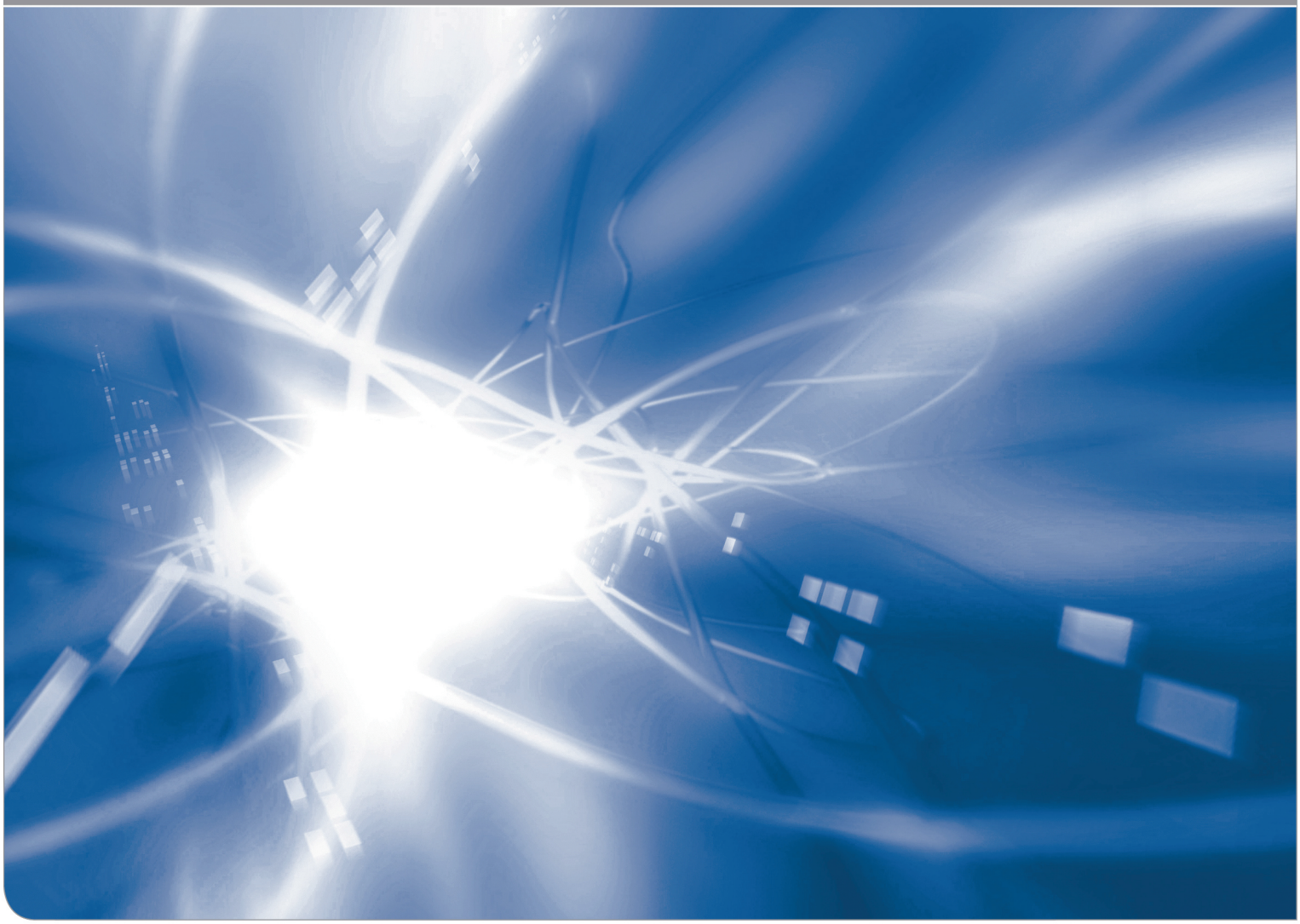
Karlsruhe Institute of Technology

Radical Technological Innovation: Case Study of the P1.18 Bicycle Transmission by Pinion

by Florian Wohlfeil [1]

KIT SCIENTIFIC WORKING PAPERS 28



[1] Institute for Entrepreneurship, Technology-Management & Innovation;
Karlsruhe Institute of Technology (KIT)

Institute for Entrepreneurship, Technology-Management & Innovation (EnTechnon)
Fritz-Erler-Str. 1-3, Bldg. 01.85
76133 Karlsruhe
www.entechnon.kit.edu

Impressum

Karlsruher Institut für Technologie (KIT)
www.kit.edu

2015

ISSN: 2194-1629

Radical Technological Innovation: Case Study of the P1.18 Bicycle Transmission by Pinion

Florian Wohlfeil

Abstract

In contrast to incremental innovations, radical technological innovations have a high level of novelty. Thus, radical innovations are risky, but correspondingly the correlated market opportunities are better. As technological development and successful market introduction have independent success parameters, the arising challenges for companies are obviously both, technical and entrepreneurial in nature. To shed some light on the concrete factors that determine success of radical technological innovations a concrete case of such an innovation will be studied. In 2008, two engineers founded the Pinion GmbH to develop and exploit a new bicycle transmission concept as competitive shifting system for bicycles to overcome the existent disadvantages of traditional derailleur systems and internal gear hubs. In the focal study the technology and the target market for Pinion's bicycle transmission, the organizational characteristics of Pinion, the entrepreneurial team, the innovation process, and the subsequent innovation success will be analyzed.

Table of Contents

Technology

The main goal of the two Pinion founders was to develop a competitive shifting system for bicycles to overcome the existent disadvantages of traditional derailleur systems and internal gear hubs (Steinke, 2013).

After years of development the team ended up in July 2012 with a compact, totally enclosed, and maintenance free gearbox solution ready for series production. The P1.18 is a spur gear consisting of two transmission structures that are connected in series (Pinion, 2013, p. 3). Via pedal the first of the two parallel partial shaft transmissions, equipped with three pairs of gears, will be driven.

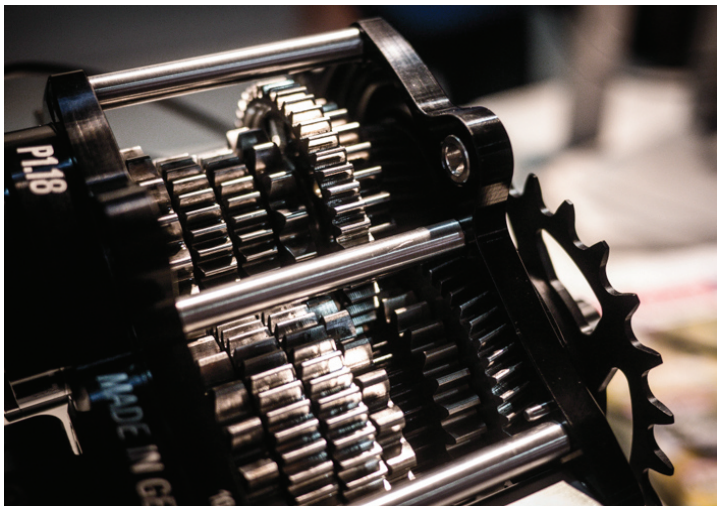


Figure 1: Exposed P1.18 Gearbox (Steinke, 2013)

The second shaft transmits the power on six pairs of gears. The multiplication of six by three ratios gives 18 real ratios.

Contrary to overlapping gears of conventional derailleur systems, the gears of the P1.18 are evenly spaced in steps of 11.5 %. In sum, the Pinion transmission achieves a total gear ratio of 636% what is higher than the maximum transmission ratios of currently available derailleur systems (~620%) and internal gear hubs (~530%) (Schäfer, 2013; Pinion, 2013, p. 6; Birkhofer, 2013).

Unlike any current bicycle shifting system, the Pinion transmission needs two cables to operate its rotary shifting mechanism (Wragg, 2012). This mechanism inside the gearbox is actuated with a turning handle. Within the shaft of the upper cluster gear (not the drive shaft) the intended ratio is engaged (Birkhofer, 2013). This shaft is constructed as a continuous hollow shaft in which a camshaft and switchable pawl freewheels are integrated (Lermen, 2011). When you call for a shift, the camshaft activates the pawls inside the hollow shaft.

Figure 2: Hollow shafts with camshaft and pawl freewheels (Staudt, 2011)

These pop up underneath the selected gears and subsequently lock them in place. Thus, the P1.18 engages only two pairs of spur gears in each gear to transmit the power (Pinion, 2013, p. 6; Wragg, 2012; Lermen, 2011).

The reason for a turning handle as shifting actuator is the required movement radius of the camshaft. As the shaft reaches a maximum angle of 1020° between the lowest and highest gear, the shift cable has to be pulled quite far although there is a planetary transmission to reduce this distance (Stahl, 2011). This is the explanation why a conventional thumb shifter would not work (Wragg, 2012). Even when loaded, the gearbox is switchable: It is possible to upshift at full load and downshift at part load. Additionally, the P1.18 can be shifted in standby mode without any problems (Lermen, 2010).

The use of the Pinion P1.18 bicycle transmission is only possible on frames that are specially designed by the manufacturers for the use with Pinion. By using six mounting points on a bridge assembly, the gearbox is attached that it forms an integral part of the bicycle frame (Pinion, 2013, p. 21).

