

Strategic knowledge-based innovation

Torotrak

Innovation is about converting knowledge to value. The trouble is that there is more to success than just having a great idea, as this case study shows.

Torotrak is a company which began life as part of the UK government's British Technology Group – a state-supported investment organization for new technologies. BTG was privatised and later (1998) spun off the Torotrak business which offers a radically different approach to power transmission – an infinitely variable drive. This means that the power delivered by the engine is always matched exactly to the needs of the vehicle, unlike conventional gearbox systems. When Torotrak was launched BTG claimed that it cost one-fifth less to produce than a normal automatic transmission, used at least 15 per cent less fuel and, according to those allowed a test ride in prototype cars, gave 'an unbelievably smooth ride'.

Torotrak is potentially a major fuel saving technology offering around 25% savings and in a context where fuel efficiency and emission control is increasingly important it represents a breakthrough opportunity. But although the technology has been continually updated and the applications opportunities extensively widened it remains still a high risk share on the stock market. If the company can convince major players to invest, either by taking licences and manufacturing themselves or else by buying the company, then there are significant prospects for growth. But until they do Torotrak remains on the edge, a classic entrepreneurial technology business struggling to survive.

Torotrak has continued to invest in its core knowledge base, doing so through a variety of routes from selling shares to raise R&D funding, raising income from licensing some of its ideas, partnering with bigger players and working with government agencies and international research consortia. In the process it has spread its knowledge base from reliance in the early days on its infinitely variable transmission (IVT) to include two other platforms – flywheel technology which allows the storage and release of energy and kinetic energy recovery systems (KERS) which again store and release energy, this time linked to braking systems.

Each of their technological areas is well-developed and also protected via a sophisticated mixture of patents, and other intellectual property devices linked to a rich store of tacit knowledge – it would be hard for competitors to enter because of the complexity of the technologies and the many years spent learning about them.

The technologies themselves undoubtedly show immense promise – IVT has demonstrated regularly fuel savings of around 20% and also allows much more accurate control since the wheels of a vehicle always receive just the right amount of power. One application is in precise control on slippery surfaces meaning drivers can stay in control over ice or other surfaces where skidding represents a problem. Similarly their flywheel technology offers a solution to the problem of storing and releasing energy – something of relevance to both conventional cars and the new generation of electric and hybrid vehicles. And their KERS system captures energy otherwise lost when braking, giving extra power – something which has been tried with great success on the Formula 1 racing circuits and lies behind the dominance of Ferrari in recent years.

Table 1 below lists some of the technological advantages and how these might make Torotrak an interesting innovation to explore.

Table 1: Relative advantages of Torotrak's core infinitely variable transmission (IVT) technology
(taken from company website)

Torotrak's main drive infinitely variable transmissions (IVTs) enables the engine to operate under optimum conditions, improving performance and fuel economy. Our IVTs can make a significant difference to the economy of vehicles equipped with existing internal combustion engines as well as those fitted with new, more efficient models. Transmissions incorporating our technology have demonstrated fuel savings of 20 per cent in a city bus and delivery truck..... The need to improve fuel economy in commercial vehicles has never been greater. Fuel now represents over one third of operators' costs in this sector, while legislation is forcing down noxious gas emissions worldwide.

The car industry has had access to different forms of fuel saving variable gearbox technology for years, but the high powers and torques of commercial vehicle engines have made these variable technologies impracticable – until now.

Enabling an internal combustion engine to run at its most efficient operating point is key to maximising fuel economy. Conventional fixed ratio gearboxes, whether manual, automated manual or full automatic, cannot maintain this optimum because the engine and vehicle speed must follow a fixed relationship, defined by the gear in which the vehicle is operating. In order to achieve the optimum operating point, the engine speed and vehicle speed need to be decoupled by employing a variable transmission, such as our IVT.

With no torque convertor or starting clutch in an IVT configuration, fuel efficiency is further enhanced in vehicles with high levels of 'stop/start' driving, such as city buses and distribution trucks. Emissions can be further reduced by removing the discontinuities during gear shifts in a conventional fixed ratio transmission.

Benefits include:

- *Improved Fleet Average Fuel Economy* - harmonises fuel usage across all vehicles and minimises the variability introduced by differing driver skill levels
- *Refined Drive Experience* – smooth and seamless power delivery creates an exceptionally comfortable and refined ride for passengers or goods. Driver fatigue is reduced and safety for bus passengers may be further enhanced by deletion of gear shifts and actively controlling vehicle acceleration away from rest
- *Reduced Lifetime Cost* – our IVTs are cost comparable with current Automated Manual Transmissions (AMTs), and cheaper than conventional fixed ratio automatic transmissions. Complete integration of the IVT and engine ensures optimum operation of the driveline, maximising service life and protecting against possible abuse conditions to minimise maintenance costs
- *Optimised Engine Braking* - allows the engine speed to be varied independently of vehicle speed, enabling accurate control of engine braking and reducing brake wear
- *Exceptional Low Speed Control* – enables precise vehicle manoeuvring and positioning. When integrated with parking sensors, our IVT can also help prevent collisions

And yet Twenty years on the company is still poised to become successful rather than making a big impact. It has ridden a roller coaster of successful opportunities and unfortunate threats and survived and grown through the process. In the early days the hope was for a major volume car maker to pick up on the technology and several firms took out options on the licence. But none of them put the technology into volume production and Toyota eventually pulled out, dealing a major blow to the confidence of Torotrak and its shareholders. (Arguably this was more about Toyota seeking to develop its own version of a good idea rather than as a criticism of the Torotrak technology). The company has spent an estimated £75m in developing its technology and is still looking to raise further capital to support this process.

