## Contents

**Introduction** ................................................................. 6

- Forces driving mainstream transmission changes .......................................................... 9
  - Transmission development drivers ............................................................................. 11

- Transmission efficiency gains .................................................................................. 12

- Greenhouse gas emissions and fuel efficiency ........................................................... 15
  - The European Union .................................................................................................. 15
  - The United States ..................................................................................................... 17
  - Japan ......................................................................................................................... 18
  - China ........................................................................................................................ 18
  - Other countries ........................................................................................................ 18

- Testing regimes ........................................................................................................... 19

- The influence of engine development on transmission development ......................... 21

- Product differentiation ............................................................................................... 22

- Investment and installed capacity ............................................................................... 23

**Key influences on technology development** ......................................................... 24

- Packaging and weight ............................................................................................... 24
  - Safety regulations .................................................................................................... 26

- Performance characteristics ..................................................................................... 26
  - Noise Vibration Harshness (NVH) .......................................................................... 27

- Ratio spread ............................................................................................................... 28

- Transmission costs .................................................................................................... 29

**Transmissions technology** ..................................................................................... 31

- Manual Transmissions (MTs) ..................................................................................... 32
  - Automated manual transmissions (AMTs) ................................................................. 35

- Dual clutch automated manual transmissions (DCT) ............................................... 39
  - DCT Suppliers ......................................................................................................... 39
  - DCT introduction ...................................................................................................... 49
  - Commonality of componentry .................................................................................. 52
  - Dry clutch or wet clutch? ......................................................................................... 53
  - Electro-hydraulic or electro-mechanical actuation? .................................................. 54

- Planetary automatic transmissions .......................................................................... 56
  - Automatic transmissions gear set configurations .................................................... 58
  - Torque converters ...................................................................................................... 59
  - Six-speed automatic transmissions ......................................................................... 61
  - Seven-speed automatic transmissions ...................................................................... 63
  - Eight-speed transmissions ....................................................................................... 65
  - Nine-speed and ten-speed transmissions ................................................................ 67
  - Global AT production mix forecast by number of ratios ......................................... 70
  - Manual override systems on ATs .............................................................................. 71

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Continuously variable transmissions (CVT) ........................................................................................................ 72
Market considerations ................................................................................................................................. 76
Next generation optimised CVT technology ............................................................................................ 79

Other transmission technologies ............................................................................................................. 81
Infinitely variable transmissions (IVT) or toroidal transmissions .......................................................... 81

Transmissions and electrification ............................................................................................................. 84
CVT hybrid transmissions .......................................................................................................................... 86
Planetary automatic hybrid transmissions ............................................................................................ 87
AMT hybrid transmissions ......................................................................................................................... 88
DCT hybrid transmissions ........................................................................................................................ 88
EV transmissions ....................................................................................................................................... 89

Clutch development ................................................................................................................................. 94
Clutch friction materials ............................................................................................................................. 95
Clutch-by-wire .......................................................................................................................................... 97

Market development ................................................................................................................................ 100
Global transmissions manufacturing ...................................................................................................... 100
Design source ............................................................................................................................................ 102

Supplier Profiles ...................................................................................................................................... 104
Aichi Machine Industry ............................................................................................................................... 104
BorgWarner .................................................................................................................................................. 106
Getrag .......................................................................................................................................................... 122
GKN .............................................................................................................................................................

125
JATCO ........................................................................................................................................................ 147
Kongsberg ................................................................................................................................................... 150
Oerlikon ....................................................................................................................................................... 154
Torotrak ...................................................................................................................................................... 171
Univance .................................................................................................................................................... 174
Valeo ............................................................................................................................................................ 176