The Pinion transmission is placed at the bottom bracket and has thus an optimal position within the two-wheeled vehicle bicycle. At this position, the gearbox is in the center of all three dimensions what leads to a deeper lying center of gravity and an evenly distributed rotating mass. The transmission includes all the elements that traditionally have been in or at the rear wheel: shift cable, shifting mechanism, cartridge, and gear hub. Consequently, the rear wheel can be designed simpler and lighter (Donner, 2012, p. 24).

Figure 3: Pinion gearbox (Reidl, 2012)

Contrary to a derailleur system, the chain runs just on two gearwheels of the same size and is guided by the chain tensioner that sits directly behind the gearbox (Schäfer, 2013; Wragg, 2012).

Alternatively, it is possible to assemble a belt pulley directly at the gearbox to transmit the driving force via tooth belt (Stahl, 2013).

Table 1: Technical Data of the P1.18 Gearbox (Pinion, 2013, p. 26)

Number of Gears	18
Overall Ratio	636%
Gear Steps	11.5%
Gain Ratio in 1st Gear	1.59
Gain Ratio in 18th Gear	0.25
Maximum Input Torque	250 Nm
Overall Weight	2700 g
Lubrication	Splash Lubrication
Oil Type	Synthetic Pinion Oil
Oil Capacity	60 ml (2.0 oz)
Oil Change Interval	every 6,200 miles / once a year
Temperature Range	-15°C to +40°C / 5°F to 104°F

Feasibility and Maturity

The Pinion P1.18 entered series production in July 2012. By 2014, more than 1.000 gearboxes have been sold. Thus, the deployed technology is now feasible and mature. Additionally, the Pinion team develops the product continually further (Pinion, 2013, p. 3; Schäfer, 2013; Steinke, 2013).

This was not obvious in the beginning, as the two founders received relative negative feedback by automotive R&D personnel regarding the feasibility of the initial idea. The two engineers derived their transmission design from automotive gearboxes and tried to adapt automobile technologies to bicycles. The aim to reach less than 3 kg for the bicycle gearbox compared to more than 30 kg for automobile gearboxes was a great technological challenge.

Less speed and a comparable torque of 250 Nm was indeed not easy to handle. Furthermore, the standardized calculation methods could not be applied as they were designed for automobile gearboxes. Consequently, a test rig has to be constructed to display the actual load spectrum for bicycles. In sum, it was a long way to go that lasted seven years to gain a mature product (Lermen, 2013; Pinion, 2013, p. 3).

Technological Alternatives

In principle, there are two basic alternatives to the Pinion transmission: internal gear hubs and derailleur systems. In the following, three of the most competitive internal gear hub concepts and one representative and widespread derailleur concept will be presented.

Rohloff SPEEDHUB 500/14

The Rohloff SPEEDHUB 500/14 (cf. Figure 4) gearbox consists of three in line interconnected planetary gear assemblies. It is a fully encapsulated maintenance free gear mechanism that runs within an oil bath. The engagement of the 14 evenly spaced (13.6%) real gears is controlled within the hub itself. In sum, the hub achieves an overall range of 526%, weights approx. 1800 grams and its price is starting from 750 € (Rohloff, 2011; Warentest, 2013).

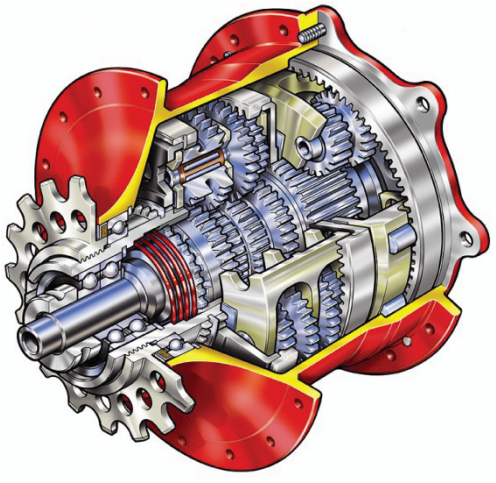


Figure 4: Rohloff Speedhub (Rohloff, 2011)

Shimano ALFINE 11

11 gears and an overall ratio range of 409% offers the Shimano ALFINE 11 (cf. Figure 5). The gear steps are nine times 13% and twice 17%. The hub transmission is realized by a helical-cut planetary gear system in an oil bath. It is completely enclosed and nearly maintenance free. The gear hub weights approx. 1600 grams and costs approx. 350 € (Simpel-ch, 2014; Warentest, 2013).

Figure 5: Shimano Alfine (Shimano, 2011)

NuVinci N360

The NuVinci N360 (cf. Figure 6) transmits mechanical power with spheres instead of gears. It changes the ratio by tilting the axes of the spheres with respect to internal input and output traction rings. The nominal ratio range is 360%, with an underdrive of 0.5 and an overdrive of 1.8 (Fallbrook, 2012, pp. 1–2). The N360 is provided with permanent lubrication for life and completely sealed. The hub weighs approx. 2450 grams and costs approx. 360 € (Fallbrook, 2014).

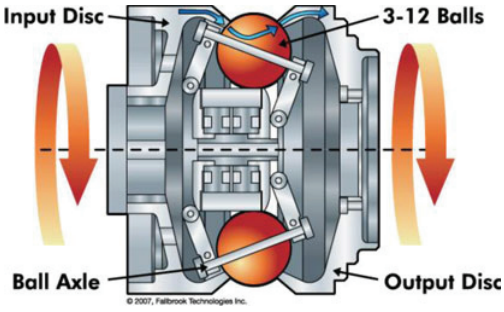


Figure 6: Nuvinci N360 (Velomobile, 2013)

Shimano DEORE XT

The Shimano Deore XT (cf. Figure 7) derailleur system has by the combination of three front chainrings (with 22-32-44 pinions) and nine rear chainrings (between 11 and 34 pinions) 27 theoretical and because of overlapping 16 practical gear steps. The shifting procedure will be realized by moving the chain from one sprocket to another.

Figure 7: Shimano Deore XT (Bergleben, 2014)

In total, the ratio range is 618%. The price for the complete system differs extremely depending on the single components. A standard version within a complete bike costs roughly 400 € (Pro Activ GmbH, 2014; Warentest, 2013).

Relative Advantageousness

To gain the relative advantageousness of the Pinion P1.18 with respect to the existent shifting alternatives, eight evaluation criteria have been derived from diverse bicycle test reports: overall ratio range, number of real gears, system weight, center of gravity, shifting performance, service and maintenance effort, requirements for construction change, and price.

Overall Ratio Range

With 634% the P1.18 has a higher overall ratio than all available alternatives. It has a greater range than you would get with the Shimano Deore XT derailleur drivetrain (618%) and without any of its overlapping or duplicate ratios (Wragg, 2012). The internal gear hub concepts have an even lower ratio range: Rohloff Speedhub - 526%, Shimano Alfine 11 - 409%, NuVinci N360 - 360%.

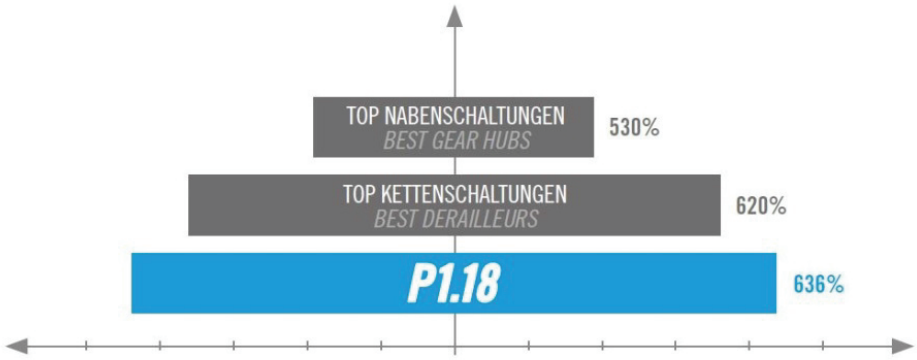


Figure 8: Ratio Range Comparison (Pinion, 2013, p. 6)

Number of Real Gears

In respect to its 18 real gears evenly spaced in steps of 11.5%, the P1.18 has great advantages. Because of its overlapping gears, the Shimano Deore XT has just 16 real gears. The Shimano Alfine has 11 almost evenly (2x17% and 9x13%) and the Rohloff Speedhub 14 evenly (13.6%) spaced gears. Admittedly, the NuVinci N360 prevails in this regard as its ratio can be chosen optionally (Pinion, 2013, p. 26; Pro Activ GmbH, 2014; Fallbrook, 2012, pp. 1–2; Simpel-ch, 2014; Rohloff, 2011).

The great range and the finely stepped ratios of the P1.18 enable the rider to choose the appropriate ratio for each potential driving situation at any time (Lermen, 2010). On the other hand, the fine steps of the gearbox can increase the need to shift. Even though gears could be skipped, there may be riders that dislike these small steps (Stiener, 2012). But in summary, the evenly spaced 18 real gears combined with the great overall ratio form the outstanding benefit of the P1.18.