Emphasis shifted to developing niche markets where the advantages of the technology would be more valued – an approach recommended by Clayton Christensen in his studies of how entrepreneurs disrupt major markets by working at the fringes and learning and refining the technology there. Transmissions for trucks, buses and SUVs became the focus and off-road vehicles like tractors and lawn mowers were also explored. In that time they have forged agreements and alliances with MTD, Tata, Allison Transmissions, an as-yet unnamed European Truck and Bus Manufacturer (ETBM) (could be Volvo | MAN | Scania | another), Jaguar, Ricardo, Flybrid, Carraro S.p.A, Williams Hybrid Power Ltd, SKF, Ford, Prodrive, Iseki, JTEKT, Optare, Shell, Xtrac and Rotrex. Once again technological success mixed with commercial promise but the major

deal remained elusive (although there has been strong interest and partnership with the giant US Allison corporation).

The flywheel systems linked to the core Torotrak IVT offer significant advantages for both traditional and electric powered vehicles and KERS has, following the publicity around its Formula 1 applications, begun to feature on the radar screens of several manufacturers. KERS was also the first instance of Torotrak receiving a royalty payment for someone actually using (rather than taking a licence option on) their technology.

Recently the company – having gone through several changes of management, has redefined itself more as a knowledge-based R&D organization offering solutions across a broader platform – as their mission statement below and their website explains:

We are Torotrak

As individuals, we share a passion for great engineering. As an organisation, we are dedicated to making transportation cleaner and more efficient.

We are pragmatic. We design, develop and deliver innovative, practical technologies focused around three key products. All use our patented full toroidal variator technology and are mechanical, compact, and, most importantly, accessible.

- *Gearless traction drive transmissions*
- *Variable drive superchargers (V-Charge)*
- *Mechanical kinetic energy recovery systems (M-KERS)*

We are innovators. Our technology and products address and anticipate a real market need for cleaner mobility. We invest substantially in our modelling, test and build facilities, and in our people, to make sure that we are always at the leading edge of our industry.

We think big. We know that the demand for cleaner vehicles affects us all, and the opportunity for our technology is global. We're working to bring our products to market through our own manufacturing facilities and our supportive commercial arrangements with licensees and partner companies from all over the world.

<http://www.torotrak.com/>

Activity: Strategic knowledge-based innovation

Below are some articles and also some links to the company website and to a blog from an investor group. They give an outline picture of the evolution of the company – and the challenges which it continues to face. Read these – and do any other research you think might be helpful. And then try the exercise on Strategic knowledge-based innovation.....

Useful links:

1997 article, explains in simple terms the underlying ideas and their potential
<http://www.independent.co.uk/news/business/lets-get-this-invention-on-the-road-1239375.html>

2002 article, explores the commercial potential and the auto industry's cautious response
http://www.thecarconnection.com/tips-article/1003884_torotrak-the-next-cvt

2005 article looking at the move into niche application markets
http://www.greencarcongress.com/2005/12/torotrak_infini.html

2007 article on KERS and Formula 1 connection
<http://fourwheelsteer.blogspot.com/2007/06/formula-1-in-new-technology-shock-long.html>

2014 article on increasing knowledge based competition in autos and role of players like Torotrak
<http://www.ft.com/cms/s/0/f3875250-40a3-11e3-ae19-00144feabdc0.html#axzz2pnBHL5MD>

2014 shareholder blog and website with wide range of commercial, technological and historical data
<http://torotrakshareholder.blogspot.co.uk/>



Activity: Strategic Knowledge-based Innovation

Read through the case study of Torotrak. This is an example of a firm which is trying to obtain strategic advantage by specialist design knowledge in the highly-competitive motor vehicle industry. If it succeeds it is likely to achieve spectacular growth, but the downside risks are equally large. Using the framework below try and list five key questions which the managers of Torotrak should be asking themselves in order to help minimize the risk. If you were invited to help them as a consultant, what advice might you give them to help build and sustain a knowledge-based business.

Question	Underlying reasons for asking it
For example: How are you going to ensure that no-one else comes in and copies your innovation, getting the benefits without having to have gone through all the hard work which you have?	Getting competitive advantage through knowledge-based activity requires paying attention to protecting the knowledge and making sure you – and not others – can appropriate the benefits of research.