Figures
Figure 1: Sensor proliferation and driveline complexity ................................................................................ 7
Figure 2: Changing industry drivers from an OEM perspective .................................................................. 9
Figure 3: Changes in transmission attributes CVT, DCT, AT .................................................................. 13
Figure 4: Market growth in AT types ......................................................................................................... 13
Figure 5: Relative fuel consumption and loss sources ................................................................................ 14
Figure 6: Global CO2 (g/km) progress normalised to NEDC test cycle ....................................................... 15
Figure 7: The effect of alternative German proposals for CO2 reduction regulation for Europe ................ 16
Figure 8: CO2 (g/km) performance and standards in the EU new cars 1994–2011 .................................... 16
Figure 9: Additional costs entailed by tougher European CO2 legislation for a vehicle with emissions of 161g 17
per km ........................................................................................................................................................
Figure 10: Comparison of different test regimes for EU, US and Japan ...................................................... 19
Figure 11: Launch response comparison of AT and DCT with turbocharging .......................................... 21
Figure 12: Engine design trends 2011–2020 ............................................................................................... 22
Figure 13: Changes in average engine displacement and power density 2011–2020 ............................... 22
Figure 14: Regional and global vehicle segment trends 2011–2020 ......................................................... 24
Figure 15: Regional and global vehicle cylinder count trends 2011–2020 ............................................... 24
Figure 16: Engine and AMT package in Volkswagen's compact up! model .......................................................... 25
Figure 17: Influence of engine trends on transmission driveline NHV ......................................................... 28
Figure 18: Consumer add-on transmissions prices ....................................................................................... 29
Figure 19: Willingness to pay extra for AMTs, CVTs and DCTs .................................................................. 30
Figure 20: Global MT production by number of forward speeds, 2012–2017 .................................................. 31
Figure 21: European transmission installations ............................................................................................ 32
Figure 22: North American transmission installation market ......................................................................... 33
Figure 23: Chinese transmission installations ................................................................................................ 33
Figure 24: Japan/ Korea transmission installations ........................................................................................ 34
Figure 25: Global MT production proportions 2012–2017 ........................................................................... 35
Figure 26: Oerlikon Graziano's innovative 7-speed AMT ............................................................................. 37
Figure 27: Global AMT production, 2012–2017 ............................................................................................. 38
Figure 28: A 3 dimensional model of FEV's 7-xDCT gearset........................................................................ 40
Figure 29: FEV's 10-xDCT overview ............................................................................................................. 40
Figure 30: The FTP C635 transmissions family in MT and DCT form ............................................................. 41
Figure 31: Fiat Powertrain Technologies transmissions portfolio 2014 .......................................................... 42
Figure 32: Getrag's FWD DCT product roadmap ............................................................................................ 43
Figure 33: Getrag's product development strategy .......................................................................................... 44
Figure 34: Getrag's 6DCT250 DCT with dry clutch ......................................................................................... 45
Figure 35: Getrag's FWD DCT family based on 7DCT300 ............................................................................. 45
Figure 36: LuK dry and wet double clutch assemblies for DCTs ................................................................... 46
Figure 37: ZF's 7DT multi-plate wet clutch DCT ........................................................................................... 48
Figure 38: ZF's Traxon modular heavy duty transmission ................................................................................. 49
Figure 39: Global DCT production, 2012–2017 ............................................................................................... 50
Figure 40: DCT hardware comparison conventional vs one-way clutch design ............................................. 52
Figure 41: BorgWarner FWD Power Split transmission architecture ............................................................... 52
Figure 42: Electromechanical gear actuation Getrag's 7DCT300 ................................................................. 54
Figure 43: AT and DCT ratio production trend, 2012–2020 ......................................................................... 56
Figure 44: Relative CO2 output improvements for AT together with powertrain electrification ................. 58
Figure 45: Hydrodynamically cooled clutch ................................................................................................. 60
Figure 46: Bosch Mechatronic Control Module ............................................................................................. 61
Figure 47: GM's 6T70 6-speed AT developed in collaboration with Ford ....................................................... 62
Figure 48: Average percentage fuel economy improvement for 7G-Tronic Plus (NEDC) ........................... 64
Figure 49: Mercedes-Benz 7G-Tronic Plus automatic transmission ............................................................... 64
Figure 50: ZF's 8HP AT .................................................................................................................................. 65
Figure 51: A schematic of ZF's hydraulic impulse storage system ................................................................. 66
Figure 52: ZF 9HP ......................................................................................................................................... 67
Figure 53: GM Ford collaboration 9-speed AT ............................................................................................... 68
Figure 54: Mercedes-Benz 9G-Tronic AT ..................................................................................................... 69
Figure 55: 7G-Tronic gear set ....................................................................................................................... 69
Figure 56: Ratio proportions 2012–2017 ........................................................................................................ 70
Figure 57: Tiptronic shifter on a 2003 Porsche 911 ...................................................................................... 71
Figure 58: Audi-LuK MultiTronic link-plate chain .......................................................................................... 72
Figure 59: Jatco's next-generation CVT, the first to apply an auxiliary gearbox ........................................... 73
Figure 60: A Fixed Pitch Continuously Variable Transmission (FPCVT) assembly with two FPCVT units connected in series .................................................................................................................. 73
Figure 61: Honda's CR-Z CVT ..................................................................................................................... 75
Figure 62: CVT production, 2012–2017 ........................................................................................................ 77
Figure 63: Jatco's CVT7 ............................................................................................................................... 77
Figure 64: CVT production by region 2012–2017 .......................................................................................... 78
Figure 65: Key technologies in improving CVT performance ..................................................................... 79
Figure 66: Partial (left) and full (right) toroidal spaces within an IVT ........................................................... 81
Figure 67: Torotrak IVT variator .................................................................................................................... 81
Figure 68: Torotrak's Flybird flywheel and IVT system .................................................................................. 82
Figure 69: Progressive drivetrain electrification ................................................................. 84
Figure 70: Additional functionality requires higher voltages – 48 volts ................................. 85
Figure 71: Toyota’s Synergy hybrid Drive (SHD) .................................................................. 86
Figure 72: ZF’s 8HP hybrid transmission .............................................................................. 87
Figure 73: IAV’s 7H-DCT280 hybrid transmission ................................................................ 89
Figure 74: Representation of a full sequence of a shift event using Oerlikon Graziano’s eDCT ....... 90
Figure 75: BorgWarner’s 31-03 eGearDrive single speed transmission ................................. 91
Figure 76: Getrag’s 2eDCT600 EV transmission ................................................................... 91
Figure 77: Wrightspeed GTD ............................................................................................... 92
Figure 78: Xtrac transmission for the Rolls-Royce 102EX ...................................................... 93
Figure 79: Comparison of baseline and forced dry-clutch cooling on traffic jam driving ........... 94
Figure 80: Controlled cooling simulation during full-throttle launch ..................................... 95
Figure 81: ZF’s hydrodynamically cooled clutch ................................................................. 96
Figure 82: LuK’s dry double clutch unit .................................................................................. 98
Figure 83: Global transmissions production by region, 2012–2017 ...................................... 100
Figure 84: Global transmissions design source by region, 2014 .......................................... 101
Figure 85: Global transmissions design source by region, 2021 .......................................... 101