System Weight

Particularly because manufacturers of high-end bikes generally struggle for each gram, the question of weight is an important one. However, not the weight of the single component but the collected system weight is decisive. The single P1.18 gearbox weights 2700 grams. Assembled on the bicycle, a Pinion equipped bike weights roughly 400-700 grams more than a comparable bike equipped with the Rohloff Speedhub, 600-900 gram more than one with a Shimano Alfine 11, and approx. 2000 grams more than one with a Shimano Deore XT derailleur system. But a Pinion bike is roughly 200 grams lighter than a bike equipped with the N360 (Donner, 2012, p. 26; Steinke, 2013; Warentest, 2013).

Center of Gravity

As mentioned before, the P1.18 bicycle transmission is positioned at the bottom bracket and is thus in the center of all three dimensions what leads to a deeper lying center of gravity. Furthermore, the rear wheel can be designed simpler and lighter causing an evenly distributed rotating mass of this wheel. In contrast, the center of gravity of both alternative shifting systems is clearly situated nearby the rear wheel (Donner, 2012, pp. 24–26).

The fewer rotating mass of the freed rear wheel of the Pinion bike leads to more agility and dynamics while driving. While being heavier is a clear disadvantage regarding high-end bike designs, the central position of the gearbox and its substantial better center of gravity overcompensates this disadvantage (Donner, 2012, p. 26).

Shifting Performance

Familiar to a traditional derailleur system, the usage of the turning handle to activate the Pinion shifting mechanism takes some time to get used to it. The necessary turning movement of nearly 20° for each gear change combined with the augmented shifting demand due to the fine gear steps (11.5%) can lead to initial difficulties (Steinke, 2013). However, the Rohloff Speedhub and the NuVinci N360 operate with a similar shifting mechanism. A traditional derailleur system like the Shimano Deore XT needs two shift levers, one for each chainring. Thus, using just a single shifter to move through every gear is an obvious advantage (Wragg, 2012).

With the P1.18 the rider has to take into account that downshifting will only be possible at part load (Lermen, 2010). If this is considered, the gear change follows fluently, properly, and exactly in either single or multiple gear steps (Donner, 2012, p. 26; Pinion, 2013, p. 6). When switching gears, the shifter gives direct feedback to the rider that the gear has changed (Pinion, 2013, p. 19).

Unlike the Rohloff Speedhub and the Shimano Alfine, which have a large number of components transmitting the drive force, the P1.18 engages only two pairs of spur gears in each gear to transmit the power. This fosters the efficiency and leads to minimal drive noise, high smoothness, and nearly lossless power transmission of the Pinion concept (Donner, 2012, p. 26; Pinion, 2013, p. 6). To sum up, after a familiarization period with the P1.18, the advantages of fast and reliable shifting become apparent.

Service and Maintenance Effort

The Pinion P1.18 has minimal service and maintenance requirements as all components of the gearbox are safely protected in an enclosed, sealed housing and suspended in an oil bath. Once a year (or respectively every 10,000 km) an oil change should be performed. The gearbox is rated for a durability of 60,000 km. However, due to wear, a few components of the system (like chainrings and shiftcables) potentially need to be replaced after a while (Pinion, 2013, p. 6, 2013, p. 22).

As all three internal gear hub concepts are encapsulated, sealed, and do not require maintenance, this feature of the P1.18 is not a unique selling proposition. Nevertheless, the maintenance freedom of internal gear hubs in general is definitely an advantage compared to traditional derailleur systems.

Furthermore, none of the defect-susceptible parts of a derailleur system like rear and front derailleur, chainguide, and set of chainrings are existent. This avoids damages and additionally, increases the ground clearance and therewith the capabilities of the bicycle in rough terrain (Steinke, 2013; Pinion, 2013, p. 5).

Requirements for Construction Change

The use of the P1.18 is only possible on frames that are specially designed by the bicycle-OEMs for the use with Pinion. Together with the frame the gearbox forms a unified whole. This causes a relatively high level of system integration on the one hand, but later on, offers in case of disfavor or breakdown no alternatives to the P1.18, on the other hand. The bicycle manufacturers find themselves in a similar situation. They face a higher entrepreneurial risk as well as additional expenditures regarding development efforts and costs (Donner, 2012, p. 26; Stiener, 2012; Pinion, 2013, p. 21).

In this regard, the alternative internal gear hub concepts gain advantages, as all of them are placed within the rear wheel. Thus, they are easy to adapt and do not need construction changes of the frame or the rear wheel design. As the derailleur system is the standard mechanism and correspondingly widespread, the current frame designs are specified for this system.

Price

Beside the technological advantages, the price is an essential criterion for evaluating the chances of mainstream market success. Until now, the Pinion P1.18 is not available as a single component as it is just sold as an integral part of a fully equipped bicycle of certain partner OEMs. According to industry experts, the price for the gearbox ranges around 2,000 €. Depending on the utilized components, the price for a complete Shimano Deore XT derailleur system differs extremely. All single components can be ordered separately. Altogether a standard version within a complete bike costs roughly 400 €. The price for a Rohloff Speedhub is starting from 750 €, the Shimano Alfine costs approx. 350 €, and the NuVinci N360 costs 360 € (Warentest, 2013).

It is obvious, that the P1.18 is the most expensive shifting system. This is due to the fact that the series production just started and the gearbox has exclusively been integrated into only a few high-end premium bikes with moderate market distribution. To become a real competitive alternative on the mainstream bicycle market, the total price for the P1.18 gearbox must be significantly reduced. In view of potential leverage effects by economies of scale, this should be possible in the long term.

Overview of the Relative Advantages of the P1.18

To get a better overview of the relative advantages of the P1.18 bicycle transmission, the different shifting systems have been evaluated with respect to the degree to which they meet the eight evaluation criteria on a ten-stage scale (cf. Figure 9).

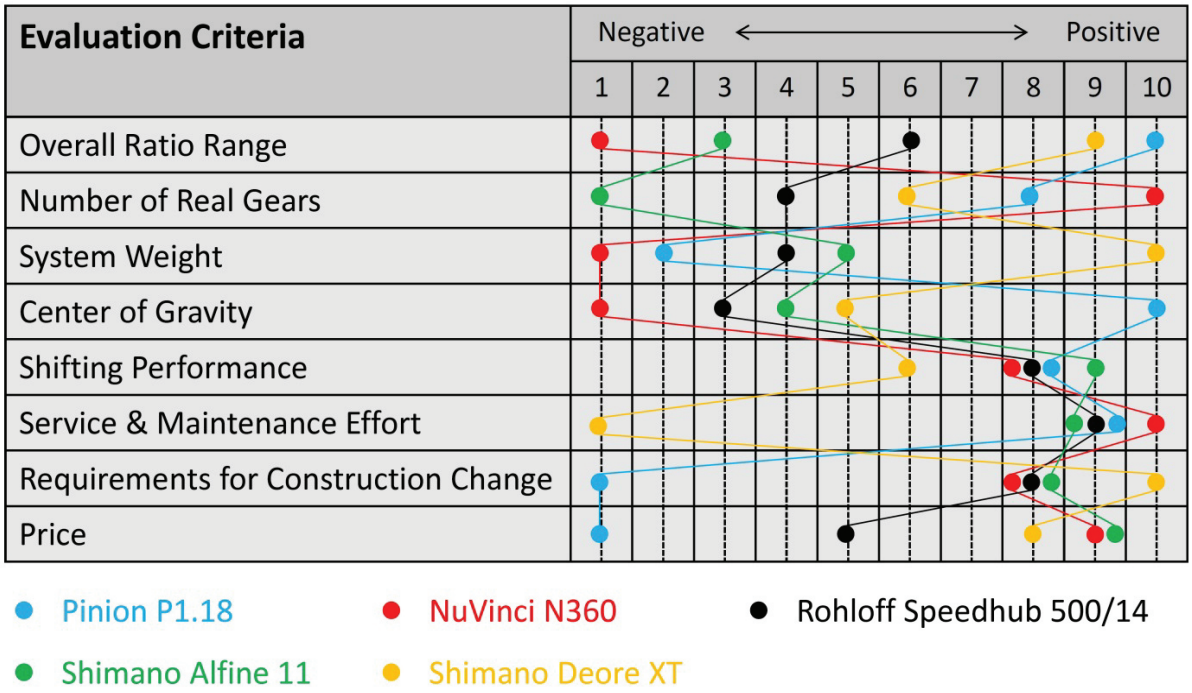


Figure 9: Overview of Relative Advantages of the P1.18 (Wohlfeil, 2014)

Ultimately, the unique advantages of the P1.18 gearbox compared to the existent alternatives are the great overall ratio range, the number of real gears, and the position of the center of gravity. In contrast, the high system weight, the obligatory need for frame construction change, and the currently high price are the disadvantages of the Pinion P1.18.

It becomes apparent that all shifting systems have their specific advantages and disadvantages. The absolute highflyer fulfilling all potential requirements and needs of a bicycle shifting system is still not available. Due to subjective customer preferences, an evaluative comparison from an overall perspective is difficult and almost impossible. Decisive for the general success of a single shifting system are the individual requirements and needs of the targeted customer groups. Therefore, it is essential to know and meet the requirements of the distinct target market. Consequently, in the following chapter the target market will be analyzed (Stiener, 2012).

Target Market

Naturally, Pinion initially addresses the German bicycle market. Both founders are German and additionally enthusiastic cyclists. Thus, they are used to the characteristics of the local market. Looking at the market share (cf. Figure 10) of the different models on the German bike market, it becomes obvious that the trekking bikes dominate with roughly 33% followed by the city- & urban bikes with approx. 24%. Mountain bikes, all terrain bikes, and e-bikes are nearly on the same level with about 10% (ZIV, 2013b, p. 68).

