the vehicle back and forth to maneuver out of the stuck condition. A combination of carefully pressing and releasing the accelerator, to ease the vehicle forward or backwards, will produce the rocking motion to elongate the wheel tracks which have caused the vehicle to become stuck. To utilize this feature, take the following steps:

- Engage differential locks
- Turn off traction control
- Select Performance/P+ mode of the I-Shift
- Move the gear selector to the M-Manual position, 1st gear, or the 1st reverse gear
- Carefully press accelerator pedal up and down with a smooth pumping action

The Ultrashift PLUS transmission does not have this feature.



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Power Launch

If a vehicle becomes “really stuck” in sand or very soft soil and is equipped with the Performance+ software package, the I-Shift has the ability to use extra engine torque to get the vehicle moving once again. To utilize this feature, take the following steps:

- Select P+ mode of the I-Shift
- Move the gear selector to the D or M position, 1st gear, or the 1st reverse gear
- Press in the minus (-) button on the gear selector
- Completely depress the accelerator – the engine will rise to 1300 rpm
- Release the minus (-) button and the clutch is engaged, launching the vehicle free

The Ultrashift PLUS transmission does not have this feature.

Runaway Control

This safety feature of the I-Shift transmission works automatically if the vehicle starts to run away in the opposite direction of the gear that is selected. This could be when driving up a steep hill and the driver's foot slips off the accelerator. In this case, the truck could start going backwards down the hill. The Runaway function will engage and bring the vehicle to a standstill using the clutch to brake the vehicle. It will then release, allowing the vehicle to roll a little further, and then engage once again. This action is repeated until the vehicle is stationary or until the driver regains control. This function is something the driver may never need to use, but it is nice to know that the vehicle will behave in this way if it ever starts to run away.

The Ultrashift PLUS transmission does not have this feature.

Avoid Shifts in Drive Mode

To avoid the I-Shift transmission downshifting when in Drive (D) mode, push the plus (+) button on the gear selector while the engine rpms are very low. This could be used approaching the top of a hill when a downshift is not desired by the driver.

To avoid the I-Shift transmission up-shifting when in Drive (D) mode, push the minus (-) button on the gear selector. This could be when driving uphill with poor traction or when approaching a hill where higher engine rpms are needed for more efficient operation.

The Ultrashift PLUS transmission does not have this feature.

Greatest Possible Downshift

With the I-Shift, to evoke one large downshift instead of several smaller ones, push the minus (-) button and change the gear selector from Drive (D) to Manual (M) mode. Release the minus (-) button. This gives a large downshift for the purpose of immediately getting a high engine speed in the vehicle, for instance when approaching a steep hill in off-road conditions. The I-Shift uses its grade sensor and GCW calculations to determine the best gear.

The Ultrashift PLUS transmission does not have this feature.

Upgradeability Allowed

I-Shift transmissions work with any of the engines inside a displacement family. For example, a truck can be ordered with a D13 405 HP 1450 lb-ft torque rating. Upon resale, the engine can be safely upgraded the entire way to a 500 HP 1750 lb-ft rating for higher residual values, without the need to upgrade the clutch or transmission.

The Ultrashift PLUS transmission does not have this feature.

Full OEM Integration

Volvo I-Shift transmissions have been fully designed and engineered by the Volvo – by the same overall Engineering Department that engineers Volvo engines. Thus the engine and transmission can be truly designed together as one. They speak the same language, using proprietary protocols, are designed to meet the same project goals and timing, and are designed with mutually agreed upon engineering concepts and strategies. For example, the I-Shift transmission is given significant authority to control the engine under various conditions.

This allows Volvo to put the customer first, in a way that no other Powertrain can!