HOW HARD CAN IT BE?

Dave Ashcroft's fascinating insight into Ashcroft's Puma auto – by far their most complex project yet

FUNNILY ENOUGH, this brings our company full circle, in a sense, writes DAVE ASHCROFT. In the early days Ashcroft Transmissions was known as 'Automatic Conversions', initially converting Series Land Rovers to automatic. However, as the market moved on we became more involved with the re-manufacture of all Land Rover transmission/drive line components.

As the demand for Series conversions decreased we initially manufactured a 200 Tdi auto kit, soon replaced by a kit to suit the 300 Tdi Defender with parts, largely made up from 300 Tdi Discovery factory parts, at this time we made our first in-house gearbox tunnel console as the factory 'NAS' spec console was no longer available.

The introduction of the Td5 brought another series of challenges but we brought out a kit to convert the Td5 Defender to automatic. At this time we did not have a viable 'electronic' route as fitting the ex-Discovery electronics to a Defender was fraught with problems. As a known alternative we changed the electronic control back to hydraulic control and added a kick down from the throttle pedal.

As it became known that a new Defender model with a Ford engine was due to be launched in 2007, we began to receive enquires as to the feasibility of supplying an automatic conversion. Also, because working on automatic conversions is our established field of experience, we wanted to be up-to-date with the market place and be able to offer a conversion as early as possible.

tick the right box

The 2.4 TDCi or 'Puma' Defender turned out to be the most challenging of our conversions to date and used all our accumulated knowledge – and then some!

We initially started looking at the project about 12 months before the new Defender was launched. One of our earliest decisions was whether to use a Ford gearbox or to use the ZF. a gearbox with which we were already very familiar and that is also readily available.

This decision was, in the end, a 'no brainer' as it turned out there are no automatic Transit gearboxes and converting an existing Ford car box to suit the Puma and LT230 seemed a much bigger job than fitting a ZF. At least using the ZF box we would only have to make a new front end to suit the Puma 2.4. We were familiar with the torque converters and so would be in familiar territory.

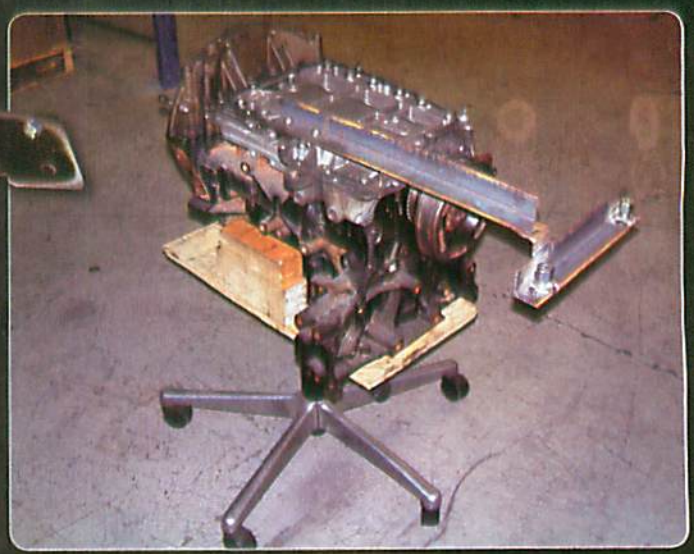
The conversion, as with all our other conversions, had to fit certain criteria. It had to:

- Be a direct replacement for the manual gearbox;
- Leave the transfer box in its original position;
- Leave the exhaust untouched;
- Leave all transfer box

Clockwise from far left: You can just see Ashcroft's auto Defender 'mule' (test vehicle) shown in front of their impressive premises; And this is what all the fuss is about: A brand-new, Puma-engined automatic Defender that you won't find in Land Rover's own showrooms; This 2.4 Tdci engine block was used to mock up the locations of the transmission oil cooler pipes; Ashcroft use a specially mounted high-efficiency oil cooler.

FACT FILE

- PCD stands for Pitch Circle Diameter and is the diameter of a circle drawn through the centres of the bolt holes.



functions as standard and in their original position.

As the information we needed was under close wraps and, because the vehicle had not been launched and so there were no models in our local showroom to study and measure, it was initially a case of gathering as much information as we could then making some informed decisions. Armed with this 'best guess' information and our decision to use a ZF, off we went into the unknown.

size matters

First thing to do was to accurately measure the bolt pattern from the back of the engine. Simple! You think?

For a start, the block would not fit under our measuring machine so it had to be converted to a 'short block', a unique 2-cylinder Puma 'engine'. By this time we had established an overall transmission length and were able to decide on the bell housing length.

Another decision that had to be made at this time regarded the torque converter size. There are basically three sizes of converter used in the ZF box. The 300Tdi and the Td5 use the 'small' converter, V8 engines use the 'medium' converter, and the 'large' converter was used on the early 4.6 V8 (while interestingly, the later 4.6 engines have the medium converter).