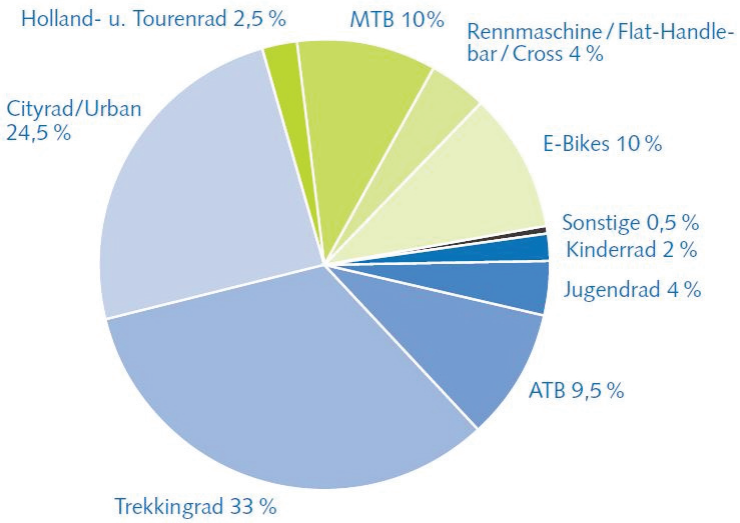


Figure 10: Market Share of the different Models on the German Bike Market in 2012 (ZIV, 2013b, p. 68)

Pinion is initially focusing on mountain bikes and the trekking & touring sector. In both segments the advantages of the gearbox are highly visible (Lermen, 2013). The enclosed system of the P1.18 has no exposed shifting elements that could be damaged. This additionally increases the ground clearance and therewith the possibilities in rough terrain. Furthermore, the advantageous position of the center of gravity fosters bike handling and favors the usage for mountain bikes. Especially the maintenance freedom and the steady shifting comfort in various situations, forms the benefits of using the P1.18 at trekking & touring bikes (Pinion, 2013, p. 5; Donner, 2012, p. 26).

The P1.18 is meant to be a premium product. As it is relative expensive, the high-end segment is addressed. Furthermore, an expansion of the initial product portfolio seems obvious. The application of the gearbox for recumbent, tandem, and e-bikes is currently under conception. With the German niche market for high-end mountain, trekking, and touring bikes Pinion has a regional, model segment, and quality level focus. However, the company is planning to cover the entire bicycle market little by little in Europe and subsequently, globally later on (Lermen, 2013; Schäfer, 2013).

Industry Context

The industry context for the Pinion GmbH was predominantly positive. Environment and sustainability have become important topics in society and politics. Different laws and regulations already reflect this growing environmental awareness. Thus, strict emissions directives for commercial vehicles, clear zones in inner-city areas, and environmental certificates have been introduced inter alia. Correspondingly, a trend towards new and energy-efficient mobility concepts in particular for urban spaces is observable. For these reasons, the bicycle gains in importance as urban transport tool. Thus, a maintenance free

bicycle gearbox seems to match the spirit of the time and to be a product with good prospects (Pinion, 2013, p. 16; Reidl, 2012).

Furthermore, the German government supports the creation of technology and knowledge based business start-ups with their EXST program. To cover expenses, the entrepreneurs receive a grant of 800 to 2,500 € per month, depending on their academic degree, for a maximum period of 12 months (BWMi). The Pinion team received this grant in 2008 (Lermen, 2013).

However, Pinion has to suffer from the economic upturn of the automotive industry. Pinion mainly trusts on suppliers of the automobile industry. As these suppliers had full order books, the start-up immediately slipped to the end of the order list (Reidl, 2012).

Competitive Situation

By now, Pinion is the only company to distribute this specific gearbox technology. Thus, it just has to compete with its technological alternatives. Those have been introduced and compared previously. However, Pinion needs to be aware of emerging and established market rivals. If the Pinion technology proves to be valuable, it is just a question of time until capable competitors will develop cannibalizing innovations and possibly enter the market (Schilling, 1998, p. 277).

Market Barriers

Initially, the Pinion team expected that the biggest obstacle to market entrance would be the necessity to persuade frame-builders to design and produce a modified frame to integrate the gearbox. Therefore, a forged part needs to be welded at the bottom of the frame. The gearbox will be screwed to this forged part. In retrospective, the frame-building process was not a problem. Nearly all frames are produced in Asia and these manufacturers nearly do not care if they have to weld the bottom bracket tube to the frame or a forged part for the gearbox (Lermen, 2013).

The de facto biggest barrier to market entry was the challenge to persuade the bicycle manufacturers to apply the Pinion technology. The main point that hampered the market introduction was the skepticism towards the new technology and even more towards the young company. This was the same with all bicycle manufacturers. They questioned the reliability of the young start-up and it took some time to trust Pinion. Lermen stated, that the way to become a serious partner within the bicycle industry is a long and though one (Lermen, 2013).

Additionally, there are several mountain bike manufacturers that have some issues regarding the P1.18 performance, mainly regarding loaded shifting and system weight. However, the major barrier is the existing question towards the reliability of a young start-up (Lermen, 2013).

Opportunity

The global market for bicycles is very big. Every year over 130 million bikes are sold worldwide (GloboMeter). Understandably, Pinion initially started to address their German home market. With sales numbers of roughly 4 million bikes per year Germany accounts for 20% of the European market with approx. 19.7 million items in 2012 (Colibi, 2013, p. 19). The total value of the accumulated bike sales in Germany was about 2.03 billion € (ZIV, 2013a, p. 13). In Europe, the German average price for a bicycle of 513 € was solely outreached by the Netherlands with 724 € (Colibi, 2013, p. 21). With 260 million € Germany is responsible for 16% of the total 1.65 billion € for the European production of bicycle parts

& accessories (Colibi, 2013, p. 15). In sum, the approx. 50,000 employees of the German bicycle branch generated revenue of 4 billion euro in 2012. With 71 million bikes in Germany there are 80% cyclists among the population (ZIV, 2013b, pp. 62–63).

The average price per bike (513 €) in Germany is the second highest in Europe. This indicates that the quality requirements are accordingly high what is good for Pinion. The total revenue of 4 billion € within the German bicycle branch displays its potential (ZIV, 2013b, p. 62).

Lermen stated, that the German bicycle market in total is very big and even the high-end sector of a submarket is very attractive regarding absolute numbers for a start-up like Pinion. There are still several thousand gearboxes potentially saleable (Lermen, 2013).

It seemed logic for the two founders to start at the high-end market with high prices and low volumes. Not before the brand name has been shaped and an image of technological reliability has been developed the mainstream market could successfully be addressed. Beyond that, it would not be possible for a start-up like Pinion to immediately purchase a large number of gearboxes due to their company infrastructure. Similarly, the bicycle manufacturers need to prepare their production as the P1.18 requires a design change of the frame (Lermen, 2013). To sum up, choosing a market niche, like Pinion, seems to be the right way to commercialize a radical technological innovation like the P1.18 transmission.

Organization

The Pinion GmbH has officially been founded at the 29th of October 2008. As the former company site gradually became too small, Pinion moved in April 2012 to larger production facilities from Feuerbach to Denkendorf, near Stuttgart (Pinion, 2013, p. 3). Christoph Lermen and Michael Schmitz are entered in the commercial register as executive directors (Creditreform Deutsche Firmenprofile, 2014). By 2014, Lermen and Schmitz hold 23.24 % of the company's shares each and the Pomian GbR 53.52 % (Hoppenstedt Firmenprofile, 2014). Beside the two founders, Pinion has nine employees since the beginning of 2014 (Lermen, 2013).

Strategy

It is Pinion's vision to develop and commercialize a competitive bicycle transmission in accordance to automotive standards. This bicycle transmission should become a natural alternative to the traditional bicycle shifting systems. Therefore, Lermen and Schmitz have founded Pinion. Thus, it is the genuine purpose of the company to realize this vision. To reach this goal, Pinion developed primary autarkic and waited long before presenting their gearbox to the public (Lermen, 2013).

At first, Pinion addresses the premium segment of the German mountain, trekking, and touring bikes market to get established. Later on, the company is planning to cover the entire bicycle market in Germany, Europe, and finally, all over the world (Lermen, 2013; Schäfer, 2013).

Structure and Processes

With nine employees and the two founders the Pinion GmbH has a small size. Correspondingly, the structure and processes are relative loose. The company has a flat hierarchy and little predefined processes with a low level of bureaucracy (Lermen, 2013, 2014). Accordingly, the company had no organigram by 2014. In addition, the company is quite autonomous. Due to the fact, that the company was founded to commercialize the

Pinion technology, it is not integrated into a coherent whole of an established concern structure. The total structure was established to foster the technology commercialization process. Furthermore, the investor does not force the team to follow strict milestone-plans, but leaves the operational management to Lermen and Schmitz (Lermen, 2013).

For the evolution of the highly innovative gearbox this was beneficial as innovations could not evolve within tight structures and hierarchies (Holzschuher and Pechlaner, 2007, p. 45). Since 2012, Pinion has reached series production and therewith reduced uncertainty. The need to become more efficient with respect to its processes is obligatory. Therefore, Pinion hires experienced employees, such as a new assembly and quality assurance manager, during 2014, to establish clear structures for processes like purchasing and quality management. Additionally, Pinion thinks about getting certified according to DIN EN ISO 9001. For the bicycle-branch this is not a prerequisite. Thus, Pinion does not strive for it just for the sake of the certificate, but for being forced to establish certain structures and processes (Lermen, 2014).