Tables

Table 1: Relating sector drivers to technical requirements .......................................................... 7
Table 2: Range of fuel consumption reduction potential, 2015-2020, for powertrain technologies .......................................................... 11
Table 3: Comparison of fuel economy regulations ..................................................................... 11
Table 4: Transmission value contribution by technology ......................................................... 29
Table 5: Dry versus wet DCT performance .............................................................................. 53
Table 6: Getrag’s FWD DCT family showing hybridisation options .......................................... 88
Table 7: Top 20 transmissions manufacturers 2012 and 2020 ..................................................... 102
The General Motors Easytronic system was developed in collaboration with LuK and, in an attempt to improve shift quality the clutch release travel was set so that the clutch was engaged only sufficiently to transmit the amount of torque being delivered at the time in order to reduce the interruption time. Mitsubishi, on the other hand, used a drum-operated shifting system on the Allshift similar to that used in motorcycle transmissions, so that the synchromesh of the next gear is engaged as that of the other gear is being disengaged.

The optimisation of shift strategies can increasingly make up for the torque interrupt shortfalls of the AMT and reduce this to a minimum through intelligent gear change actuation. Sensors, as illustrated in Error! Reference source not found., can be used to relay a complex matrix of information to the control system, and using relevant algorithms the system calculates optimum shift points and controls the clutch and shift points automatically. Today this technology can also be used to enhance safety by briefly interrupting torque in order to counter the risk of skidding.

However, despite the technological progress made and the potential for both fuel and cost efficiency, AMTs have continued to suffer from poor or inconsistent shift quality under all driving conditions compared with ATs and DCTs. While there have been several technological attempts to rectify this, some of which have been mentioned above, the single-clutch AMT has never really been accepted by consumers apart from in low-cost A and B segment cars in which shift quality has been less of an issue.

There has been a wide range of exercises designed to benchmark AMTs against both MTs and DCTs because, despite shortcomings the overall concept is highly attractive:

Theoretically AMTs have advantages over MTs, DCTs and ATs:

- Optimising shift strategies minimises fuel consumption more successfully than MTs;
- Similarly the optimisation of shift management can minimise emissions compared to MTs;
- AMTs are favourably priced in comparison to both ATs and DCTs, and in fact can be very competitive against MTs where suitable modularisation and scale economies can be used together with existing installed capacity for MTs;
- AMTs generally enjoy packaging advantages over ATs and DCTs;
- On-vehicle weight is usually round 20% lower for AMTs over DCTs, which usually amounts to some 40Kg;
- The AMT can be around 4% more fuel-efficient than a wet clutch DCT.