The size of the converter is important for two reasons: A small converter working with the torque converter 'unlocked' will generate more heat than the larger converter, and the larger the converter the larger the lock-up clutch has to be. (This locks the transmission to prevent torque converter 'slip' above a set road speed.)

However, in the case of the Puma 2.4 engine, because the diameter (PCD) of the block bolt pattern determines the internal diameter of the bell housing, we are limited to using the small converter.

But then, as it turned out, an enlarged bell housing would have caused even more problems, interfering with ancillaries and especially the exhaust down pipe. Also as we had now established that we were going to use Compushift with its inherent control advantages, the smaller clutch was not a concern.

off the drawing board

Now we had decided on the length and the diameter of the bell housing, we were ready to make the first feasibility castings. But first we needed a 'pattern'.

Anyone who has been involved with development will know the costs involved in this process so, as this was still in prototype stage, we made our own pattern using the old techniques, involving wood, fibreglass and lots of filler. It was good enough to get the job done without breaking the bank.

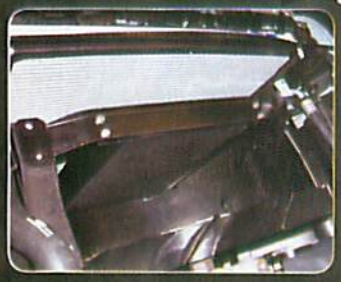
Then, once the prototyping was completed, a production pattern had to be made (this one cost serious money) allowing thinner walls, better strengthening ribs and all necessary clearances.

Another area to complete was the crank boss and flex plate.

The boss itself was simple once we had established the bell housing size. It only required the dimension from the crank to the torque converter feet and the associated bolt hole patterns to complete it.

The flex plate on the other hand was a little more complicated, as the stock Land Rover 300Tdi flex plate has a poor record with regard to cracking. This was an ideal time to change both design and material and go to spring steel, which provides more strength and reliability.

Even this was easier said than done. The problem



Clockwise from right: Space is very limited behind the grille so the oil cooler is mounted in the area behind the radiator; Ashcroft have their own, purpose-made bell housings; A bevy of bell housings, before being built-up; Compushift electronic change controllers are specially built to Ashcrofts' specifications.
Opposite page: Compushift enabled Ashcroft to fine-tune the ZF gearbox to suit the characteristics of the Puma engine.

we had was sourcing flat spring steel plate, large enough to make a flex plate. But once sourced, this was laser cut to shape.

The next problem was that the crank bolts on the Puma engine are the 'odd' size of 11mm. A simple Hex or Torx head bolt of this size, in 12.9 grade, is not available, so special bolts had to be made.

About this time we purchased our own 2007 Defender to allow proper measuring and fitting to take place without any customer pressure. First thing we noticed was that the engine was raised and the transfer case was rotated by about 10° to bring the propshafts back to their original positions.

As we were using the original LR/ZF back end this meant the automatic gearbox had to be rotated by the same amount. This, in turn, involved rotating, or 'clocking', the bolt pattern in the bell housing to accommodate the rotation. Nothing is simple!

This rotation moved the x-y switch on the ZF gearbox much closer to the side of the tunnel and led to additional work in making an inspection panel to provide clearance for, and allow fitting of the x-y switch, similar to the 3-speed auto Range Rover. Like many other things, once done this has turned out to be a very useful feature, allowing easy access to adjust the x-y switch, but at the time it felt like just one more unwanted problem.

electronic switch

Initially, because of our familiarity with hydraulic auto boxes, which are very successful with Defender Td5 conversions, we were tempted to follow the same route. However we felt that a system that would offer additional features and more flexibility, which could never be achieved with the hydraulic control, would be of great benefit.

Searching the market, as we often do, we came across the Compushift, an American, individually programmable electronic control system. This seemed to meet our needs of total flexibility while providing the facility for each owner/driver to tweak the system to suit their own preferences.

On a regular electronic auto box, the ECU works by receiving a certain number of inputs such as vehicle speed, throttle position, transmission temperature and more, depending on the vehicle. The ECU then 'looks' at the various preset shift patterns (which are set for different engine/vehicle combinations) and then selects the correct gear.

The problem with this system in a non-standard vehicle is that it was designed for a different vehicle and the shift pattern will never quite match the new engine/transmission combination.

simple and flexible

This is what makes the Compushift different. It's a stand-alone system that controls the electronic version of the ZF 4HP22/24 auto transmission. The beauty of it is that you, the driver, can very easily 'map' these shift points and shift pressures to suit yourself. Better still, this is done using the Compushift display unit without the complexity or hassle of having to plug in a laptop.

Compushift takes four inputs from the vehicle and calculates the shift points, shift pressures and torque converter lock-up speed, depending on the shift tables or 'maps' in its ECU. This is a major step forward for anyone using the ZF gearbox in non-factory applications as you are not constrained with the preset maps and can adjust them to make the transmission drive like it would in a 'factory' vehicle.