Company Culture

An innovation friendly company culture is essential to successfully realize technological innovations. According to Lermen, the company atmosphere is very good (Lermen, 2013). The employees have a lot of ideas that are appreciated by Lermen and Schmitz. In general, Pinion is quite open with respect to new ideas. Nevertheless, since the start of series production, the company has left its creative startup-phase. Now, Pinion has to prioritize the emerging ideas regarding feasibility and rapid realizability due to certain obligations like concrete delivery dates. Being aware that this would hamper creativity even more, Lermen and Schmitz are trying to hire experienced employees within the next recruiting round for establishing a solid company. With an eye to the future, Lermen thinks of an independent advanced development division as a sort of creative pool for the development and realization of new ideas (Lermen, 2014).

The commercialization of technological innovations is a highly uncertain endeavor, and thus the need for an intensive information exchange is great (OECD, 1971, p. 13). At the moment, Pinion's internal communication is primarily issue-specific and on an ad hoc basis. There are no regular meetings. In case of an emerging topic or problem, the employees spontaneously walk and talk to the responsible colleagues. According to Lermen, this leads to a rapid solution but sometimes interrupts working processes and leads to a certain kind of inefficiency (Lermen, 2014).

In addition, the team is growing, and to keep everybody informed team and topic-specific meetings needs to be implemented. Previously, such continuous meetings have been unnecessary as the team was small and worked together in the same office (Lermen, 2014).

A central knowledge management is not existent within Pinion. For archiving CAD-files the company uses the integrated product data management system of SolidWorks, Pinion's CAD-system. The remaining data like Microsoft-Office-files are stored on a server solution (Lermen, 2014).

Funding and Commitment

Gear manufacturing, in particular the creation of prototypes, is expensive. Thus, Lermen and Schmitz decided to search for an investor even before they founded the company. Pinion had an advantage in their search, since their product innovation was quite tangible. The majority of potential investors had a more or less close connection to the field of bicycles and furthermore, the advantages and disadvantages of traditional derailleur systems and internal

hubs were easy to explain. Hence, it was not a big challenge for the team to get access to potential investors. The team carefully selected its partners and even neglected the cooperation with one investor due to bad gut feeling. Finally, Lermen and Schmitz got to know their future investor at an event organized by the Technologie-Transfer-Initiative GmbH (TTI) (Lermen, 2013). The TTI is the central place to go at the University Stuttgart for people, who need advice and support in all issues concerning company foundation (TTI). At this event, several founders had the chance to introduce themselves and their business concept to a group of investors. On this occasion, the Pinion team met an investor, who was a supplier of the automotive industry from Pfullingen and showed great interest in the project. After several discussions and tough negotiations, the team officially founded the company together with this investor in October 2008 (Lermen, 2013).

In 2008, the team additionally received the EXIST-grant. This is a German government funding for the creation of start-ups. Repeatedly, Lermen and Schmitz applied for this sponsorship. Two to three times the application has been refused, during a period in which the two founders would have needed it most. When they finally obtained the grant, it was not absolutely necessary as they already found an investor (Lermen, 2013).

By the end of 2008, the automobile crisis emerged quite fast and heavy. As the investor was active in the automotive industry, he informed the Pinion team in the beginning of 2009, that he was not able to further fund the company. He could not take the responsibility to invest risk capital into a start-up on the one hand, and send his employees into short-term work or even lay them off on the other (Lermen, 2013). As a result, the Pinion team was left without an investor just a few months after contract signing (Reidl, 2012).

The involved people from the company of the first investor regretted their exit and tried to support Lermen and Schmitz to build and establish contacts. Consequently, the two founders got in contact with a person from Munich, who was originally meant to provide contacts to potential investors within his broad network. Educated as a physicist, he worked in science and was part of the management board of several German industrial concerns. Furthermore, he founded and sold his own venture. Now in his advanced age of about 70 years, he is investing in miscellaneous projects and start-ups (Lermen, 2013). In the spring of 2009, the Pinion team arranged a meeting with him and presented their new gearbox design. Instead of exclusively discussing target markets and potential sales figures, the three were analyzing technical challenges and the details of the new design (Reidl, 2012). Beyond that, the future investor conducted a due-diligence investigation to work out in deep the main risks, strengths, and weaknesses of Pinion's business. Due to this intensive evaluation period, the three got to know each other very well and were on good terms. Subsequently, he left rather to acquire an investor for the Pinion team. One week later, he called and told the team that he would like to participate on an equity basis himself. The Pinion team signed a cooperation contract with him in October 2009 (Pinion, 2013, p. 2; Lermen, 2013). The new investor enjoyed full voting right but left the operative management to Schmitz and Lermen, who maintained their position as main associates and executive directors of Pinion (Lermen, 2013).

With their new investor, Lermen and Schmitz were lucky, as he is enthusiastic about the product and provides not just money, but additionally technical and personal interest (Donner, 2012). Hence, he is not just an investor but mentor and consultant as well (Reidl, 2012). In the face of high uncertainties and longtime horizons, technological innovations pose specific challenges not only to the founders but also to the investor. Deep support, cautiousness, and goodwill of the investor are required to reach market maturity and commercial success (Meier, 2007, p. 282). In the case of Pinion, this becomes apparent, as

the team developed seven years without selling a single product and generating revenue (Donner, 2012).

According to Lermen, among the investor's reasons to enter have been the joy and ambition to participate and shape the future of this promising project. Thus, he does not follow strict rules of general institutional investors regarding return expectations and exit strategies (Lermen, 2013).

Since signing the contract, the partnership has been undisturbed. Once every six to eight weeks, both parties meet to discuss open issues and the current status. The investor is totally informed and the relationship bases on absolute mutual trust. Without this trust, it could have become pretty troublesome for Pinion, as there have been various challenges during initial production phases. In general, new developments take time in the mechanical engineering sector. So it was with Pinion. When the two engineers destroyed several prototypes on the test rig and the spare parts frequently had a delivery time of three to four months, the progress stagnated. As Pinion mainly trusts on suppliers of the automobile branch, its bookings steadily slip to the end of the order list in times of high capacity utilization. Especially in these situations, true investor commitment is cruical (Lermen, 2013; Reidl, 2012).

Entrepreneurial Team

Since the beginning of 2014, Pinion has nine employees beside the two founders, Lermen and Schmitz. The whole team is quite young with an age distribution of 26 to 36 years and is thus very homogenous. Schmitz and Lermen are jointly responsible for managing the businesses of the company like financial affairs and negotiations with suppliers and customers. Additionally, they are working in the design engineering. By 2010, the first employee, a design engineer, was hired and is still on board in 2014. Furthermore, there are two sales representatives, two additional design engineers, an assembly worker, an assembly manager, a part-time accounting employee, and an office worker (Lermen, 2013, 2014).

According to Lermen, the management and the team pull together and are highly motivated. They share a relaxed relationship among each other with a good atmosphere. The young, enthusiastic employees are very creative and have a lot of ideas. On the other hand, Pinion lacks experienced personnel that possess serenity, sovereignty, and know-how to deal with challenging situations. The Pinion staff mainly consists of university graduates and first-time employees, who need to learn and expect guidelines from the management. Lermen and Schmitz are only able to make a limited contribution to providing the desired assistance, as they are equally doing it for the first time. The two founders are aware of this and are therefore planning to hire preferentially senior professionals within the next recruiting round (Lermen, 2013, 2014).

Innovation Process

Opportunity Identification

In 2006, the two engineers Christoph Lermen (Aerospace Engineering) and Michael Schmitz (Business and Engineering) got to know each other when they were working students at the engine and transmission design department within the Porsche R&D-center in Weissach, Germany (Lermen, 2013). Soon, both detected that they shared enthusiasm not just for motorsport, but for mountain biking as well (Donner, 2012, p. 24). It was within this context that the initial idea for the foundation of a company emerged. However, it was not entrepreneurship for its own sake that was the focus of the Pinion team. Rather it was the ambition to solve the central technological challenge that drove them to start their own business (Lermen, 2013). Lermen and Schmitz were unsatisfied with traditional derailleur systems with their typical problems of stuck chains, bent derailleurs, and the need for time-consuming care and maintenance after each ride. Internal hubs did not provide a real alternative, since they are less efficient in certain gears, did not meet high standards regarding bicycle handling and dynamics, and have an unfavorable weight distribution (Pinion, 2013, p. 3). Lermen and Schmitz asked themselves why there should be maintenance free gearboxes in cars and motorbikes but not in bicycles (Lermen, 2013). Having found no satisfactory answer to this question, they decided to realize their vision of developing a competitive gearbox for bicycles in accordance to automotive standards in order to offer a real alternative to the traditional derailleur system. However, to get from mind to market, the team had to go a long way (Donner, 2012, p. 24).