This means that there is considerable motivation for AMTs to be developed that can boast a higher shift quality, the single real impediment to their widespread use.

To this end electrification has begun to provide the solution, using an electric machine to infill torque during the gearshift. In addition, this development solution lends itself well to progressive hybridisation solutions.

Oerlikon Graziano and Vocis Driveline Controls, its part owned UK partner, have developed an innovative 7-speed automated manual transmission (AMT) that combines the dual-clutch principle of a DCT with the lightweight and compactness that is possible with an AMT when no manual option is required.

Designed for application in the new Lamborghini Aventador, the 79kg gearbox is substantially lighter than its predecessor yet provides an extra ratio, handles more torque and maximises cabin space by packaging into an exceptionally narrow transmission tunnel.

The new, 6.5 litre Lamborghini engine delivers 700 bhp (515 kW) at 8,250 rpm and 509 lb ft (690 Nm) at 5,500 rpm, which would normally require a substantial transmission. A conventional AMT, with external control systems, would not fit the available space; neither would a DCT, which would require bulky wet clutches to meet the power handling requirements.

An AMT uses the established “H” pattern gearshift of a manual gearbox, in which the various gears are selected by sliding
Dual clutch automated manual transmissions (DCT)

The DCT is now making serious inroads into the transmissions market, particularly in Europe and IHS forecasts that they will make up around 8% of global production by 2017 or 7.5 million units, up from 5% in 2013 (4 million units).

The underlying advantages of DCT as a transmission technology have proved compelling in recent years, particularly as wet-clutch DCTs have proved to have shift quality as good as that of a planetary AT. They are also as easy to drive while providing a more responsive drive for sporting applications. DCTs are more economical than a six-speed MT and hence can make a useful contribution to CO2 reduction across the full range of vehicle segments, with feature content adjustable through electronic control mechanisms, particularly the capacity to ensure that the engine is kept within its most efficient operating range.

Historically the DCT was developed to deal with the torque interruption and shift quality issues associated with automating manual transmissions with a single clutch set. This was achieved using two clutches configured so that one is always engaged. However, due to the design challenges encountered when developing DCTs, the underlying relationship between MT and DCT design and production was quickly diluted and negated as an underlying development driver.

DCTs can be considered as two AMTs in parallel (one with first, third, fifth, seventh where fitted and reverse gears, the other with second, fourth and sixth gears) with the next gear pre-selected and ready to be engaged in the inactive part of the gearbox before the torque is moved from one clutch to the other without torque interruption. The electronic control system can also be used to fill the ‘torque hole’ during the shift by increasing engine torque output momentarily, a feature that Ford promotes on its Getrag-developed ‘PowerShift’ DCT. The driver can only just feel this torque handover and the shift characteristic is similar to a traditional AT.

A DCT can be operated in fully automatic mode, typically with the options of ‘drive’ automatic or ‘sport’ automatic settings, or in ‘manual’ via a shift lever or steering wheel-mounted paddles that enable sequential shifting. In the ‘drive’ automatic mode, the engine is kept in its more fuel-efficient operating range while in ‘sport’ mode the shift points are at higher engine speeds. The technology is also easily suited to stop-start technology, since the transmission is typically designed to shift to neutral when the vehicle is stationary in order to be ready for launch in first gear and to minimise oil churning losses.

Both dry and multi-plate wet clutch systems have been employed, typically in a concentric arrangement, although BorgWarner’s low-cost DT170 unit has two separate clutches mounted on the two separate gear shafts and linked by a chain.

DCT Suppliers

**BorgWarner**

BorgWarner, and is the leading global supplier of wet dual clutch and electro-hydraulic control modules. The company has been producing for the Volkswagen Group since 2003 (re-branded Direct Shift Gearbox (DSG) transmissions) and they are a major supplier of DCT components to a number of other European OEMs.

In 2009 the company established a joint-venture with the China Automobile Development United Investment Co. (CDUI), which is owned by 12 Chinese OEMs. This joint-venture is known as the BorgWarner United Transmission Systems Co., Ltd., and is located in Dalian, China. The company has produced various dual-clutch transmission modules beginning in 2011. The JV will manufacture and develop core modules for the DCT assembly including dual clutch modules, torsional vibration dampers and control modules.