After discussions with the supplier at his workshops in California, we agreed a basic package and ordered an initial stock of supplies.

The last of the major components to be decided on

WHAT'S SO SPECIAL?

- Land Rover have *never* offered automatic transmission versions of the diesel Defender.
- When there were automatic diesel Discovery equivalents around, the conversion was relatively straightforward and, as usual with transmission work, Ashcroft led the way.
- Ashcroft point out that there has never been an auto version of a vehicle fitted with Ford's Puma engine, as used in the new Defender from '07-on. So they developed one from scratch!
- You can purchase a kit for fitting yourself or have Ashcroft carry out all the work for you – the choice is yours.

was the oil cooler. The cooling needs to be good to allow for the small converter. After some debate, we decided not to use the standard cooler – which could have been fitted below the radiator – and instead to install a block matrix cooler with a higher capacity.

fitting it all in

Finding a suitable mounting position for this enlarged cooler while ensuring adequate air flow at all times led to our mounting the cooler behind the radiator in the space under the cowl. This position loses some efficiency as it is behind the radiator but this is more than compensated for by its size and in being cooled by the engine fan.

So far, this decision has proved to be correct. One of our conversions recently completed a trip around the Pyrenees with long, continuous, uphill pulls without overheating.

You would think that with the major components of the gearbox and its control unit in hand, the rest would be simple. But there was more to come!

We have been making a moulded interior console, based on the factory-fit NAS-spec Defender for some time now and this has been used in our Td5 conversions. However, the 2007 model Defender has a different dash which meant making a new console to suit the Puma, requiring further development, a new injection mould and so on. Now that we had our own vehicle, we were in a position to carry on with this and, after cutting and modifying a Td5 console, we had a prototype to work with.

At last, with all the major development work completed, we were able to assemble a full kit and start the conversion to our Defender. Installation proved relatively trouble free, though there were a couple of false starts due to differences between the Ford Transit's and Land Rover's version of the Puma engine.

For example, the Transit has a dual-mass flywheel, to reduce low-speed vibration. It is made in two parts and, to prevent it from shaking itself apart, the Transit is set to stall below a certain engine speed. This wouldn't be

WHAT THE COMPUSHIFT HAS TO 'READ'

1. The x-y switch on the selector shaft, to the left of the electronic ZF gearbox housing, is a gear position switch. Compushift needs to be wired into this switch so that its ECU knows what gear you have selected with the shifter. You also wire the reverse lights through this switch (no relay needed) and the starter inhibiter, through the low current starter solenoid signal wire.

2. A clean, 12V ignition-switched feed.

3. Throttle Position Sensor (TPS). The ECU needs to know the throttle position. This signal comes directly from the throttle pedal potentiometer on the 2.4 TDCi engine.

4. Temperature Sensor. This is used for two reasons. The shift pressures are adjusted dependent on the oil temperature to allow for changes in viscosity. And if the system is used with the optional display, you can monitor the temperature. Ashcroft braze a spigot into the sump to fit the sensor.

Left: If the owner wants it, the Compushift unit can be left to hand to adapt change points as required.
Above: The brains of the Compushift system, its electronic control unit.
Below left: The console is specially made to Ashcroft's specification and has a useful cubby box.
Below right: The shift lever falls nicely to hand for those who like to select their own gears when towing, for example.

appropriate for a Land Rover and so the Defender has a conventional flywheel which altered the boss length and the bell housing inner diameter. Aaagh!

The starter motor is also different, requiring a different shape cutout in the bell housing. After a few other relatively minor differences the installation was, at last, complete.

We carefully filled with oil, turned the ignition on and calibrated the throttle position sensor for the Compushift, took a deep breath and turned the key half expecting a loud banging and clanking. The engine quietly idled and all was well.

I shifted it into drive and the revs dropped which was a very good sign, I gingerly crept up the road and it shifted up to second then third. Then it was back to the workshop with a mighty big smile on my face for a leak test, bolt checking and the like.

making it just so

The next week was spent fine-tuning the shift maps on the Compushift until we had it driving perfectly, not only shifting up when it should but also kicking down when it should and locking up at the correct speed too.

We have now covered about 5,000 miles in our demo 90 and it's performing flawlessly. This has been our longest and most expensive product development to date and the learning curve has broadened our technical understanding which will help us improve our existing product range.

We are very pleased with the solution we have arrived at, as well as being very pleased with the enhanced drive-ability of the Defender.

■ In a future issue, **LRM** will show you, step-by-step, how to carry out a variety of Ashcroft Defender conversions – 300Tdi, Td5 as well as Puma – and we'll be able to test Ashcroft's Defender Puma auto fitted with the final production version of their conversion kit.

Watch this space! **LRM**

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