Product Development

After idea generation in 2006, Lermen and Schmitz developed the initial concept further in parallel with their university education and their employment as working students at the Prosche AG, activities that naturally limited their available time. Starting with rough paper sketches, the team refined their ideas to gain first CAD-drafts (Lermen, 2013). During 2006 and 2007, various transmission concepts were developed, discarded, and revised (Pinion, 2013, p. 2). Ultimately, the team settled on one concept and elaborated it to such an extent that the main components were specified – practical realization seemed feasible (Lermen, 2013).

For testing their gearbox-prototypes, the two engineers installed a test rig and subsequently tested their first prototype in November 2008 (Pinion, 2013, p. 2).

When Pinion lost its first investor in the beginning of 2009, the team used the arising unoccupied time to thoroughly revise their design concept (Lermen, 2013). The initial gearbox design contained three intermediate shafts (Pinion, 2013, p. 2). During the manufacturing and testing of the prototype, the team discovered huge technical weaknesses of this initial design concept. According to Lermen in retrospect, this concept could not have been manufactured in serial production. As the former investor drove them by milestones and deadlines, the team probably would have been caught within this initial concept and forced to retain and refine it (Lermen, 2013). Due to their obligations towards their investor, they just had no time to fundamentally optimize and question their invention (Reidl, 2012). Thus Lermen summarized, that the exit of the investor at precisely this point in time, has been a stroke of good fortune (Lermen, 2013). Within the subsequent unoccupied time of the first half of 2009, the team developed a design concept with two transmitting shafts, which was brought to serial production later on and which is equivalent to the current design of the gearbox (Pinion, 2013, p. 2).

In December 2009, a newly developed test rig was commissioned (Pinion, 2013, p. 3). On this test rig the Pinion team tested primary the load capacity and performance of the gearbox. Endurance and long-time tests have been conducted by experienced bikers on the track (Lermen, 2013).

The gearbox went through its baptism of fire when extreme biker Felix Fröhlich crosses the Himalayas riding a Pinion bicycle transmission prototype in the summer of 2010 (Pinion, 2013, p. 2). The team felt slightly uncomfortable, but Felix Fröhlich knew the risk and dared the adventure carrying a replacement gearbox in his luggage. The prototype overcame the strains of the tour and this has led to a huge media attention (Reidl, 2012).

On the trade fair Eurobike 2010 the Pinion team exhibited an advanced prototype under the name Pinion P1 for the first time to the public (Pinion, 2013, p. 3). Heretofore, the team has developed their innovation over four years without considerable contact to bicycle manufacturers. The reaction and response to the product was overwhelming and strongly motivated the team (Reidl, 2012).

In the spring of the following year 2011, the first bicycle manufacturers began to develop a framework for the gearbox, which bore the official name P 1.18 from then on. As a result, the first bikes equipped with a P 1.18 pre-series model were presented on the bicycle trade show Eurobike 2011. By the end of 2011, the team finally revised the design and lifted the P 1.18 from pre-series state to production standard. After that, general production began (Pinion, 2013, p. 3).

Lead User Integration

Pinion particularly integrated lead users at testing gearbox prototypes. Primary, these were skilled amateur cyclists that contributed to the product development by serving detailed feedback regarding performance and existing problems of the gearbox (Lermen, 2013). Additionally, they provided concrete advice for modification when they highlighted the potentials for improvement of the chain guide, the freewheel, and the shifter for instance (Donner, 2012, p. 25; Stahl, 2011). Beside this, several of these cyclists documented their trials in test reports that were published in diverse bike magazines. This generated publicity and increased the awareness for the new shifting alternative.

Accordingly, the breakthrough of the P1.18 was accomplished when in 2010 Felix Fröhlich, a friend of the two Pinion founders and extreme cyclist, crossed the Himalaya riding a P1.18. Therefore, Fröhlich made an important contribution to the commercialization of the P1.18 (Reidl, 2012).

Risk and Quality Management

Pinion had no structured risk and quality management system, but used some methods to deal with risks and quality issues. In contrast of having a detailed risk analysis and evaluation procedure, the two founders mainly trusted their personal gut feeling and intuition. Lermen assumed, that Pinion has only come this far not because, both founders did so many things the right way, but due to the fact that both refused to do certain things. In retrospect, they are happy that they have not accepted several offers or did not cooperate with certain firms. Mainly intuition and collective decision making after a short conversation was the base for their risk evaluation (Lermen, 2014).

The risk of negative feedback and bad market sentiment in case of market introduction of technological immature products is relatively high. Especially for technological innovations negative market feedback during early development stages is commonly unfavorable as bad attitude towards an innovation is generally difficult to transform later on. Thus, Pinion

developed primary autarkic roughly over four years and waited long before presenting their gearbox to the public (Lermen, 2013).

Another risk to deal with was the great technological challenge. As written above, the gearbox has to withstand a torque of 250 Nm. Due to the fact that the standardized calculation methods could not be applied for the P1.18 as they were designed for automobile gearboxes, a test rig was created. To simulate the effects of many years of use under realistic conditions in a short time frame, initially a load spectrum of real-world peak forces was captured. By an iterative and empirical approach, the decisive parameters for designing a bicycle gearbox have been laboriously derived. Subsequently, the complete gearbox, and each individual component was tested under repetitive use at extreme load to ensure durability and performance (Pinion, 2013, pp. 14–15, 2013, p. 3; Lermen, 2013).

In times of series production, Pinion receives roughly 100 elements of the gearbox from approximately ten suppliers from the Stuttgart region. Not all of them delivered the expected quality right from the start. Accordingly, the incoming goods inspection and the subsequent product test on the test rig played an important role for quality assurance (Schäfer, 2013).

One of the biggest risks Pinion still has to handle is the fact that its suppliers originate from the automobile industry. In times of economic upturn, Pinion will be the last to receive their products due to their lower purchase quantity. Pinion already suffered this condition when they had to postpone their launch of the first series gearboxes (Donner, 2012, pp. 25–26).

Platform Strategy and Product Family

As far as possible, Pinion is trying to establish a common-part and platform strategy. During the development of the 18-speed gearbox the company has developed a modularized system with different components and mechanisms. At the conception of new products, these can be transferred with little modification as the basic development has been done. Accordingly, the fundamental shifting mechanism with its camshaft, pawls, and gearwheels is transferrable to any further product version. Equally, the sprocket geometry or the gearwheel design is versatile. At the establishment of a product family, this strategy approach could help Pinion (Lermen, 2014).

Pinion's next product should be a gearbox with a reduced number of gears at a lower price level. The current P1.18 has a huge performance range with respect to the number of real shifts and its transmission ratio. According to Lermen, average cyclists do not need this wide range of performance (Lermen, 2014). Furthermore, Pinion has conducted a design study of an electric motor-gear unit for bicycles (Pinion, 2013, p. 3). Nevertheless, in the medium term the company initially focuses on the classic gearbox transmissions (Lermen, 2014).

Intellectual Property

It has not been possible to obtain a patent for the fundamental gearbox concept. The idea of a bottom bracket gearbox or a spur gear in the center of the bike was not new. Correspondingly, Pinion strives for protecting individual aspects of the principle concept. Primary, several minor innovations for solving the technological challenge of the P1.18 form the main subjects of Pinion's patent applications. Recently, the company is trying to protect complementing parts like the shifting mechanism of the system. The team handed in their first patent application in October 2007. By 2014, Pinion had filed for eight to nine patent applications. Several of these have already been granted (Pinion, 2013, p. 2; Lermen, 2014).

Pinion's scope of protection contains Europe, USA, and several Asian countries. Causally for this are market-relevant data and partly also the competitors' approach. In Europe, Germany and the Benelux states are most important. As the European Patent Law admits an overall

protection at reasonable costs, Pinion opts for this option. Furthermore, the company assesses the US and Japan market to become critical for the future (Lermen, 2014).

The IP-strategy of the company is also dependent on its financial situation. In general, Pinion strives for a patent protection with respect to inventions that are decisive for the consolidation and expansion of its market position from their point of view. According to Lermen, Pinion could apply for more patents but due to the company's financial situation it has to be selective. Using their patent portfolio as a strategic lever is correspondingly not focused (Lermen, 2014).

The elaboration of Pinion's patent applications is done by a patent attorney from Stuttgart. Due to the intense cooperation, he is used to the mechanisms of the gearbox. Based on a brief invention description and some additional drawings, he is able to independently elaborate the applications. After an iterative process the patent applications are submitted (Lermen, 2014).

Commercialization

Value Proposition and Business Model

Pinion does not directly sell their gearboxes to the end-user. The P1.18 transmission is solely available as an OEM component for volume bicycle manufacturers. Thus, they cooperate with several bicycle manufacturers, who are Pinion's customers and the de facto technology disseminators. Finally, the bicycle dealers sell Pinion equipped bicycles to the end-users (Pinion, 2013, p. 21; Lermen, 2013).

Beside the technical and economic benefits (cf. relative advantageousness), the value proposition of a company is shaped by its service and social benefits (Wouters, 2009, p. 1028). Pinion tries to ease and support the use of its gearbox for its customers. As the P1.18 is not completely maintenance free, the company has uploaded several video guides to its homepage for each of the maintenance tasks to be carried out. Additionally, Pinion offers a complete spare parts program, a continually expanding range of accessories, and specialist tools through its conventional distribution channels (Pinion, 2013, p. 22, 2013, p. 27).

Furthermore, the company fosters the reputation of a high tech quality product that is able to give a signal towards urban mobility. Therewith, Pinion tries to shape the image of setting a social statement by choosing the P1.18 (Pinion, 2013, p. 16).

Cope with Uncertainty and Sensitiveness to Market Needs

Within the mechanical engineering branch, reaching the minimal viable product to gain suitable market feedback is not easy. It takes quite long to develop a mature technological innovation and half-baked products can easily lead to negative market feedback. Accordingly, Pinion developed primary autarkic roughly over four years (Lermen, 2013).

However, it is decisive during the technology commercialization process to ensure that the end product will match the market needs. Therefore, Pinion has conducted a market analysis in an early development phase and derived a requirements list together with a small bicycle manufacturer. Furthermore, Lermen and Schmitz themselves were passionate cyclists and had a broad network in the biking scene. Thus, they tested a lot on their own and discussed with friendly bikers. In due course, they involved lead users (cf. lead user integration) at testing gearbox prototypes to gain feedback (Lermen, 2013). These lead users have pointed out several weaknesses and options for improvement like the request for an integrated chain guide, a chain tensioner, or a gear indicator at the twist grip. During product development, Pinion paid attention and managed to satisfy these needs until series production (Stahl, 2011; Donner, 2012, p. 25).

In 2010, Pinion eventually exhibited for the first time on the Eurobike. The interest and enthusiasm was great and surprised the team as they had nearly no contact to the public before. Hence, it pushed the team and strongly motivated them for their further development and market introduction (Reidl, 2012).

Timing

The optimal timing of entry is a crucial decision. Pinion has prepared their market introduction strategically. In 2010, the company exhibited on the trade fair Eurobike an advanced prototype (Pinion, 2013, p. 3). According to Lermen, the Eurobike, which takes place every September in Friedrichshafen, is the most important bicycle trade fair in Europe and was correspondingly adequate for presenting their innovation to a broader publicity. The team deliberately chose their first trade fair attendance to be early and before reaching series maturity. As Pinion's customers need one to two years for preparing bicycle models for the usage with the P1.18 gearbox, Pinion had to assume the specific moment in time when the series maturity of the gearbox could be reached within the next one to two years. If the development would last longer, potential earnings could be lost. However, presenting the bicycle transmission too early would be unfavorable just the same. The emerging hype when showing the innovation to the public and the corresponding interest for the product could fade away if Pinion could not deliver for a longer period. Thus, not an easy decision, but all in all Pinion's assumptions were good as the company reached series maturity in 2012 (Lermen, 2014).

Additionally, a fortunate coincidence pushed Pinion's prototype presentation at the Eurobike 2010. The Spiegel magazine reported in their Eurobike-article about Pinion just before the trade fair starts. Correspondingly high was the attention of the visitors and media representatives at the trade fair (Lermen, 2014).

Marketing

Pinion clearly addresses the premium market segment. Thus, the company is trying to position its gearbox as a high-quality, reliable, and long lasting bicycle component contrary to the putative disposable culture of the recent past (Pinion, 2013, p. 8). Therewith, the company wants to emphasize its contribution to the modern urban mobility (Pinion, 2013, p. 16). Accordingly, Pinion chose its sales strategy. To ensure the targeted quality and safety standards of the final bicycle, the company just sells its P1.18 transmission as an OEM component for volume bicycle manufacturers working to a high industrial quality standard. Thus, the gearbox is currently not available to the public via wholesale and retail (Pinion, 2013, p. 21).

The company strategically plans its marketing efforts. Since 2010, Pinion steadily exhibits at the Eurobike and presents its innovations to the public. After the first P1.18 series products were produced, bike manufacturers were equipped with sample gearboxes to attract them (Pinion, 2013, p. 3). At consciously chosen times, the team involves journalists to highlight its products. Additionally, Pinion provides links to certain test reports of the gearbox via its homepage (Pinion).

Furthermore, Pinion cooperates with an external marketing agency regarding issues like external presentation of the company, corporate design, creation of the homepage, and generation of its image brochure (Lermen, 2013).

Strategic Alliances / Partnerships

During the commercialization process, it was essential for Pinion to create a sound network of partnerships. Within the early stages and test phase, the two bicycle manufacturers

Endorfin and Hot Chili participated in Pinion's development process. Furthermore, Pinion involved some additional manufacturers till the series production of the gearbox (Lermen, 2010).

The bicycle manufacturers in general played a very important role. It was the biggest barrier to market entry to persuade them to apply the Pinion technology. At the start of series production in 2012, there have been 15 and by the end of 2013, 40 bicycle manufacturers offering Pinion equipped bikes with a steadily rising number (Pinion, 2013, p. 21; Lermen, 2013).

Of course, Pinion has to cooperate with frame-builders as well that design and produce the modified frames for the gearbox. However, according to Lermen, this modification was not a problem for these companies (Lermen, 2013).

All parts of the gearbox were completely developed and designed by Pinion and subsequently, fabricated in contract production by ISO certified suppliers. Like Porsche in the automobile industry, Pinion is a pure assembly-firm. Roughly 95% of Pinion's suppliers originate from the automotive supplier industry around the city of Stuttgart (Lermen, 2013). On the one hand, this leads to a high level of product quality, but on the other hand, causes supplier shortages in times of economic upturn of the automotive industry (Donner, 2012, pp. 25–26). With growing quantities of sales, Pinion is planning to build up new supplier relationships even for common parts to share the risk and reduce the dependency on individual suppliers (Lermen, 2014).

Further important alliances for the company exist with the dealers offering Pinion equipped bicycles. Looking at the dealer network in Europe (cf. Figure 11), it becomes obvious that Pinion's current sales focus is clearly situated on the German market with strategically selected distributors in neighboring foreign countries (Pinion, 2014).

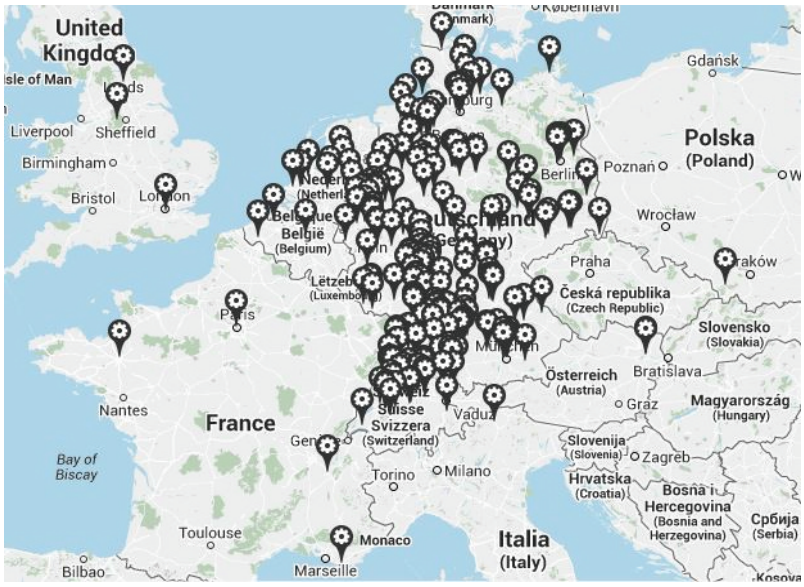


Figure 11: Pinion Dealer Network in Europe (Pinion, 2014)

Innovation Success

Performance

Product Performance

Since the Pinion P1.18 entered series production, more than 1,000 gearboxes have been sold by 2014. The gearbox is a mature product that meets its high requirements with respect to load, durability, and performance (Pinion, 2013, p. 3). Several benchmark tests have been conducted and the reaction and response to the gearbox were predominantly positive (Reidl, 2012).

In comparison with the alternative shifting systems, the Pinion P1.18 has concrete advantages as well as concrete disadvantages (cf. relative advantageousness). Therefore, it is essential to hit the customer preferences of the chosen target group, mountain bikes and trekking & touring bikes. In both markets the P1.18 is beneficial (Pinion, 2013, p. 5; Lermen, 2013).

For the creation of the P1.18, Pinion was awarded with the BIKE Milestone Award for the best bicycle component of 2011 (Pinion, 2013, p. 3).

Sales Performance

With the start of series production in 2012, Pinion cooperated with 15 bicycle manufacturers and ended up with three-digit sales figures. 2013 Pinion generated with 40 manufacturers a low four-digit sales figures and roughly 1.1 million € revenue. The number of collaborations with bicycle manufacturers is rising on and on. Pinion expects to reach sales figures of middling four-digit range within the next years (Lermen, 2013).

According to Lermen, on a scale from great skepticism if Pinion will still have a product on the market in the future until the P1.18 is a natural alternative to the established shifting components, Pinion is positioned right in the middle. By the end of 2013, Lermen stated, most of the bicycle manufacturer have realized that the Pinion transmission is not just a flash in the pan, but will be a longtime business (Lermen, 2013).

Efficiency

According to Lermen, one of the decisive factors at commercializing technology is to possess immense power of perseverance. He estimates that it takes seven to ten years from idea emergence of a technological innovation to its full establishment in the market. Since the idea generation of the Pinion gearbox, it has been seven years by now, and risk of failure still exists. Therefore, it is important to take the time that is needed to develop a technological mature product and not to bring half-baked development results to the market (Lermen, 2013; Reidl, 2012).

The de facto technological breakthrough took place when the first investor stopped his investment in Pinion. Previously, the team has to keep tight timelines and strict specifications. After the investor's withdrawal, the team took their time to question and to optimize their invention (Lermen, 2013). Being efficient is important, but just being fast is not the preferred method to take when it comes to the development and commercialization of radical technological innovations.

However, for the sake of efficiency the development costs need to be kept down. The founders did not take high salaries and firstly worked with student licensees of their CAD-software SolidWorks. Not before company foundation, they finally bought a full license (Lermen, 2014). As gearbox manufacturing is expensive and prototypes in particular, the team tries to save costs as far as possible. Initially, the prototypes have been tested externally at an automobile gearbox test rig. Since this was very expensive, Pinion decided early to develop and build its own test-rig (Lermen, 2013).

Interestingly, Lermen stated that the time at the Porsche R&D-center has not helped them to develop the P1.18 gearbox. According to him, the influence of Porsche with respect to the fundamental technique has been marginal and is mainly limited to inspiration. The team has not transferred any concept of Porsche gearboxes to their bicycle gearbox. Furthermore, no employee of Porsche helped them with their development and their engagement as working students did not enable them to gain deep insights into Porsche's process structures (Lermen, 2014).

References

Bergleben (2014), “Shimano XT Schaltung”, available at: http://www.bergleben.de/mountainbike/2269-e_418667,parentE_418669.html#thePic (accessed 12 February 2014).

Birkhofer, M. (2013), *Pinion 2014 - Eurobike*.

BWMi, “The EXIST program”, available at: http://www.exist.de/englische_version/index.php (accessed 5 March 2014).

Colibi (2013), “European Bicycle Market & Industry Profile - Edition 2013”, available at: http://www.colibi.com/docs/issuu/European%20Bicycle%20Market%20&%20Industry%20Profile%20-%20Edition%202013.pdf (accessed 27 February 2014).

Creditreform Deutsche Firmenprofile (2014), “Pinion GmbH” (accessed 22 January 2015).

Donner, J. (2012), “Die Pinions kommen”, *Trekkingbike No.* 4, pp. 22–29.

Fallbrook (2012), “Nuvinci_N360_Datasheet”, available at: http://www.fallbrooktech.com/sites/default/files/videos/N360_Datasheet_English_Web.pdf (accessed 12 February 2014).

Fallbrook (2014), “FAQ - Fallbrook Technologies Inc.”, available at: http://www.fallbrooktech.com/cycling/faq (accessed 12 February 2014).

GloboMeter, “Die Welt in Zahlen”, available at: http://de.globometer.com/sport-fahrrad.php (accessed 27 February 2014).

Holzschuher, W. von and Pechlaner, H. (2007), “Wie sollen Ausgründungen ablaufen? - Realisiserung von Ausgründungen im Rahmen eines prozessbezogenen Transformationskonzeptes”, in Pechlaner, H., Hinterhuber, H., Holzschuher, W. von and Hammann, E.-M. (Eds.), *Unternehmertum und Ausgründung: Wissenschaftliche Konzepte und praktische Erfahrungen*, 1st ed., Deutscher Universitäts-Verlag, Wiesbaden, pp. 41–54.

Hoppenstedt Firmenprofile (2014), “Pinion GmbH” (accessed 22 January 2015).

Lermen, C. (2010), *Eurobike 2010 - Pinion Getriebenabe*.

Lermen, C. (2011), *Fahrbericht Pinion / Nicolai Helius AM*.

Lermen, C. (2013), *Expert interview regarding the commercialization of technological innovations at the Pinion GmbH as example (conducted by Florian Wohlfeil)*, Telefoninterview.

Lermen, C. (2014), *Second expert interview regarding the commercialization of technological innovations at the Pinion GmbH as example (conducted by Florian Wohlfeil)*, Telefoninterview.

Meier, J. (2007), “Wie man Ausgründungen zum Erfolg führt – Die Sicht des Finanziers”, in Pechlaner, H., Hinterhuber, H., Holzschuher, W. von and Hammann, E.-M. (Eds.), *Unternehmertum und Ausgründung: Wissenschaftliche Konzepte und praktische Erfahrungen*, 1st ed., Deutscher Universitäts-Verlag, Wiesbaden, pp. 263–284.

OECD (1971), *The conditions for success in technological innovation*, Paris.

Pinion, “Testberichte | PINION / P1.18 / DRIVE TECHNOLOGY”, available at: http://pinion.eu/discover-pinion/test-reports/ (accessed 12 March 2014).

Pinion (2013), “Pinion Imagebrochure 2014”, available at: http://www.pinion.eu/PDF/pinion-broschure-2014-web.pdf (accessed 22 January 2014).

Pinion (2014), “HÄNDLER-Netzt Pinion”, available at: http://pinion.eu/discover-pinion/haendler/ (accessed 22 January 2014).

Pro Activ GmbH (2014), “Handbike - Tetra-Ausstattung - Kettenschaltungen - Komponenten”, available at: http://www.proactiv-gmbh.de/tetra-ausstattung_handbikes_kettenschaltungen_komponenten.php (accessed 12 February 2014).

Reidl, A. (2012), “Getriebe-Gründer Pinion: Tandem mit dem Trauminvestor”, available at: http://www.spiegel.de/karriere/berufsstart/pinion-am-fahrrad-wie-die-getriebe-gruender-ihren-investor-fanden-a-869417.html (accessed 23 January 2014).

Rohloff (2011), “SPEEDHUB”, available at: http://www.rohloff.de (accessed 12 February 2014).

Schäfer, M. (2013), “Ein Fahrradgetriebe für den Alltag - Stuttgarter Zeitung”, available at: http://www.stuttgarter-zeitung.de/inhalt.technik-ein-fahrradgetriebe-fuer-den-alltag.2b53d10d-33fb-4293-a2fd-764bcb01fd45.html (accessed 23 January 2014).
Schilling, M.A. (1998), “Technological Lockout: An Integrative Model Of The Economic And Strategic Factors Driving Technology Success And Failure”, *Academy of Management Review*, Vol. 23 No. 2, pp. 267–284.
Shimano (2011), “Shimano Alfine”, available at: http://www.shimano.com/publish/content/global_cycle/en/us/index/products/0/alfine/product.-code-SG-S700-S.-type-.html (accessed 12 February 2014).
Simpel-ch (2014), “Shimano Alfine 11 Gang Nabe - simpel.ch Velos”, available at: http://www.simpel-ch.de/fahrrad/nabenschaltung/shimano_alfine_11gang.html (accessed 12 February 2014).
Stahl, S. (2013), “Pinion 2014 mit optimiertem Zubehör von Gates und Carbocage”, available at: http://www.mtb-news.de/news/2013/08/28/eurobike-2013-pinion-mit-optimiertem-zubehoer-von-gates-und-carbocage/ (accessed 23 January 2014).
Stahl, T. (2011), “Nicolai Helius AM Pinion - Fahrbericht vom ersten Mountainbike mit Pinion Getriebe”, available at: http://www.mtb-news.de/news/2011/08/23/nicolai-helius-am-pinion-fahrbericht-vom-ersten-mountainbike-mit-pinion-getriebe/ (accessed 23 January 2014).
Staudt, J. (2011), available at: http://www.mtb-news.de/news/2011/08/23/nicolai-helius-am-pinion-fahrbericht-vom-ersten-mountainbike-mit-pinion-getriebe/ (accessed 7 February 2014).
Steinke, A. (2013), “Dauertest-Review #02: Die Pinion P1.18 im Alutech Fanes”, available at: http://enduro-mtb.com/dauertest-review-02-die-pinion-p1-18-im-alutech-fanes/ (accessed 23 January 2014).
Stiener, S. (2012), “Pinion-Getriebe in der Fahrpraxis”, available at: http://velotraum.de/news/pinion-getriebe-in-der-fahrpraxis (accessed 23 January 2014).
TTI (2014), “Gründen an der Uni Stuttgart TTI GmbH Stuttgart”, available at: http://www.tti-stuttgart.de/ (accessed 29 January 2014).
Velomobile (2013), “Velomobile Media Sales of NuVinci Continous Variable Planetary Transmission”, available at: http://velomobilemedia.com/nuvinci.htm (accessed 12 February 2014).
Warentest, S. (2013), “Fahrradtechnik im Überblick - Fahrradschaltungen im Überblick - Special - Stiftung Warentest”, available at: http://www.test.de/Fahrradtechnik-im-Ueberblick-In-die-Gaenge-kommen-1791218-1791324/ (accessed 13 February 2014).
Wouters, M.J.F. (2009), “Customer Value Propositions for Technology Commercialization: Investigating the Feasibility of a Real Options Approach. Conference Publications”, available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5373513 (accessed 15 March 2013).
Wragg, M. (2012), “Pinion P1.18 Gearbox: First Ride - Pinkbike”, available at: http://www.pinkbike.com/news/Pinion-Gearbox-First-Ride.html (accessed 30 January 2014).
ZIV (2013a), “Statistik Informationen für das Jahr 2012 – Präsentation des ZIV”, available at: http://www.ziv-zweirad.de/public/pk_2013-ziv-praesentation_20-03-2013_ot.pdf (accessed 27 February 2014).
ZIV (2013b), “ZIV-Jahresbericht 2013”, available at: http://www.ziv-zweirad.de/public/ziv_jahresbericht_2013.pdf (accessed 27 February 2014).

KIT Scientific Working Papers
ISSN 2194-1629

www.kit.edu